Innovative Livelihood Options for Sustainable Rural Development in Central Himalaya, India

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Abstract

The Central Himalaya is known world over for its rich and diverse natural bio- resources. In order to utilize these natural resources in a sustainable manner, it is important that resources be harnessed efficiently to meet the people's development aspirations without degrading them and therefore, urgent need for large scale establishment of technology resource centre was realized. 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 in the Central Himalaya. Technology change is an important instrument in the continuous process of socio-economic development. Of late, development planners have realized the importance of suitable or appropriate technologies and practices, and therefore, have stressed upon the need for a large scale demonstration, on-site training, capacity building and skill development of user groups in rural and marginal areas. In this regard, the Rural Technology Demonstration and Training Centre (RTDTC) established by Garhwal Unit of G.B. Pant Institute of Himalayan Environment and Development have been perceived as a means of developing and disseminating improving technologies through action and participatory research. The new approach, on the one hand, may be able to diversify livelihood earning options for local communities and may also help conserve natural resources on which these options depend on the other. Rural technology is widely recognized as one of the major determinants of socio-economic development, and the idea that the simple and hill specific transfer of technology from lab or field lab to field/land will result in growth and thereby poverty is alleviating. As a result of these efforts, a number of farmers and other stakeholders, including NGOs have adopted some of the potential rural technologies at various levels. The programme facilitated regular interactions among scientists and primary stakeholders during the period 2004–2012, so as to ensure that farmers acquired all necessary knowledge related to a technology and entrepreneurship. 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 facing common problems/issues and having similar environmental and socio-economic conditions.

Keywords: Rural technology, Capacity building, Natural resource, Livelihood, Sustainability

Introduction

The Himalayan mountain system is one of the most fragile and complex ecosystems in the world. People living in this region rich in terms of natural resources happen to be the poorest of the poor and marginalized. They are primarily dependent on subsistence agriculture and forest resources and are struggling for raising their income and quality of life. Frustrated youth are migrating in large numbers to the urban and industrial regions in the plains in search of employment (Maikhuri et al. 2011; Negi et al. 2011). Land degradation, deforestation, deterioration of natural resources and increasing poverty are threats to the livelihoods of not only 115 million mountain people but also the much larger population inhabiting the adjoining Indo-Gangetic plains (Ramakrishnan et.al. 1996; Saxena et al. 2001). In India, both the Central and State Governments have realized the urgency and importance of socio-economic development of hill people together with environmental regeneration/conservation in mountain ecosystems and the Government over a period of time, it is felt that the potential of science and technology has not been adequately and appropriately harnessed in overcoming the development constraints posed by the fragile Himalayan environment (Palni 1996; Palni and Rawat 2000; Messerli and Bernbaum 2004; Maikhuri et al. 2007). The great disparities in levels of human development between the urban and rural areas particularly in the central Himalayan Mountains are mirrored by a technology divide. The lack of access by marginal people to the most simple and basic technologies and knowledge needed to create sustainable livelihoods has condemned millions of people to an existence of recurrent poverty, food, nutritional and health security (Maikhuri et al. 2011). In this regard, the establishment of Rural Technology Demonstration and Training Centre (RTDTC) by Garhwal Unit of GBPIHED at two different locations i.e. Triyuginarayan (2200 m asl) and Maletha (560 m asl) in rural setup has been perceived as an action that could provide viable options for improving the yield potential of farm produce, income generation from off-farm activities as well as conservation and efficient management of existing natural resources while developing/improving appropriate technologies and disseminating them for sustainable rural development in the Himalayan region. The eco-friendly, appropriate technology for mountains means a technology which people can easily adopt to meet their needs, socially, economically and culturally embedded in the way that local communities derive their livelihoods (Maikhuri et al. 2007, 2011). The top-down approach of pushing new technologies for sustainable rural development without transfer of adequate knowledge and building capacities to local communities mostly failed to achieve the desired objectives in the past (Agarwal and Joshi 2006). The main objectives of these demonstration centers is to train and build capacities of local farmers and other user groups and to make them adopt some of the simple, low cost, hill specific rural technologies in participatory mode. It was done with the hope that the improved capacities of local farmers help widespread adoption of rural technologies in Uttarakhand and thus help expand the existing limited livelihood earning opportunities in remote and far isolated areas of this Himalayan state. Farmers' capacity building and large scale adoption was considered most distinguished feature of demonstration of appropriate technology programme. The broad areas covered for technological interventions based on new and evolving approaches include improvement in agricultural productivity (protected cultivation), off-farm technologies, use of organic composting and other supporting technologies (Singh et al. 2006; Rawat et al. 2010). This learner-centered experimental learning approach improved the capacities of the farmers to analyse livelihood and conservation related problems in order to find out appropriate solution locally. This is particularly important in the Himalayan Mountains where local communities have very limited access to modern facilities or to secure external help for solving the local problems. The level of knowledge, skills, enthusiasm and values of the user groups were considered key factors in stimulating the learner’s interest and appreciation of implementation of rural technologies.

