Chapter - V

Results and Discussion

- NRM and Technology Interventions for Rural Livelihoods in Study Area
- Impact Analysis and Emerging Technology Models: Garhwal Himalayas, Uttarakhand
- Impact Analysis and Emerging Technology Models: Himachal Himalayas
- Technology Intervention Models (TIM) and Effective Delivery Mechanisms for Sustainable Rural Livelihoods (SRL)
5.1. Natural Resource Management (NRM) and Technology Interventions for Rural Livelihoods in Study Area

Present study was carried out in eight villages of Uttarakhand and Himachal Pradesh to evaluate the impact of eight technological interventions for sustainable livelihood development of the local inhabitants. Based on the field visits to study sites, following specific technological interventions (Table 5.1) in potential sectors of natural resource management were purposely selected to explore their potential for macro level application as generic or household/community level technology models/packages. Discussion with village level institutions and community in selected villages about the need and application of science and technological interventions revealed wider utility and benefit of such specific technological interventions to address the livelihood issues based on available natural resources. However, micro level study with impact analysis and measurable indicators for techno-economic and socio-ecological benefits was required to understand the potential and limitations of such technological interventions in remote mountain areas as complete models at different scales for visible change to strengthen local livelihoods in farm, non-farm and off-farm sectors. In this context, role of different stakeholders in designing, development and effective delivery of such intervention as a complete package was also studied to identify important factors responsible for adoption by the community.

The brief about study sites along with technological interventions studied is presented in the Table No.5.1. The details of these study sites were mentioned in Chapter 4.

Results of each technological intervention from Garhwal and Himachal Himalayas were compiled and presented individually for further analysis and discussion in this chapter.

A. Impact Analysis and Emerging Technology Models: Garhwal Himalayas, Uttarakhand

**Water Resource Management:** Out of total 18 major rivers of the country, 12 are part of the Himalayan Mountain system. Hundreds of small rivulets and thousands of streams make the Himalayas popularly known as “Water bank of Asia”. Despite of these large resources, mountainous regions are currently facing acute water shortage. The traditional water sources like Dhara, Nala, Chaal, Khaal and Taal have depleted in recent past due to poor water management (Rautela, 1998). The opportunities that exist in the mountains
include the huge potential of hydropower and irrigation system along with indigenous technical knowledge systems for diversification of local economies.

Table 5.1. Technological Interventions identified for Impact Assessment in Study Areas for Rural Livelihoods Enhancement

<table>
<thead>
<tr>
<th>District</th>
<th>Block</th>
<th>Study Sites (Villages)</th>
<th>Above MSL</th>
<th>Natural Resource Sector(s)</th>
<th>Technological Interventions (TI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garhwal Himalayas, Uttarakhand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dehradun</td>
<td>Sahaspur</td>
<td>i. Dokhwala</td>
<td>750m</td>
<td>Water Resource Management</td>
<td>Multi-purpose use of Improved Water Mill (TI-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Ambiwala</td>
<td>650m</td>
<td></td>
<td>Integrated farming for Resource Management (TI-2)</td>
</tr>
<tr>
<td>Uttarkashi</td>
<td>Dunda</td>
<td>iii. Chaundiyat</td>
<td>1800m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudraprayag</td>
<td>Agustmuni</td>
<td>iv. Gagotu</td>
<td>1200m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Balanced use of Biomass and Value Addition</td>
<td>Multi-purpose use of Invasive/Unutilized Biomass (TI-3)</td>
</tr>
<tr>
<td>Chamoli</td>
<td>Joshimath</td>
<td>v. Saldhar</td>
<td>2100m</td>
<td>Income Generation and Skill Development in Rural Farm and Non-Farm/Off-Farm Sector</td>
<td>Carpet Weaving and Improved Loom (TI-5)</td>
</tr>
<tr>
<td>Himachal Himalayas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sirmour</td>
<td>Rajgarh</td>
<td>vii. Dhangiyara</td>
<td>1820m</td>
<td>Income Generation and Skill Development in Rural Farm and non-farm/off-farm Sector</td>
<td>Agriculture based Enterprise (TI-7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>viii. Shalla</td>
<td>1780m</td>
<td>Integrated Resource Management</td>
<td>Integrated Village Development (TI-8)</td>
</tr>
</tbody>
</table>

Keeping these facts in view, two potential small scale technology interventions (TI-1 and TI-6) identified on water use and management at field level application for better livelihoods were studied in selected villages namely Dhokwala (Dist. Dehradun, Uttarakhand) and village Shilanji Dangra (Sirmour, Himachal Pradesh) considering the need oriented approach of appropriate scale suitable for scattered small settlement pattern in study areas. Limited interventions were available only at NGO level in the field for technology applications. The analysis carried out was to understand the effectiveness for replication. Results and impact assessment details about TI-1 are described as under, while, for TI-6 on water harvesting and conservation these are described in Part B of this chapter under item no. 5.1.6.
5.1.1. Technology Intervention: Improved Water Mill and Multiple Use of Water (TI-1)

5.1.1.1 Traditional Watermills

Traditional watermills have been in use in the Indian mountain region (IMR) since time immemorial. This eco-friendly device that harnesses waterpower for energy production at a small scale is a symbol of local technical excellence and the traditional wisdom of the people inhabiting the mountain region. A watermill is a traditional device run on the principle of using the kinetic power of a water stream running on a gradient. Traditionally, the mill functioned in a single mode to grind grain. In India, experts estimate that the watermill originated somewhere in the north-eastern region around 7th century AD. The system worked harmoniously with nature for over 2700 years and is abundantly scattered across the Himalayas. The widespread use of watermills and their popularity owed much to their simple and cost-effective mechanism.

According to Saxena (1998), there are nearly 200,000 watermills in the Himalayas from Uttarakhand, Himachal Pradesh, Jammu and Kashmir to the North-Eastern States of the country. In Uttarakhand alone there are about 15,448 watermills. As mentioned above, the design of traditional watermills is centuries old. Their low output does not provide enough profit to the owners. In recent years, several watermills have thus become non-functional. This is probably due to the fact that they were serving only the remote rural communities of the Himalayan region and their potential in the overall energy framework remained hidden or was neglected. In the absence of appropriate technology, watermills were not used for any purpose other than grain grinding. The importance of watermills was further overshadowed by the introduction of diesel and electricity powered mills, motivating the people towards high-speed grinding machines. Moreover, owners of traditional watermills were often forced to move to the plains to seek better employment, therefore, were unable to do anything to save their watermills.

To address these issues, sporadic efforts have been made by Government and Non-Government developmental agencies to develop and demonstrate upgraded design of watermills at select locations. Also performance evaluation and impact analysis for such technological interventions under field conditions is lacking (Rijal, 2000), which is very essential to revive traditional watermills (functional as well as non-functional) existing in Indian Mountain Region for macro level application to strengthen livelihood support to watermill owners as well as local community residing in non grid remote and inaccessible mountain areas.

i. Traditional Watermill at Dokhwala Village

Considering the above facts and need, the present study was done to evaluate
technological interventions made at field level in Garhwal Himalaya, which has shown potential for improving the efficiency of traditional watermills, not only for grain grinding, but also to produce electricity to meet local energy requirements and promote multi-purpose use of decentralized power and enhance local income. A detailed impact analysis of upgraded water mill with relevant data was done for three years at study village Dokhwala, Dist Dehradun to evaluate the performance and viability of existing three improved watermills in the area in terms of cost-benefit and technology adoption by the community as compared to traditional watermill.

These three watermills were traditionally used only for grain grinding with low out put (7-10 kg of flour per hour) with a net return of Rs. 8,000 to 10,000/annum as estimated in Table 5.2 at three sites. A minimum input maintenance cost of Rs. 250 -350/annum was required to run traditional watermills. These three watermills were used as replicates for cost benefit analysis of activities related to traditional water mills and comparison with improved water mills.

<table>
<thead>
<tr>
<th>Replications</th>
<th>Activity</th>
<th>Input Cost/Yr (Rs.)</th>
<th>Average Total Grinding/Day (Kg.)</th>
<th>Returns</th>
<th>Net Return (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>Wheat Grinding</td>
<td>300</td>
<td>10 Kg/hrs * 6 hrs</td>
<td>30</td>
<td>10800</td>
</tr>
<tr>
<td>L.2</td>
<td>Wheat Grinding</td>
<td>325</td>
<td>7 Kg/hrs * 7 hrs</td>
<td>24.50</td>
<td>8820</td>
</tr>
<tr>
<td>L.3</td>
<td>Wheat Grinding</td>
<td>250</td>
<td>8 Kg/hrs * 6 hrs</td>
<td>24</td>
<td>8640</td>
</tr>
</tbody>
</table>

Table 5.3: Co-relation Matrix: Traditional Water-Mill Usage

<table>
<thead>
<tr>
<th>Factors affecting gross returns with reference to input cost and grinding capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input cost = 0.166 (Regression Coefficient), Average Grinding = 30.44 (Regression Coefficient)</td>
</tr>
</tbody>
</table>

ii. Co-relation Matrix Analysis: Traditional Watermill

To evaluate the performance of traditional watermill, Correlation matrix calls for a multiple correlation solutions. Two variables, input cost and average grinding capacity/annum are measures of supposed determination of gross returns. A gross return
is the dependent variable. The examination of co-relation matrix, Table 5.3, about functioning of traditional watermills shows that average grinding/annum has maximum co-relation with gross returns. However, average grinding capacity has minimum co-relation with input cost. In other words, 99 per cent of gross returns variability depends on grinding capacity. Implication arising out of the best fit regression equation is that one unit increase in grinding capacity will increase gross returns 30.44 units. Regression equation further explains that unit increase in input cost will increase the gross return only by 0.2 units.

The analysis of traditional water mill clearly indicates that technology input to increase the average grinding capacity will help in increasing the gross return of the traditional water mill.

5.1.1.2. Technological Interventions: Improved Water Management and Watermill (IWM)

For effective usage of available water and better efficiency of traditional watermill, during the study, it was found that technological interventions were made at all three sites during 2004 with following components as indicated in Table 5.4 to 5.6 and 5.13.

i. Up-gradation of Watermill

In upgraded watermill the turbine is simply an upgraded local design. The new horizontal turbine system replaced the wooden water wheel with a cast steel runner mounted on a steel shaft. The flat fins of the water wheel have been curved to harness maximum energy (Figure 5.1). The number and size of blades was proportional to head and water availability. To allow free rotation of the wheel, a single steel ball bearing is used at the bottom of the water wheel, increasing efficiency to a significant degree. The other parts of the watermill such as flumes that bring water from channel to turbine; wheels attached to the turbine to obtain the appropriate number of revolutions per minute for electricity generation; and other agro-processing applications such as paddy de-husking and grain grinding were upgraded depending upon the quantity of water and water head availability (which is 2 m at water source). Altogether, these innovative measures have increased the power and efficiency of the traditional single mode system to a significant degree in terms of product diversification and net outcome.

Data collected for the three improved water mills for three years is presented year-wise in Table No 5.4 to 5.6). Three water mills were taken as replicates to analyse the data for cost benefit analysis of improved water mills and comparison with traditional water mills.
### Table 5.4: Cost-Benefit Analysis of Improved Watermill (IWM-3KW) Model for their Multi-Purpose Use of Water at village Dhokhwala, Uttarakhand.

<table>
<thead>
<tr>
<th>Replications</th>
<th>Technology Components</th>
<th>Multi-purpose use &amp; new components</th>
<th>Input Investment Cost (Rs.)</th>
<th>Output Cost</th>
<th>Gross Income/yr. (Rs.)</th>
<th>Net Return (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong></td>
<td>L.1 (IWM - 1)</td>
<td>Watermill Components</td>
<td>Wheat Grinding</td>
<td>38990</td>
<td>Cost of grinding Rs. 105/day (average 30 kg/hrs * average 7 hrs/day * 0.50 p./Kg.)</td>
<td>37800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Power Generation</td>
<td></td>
<td>2 KW power supply (lighting at household level)</td>
<td>3600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other components (Effective water usage)</td>
<td>Fishery (1000 Sq. feet)</td>
<td>10500</td>
<td>Sale of 500 kg fish @ Rs. 60/kg</td>
<td>30000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bee keeping (2 bee box and colony)</td>
<td>3800</td>
<td>Sale of 44 kg honey @ Rs. 100/kg</td>
<td>4400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small Nursery (1500 sq. ft.)</td>
<td>2000</td>
<td>Sale of MPTs /Ornamental plants</td>
<td>8000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>55290</td>
<td>83800</td>
<td>28510</td>
</tr>
<tr>
<td><strong>2.</strong></td>
<td>L.2 (IWM - 2)</td>
<td>Watermill Components</td>
<td>Wheat Grinding</td>
<td>45950</td>
<td>Cost of grinding Rs. 81/day (average 27 kg/hrs * average 6 hrs/day * 0.50 p./Kg.)</td>
<td>29160</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Power Generation</td>
<td></td>
<td>2 KW (lighting at household level)</td>
<td>3400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paddy Dehusking</td>
<td></td>
<td>80 kg/day * 200 days/yr @ 75 p./kg</td>
<td>12000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other components (Effective water usage)</td>
<td>Bee keeping (3 bee box and colony)</td>
<td>5183</td>
<td>Sale of 80 kg honey@ Rs.100/kg</td>
<td>7950</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nursery (4500 sq.ft.) with polyhouse (20”x10”)</td>
<td>31000</td>
<td>Sale of MPTs/ornamental plants/vermi-compost</td>
<td>65000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>82133</td>
<td>117510</td>
<td>35377</td>
</tr>
<tr>
<td><strong>3.</strong></td>
<td>L.3 (IWM - 3)</td>
<td>Watermill Components</td>
<td>Wheat Grinding</td>
<td>45155</td>
<td>Cost of grinding Rs. 75/day (average 25 kg/hrs * average 6 hrs/day * 0.50 p./Kg.)</td>
<td>27000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Power Generating</td>
<td></td>
<td>2 KW (lighting at household level)</td>
<td>3450</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spices Grinding</td>
<td></td>
<td>50 (10 kg/ day * Rs. 5/kg)</td>
<td>18000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other components (Effective water usage)</td>
<td>Bee keeping (2 wooden bee box)</td>
<td>4500</td>
<td>Sale of 55 kg honey@ 100/kg</td>
<td>5550</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small Nursery (1800 sq.ft.)</td>
<td>3560</td>
<td>Sale of MPTs/ornamental plants</td>
<td>12000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>53215</td>
<td>66000</td>
<td>12795</td>
</tr>
</tbody>
</table>
Table 5.5. Cost-Benefit Analysis of Improved Watermill (IWM-3KW) Model for their Multi-Purpose Use of Water at village Dhokhwala, Uttarakhand.

<table>
<thead>
<tr>
<th>Technology Intervention’s Details</th>
<th>Replications</th>
<th>Technology components</th>
<th>Multi-purpose use of Improved Water Mill and new components</th>
<th>Input Recurring Cost (Rs.)</th>
<th>Output Cost</th>
<th>Gross Income/yr. (Rs.)</th>
<th>Net Return (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>L.1 (IWM - 1)</td>
<td>Wheat Grinding</td>
<td>Cost of grinding Rs. 105/day (average 30 kg/hr * average 7 hrs/day * 0.50 p./Kg.)</td>
<td>1250</td>
<td>37800</td>
<td>40150</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Watermill Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Generation</td>
<td>2 KW power supply(lightning at household level)</td>
<td>3600 (Revenue collection)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fishery (1000 Sq. feet)</td>
<td>540 kg @ Rs. 60/kg</td>
<td>32400</td>
<td>31350</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bee keeping</td>
<td>Sale of 50 kg honey</td>
<td>4690</td>
<td>3825</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small Nursery</td>
<td>Sale of MPTs /ornamental plants</td>
<td>10250</td>
<td>8750</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>4665</td>
<td>88740</td>
<td>84075</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>L.2 (IWM - 2)</td>
<td>Wheat Grinding</td>
<td>Cost of grinding Rs. 81/day (average 27 kg/hr * average 6 hrs/day * 0.50 P/kg)</td>
<td>2390</td>
<td>29160</td>
<td>44770</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Watermill Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Generation</td>
<td>2 KW (lighting at household level)</td>
<td>3600 (Revenue collection)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paddy Dehusking</td>
<td>80/day * 200days/yr @ 90 p./Kg.</td>
<td>14400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bee keeping</td>
<td>Sale of 100 kg honey</td>
<td>9950</td>
<td>8750</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nursery</td>
<td>Sale of MPTs/ornamental plants/vermi-compost</td>
<td>59000</td>
<td>48500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>14090</td>
<td>116110</td>
<td>102020</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>L.3 (IWM - 3)</td>
<td>Wheat Grinding</td>
<td>Cost of grinding Rs. 75/day (average 25 kg/hr * average 6 hrs/day * 0.50 P/kg)</td>
<td>2300</td>
<td>27000</td>
<td>42550</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Watermill Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Generating</td>
<td>2 KW (lighting at household level)</td>
<td>3450</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spices Grinding</td>
<td>40 (8 kg/day * Rs. 5/kg)</td>
<td>14400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bee keeping</td>
<td>Sale of 70 kg honey</td>
<td>6580</td>
<td>5680</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nursery</td>
<td>Sale of MPTs/ornamental plants</td>
<td>18900</td>
<td>14340</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>7760</td>
<td>70330</td>
<td>62570</td>
<td></td>
</tr>
</tbody>
</table>


## Table 5.6. Cost-Benefit Analysis of Improved Watermill (IWM-3KW) Model for their Multi-Purpose Use of Water at village Dhokhwala, Uttarakhand.

<table>
<thead>
<tr>
<th>Replications</th>
<th>Technology components</th>
<th>Multi-purpose Use and new components</th>
<th>Input Recurring Cost (Rs.)</th>
<th>Cost- Benefit (3rd Yr.)</th>
<th>Net Return (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. L.1 (IWM - 1)</td>
<td>Watermill Components</td>
<td>Wheat Grinding</td>
<td>1500</td>
<td>Cost of grinding Rs. 135/day (average 30 kg/hr * average 6 hrs/day * .00.75 p./Kg.)</td>
<td>48600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Generation</td>
<td>2 KW power supply (lighting at household level)</td>
<td>4000 (Revenue collection)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other components (Effective water usage)</td>
<td>Fishery (1000 Sq. feet)</td>
<td>1200</td>
<td>520 kg @ Rs. 60/kg</td>
<td>31200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bee keeping (3 box)</td>
<td>1075</td>
<td>Sale of 60 kg honey</td>
<td>5570</td>
</tr>
<tr>
<td></td>
<td>Small Nursery</td>
<td>1500</td>
<td>Sale of MPTs/ornamental plants/vermi-compost</td>
<td>12550</td>
<td>11050</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5275</td>
<td>101920</td>
<td>96645</td>
<td></td>
</tr>
<tr>
<td>2. L.2 (IWM - 2)</td>
<td>Watermill Components</td>
<td>Wheat Grinding</td>
<td>2950</td>
<td>Cost of grinding Rs. 112.50/day (average 25 kg/hr * average 6 hrs/day * .00.75 p./Kg.)</td>
<td>40500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Generation</td>
<td>2 KW (lighting at household level)</td>
<td>3800 (revenue collection)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paddy Dehusking</td>
<td>80 kg/day * 200 days/yr @ Rs. 1.00/Kg</td>
<td>16000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other components (Effective water usage)</td>
<td>Bee keeping (8 boxes)</td>
<td>7183</td>
<td>Sale of 210 kg honey</td>
<td>21330</td>
</tr>
<tr>
<td></td>
<td>Nursery</td>
<td>11000</td>
<td>Sale of MPTs/ornamental plants/vermi-compost</td>
<td>59800</td>
<td>48800</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>21133</td>
<td>141430</td>
<td>120297</td>
<td></td>
</tr>
<tr>
<td>3. L.3 (IWM -3)</td>
<td>Watermill Components</td>
<td>Wheat Grinding</td>
<td>2400</td>
<td>Cost of grinding Rs. 112.50/day (average 25 kg/hr * average 6 hrs/day * .00.75 p./Kg)</td>
<td>40500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Generation</td>
<td>2 KW (lighting at household level)</td>
<td>3400</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spices Grinding</td>
<td>40 (8 kg/day * 5 Rs/kg.)</td>
<td>14400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other components (Effective water usage)</td>
<td>Bee keeping (6 wooden boxes)</td>
<td>6890</td>
<td>Sale of 200 kg honey</td>
<td>19795</td>
</tr>
<tr>
<td></td>
<td>Nursery</td>
<td>7800</td>
<td>Sale of MPTs/ornamental plants/vermi-compost</td>
<td>31455</td>
<td>23655</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17090</td>
<td>109550</td>
<td>92460</td>
<td></td>
</tr>
</tbody>
</table>
During the study it was found that watermills which were traditionally functioning in a single mode i.e. only for grinding purpose were upgraded considering following innovative elements to create new dimensions of performance:
  o Promotion of multiple uses of water for income generation; in particular, use for power generation and processing of agro-produce;
  o Introduction of modern technology to ensure acceptability in the community;
  o Ensuring that local repairing of machinery is possible;
  o Promotion of local manufacture for larger multiplication and creation of employment.

To harvest the optimum use of available water and available land in the proximity of watermills, feasibility of new components like fish culture, nursery raising of vegetables and ornamental plants and bee-keeping showing potential to supplement the income were studied from techno-economic sustainability point of view as per details given in Table 5.4 to 5.6.

**ii. Improved Watermills System: Impact Assessment**

Improved watermills of 3KW capacity when compared to traditional system as given in Table 5.2, besides wheat grinding other multi-purpose usage like power generation, paddy de-husking in IWM-2 and spice grinding in IWM-3 were carried out. Other new components fishery (IWM-1), bee-keeping and nursery raising of different scale were introduced in all three watermills’ (L.1 - L.3) at village Dokhwala involving mill owners and village community.

**IWM-1:** IWM-1 at location I has component of wheat grinding with provision for power supply to meet the lighting needs at household level generating revenue contributing to total net return. While other water usage components viz. fishery, bee-keeping and small nursery raising contribute substantially to net income in each year by utilizing the wasteland in the vicinity of watermill as indicated in Table 5.4 to 5.6. As compared to traditional one (used only for grain grinding – Table 5.2), increase in net return for watermill component was many fold in 2nd and 3rd year from wheat grinding and revenue generated from power supply which increases to 3.82 fold in 2nd year to 4.87 fold in 3rd year after recouping the investment made in first year towards improvement to increase efficiency of watermill for its multiple uses and income generation. It was also found in IWM-1 as a tangible benefits that total net return value which was Rs.28,510/- with total investment cost of Rs.55,290/- for all components (Watermill + other water usage components) in 1st year increases to Rs.84,075/- (2.95 fold) in 2nd year and Rs.96,645/- (3.39 fold) in 3rd year.

**IWM-2:** This improved system at location 2 also has another component of paddy de-husking besides wheat grinding with provision for power supply to meet the lighting
needs at household level generating revenue contributing to total net return. Unlike IWM-1, it has other components of slightly higher scale and size viz. bee-keeping with three bee-boxes and nursery with polyhouse for planting materials like multi-purpose trees/ornamental plants contributing substantially to net return in each year by utilizing the wasteland in the vicinity of watermill as indicated in Table 5.4 to 5.6. As compared to traditional one (used only for grain grinding – Table 5.2), increase in net return for watermill component was many fold in 2nd and 3rd year from wheat grinding, rice de-husking and revenue generated from power supply which increases significantly to 5.27 fold in 2nd 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. However, this net increase in income value was more as compared to IWM-1. It was also found in IWM-2 as a tangible benefits that total net return value which was Rs.35,377/- with total investment cost of Rs.82,133/- for all components (Watermill + other water usage components) in 1st year increases to Rs.1,02,020/- (2.88 fold) in 2nd year and Rs. 1,20,297/- (3.40 fold) in 3rd year.

