Chapter VI

Summary and Recommendations
SUMMARY & RECOMMENDATIONS

Mountain areas are well known the world over for their diversified and rich natural resources available for its inhabitants. In order to utilize these natural resources on a sustained basis, it is of utmost importance that these resources be harnessed efficiently to meet the people’s requirements for sustainable livelihoods without causing much destruction to the environment. The livelihood of majority of the people in mountain areas is invariably dependent on natural resources such as land, water and forest - the main component of rural food security. These areas may be substantially rich in terms of natural resource capital and ecosystem services as compared to many mainstream areas, but, in terms of socio-economic development indicators, majority of the inhabitants are invariably much less developed with a vicious circle of poverty and environmental degradation.

Now at a global level, much of the thinking is on development, which mainly constrained by the depletion of natural resources, the deterioration in the environment and the diminishing quality of life. The Millennium Development Goals agreed upon at a summit at the United Nations in the year 2000 to be achieved by 2015 also include eradication of extreme poverty and hunger, promote gender equality and empower women, ensure environmental sustainability which requires specific strategies to overcome them in relation to their different dimensions for enhancement of livelihoods in mountain areas. Infact, at a number of United Nations forums commitment has been given to the need for empowerment of the poor to eradicate poverty for which good governance is stated to be prerequisite to successful rural transformation.

Accordingly, technology change is an important element in the process of development. Designing and implementing innovative approaches, which may enhance local livelihoods coupled with conservation and sustainable use of natural resources, is therefore a challenge to the scientists and to the development planners and practitioners as well. To address this, need is being felt to develop and introduce ‘appropriate technologies’ coupled with sound delivery system as a package, which ensures economic and ecological sustainability and optimum use of mountain resources emphasizing on technology capacity building amongst rural people. There is also an urgent need to improve the existing practices and technologies so as to provide viable and cost-effective alternatives for improving the socio-economic conditions of the mountain people ensuring ecological and livelihood security. In this context, present study was conceived and carried out to study the concept of decentralized technologies, local resource use - conventional and non-conventional, strengthening of local market and upgradation of human skill which have
largely been ignored in mountainous parts of the country. Hence, the study was based on hypothesis “Science and Technology interventions in mountain natural resources will provide better livelihood support to rural communities in terms of employment generation and drudgery reduction through effective delivery mechanisms”.

In the present study, efforts were made to study the status of natural resources and selected technological interventions made and approaches required for management and utilization of natural resources to ensure sustainable livelihoods of rural people with special reference to Garhwal and Himachal Himalayas. Eight mountain villages in Gharwal (5 villages i.e. Dokhwala, Ambiwala, Chaundiyat, Gajotu and Saldhar) and Himachal (3 villages i.e. Shilanji Dangra, Dhangiyara and Shalla) Himalayas were selected as the study area so as to explore and suggest viable and replicable models for improvement of livelihood of local community particularly small farmers and artisans with conservation of natural resources and to understand the role of civil society in NRM system with innovative approaches.

Following specific areas and objectives were touched and investigated:

1. Status of Natural Resources in North-Western Himalayas;
2. Natural Resources Management and Technological Interventions Scenario in selected Rural Areas falling in Himachal & Garhwal Himalayas;
3. Impact Analysis and Identification of Successful Approaches, Promising Technology Models/packages with effective Delivery Mechanisms (5-6 of different scale) for Natural Resource Management (NRM) and enhancing Sustainable Rural Livelihoods (SRL);
4. Institutional Management, Grassroots Innovations, People’s Participation and Gender Issues in Resources Management vis-à-vis Sustainable Livelihoods and
5. Policy and Strategic Issues for Sustainable Utilization and Management of Natural Resources in Himalayas.

To meet the overall objectives a study on impact assessment of eight technology-based interventions related to NRM and SRL and their technology delivery mechanisms at the grassroots level were evaluated in the sectors like water resource management, improved agriculture and integrated farming practices, balanced use of biomass and value addition, income generation and skill development in farm, off farm/non-farm sectors and integrated resource management for village development invariably focusing on traditional and improved technologies.

For this purpose, participatory and systems based impact assessment of each livelihoods related identified technological interventions (TI) was attempted with suitable indicators as decision support tools. Impact analysis was carried out broadly for specific interventions made by S&T institutions especially science based field groups to address
specific local developmental challenges through conservation and income generating technologies at the grassroots level in study areas, based upon the traditional knowledge and wisdom and thereafter modulating the same to develop appropriate technology packages specifically contributing towards sustainable rural livelihoods to benefit mountain community.

The data collected was organized and analyzed to study the different aspects and impact of each technology interventions and delivery mechanisms applied for effective use and management of resources to enhance rural livelihoods. The survey schedule was designed for interview to elicit the opinion of people to discuss how technology based developmental programmes have helped/empowered them in terms of skill, capacity building and economic returns etc. or failed if properly not disseminated/due to faulty technologies-vis-à-vis delivery mechanisms leading to greater difficulties in the effective utilization and their dependence on available natural resource in the study areas.