Study area and Methodology

Present study was carried out in the Central Himalaya (Uttarakhand), situated between $20^0$31’9” to 31^0 26’5” N & $77^0$35’5” to $80^0$6’ E. The total population of the state is 8.48 million of which rural and urban population is 74.33% and 25.67% respectably (GoI, 2004). The region can be divided into three markedly different agro-climatic zones along the elevation gradient (vertical zonation) viz., lower altitude, 500 to 1000 m, middle altitude between 1000 to 1800 m and higher altitude, above 1800 m.

Before initiating the programme, an in-depth rapid rural appraisal survey was carried out in few selected cluster of villages of the region in order to identify and select progressive farmers interested to receive sustained training and exposure at demonstration sites. Participatory learning and sharing of knowledge was the method adopted during the present field based capacity building programme. For successful demonstration and transfer of rural technologies among local farmers and other user groups, field demonstration and training center's were established at two different altitude under diverse climatic conditions and agro-ecological zones of Uttarakhand i.e. Maletha village located at an altitude of 560 masl (district Tehri Garhwal) and Triyuginarayan village at 2200 masl (District Rudraprayag). Sixteen potential simple rural technologies were successfully demonstrated based on science and technology inputs (Table 1). A total of 45 training programmes were organized at demonstration sites for different stakeholders i.e. farmers, students, NGOs and officials of government line departments for capacity building and skill development. A monitoring and evaluation mechanism was followed to measure the successes of the programme.

The cost-benefit analysis of each technology demonstrated at the sites was worked out and mainly depends on the nature of intervention, materials/items required for infrastructure development, land area treated/covered and other monetary inputs, yield of the products (agro and others) and their monetary equivalent. The major monetary inputs for the technologies tested/demonstrated mainly includes materials/items such as iron rod, UV polythene, bamboo poles, sand, cement, brick/stone, honeybee colony and rearing box and kits, vegetable seeds, mushroom spores, sugar, preservative, plastic containers, barbed wire, etc. The monetary output includes yield of the produce/products and their monetary equivalent based on the current market rates. The manpower required for different activities/operations under each technology was calculated based on the prevailing daily wage labor rates (Table 2).

During the implementation of the present programme, training and related material was developed both in Hindi and English languages to enable different stakeholders including local farmers to refer to them in their own preferred language whenever needed. Scientists, field/extension workers from local NGOs, officials of government line departments and local knowledgeable people were invited to deliver lectures or share their views/ideas on various rural technologies. Transfer of technology (TOT) requires high levels of planning, management and evaluation skills to ensure clarity of purpose, focused partnerships and assessment of effective progress. Therefore, integrated framework was developed taking into account the experiences and expertise of different disciplines, was able to provide the most effective way of understanding the issues and solving the problems related to rural technology adoption (Figure 1). The cost-benefit analysis of each technology demonstrated at the sites was worked out and was mainly depends on the nature of intervention, materials/items required for infrastructure development, land area treated/covered and other monetary inputs, yield of the products and their monetary equivalent. The monetary output includes yield of the produce/products and their monetary equivalent based on the current market rates. The manpower required for different activities/operations under each technology was calculated based on the prevailing daily wage labour rates.

Experimentation on vegetable cultivation under protected technology was carried out for evaluating the suitable condition for cultivation of vegetables, three treatments viz., polyhouse, shadenet and plastic-mulch are selected with comparison to open condition at both the altitude. Some important vegetables viz. *Lycopersicon esculentum* (Tomato), *Solanum melongena* (Brinjal), *Brassica capitata* (Cabbage), *Brassica oleracea* (Cauliflower), *Capsicum annuum* (Capsicum), *Phaseolus coccineus* (Beans), *Pisum sativum* (Pea), *Coriandrum sativum* (Coriander), were selected for cultivation trial for all treatments**.** The economic yield of plants was estimated by using the data of harvested mature vegetables from five plants of each replicate during growing season.