IWM-3: In comparison to IWM-2, IWM-3 at location 3 has another component of spices grinding besides wheat grinding with a provision for power supply to meet the lighting needs at household level generating revenue contributing to total net return. Similarly to IWM-1, it has other components viz. bee-keeping with two bee-boxes and small nursery set-up for multi-purpose trees/ornamental plants contributing substantially to net return in each year by utilizing the wasteland in the vicinity of watermill as indicated in Table 5.4 to 5.6. As compared to traditional one (used only for grain grinding – Table 5.2), increase in net income for watermill component was many fold in 2nd and 3rd year from wheat grinding, spices grinding and revenue generated from power supply which also ranges between 5 to 6 folds in 2nd and 3rd year after recouping the capital investment made in 1st year towards improvement to increase efficiency of watermill for its multiple uses and income generation. However, this net increase in return was more as compared to net return reported in IWM-1 but it was lesser than IWM-2. It was also found in IWM-3 that tangible benefits in terms of net return value which was Rs.12,795/- with total investment cost of Rs.53,215/- for all components in 1st year increases to Rs.62,570/- (4.89 fold) in 2nd year and Rs.92,460/- (7.23 fold) in 3rd year.

iii. Correlation and Regression Analysis: Upgraded Watermill System

As discussed above in all three improved water management and watermill system (IWM – 1, 2 and 3), technology inputs were provided to increase the grinding capacity of the traditional water mills. Analysis of results in Table 5.3 and 5.4 to 5.6 reveals that average annual grinding capacity of the traditional water mill has increased from 2720 Kg to 31755 Kg/annum through technological upgradation. Since water mills were used
only for grinding in traditional set up, therefore, comparison of grinding was done in improved water mills through correlation and regression analysis in three years duration as indicated in Table 5.7 to 5.9.

Table 5.7. Correlation Matrix for 1st year improved Grinding in terms of Gross return and Input cost.

<table>
<thead>
<tr>
<th>Gross Return</th>
<th>Input cost</th>
<th>Average Grinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Return</td>
<td>-</td>
<td>-0.9569</td>
</tr>
<tr>
<td>Input cost</td>
<td>-0.9569</td>
<td>1</td>
</tr>
<tr>
<td>Average Grinding</td>
<td>-</td>
<td>-0.95690</td>
</tr>
<tr>
<td>Mean</td>
<td>31320</td>
<td>43365</td>
</tr>
<tr>
<td>SD ±</td>
<td>5714.82</td>
<td>3809.65</td>
</tr>
</tbody>
</table>

Factors affecting Gross returns with reference to input cost and grinding capacity
Input cost =0.0, Average Grinding =0.0
(Gross returns, average grinding and input cost verified that all these factors are independent of each other.

Correlation matrix for first year grinding activity in improved water mill is presented in the above table 5.7. Correlation matrix analysis presented in this table clearly exhibits a perfect correlation between gross returns and average grinding capacity. However, gross return and input cost exhibit negative correlation. Similarly, grinding capacity and input cost are also correlated negatively. Further regression analysis of gross returns and average grinding and input cost verified that all these factors are independent of each other as calculated values stand at zero as presented in the Table 5.7. Further, analysis of the data for 2nd and 3rd years of gross returns, grinding and input cost in Table 5.8 and 5.9 also exhibited the similar results.

Table 5.8. Correlation Matrix for 2nd year improved Grinding in terms of Gross return and Input cost.

<table>
<thead>
<tr>
<th>Gross Return</th>
<th>Input cost</th>
<th>Average Grinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Return</td>
<td>-</td>
<td>-0.64</td>
</tr>
<tr>
<td>Input cost</td>
<td>-0.97</td>
<td>0.81</td>
</tr>
<tr>
<td>Average Grinding</td>
<td>-</td>
<td>31755</td>
</tr>
<tr>
<td>Mean</td>
<td>23220</td>
<td>1980</td>
</tr>
<tr>
<td>SD ±</td>
<td>18228.0</td>
<td>633.79</td>
</tr>
</tbody>
</table>

Factors affecting Gross returns with reference to input cost and grinding capacity
Input cost =0.0, Average Grinding =0.0
(Gross returns, average grinding and input cost verified that all these factors are independent of each other.

Table 5.9. Correlation Matrix for 3rd year improved Grinding in terms of Gross return and Input cost.

<table>
<thead>
<tr>
<th>Gross Return</th>
<th>Input cost</th>
<th>Average Grinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Return</td>
<td>-</td>
<td>-0.93</td>
</tr>
<tr>
<td>Input cost</td>
<td>-0.93</td>
<td>1</td>
</tr>
<tr>
<td>Average Grinding</td>
<td>-</td>
<td>(-0.93)</td>
</tr>
<tr>
<td>Mean</td>
<td>43200</td>
<td>2283.33</td>
</tr>
<tr>
<td>SD ±</td>
<td>4676.53</td>
<td>732.00</td>
</tr>
</tbody>
</table>

Factors affecting Gross returns with reference to input cost and grinding capacity
Input cost =0.0, Average Grinding =0.0
(Gross returns, average grinding and input cost verified that all these factors are independent of each other.
To elucidate further the cost benefit analysis carried out for traditional watermill vs. improved water mill for different operational durations and at the same time there to dispel confusion regarding L.1, L.2 and L.3.

### Table 5.10: Data Analysis of Traditional Water-Mill Usage at village Dhokhwala

<table>
<thead>
<tr>
<th>Replicate</th>
<th>Gross Returns</th>
<th>Average Grinding</th>
<th>Input Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>10800</td>
<td>3650</td>
<td>300</td>
</tr>
<tr>
<td>L.2</td>
<td>8820</td>
<td>2255</td>
<td>325</td>
</tr>
<tr>
<td>L.3</td>
<td>8640</td>
<td>2255</td>
<td>250</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>9420</strong></td>
<td><strong>2720</strong></td>
<td><strong>291.6666667</strong></td>
</tr>
<tr>
<td><strong>STDEV</strong></td>
<td><strong>805.4036255</strong></td>
<td><strong>38.18813079</strong></td>
<td></td>
</tr>
</tbody>
</table>

#### Coefficient of Correlation

<table>
<thead>
<tr>
<th>Gross Returns</th>
<th>Average Grinding</th>
<th>Input Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Average Grinding</td>
<td>0.997176465</td>
<td>1</td>
</tr>
<tr>
<td>Input Cost</td>
<td>0.26218941</td>
<td>0.188982237</td>
</tr>
</tbody>
</table>

### Table 5.11: Data Analysis of Improved Water Mill for their Multiple Usage at village Dhokhwala

#### 1st Year

<table>
<thead>
<tr>
<th>Replicates</th>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>83800</td>
<td>55290</td>
<td>28510</td>
</tr>
<tr>
<td>L.2</td>
<td>117510</td>
<td>82133</td>
<td>35377</td>
</tr>
<tr>
<td>L.3</td>
<td>66000</td>
<td>53215</td>
<td>12795</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>89103.3333</strong></td>
<td><strong>63546</strong></td>
<td><strong>25560.66667</strong></td>
</tr>
<tr>
<td><strong>STDEV</strong></td>
<td><strong>26161.30794</strong></td>
<td><strong>11576.29502</strong></td>
<td></td>
</tr>
</tbody>
</table>

#### Coefficient of Correlation

<table>
<thead>
<tr>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input cost</td>
<td>0.960288554</td>
<td>1</td>
</tr>
<tr>
<td>Net Returns</td>
<td>0.921471992</td>
<td>0.776499501</td>
</tr>
</tbody>
</table>

#### 2nd Year

<table>
<thead>
<tr>
<th>Replicates</th>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>88740</td>
<td>4665</td>
<td>84075</td>
</tr>
<tr>
<td>L.2</td>
<td>116110</td>
<td>14090</td>
<td>102020</td>
</tr>
<tr>
<td>L.3</td>
<td>70330</td>
<td>7760</td>
<td>62570</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>91726.66667</strong></td>
<td><strong>8838.33333</strong></td>
<td><strong>82888.3333</strong></td>
</tr>
<tr>
<td><strong>STDEV</strong></td>
<td><strong>23035.67306</strong></td>
<td><strong>8240.139708</strong></td>
<td><strong>19751.7533</strong></td>
</tr>
</tbody>
</table>

#### Coefficient of Correlation

<table>
<thead>
<tr>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input cost</td>
<td>0.739113001</td>
<td>1</td>
</tr>
<tr>
<td>Net Returns</td>
<td>0.986488169</td>
<td>0.618771688</td>
</tr>
</tbody>
</table>

#### 3rd Year

<table>
<thead>
<tr>
<th>Replicates</th>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>101920</td>
<td>5275</td>
<td>96645</td>
</tr>
<tr>
<td>L.2</td>
<td>141430</td>
<td>21133</td>
<td>120297</td>
</tr>
<tr>
<td>L.3</td>
<td>109550</td>
<td>17090</td>
<td>92460</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>117633.3333</strong></td>
<td><strong>14499.33333</strong></td>
<td><strong>103134</strong></td>
</tr>
<tr>
<td><strong>STDEV</strong></td>
<td><strong>20958.65533</strong></td>
<td><strong>8240.309844</strong></td>
<td><strong>15010.16266</strong></td>
</tr>
</tbody>
</table>

#### Coefficient of Correlation

<table>
<thead>
<tr>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input cost</td>
<td>0.816020464</td>
<td>1</td>
</tr>
<tr>
<td>Net Returns</td>
<td>0.948317097</td>
<td>0.590425434</td>
</tr>
</tbody>
</table>
Tables (5.10-5.12) have been provided for the various locations as finalized for the detailed investigations on the aspect in the village Dhokhwala.

**Table 5.12: Data Analysis of Improved Water Mill for Grinding at village Dhokhwala**

<table>
<thead>
<tr>
<th>Replicates</th>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Capacity Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>37800</td>
<td>38990</td>
<td>38325</td>
</tr>
<tr>
<td>L.2</td>
<td>29160</td>
<td>45950</td>
<td>29565</td>
</tr>
<tr>
<td>L.3</td>
<td>27000</td>
<td>45155</td>
<td>27375</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>31320</strong></td>
<td><strong>43365</strong></td>
<td><strong>31755</strong></td>
</tr>
</tbody>
</table>

**STDEV 5714.822832 3809.655496 5794.195371**

**Coefficient of Correlation**

<table>
<thead>
<tr>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input cost</td>
<td>-0.956902099</td>
<td>1</td>
</tr>
<tr>
<td>Net Returns</td>
<td>1</td>
<td>-0.956902099</td>
</tr>
</tbody>
</table>

**2nd Year**

<table>
<thead>
<tr>
<th>Replicates</th>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Capacity Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>37800</td>
<td>1250</td>
<td>38325</td>
</tr>
<tr>
<td>L.2</td>
<td>29160</td>
<td>2390</td>
<td>29565</td>
</tr>
<tr>
<td>L.3</td>
<td>27000</td>
<td>2300</td>
<td>27375</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>23220</strong></td>
<td><strong>1980</strong></td>
<td><strong>31755</strong></td>
</tr>
</tbody>
</table>

**STDEV 18288.38976 633.7980751 5794.195371**

**Coefficient of Correlation**

<table>
<thead>
<tr>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input cost</td>
<td>-0.63731402</td>
<td>1</td>
</tr>
<tr>
<td>Net Returns</td>
<td>0.814689523</td>
<td>-0.966084421</td>
</tr>
</tbody>
</table>

**3rd Year**

<table>
<thead>
<tr>
<th>Replicates</th>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Capacity Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>48600</td>
<td>1500</td>
<td>49275</td>
</tr>
<tr>
<td>L.2</td>
<td>40500</td>
<td>2950</td>
<td>41062</td>
</tr>
<tr>
<td>L.3</td>
<td>40500</td>
<td>2400</td>
<td>41062</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>43200</strong></td>
<td><strong>2283.33333</strong></td>
<td><strong>43799.66667</strong></td>
</tr>
</tbody>
</table>

**STDEV 4676.53718 732.0063752 4741.777761**

**Coefficient of Correlation**

<table>
<thead>
<tr>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Net Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input cost</td>
<td>-0.926749533</td>
<td>1</td>
</tr>
<tr>
<td>Net Returns</td>
<td>1</td>
<td>-0.926749533</td>
</tr>
</tbody>
</table>

Technological improvement of grinding as explained earlier for improved water mill is achieved to the maximum level and further investment in improvement will not result in any substantial increase in the gross returns. Therefore, an enterprise model of water mill has emerged with addition of subsidiary activities other than grinding like electricity generation, bee keeping, fish culture, nursery etc.
5.1.1.3. Emerging Technology Intervention Model (TIM) for Livelihoods Gain

Thus, findings of above study clearly support and justify large scale utility for macro level application of above technological interventions for improved watermill as field level replicable technology model (TIM -1) to strengthen small scale livelihoods in remote mountain regions due to followings:

i. Inducing Economic Potential and Scaling Up

These interventions have won community approval and are widely accepted, as shown in Table 5.14. Techno-economic impact analysis of improved watermills in present study shows that technological innovations in terms of effective water use and management (upgraded watermills, agro-processing and electrification, nursery management, beekeeping, etc) is standardized for hilly conditions to manage and use natural resources sustainably. Study also reveals that such changes have inspired improvements in some watermills of different capacity across the Uttarakhand and also in remote forest areas of Himachal Pradesh. Increased net income and utilization of watermill of bigger capacity may further add to process of scaling up to significant benefit to the community at large. Upgradation of existing 15,448 traditional watermills in Uttarakhand alone would directly benefit local community.

ii. Integrated Technology Components for Multi-Purpose Use

Given the abundant availability of land and water in the vicinity of improved watermills, water-millers were encouraged to initiate nursery raising and floriculture related activities linked to beekeeping for income generation. Low-cost bee boxes (which make use of the stems of the locally available invasive weed lantana) developed by HESCO were introduced in the area. It was found that 2-8 bee boxes can be maintained easily at one watermill site, which gives a significant return in all three years at all three sites which varies due to available quantity and quality of honey collected and market demand.

Since water is an essential component for mills as well as for fisheries, a composite fish culture was made part of this integration in IWM -1 to get the maximum advantage from available water. A tank of 1000 square feet was constructed, and after appropriate treatment, different types of carp were introduced. The advantage of carp is that they are in demand, accepted by local people, and fetch a good income for pond owners and mill owners. This is not the first time they have been introduced and cultured in the region. In addition, integration of vegetable and ornamental plants in areas measuring 1500-1800 square feet, with assured irrigation from the water channel of a watermill, provides further returns to water-millers and the local community as mentioned in Table 5.4 to 5.6. These activities are seasonal and can be integrated and managed locally.

The whole technology package of water management has focused on the watermills,
which are abundant and scattered throughout the Himalayas. Technological upgrades with small and affordable changes have improved the functional efficiency of the watermill in a user-friendly way to generate power. Besides, providing shaft power, watermills can now be converted into electrical generating systems that can be used by villagers for lighting at night and operating small-scale enterprise in the daytime. The different options of integrated use of water in IWM 1-3 in present study show how a water stream can be useful to the local community through various applications (Figure 5.2). Specifications for an integrated watermill as complete package, including adoption factors, technology flow, and development indicators, are given in Table 5.13 and 5.14 justifying the immense potential as replicable model.

iii. Community Empowerment: Adopting Technology to Improve Livelihoods

Considering the economic incentives for households and communities as a whole, the adoption of improved watermill as integrated and multipurpose model has had an important impact on socio-economic conditions. Enterprising millers who had set up diesel and electric mills are now switching over to the improved watermill model because of cost-effectiveness, multipurpose benefits, and the environment friendly way this system functions. Survey and discussion with field level developmental agencies at the later part of the study shows that technology flows from village to village and within Indian Himalayan region have been very effective and efficient, but it was also noted that this requires initial stimulus and continuous encouragement from local NGOs and developmental agencies to empower communities with a complete technology package in partnership mode, ensuring forward and backward linkages.

“During the discussion with Mr. Heera Singh, a watermill owner (IWM -1) of Dokhwala village, it was found that traditional watermill was not able to fulfill the livelihood needs for his family. Using the traditional mill system, he was able to grind only 7-10 kg of grains per hour. This did not even compensate for the labor input. With help and technical assistance provided by HESCO, Dehradun he upgraded the watermill and the nearby site by adopting the multi-purpose model. According to him “we adopted the improved watermill model and began to grind 25-30 kg of grain per hour, or 2-2.5 quintals per day. We also began to market our own flour in 10-kg bags with the brand name Janahar. Now, we have large numbers of consumers. The system has never troubled us and we find it economically viable, as a one-time input of Rs. 55,000 has given us a return of more than Rs. 6000/month. This recovered input costs within nine months” As a result, rapid technology adoption took place by upgrading 2 other watermills in this village. Due to good coordination among 3 mill owners and the village community, the entire Dokhwala village is now electrified, whereas it had earlier been without electricity. Watermills are running 6-8 hours a day for grinding grain, de-husking rice, or spice grinding. At night
these watermills provide lighting. Three mills with a capacity of 3 KW each are meeting the electricity needs of all fifteen families in Dokhwala Village through innovative application”.

iv. Technology Success Factors

One-time low investments, and added value combined with high income and employment opportunities, are important factors in adoption and technology flow, as indicated in Table 5.14. The watermills have been in operation almost 3 years now, and have had some minor breakdowns, but people are able to repair and manage upgraded mills and other activities locally.

This study clearly shows that a community responds quickly to new income generating opportunities and readily adopts new activities for economic benefits. Water millers and other families in the village, are now making use of surplus water for multipurpose activities such as nursery cultivation, fisheries, and bee-keeping near watermills. This integration of technology components has empowered local communities to manage and make sustainable use of local resources, thus reducing the risk of migration to seek income-generating opportunities. Impact assessment demonstrates that simple upgradation of watermills has impacts for both the water-miller, who can sustain and improve a declining business, and the end user, who saves time and money. This is particularly true for women, who previously had to wait for long periods to grind grains. Reliable functioning of all three IWM has not only reduced the drudgery of women but also changed the division of labour of gender. Improved system do not have many of the disadvantages, such as costly transmission and environmental problems, dependence on fossil fuels and need for highly skilled manpower associated with large hydro plants.

v. Institutional Success Factors: The Process Approach and Innovative Elements

The role of Himalayan Environmental Studies and Conservation Organization (HESCO), a science and technology - based NGO located in Dehradun was crucial in improvement of design for multipurpose use of watermill and effective use of available water for other income generating activities to provide livelihoods opportunities for local artisans/farmers and unemployed youths. As local institutional support ensuring forward and backward linkages with inbuilt component for social engineering and capacity building led to community’s participation and empowerment in technology design, testing and diffusion with high adoption rate. A demand-driven approach by providing the initial technical and financial support for technology transfer with partnership between the community, NGOs and government ensures the institutionalization and subsequent sustainability of innovative initiatives by the community on their own. Moreover, harnessing of hydro-power with such system’s approach leads to decentralized use and local management,
Table 5.13. Impact Analysis of Improved Water management and Watermill for Multi-Purpose Use showing Tangible and Intangible Benefits.

<table>
<thead>
<tr>
<th>Technology Package</th>
<th>Improved Water Mill</th>
<th>Traditional Water Mill System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Tangible Benefits</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st Yr.</td>
<td>2nd Yr.</td>
</tr>
<tr>
<td></td>
<td>Investment Cost (Rs.)</td>
<td>Output (Rs.)</td>
</tr>
<tr>
<td>IWM – 1</td>
<td>55290</td>
<td>83800</td>
</tr>
<tr>
<td>IWM – 2</td>
<td>82133</td>
<td>117510</td>
</tr>
<tr>
<td>IWM – 3</td>
<td>53215</td>
<td>66000</td>
</tr>
<tr>
<td>B. Intangible Benefits: Indicators</td>
<td>Problems</td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>Livelihood diversification with technology Inputs, Improved income and household level food security</td>
<td>Poor return, more drudgery involved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not economically viable</td>
</tr>
<tr>
<td>Ecological</td>
<td>Average Annual Carbon Abatement Potential of IWM: Very High</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacity of 1 water mill – 3 KW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average operating time – 6 hrs / day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual power generation by water mills @ 300 days of operation /yr = 5400 KWH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Replacing power generation from coal</td>
<td>Replacing power generation from small diesel gensets</td>
</tr>
<tr>
<td></td>
<td>1 KWH = 1 kg of coal (if low grade, high ash coal is used for power generation)</td>
<td>1 KWH = 0.4 l of diesel</td>
</tr>
<tr>
<td></td>
<td>5400 KWH = 5400 kg coal or 5.4 tons</td>
<td>5400 KWH = 2160 l or 2.16 KL</td>
</tr>
<tr>
<td></td>
<td>Assume that 1 ton coal would release 2.2 tons of CO₂, Carbon abatement by 1 water mill annually = 5.4 x 2.2 = 11.88 tons of CO₂:</td>
<td>Assume that 1 KL diesel would release 3.2 tons of CO₂, Carbon abatement by 1 water mill annually = 2.16 x 3.2 = 6.912 tons of CO₂:</td>
</tr>
<tr>
<td></td>
<td>Proper utilization of uncultivated (waste) land, improved plant bio-diversity, less run-off, environment friendly</td>
<td>Abandoned land</td>
</tr>
<tr>
<td>Social</td>
<td>Lightening facility: Recreation, Education to children, Reduced drudgery and check on migration</td>
<td>Migration, poor literacy rate</td>
</tr>
</tbody>
</table>
thereby making rural development possible through self reliance and use of local natural resources.

vi. Replicability and Outlook
Impact assessment and cost-benefit results of all three improved systems clearly indicates significant increase in net income value along with subsidiary activities, from 2nd year after recovering the initial capital investment in 1st year itself which get established in 3rd year with recurring expenses for bee-keeping and nursery activities.

| Table 5.14: Improved Watermill Model (3 KW) for Decentralized Power Generation and Multi-purpose Use: Technology Inputs and Adoption Factors for Replicable Technology Package. |
|---------------------------------|-------------------------------------------------|------------------------|------------------------|-----------------------------|
| **Upgraded Technology / New Components** | **Multipurpose use (Activities)** | **People’s Contribution** | **Adoption rate** | **Technology Package Flow** |
| Water Mill | • Cemented Channel | • Flour grinding (IWM - 1, 2 & 3). | • Land | High (Increased output performance > 6-8 times) |
| | • Flume covering with aluminum sheet/GI sheet | • Additional provision for: | • Labor | • Extension to Local artisans and unemployed youth. |
| | • Change in runner/turbine | • Paddy Dehusking (IWM –2) | • 25 per cent input cost with repayment of bank loan in three years. | • Village to village in other Himalayan regions for revival of traditional watermills |
| | • Alternator | • Spices grinding (IWM = 3) | | • Creation of multi-purpose common facility centre. |
| | • Use of single ball bearing | • Power Generation | | • Model accepted by State Govt. UREDA, Uttarakhand and HIMURJA, HP |
| | • Stone dressing | • Rope ways | | • Now in other Himalayan states including HP (Mangrah Panchayat), Kullu –Bhuthi Forest Range (3-5KW); North Eastern Region including border areas of J and K region, especially in non-grid remote areas. |
| | | • Cotton Combing | | • Natural Resource Management |
| | | • Oil expelling | | • Clean Eco-friendly energy |
| | | | | • Value addition by agro-processing |
| Other Components / Additional Components (Seasonal) | | | | • Additional income generation |
| Fishery (IWM –1) | Major carps | • Land | Medium |
| | | • Labor | |
| | | • Seed | |
| Nursery Raising (IWM –1, 2 and 3) | Ornamental plants and vegetables | • Land | High |
| | | • Labor | |
| | | • Seed | |
| Bee-keeping (IWM - 1, 2 and 3) Bee-boxes with frames | • Alternative use of *Lantana*, an invasive weed to make bee-boxes. | • Land | High |
| | | • Quality honey production | | |
| | | | | • Human Resource Development |
| | | | | • Local skill developments |
| | | | | • (Masons, blacksmiths) |
| | | | | • Local employment and prosperity |
| | | | | • Natural Resource Management |
| | | | | • Clean Eco-friendly energy |
| | | | | • Value addition by agro-processing |
| | | | | • Additional income generation |
| | | | | • Facilities |
| | | | | • Electricity |
| | | | | • Communication facility |
| | | | | • Irrigation facilities |
| | | | | • Socio-cultural Values-Check on migration |
| | | | | • Conservation of traditional wisdom |
| | | | | • Local empowerment and self-dependency |

As analyzed in Table 5.14, technology adoption rate for nursery raising and bee-keeping was found high amongst local community due to better return from sale of planting material and honey collected, while for fishery in IWM -1, it was medium probably due to irregular market and related risk of fish mortality. In terms of intangible benefits,
multi-purpose use of improved water mill and integration of other components for effective water usage have helped in complete check on human migration due to alternative livelihood opportunities generated through their technological empowerment to make value added products by managing local natural resources. Power generation through three watermills in the Dokhwala village has also provided minimum electrification needs to all 15 households to address minimum energy needs. Further, an analysis in Table 5.13 also shows 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. Thus, it also justifies the immense potential of watermill as environment friendly clean technology system in remote non grid mountain areas to address the small energy needs for lightening and running micro-enterprise for income generation thereby increasing the productivity and economic efficiency of the local resource use of mountain areas.