Special emphasis was also given to identify the role of the local institutions-community organizations to directly articulate people’s needs and priorities, people’s participation, technological innovations, social engineering and linkages amongst stakeholders to understand their contribution in the success of demand driven interventions and post intervention sustainability of technology developmental and adoption programmes that allow local networking, scaling up participatory research and technology development and evolution of change, rather than blueprint models.

Study Outcomes: Technology Intervention Models for NRM and SRL

Keeping in view estimates available there are nearly 2, 00,000 watermills in the Himalayas right from Jammu and Kashmir, Himachal Pradesh, Uttarakhand to the North-Eastern States of the country. In Uttarakhand alone there are about 15,448 watermills rarely in use due to low efficiency and profit. For revival of these existing watermills, technology interventions made for improvement of three watermills at village Dokhwala, Dehradun were studied. It was observed that the design of traditional watermills was centuries old being used only for grain grinding with low out put of 7-10 kg of flour per hour with a net return of Rs.8,000 to 10,000/annum thereby leading towards non-functionality. A minimum maintenance cost of Rs.250-350/ per annum was also required to run these traditional watermills. In other words, 99 per cent of gross returns is invariability reflected by the grinding capacity. Technological intervention in terms of effective water use and management showing potential to supplement the income were studied from techno-economic sustainability and ecological efficiency point of view. Analysis revealed that average annual grinding capacity of the traditional water mill has increased from 2720 Kg
to 31755 Kg/annum through technological upgradation. Incorporation of different activities to the improved water mill exhibited the maximum correlation between gross returns and input cost and minimum correlation between input cost and net returns. Implication arising out of the best fit regression equation is that one unit increase in input cost will increase the gross returns by 0.99 units. Similar is the case between gross returns and net returns in the first year of integrated enterprise model of improved water mill. During second and third years the correlation analysis exhibited more or less the same status as that of first year in terms of correlation and regression between gross returns, input cost and net returns. Impact assessment of all three improved watermills clearly demonstrated that simple and affordable changes with innovative technology component have improved the functional efficiency of watermills having direct impact on the watermiller, who can sustain and improve a declining business, and the end user, who saves both time and money. This is particularly true for women, who previously had to wait for long periods to grind the grains. Reliable functioning of all three IWM with integrated components of multi-purpose use has evidently shown utility to generate power for operating small scale-enterprise in daytime and for lighting purpose at night in non-grid remote areas. All three models of multiple utility components have shown tangible benefits in second and third year after recouping the investment in first year with other tangible benefits for improved livelihoods. As compared to traditional one (used only for grain grinding), increase in net return from IWM -2 which was comparatively higher to IWM-1 and 3, was found many fold in second and third year from wheat grinding, rice de-husking and revenue generated from power supply which increases significantly to 5.27 fold in second year to 6.75 fold in third year after recouping the investment made in first year towards improvement to increase efficiency of watermill for its multiple uses and income generation. Further, analysis also showed that running of single improved watermill (3KW) with an average operating time of 6hrs/day will help in carbon abatement of 11.88 tons of CO₂ annually replacing power generation from coal, while, it will be 6.912 tons of CO₂ from small diesel gensets used to run mills. Thus, the result justify the immense potential of improved watermill with multiple use of water (TIM -1) to upgrade existing watermills as environment friendly clean technology system in remote non-grid mountain areas to address the small energy needs for lightening and running micro-enterprise.