Results and Discussion

An understanding of the relationship between existing capacities and human resource development was considered critical for making cost-effective technology transfers that help minimize poverty (Maikhuri et al. 2011; Negi et al. 2011). Enabling access to hill specific technologies was partly about making more productive, useful technologies available and partly providing opportunities (institutional, financial, social, micro-credit, skill etc.) that support access to marginalized communities to these technologies. Building community's capacity/skill to make these choices means not just bringing new rural technologies to their doorstep, but addressing their organizational capacities and opening new channels of information and knowledge. This is particularly important in the Himalayan Mountains where local communities have very limited access to modern facilities or to secure external help for solving the local problems. Recognizing the fast changing environmental, socio-economic and cultural traditions that hill communities find themselves in and the need for innovation and thus require building of local capabilities. This will require both institutional and technical capabilities of the local communities and therefore, the notion of choice must be technologies that are appropriate, hill-specific and eco-friendly. As evident a top-down approach in the past of pushing new technologies for sustainable rural development without transfer of adequate knowledge and building capacities to local communities mostly failed to achieve the desired objectives (Palni 1996; Rawat et al. 1998; Joshi et al. 2006; Sah et al. 2007). Therefore, formal institutions have to ensure effective people's participation applying bottom up approaches to be effective as has been done during the present intervention. Areas that require immediate attention for technological interventions based on new and evolving approaches include improvement in agricultural productivity, minimizing human drudgery and value addition in wild and cultivated local resources. The skills developed during training help local farmers to become salient on the basis of their own strengthened capacities. Participatory action research and on-site demonstration and dissemination have built up the capabilities of user groups/local farmers, extension workers, NGOs and government organizations (GOs) involved in transfer of rural technologies in this region. It has also verified that local people and institutions not only adopt technologies but also strengthen their capacities to further upgrade/renovate/redesign introduced technologies based on the ecological set up and resource availability.

A total of 45 training programmes (each of 2-3 days) on rural technologies were organized at both technology centres between 2004 to 2012 and provided technical skill/knowledge to a total of 3930 participants (Table 3) belonging to different group of different region. The target group for training and demonstration was rural and marginal farmers and 885 farmers from low altitude villages and 879 farmers from high altitude villages have participated and benefited. Training was also provided to the students from high school standard (748) to post-graduate (917) level to carry forward scientific spirit, popularize knowledge and methods related to simple rural technology among their villages and adjoin area (Figure 2). These sciences motivating training programme is considered as an effective tool in generating and invigorating curiosity and interests among them to have a preference for future careers in science and technology. Training was also opened for members of NGOs and officers from government line departments to make wider dissemination of rural technologies in the region and also wish to incorporate in the management plan of government at district or block level.

As a direct result of these efforts, there are now a number of farmers who have adopted many of these technologies with different degree of success that enhanced their livelihood significantly (Table 2). Among all the technology bioprospecting of wild edibles was most favoured by the rural farmers and adopted by 172 household followed by organic composting (186 families) and protected cultivation (132), respectively. Potential wild edibles i.e. *Hippophae salicifolia, Spondias pinnata, Rhododendron arboretum, Myrica esculenta, Diplazium esculenta, Viburrnum mullaha, Aegle marmelos, Embilica officinalis, Peonia emodi* were selected by rural people for bioprospecting by making various value added products like juice, squash, pickle, sauce etc. The cost-benefit analysis of each value added product prepared from selected wild edibles was worked out in detail and these analyses revealed that total monetary output, as well as the net return, is very high for all value added products prepared. Since wild edible fruits or other edible parts can be collected from wild free of cost except labour is involved in collection of these wild edibles bio-resources. Owing market demand and people interest towards nutritional food products of wild edibles, some NGOs, stakeholders started to adopt this venture for entrepreneur by making various value added products. Now the products are being advertised through various exhibition and fairs organized at local, district, state and national level and also being sold under the brand name of *Kedar Products* in the market. Continuing prospects of wild edibles based value added products as a source of income are quite good and their demand and taste is growing continue in the region. Among the technologies adopted by farmers, the net monetary return was higher under protected cultivation, followed by biobrequetting, mushroom cultivation, vermicomposting etc. However it was observed that the income increased gradually after 2nd year onwards because during first year net monetary return obtained was low and even in some cases it was estimated in negative (-) due to higher cost involved in purchasing the materials for creating/developing infrastructure (i.e. polyhouse, shadenet, water harvesting tank, honey bee rearing etc.). The participatory action research and demonstration centers on rural technologies developed wide popularity and created awareness among the masses of the region. It has tempted and motivated school children, university students, farmers, NGOs and officials of the financial institutions particularly National Bank for Agriculture and Rural Development (NBARD), Alaknanda Gramin Bank and other interested people those performed short exposure visit to the demonstration sites through their own support.