Above findings under the present study validate the premise that mini hydro based renewable power systems are reliable and feasible alternatives for supporting small loads operating units independently to isolated communities. If this is applied appropriately especially in remote non – grid mountain areas where high transportation cost of fossil fuel and maintenance costs of diesel stations and poor load centers kind of constraints can be overcome through these system on economically viable costs. It becomes imperative in view of high costs involved and inadequate funding for installation and management of new micro and pico-sized hydro power systems as also experienced and reported from China, Nepal, and Pakistan in Hindu Kush Himalayan Region requiring huge capital subsidy with high failure rate from adoption point of view by the community (Rijal, 2000). Thus, considering mountain specificities such as inaccessibility, fragility and marginality improvement of existing traditional watermills and knowledge system for small hydro power use as well as end use diversification as discussed above by appropriately integrating local management skills contributes to create jobs in a small and medium sized community enterprises, bring socio-economic cohesion within the community and has a positive implications for security of energy supply and protection of environment. These findings are in consonance with the studies of Lijumba and Wekesah (1996); Rijal, (2000) and Nouni, et al. (2004) and Pande, et al. (2006) who had postulated the above hypothesis. Barte, (2002); Francis (2002) and Maher, et al. (2003) have also supported technical feasibility of micro-hydropower for offering number of environmental and technical advantages, in terms of avoided generation based on fossil fuels in a similar study carried out in China, Kenya and developing countries reporting different types of services and generating environmental and social impacts of different nature and magnitude particularly for rural electrification.
Above findings and discussion suggests that traditional watermills could be directly used for improved grinding of the grains through technological interventions which will also help in power generation and development of other farm and non farm artisanal activities across the Himalayas. Surplus power generated could be transmitted to far-flung and remote mountain areas through small hydropower grids. Indeed, upgrading of existing watermills in the Indian mountain region would lead to considerable power generation, considering that each watermill has the capacity to generate 5 KW of power. It is estimated that 2 million people or nearly 500,000 families with 4 members each could directly benefit from technological upgrading of watermills and related activities. Moreover, potential of carbon abatement as discussed above by bundling of carbon credits from improvement of number of watermills will create additional income as carbon revenue annually under clean development mechanism (CDM) process of Kyoto protocol as intangible benefit to mountain society. Such technology driven initiative has an importance in view of recent UN Human Development Report predicting ecological disaster and a virtual end of the world scenario by 2050 unless we cut carbon emissions by 50 per cent.

The multipurpose use of this field tested technology intervention model (TIM -1), with careful approaches to innovation and transfer, can play an important role in the overall development of local areas in terms of commercial activities. For traditional activities in the mountains, there is a need to strengthen the knowledge, skills, and infrastructure already available and scale them up in a business model, in order to bring significant impacts in terms of better output and efficiency. A range of skilled and unskilled employment opportunities for pre- and post-installation services related to electricity supply and mechanical and civil work can be generated. If properly pursued, this opportunity would provide immense employment opportunities to local young people in mountain regions, who are currently migrating to bigger cities or industrial areas in search of jobs. Large scale replication and application of this model will play a lead role to diversify mountain economies, to improve the productivity of mountain areas and to reduce the existing environmental damages of the eco-system.
Fig. 5.1: Improved Water mill System and visit to Study Sites
Fig. 5.2: Outcome Model of Technology Development and Transfer (TIM-1): Multipurpose use of IWM in Non - Grid Mountainous Remote Areas
Improved Agricultural Practices

Crisis in the small and marginal peasant farming sector has been of serious concern in the recent time. Large section of the small and marginal farming community across the country is facing drudgery and is at a loss to sustain their age old livelihood option. Following nearly three decades of practicing high external input driven mono-cropping production paradigm, there has been large scale loss of soil fertility, repeated pest outbreaks and other related agro-ecological maladies. This has led to stagnating and often falling land, input and labor productivities. There has been progressive decline in local market options of value addition and retailing of the primary agricultural produces following entry of large business conglomerates causing shrinking income base of the vast section landless but biomass based rural poor. This has also taken away the supplementary income generation options of the farm households seen more prevalent in the Indian Mountain Region also. In this approach, development and economic growth are perceived exclusively in terms of processes of capital accumulation by diverting natural resources from people’s survival economy, and nature’s economy. This has created both environmental and social non-sustainability, breaking ecological farming inter-linkages, and conflicts over natural resources (Shiva, 1991; Singh, et al. 2003).

Thus, transition to sustainable agriculture requires that the two neglected economies of nature and people should be made visible in the assessment of productivity and cost-benefit analysis in agriculture. For this, sustainability criteria should take into account regeneration and revitalization of the culture and local economy of agriculture production system by maintaining the conditions of production to ensure domestic needs, accumulation of capital, and better returns on investment to sustain livelihood needs of small and marginal farmers.

Considering the above facts in mind and need emerged during participatory discussion and survey, village Ambiwal in sub-tropical region and village Chaundiyat in tropical region of Garhwal region, Uttarakhand (Table 4.1) were selected to study impact of small scale technological interventions (TI-2) made to develop sustainable small and marginal farm(s) based on agro-ecosystem principles and designs to improve ‘Whole Farm Productivity’. While, village Gagotu in Rudraprayag District, Uttarakhand was selected considering the large scale potential for value addition and income generation at source itself through appropriate technological interventions (TI-3) and delivery for horti-processing to benefit small growers. Results and impact assessment details about TI-2 and TI-3 are described as under.
5.1.2. Technology Intervention: Integrated Farming for Resource Management (TI-2)

In the rural area of Uttarakhand most of the population depends on agricultural activities, which have various constraints leading towards low productivity. Subsistence agriculture on the terraced slopes covering 85 percent of total agriculture is rain fed and is the prime source of livelihood for more than 80 percent people of the state. Land fragmentation, small farm size, terraced farming, rain fed agriculture, lack of basic infrastructure facilities, ignorance and poor implementations of agriculture based programmes by developmental agencies are major constraints to sustain agriculture based local livelihoods. These factors prevent the poor rural population in securing updated scientific and technological know-how for adequate resource management and human resources development. Thus, people of the region are forced to migrate to plain and urban areas to earn better livelihood. Therefore, there is a need for introduction of appropriate technologies in agriculture sector of mountain rural ecosystem, which would not only provide livelihood and food security but at the same time will also reduce the pressure on forest resources.

5.1.2.1. Traditional Farming System in Garhwal Himalaya

Garhwal Himalaya has a long heritage of subsistence economy, with agriculture being the core component involving over 80 percent of its population. Obviously, on account of great variation in the altitude, topography, climate, forest resources, availability of water for irrigation and socio-economic and cultural factors, there exist a wide variety of land use patterns in the region. Broadly, three basic farming systems have been identified in the central Himalaya, of which this region is a part. All the farming systems are livestock based and form a spectrum of economic activities ranging from nomadism practiced by Gujjars and Bhotias to settled agriculture which has been in practice by a majority of the people. Settled agriculture, a mixed ‘crop livestock’ farming system predominating over a broad range of altitudes between 300 – 2500m amsl is practiced on terraced agricultural fields on steep slopes and sometimes without terrace on gentle slopes of higher altitudinal areas. Mostly, the size of the terraces varied between 0.01 and 0.1 ha. Except for the narrow strips of Bhabar in the foot hills and Doon valley where modern agriculture is practiced on flat land under irrigated conditions, rest of the mountainous terrain of the region still follows the traditional lines under rain fed conditions with insignificant land (<15 per cent) under irrigation.

Mostly, there are marginal farmers (above 68 per cent) in the region whose land holding usually ranges from 0.02 to 1.0 ha. Small land holders possessing 1.0 to 4.0 ha of agricultural land represent about 29 per cent, while, the big farmers having the land
holding between 4.0 and 10.0 ha constitute only three percent of the farming community. The total agricultural land occupied by each category is about 56 per cent (maximum) for small farmers followed by marginal (23.5 per cent) and big farmers (20.5 per cent). The average per capita land holding in the region is around 0.19 ha. Further, it is interesting to note that across the altitudinal gradient, the per capita land holding is often significantly higher at higher altitude than middle and lower altitudes. It is because of low population density and sometimes due to the encroachment upon the forest land by the high altitude inhabitants.

Irrigated land is often confined to the river valleys of the lower altitude and sometimes in the small chunks as terraced agricultural fields of middle altitude where water is available. Traditionally, water is channeled from the river through khuls (non cemented canals) to the agricultural fields. However, in the recent past, canal (cemented) irrigation has also made its appearance in the region through governmental developmental efforts. Mainly the spring-fed rivers and small rivulets provide the irrigation water. Owing to difficult topography and lack of planning skills, irrigation through snow-fed rivers could not been utilized in the region so far despite the rich potential. In the higher altitudes, agriculture on the terraced and sometimes un-terraced gentle slopes despite availability of water is entirely practiced under rain-fed condition.

The cropping patterns, up to 1800m amsl and sometimes up to 2000m amsl are built around two major cropping seasons viz., Kharif (April – October) and Rabi (October – April). Kharif season crops occupy about 63 per cent while Rabi season crops about 59 per cent of the gross cropped area of the region with the cropping intensity of 159.29 per cent (Swarup, 1993). From the rain-fed agriculture generally three crops are taken in every two years, while from irrigated land two crops per year are taken. However, sometimes in the some lower altitude localities (below 1000m amsl), a third crop is also taken from irrigated land between April and July, though on a smaller scale. Owing to cold climatic conditions in higher altitude, particularly above 2000m amsl, the cropping patterns are different from the above cropping seasons as most of the crops are cultivated between March and October (summer season crops).

The traditional settled agriculture of Garhwal Himalaya exhibits a great deal of variety in crop diversity, crop rotation and crop composition etc. along an altitudinal transect due to corresponding variations in a number of factors. However, during the advancement of new technical era, the traditional crops and practices were highly ignored as all the these crops were replaced by cash crops, thus reducing crop diversity, and traditional organic practices were affected by use of chemical fertilizers (Tripathi and Saha, 2001; Semwal, et al. 2004).
As far as the economic condition of the farmers of different altitudes is concerned, the higher altitude farmers are economically better off than their lower and middle altitude counterparts. The major reasons are being low population pressure, bigger land holdings, greater accessibility to natural resources and more importantly suitable niche for specific crops that has great market demands nowadays. The comparatively poor economic condition of the farmers of lower and middle altitudes could be attributed to the factors like higher population pressure, smaller land holding and lesser accessibility to natural resources and weak integration between resources. The agriculture in lower zones has further suffered due to the influence of new cultivation techniques with high input cost like usage of chemical fertilizers, irrigation, tillage and harvesting which are necessarily not affordable leading to the migration of people which is more pronounced in study area. The migrated people generally hand over their cultivable land to local persons (lessee) who cultivate the land and in turn give half of the grain production to the owner of the land (lessor). In such situations, the lessee does not pay due attention to the lessor’s land, and as a consequence of this land degrades gradually. In some instances, the absentee owners of the land have given their rights in favor of the actual operators.

Further, besides above factors narrowing down of the traditional diverse food base under the influence of market economy implies more risks to local livelihoods associated with cash crops as reported from different mountain regions (Allan, 1986; Bohle and Adhikari, 1998; Chun-Lin, et al., 1999). It is evident from the land use change and participatory study survey carried out during 1963-1993 period in Central Himalaya of which the Garhwal region is a part, that cash crop like potato cultivation partially replaced the traditional crops amaranth, buckwheat and millets etc., while, manure input, soil loss and run-off increased by 46, 90 and 51 per cent respectively with decline of mean annual fodder yield from cropland by 44 per cent. (Semwal, et al., 2004). Evidently, appropriate measures need to be taken in the region if the sustainability and revival of the traditional agricultural system alongside the natural resource base is to be achieved. One of the effective strategies could be planning agriculture not just as production system but an ecological system as well. Fortunately, with the renewed global interest in traditional agricultural system a positive trend in this direction has now emerged. Mixed cropping, otherwise, practiced by the traditional societies throughout the world, and which was also common in the Garhwal Himalaya, is once again receiving due attention. Alongside, being a tool to enhance per unit area production, the traditional agriculture is also significant for controlling weeds and pests and is effective for recycling of biomass (Altieri, 1995; Tripathi and Saha, 2001).
5.1.2.2. Technological Interventions and Impact Assessment: Integrated Farming for Resource Management (INFARM)

Two villages namely Ambiwala, Sahaspur block of District Dehradun at low altitude (650m amsl – Site 1) and Chaundiyat, Dunda block of District Uttarkashi at higher altitude (1800m amsl – Site 2) intervened by the non governmental developmental agency during study period were selected for the impact study. Both the villages are different in demography and soil conditions etc. as described in Chapter 4. Ten progressive farmers (denoted F1, F2, F3, F4 and F5 in village Ambiwal a and F6, F7, F8, F9 and F10 in village Chaundiyat) were selected with small farms of different sizes for improved production system and cost benefit analysis. After initial survey, it was found that the crop productivity and diversity of crops was very low with poor resource management and lack of technical know-how. Majority of the population migrates to the plains in search of employment. The land holding was higher at Chaundiyat as compared to Ambiwala. At each experimental farm, technological intervention was tried through introduction of good quality seeds with improved agriculture practices, diversifying the farm sub-systems and components and integrating locally available biological resources. Apart from agricultural activities, three cash income generating activities were also introduced in both the villages namely Poultry, Bee Keeping and Vermi-composting to develop bio intensive model farm and/or farm clusters through participatory research. Scientific bee-keeping assumed much importance not only for increased honey production and income generation, but also for increasing the agricultural and horticultural crop yield through cross-pollination which is poor in mountains due to low insect intensity. The bees (Apis mellifera) were introduced at both the sites using low cost bee boxes made from Lantana, an invasive weed. To full-fill the fodder requirement, fodder trees (Grewia optiva) and grasses (Napier hybrid-CO-3) were planted on field bunds, and horticultural trees viz. Peach, Pear, Plum and Pomegranate were also planted having multi-purpose utility. After intensive training, the scientific and material inputs were provided to the selected farmers and studied for their additional income generation and other impact on farm productivity. The data were collected for crop diversification and introduction of off-farm activities like bee-keeping and vermi-composting in Kharif and Rabi season at both the location 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 (Table 5.19 to 5.21; 5.23 to 5.25 and Fig 5.5 and 5.9). The collected data were analyzed statistically through Leontief input-output analysis as described in chapter 3 which was compared with base-line data for traditional system to find out the suitability of technological interventions for diversification and integration of various farm components.
i. Impact of INFARM Interventions on Soil Status:

The soil of all the five selected farmers at both the sites were collected before and after intervention and analyzed to find out the impact of intervention on soil health (Table 5.15 to 5.18 and Fig 5.3 to 5.4). The data reveals that pH value exhibited increasing tendency towards neutral soil. The conductivity, organic carbon, nitrogen, phosphorus and potash content were also found in increasing order in 1st, 2nd and 3rd year in case of all farmers in both the sites. The increase in all the parameters may be due to use of vermi-compost, which was earlier not in practices. The results indicate that the soil health directly depend on the proper nourishing and crop management in the field. In general, it was also observed that soil health is one of the important parameter, which has influenced the productivity per unit area and quality of the produce. The results are in the agreement of Sen, et al. 1997; Pilbeam, et al. 1999 and Murage, et al. 2000.

ii. Impact of INFARM Interventions on Productivity and Income:

INFARM at Site 1: Village Ambiwala

The data for various parameters selected for INFARM technology are presented in Table 5.19 to 5.21. A perusal of results indicate that at site I (Ambiwala) village, the area undertaken for different crop interventions in the agricultural fields were different for five farmers and ranged from 0.65 to 1.30 acre. Different input levels were tried for different farmers and data were collected for productivity and presented in terms of cash income. Interventions were carried out in two major crop seasons i.e. Rabi and Kharif in two cropping systems viz. traditional two species crops, and introduced three species crops cultivation as practiced after intervention in the area with introduction of bee-keeping and vermi-composting technologies. Traditionally, the farmers were growing paddy and cabbage or maize in Kharif season and wheat and mustard in Rabi season. In three crop species cultivation, species tried were paddy, black gram and cabbage or maize in Kharif season; and wheat, mustard, and lentil in Rabi season respectively. The results were compared with the traditional input and output (baseline data) in terms of cash income. After intervention with new crops and crop combinations, in general, the crop diversity increased from two crop system to 4 crop system in site 1. The livestock diversity also increased from 1 to 3 almost in all the cases.

In traditional system, inputs given by different farmers varied depending upon size of the farms. F1 farmer initiated INFARM intervention in one acre land wherein for agriculture component, traditionally, the average annual input was about Rs 1000/- with net return of Rs 7840/-. In first year, through INFARM technology interventions with an input of Rs.1,
240/- increase in income was reported to Rs.10, 225/- . In second year, the input was Rs.975/- and net return was noted to be Rs.14, 065/- . In third year, the net input was Rs.1, 025/- with a net return of Rs.15, 615/- (Tables 5.19 to 5.21). After INFARM interventions, the net income for agricultural component increased 30.42 per cent, 79.40 per cent and 99.17 per cent in the 1st, 2nd and 3rd year respectively as compared to base line.

<table>
<thead>
<tr>
<th>Site</th>
<th>Baseline (Control)</th>
<th>pH</th>
<th>Conduct.</th>
<th>C %</th>
<th>N %</th>
<th>P Kg/ha</th>
<th>K Kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
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<td>0.8</td>
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<td>F_4</td>
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<td>0.05</td>
<td>1.0</td>
<td>0.10</td>
<td>410</td>
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<table>
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<td>F_2</td>
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<td>0.08</td>
<td>1.5</td>
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<td>294</td>
<td>936</td>
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<td>F_3</td>
<td>8.0</td>
<td>0.07</td>
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<td>0.13</td>
<td>491</td>
<td>1141</td>
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<tr>
<td>F_4</td>
<td>7.7</td>
<td>0.06</td>
<td>1.3</td>
<td>0.12</td>
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<td>1120</td>
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<td>1.4</td>
<td>0.15</td>
<td>351</td>
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<tbody>
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<td>0.08</td>
<td>1.2</td>
<td>0.14</td>
<td>326</td>
<td>769</td>
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<tr>
<td>F_2</td>
<td>6.7</td>
<td>0.09</td>
<td>1.7</td>
<td>0.16</td>
<td>294</td>
<td>937</td>
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<tr>
<td>F_3</td>
<td>8.2</td>
<td>0.08</td>
<td>1.5</td>
<td>0.15</td>
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<td>1144</td>
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<tr>
<td>F_4</td>
<td>7.8</td>
<td>0.08</td>
<td>1.6</td>
<td>0.14</td>
<td>495</td>
<td>1223</td>
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<tr>
<td>F_5</td>
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<td>0.07</td>
<td>1.5</td>
<td>0.16</td>
<td>353</td>
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</table>

<table>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F_1</td>
<td>7.3</td>
<td>0.09</td>
<td>1.3</td>
<td>0.16</td>
<td>327</td>
<td>767</td>
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</tr>
<tr>
<td>F_2</td>
<td>6.9</td>
<td>0.09</td>
<td>1.9</td>
<td>0.17</td>
<td>296</td>
<td>939</td>
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<tr>
<td>F_3</td>
<td>8.4</td>
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<td>0.16</td>
<td>495</td>
<td>1145</td>
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<tr>
<td>F_4</td>
<td>7.8</td>
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<td>1.7</td>
<td>0.16</td>
<td>497</td>
<td>1226</td>
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<tr>
<td>F_5</td>
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<td>0.08</td>
<td>1.6</td>
<td>0.17</td>
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<td>932</td>
<td></td>
</tr>
</tbody>
</table>

The poultry, bee-keeping and vermi-composting were integrated as new sub-systems with agriculture component to enhance the livelihood support to the farmers. The annual net income from poultry sub-system was Rs.1, 911/- in 1st year, which increased to Rs.1, 830/- in 2nd year and Rs.2, 118/- in 3rd year. While, in the case of bee-keeping it was Rs.490/- Rs.11, 020/- and Rs.17, 685/- in 1st, 2nd and 3rd year respectively. While, vermi-composting contributed towards additional income of Rs.3, 660/-, Rs.5, 880/- and Rs.6, 600/- in the 1st, 2nd and 3rd year respectively. Thus, total net annual income with integration of all these components was found to be Rs.16, 366/-, Rs.32, 795/- and Rs.42, 018/- for 1st, 2nd and 3rd year respectively.
### Table 5.16. Status of Composting in Village Ambibala, Dehradun

<table>
<thead>
<tr>
<th>Elements (%)</th>
<th>Traditional (%)</th>
<th>Vermi (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>0.5 – 0.9</td>
<td>1.9 – 2.8</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.2 – 0.5</td>
<td>2.0 – 2.1</td>
</tr>
<tr>
<td>Potash (K)</td>
<td>0.4 – 1.0</td>
<td>0.9 – 1.2</td>
</tr>
</tbody>
</table>

### Table 5.17. INFARM Technology Intervention Approach: Soil Status of Farmers Plots at Village Chaundiyat, Uttarkashi (Site 2)

<table>
<thead>
<tr>
<th>Site</th>
<th>pH</th>
<th>Conduct.</th>
<th>C %</th>
<th>N %</th>
<th>P Kg/ha</th>
<th>K Kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F_6</td>
<td>7.2</td>
<td>0.050</td>
<td>1.2</td>
<td>0.10</td>
<td>408</td>
<td>995</td>
</tr>
<tr>
<td>F_7</td>
<td>7.1</td>
<td>0.048</td>
<td>1.0</td>
<td>0.08</td>
<td>400</td>
<td>870</td>
</tr>
<tr>
<td>F_8</td>
<td>7.4</td>
<td>0.049</td>
<td>1.1</td>
<td>0.10</td>
<td>310</td>
<td>980</td>
</tr>
<tr>
<td>F_9</td>
<td>7.1</td>
<td>0.060</td>
<td>1.0</td>
<td>0.12</td>
<td>415</td>
<td>1020</td>
</tr>
<tr>
<td>F_10</td>
<td>7.0</td>
<td>0.060</td>
<td>1.2</td>
<td>0.10</td>
<td>310</td>
<td>840</td>
</tr>
</tbody>
</table>