Crisis in the small and marginal peasant farming sector remains another serious concern in the recent time in the Indian Mountain Region breaking ecological farming inter-linkages, and conflicts over natural resources to sustain their livelihood under rain-fed conditions with limited and fragmented land holdings and other socio-economic factors. The data as collected for crop diversification and introduction of off-farm activities like bee-keeping and vermi-composting in Kharif and Rabi season in terms of material input given in
different sub-systems and net return in three successive years in productivity terms and presented in monetary value at village Ambiwal and village Chaundiyat revealed that after intervention with new crops and crop combinations (paddy, black gram and cabbage and Maize in Kharif season; and wheat, mustered and lentil in Rabi season) in general, the crop diversity increased from two crop system to 4 crop system at village Ambiwal (INFARM-1). The livestock diversity also increased from 1 to 3 in almost all the cases. A perusal of results in respect of traditional baseline data and improved INFARM technology intervention system clearly indicated increase in net income value at all the farmers sites irrespective of farm sizes in first year which got increased further significantly in second year and third year due to improved productivity with crop diversification and integration of other sub-systems contributing further not only to annual income through sale of by-products like honey, vermi-compost, poultry birds and eggs, but also in nurturing soil and establishing farm productivity. Further, INFARM related livelihood indicators for this site (Village Ambiwal) also showed declining trends in stress periods with improved off farm income activity, food and vegetable availability round the year and reduced migration pattern. On another site i.e. Village Chaundiyat (INFARM -2) located at high altitude (1800m amsl), after intervention with new crops and crop combinations (Finger Millet, Paddy, Amaranth and Razma or Maize during Kharif season, and Wheat, Mustard and Lentil during Rabi season) in general, the crop diversity increased from three crop systems to 4 crop systems in Kharif and from one crop system to 3 cropping systems in Rabi season. The livestock diversity also increased from 1 to 3 in almost all the cases as also reported at INFARM site - I. Detailed data analysis in respect of traditional and improved INFARM technology intervention system at village Chaundiyat, Uttarkashi located at higher altitude clearly indicated increase in net income value at all the farmers sites irrespective of farm sizes in first year which got increased further significantly in second year and third year due to improved productivity with crop diversification and integration of other sub-systems. Further, INFARM related livelihood indicators for this site (Village Chaundiyat) also showed declining trends in stress periods with improved off farm income activity, food and vegetable availability round the year and reduced migration pattern. Statistical analysis reflected that all the farming integration process at these locations were successful. The consolidated analysis for all the ten farmers at both locations showed that F10 farmer at site 2 was the most successful farmer in terms of integration of various farming components. It was found that once the traditional inputs into agriculture are taken into account as noticed in the present study by strengthening and revitalizing mixed and multi cropping system, any productivity growth (or change) has to be explained using other factors. This is visibly evident from the results for various parameters at both the study site in terms of net monetary benefit with improved productivity and contribution of other sub-systems to improve linkages and integration of resources which shows stabilization of technological intervention process

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during three years of cropping seasons at each experimental farm site. The results for possibilities of village ecosystem re-development through INFARM interventions are in agreements with the earlier studies indicating that the village ecosystem functions of mountain particularly at higher altitude is based upon the recycling of resources within the systems as earlier reported for Central Himalaya. It was observed that the crop diversity and linkages in agriculture system have increased with the introduction of new sub-systems like poultry, bee-keeping and vermi-composting for livelihood support. In lower altitude (Site 1), the backyard vegetable cultivation with small polyhouse technology also come into existence first time, while at higher altitude (Site 2), the traditional crops (Grain Amaranth, Finger millet – VL-146; VL-149) having nutritious values have been re-established with quality seeds, which in the past were replaced by cash crops and monocropping system. Diversification in farming system has shown higher output with diverse functions at the total systems level than modern conventional capital intensive farming system which have focused on a single output. These results are also similar to the earlier findings those indicated that small farms with diversified farming are more productive due to addition of a new productive element to a farm system; better use of a natural capital for integrated systems of agriculture providing protection from adverse price changes in a single commodity with better seasonal distribution of inputs and income throughout the year. Thus, results clearly suggest that policy level interventions are essentially required for human resource development and in skill strengthening through INFARM Model approach (TIM-2) to serve agriculture needs.

Rural industrialization, based largely on value-additions to rural natural resources is clearly the way forward. It is estimated that about 20-30 per cent of the total production of fruits and vegetables go waste due to spoilage at various stages right from collection till sale points. Transportation cost of produce is also higher from the village to road head. Different topography, climate and other factors have bestowed a variety of fruits and capacity to grow non-seasonal and other horticulture produce in the mountainous region which then necessitates such type of investigations. A detailed impact analysis of potential small scale technology intervention (TI-3) for value addition technologies on cash income generation of local growers with relevant data was done for three years at village Gagotu, Distt. Rudraprayag covering cluster of villages like Gwar-Chauki, Mayali and Dulli etc within the catchments 10- 15 km in Garhwal Himalaya for three years both for tangible and intangible benefit details.

A perusal of results indicated that total investment on fixed assets and recurring cost was amounting to Rs.7,75,000/- in first year excluding land provided by the village community for setting up CFC, and Rs.1,95,000/- each in second and third year of intervention. Besides, It also included recurring cost of raw produce processed i.e. 60-68 tons/annum.
Due to higher cost involved in setting up of CFC in the first year, the net return was obtained in negative i.e. Rs. (-) 9,250/-, but, after recovering the capital investment. However, during subsequent second and third year the net monetary return increases significantly i.e. Rs.5,61,500/- deducting the negative cost of net return in first year, and Rs.7,03,540/- respectively with benefit sharing mechanism amongst all the stakeholders providing direct benefit to a network of 150 small and marginal growers from 20 villages to run the facility on self-sustainable basis. Thus, it was found evidently that through decentralized and network approach and local institutional support mechanisms for technology know-how and managerial capability to local growers, a quality chain can be established for round the year production and marketing of innovative products with adaptive R & D as analyzed leading towards improved livelihoods and employment opportunities. The statistical analysis of data further exhibited that the intervention of network model of horti-processing has further scope of processing and is being utilized at a very low capacity. This is one of the most important finding and will help in linking of more households to the existing unit for processing of their produce. Thus, such need based approach network model (TIM-3) for bio-prospecting and year round efficient resource use with minimum wastage and value addition is crucial in maintaining subsistence lifestyles of traditional mountain societies particularly inhabiting the high mountain areas with huge economic and ecological potential.