About 2611 participants were visited the centers for exposure with maximum number of participants belongs to the categories of students followed by farmers, NGOs, etc. (Table 3).

Performances of important vegetable crops in protected and open field condition were evaluated in high (2200m asl) and low (560m asl) altitude villages to compare the yield under different conditions (Table 4). Observations were recorded for two successive growth seasons for economic yield and recorded maximum for protected condition at both the altitudes. The yield of selected vegetables was increased significantly (P<0.05) under protected cultivation as compared to open condition at both higher and low altitude. These all experimentation was also demonstrated to the rural farmers to get the practical knowledge and exposure. Protected farming is an alternative new technique for seasonal and off-seasonal vegetable cultivation particularly in high altitude region and can be successfully employed for niche areas of agriculture. Demonstrations of experimental trials and yield under protected and open condition were made regularly before the farmers through organizing regular training programme to differentiate and compare the yield under the protected and open conditions. Seasonal and off-seasonal vegetable cultivation under protected condition not only providing food and livelihood security to the farmers but indirectly playing a major role in improving nutritional status of the rural people by enrich household diets and diversity in food. Rural people are more likely to be able to grow a small patch of vegetables for their own consumption and marked surplus amount to the nearby market as an option of livelihood that is not available for them before adoption of protected cultivation. Protected cultivation technology can also play a key role in domestication, cultivation and conservation of medicinal plants in hilly area of the mountain region. Protected cultivation linked to the organic farming to improve the yield and better quality of farm produce by adopting bicompost, vermiwash and vermicomposting technology. Now farmers are able to produce vegetables that are safer for consumers, and better for their own health and that of their farm. Among all farming systems, organic farming is gaining wide attention among farmers, entrepreneurs, policy makers and agricultural scientists for varied reasons such as it minimizes the dependence on chemical, thus safeguards/improves quality of resources, environment and health

Though capacity building and training programme was initiated mainly to provide technical inputs to local farmers and local institutions, a number of new issues began emerging during initial interactions with local communities which led to redesigning, testing and development of modified approaches for making the programme more effective and successful. The integrated framework developed taking into account the experiences and expertise of different disciplines, was able to provide the most effective way of understanding the issues and solving the problems related with appropriate rural technology adoption (Figure 1). The approach initiated and steps followed had well defined criteria, indicators, and purposes that were developed by a multi-disciplinary team of experts for this rural technology transfer programme and was completed in nine steps for effective implementation i.e., i) appropriate site selection, ii) resource survey, iii) development of operational framework, iv) planning and management, v) people participation, vi) capacity building and skill development, vii) implementation/adoption, viii) monitoring and evaluation and ix) feedback. The framework was considered very successful by the stakeholders as it has brought ecologically sound, economically viable, socially acceptable, and institutionally enforceable outputs.

The programme facilitated regular interactions and discussions among scientists and primary stakeholders. The interaction of the scientists with primary stakeholders was initiated soon after the programme activities started in 2004 and continued till the farmers acquired full knowledge about the technologies in which they were interested. The regular visit of scientists/ researchers was ensured during field experiments. At the same time, farmers-scientists interactions, farmers were provided opportunities to take detail observations in the field, analyze them, and communicate their observations among themselves and to the scientists through group discussion and presentations in the programmes. The way farmer's trained and regular interactions were maintained by the team of scientists/researchers with farmers was totally and radically different from the formal training programmes in which generally experts deliver lectures to the user groups to transfer appropriate technologies in a conventional way.

Conclusions

These simple rural technologies were introduced, redesigned and developed with the goal of bringing change over a period of time, leading to socio-economic improvement, generation of employment opportunities and promotion of sustainable use of bioresources. In the Central Himalaya, for large scale adoption it would be an expensive venture for marginal farmers to adopt new technologies on experimental basis. The marginal farmers would prefer adopting technology already undergone location specific modifications with proven potential to minimize risks rather than listening and implementing technologies recommended by scientist, NGOs/GOs. etc. Training programme need to be developed for specific target audience, in ways that reach beyond awareness raising. In this endeavor, institutional linkages, active participation amongst voluntary agencies, field research groups, developmental institutions, financial agencies and all people who are the primary stakeholders become crucial for improving the quality of life in remote and rural areas to achieve short and long term sustainability. Therefore, the technologies demonstrated/introduced, tested implemented/adopted and described here can play crucial role in building up local capacity to devise solutions for tackling the identified problems to improve the livelihoods of the rural people. Besides, they will be empowered with skill and critical thinking which will fosters a sense of self- reliance, self-confidence and ability to evaluate what is beneficial and which will improve their access to affordable, environmentally sound technologies and generate meaningful employment based on locally available natural resources of the region.