After INFARM Intervention

<table>
<thead>
<tr>
<th>Site</th>
<th>pH</th>
<th>Conduct.</th>
<th>C %</th>
<th>N %</th>
<th>P Kg/ha</th>
<th>K Kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_6</td>
<td>7.4</td>
<td>0.054</td>
<td>1.4</td>
<td>0.13</td>
<td>419</td>
<td>1041</td>
</tr>
<tr>
<td>F_7</td>
<td>7.7</td>
<td>0.059</td>
<td>1.1</td>
<td>0.13</td>
<td>479</td>
<td>1115</td>
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<td>F_8</td>
<td>7.6</td>
<td>0.050</td>
<td>1.3</td>
<td>0.14</td>
<td>348</td>
<td>1110</td>
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<td>F_9</td>
<td>7.0</td>
<td>0.065</td>
<td>1.3</td>
<td>0.14</td>
<td>495</td>
<td>1138</td>
</tr>
<tr>
<td>F_10</td>
<td>7.1</td>
<td>0.067</td>
<td>1.4</td>
<td>0.13</td>
<td>366</td>
<td>1015</td>
</tr>
</tbody>
</table>

Soil Status: 2nd Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>pH</th>
<th>Conduct.</th>
<th>C %</th>
<th>N %</th>
<th>P Kg/ha</th>
<th>K Kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_6</td>
<td>7.6</td>
<td>0.057</td>
<td>1.5</td>
<td>0.15</td>
<td>421</td>
<td>1043</td>
</tr>
<tr>
<td>F_7</td>
<td>7.8</td>
<td>0.061</td>
<td>1.3</td>
<td>0.14</td>
<td>481</td>
<td>1118</td>
</tr>
<tr>
<td>F_8</td>
<td>7.7</td>
<td>0.051</td>
<td>1.6</td>
<td>0.17</td>
<td>351</td>
<td>1114</td>
</tr>
<tr>
<td>F_9</td>
<td>7.1</td>
<td>0.067</td>
<td>1.4</td>
<td>0.15</td>
<td>497</td>
<td>1139</td>
</tr>
<tr>
<td>F_10</td>
<td>7.3</td>
<td>0.068</td>
<td>1.5</td>
<td>0.15</td>
<td>467</td>
<td>1017</td>
</tr>
</tbody>
</table>

Soil Status: 3rd Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>pH</th>
<th>Conduct.</th>
<th>C %</th>
<th>N %</th>
<th>P Kg/ha</th>
<th>K Kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_6</td>
<td>7.9</td>
<td>0.058</td>
<td>1.7</td>
<td>0.18</td>
<td>422</td>
<td>1045</td>
</tr>
<tr>
<td>F_7</td>
<td>7.9</td>
<td>0.063</td>
<td>1.4</td>
<td>0.15</td>
<td>484</td>
<td>1121</td>
</tr>
<tr>
<td>F_8</td>
<td>7.8</td>
<td>0.053</td>
<td>1.9</td>
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<td>1116</td>
</tr>
<tr>
<td>F_9</td>
<td>7.3</td>
<td>0.069</td>
<td>1.6</td>
<td>0.17</td>
<td>448</td>
<td>1142</td>
</tr>
<tr>
<td>F_10</td>
<td>7.5</td>
<td>0.070</td>
<td>1.8</td>
<td>0.16</td>
<td>468</td>
<td>1018</td>
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### Table 5.18. Status of Composting in Village Chaundiyat, Uttarkashi

<table>
<thead>
<tr>
<th>Elements (%)</th>
<th>Traditional (%)</th>
<th>Vermi (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>0.4 – 0.8</td>
<td>1.5 – 2.5</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.3 – 0.6</td>
<td>1.8 – 2.0</td>
</tr>
<tr>
<td>Potash (K)</td>
<td>0.5 – 1.2</td>
<td>0.7 – 1.0</td>
</tr>
</tbody>
</table>

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In case of farmer F2, total area taken for the study was 0.65 acre with similar INFARM technological interventions. Traditionally, the average annual input for agriculture component was about Rs.930/- with net return of Rs.6,505/-. Through INFARM intervention, input material cost was raised to Rs.990/- The net gain was recorded to be of Rs.13,100/- in one year duration. In second year, net input through INFARM technology intervention was amounting to Rs.1,145/- during the whole year and found significant increase in net gain of Rs.14,965/- as compared to first year’s net return. In third year, the net input given through the introduced technology package was noted to be of Rs.1, 420/- with net gain of Rs.19, 960/-. After the intervention the net income for agricultural component increased ca. 101 per cent, 130.05 per cent and 206.8 per cent in the 1st, 2nd and 3rd year as compared to baseline.

The annual net income from poultry sub-system to farmer F2 was Rs.1,529/- in 1st year, which increased to Rs.2,325/- in 2nd year and Rs.2,285 in 3rd year. While, in the case of bee-keeping it was Rs.1,550/-, Rs.15,450/- and Rs.19,753/- in 1st, 2nd and 3rd year respectively. The vermi-composting sub-system contributed towards additional income of Rs.4,490/-, Rs.6,500/- and Rs.5,400/- in the 1st year, 2nd year and 3rd rd year respectively. Thus, total net annual income with integration of all these components was noted to be Rs.20,669/-, Rs.39,240/- and Rs.47,398/- for 1st, 2nd and 3rd year respectively.

The data collected for farmer F3 indicated that traditionally the average annual input cost in farming practices for his farm of 0.80 acre area was Rs.1,230/- with net return of Rs.6,025/-. In 1st, through INFARM technology interventions with an input of Rs.995/- increase in income for agriculture component was reported to Rs.9,855/-. While, in 2nd and 3rd year input cost was Rs.1,395/- and Rs.1,605/- with net return of Rs.16,420/- and Rs.18,845/- respectively (Tables 5.3.5.to 5.3.7). After INFARM interventions, the net income to F3 for agricultural component increased ca. 63.57 per cent, 172.53 per cent and 212.78 per cent in the 1st, 2nd and 3rd year respectively as compared to base line.

The annual net income from poultry sub-system was Rs.1,464/- in 1st year, which increased to Rs.2,190/- in 2nd year with slight decrease to Rs.2,135/- in 3rd year. While, in the case of bee-keeping net income was noted Rs.1,000/- in 1st year which increased significantly to Rs.15,500/- and Rs.18,880/- in 2nd and 3rd year respectively. The vermicomposting contributed towards additional income of Rs.4,290/-, Rs.5,880/- and Rs.5,640/- in the 1st, 2nd and 3rd year respectively. Thus, total net annual income with integration of all components was found in increasing order i.e. Rs.16,609/-, Rs.39,990/- and Rs.45,500/- for 1st, 2nd and 3rd year respectively.
Table 5.19. Cost Benefit Analysis of Small Scale INFARM Technology Intervention at Study Site 1: 1st Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>Cultivated Area (Acre)</th>
<th>Traditional System (Base line)</th>
<th>Improved Systems: Crop Diversification</th>
<th>Other Sub-systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paddy + Cabbage or Maize (2 crop system)</td>
<td>Paddy + Cabbage + Maize (3 crop system)</td>
<td>Poultry(5+1) &amp; Bee-Keeping(2 box)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kharif: Wheat + Mustard</td>
<td>Rabi: Wheat + Mustard + Lentil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input (Rs.)</td>
<td>Gross return (Rs.)</td>
<td>Net return (Rs.)</td>
</tr>
<tr>
<td>F1</td>
<td>Kharif</td>
<td>1.00</td>
<td>700</td>
<td>3840</td>
<td>3140</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td></td>
<td>300</td>
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<td></td>
<td>1000</td>
<td>8840</td>
<td>7840</td>
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<tr>
<td>F2</td>
<td>Kharif</td>
<td>0.65</td>
<td>650</td>
<td>3400</td>
<td>2750</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td></td>
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<td></td>
<td>930</td>
<td>7435</td>
<td>6505</td>
</tr>
<tr>
<td>F3</td>
<td>Kharif</td>
<td>0.80</td>
<td>700</td>
<td>1950</td>
<td>1250</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td></td>
<td>530</td>
<td>5305</td>
<td>4775</td>
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<td>Total</td>
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</tr>
<tr>
<td>F4</td>
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<td>6435</td>
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<td>F5</td>
<td>Kharif</td>
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<td>2605</td>
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<td>Rabi</td>
<td></td>
<td></td>
<td>930</td>
<td>9300</td>
<td>8370</td>
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<td></td>
<td>1415</td>
<td>12390</td>
<td>10975</td>
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</table>

Note: The cost-benefit analysis was calculated based on the prevailing daily wage labor rates, input material cost and market value/rates of agro-produce.
Table 5.20. Cost Benefit Analysis of Small Scale INFARM Technology Intervention at Study Site 1: 2nd Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>Cultivated Area (Acre)</th>
<th>Traditional System (Base line)</th>
<th>Improved Systems: Crop Diversification</th>
<th>Other Sub-systems</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kharif: Paddy + Cabbage or Maize (2 crop system)</td>
<td>Kharif: Paddy + Cabbage + Maize or Black Gram (3 crop system)</td>
<td>Poultry(5+1) &amp; Bee-Keeping(4 box)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rabi: Wheat + Mustard</td>
<td>Rabi: Wheat + Mustard + Lentil</td>
<td>Input (Rs.)</td>
</tr>
<tr>
<td>F1</td>
<td>Kharif</td>
<td>1.00</td>
<td>700</td>
<td>3840</td>
<td>3140</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
<td>300</td>
<td>5000</td>
<td>4700</td>
<td>465</td>
</tr>
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<td></td>
<td>Total</td>
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<td>8840</td>
<td>7840</td>
<td>975</td>
</tr>
<tr>
<td>F2</td>
<td>Kharif</td>
<td>0.65</td>
<td>650</td>
<td>3400</td>
<td>2750</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
<td>280</td>
<td>4035</td>
<td>3755</td>
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<tr>
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<td>Total</td>
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<td>7435</td>
<td>6505</td>
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</tr>
<tr>
<td>F3</td>
<td>Kharif</td>
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<td>700</td>
<td>1950</td>
<td>1250</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
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<td>Total</td>
<td>1230</td>
<td>7255</td>
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</tr>
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<td>F4</td>
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<td>2950</td>
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<td></td>
<td>Rabi</td>
<td>340</td>
<td>4425</td>
<td>4085</td>
<td>840</td>
</tr>
<tr>
<td></td>
<td>Total</td>
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<td>7375</td>
<td>6435</td>
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</tr>
<tr>
<td>F5</td>
<td>Kharif</td>
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<td>3090</td>
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<tr>
<td></td>
<td>Rabi</td>
<td>930</td>
<td>9300</td>
<td>8370</td>
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<td>Total</td>
<td>1415</td>
<td>12390</td>
<td>10975</td>
<td>2035</td>
</tr>
</tbody>
</table>

Note: The cost-benefit analysis was calculated based on the prevailing daily wage labor rates, input material cost and market value/rates of agro-produce.
Table 5.21. Cost Benefit Analysis of Small Scale INFARM Technology Intervention at Study Site 1: 3rd Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>Cultivated Area (Acre)</th>
<th>Traditional System: Paddy + Cabbage or Maize (2 crop system)</th>
<th>Improved Systems: Paddy + Cabbage + Maize or Black Gram (3 crop system)</th>
<th>Other Sub-systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kharif: Wheat + Mustard</td>
<td>Rabi: Wheat + Mustard + Lentil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input (Rs.)</td>
<td>Gross return (Rs.)</td>
<td>Net return (Rs.)</td>
</tr>
<tr>
<td>F1</td>
<td>Kharif</td>
<td>1.00</td>
<td>700</td>
<td>3840</td>
<td>3140</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
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<td>Total</td>
<td></td>
<td>1000</td>
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<td>7840</td>
</tr>
<tr>
<td>F2</td>
<td>Kharif</td>
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<td>2750</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
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<td></td>
<td>930</td>
<td>7435</td>
<td>6505</td>
</tr>
<tr>
<td>F3</td>
<td>Kharif</td>
<td>0.80</td>
<td>700</td>
<td>1950</td>
<td>1250</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
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<td>6025</td>
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<td>940</td>
<td>7375</td>
<td>6435</td>
</tr>
<tr>
<td>F5</td>
<td>Kharif</td>
<td>1.30</td>
<td>485</td>
<td>3090</td>
<td>2605</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
<td></td>
<td>930</td>
<td>9300</td>
<td>8370</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>1415</td>
<td>12390</td>
<td>10975</td>
</tr>
</tbody>
</table>

Note: The cost-benefit analysis was calculated based on the prevailing daily wage labor rates, input material cost and market value/rates of agro-produce.
In case of farmer F4 and F5 each with 1.30 acre land, for agriculture component, traditionally, the average annual input cost was noted about Rs.940/- and Rs.1,415/- with net return of Rs.6,435/- and Rs.10,975/-. Through INFARM technology interventions, for agricultural component the net income in case of F4 increased ca, 45.92 per cent, 264.7 per cent and 274.60 per cent in the 1st, 2nd and 3rd year respectively. While, this incremental trend was also noted in the case of F5 i.e. 30.48 per cent, 137.85 per cent and 123.96 per cent in the 1st, 2nd and 3rd year respectively, but, it was lower as compared to net income of F4 having same size of farm.

The total net annual income with integration of agriculture and other new sub-systems (poultry, bee-keeping and vermi-composting) was Rs.16,754/-, Rs.48,668/- and Rs.50,120/- for farmer F4, which contributed more significantly in case of F5 i.e. Rs.21,409/-, Rs.43,403/- and Rs.50,094/- for 1st, 2nd and 3rd year respectively.

A perusal of above results and detailed data presented in Tables 5.19 to 5.21 in respect of traditional baseline data and improved INFARM technology intervention system clearly indicates increase in net income value at all the farmer(s) sites irrespective of farm sizes in 1st year. During this, the input cost increased in Kharif and Rabi seasons due to introduction of three to four species cropping system, and the net return was not found increasing significantly mainly because most of the investment was of permanent types for field leveling, procurement of seed, integrated pest management (IPM) and for irrigation, and to meet the cost of small infrastructure related to poultry, bee-keeping and vermi-composting pits and sheds etc. But, the net income value got increased further significantly in 2nd year and 3rd 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 as indicated in Figure 5.5 and resource flow diagram (Figure 5.6).

**Leontief Input-Output Matrix Analysis:** Thus, improved INFARM system has shown visible change benefiting all the farmers (F1 to F5) as shown in Figure 5.7 though statistical analysis in terms of economic analysis and integration of various farming components justifying all the farming sub-systems are successful which supplies adequate demand for other sub-systems in subsequent year including the household needs and the market sector which was more prominent in 3rd year. Leontief input-output matrix analysis for all the farmers for this site with average for all three years may be seen in Figure 5.7 showing farmer’s integration status which was best in 3rd year in all the cases particularly for F5 as shown in Table 5.22 as most successful farmer. While, average
minverse analysis for all three years shows best and uniform integration for F2 and F3 also in addition to F5 fulfilling the Hawkins – Simon condition.

Table 5.22. INFARM: Leontief Input-Output Analysis for F5 Site (3rd Yr.)
Best Integration at Site 1: Most Successful Farmer

<table>
<thead>
<tr>
<th>Integration Calculation ( Rs.)</th>
<th>Trial plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
<th>HHs</th>
<th>Market</th>
<th>Gross demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
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<td>2710</td>
<td>1800</td>
<td>6540</td>
<td>13530</td>
<td><strong>24580</strong></td>
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<tr>
<td>Livestock</td>
<td>700</td>
<td>0</td>
<td>950</td>
<td>5900</td>
<td>12164</td>
<td><strong>19714</strong></td>
</tr>
<tr>
<td>Vermi-Compost</td>
<td>2200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3600</td>
<td><strong>5800</strong></td>
</tr>
<tr>
<td></td>
<td><strong>2900</strong></td>
<td><strong>2710</strong></td>
<td><strong>2750</strong></td>
<td><strong>12440</strong></td>
<td><strong>29294</strong></td>
<td><strong>50094</strong></td>
</tr>
</tbody>
</table>

(The inputs from household and market are deducted to various sub-systems.)

### Matrix – A

<table>
<thead>
<tr>
<th>Trial plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
<td>0</td>
<td>0.13746576</td>
</tr>
<tr>
<td>Livestock</td>
<td>0.0284784</td>
<td>0.163793103</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>0.0895037</td>
<td>0</td>
</tr>
</tbody>
</table>

### Identity (I) Matrix

<table>
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<tr>
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<th>Livestock</th>
<th>Vermi-Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
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<td>0</td>
</tr>
<tr>
<td>Livestock</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

### Matrix - (I - A)

<table>
<thead>
<tr>
<th>Trial plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
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<td>-0.1374658</td>
</tr>
<tr>
<td>Livestock</td>
<td>-0.028478</td>
<td>-0.16379313</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>-0.0895</td>
<td>1</td>
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</tbody>
</table>

### INVERSE MATRIX OF (I - A)

<table>
<thead>
<tr>
<th>Trial Plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
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</thead>
<tbody>
<tr>
<td>Trial Plot</td>
<td>1.0348821</td>
<td>0.1422963</td>
</tr>
<tr>
<td>Livestock</td>
<td>0.0294941</td>
<td>1.0348821</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>0.0926219</td>
<td>0.3211239</td>
</tr>
</tbody>
</table>

Observation: As all the values in the matrix are greater than zero (>0), It implies that Hawkins – Simon condition fulfilled.
Further, INFARM related livelihood indicators for this site (Village Ambiwalala) also shows declining trends in stress periods (Figure 5.8) with improved off farm income activity, food and vegetable availability round the year and reduced migration pattern.

INFARM at Site 2: Village Chaudiyant

The results obtained from the traditional system (base line) and after intervention in first second and third year’s duration with data for various parameters selected for INFARM technology are presented in Table 5.23 to 5.25 in respect of Site 2. A perusal of results indicate that at village Chaudiyant of Dunda block of Uttarkashi district, the area undertaken for different crop interventions in the agricultural fields were different for five progressive farmers and ranged from 1.75 to 3.5 acres. Different input levels were tried for different farmers and data were collected in terms of cash income. It was noted that traditionally three species viz., Finger millet, paddy and Amaranth or Razma were cultivated as mixed crop in Kharif season and only wheat was cultivated in Rabi season. Through INFARM technology intervention, four species cropping system was introduced for Kharif season that included nutritious crops viz. Finger Millet, Paddy, Amaranth and Razma or Maize, and during Rabi season three species cropping system was introduced that included Wheat, Mustard and Lentil. Inputs were given in terms of varietal seeds, irrigation, fertilizer and IPM along with introduction of bee-keeping and vermi-composting technologies. The results were compared with the traditional input and output (base line) in terms of cash income. After intervention with new crops and crop combinations, 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 almost in all the cases as also reported at Site I.

In traditional system, inputs given by different farmers varied depending upon size of the farms. F6 farmer initiated INFARM intervention in 3.5 acre land wherein for agriculture component, traditionally, the average annual input was about Rs.6,800/- with net return of Rs.39950/-. In 1st year, through INFARM technology interventions with an input of Rs.6,295/- increase in income was reported to Rs.58,085/-. In 2nd year, the input was Rs.7,850/- and net return was noted to be Rs.58,680/-. In 3rd year, the net input was Rs.6,940/- with a net return of Rs.69,760/- (Tables 5.23 to 5.25). After INFARM interventions, the net income for agricultural component increased ca. 45.38 per cent, 46.88 per cent and 74.61 per cent in the 1st, 2nd and 3rd year respectively as compared to base line.
The poultry, bee-keeping and vermi-composting were also integrated as new sub-systems with agriculture component to enhance the livelihood support to the farmers. The annual net income from poultry sub-system was Rs.1,280/- in 1st year, which increased to Rs.2,070/- in 2nd year and slightly lower i.e. Rs.2,250 in 3rd year. While, in the case of bee-keeping it was Rs.3,200/-, Rs.15,300/- and Rs.17,840/- in 1st, 2nd and 3rd year respectively. While, vermi-composting contributed towards additional income of Rs.2,700/-, Rs 7,000/- and Rs.6,300/- in the 1st, 2nd and 3rd year respectively.

Thus, total net annual income with integration of all above components for F6 was found to be in increasing order from Rs.65,265/- in 1st year to Rs.83,050/- and Rs.96,150/- in 2nd and 3rd year respectively.

In case of farmer F7, total area taken for the study was 2.5 acre with similar INFARM technological interventions. Traditionally, the average annual input for agriculture component was about Rs.5,950/- with net return of Rs.33,200/. Through INFARM intervention, input material cost was Rs.5,770/-. The net gain was recorded to be of Rs.50,580/- in one year duration. In 2nd year, net input through INFARM technology intervention was amounting to Rs.5,690/- during the whole year and found significant increase in net gain of Rs.55,850/-. While, in 3rd year, the net input given through the introduced technology package was noted to be of Rs.4,950/- with net gain of Rs.50,980/-. Thus, after the INFARM technological interventions the net income for agricultural component increased ca. 52.35 per cent in 1st year, 68.22 per cent in 2nd year and 53.55 per cent in 3rd year with less input cost as compared to baseline.

The annual net income from poultry sub-system to farmer F7 was Rs.1,000/- in 1st year, which increased to Rs.2,480/- in 2nd year and Rs.2,150/- in 3rd year. While, in the case of bee-keeping it was Rs.4,250/-, Rs.15,750/- and Rs.18,200/- in 1st, 2nd and 3rd year respectively. The vermi-composting sub-system contributed towards additional income of Rs.3,300/-, Rs 6,400/- and Rs.6,000/- in the 1st year, 2nd year and 3rd year respectively.

Thus, total net annual income with integration of all above components for F7 was noted to be Rs.59,130/-, Rs.80,480/- and Rs.77,330/- for 1st, 2nd and 3rd year respectively.

The data collected for farmer F8 indicated that traditionally the average annual input cost in farming practices for his farm of 2.25 acre area was Rs. 4350/- with net return of Rs.22,050/-. In first year, through INFARM technology interventions with an input of Rs.5,425/- increase in income for agriculture component was reported to Rs.42,625/-. While, in 2nd and 3rd year input cost was Rs.5,310/- and Rs.5,910/- with net return of Rs.43,140/- and Rs.49,620/- respectively (Tables 5.23 to 5.25). After INFARM
interventions, the net income to F8 for agricultural component increased significantly from 93.31 per cent in 1st year to 95.65 per cent and 125.03 per cent in the 2nd and 3rd year respectively as compared to base line.

The annual net income from poultry sub-system was Rs.850/- in 1st year, which increased from Rs.2,097/- in 2nd year to Rs.2,460/- in 3rd year. While, in the case of bee-keeping, net income was noted Rs.3,350/- in 1st year which increased significantly to Rs.14,600/- and Rs.17,650/- in 2nd and 3rd year respectively. The vermi-composting contributed towards additional income of Rs.4,700/-, Rs.6,400/- and Rs.5,200/- in the 1st, 2nd and 3rd year respectively.

Thus, total net annual income with integration of all above components for F8 was found increasing significantly i.e. Rs.51,525/-, Rs.66,237/- and Rs.74,930/- for 1st, 2nd and 3rd year respectively.