Utilization of available biomass resource (invasive/unutilized or under utilized) is one of the major resource of hill economy which needs to be exploited judiciously. Amongst biomass resources, *Grewia sp.* (Bhimal) as a family tree, and *Lantana* (Kurri) as an invasive weed have been found to be common and abundantly available biomass resource in Garhwal and Himachal Himalayas. Accordingly, to give adequate consideration about the use of these unexploited resources, relevant technological interventions of small scale were evaluated considering the ecological and economic importance to supplement livelihood needs of poor in mountain areas. A detailed impact analysis of value addition technologies with relevant data was done during study period at identified village sites viz. Dokhwala Dehradun and Gagotu Rudrapraya, Uttarakhand to evaluate the performance and viability of new intervention strategies introduced in the area for utilization of such identified biomass resources in terms of cost-benefit and technology adoption by the farmers and artisanal community. The fibre availability data with ten identified households having *Grewia optiva* as family trees revealed that improved bio-degradation process technology in stagnant water for fibre extraction has resulted in about 25 per cent reduction in time taken in rattening process with recovery of 40 per cent increased recovery of fiber of refined quality as compared to traditional retting practice in running water probably due to fast microbial enzymatic process of white-rot fungi in delignification’s process and to decompose cellulose. In case of *Lantana*, the technical
components included finishing and finalization of the products for market through training on product diversification, design up gradation with better production efficiency data showed that artisans were able to generate average net income ranging from Rs.3000/- to Rs.8000/- per month by making different products showing the potential and utility of small scale intervention to supplement the income. Dissemination of such natural product-based enterprise model, which simultaneously ensures positive conservation outcomes with adequate community participation, is important from ecological as well as economic considerations with positive livelihood strategies and for effective management of highly competitive and adaptable lantana species. Results evidently suggest generation of natural resource based technology intervention model with ‘opportunistic use’ of Grewia and Lantana (TIM-4) to create win-win situation covering economic, technological, ecology and society and to set up a rural economic activity.

The progressive diversification of rural livelihoods strategies with local non-farm activities or off-farm activities is gaining an ever increasing importance in rural household economy. To give adequate consideration to the importance of above aspects for non-farm sector, technological intervention for improving traditional practice of carpet weaving with improved loom (TI-5) as wool based livelihood option was evaluated at Village Saldhar, District Chamoli, Uttarakhand focusing particularly on exploring the need and linkages support for technological and institutional aspects in remote and high altitudinal mountain areas for improved livelihood through effective use of mountain resources and traditional knowledge system. Data as collected covering all 19 households in the study village for three years indicated that the average income generated per household from non-farm activity was as high as 77 per cent with two fold increase in income from carpet production, which was 40 per cent more as compared to income among farming households in nearby villages. Impact analysis also suggested that small scale technology intervention model (TIM-5) have addressed the problem of harsh environment vis-à-vis livelihood and gender related concern in study area by reducing vulnerability to drudgery with improved economic and ecological potential within specific agro-climatic conditions.

To assess and achieve the desired concept of sustainable use of natural resources, the study was carried out in Bagni ka Khala micro-watershed located in Shilanji Panchayat, Rajgarh Development Block, Sirmour Dist., Himachal Pradesh to find out factors with appropriate indicators to evolve effective working model (TIM-6) of process innovation and technology delivery for natural resource management. Data revealed that the average net income increased after intervention of technologies with crop diversification and using post intervention protected cultivation technologies is estimated to Rs.33,829/-, Rs.35,181/- and Rs.36,154/- for average farm size of 1.45 ha in first, second and third year of the study period respectively, which was found to be about 2 fold as compared to pre-
intervention period for average farm size of 1.38 ha thus expanding self employment horizons. Small scale hill specific technologies particularly poly-house and net-house using bamboo instead of iron structure were found remunerative and useful to farmers having small land holdings in which multi-tired cultivation in trays with the help of racks is possible to save the plants in both summer and winter seasons by suitably moderating climatic conditions, and also minimizes the water requirements. The increase in income is the cumulative effect of all biophysical and social engineering efforts in watershed management done earlier which was significant mainly due to improved irrigation facilities and protected cultivation technologies, while, net increase in cultivable irrigated land of average farmer from 1.38 ha to 1.45 ha may also be the contributing factor for improved productivity and income. Need based intervention with mechanical and biological measures have helped in efficient utilization of natural resources which significantly improved the ecology, productivity and socio-economic conditions.