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Table 1. List of simple rural technologies introduced & demonstrated at Rural Technology Demonstration and Training Centre (RTDTC), Uttarakhand, Central Himalaya

Name of technologies	Functions	Advantage
	Protected cultivation	
Polyhouse	The polythene sheet used in the construction of a polyhouse prevents the entry of the ultraviolet rays and conserves green house gases, enhance the efficiency of plant growth and development. The temperature and moisture inside the polyhouse is greater as compared to outside environment, which enhances the rate of photosynthesis and helps in better and uniform growth of plants.	It is used for enhancing the production of quality vegetables, flowers and ornamental plants etc. and also provides protection to crops from severe effect of frost and cold and diseases. It is very useful in high altitude areas for vegetables cultivation round the year. It is particularly useful for farmers having small landholding in which multi-tiered cultivation in trays with the help of racks is possible.
Nethouse	A nethouse protects the crops grown inside from harmful ultraviolet rays as well as from 60% infrared radiation. Thus a nethouse saves the plants from extreme summer temperature and help in maintaining required air and soil moisture.	It is useful for the farmers with small holding and can be used effectively like polyhouse. Off seasonal vegetables cultivation and nursery raising of medicinal plants provide better yield under net house.
Polypit	Polypit technique is used for cultivation of off-season vegetables and growing other crops. The polypit trench helps in the buffering of temperature inside resulting into increased CO_2 fertilization effect, and also minimizes the water requirement.	It is a simple, low cost, practicable and effective technique for raising and protecting plant materials from severe winter temperature.
Poly-tunnels	Low tunnels generally covers row of plants in the field providing protection against low temperature, frost, winds and insects.	It is a simple, low cost, practicable and effective technique for raising and protecting plant materials from severe winter temperature. It is equally beneficial as polyhouse.
Mulching	It is practice of covering soil around cultivated plants to make condition more favourable to the plant by conserving soil moisture, maintaining higher soil temperature, controlling weed and keeping root zone more friable allowing soil aeration for better growth.	It is used for enhancing the production of quality vegetables, flowers and ornamental plants etc. and also provides protection to crops from severe effect of frost and cold and diseases.
	Organic composting	
Biocomposting	The compost prepared through traditional methods usually take 8-10 months to fully decompose. However, compost prepared through improved techniques in which weeds/dry leaves, mixed with cow dung and is placed kept inside the pit. Through this method compost is ready for use between 45 day depending upon the materials used	The compost prepared through this technique is richer in nutrients as compared to the compost prepared traditionally. Through this technique, the decomposing time as well as loss of nutrients can be minimized considerably and higher production can be achieved.
Vermicomposting	Vermicompost is a simple technique in which biodegradable waste i.e. agricultural and vegetable residues, weeds, excreta of animals etc are converted into organic manure with the help of earthworms. In this process the earthworms (*Eisenia foetida* species used at demonstration site) are bred in a mixture of cow dung, soil and agricultural residues.	Vermicompost provides the necessary ingredient for optimum growth of cultivated plants. Continuous use of vermicompost replenishes soil fertility quickly by improving physico-chemical and biological properties of the less fertile soils. Higher and quality production can be achieved through this.
Vermiwash	Vermiwash is a liquiform biocompost, which is applied on vegetables and horticultural crops through sprinkling. It is consists of necessary ingredient for plant growth and development including nitrogen, potassium, and phosphorus. Thus it is an excellent source of nutrients for plant growth and could also be used as pesticide in leafy vegetables.	It helps in enhancing the number of macro-micro organisms and essential elements in soil for plant growth and development. It acts as pesticides and also improves soil fertility to get better and quality production.
	Other supporting technologies/options	
Mushroom cultivation	Oyster mushroom (*Pleurotu*s sp, locally known as dhingari) offers a protein rich diet, which can be grown with in a temperature range of 10-30 ^oC up to an altitude of 2600m. Its cultivation require straw	It is a good substitute /source of employment for landless farmers and unemployed people. Its production can be started in a room at low cost. It is considered as the best food for diabetic and heart