In case of farmer F9 and F10 each with 1.75 and 2.0 acre land, for agriculture component, traditionally, the average annual input cost was noted about Rs.3,960/- and Rs.5,400/- with net return of Rs.19,015/ and Rs.28,440/- respectively. After INFARM technology interventions, for agricultural component the net income in case of F9 increased ca. 90.03 per cent, 99.94 per cent and 137.08 per cent in the 1st, 2nd and 3rd year respectively. While, this incremental trend was found to be more consistent in the case of F10 i.e. 61.88 per cent, 65.75 per cent and 81.86 per cent in the 1st, 2nd and 3rd year respectively. Further, The total net annual income with integration of agriculture and other new sub-systems (poultry, bee-keeping and vermi-composting) was Rs.42,810/-, Rs.62,925/- and Rs.66,765/- for farmer F9, which contributed more significantly in case of F10 i.e. Rs.54,680/-, Rs.70,961/- and Rs.74,940/- for 1st, 2nd and 3rd year respectively.

A perusal of above results and detailed data presented in Tables 5.23 to 5.25 in respect of traditional and improved INFARM technology intervention system at village Chaundiyat, Uttarkashi located at high altitude (1800m amsl), clearly indicates increase in net income value at all the farmer(s) sites irrespective of farm sizes in 1st year. During this, the input cost was increased in Kharif and Rabi seasons due to introduction of three to four species cropping system, and the net return was not found increasing significantly mainly because most of the investment was of permanent types as field leveling, IPM and for irrigation, and to meet the cost of small infrastructure related to poultry, bee-keeping and vermi-composting pits and sheds etc. But, net monetary return got increased further significantly in 2nd year and 3rd 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
Table 5.23. Cost Benefit Analysis of Small Scale INFARM Technology Intervention at Study Site 2: 1st Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>Cultivated Area (Acre)</th>
<th>Traditional System (Baseline)</th>
<th>Improved Systems: Crop Diversification</th>
<th>Other Sub-systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kharif: Finger millet + Paddy + Amaranths or Rajma (3 crop system)</td>
<td>Kharif: Finger millet + Paddy + Amaranths + Rajma or Maize (4 crop system)</td>
<td>Poultry(5+1) &amp; Bee-Keeping (4 box)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rabi: Wheat</td>
<td>Rabi: Wheat + Mustard + Lentil</td>
<td>Input (Rs.)</td>
</tr>
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<td>Total</td>
<td>5400</td>
<td>33840</td>
<td>28440</td>
<td>6400</td>
</tr>
</tbody>
</table>

Note: The cost-benefit analysis was calculated based on the prevailing daily wage labor rates, input material cost and market value/rates of agro-produce.
### Table 5.24. Cost Benefit Analysis of Small Scale INFARM Technology Intervention at Study Site 2: 2nd Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>Cultivated Area (Acre)</th>
<th>Rabi: Wheat</th>
<th>Rabi: Wheat + Mustard + Lentil</th>
<th>Other Sub-systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Traditional System (Baseline)</td>
<td>Improved Systems: Crop Diversification</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Input (Rs.)</strong></td>
<td><strong>Gross return (Rs.)</strong></td>
<td><strong>Net return (Rs.)</strong></td>
</tr>
<tr>
<td>F6</td>
<td>Kharif</td>
<td>3.5</td>
<td>4800</td>
<td>20400</td>
<td>15600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2000</td>
<td>26350</td>
<td>24350</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>6800</td>
<td>46750</td>
<td>39950</td>
</tr>
<tr>
<td>F7</td>
<td>Kharif</td>
<td>2.5</td>
<td>4450</td>
<td>16200</td>
<td>11750</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1500</td>
<td>22950</td>
<td>21450</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>5950</td>
<td>39150</td>
<td>33200</td>
</tr>
<tr>
<td>F8</td>
<td>Kharif</td>
<td>2.25</td>
<td>2750</td>
<td>10250</td>
<td>7500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1600</td>
<td>16150</td>
<td>14550</td>
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<tr>
<td></td>
<td>Total</td>
<td></td>
<td>4350</td>
<td>26400</td>
<td>22050</td>
</tr>
<tr>
<td>F9</td>
<td>Kharif</td>
<td>1.75</td>
<td>2610</td>
<td>8525</td>
<td>5915</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1350</td>
<td>14450</td>
<td>13100</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>3960</td>
<td>22975</td>
<td>19015</td>
</tr>
<tr>
<td>F10</td>
<td>Kharif</td>
<td>2.0</td>
<td>3400</td>
<td>10040</td>
<td>6640</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>21800</td>
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<tr>
<td></td>
<td>Total</td>
<td></td>
<td>5400</td>
<td>33840</td>
<td>28440</td>
</tr>
</tbody>
</table>

Note: The cost-benefit analysis was calculated based on the prevailing daily wage labor rates, input material cost and market value/rates of agro-produce.
Table 5.25. Cost Benefit Analysis of Small Scale INFARM Technology Intervention at Study Site 2: 3rd Yr.

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>Cultivated Area (Acre)</th>
<th>Traditional System (Baseline)</th>
<th>Improved Systems: Crop Diversification</th>
<th>Other Sub-systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Traditional System (Baseline)</td>
<td>Improved Systems: Crop Diversification</td>
<td>Other Sub-systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kharif: Finger millet + Paddy + Amanarths or Rajma (3 crop system)</td>
<td>Kharif: Finger millet + Paddy + Amanarth + Rajma + Maize or Rice bean (5 crop system)</td>
<td>Poultry(5+1) &amp; Bee-Keeping (4 box) Vermi-Compost(1 unit)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rabi: Wheat</td>
<td>Rabi: Wheat + Mustard + Lentil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input (Rs.)</td>
<td>Gross return (Rs.)</td>
<td>Net return (Rs.)</td>
</tr>
<tr>
<td>F6</td>
<td>Kharif</td>
<td>3.5</td>
<td>4800</td>
<td>20400</td>
<td>15600</td>
</tr>
<tr>
<td>Rabi</td>
<td>2000</td>
<td>26350</td>
<td>24350</td>
<td>2590</td>
<td>45950</td>
</tr>
<tr>
<td>Total</td>
<td>6800</td>
<td>46750</td>
<td>39950</td>
<td>6940</td>
<td>76700</td>
</tr>
<tr>
<td>F7</td>
<td>Kharif</td>
<td>2.5</td>
<td>4450</td>
<td>16200</td>
<td>11750</td>
</tr>
<tr>
<td>Rabi</td>
<td>1500</td>
<td>22950</td>
<td>21450</td>
<td>2450</td>
<td>34430</td>
</tr>
<tr>
<td>Total</td>
<td>5950</td>
<td>39150</td>
<td>33200</td>
<td>4950</td>
<td>55930</td>
</tr>
<tr>
<td>F8</td>
<td>Kharif</td>
<td>2.25</td>
<td>2750</td>
<td>10250</td>
<td>7500</td>
</tr>
<tr>
<td>Rabi</td>
<td>1600</td>
<td>16150</td>
<td>14550</td>
<td>2510</td>
<td>26550</td>
</tr>
<tr>
<td>Total</td>
<td>4350</td>
<td>26400</td>
<td>22050</td>
<td>5910</td>
<td>55530</td>
</tr>
<tr>
<td>F9</td>
<td>Kharif</td>
<td>1.75</td>
<td>2610</td>
<td>8525</td>
<td>5915</td>
</tr>
<tr>
<td>Rabi</td>
<td>1350</td>
<td>14450</td>
<td>13100</td>
<td>2050</td>
<td>27600</td>
</tr>
<tr>
<td>Total</td>
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<td>19015</td>
<td>5340</td>
<td>50480</td>
</tr>
<tr>
<td>F10</td>
<td>Kharif</td>
<td>2.0</td>
<td>3400</td>
<td>10040</td>
<td>6640</td>
</tr>
<tr>
<td>Rabi</td>
<td>2000</td>
<td>23800</td>
<td>21800</td>
<td>2590</td>
<td>36850</td>
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<tr>
<td>Total</td>
<td>5400</td>
<td>33840</td>
<td>28440</td>
<td>5790</td>
<td>57510</td>
</tr>
</tbody>
</table>

Note: The cost-benefit analysis was calculated based on the prevailing daily wage labor rates, input material cost and market value/rates of agro-produce.
nurturing soil and establishing farm productivity as indicated in Figure 5.9 and resource flow diagram (Figure 5.10).

**Leontief Input-Output Matrix Analysis:** Thus, improved INFARM system has shown visible change benefiting all the farmers (F6 to F10) as shown in Figure 5.11 though statistical analysis in terms of economic analysis and integration of various farming components justifying all the farming sub-systems are successful which supplies adequate demand for other sub-systems in subsequent year including the household needs and the market sector which was more prominent in 3rd year. Leontief input-output matrix analysis for all the farmers for this site with average miniverse for all three years may be seen in Figure 5.11 showing farmer’s integration status which was best in 3rd year in all the cases particularly for F10 as shown in Table 5.26 as most successful farmer. It is also evident from average miniverse analysis for all three years that there is visible and uniform integration for F6 to F9 farmers’ in addition to F10 farmer fulfilling the Hawkins – Simon condition.

Further, INFARM related livelihood indicators for this site (Village Chaundiyat) also shows declining trends in stress periods (Figure 5.12) with improved off farm income activity, food and vegetable availability round the year and reduced migration pattern.

**iii. Farming Integration Process: Overall Assessment**

At site 1, apart from agricultural activities, the net gain received by identifies farmers as additional income through introduction of livestock component (poultry and bee-keeping technology) was amounting to Rs.2,481/- (F1 farmer), Rs.3,079/- (F2 farmer), Rs.2,464/- (F3 farmer), Rs.3,484/- (F4 farmer) and Rs.3,499/- (F5 farmer) in 1st year; Rs.12,850/- (F1 farmer), Rs.17,775/- (F2 farmer), Rs.17,690/- (F3 farmer), Rs.18798/- (F4 farmer) and Rs.10,978/- (F5 farmer) in 2nd year; and Rs.19,803/- (F1 farmer), Rs.22,038/- (F2 farmer), Rs.21,015/- (F3 farmer), Rs.20,015/- (F4 farmer) and Rs.19,714/- (F5 farmer) in 3rd year intervention of INFARM activities at Site 1 (Ambiwal village). Further, the one time investment of Rs.1,940/-, Rs.1,910/-, Rs.1,905/-, Rs.1,920/- and Rs.1,910/- was provided to F1, F2, F3, F4 and F5 farmers of Ambiwal village (Site 1) in the form of vermi-compost pits and worms. The net return earned by these farmers was amounting to Rs.3,660/- (F1), Rs.4,490/- (F2), Rs.4,290/- (F3), Rs.3,880/- (F4) and Rs.3,590/- (F5) in the 1st year of intervention; Rs.5,880/- (F1), Rs.6,500/- (F2), Rs.5,880/- (F3), Rs.6,400/- (F4) and Rs.6320/- (F5) in the 2nd year of intervention; and Rs.6,600/- (F1), Rs.5,400/- (F2), Rs.5,640/- (F3), Rs.6,000/- (F4) and Rs.5,800/- (F5) in the 3rd year of intervention. Therefore, total net income from integration of all components and sub-system including improved system of agriculture was amounted to Rs.16,366/- (F1 farmer), Rs.20,699/- (F2
farmer), Rs.16,609/- (F3 farmer), Rs.16,754/- (F4 farmer) and Rs.21,409/- (F5 farmer) in 1st year; Rs.32,795 (F1 farmer), Rs.39,240/- (F2 farmer), Rs.39,990/- (F3 farmer), Rs.48,668/- (F4 farmer) and Rs. 43,403/- (F5 farmer) in 2nd year; and Rs.42,018/- (F1 farmer), 47,398/- (F2 farmer), 45,500/- (F3 farmer), 50,120/- (F4 farmer) and Rs.50,094/- (F5 farmer) in 3rd year (Table 5.19 to 5.21).

At site 2, village Chaundiyat of Dunda block of District Uttarkashi, the net return received by the farmers through livestock component (Poultry and Bee-Keeping activities) was amounting to Rs.4,480/- (F6 farmer), Rs.5,250/- (F7 farmer), Rs.4,200/- (F8 farmer), Rs.2,575/- (F9 farmer) and Rs.4,540/- (F10 farmer) in the 1st year of intervention; Rs.17,370/- (F6 farmer), Rs.18,230/- (F7 farmer), Rs.16,697/- (F8 farmer), Rs.18,905/- (F9 farmer) and Rs.17,821/- (F10 farmer) in the 2nd year of intervention; and Rs.20,090 (F6 farmer), Rs.20,350/- (F7 farmer), Rs.20,110/- (F8 farmer), Rs.16,325/- (F9 farmer) and Rs.18,120/- (F10 farmer) in 3rd year intervention of INFARM activities. Like Ambiwala, one time investment of Rs.1,500/- was provided for vermi-composting activity to all the identified farmers (F6 – F10). The net return obtained by these farmers from this activity was amounting to Rs.2,700/- (F6), Rs.3,300/- (F6), Rs.4,700/- (F8), and Rs.4,100/- (F9 and F10) respectively in the 1st year of intervention; Rs.7,000/- (F6), Rs.6,400/- (F7 and F8) and Rs.6,000/- (F9 and F10) respectively in second year of intervention; and Rs.6,300/- (F6), Rs.6,000/- (F7), Rs.5,200/- (F8), Rs.5,300/- (F9) and Rs.5,100/- (F10) in the 3rd year of intervention. Therefore, total net income from integration of all components and sub-system including improved system of agriculture was amounted to Rs.65,265/- (F6 farmer), Rs.59,130/- (F7 farmer), Rs.51,525/- (F8 farmer), Rs.42,810/- (F9 farmer) and Rs.54,680/- (F10 farmer) in 1st year; Rs.83,050/- (F6 farmer), Rs.80,480/- (F7 farmer), Rs.66,237/- (F8 farmer), Rs.62,925/- (F9 farmer) and Rs.70,961/- (F10 farmer) in 2nd year; and Rs.96,150/- (F6 farmer), Rs.77,330/- (F7 farmer), Rs.74,930/- (F8 farmer), Rs.66,765/- (F9 farmer) and Rs.74,940/- (F10 farmer) in 3rd year (Table 5.23 to 5.25).

Through all the methodologies explained in chapter 3 for Leontief Input-Output Matrix Analysis, all the 10 farmers’ 3rd year data was analyzed individually and at the end all the farmers’ three years data were put in average minverse to find out the most successful farmer. With this statistical analysis, it is observed that all the farmers as discussed above at both site 1 and 2 are fulfilling the Hawkins – Simon condition, in other word, all the farming sub-systems are successful. The consolidated graph (Fig. 5.13) shows that F10 farmer at site 2 is the most successful farmer in terms of integration of various farming components.
5.1.2.3. Emerging Technology Intervention Model (TIM) for Livelihoods Gain

In the third year of the study, there are enough indicators to show that through **diversification**, **resource integration** and careful **designing** of the farm eco-systems (Table 5.27), it has been possible to:

Table 5.26. INFARM: Leontief Input-Output Analysis for F10 Site (3rd Yr.)
Best Integration at Site 2: Most Successful Farmer

<table>
<thead>
<tr>
<th>Integration Calculation in Rs.</th>
<th>Trial plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
<th>HHs</th>
<th>Market</th>
<th>Gross demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
<td>0</td>
<td>1300</td>
<td>2100</td>
<td>9500</td>
<td>38820</td>
<td>51720</td>
</tr>
<tr>
<td>Livestock</td>
<td>900</td>
<td>0</td>
<td>1400</td>
<td>6100</td>
<td>9720</td>
<td>18120</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>4800</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>300</td>
<td>5100</td>
</tr>
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<td>5700</td>
<td>1300</td>
<td>3500</td>
<td>15600</td>
<td>48840</td>
<td>74940</td>
</tr>
</tbody>
</table>

*(The inputs from household and market are deducted to various subsystems.)*

<table>
<thead>
<tr>
<th>Matrix – A</th>
<th>Trial plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
<td>0</td>
<td>0.07174393</td>
<td>0.411764706</td>
</tr>
<tr>
<td>Livestock</td>
<td>0.0174014</td>
<td>0</td>
<td>0.274509804</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>0.0928074</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Identity (I) Matrix</th>
<th>Trial plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Livestock</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Matrix - (I - A)</th>
<th>Trial plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial plot</td>
<td>1</td>
<td>-0.0717439</td>
<td>-0.41176471</td>
</tr>
<tr>
<td>Livestock</td>
<td>-0.017401</td>
<td>1</td>
<td>-0.2745098</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>-0.0928074</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INVERSE MATRIX OF (I - A)</th>
<th>Trial Plot</th>
<th>Livestock</th>
<th>Vermi-Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial Plot</td>
<td>1.0430673</td>
<td>0.0747879</td>
<td>0.4295351</td>
</tr>
<tr>
<td>Livestock</td>
<td>0.0181494</td>
<td>1.0430673</td>
<td>0.286322</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>0.0967966</td>
<td>0</td>
<td>1.0430673</td>
</tr>
</tbody>
</table>

**Observation:** *As all the values in the matrix are greater than zero (>0), It implies that Hawkins – Simon condition fulfilled.*

5.1.2.3. Emerging Technology Intervention Model (TIM) for Livelihoods Gain

In the third year of the study, there are enough indicators to show that through **diversification**, **resource integration** and careful **designing** of the farm eco-systems (Table 5.27), it has been possible to:
a) Increase whole farm productivities (land, labour and input),
b) Ensure food and nutritional securities of the farm families,
c) Reduce stress periods in the farm,
d) Improve diversity in the farm,
e) Increase the profitability of the farming enterprises, and
f) Increased cash flows in the farm families.

Two major foci of the intervention have been (i.) diversification of the farm sub-systems and various elements within each sub-system and (ii.) integration among and within sub-systems to ensure tighter cycling of resources so that the ‘whole farm system’ becomes more energy optimized and self sustainable in terms of inputs, ecological health and economics. Further, 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 during the three years of cropping seasons at each experimental farm site. These results for possibilities of village ecosystem re-development through INFARM interventions are in agreements with similar results of others that the village ecosystem functions of mountain particularly at higher altitude is based upon the recycling of resources within the systems (Mishra and Ramakrishnan, 1982; Sundarraj and Mitchell, 1987) and less costly to maintain than the energy intense agriculture systems probably due to abundant availability of natural resources and relatively low population pressure (Toky and Ramakrishnan, 1982; Altieri, et al. 1982; and Maikhuri and Ramakrishana, 1990) leading to better energy efficiency and 3-5 fold economic returns. Although, gross output and net income was variable at the end of 3rd year at all the farmers’ sites may be due to local ecological factors, but, all the farming sub-systems were successful, as observed with 10 farmers at both site 1 and 2 which is justified statistically fulfilling the Hawkin-Simon condition. The results are in conformity with Craig, et al. (1997) and Pardey, et al. (1997) who also investigated the role of input quality (agricultural labour skills, better quality fertilizers, and enhanced seed varieties), infrastructure and research that have a direct influence on total factor productivity growth with diverse outputs.

Above findings and results of INFARM technological interventions clearly show process innovation and effective technology delivery with other support services due to following as potential replicable model (TIM -2).
i. Technology Success Factors

These results paint an interesting picture of the determinants of agricultural productivity. Many factors which determine agricultural productivity, particularly the quantities of land and labour, but also the geography of the land in terms of climate and distance to the core economy, are relatively fixed. Thus, sustainable rural livelihoods in remote mountain areas will not come through additions to these inputs. Rather, continued development comes through increases in the quality of labour and land by managing resources both human and natural capital, and through better infrastructure and technical support. The results indicates that improved agriculture practice and seeds, quality of planting material and compost, better crop combinations and land use pattern with bio-fencing have contributed significantly for increased productivity and income at both the sites after INFARM interventions. The data for three years also reveals that soil condition in both the sites have improved considerably due to use of vermi-compost, otherwise, farmers were traditionally using only dung as compost at the both the sites, and at site 2 free-grazing and burning of agricultural residue was common feature. The intensity of improvement with INFARM inputs increased consistently in subsequent years representing a conversion period which indicates stabilization of whole farm system(s) as compared to conventional system. The figures 5.6 and 5.10 show 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 were earlier replaced by cash crops and monocropping system ultimately reducing the crop diversity during the green revolution period. 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 single output. It agree with others that traditional crop-livestock mixed farming and surrounding ecosystems and natural resources which drive agricultural production process are critical for sustainable livelihoods of mountain community and backbone of rural economy (Rao and Saxena, 1996; Sen, et al. 1997; Lefroy, et al., 2000 and Von Wiren-Lehr, 2001). These factors culminates in the genesis of subsistence production system which are sustained with the organic matter and nutrients probably derived from the forest litters, agricultural waste used in vermi-composting as also reported by Maikhuri, et al. 1997. The introduction of fodder grasses and plantation of fodder trees also helped in reducing the intensity of fodder scarcity at both the sites. It also helped to use the wasteland available in both villages for more productive use. Such an intervention model (TIM-2) will also help to address the local problem of extension of
agricultural land use into forest lands coupled with ecosystem degradation; excessive grazing and lopping in forests reported by Singh et al. 1984; Schreier, et al. 1994 and Semwal, et al. 2004 in mountain areas of Nepal and Central Himalaya. These results suggest several avenues as enterprising model for quality honey and compost production; value addition in horticulture produce by which hill agriculture may increase their total factor productivity and income in the rural sector by adopting INFARM model designed carefully for effective resource integration and diversification. These results are in conformity/similar to those of with findings of FAO’s analysis and work carried out by Pretty, et al. 2002 in select countries which also 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.

ii. Institutional Success Factors: The Process Approach and Innovative Elements

The role of local institution was crucial in above process for INFARM interventions to make effective use of farm resources in integrated way with related income generating activities to provide livelihoods opportunities for local farmers. Besides, as community development strategies, it motivated trained farmers who have been assisted with developmental funds to help and serve other farmers particularly deprived ones by sharing knowledge and material endowments. Farmers after benefiting from assistance with new improved seeds, tools and new knowledge of crop combination and production, then extend both material and knowledge to help farmers in neighboring villages. This practice is called “Shridan” with replication and quick flow of INFARM technology model as a development chain of support shared with farming community within the village. After, a group of farmers used community development knowledge and minimal funds to assist themselves and other farmers within the village, they in turn, shared their newly acquired knowledge and resources with a neighboring village community. This return of payment, voluntarily passing from one village community to another, is catching up as sustainable “INFARM community model”. Shridan, a community initiative which is developing a helping chain from one farmer/community to another, has given a new vision to bringing about a new quality of village life; communal harmony; self dependence; personal/community identity and respect; knowledge transfer and knowledge transparency. This is the process through which communities receive and give support to each other in decentralized way for technological empowerment and capacity building. In this way, the march towards rural development can continue, and reproduce itself, community to community. Thus, the concept and mechanism of self help/communal inter-dependence emerges reducing dependency on limited public funds and development
projects to provide ongoing supports to others. This is essential in view of the community development strategies adopted in the past which have shattered the value of fostering relations between the communities, placing a higher value on individualism. Establishment of common facility centers and seed banks equipped with necessary tools, information being maintained by villagers is important component of INFARM model. Thus, at the policy level initiatives are required to assist and nurture an institutional and financial environment to attract civil societies that lessens risk to small holder families with options for farm system diversification and for off-farm rural employment, improved access to technologies and affordable micro-credit with a component of risk management insurance.