Various indicators (economic, ecological and social) employed to assess the impact of different activities during post intervention period showed significant improvement in biophysical, participatory and socio-economic attributes to maximize productivity on sustained basis through efficient use of natural resources. Study showed that 80 per cent of the village respondents felt that their awareness level about watershed development and management has increased, whereas 85 per cent felt that the water availability in the area has increased due to effective process approach during implementation and post intervention period for more diverse crop production through effective water management and other resource. The impact analysis illustrated that innovative technological intervention approaches with institutional arrangements (financial, social, micro-credit and skill etc. by Watershed Management Committee) are major contributing factors to sustain and improve the livelihoods in given watershed area.

To give adequate consideration to the importance of off-farm sector, related activities data from the study village Kandhi (Dhangiara), Distt., Mandi, HP was evaluated particularly covering households from low income group having average annual family income of Rs.20,000/-, which constitute 82.7 per cent of total households in the study village. The data was collected from 77 low income households group (farmers with land holding below 0.5ha) related to vermi-compost production, sale and self use in the agriculture production. A perusal of results indicate that total average investment cost/household was amounting to Rs.2,620/- to meet the cost for construction of shed with three beds and vermiculture in first year, with average yield of 2,400 kg vermi-compost from three cycles resulting in net monetary return of Rs.1,580/-. Due to initial cost involved in setting up facility in the first year, the average net return was obtained low after recovering the capital investment. However, during subsequent second and third year the net monetary
return increases significantly i.e. Rs.4,500/-, and Rs.5,500/- respectively with saving in use of chemical fertilizers. Besides, such off-farm intervention provides indirect benefits to farmers considering the market value of increased earthworms yield and vermicompost used in own field as compared to traditional composting. Regression analysis exhibited that one unit increase in input cost will result in 0.489 unit increase in gross returns leaving no scope for further refinement of the production model thus indicating optimization of technology for field level application. Regarding Mushroom cultivation technology, results indicated that total average investment cost/household was amounting to Rs.13,000/- to Rs.14,000/- to meet the operational and raw material cost like compost to maintain small household level mushroom production facility with four tier wooden racks. In three cycles, average yield was found to be 640-670 kg with significant net monetary return ranging from Rs.10,910/- to Rs.14,920/- for fresh upgraded, unwashed and unpacked mushroom. Study data provides a sound basis that such off-farm intervention as allied enterprise has provided indirect benefits to women farmers to use spent compost for vermi-composting for use in agricultural field with other ecological and social benefits in terms of livelihood improvement and household level food and nutritional security. In another field level intervention studied in TI-7 to supplement the income with crop diversification in farm sector for cultivation of one of the high value Himalayan medicinal plants Swertia sp. (Chirata) used by pharmaceutical industry, data was collected for understanding the cost benefits of its cultivation through active participation of 18 households of same village Kandhi (Dhangiara) where women were identified as the main stakeholder to undertake this activity. A perusal of results indicate that total average investment cost/household/bigha was amounting to Rs.10,600/- to Rs.10,820/- to meet the cost of seed material etc. in first year and second year due to cropping cycle of 18 months duration. Investment of first two sowings is recouped from the return of first crop in second year with net monetary benefit of Rs.13,540/-, and significant return of the subsequent crop from third year onwards account for better return amounting Rs.33,700/- with saving in seed cost from third year onwards for further cultivation. Thus, an incremental benefit (3-fold/annum/bigha) was found to be interesting in terms of average gross returns as compared to traditional farming. Besides, it provides indirect ecological and social benefits in terms of conservation of species in nature, and livelihood diversification with improved income to local farmers with technological inputs to provide characterized planting material to the industry.

The impact assessment and statistical analysis of data also exhibited the role of technology inputs as dependable variable factors such as quality spawn in mushroom production and planting material for medicinal plant cultivation in addition to social engineering aspects and strong marketing as essential backward and forward linkages. It was observed that there was a net monetary income in third year to 21 household who adopted both vermi-
compost as well as mushroom cultivation amounting Rs.20,420/-/hh/annum, while, it was Rs.54,120/hh/annum to 18 households who adopted all three activities. It is clearly evident from the outcome of this study that as compared to base line, total average annual household income augmented (2-fold) due to additional income from both off-farm activities i.e. vermi-compost and mushroom production, whereas it is 3.5 fold if linked further with farm based Chirata cultivation, a high value medicinal crop in 1 bigha land. This justify the role of science based civil society for institutional innovation facilitating and improving relationship between farm and off-farm activities of small farmers/growers in terms of supply inputs in the form of credit and technical assistance, production, and assured marketing.

As discussed in earlier models (TIM-1 to TIM-7) explored in present study related to different sectors for developing technologies and resource management systems to promote farm or off-farm activities, a technology intervention with holistic and integrated village development planning for improved and sustainable livelihoods was also studied covering farm, off-farm and particularly artisanal sectors and their inter-linkages that raise overall productivity and protect or improve the environment needs. An impact analysis of value addition and diversified technologies was done during study period at village Shalla, District Mandi, Himachal Pradesh to evaluate the performance and viability of integrated technology intervention strategy (TI -8) introduced in the area for effective management and utilization of resources in terms of technology adoption and benefit to the village community. This was carried out keeping in view the survey findings and livelihood assessment and potential of such technological intervention strategy for replication as compared to traditional livelihood system relying mostly on rain fed agriculture.