	(wheat/paddy), soaked in the water at 70-80 ^{o}C temperature for about one hour and kept aside so as to remove excess water. Thus the straw gets ready for spawn (mushroom spore).	patients.
Water harvesting tank	Low cost water harvesting tank store rain water/unused spring or waste water for irrigation and other purpose during lean period. This technique is of great value for areas having paucity of water for livestock and minor irrigation needs.	The water harvesting tank technology is easy and cost- effective. It can retain water for a year in water deficient areas for minor irrigation and thus helps save the time and minimize drudgery.
Biobrequetting	Biobrequetting is an improved traditional practice for conversion of weeds and waste biomass for making low cost, energy efficient, non hazardous fuel.	Biobriquette is utilized in winter for warming and room heating. It can be used in room since it is smokeless and can be prepared very easily. Its application may also help in forest conservation.
Sweet technology	Slopping Watershed Environmental Engineering Technology (SWEET) is a cost-effecting mostly designed to rehabilate/restore sloping waste lands belongs to village community and private owner in the Himalaya. It involves use of lowcost bioengineering measures with active people's participation to check the environmental degradation and provide opportunity for income generation.	Capitalizing upon the positive aspect of traditional knowledge and supplementing it with appropriate scientific innovation, could substantially reduce rehabilitation cost, speed up the rehabilitation process and mobilize local participation so crucial in inaccessible Himalayan region.
Honeybee rearing	Because of diversity of rich flora, the hills and mountains of Uttarakhand are suitable for bee rearing. Majority of the flowering plants require honeybees for cross-pollination for higher quality yields.	Honey is used as a medicine and bees are known to be a good pollinator and improve the agricultural production. Short term employment can be generated through adopting this venture as a small entrepreneurship.
Bioprospecting of Wild fruits	Wild edible bioresources are being viewed as untapped or underutilized resources that could play a significant role in hill area development, poverty alleviation, livelihood and nutritional security of local communities through some appropriate technological interventions and local value addition.	Farmers have adopted this as small household activity for income generation. The various local value added products i.e. squash, juice, jam, pickle, sauce etc. are being prepared from about 25 wild plant species by the people for their household consumption and also for marketing.
Zero energy cool chamber	In this chamber, fruits and vegetables can be kept in fresh condition over a long duration. It is cost-effective, simple, eco-friendly and easily adoptable technique which works on the principle of evaporative cooling, i.e. cooling effect due to evaporation of water. The chamber can maintain the temperature 10-12^{0}C less than the outside temperature and conserve about 90% relative humidity	There is no need of electricity for its operation. In this chamber, small farmers can keep their agro-products and vegetables for longer duration in fresh and preserved condition. This structure may be utilized to preserve the domestic food item like, milk, curd, ghee, water etc except cooked food.
Floriculture	Floriculture is emerging as a viable employment industry and diversification from the traditional crops considering the increased per unit returns.	Cultivating different species of flowers i.e. Gladiolus (Nava Lux-Yellow, White Prosperity-White, Rose Supreme-Pink, Peter Plus-Pinkish, American Beauty-Red) provides good source of income to rural farmers.
Medicinal Plant cultivation (*Picrorrhiza kurrooa, Saussurea costus, Asparagus racemosus, Stevia rebaudiana, Valeriana jatamansi, Origanum vulgare*)	Medicinal and aromatic plants (MAPs) are an important component for economic development of the mountain people. Unavailability of quality planting material has been identified a major constraint in cultivation of MAP, therefore, technical backstopping has been assured to develop stock of quality of planting material.	Medicinal plant cultivation offer good opportunity of livelihood to the rural farmers. Some of the farmers mostly youth have become fully trained in cultivation, post harvesting techniques and marketing of MAPs and find it an option for livelihood enhancement as against the traditional farming.