With the above observations, results and conclusions it is clear that technological interventions have had a key role to play in promoting agriculture, however, the extent of interventions as well as the exact nature of impact has varied across altitudinal gradient. From the findings, it is safe to conclude that that the lives and livelihoods of the small and marginal farmers can be sustainable if their basic necessities are fulfilled from their farm itself and their dependency on market forces for seed and fertilizers is reduced with integration of farm sub-systems, recycling processes and good soil health.

iii. Community Empowerment and Replicability Potential: Adopting Technology to Improve Livelihoods

The findings of the study in 3rd year indicates that the total annual net income is more from allied sub-systems as compared to the agriculture at Site 1, which is due to low land holdings as compared to Site 2 at higher latitude. Whereas, at Site 2, the total annual net income was more from agriculture due to large landholdings and improved multiple and mixed cropping pattern supported with surrounded ecosystems rich in forest resources. Within the allied sub-systems at both the site during participatory discussion and assessment, it was found that income from bee-keeping as micro-enterprise was more prominent due to market demand of the natural honey, while, vermi-compost and poultry products (eggs, birds, poultry litter) were used by the farmers primarily for use in their farms and to improve the nutritional value of their own food besides enhancing their income to be invested further in the household farms to intensify, diversify and enhance productivity.

Above findings are in consonance with the studies of Altieri,1990 ; and Singh, et al., 1997 from Chhakinal watershed, Kullu, Himachal Pradesh validating the premise that diversified and integrated farming system are better practiced and adopted by the small farmers by conserving and/enhancing agro-diversity evolved over time that also covers
both natural resources and livelihood and food security aspects of the farming communities thus protecting ecological capital from sustainability point of view and increasing profit margin 2-3 times compared to mono cropping as reported by Shiva and Pandey, 2006 in a study carried out in rainfed areas of Almora district by practicing the mixed farming (3-5 crops). It suggests that solution to the crisis, especially with regards to the small and marginal farmers in the mountain, lies in evolving an efficient farm level agro-system management model through integration of various biological resources in and around the farm.

Thus, findings suggests that policy interventions are required to strengthen and empower small-holder farmers to reverse declining trends by evolving and making use of such INFARM models to enhance equity and sustainability of income and livelihoods through public investment in agriculture and its infrastructure, who constitute the 78 per cent of the county’s farmers (Singh, 2003). It also agree and support Amartya Sen (1999) that during years when non-agricultural rural employment/opportunities increases, rural poverty declines, thus, on-farm, off-farm, and on-off-farm rural employment is essential to secure adequate livelihoods within the households of small holders, and thereby help to prevent the urbanization of poverty due to migration. It also requires expanding banking system rural credit for non-farm employment- creating natural resource based rural enterprises in mountain ecosystem to support technology driven production system for value addition such as honey production. Such a policy intervention for human resource development and in skill strengthening through INFARM Model approach (TIM -2) to serve agriculture needs will help for raising factor productivity with the utilization of new or/and existing farmer-driven technologies to develop group farming enterprise by pooling and sharing their farming resources, operations and benefits to transform subsistence agriculture to sustainable agriculture in hills (Fan, et al. 1999; Kumar and Mittal, 2000, Semwal, et al. 2004). Such policy level change is essential in view of current forest policies which provide limited scope of direct economic benefits from forest resources. Policy support for sustainable technologies enhancing agricultural productivity through promotion and cultivation of traditional crop diversity and efficient resource recycling for soil fertility management within farm agro-ecosystems is urgently needed for sustaining local livelihoods with appropriate scientific inputs in mountain ecosystems, and to reduce pressure on forest resources for litter removal, looping or grazing.
<table>
<thead>
<tr>
<th>Upgraded Technology/ New Components</th>
<th>People’s Contribution</th>
<th>Adoption rate</th>
<th>Technology Package Flow</th>
<th>Impact Indicators/ response variables</th>
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<tr>
<td><strong>Agriculture</strong></td>
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<tr>
<td>• Revival of traditional crops: Cereals/pulses/millet</td>
<td>• Land</td>
<td>High</td>
<td>• Extension to other farmers</td>
<td>Human Resource Development</td>
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<tr>
<td>• Introduction of new crops and combination</td>
<td>• Labor</td>
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<td>• Village to village at block level</td>
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<tr>
<td>• Introduction of new variety of seeds with improved agriculture practices</td>
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<td>• Introduction of multipurpose trees species: Fodder and fruit trees; fodder grass (Napier CO-3)</td>
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<td>• Introduction of nutritious crops (finger millet, grain amaranth us and rice bean and horse gram)</td>
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<td><strong>Other Components / Additional Components for resource integration &amp; income generation</strong></td>
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<tr>
<td><strong>Vermi-composting</strong></td>
<td>Composting of agriculture and forest residues</td>
<td>• Land</td>
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<td>Natural Resource Management</td>
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<tr>
<td><strong>Nursery Raising</strong></td>
<td>• Ornamental plants &amp; vegetable cultivation under polyhouse conditions</td>
<td>• Land</td>
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<td>Facilities</td>
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<td>• Backyard vegetable cultivation: Introduction of spices and vegetable cultivation through improved practices</td>
<td>• Labor</td>
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<td>• Seed</td>
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<td>• Village level agro service center managed by farmer (Agri-inputs &amp;small implements)</td>
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<td><strong>Livestock (Bee-keeping/Poultry)</strong></td>
<td>• ‘Alternative use of Lantana, an invasive weed to make bee-boxes,</td>
<td>• Land</td>
<td>High</td>
<td>• Irrigation facilities</td>
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<td>• Quality honey production</td>
<td>• Labor</td>
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<td>• Quality seed production</td>
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<td>• Backyard Poultry (5+1)</td>
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<td>• Introduction of fodder management by stall feeding: Reduced 30 per cent wastage during feeding</td>
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</table>

**Table 5.27. INFARM Model: Technology Flow, Adoption Factors with Impact Indicators for Replicable Technology Package**
Figure 5.3: Soil Status at Village Ambiwala, Dehradun (Site 1)
Figure 5.4: Soil Status at Village Chaundiyat, Uttarkashi (Site 2)
Figure 5.5: Economic Analysis (Net Profit) from INFARM Activities of selected Farmers from Village Ambiwala, Dehradun (Site 1).
Fig. 5.6. Resource Flow Diagram showing Improved Linkages (red arrows) within Farm System due to INFARM Interventions and Sub-Systems at Village Ambiwal (Site 1).
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<th>SITE - 1</th>
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<th>III Year</th>
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<td>0.98947322</td>
<td>0.986818</td>
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Figure 5.7. Transaction Matrix Analysis showing Integration Status through INFARM interventions at Farmers’ Plots (Village Ambiwala – Site 1) indicating F5 as Best Farmer.
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Figure 5.8: INFARM linked Livelihood Indicators: Stress Periods and Impact Changes at Study Village Ambiwal, Dehradun (Site 1).
Figure 5.9: Economic Analysis (Net Profit) from INFARM Activities of selected Farmers from Village Chaundiyat, Uttarkashi (Site 2).
Fig. 5.10. Resource Flow Diagram showing Improved linkages (red arrows) within Farm System due to INFARM Interventions and Sub-Systems at Village Chaundiyat, Uttarkashi (Site 2).
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**Figure 5.11.** Transaction Matrix Analysis showing Integration Status through INFARM interventions at Farmers’ Plots (Village Chaundiyat – Site 2) indicating F₁₀ as Best Farmer.
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Figure 5.12: INFARM linked Livelihood Indicators: Stress Periods and Impact Changes at Study Village Chaundiyat, Uttarkashi (Site 2).

Figure 5.13. Transaction Matrix Analysis showing Integration Status through INFARM Interventions at Farmers’ Plots indicating F₁₀ as Best Farmer.
5.1.3. Post Harvest Processing of Horticultural Produce for Value Addition (TI-3)

The essential foundation for rural industrialization must be the natural resources available locally whether these are cultivated or gathered from nature. These constitute the basic produce and raw material in the hands of the rural population, especially weaker sections, to which value is sought to be added. Such a strategy of local value-addition at/near the source of raw materials would also have enormous additional advantages to the national economy in reducing wastage, energy savings and obviating of unnecessary non-productive expenditures along the value chain, especially given the perishable nature of most of these commodities. It is well known that over 15 per cent of cereals and other food grain as well as around 25 per cent of horticultural produce are lost each year, resulting of losses running into thousand of crores, due to spoilage at different stages between harvest and retail sale. Much of this national loss could be mitigated, with enormous benefits to rural producers, the national economy and consumers, if proper preservation and processing or semi-processing are undertaken in producing areas themselves (Gupta, 1955). Rural industrialization based largely on value-addition to rural natural resources is clearly the way forward.

India is bestowed with a varied agro-climate, which is highly favorable for growing a large number of horticultural crops such as fruits and vegetables. Horticultural development had not been a priority in India until recent years. In the period 1948-80, the main focus of the country was on cereals and development efforts for specific commodities like spices, coconut and potato. The productivity of horticultural crops has increased only marginally from 7.5 tones per hectare in 1991-92 to 8.4 tones per hectare in 2004-05 (NHB, 2005). The relative profitability of horticultural crops compared to cereals has been shown to be a determining factor for crop diversification into horticultural production in many countries of South and South-East Asia including India, particularly under conditions where the average size of landholding is among the lowest, and labor is abundant (Joshi, et. al. 2003). Presently, horticultural crops occupy around 13 per cent of India’s gross cropped area, producing 177.41 million metric tones during 2005-06 with increase emphasis under National Horticulture Mission on sustaining the production and processing of fruits and vegetables and to establish a sound infrastructure in the field of production, processing and marketing focusing on post-harvest management to reduce losses. The share of fruits and vegetables in the total value of agricultural exports has increased over the years from 9.5 per cent in 1980-81 to 16.5 per cent in 2002-03. But, India is still lagging behind in actual exports of these produce. Horticulture contributes nearly 28 per cent of GDP in agriculture. As a result of this huge spurt in horticulture produce, India has become the second largest producer of fruits and vegetables in the world, next only to China. There is an overall increase in the demand for
fruits and vegetables for consumption both in the fresh and the processed form as a growing relationship between diet and health. It is estimated that insufficient fruits and vegetable intake causes some 2.7 million deaths each year, making it one of the top ten risk factors contributing to mortality (Weinberger and Lumpkin, 2005). Income in this sector is increasing which is indeed driving the supply. Yet a lot needs to be done in this sector. It is true that India is the second largest producer of fruits and vegetables in the world, but, processing is very low, approximately 3-5 per cent. This may be compared to 30-70 per cent utilization by processing industries in South-East Asian countries. In spite of being one of the largest producers of fruits and vegetables in the world, the post-harvest losses and the wastage due to poor infrastructure facilities, among the Indian producers also remains high. Though in recent years India has witnessed a shift towards the use of processed fruits and vegetables, there exists a vast and growing demand for such products, both at the rural and urban levels.

5.1.3.1. Technology: Value Addition in Horticulture Sector in Garhwal Himalaya

Horticulture, though rather a new change in the land use in Uttarakhand, has been considerably successful in certain areas of the region particularly situated between 1500 and 2400 m altitudinal range. Uttarakhand produces 4.41 metric ton fruits and 10.96 metric ton vegetables per annum. Different topography, climate and other factors have bestowed a variety of fruits and capacity to grow non-seasonal and other horticulture produce in this region. Within this region, there exists a total of 89764 ha land under the various horticultural crops in Garhwal area. Of the total area under horticulture in Garhwal, about 30.23 per cent is utilized to raise apples followed by walnut (12.78 per cent), Citrus fruits (12.37 per cent), peach (6.22 per cent) and apricot (4.20 per cent). To mention some important horticultural crops of Garhwal Himalaya are apple, citrus, apricot, peach and walnut with an estimated yield of 332 Qtl/ha, 232 Qtl/ha, 216 Qtl/ha, 210 Qtl/ha and 50.7 Qtl/ha respectively. Mangoes and litchis are grown mainly in the plain areas and partly in the warmer valleys of the region. The average horticultural yield of Garhwal Himalaya has been reported as 219.7 Qtl/ha (Semwal, et al., 2001). Thus, horticulture in the mountain regions is a natural gift and an economic necessity because it has the potential not only to stabilize the agricultural economy but also to strengthen local livelihood needs and concern to promote environmental conservation of the region.

Horticulture development, as narrated above, is directly linked with the cash income of the poor farmers in hill region. Keeping these facts in view, potential small scale technology intervention (TI-3) was identified for impact study on horti-processing at village level for better livelihoods of small and marginal growers in Rudraprayag District, Uttarakhand considering the need oriented approach of appropriate scale suitable
for value addition in horticultural rich belt in study areas which were lacking in infrastructural development.

5.1.3.2. Technological Intervention with Networking Approach for Horti Processing: Impact Analysis

Village namely Gagotu, Agasthamuni Block of Rudraprayag in temperate region at mid altitude (1200m amsl) was selected for the present study as described in Chapter 4. The study was done to evaluate technological interventions made at this location by science based field group covering cluster of villages Gwar-Chauki, Mayali and Dulli etc within the catchments 10-15 km in Garhwal Himalaya, which has shown potential for value addition at village level itself to process locally available horticultural produce, not only to enhance the cash income, but also to promote decentralized production system with participatory technological interventions. A detailed impact analysis of value addition technologies on cash income generation of local growers with relevant data was done for three years at study site to evaluate the performance and viability of new networking production and processing approach introduced in the area for resource utilization in terms of cost-benefit and technology adoption by the community. Data collection in participatory mode was done as described in Chapter 3. The capital investment for this intervention was made almost eight years earlier with certain level of feasibility and has sustained over the years with good production and livelihood benefits even in the recent years. Therefore, it was felt that production unit and functional system approach of intervention needs to be studied for further feasibility and assessment of cost benefit issues keeping in view the latest market scenario for further replication in similar situations in the country with capital investment (based on actual basis and prevailing market value) to the tune of what was made at the time of installation for the analysis of data and expression of results.

i. Need Assessment and Conceptualization

After initial survey, it was found that small farmers and other poor growers of fruits, vegetables and other horticultural produce in study area and nearby villages suffer from the pressure to dispose off perishable produce, often at distress prices due to poverty, poor resource management and lack of technical know-how, storage, processing or preservation facilities. These distress sales are all the more debilitating for small and marginal farmers who produce a larger proportion of fruits and vegetables. It is also estimated that about 20-30 per cent of the total production of fruits and vegetables goes waste due to spoilage at various stages from collection to sale, and transportation cost of produce is higher from village to road head. Thus, not only valuable source of nutrient wasted, but its producers face impoverishment and misery. Therefore, the scope of value
addition through processing exists and in fact was a widely articulated need. It was found that intervention was initiated with ‘systems approach’ to establish the economically viable and self-sustainable production unit having networking of poor/marginal growers and other weaker sections, especially women through appropriate technology package for value addition at village level. A suitably de-scaled processing unit was established in the study area close to the source of raw material and easily accessible to growers. It was ensured that local market potential should exist and range of raw produce should be available in order to run the unit round the year.

ii. Technology Package

The technology package includes some innovative techniques in harvesting, on farm and off farm storage management, handling, grading and packing techniques, suitably de-scaled and adopted equipments/machines to produce conventional products or intermediates like juice, pulp, puree, pickles etc. with a major emphasis on production of innovative dehydrated/osmo-dehydrated products such as onion and garlic powder, dried apricots/plums, apple chips and papaya candy etc. Given the focus on innovative work, and the perspective of adopting low cost energy saving technologies (such as agro-residue based flue-heated driers, zero energy cooling chamber for on farm fruits and vegetable storage based on the principle of evaporative cooling, lactic acid fermentation and other nutrient preservation techniques), major thrust under this package was given on minimizing pre and post harvest losses; increased shelf life with quality control built into the system; controlled atmospheric and aseptic packaging, and emphasizing on drying and dried products to have all year round production and sustainable income ensuring maximum benefit to the women groups as depicted in Table 5.30.

iii. Systems Design: Network and Management

Production system comprises of mother or nodal unit at village level near to road head as central facility for drying, quality product production, packaging and marketing linked with two satellite units and some home based or cluster of village based sub-units for providing semi-processed produce to mother unit, together covering a cluster of 20 villages in a catchment’s area. Adaptive R&D work, training in quality control and production process, and packaging is carried out at mother unit with overall organization and supervision by the S & T field group with a network of trained women. Training, an essential element of the programme for capacity building was designed to be imparted at two levels: at institutional level by resource agency (Indian Agricultural Research Institute, Delhi) to core women group and at field level by trained women core group to network beneficiaries. It was ensured that at every level of operation, network of women
is closely involved in production, processing, packaging and marketing promotion. The science based field group, an NGO manages and co-ordinates all the activities from networking of growers to marketing the products, and also provides technical support.

The system design for processing and marketing of horticultural produce includes following:

- A network of women from small grower families (members of Mangal Dals, SHGs) who collect the produce and do preliminary processing like sorting, peeling, washing etc. at the household/village level including pickling – small (S) level.
- A village - (group of villages-) level satellite unit which undertakes semi-processing and preservation of the materials provided by the previous level. This includes pulping/juicing for supply to Nodal Unit in bulk and sun-drying. Some local sale may be undertaken too – Big (B) and medium (M) level.
- The processing unit at the Nodal level which receives the semi-processed materials from the previous level for drying, final processing and packaging. Much of the training is imparted here. Large scale marketing, other management aspects such as obtaining FPO license, training workers in quality control and in production and supervision is undertaken here. Adaptive R & D work is also carried out at the nodal level. Overall organization of the production centre is taken up by the NGO. The network of women’s growers is closely involved in all these activities at Nodal (N) level. At full scale production levels, the system would be expected to process about 5-15 quintals of raw produce per day with decentralized operations at the village level or even domestic level.

Data was collected on value addition of fruit and vegetable produce by setting up of decentralized production unit as common facility centre (CFC) for the three years presented year-wise in Table 5.28. The cost-benefit analysis of processing cum production facility as given in the table was calculated based on actual basis and market value/rates of horti-produce. The net income generated through the intervention was analyzed in terms of tangible benefits, while, ecological and social benefits to local community in study area were analyzed as intangible benefits. A perusal of results indicate that total investment on fixed assets and recurring cost was amounting to Rs.7,75,000/- in 1st year excluding land provided by the village community for setting up CFC, and Rs.1,95,000/- each in 2nd and 3rd year of intervention. Besides, It also include 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 2nd and 3rd year the net monetary return increases significantly i.e. Rs.5, 61,500/- deducting the negative cost of net return in 1st year, and Rs.7, 03,540/- respectively with
benefit sharing mechanism amongst all the stakeholders as shown in Table 5.28 providing direct benefit to a network of 150 small and marginal growers from 20 villages to run the facility on self-sustainable basis.

**Table 5.28. Cost Benefit Analysis of Village level Small Scale Decentralized Horti-Processing unit as Common facility Centre (CFC)**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Detail</th>
<th>Value/quantity 1st Year</th>
<th>Value/quantity 2nd Year</th>
<th>Value/quantity 3rd Year</th>
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<tr>
<td>I.</td>
<td>Tangible Benefits</td>
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<tr>
<td>A.</td>
<td>Investment*</td>
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<tr>
<td>1</td>
<td>Fixed cost (Rs.):</td>
<td>2,10,000</td>
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<td></td>
<td>Cost of work shed Construction (1000 sq.ft.)</td>
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<td>2</td>
<td>Cost of properly scaled equipments (Boiler, drier, pulper, juicer, steam jacketed kettle etc.) with small quality control facility (For 1 nodal and 2 satellite units)</td>
<td>3,70,000</td>
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<tr>
<td>3</td>
<td>Supplies, raw materials, chemicals wages, fuel and packaging cost etc.</td>
<td>1,95,000</td>
<td>1,95,000</td>
<td>1,95,000</td>
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<td></td>
<td>Total Investment (Rs.)</td>
<td>7,75,000</td>
<td>1,95,000</td>
<td>1,95,000</td>
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<td>B.</td>
<td>Returns*</td>
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<tr>
<td>1</td>
<td>Average produce processed/annum (tons)</td>
<td>60</td>
<td>60</td>
<td>68</td>
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<tr>
<td>2</td>
<td>Average value of raw produce/annum (Rs.)</td>
<td>3,17,500</td>
<td>3,17,500</td>
<td>3,59,825</td>
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<tr>
<td>3</td>
<td>Value of finished processed products/annum(Rs.)</td>
<td>7,73,750</td>
<td>7,73,750</td>
<td>8,99,562</td>
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<td>4</td>
<td>Sale price of finished products/annum(Rs.)</td>
<td>10,83,250</td>
<td>10,83,250</td>
<td>12,58,365</td>
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<td>C.</td>
<td>Gross return/annum(Rs.) A + B.2 – B.4</td>
<td>-9250</td>
<td>5,52,250</td>
<td>7,03,540</td>
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<td>D.</td>
<td>Net Return/Annunm</td>
<td>-9250</td>
<td>5,61,500</td>
<td>7,03,540</td>
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<td>II.</td>
<td>Intangible Benefits</td>
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<tr>
<td>1.</td>
<td>Economic and benefit sharing</td>
<td>Buying price was given 25% higher to small growers as compared to existing selling (support) price. Model suggests round the year quality production system covers 4 panchayats with 20 villages and support about 2000 households directly or indirectly. 25 % profit is ploughed back as working capital, while, a significant proportion is front ended given to small farmers and growers as better price for raw produce, and to meet the cost for adaptive R &amp; D, and technical support.</td>
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<td>2.</td>
<td>Ecological</td>
<td>• Natural resource conservation and value addition.</td>
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<td></td>
<td></td>
<td>• Reduction of post harvest losses of fruits/vegetables.</td>
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<td>3.</td>
<td>Social</td>
<td>• Employment generation and improved livelihood to small farmers and unemployed youths.</td>
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<td>• Full time employment to 15-20 women from small growers households’ at home-scale pre-processing, satellite and main units.</td>
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<td></td>
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<td>• Formation of women growers’ group/Fruit processing association.</td>
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<td></td>
<td>• Networking of about 150 small and marginal growers receiving an additional income of 2.00 lakh/annum from 2nd yr onwards after the net return was obtained negative in 1st yr.</td>
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* Calculated on existing rates.
iv. Correlation and Regression Analysis: Finally correlation and analysis of decentralized production system for cost benefit impact was also done as shown in Table 5.29. to statistically analyze the viability and potential of technology intervention with above discussed network approach for village level production system in terms of value addition to horticultural produce and cash income flow to local growers. Correlation matrix analysis exhibited negative correlation of gross returns with capital cost and perfect correlation with recurring cost. On further analysis of the gross returns through regression equation with capital cost and recurring cost exhibited that gross return is independent of capital cost. However, one unit increase in recurring cost for processing of raw material will increase the gross returns by 350 units. This indicates that processing unit is used at a very low efficiency and there is ample scope for increase in the processing capacity of the nodal unit through involving more number of satellite units and growers for increasing the intake of raw produce to utilize the equipment and infrastructure. Thus, it is evident that through de-centralized 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 in Table 5.30 leading towards improved livelihoods and employment opportunities.
5.1.3.3. Emerging Technology Intervention Model (TIM) for Livelihoods Gain

Thus findings of above technological intervention as potential Generic Technology Model for rural application clearly shows and justify large scale utility for macro level application particularly in hilly areas through horizontal spread for effective dissemination as complete package to benefit and empower group of small growers at source itself due to followings:

i. Inducing Economic Potential and Community Empowerment: Adopting Technology to Improve Livelihoods through Local Enterprise

As a result of above network efforts with village level NBMS (Nodal, big, medium and small – Figure 5.15) structure, a model has emerged for full scale processing and production unit as common facility centre with technological back-up/training from R & D institution (in this case Indian Agricultural Research Institute, Delhi) with subsequent local support by S&T based field group to provide technical back-up as well as managerial support to local growers and farmers in participatory mode as complete technology package. It has innovative elements to carefully develop low cost technology package, recipes and processing protocols through field trials based on traditional knowledge/techniques upgraded with modern S & T inputs, availability of raw material in the area and market demand of innovative products. Technologies of appropriate scale/type are introduced or wherever necessary adapted/standardized under field conditions with functional networking between different levels of production. The Unit has a core team of 4-5 trained women with on line quality control lab. facility. These trained women as para-technologists are involved in imparting training and technical know-how to other women of the catchment’s area as on-going activity having multiplier effects and horizontal flow of technology. Unit also has got requisite FPO license and is now self sustainable, being managed by women co-operative to process, preserve, pack and market the finished products. During the study and discussion with growers it was found that 100-120 families around this unit from 20 villages have benefited directly to have all year round production for self consumption and sustained income with minimum wastage. Innovative products like natural plum and apricot drinks, Rhododendron squash and ginger powder made from local produce and utilization fruit waste (peel of malta) for candy by the caring and knowing hands of trained women are now available in the market. The innovative products are now being marketed successfully by them under the common brand name “Suvas” ensuring maximum benefits to women growers/beneficiaries at the village level with an approach of value addition at source itself – thus reducing dependency on middle-men, reduction in
post harvest loses, saving in transportation cost, and time. New senses of accomplishment by way of new skills and earning independent incomes have given them the confidence to bring about other reforms in their lives. Many of them are now developing fruit belts around the unit through better nursery plantations techniques for better production. Unit is estimated to have year-round production of 500 kg/day of finished products with monthly turnover of Rs. 50,000 to Rs. one lakh.