The technology intervention has been directed both for human resource as well as natural resource management to strengthen village economy following systems approach for location-specific, need-based and affordable technological solutions covering different sectors for livelihoods diversifications bridging the existing gaps of basic requirements (food, fodder, fuel-wood, water and livelihood). Upgrading traditional skills, diverse forms of organized production activities, better use of local resources and markets were taken up at individual as well as community level by revival of artisanal trades (leather, pottery and black smithy) with introduction of suitable de-scaled technologies and supportive environment for micro-enterprise related livelihoods. A visible impact with simple intervention was made by constructing gravity water channel (Kuhl) to channelize water from one valley to another with the involvement of village community using local material to address the problem of water scarcity/storage for drinking water and irrigation needs in study village. It was found that with the construction of 1600 mts. Kuhl and hydram technology, whole un-irrigated cultivated land (65 ha) in the village watershed area got
irrigated as enabling farmers to grow vegetable crops besides traditional staple crops with improved agricultural practices leading to average 2 fold increase in income through sale of produce as per the perception and discussions held with village community. At institutional level Intervention strategy has resulted in formation of 8 SHGs ascertaining sustainability of this intervention model (TIM-8) to mobilize economic enterprises in these trades to carry out related income generating activity with marketing ensuring social acceptance (and hence, sustainability) among the intended end user. On the basis of above discussed technological interventions (TI) and related models (TIM) evolved, it is observed that the mountain village economy consists of livelihood systems that use resources in three categories: on farm, off-farm and non-farm to raise incomes and reduce environmental risks.

Results and outcome of different technological interventions evolved as “technology intervention models” with systems approaches were crystallized and following technology models of different scales found to be effective under field conditions for NRM and improved livelihoods in mountain areas:

1. Individual/Household levels: INFARM activities, Carpet weaving with Improved Loom, Mushroom Cultivation, Fibre based value added products.
2. Network: Town – Village (Community level): Primary producers and secondary processing units (Horticulture processing).
3. Franchise: Improved Watermill and multiple use of water.
5. Convergence at Multi-Sectoral levels: Micro-Watershed Management link up with income generation; INFARM Model and Village Development Programmes.

Above models emerged from the study were found to be effective in terms of their upgradation based on traditional knowledge and practices and their utility to benefit and empower local communities in rural mountain areas. These models have shown promises for sustainable utilization of local resources in hills and better livelihood opportunities to small and marginal farmers/households in mountain production system. Technological empowerment in traditional occupations and artisanal trades like Blacksmithy, pottery covering rural engineering was found to be equally important to secure livelihoods of artisans, landless labourers through cost effective technological interventions to nurture their skills.
Success Factors and Strategic Issues: Technology Delivery and Adoption

1. Systems Approach and Institutional Management

During impact study, special emphasis was laid on to isolate and identify the role of local institutions-community organizations in the context of technology percolation vis-à-vis natural resources management and utilization to directly articulate people’s needs and priorities. People’s participation, technological innovations, social engineering and linkages amongst stakeholders were found to be other important factors to understand their contribution in the success of demand driven interventions and post intervention sustainability of technology developmental and adoption initiatives that allow local networking, scaling up participatory research and technology development and evolution of change, rather than blueprint models. It was found during study of above discussed technological interventions that for effective rural technology base and rural transformation in mountain areas, there is a need for development and introduction of such appropriate technologies coupled with sound delivery system having ‘systems approach’ for need identification, technology choice and appropriate scaling, technology modulation/innovation, economic and ecological sustainability and optimum use of local resources and material with emphasis on technology capacity building amongst local people. It was also found that in all the technology intervention models except TIM-8, process of technology development and transfer for direct benefits to end users (farmers/artisans, women) has some unique features which are quite different from the issues and the processes of the standard method of such transfer mechanisms from research laboratory to industry. This clearly indicates that more than technology development it is the total system which is important for acceptance by the people at the grassroots level leading to creation of sustainable livelihood with bottom up approach.

The common salient features could be summarized as under for emerging ‘systems approach’ as management tool to modulate, customize and transfer technology at field level specific to mountain complexities as user and environmental friendly so as to have easy adaptability and explicable.

- The need of technology is assessed from the people with the assistance of local S&T based field groups/NGOs. The NGOs concerned then look for an ideal technology option keeping in mind the availability of local resources and skills.
- Technology is developed with their in-house capability or with assistance of nearby technical/financial institutions for adaptive R & D based on field generated specifications. Thereafter, the technology is appropriated to a scale and level, which is
acceptable to the people, and also which will be suitable in the local conditions for long-term sustainability.