Table 2. Cost-benefit analysis (Rs±SE) of mountain specific rural technologies demonstrated and experimented at RTDTC, Uttarakhand, Central Himalaya

Name of the Technologies	Adoptions (no. of families)	Land area covered/treated or materials used	Total monetary inputs (Rs±SE)	Total monetary outputs (Rs±SE)	Net monetary return (Rs±SE)		
					Ist year	IInd year	IIIrd year
Protected cultivation							
Polyhouse (i). Iron made (ii). Bamboo made (iii). Without polyhouse	88	10mx5mx2.5m	10680±540 3250±85 360± 18	4230±120 4230±120 1710±74	-6450±170 980±25 1350±55	4720±125 4720±125 1350±55	4990±130 4990±130 1350±55
Shadenet house (i). Iron made (ii). Bamboo made (iii). Without nethouse	32	10mx5mx2.5m	9830±510 3050±124 360±18	4150±215 4150±215 1710±74	-5680± 325 1100±56 1350±55	4610±253 4610±253 1350±55	4780±259 4780±259 1350±55
Polypit	12	3mx2.5mx1m	1025±54	1810±79	785±35	1980±85	2235±106
Plastic-mulch (i). With plastic-mulch (ii). Without plastic-mulch	32	10mx5m	750±18 360±18	2850±38 1710±74	2100±15 1350±55	3650±21 1350±55	3650±25 1350±55
Organic composting							
Biocompost	74	5mx2mx1m	1300±65	1800±78	500±40	1920±81	2133±98
Vermicompost (i). With pit (high-cost) (ii). Without pit	94	5mx2mx1m	4550±278 461±25	4710±295 1340±54	160±15 879±45	5110±302 879±45	5321±310 879±45
Vermiwash	18	50 Ltr	1460±68	326±25	-1134±55	452±210	452±210
Off-farm income generating technologies							
Oyester mushroom (i). With infrastructure (ii). Without infrastructure	78	120 kg base material	2890±135 840±52	6800±312 2845±120	3910±185 2005±85	7200±385 2005±85	7200±385 2005±85
Honeybee rearing (i) With improved wooden box (ii) Traditional technique	24	Single box	500±70 250±20	600±38 200±15	-900±45 -50±5	1100±56 250±20	1800±85 250±20
Bioprospecting of wild fruit species	172	Wild edible fruits	1725±86	3520± 124	1795±90	4826(±265)	4826(±265)
Zero energy cool chamber	06	2mx1mx1m	1900± 75	2500±112	600±35	2960±120	2960±120
Water harvesting tank (a) cemented structure(high-cost) (b) Temporary polythene lined (low-cost)	21	6m x 3m x 1.5m	9000±450 1750±90	2350±105 2350±110	-6650±375 600±30	2660±112 2660±112	2980±122 2980±122
Biobrequetting/bioglobule	39	1mx1mx1m	1820±85	5460±280	3640±180	8645±355	11880±385
Sweet technology	07	1 ha	11400±585	1806±70	-9594±455	3655±215	4756±355
Floriculture (Gladiolus cultivation)	13	1 ha	29318±273	30452±293	1134±42	24134±121	28134±312
Medicinal plant cultivation	09	1 ha	42500±23.2	168750±18.3	126250±21.3	126250±21.3	126250±21.3

One US $ = Rs. 56

Table 3. Capacity building and onsite training and exposure visit of different stakeholders in the field of hill specific rural technologies at RTDTC, Uttarakhand, Central Himalaya.

Category of Participants	Tehri district (Maletha)	Rudraprayag district (Triyuginarayan)	Total
Farmers	885 (398)	879 (502)	1764 (900)
NGOs	166 (87)	135 (56)	301 (143)
Students (from secondary to Ph.D)	689 (564)	228 (75)	917 (639)
Students (Junior level)	456 (486)	292(156)	748 (642)
Ex- Army personnel	47 (89)	17 (25)	64 (114)
Official of govt. line depts.	49 (75)	33 (26)	82 (101)
Academicians, officials from financial institutions etc.	37 (49)	17 (23)	50 (72)
Total	2329 (1748)	1601 (863)	3930(2611)

Values in parenthesis for exposure visit

Figure 1. Framework for appropriate rural technologies demonstration, dissemination, capacity building, education and communication, Central Himalaya