Moreover, local processing as rural enterprise with management support from local NGO and portfolio management are vertically integrated for fine tuning of process technology to develop innovative products suited to local requirements. This process chain will be solution package - most suited to areas of poor connectivity and to benefit poor growers. Although, it may not suit a high growth model to compete with organized sector, but, it has helped not only in extending the shelf-life of otherwise perishable produce, but also in generating local employment in rural production system through collective processing at source itself being managed by growers themselves. Similar finding has been reported by Amudeshwari, et al. (2005) in rural production system for technology transfer in case of rural leather sector for developing network model managed by NGOs, indicating it as developmental oriented which is not driven by market forces and requiring high investment to become sustainable in rural settings. But, present findings evidently suggest emerging network model of technology solutions for horticulture sector (TIM-3) as viable one with initial investment grant as stimulus mentioned in Table 5.28 which is driven not only by local market and as a an important tourist destination in study area, but also by outside market. The statistical analysis of data through correlation matrix 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. This is possible due to best use of technology, local resources for production of innovative products with careful systems approach taken place in remote villages and for creation of rural employment in the context of mountain environments. Impact analysis also suggests that intervention outcomes have addressed the problem of enabling environment for the poor and gender concern in study area by reducing vulnerability to drudgery, and to policy changes related to use and conservation of forest resources successfully - possibly strengthened by a well developed livelihood and stakeholder analysis approaches still continued due to powerful presence for technical backstopping by field agency (Underwood, 2002). Thus, such need based approach model for bio-prospecting and efficient year round 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 (Maikhuri, et al. 2004).
Big-village growers / Farmers Concentration & Market centre

Typically: 16-20 km radius
20-25 Villages

Market radius of B-Village (6-8 km approx)

Decentralized production centres

Nodal Centre: Mother Unit (N)

M - Medium Village (services in 2-3 km radius)

Small villages (S)

Fig. 5.15: Cluster of Village level Network Production Model for Horti-Processing (TIM-3).
ii. Technology and Institutional Success Factors: The Process Approach and Innovative Elements

Success of this technology intervention model (TIM-3) evolved lies in “bottom up approach” and linkages amongst different stakeholders - S&T based Field Group, S&T Institution and above all target group (Women growers) – from planning to implementation stage as partners, carriers and change agents in technology development and transfer in de-centralized way of functioning. This has resulted in long term sustainability by linking the women from small grower families in the area with the production and marketing system – involving their full participation at all levels, thus, making them self confident. Technical support provided and / or the participatory technology development and transfer process with low risk combined with high economic return and benefits due to saving in labour costs, were found to be main factors influencing high adoption by the local community as also reported by Roder, W. (2004) for agriculture sector in Bhutan a mountainous country. It is an interesting field tested model of how grassroots’ level intervention/innovation can actually lead to long-term sustainable changes that survives the withdrawal of donor, having built local capacity that truly means self-sufficiency. These findings showing significance of institutional factors – the grouping of partners influencing technology development and promotion are in tune with Clark, et al. (2003) in case of NGO facilitated post harvest innovation systems developed, promoted and sustained with the support of International Development Enterprise (IDE) India, local NGO and IIM, Ahemdabad as appropriate technology provider thus, benefiting small scale hill farmers from eight villages in two districts Kullu and Solan of Himachal Pradesh for total production and supply chain for high value horticultural produce as packaging material made of cardboard boxes (as alternative technology to wooden boxes for economic and environmental reasons). Thus, justifying the need of network approach model evolved in present study not only for packaging component but as a holistic package for decentralized round the year production and processing of local horticultural produce to encompass the range of organizational forms and institutional settings – Non Government Organizations as key actor in technology search, testing and dissemination; farmers/growers association, Technology providers’ agency etc. – that actually make up the technology delivery system more effective and sustainable.

It was also found that migration which was frequent in the study area mainly due to push factors rather than pull factors has come down considerably due to improved income and livelihood. Seeing the success potential and ‘systems approach’ in planning and implementation process, this model unit with trained women is serving as resource agency to replicate this model in other areas within the Uttarakhand state and other hilly
states and is therefore, a path-breaking effort to carry S&T for the socio-economic upliftment of poor rural women. As a village based S&T intervention, it is well suited to rural women as income generating activity based on sustainable use of local resources and material for large scale replication in resource rich mountain areas.

iii. Future Prospects and Possibilities of Replication:

The very specific agro-climatic conditions of the mountain region offer tremendous potential for the development of horticulture. The varied climatic and soil conditions are ideally suited for growing different sub-tropical and temperate fruits, vegetables and ornamentals crops. However, this sector is facing severe constrains such as low crop productivity, limited irrigation facilities and underdeveloped infrastructure support like cold storages, roads, transportation facilities and lack of proper marketing facilities and non-availability of suitable cheap packaging material etc. There are heavy post-harvest and handling losses, resulting in low productivity per unit area and high cost of production. Thus, efforts are needed in the direction to capitalize on our strengths and remove constrains to meet the goal of moving towards a formidable horticultural growth in India and particularly in mountain areas with knowledge-based technology.

Present study as discussed above shows the evolution of an innovative developmental model focused on small-scale farmers especially women growers in horticulture belt of the mountain regions in the country. Above findings reflect more widely on its inception and subsequent relationships and activities concentrated on the attempt at a new type of partnership in the mountain context, i.e., amongst a research organization, local institution and local growers for development of horticultural sector in network approach for promoting farm/village level processing at various level from household to cluster of villages and at block level to sustain in rural settings (Figure 5.15 and Table 5.30). Bankability of this model was frequent as some of the trained women have become individual entrepreneurs at household level and collectively through co-operative formation who have got their own FPO license.

In the present system of horticulture processing industry, there exists a huge mismatch between production and post harvest handling which may be bridged through adoption of network model approach in the hilly states with active participation of all the stakeholders. Due to lack of processing facilities, great losses occur in fruits and vegetables. It is, therefore, necessary to give thrust to processing of fruits and vegetables both in informal and organized sectors. Training in processing of fruits and vegetables and organizing cooperatives for production and marketing of processed products needs to be undertaken in future. To achieve this, strengthening of existing processing facilities;
developing cultivars suitable for processing; promoting chain of small scale cooperative processing units and demonstrating processing techniques for cottage level industries are recommended to be the state policy. The desired growth of horticulture sector in general and economic prosperity of rural farmer in particular is achievable only with the effective integration process and synergy between different partners ensuring value addition at source itself ensuring better market and remunerative price of the products.

Further, as emerged from the discussion with all the stakeholders during study that going for the monoculture of a particular fruit crop indiscriminately (as it happening in this region for citrus fruits and apple in the mountain areas) has more hazards than the short term economic incentives and monetary benefits to the farmers. Environmental and social costs of horticultural development are now being realized. A large scale cultivation of horticultural crops has often led people to encroach upon forest land and that too in the zone dominated by ecologically and socially important forests like that of the Pine and Oaks. Demands of packing material have further enhanced the pressure on the already dwindling forest resources (Negi, 1994) which has emerged in the development of packaging industry in the recent past to reduce pressure on the natural resources. Thus, efforts need to be made to diversify the horticultural land use of the region by giving priority to grow multi-purpose indigenous fruit trees and to develop ancillary horticultural activities like floricultural, apiculture, mushroom etc. for round the year production through diversified production system for adequate availability of raw produce. Further, when the majority people of the region are economically poor, a large number of wild fruit yielding plant species growing abundantly in nature should be utilized substantially as also reported by Maikhuri, et al., 1994.

The study on horticulture crop processing clearly exhibited that use of location specific technology implemented in a network model is one of the most suitable model for providing maximum benefit to the community and sustain the activity on long term basis. It also explore that technology delivery process is much more important rather that technology development per se in rural settings to change possibilities for economic production with ‘technology’ as a heterogeneous collection of capabilities or capacities. The installation of small scale units will reduce the pressure on natural resources for packaging and farmers will invest least in transportation and consequently earn maximum financial benefit through local processing of the crop. Multiplication of such small scale production system (s) through enlarged network chain with FPO certification may address the growing concern as reported recently by the World Vegetable Centre, AVRDC about the small scale producers being pushed out of the market or due to increasing attention worldwide about food quality and safety (Weinberger and Lumpkin, 2005). Further, this kind of approach will help in generation of employment opportunities to the educated
youths and help in containing the migration of people from rural areas to the surrounding urban centers and metros in different parts of the country. It also illustrates how a generic approach to rural development often has to be modified to work on innovation systems according to local need with technology change and capacity building initiatives. Therefore, relevant technology or natural resource policy and initiatives in this sector should be oriented to facilitate such model of interactive systems and enabling environment, allowing resource poor farmers in different fruit growing areas of the country for economic growth through innovative performances (Hall, et al. 1998; Freeman, 1991; Clark, 2002, and Ekboir and Parellada, 2002).
Table 5.30. Replicable Network Business Model for Processing and Preservation of Horticultural Produce at Village level

<table>
<thead>
<tr>
<th>Upgraded Technology/ Innovative Components</th>
<th>People’s /Community’s Contribution</th>
<th>Adoption rate</th>
<th>Technology Package Flow</th>
<th>Impact Indicators/ response variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of rural horticultural processing enterprises with appropriate technology package and field model (NBMS structure) with a cluster of 20 villages through participatory adaptive R &amp; D work:</td>
<td>• Land • Labor</td>
<td>High</td>
<td>• Extension to other mountain states • Panchayat level adoption at block level within state</td>
<td>Human Resource Development • Local skill/capabilities up gradation • Nutritional security at household level • Livelihood security: Value addition in agriculture and horticulture produce, • Better Return, augmentation of income for women</td>
</tr>
<tr>
<td>• Standardization of available technologies and scaling of equipments/machinery under field conditions.</td>
<td></td>
<td></td>
<td></td>
<td>Natural Resource Management • Decentralized processing and proper utilization of local resources. • Value addition up to 2.5 times at village level and reduction of post harvest losses • Linkages between farm and Non farm activities</td>
</tr>
<tr>
<td>• Innovative diversified product range from produce available in different seasons Non energy intensive processing.</td>
<td></td>
<td></td>
<td></td>
<td>Facilities • Block level common facility center networked to semi-processing units at village level managed by growers/farmer conforming to FPO quality assurance standards and methods. • Processing and packaging facilities for finished product - Quality production - Net working of 100-150 women from small growers and landless households for round the year production, supply and processing of raw produce and</td>
</tr>
<tr>
<td>• Increased shelf life of horticultural produce thereby increasing bargaining power of small/marginal farmers.</td>
<td></td>
<td></td>
<td></td>
<td>Socio-cultural Values • Reduction in migration pattern • Empowerment and self-dependency • Local employment and prosperity</td>
</tr>
</tbody>
</table>

Round the Year production Plan

<table>
<thead>
<tr>
<th>Produce</th>
<th>Product Profile (illustrative)</th>
<th>Month(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricot, Plum</td>
<td>Juice/Concentrate</td>
<td>June-July</td>
</tr>
<tr>
<td>Mango</td>
<td>Squash/Pickle</td>
<td>June/July</td>
</tr>
<tr>
<td>Tomato</td>
<td>Pulp, Puree, Sauce/Ketchup</td>
<td>August –Oct.</td>
</tr>
<tr>
<td>Citrus fruits</td>
<td>Squash/cordial</td>
<td>Nov.- Feb.</td>
</tr>
<tr>
<td>Fleshy Fruits</td>
<td>Pulp, Juice, Nectar, Jelly</td>
<td>Nov.- Jan.</td>
</tr>
<tr>
<td>Strawberry, Litchi</td>
<td>Squash/Juice</td>
<td>Feb.- May</td>
</tr>
<tr>
<td>Dried</td>
<td>Garlic</td>
<td>Powder/Paste</td>
</tr>
<tr>
<td>Mango</td>
<td>Amchur/Mango Bar</td>
<td>June-July</td>
</tr>
<tr>
<td>Ginger/turmeric</td>
<td>Powder</td>
<td>Dec. - April</td>
</tr>
<tr>
<td>Fermented</td>
<td>Off seasonal Vegetables like carrots, Cauliflower, chili</td>
<td>Pickles</td>
</tr>
</tbody>
</table>
Bhimal (*Grewia optiva*), a Multi-Purpose Family Tree

Rattening Process for Extraction of Bhimal Fibre

Valuable Eco-Friendly Products with Improved Design like File Cover, Table Mats, and magazine holders.

Figure 5.16. Showing Improved Process and Utility of Refined Natural Fibre of Bhimal for Better Livelihood Gains to strengthen Local Economy in Gagotu Village, Rudraprayag.
A. *Lantana camara*, an Invasive Plant Species

B.1: Furniture making from *Lantana* sticks

B.2: Cheap Furniture

C. Use in construction: Eco-Tourism Activities

D. Low cost Compost Pit

E. Bee hives made from *Lantana* sticks

G.1. Pyrolysing the *lantana* Biomass for Charcoal making: Traditional Technology


G.3. Clean Fuel Briquetting Technology: Standardized heat Content with Uniform Burning

Figure 5.17. Effective Control measures for Opportunistic uses of *Lantana* to make use of Small Scale Technologies of Appropriate Scale for its local Application.
Integrated Resource Management

Environment management, rural economic upliftment, biodiversity conservation and food security were considered largely as independent sectors of developmental planning for mountain development until the 1980s. However, the limited success and poor outcomes of sector-oriented approaches catalyzed to address growing concerns in recent years for livelihoods security and related environmental and socio-economic problems in integrated and holistic way which have shown potential advantages as reported by Bellamy and Johnson (2000); Lunde and Iremonger (2000); Saxena, et al. (2001) and Neef et al. (2006). This integration essentially for natural resource management meant directing developmental interventions of multiple scales from short to long term, local to regional and global level by integrating ecological and socio-economic research of traditional knowledge and science, and linking them with technological advances and different actors and stakeholders as institutional support. The major challenge, therefore, is to develop appropriate strategies that address socio-economic as well as environmental concerns across spatial (local/global) and temporal (short-term/long-term) scales to nurture and strengthen local livelihood needs of mountain community.

Considering above emerging challenges, two potential technology interventions for NRM of different scale for effective utilization of unutilized/invasive biomass (TI-4), and Integrated village Development (TI-8) with holistic and integrated planning for improved and sustainable livelihoods were studied in study villages namely Dokhwala (Dist. Dehradun) and Gagotu (Dist. Rudraprayag) at the lower and mid altitude in Uttarakhand and village Shalla (Dist. Mandi) at higher altitude in Himachal Pradesh based on indigenous knowledge and available resources as indicated in Chapter 4. It was essentially to improve and provide employment and income diversification opportunities, and to suggest integration approach into relevant policy processes so that appropriate rural policies can be evolved to make effective use of natural resources in terms of surplus biomass or alternatively to reduce dependency on natural resources like forest by empowering local community through appropriate rehabilitation technologies of small scale. Results and impact analysis details about TI-4 for balanced use of biomass through value addition are described as under, while, for TI-8 on integrated village development covering farm, off-farm and particularly artisanal sectors and their inter-linkages are described in Part B of this chapter under item no. 5.1.8.

5.1.4 Balanced use of Biomass (TI-4)

India has a large biomass resource base, which is currently being utilized inefficiently particularly in mountain areas. Though, biomass was, is, and will continue to be a major
source of primary energy in all villages in all regions of the country. However, utilization of available biomass resources (invasive/unutilized or under utilized) is one of the major resource of hill economy which needs to be exploited judiciously. Amongst biomass resources, Bhimal as a family tree, and *Lantana* as an invasive weed were found to be common and abundantly available biomass resource in Garhwal and Himachal Himalaya. 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 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 village community. Data collection in participatory mode was done for expression of results as described in Chapter 3 to evaluate the micro-level feasibility and livelihood benefits.

### 5.1.4.1 Technological Intervention: Impact Analysis

#### 1. Natural Fibre from *Grewia* and Usage

Mountain has a vast biomass resource of different natural fibre abundantly available from variety of fibrous plants viz. jute, bhang, sisal, banana and bhimal etc with production capacity of 400 million tones per year (Rai and Jha, 2004). Natural fibre has been a major resource of shelter, cloth and other necessities in rural areas. It is still in use for a variety of applications in rural areas with growing demand from environmental point of view having comparative advantage over synthetic ones being non toxic and biodegradable in nature. *Grewia optiva*, commonly known as Bhimal tree, is one of the most important multi-purpose agro-forestry trees utilized traditionally for various purposes by the village folk of Garhwal Himalaya as a family tree. The leaves and twigs are looped for fodder. It emerged from the discussion that on an average 125-165 kg fodder can be collected in a year from 20 years old tree. One of the importances of this perennial plant is production of fiber for various uses from its inner bark. This fiber is utilized for conventional purposes like ropes and handicrafts etc.

#### i. Need Assessment and Conceptualization

The tremendous potential of Bhimal as an important plant resource has not so far been fully exploited. Survey in study area indicated that it may be one of the most important resources for income generation to augment employment opportunities in mid hill areas. It was observed that to extract fibre, villagers were traditionally utilizing rattening process in which one-year-old twigs of this tree are dipped in stagnant water for 60 to 65 days and
fiber is extracted from bark of the stem by beating process. The lustrous golden yellow and very strong fiber of Bhimal with tenacity fineness is comparable to that of coir which is utilized for various purposes (Devi and Vasudevan, 1998). It is considered to be the best because of its strength, durability and affinity for dyeing, the recyclable and sustainable nature of fibre amongst available vegetable fibres from variety of fibrous plants in the mountain. But, it was noted in study villages that it was not having any economic importance except local uses and villagers get nothing for their own resources.

ii. Systems Approach and Technology Innovation: Rattening Process

To address problems of long duration rattening process and fibre based quality products, ten small farm households from village Gagotu of District Rudraprayag having Grewia optiva as family trees were selected for utilizing its fibre resource at village level for enhanced income and employment generation. Earlier, villagers used to extract fiber during winter but the appropriate use of this fibre was not known to them. The technology inputs given to them included introduction of micro-flora (particularly white rotting fungal flora) for faster rattening and enhanced quality of fiber, and technology input for the production of value added handicraft items. The inputs given and income enhancement was calculated on the basis of fiber utilization for the activity. The Bhimal resource availability with these farmers was assessed and on the basis of resource the average availability of fibre was calculated. The fiber availability with ten identified households and income generated from fiber resource without and with technology input was estimated prior and after intervention with the sample households. It was observed that introduction and subsequent multiplication of micro-flora density in stagnant water lead to 40 per cent increased recovery of fiber/tree as compared to traditional retting practice in running water as shown in Table 5.31. This Table also shows that improved biodegradation process technology has also resulted in about 25 per cent reduction in time taken in rattening process with production of refined quality fiber. This is probably due to fast microbial enzymatic process of white-rot fungi in de-lignification’s process and to decompose cellulose as evidently reported by Marsh et al. (1949); Basu and Bhattacharya (1962) and Blanchette et al. (1988).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Traditional (without S&amp;T Intervention)</th>
<th>After S&amp;T Intervention and Value Addition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Year</td>
<td>2nd Year</td>
</tr>
<tr>
<td>Production (Kg)</td>
<td>2.5 ± 0.38</td>
<td>3.2 ± 0.29</td>
</tr>
<tr>
<td>Time taken in Rating (Days)</td>
<td>60 ± 4.0</td>
<td>46 ± 2.0</td>
</tr>
<tr>
<td>Cost of fibre (Per Kg)</td>
<td>12 ± 2.0</td>
<td>18 ± 2.5</td>
</tr>
<tr>
<td>Income (Per Kg)</td>
<td>40 ± 5.0</td>
<td>150 ± 10.5</td>
</tr>
</tbody>
</table>

± = Standard Deviation
iii. Value Addition and Fibre based Enterprise Creation

Further, perusal of result in Table 5.32 indicates that on an average basis, a total of 24.6 kg fiber is produced by each household. The values are presented on individual households and on average basis. Prior to intervention of improved technology, sample households were able to generate on an average total income of Rs.932/annum by making ropes and mats as traditional practice. It was observed that as compared to traditional method, there was an average increase of income amounting Rs.2612/- (about 3 fold) in 1st year with total input cost of Rs.246/- only for same quantity of fiber available on average basis to household/annum. Same trend of enhanced income was found in subsequent 2nd and 3rd year of study as cost-benefit data shows in Table 5.32 which increases 4-6 folds with increase in input cost for better design of handicraft items showing emerging trend of technology adoption with better output production efficiency. This was possible due to skill development in adopting improved ratting process and making refined natural fiber based value added products with better design like file cover, bags, table mats, room mats, wall hangings and magazine holders etc. (Figure 5.16) having ready demand in urban market. It can be concluded here that if we increase the input in terms of material, design and better technology, there is a scope of enhanced income and employment generation to make opportunistic but judicious use of fibre from Bhimal tree. Thus, the role of fiber in development of local economy can be foresighted by making effective and judicious use of Bhimal as resource in other hilly areas.