- For a period of 2 to 3 years the people are trained to handle the technology (as noticed in TIM-1, TIM-2 and TIM-3) that is being developed or transferred. During this period, technology back up through continuous handholding is provided by the NGO concerned, if necessary, with assistance of the technical institutions.
- The NGOs/S&T based field groups in the meanwhile also sets up the process for backward and forward linkages both for production as well as marketing for long-term sustainability.
- Qualitative shift in production/distribution from household models to collective, networked “industrial” forms for higher productivity, incomes and reduced drudgery as found in TIM-3 for horti-processing;
- Constant interaction between the innovator, the producer and deliverer or technology transfer group for technology assessment and further refinement; and finally
- Innovations should be in the spheres of both social behaviour and technology to bring about the desired ends of self-reliance, equity and sustainability.
- The system once in place with the total package of sourcing of raw material, processing, final product preparation, packaging, marketing, etc. the NGO gradually withdraws giving the entire responsibility to the locally formed people’s organization or groups as found evidently in TIM-3, TIM-6 for further dissemination and continuation of activities on self-sustainable basis.

Therefore, entire technology package as model will have to be developed based on local felt needs which, in turn must be evolved through a detailed scientific micro-planning exercise. With ‘systems approach’ for process innovation and technology delivery as suggested above it is conclusive that effective technological interventions can be made at the grass-root level to protect and improve the rural livelihoods of disadvantaged people in mountain areas to strengthen their organization capabilities with technical backup support of its technology generator/provider groups.

2. People’s Participation and Empowerment

The study also tried to assess people’s participation by statistically analyzing people’s participation index (PPI) during planning, implementation and post intervention period of each livelihood related technology intervention; Stakeholders perceptions towards appropriateness and feasibility of livelihoods related TIM models evolved with a sample of 30 respondents for each. Besides appropriateness and feasibility of technology models, there are other factors like socio-economic characteristic which have significant relation
with adoption phenomena were also studied which influenced/promoted the effective delivery and adoption of technology models among the end users by working out Pearson correlation coefficient.

It was found that people’s participation was in increasing order which was highest during maintenance stage in all the technology interventions except TIM-2 (INFARM-1), TIM-4 (Biomass utilization) and TIM-7 (Mushroom activity), wherein people’s participation was marginally decreased from implementation to maintenance stage. The increasing order for TIM-1 (IWM-I, 2 & 3), TIM-2 (INFARM -2), TIM-3 (Hort-processing), TIM-5 (Improved loom) and TIM-7 (Vermi-composting and medicinal plants activity) was attributed medium in planning to implementation stage as initial learning period followed by highest participation in post intervention or maintenance period. While, for TIM-6 (watershed management) people’s participation was found of same order both at implementation and maintenance stages showing realization of empowerment and technological benefits within the community with newly acquired knowledge and skill to manage watershed at micro level with protected cultivation technologies of appropriate scale and water distribution system.

Overall PPI ranging from medium to high for different models shows establishment of participation process with technological empowerment and hand-holding of local community in entire process of participatory action research for design, testing and diffusion of technologies as complete technology model/package. Overall people’s participation index (PPI) i.e. 76.22 per cent for TIM-5 (improved loom) followed by 73.33 per cent for TIM-3 (Horti-processing), 72 to 72.44 per cent for TIM-1 (Improved watermill), 68.88 per cent for TIM-2 (INFARM -2) and 67.11 per cent for TIM-6 (Watershed management) clearly indicates highest adoption and sustainability of these technological interventions customized to location specific livelihood needs and available natural resource base.

It is interesting to note that stakeholders’ perceptions with respect to 15 livelihood related indicators for all the technological intervention models was high particularly in terms of simplicity, feasibility, adoptability, profitability, natural resource compatibility, livelihood security and technological empowerment except TIM-4 (Biomass utilization) and TIM-8 (IVLD). In case of TIM-4, perception was found medium with respect to physical compatibility, cultural compatibility and natural resource compatibility. This elucidates that people’s perception was relatively low for TIM-8 followed by TIM-4 probably due to diverse nature of intervention with set of technologies and capital investment required for integrated village development programme (TIM-8), and opportunistic use of biomass (TIM-4) as also evidently found while measuring PPI.
Regarding the relation between adoption and socio-economic factors/characteristics of the end users for each TIM it was found that in case of extension linkages, correlation was significant (P<.05) for TIM-2 (INFARM-1 and 2), TIM-7 (VC, mushroom, medicinal plant) and TIM-8 (IVLD), while, the correlation was highly significant (P<.01) for the technologies TIM-1(IWM-1, 2and 3), TIM-3 (Horti-processing), TIM-8 (Watershed Management). The study also revealed innovativeness of an individual as a highly important factor for adoption of the technologies as it showed a highly significant correlation (P<.01) with adoption of all the technologies (TIM 1-8) amongst end users in study area. However, in case of Tim-5 (improved loom technology) the correlation was significant at P<.05 as found with other factor i.e. education which is certainly linked with innovative capacity of individual thus, both were found to be low in Saldhar village, Dist. Chamoli, Uttarakhand as compared to the users in other technology intervention areas probably due to lack of basic infrastructure facilities.