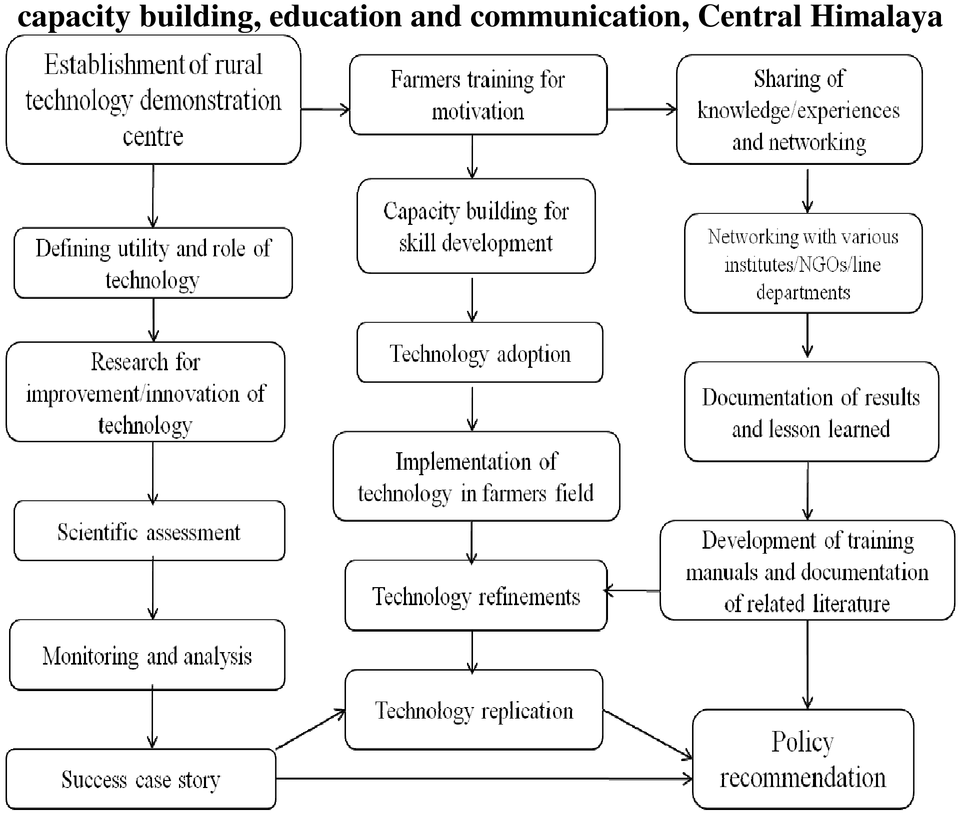

Table 4. Comparative yield of vegetables under protected condition at lower and high altitudes, Central Himalaya

	Vegetable yield kg/m^2							
High altitude	Tomato	Brinjal	Cabbage	Cauliflower	Capsicum	Beans	Pea	Coriander
Open condition	0.6±0.02^c	0.45±0.02^d	6.58±0.04^c	3.85±0.07^d	0.20±0.02^d	0.50±0.02^c	0.17±0.02^d	0.12±0.02^c
Polyhouse	2.03±0.09^a	3.07±0.20^a	13.96±0.66^a	12.55±0.31^a	2.11±0.08^a	1.91±0.07^a	1.30±0.02^a	0.50±0.02^a
Shadenet	0.94±0.03^b	0.65±0.05^c	8.07±0.45^b	6.28±0.98^b	0.34±0.02^c	0.70±0.02^b	0.64±0.01^b	0.15±0.01^b
Polymulch	0.94±0.07^b	1.17±0.04^b	8.64±0.20 ^{b}	5.28±0.09^c	0.58±0.06^b	0.77±0.05^b	0.34±0.05^c	0.13±0.01^b
Low altitude								
Open condition	2.00±0.05^c	3.41±0.03 ^{d}	12.78±1.00^b	10.93±1.01^b	1.40±0.02^d	1.73±0.03^c	1.39±0.02^b	0.40±0.03^b
Polyhouse	2.82±0.05^a	5.22±0.02^a	15.11±0.18^a	13.89±0.04^a	2.09±0.04^b	2.29±0.03^b	2.04±0.03^a	0.59±0.01^a
Shadenet	2.85±0.04^a	5.09±0.04 ^{b}	12.93±0.27 ^{b}	12.27±1.52^a	2.76±0.02^a	2.43±0.02 ^{a}	2.03±0.06^a	0.60±0.02^a
Polymulch	2.23±0.05^b	4.05±0.08^c	14.84±0.10 ^{a}	11.47±0.43^b	1.90±0.02^c	1.64±0.05^d	1.91±0.39^a	0.52±0.08^a

Values are mean ± standard error; Means values followed by the same letter(s) in a column are not significantly different (*P* >0.05) based on DMR

Figure 2: a & b on-site demonstration on protected cultivation and adoption by farmers **c,** Demonstration on water harvesting tank technology **d,** Demonstration and training on vermicompost **e,** Training on honeybee rearing **f,** People participation on land rehabilitation programme **g,** Value addition of *Spondia pinnatta* and its product ***h*,** Capacity building of women farmers on mushroom cultivation **i,** Demonstration on *Azolla* cultivation **j**, Demonstration and training center at Maletha