The above findings are in confirmation to support results of techno-economic feasibility for each related technology intervention studied and discussed earlier in terms of tangible and intangible benefits for livelihood gain. For instance, in the case of improved watermill (TIM-1), tangible benefits with net income value were found more for IWM-2 model as compared to IWM-1 and 3 which was also perceived high in terms of PPI, stake holder’s perception for different indicators of technology appropriateness and analysis for socio-economic factors thus supporting further it as a viable emerging technology intervention model for economic as well as livelihood and economic gains.

Study also suggests that technology and its scale must be carefully chosen to enable rural people to acquire and imbibe knowledge of technologies appropriate to their needs, priorities and rural environment The success of such technology based developmental models which was found high (for TIM – 1, 2, 3, 5 and 6) and medium (for TIM – 4, 7 and 8) statistically as perceived by end users and through stakeholders’ analysis also clearly indicates that more than technology development it is the total system which is important for acceptance by the people leading to creation of sustainable livelihood with diversification approach for farm and off-farm/non-farm linkages. Blending of the new knowledge with the indigenous knowledge may be a more effective approach for NRM (as evidently found in most of the models evolved like improved water mill, INFARM model and Improved loom for carpet making with technology element and diversification approach) than the replacement of one knowledge system by the other. NRM policies should ensure an element of technology’s role in NRM, and effective development and delivery process of improved and appropriate technology packages based on traditional knowledge system.

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3. Policy Interventions: Decentralized Governance and relevance of Technology interventions for NRM and SRL

Therefore, such innovative models for technology development and delivery show potential of S and T based NGOs/field groups in developing and optimizing appropriate technology packages applicable at household as well as in organized way involving cluster of villages not only from the technology point of view but also with good management and governance practices. In each model, efforts have been made to incorporate simple technologies as generic/unit technologies for cost effective output but also in generating job opportunities through self-employment at village level. Indirectly, as a intangible benefits they are also helping in drudgery reduction and conservation of forest resources as evidently found in TIM-1, TIM -4 and TIM -5. Their approach also justifies ‘problem based intervention’ rather than ‘solution based thinking’ with systems approach covering managerial and social engineering aspects as well. Study findings also clearly indicate that the "bottom up" approach for participatory technology development starting with the people and with lateral contribution from Science and Technology Institutions and close interface with science based voluntary organizations can provide sustainable technology packages for technology development and transfer.

Technology interventions studied and analyzed in present study clearly illustrated how scientific and technical interventions with ‘Systems Approach’ as a complete package can improve the quality of life in remote mountain areas involving science based civil society/NGO as effective facilitator to address livelihood needs. In comparison to approach of international agencies like DFID, FAO for five assets (Natural, physical, human, financial and social) as framework for analysis of sustainable rural livelihoods, findings of the present study suggest and recommend “Technology Component” which is otherwise lacking in these approaches as an important element and asset for implementing any developmental programmes to bring visible change in rural livelihoods with diversified livelihoods options for making judicious use of mountain resources. This requires a policy change for adoption of above discussed systems approach.

Though, the successful models of such technology transfer are not many in mountain region, however, a distinct pattern has emerged in terms of type of participatory technology customization and transfer mechanisms ensuring backward and forward linkages from present study as discussed above requiring effective inter-sectoral linkage and interaction amongst different stakeholders for development and effective delivery of functional models of appropriate scale to address rural livelihood needs. Thus, NRM and S & T policy of hilly states should encourage adoption and development of such replicable models for efficient use and conservation of available natural resources based on technologies and practices that
are environment friendly focusing on decentralized planning, employment generation to address the problem of rural poverty and economic growth.

Thus, policies encouraging such internalization of technology interventions as people’s programme will not only help in making significant contributions to tackle the present crisis of sustaining livelihoods and natural resource management, but, to the enhancement of local livelihoods, environmental sustainability and reduced dependency on forest resources as well. Adoption of such a strategy in the policy making process for macro level application in remote mountain areas is likely to contribute immensely to conservation and sustainable use of natural resources in long run to benefit the communities at large.

It may be concluded that the whole perspective of mountain development will change once the knowledge, innovations and practices from the marginal regions become the basis of generating new employment alternatives in mountain overcoming poverty and other handicaps to protect and improve local livelihoods. However, this will require a total rethinking on above lines for process change directed towards participatory technology development and delivery in S & T Policy as far as building bridges between people’s knowledge and formal science is concerned so as to ensure economic and ecological sustainability in Indian Mountain Region.