2. Lantana, an Invasive Species: Micro-Enterprise based Control Measure

Lantana camara, an offensive weed, is dispersing fast in the hilly region of Western Himalaya from lower altitude to higher areas up to 1800 m amsl. A native of America, it was introduced in India as a hedge plant. In many places it has virtually overtaken huge chunks of land and thus known as Green Fire or Land Eater (Duggin and Gentle, 1998). Due to its prolific growth and wide adaptability, this plant has overrun large areas including cultivated wasteland, forest areas, grazing and pastures lands. In India, it was reported that by 1941 it had swallowed more than 40,000 ha of land, and has rapidly invaded deforested hill slopes and abandoned crop fields upto 1500m amsl in the outer ranges of Central Himalaya (Bhatt et al. 1994). Lantana species has adapted itself well especially in hilly areas where cultivated land is limited due to topography. It has invaded in parts of Uttarakhand, mainly outskirts of Dehradun, particularly the Shiwalik ranges and in some areas of Chamoli and Rudraprayag District.
Table 5.32. Cost Benefit Analysis for making Fibre based Products using Improved Rattening Process: Opportunistic Use of Bhimal tree

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Farm Households</th>
<th>Fiber available Kg/Yr</th>
<th>Income (Rs.) from Traditional Method</th>
<th>Income from Improved Method and Fibre based Product Development (hat, bag, file cover etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Yr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input cost (Rs.10/kg.)</td>
<td>Output (Rs.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Yr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input cost (Rs.25/kg.)</td>
<td>Output (Rs.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Yr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input cost (Rs.25/kg.)</td>
<td>Output (Rs.)</td>
</tr>
<tr>
<td>1.</td>
<td>F&lt;sub&gt;1&lt;/sub&gt;</td>
<td>27(10)</td>
<td>980</td>
<td>270</td>
</tr>
<tr>
<td>2.</td>
<td>F&lt;sub&gt;2&lt;/sub&gt;</td>
<td>18(7)</td>
<td>710</td>
<td>200</td>
</tr>
<tr>
<td>3.</td>
<td>F&lt;sub&gt;3&lt;/sub&gt;</td>
<td>25(10)</td>
<td>950</td>
<td>250</td>
</tr>
<tr>
<td>4.</td>
<td>F&lt;sub&gt;4&lt;/sub&gt;</td>
<td>32 (12)</td>
<td>1125</td>
<td>320</td>
</tr>
<tr>
<td>5.</td>
<td>F&lt;sub&gt;5&lt;/sub&gt;</td>
<td>39 (12)</td>
<td>1525</td>
<td>390</td>
</tr>
<tr>
<td>6.</td>
<td>F&lt;sub&gt;6&lt;/sub&gt;</td>
<td>21(8)</td>
<td>880</td>
<td>210</td>
</tr>
<tr>
<td>7.</td>
<td>F&lt;sub&gt;7&lt;/sub&gt;</td>
<td>16 (6)</td>
<td>590</td>
<td>160</td>
</tr>
<tr>
<td>8.</td>
<td>F&lt;sub&gt;8&lt;/sub&gt;</td>
<td>24(8)</td>
<td>910</td>
<td>240</td>
</tr>
<tr>
<td>9.</td>
<td>F&lt;sub&gt;9&lt;/sub&gt;</td>
<td>32(11)</td>
<td>1140</td>
<td>320</td>
</tr>
<tr>
<td>10.</td>
<td>F&lt;sub&gt;10&lt;/sub&gt;</td>
<td>12(4)</td>
<td>510</td>
<td>120</td>
</tr>
</tbody>
</table>

- Figure in parentheses indicates number of trees/family
- Input cost only for value addition excluding external labor cost and cost of fiber contributed by households.
i. Need Assessment and Conceptualization

In spite of the fact that the *Lantana* species has created such a large ominous effect on the land, possible measures to control it are not available if available as chemical or mechanical measures are not cost effective, thus, offers a challenge to strategies effective plan in the context of fragile and harsh conditions in mountains (Sharma, 1988; Gujral and Vasudevan, 1983). An estimated 33 percent of agricultural GNP is reported to be lost every year due to weeds, *lantana* included (Sharma, 2006). Therefore, present pilot study carried out in village Dokhwala, Dist Dehradun and Village Gajotu in Rudraprayag District to find out suitable and cost effective control measures for *lantana* spread to avoid encroachment of limited agricultural and community land.

Therefore, in the present study, density and distribution of *lantana* was evaluated following the method of Mishra (1968). The growth parameters of *Lantana camara* is evaluated following the method used by Singh (1989). Table 5.33 expresses the density of the *Lantana* species in these two selected sites with different growth parameters that are height, girth, circumference, canopy diameter and number of branches. It was noticed there is marked effect of altitude and other factors on the height and other parameters of growth of the plant in decreasing order as noticed in the community land of Gagotu village at 1200m amsl as compared to Dokhwala village located at 750m amsl. The study also reveals that *Lantana* has high regeneration potential. It regenerates within three months after cutting and accumulates similar biomass within 9 to 12 months. The regeneration capacity depends upon environmental conditions as growth rate is very high in rainy season (Table 5.34).

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Altitude (amsl)</th>
<th>Density (pl/ha)</th>
<th>Height (cm)</th>
<th>Girth (cm)</th>
<th>Circumference (cm)</th>
<th>Canopy diameter (cm)</th>
<th>No. of branches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community land (Dokhwala Village)</td>
<td>750m</td>
<td>2840± 250</td>
<td>180± 1.5</td>
<td>47.9± 7.5</td>
<td>56.2± 3.1</td>
<td>306± 24.0</td>
<td>57.0± 5.7</td>
</tr>
<tr>
<td>Community land (Gagotu village)</td>
<td>1100m</td>
<td>1700± 150</td>
<td>241± 3.8</td>
<td>67.7± 8.6</td>
<td>44.6± 1.5</td>
<td>258± 16.1</td>
<td>42.0± 4.5</td>
</tr>
</tbody>
</table>

± = Standard Deviation
Table 5.34. Regeneration Values of *Lantana camara* at Community land in two different sites at different intervals.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Sites (Biomass kg/bush)</th>
<th>Dokhwala Village (750m amsl)</th>
<th>Gagotu village (1100m amsl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>9.0 ± 0.65</td>
<td>7.5 ± 0.58</td>
<td></td>
</tr>
<tr>
<td>3 Months</td>
<td>1.5 ± 0.31</td>
<td>1.8 ± 0.27</td>
<td></td>
</tr>
<tr>
<td>6 Months</td>
<td>3.5 ± 0.28</td>
<td>4.0 ± 0.35</td>
<td></td>
</tr>
<tr>
<td>9 Months</td>
<td>7.0 ± 0.29</td>
<td>7.0 ± 0.56</td>
<td></td>
</tr>
<tr>
<td>12 Months</td>
<td>8.5 ± 0.90</td>
<td>8.0 ± 0.59</td>
<td></td>
</tr>
</tbody>
</table>

From utility and control measure point of view considering the available density and regeneration potential, it was found during study that efforts have been made traditionally at the community level for diverse application of the weed as control measures for local use such as material for incense sticks, as a mosquito repellent due to aromatic nature of leaves (Thakur *et al.* 1992; Vasudevan, 1997); and pyrolysing of *Lantana* biomass followed by briquetting with the binder having calorific value of 5050 K. cal/kg (Figure 5.17). For this, brick pyrolyser is constructed with local available stones and fine clay and its roof is doomed shape with wall in contact of air for carbonization of the biomass. Possibility of *Lantana* based gasifiers for commercial use and village electrification was also found as another alternative use, but its scale and operation efficiency specific to the hilly conditions on sustainable basis and under fragmented settlements was not effective relying mostly upon the sustained availability of *Lantana* biomass requiring huge capital investment and maintenance cost. It was also noticed that *Lantana* stems which are reported to be durable and resists against insects and pests have been used to make cheap furniture i.e. chair, easy chair, table, book shelf, cloth racks etc. and other fancy items like file trey, baskets etc. Thus, seeing the ecological considerations and livelihood needs of local community, further impact study based on the discussion was carried out in study area to understand and analyze techno-economic viability and other aspects of technological intervention made for effective use of *lantana* as a resource in making value added products.

**ii. Systems Approach and Technology Innovation**

To address the problems of *Lantana* infestation, an intervention was made to involve local artisans from village Dokhwala, Dehradun in making value added products like furniture and fancy articles to improve their livelihood. The technical components included finishing and finalization of the products for market through training on product diversification, design upgradation with better production efficiency. Table 5.35 shows that artisan were able to make average net income ranging from Rs.3000/- to Rs.8000/- per month by making different products (Figure 5.17 - B, D and E) showing the potential
and utility of small scale intervention to supplement the income. It was found that an artisan can earn net profit of Rs.3, 250/- per month by making 25 Lantana based Bee-hives boxes with unit input cost of Rs.200/- earning a net profit of Rs.130/- which is in great demand for bee-keeping in the study area as compared to costly wooden bee-box with added advantage of decline in collection of wood from forest. The inputs given and income enhancement was calculated on the basis of cost of raw material utilization for making each product at prevailing market prices.

Table 5.35. Cost Benefit Analysis for Effective use of Lantana as a Resource in making Diversified Products

<table>
<thead>
<tr>
<th>Value Added products manufactured</th>
<th>Input Cost (Rs.)</th>
<th>Unit Cost of Article (Rs.)</th>
<th>Net Profit (Rs.)</th>
<th>Days taken for designing of article (s)</th>
<th>Per Capita/Month Income (25 working day/Month) (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy Chair (Heptangular)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana sticks</td>
<td>Rs. 60</td>
<td></td>
<td>500/-</td>
<td>270/-</td>
<td>6750/-</td>
</tr>
<tr>
<td>Nails</td>
<td>Rs. 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint</td>
<td>Rs. 40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Rs. 110</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Rs. 240</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana sticks</td>
<td>Rs. 50</td>
<td></td>
<td>320/-</td>
<td>170/-</td>
<td>4250/-</td>
</tr>
<tr>
<td>Nails</td>
<td>Rs. 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint</td>
<td>Rs. 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Rs. 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Rs. 150</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sofa (Two Seater)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana sticks</td>
<td>Rs. 50</td>
<td></td>
<td>550/-</td>
<td>370/-</td>
<td>4625/-</td>
</tr>
<tr>
<td>Nails</td>
<td>Rs. 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint</td>
<td>Rs. 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Rs. 80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Rs. 180</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sofa (Three Seater)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana sticks</td>
<td>Rs. 75</td>
<td></td>
<td>800/-</td>
<td>525/-</td>
<td>6562/-</td>
</tr>
<tr>
<td>Nails</td>
<td>Rs. 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint</td>
<td>Rs. 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Rs. 120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Rs. 275</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center Table</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana sticks</td>
<td>Rs. 50</td>
<td></td>
<td>500/-</td>
<td>325/-</td>
<td>8125/-</td>
</tr>
<tr>
<td>Nails</td>
<td>Rs. 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint</td>
<td>Rs. 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Rs. 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Rs. 170</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>File Rack</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana sticks</td>
<td>Rs. 40</td>
<td></td>
<td>280/-</td>
<td>145/-</td>
<td>3625/-</td>
</tr>
<tr>
<td>Nails</td>
<td>Rs. 25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint</td>
<td>Rs. 40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Rs. 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Rs. 135</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana Bee Hive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lantana sticks</td>
<td>Rs. 40</td>
<td></td>
<td>200/-</td>
<td>130/-</td>
<td>3250/-</td>
</tr>
<tr>
<td>Nails</td>
<td>Rs. 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Rs. 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Rs. 70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Cost included in others include labour expenses.

It was found to be cost effective method of ‘opportunistic local use and application of Lantana’ besides ecological benefit to avoid encroachment of limited agricultural land particularly for mountain areas. At household level, use of such intervention by five
sample artisanal family (A1 - A5), out of total 15 in Dokhwala village, Dehradun revealed net monetary benefit (about 2 fold) by A2, A3 and A4 by making different *Lantana* based products (Table 5.36) due to better design input of products made indicating dependency of net income on design and finished product. Earlier, villagers used to collect *Lantana* stem for burning as fuel, but, the appropriate use of this was not known to them for the production of value added items. Here, it was seen as an opportunity to improve the livelihoods of local artisans by linking them to potential buyers and urban market to ensure that this initiative is sustainable. Moreover, the system approach involves developing network strategies (Village level Institution, Local artisanal group and Forest Department) and technologies for opportunistic use of *lantana* species having local utility tend to be exploited fast.

<table>
<thead>
<tr>
<th>Artisanal Family</th>
<th>Article developed/Month</th>
<th>Input (Rs.)</th>
<th>Sale Price (Rs.)</th>
<th>Net Profit/Month (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.</td>
<td>Easy Chair (Heptangular) (8)</td>
<td>1920/-</td>
<td>4000/-</td>
<td>2080/-</td>
</tr>
<tr>
<td></td>
<td>Center Table (4)</td>
<td>680/-</td>
<td>2000/-</td>
<td>1320/-</td>
</tr>
<tr>
<td></td>
<td>File Rack (10)</td>
<td>1350/-</td>
<td>2800/-</td>
<td>1450/-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3950/-</strong></td>
<td><strong>7800/-</strong></td>
<td><strong>4850/-</strong></td>
</tr>
<tr>
<td>A2.</td>
<td>Chair (8)</td>
<td>1200/-</td>
<td>4000/-</td>
<td>2800/-</td>
</tr>
<tr>
<td></td>
<td>Center Table (8)</td>
<td>1360/-</td>
<td>4000/-</td>
<td>2640/-</td>
</tr>
<tr>
<td></td>
<td>Bee Boxes (8)</td>
<td>560/-</td>
<td>1600/-</td>
<td>1040/-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3120/-</strong></td>
<td><strong>9600/-</strong></td>
<td><strong>6480/-</strong></td>
</tr>
<tr>
<td>A3.</td>
<td>Sofa (Two Seater) (5)</td>
<td>900/-</td>
<td>2750/-</td>
<td>1850/-</td>
</tr>
<tr>
<td></td>
<td>Center table(10)</td>
<td>1700/-</td>
<td>5000/-</td>
<td>3300/-</td>
</tr>
<tr>
<td></td>
<td>File Rack (5)</td>
<td>675/-</td>
<td>1400/-</td>
<td>725/-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3275/-</strong></td>
<td><strong>9150/-</strong></td>
<td><strong>5875/-</strong></td>
</tr>
<tr>
<td>A4.</td>
<td>Sofa (Three Seater) (10)</td>
<td>2750/-</td>
<td>8000/-</td>
<td>5250/-</td>
</tr>
<tr>
<td></td>
<td>Center Table (5)</td>
<td>850/-</td>
<td>2500/-</td>
<td>1650/-</td>
</tr>
<tr>
<td></td>
<td>Bee Hive (05)</td>
<td>350/-</td>
<td>650/-</td>
<td>300/-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3900/-</strong></td>
<td><strong>11150/-</strong></td>
<td><strong>7250/-</strong></td>
</tr>
<tr>
<td>A5.</td>
<td>Chair (5)</td>
<td>750/-</td>
<td>1600/-</td>
<td>850/-</td>
</tr>
<tr>
<td></td>
<td>Easy Chair (10)</td>
<td>2400/-</td>
<td>5000/-</td>
<td>2600/-</td>
</tr>
<tr>
<td></td>
<td>File Racks (5)</td>
<td>675/-</td>
<td>1400/-</td>
<td>725/-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3825/-</strong></td>
<td><strong>8000/-</strong></td>
<td><strong>4175/-</strong></td>
</tr>
</tbody>
</table>

- Bee boxes were made of *Lantana* for outdoor bee-keeping, while, Bee hive are frames of *Lantana* fixed in the walls of houses.

During the visit and discussion at study sites, it was found that at several locations, such interventions for use of *Lantana* stem have improved the livelihoods of several forest dependent communities by providing increased income and diversification of livelihoods. However, It was also observed that such income benefit is dependent on *Lantana* resource availability as also reported by Bawa *et al.* (2007) in the MM Hills linking use of
_Lantana_ as a substitute to the recent decline in wild populations of bamboo (Uma Shaanker and Ganeshiaiah, 1998) used for making baskets, thereby helping conserve bamboos which has declined due to a combination of fire and competition from _Lantana_.

**iii. Value Addition and _Lantana_ based Micro-Enterprise**

Above findings show that development of new micro-enterprise based on opportunistic use of invasive species _Lantana camara_ in livelihood enhancement is an innovative case of small scale technological intervention to provide source of subsistence to forest-dependent communities and artisans in villages. Qualitative discussion with the villagers and poor artisans indicated formation of their network as “local artisanal group” involving nearby villages emphasizing on building production capacity and ensuring quality of products. 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. The members of the artisanal group as SHGs receive micro-credit and rely entirely on funds mobilized from among the individuals in the group. The 5 SHGs consisting of 45 families with annual income less than Rs.15, 000/- from 10 nearby villages in Sahaspur Block, Dehradun have got federated as more stable institution providing economic stability and empowerment of community creating micro-finance facilities in the villages themselves with entrepreneurship skills for such activities.

Such institutional model for community-owned and conservation-oriented micro-enterprises has served the various objectives of strengthening livelihoods and conservation concerns as also reported by Lele _et al._ (1997) and Shanker _et al._ (2005). It shows that the utilization of _Lantana_ by the people with ecological and economic benefits is the only potential solution as also reported by Bawa _et al._ (2007). Utilizing this technology intervention initiative of opportunistic use for common development of forest and village economy, the concept of invasive biomass eradication can also be transformed into an effective local resource utilization strategy creating potential for larger scale economic opportunity.

**5.1.4.2. Emerging Technology Intervention Model (TIM) for Livelihoods Gain**

i. **Inducing Economic Potential and Community Empowerment: Adopting Technology for Opportunistic Use**

Qualitative and quantitative results shows that in both the intervention for use of Bhimal and _Lantana_, an integrated approach for developing small scale rural enterprise among
sample rural households has been adopted, which found to be an important factor for growth of local economy sharing various form of clustering activities and processing utilities by forming users group association. Such integration also took into account synchronizing artisanal skills with market enabling local community to add value their products by way of finishing and designing. Thus, it can be concluded that capacity building and skill development of local community with improved technology inputs and design to make fiber based products as in the case of Bhimal can substantially supplement the income of poor households. Results evidently suggest generation of natural resource based technology intervention model (TIM-4) to create win-win situation covering economic, technological, ecology and society and to set up a rural economic activity as also reported by Nandan et al. (2006) for Sisal fibre.

ii. Technology and Institutional Success Factors: The Process Approach and Innovative Elements

Creation of livelihood-based enterprises linked to SHG institutions by other NGOs have been found major elements in the successful adoption of TIM - 4 both for use of Bhimal and Lantana. Such technological intervention designed with system approach at institutional level by HESCO, Dehradun a science based field group has helped to influence local livelihoods, institutions including governance and policy. The process approach also suggests that social benefit lies in the opportunity costs to local communities of conserving biodiversity that has global benefits particularly to control Lantana. There is now realization among the communities and their institutions, as well as in the state forest departments, and other stakeholders about the intervention strategies designed suitably to either ecosystem management or diversification of livelihoods and increase in rural incomes. It also suggests that Village level Institutions are key to ultimate sustainability along ecological, economic and social dimensions. Overall, study indicates that sound institutions at multiple scales hold the key to sustainable management of natural resources. These village level institutions can make plans for economic development within their geographical jurisdiction as empowered by the constitution of India (Talwar, 2006).

5.1.4.3. Future Prospects and Possibilities of Replication: Development of Policies for community-owned and Conservation-oriented Micro-enterprises

The purpose of these two interventions for community-owned and conservation-oriented micro-enterprises is to improve the well being of the people with an underlying assumption that diversification of livelihoods will decrease direct dependence on forest resources to some extent. The local communities in Dokhwala and Gagotu villages’ particularly small farmers in the case of Bhimal, and Artisans and landless people in the
case of *Lantana* have improved their share of the income generated through the sale of innovative natural products designed and developed. But, in both the intervention, it is important to mention that such biomass based livelihood options unlike other TIM models discussed earlier were opportunistic in use and not as regular source of income. Here, it is precisely seen as an opportunity to improve the livelihoods of local communities particularly artisans by nurturing their technical skill and linking them to potential buyers.

Finally, at the policy level, uses of such intervention have started to motivate changes in the state's governance and policies both in Uttarakhand and Himachal Pradesh. However, large scale dissemination and scaling up such natural product-based enterprise, while simultaneously ensuring positive conservation outcomes with adequate community participation, is a complex challenge which needs to be addressed further at policy level by designing such technology models for use of under-utilized and invasive biomass in mountain areas.
Income Generation and Skill Development in Rural Farm and Non-Farm/ Off-Farm Sector

The 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. To the household in the mountain particularly in remote high altitudinal areas, the outputs of production provide direct subsistence mainly from on-farm activities and cash revenue from sales to the limited extent. In order to overcome disadvantages arising from remoteness and rigorous terrain, insecure and unproductive jobs, discrimination as ethnic minorities, the rural poor in mountain areas need secure access to productive and limited assets (mainly land, forests and water); opportunities to participate in decentralized resource management; sustainable agricultural technologies; access to markets and financial services linked with non-farm technological services to sustain their livelihoods.

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. The promotion of rural non-farm enterprises has now become a mainstream concern of many in developed and developing economies globally to stimulate rural development and overcome rural poverty (Ellis, 1999). A literature review by Natural Resource Institute (NRI), UK has indicated that the non-farm sector is now becoming increasingly significant factor for rural households in the transition economies for providing rural employment and extra income not only in Central and Eastern Europe but also in Central Asia (Bright et al., 2000). Developmental agencies like World Bank and International Fund for Agricultural Development (IFAD) in their developmental initiatives have primary focus now towards the improvement of income and living standards of small farmers through increased productivity in agricultural and expansion of small-scale non-farm rural livelihoods. Since agriculture sector has been showing declining trends for livelihood security, it is, therefore must to look for livelihoods diversification by adding value to local rural produce or otherwise through processing in non-farm sector. The shift of employment from farm to non-farm sector is quite evident as farming on its own is increasingly unable to provide sufficient means of survival in rural areas. For instance, according to an estimate, share of employment in the farm sector has declined from around 75 per cent to 65.5 per cent between 1971 and 2001 in Uttarakhand. Further, negative impacts on agricultural productivity and loss in the quality and quantity of forests in mountain areas are having direct implications for well being of the rural households who traditionally depend on these two primary resources for their sustenance (FAO, 1993; Sati, 2005). Within this, the strengthening of institutions has now been regarded as central to the success for sustainable rural livelihoods (SRL) by organizing local communities and promoting their better participation in rural
development with decentralized area based approach, particularly in terms of defining local needs, building new capacities and preparing and setting priorities to manage mountain resources due to lack of opportunity on-farm as a result of small land-holdings (Marsland, 2000; Biggs, 2003; Biggs and Messerschmidt, 2003) and other man-made factors.

Keeping above facts in view, two potential technology interventions (TI-5 and TI-7) of different scale identified in non-farm and off-farm sector for conservation and effective use of locally available natural resources for improved livelihoods were studied in selected villages namely Saldhar (Dist. Chamoli, Uttarakhand) and village Dhangiyara (Dist. Mandi, Himachal Pradesh) considering the need assessment of appropriate technology choice and scale suitable for scattered small settlement pattern in these high altitudinal study areas. It was essentially to improve understanding of the dynamics of the non-farm sector in providing employment and income diversification opportunities, and to suggest integrating research results into relevant policy processes so that appropriate rural policies can be developed. Results and impact assessment details about TI-5 for wool based micro-enterprise are described as under, while, for TI-7 on agriculture based enterprise focusing on farm and off-farm linkages are described in Part B of this chapter under item no. 5.1.7.

5.1.5 Wool based Micro – Enterprise (TI-5)

Wool production and its utilization at household level is one of the major entrepreneurship activities at high Himalayan ranges of Garhwal hills. The major occupation of the tribal population living in the pockets of such high ranges of border area under their economic system is an aggregation of many elements such as trade, subsistence agricultural activities, pastoralist and regional source of income though sheep rearing, wool and wool based handicraft production in their socio-economic setup. The mountainous terrain of the resident of these areas is snow bound for almost half of the year and the other half not being very arable due to physical conditions, forced these communities to pursue trade and non-farm activities to sustain their livelihoods in harsh climatic conditions and rough topography. About eighty percent of these communities have sheep for wool production. An approximate of total 2.50 lakh sheep are reared by these high hill communities. One sheep produced about one kg of wool every year in two shearing. It is estimated that only 2 per cent of total production of wool is utilized by these communities for the production of hand woven articles for marketing, while, rest of the wool is brought to the market for sale. But, due to lack of technical skills for quality products and market opportunities, their produce do not fetch good price and these tribal people always suffer with lots of drudgery and the poor market opportunities for their
produce. It was observed that the hill communities living at such higher ranges in Chamoli and Uttarakashi Districts are ethnic, cultural and backward who are always bypassed from the economic development activities and technological developmental initiatives. Thus, in prevailing socio-economic and ecological conditions at high Himalayan ranges, new institutional strategies are needed for developing technologies and resource management systems to promote non-farm activities to augment income and protect or improve local livelihood needs by linking extension efforts and community based scientific organizations.

5.1.5.1. Technology: Carpet Weaving and Improved Loom

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 as wool based livelihood option was evaluated in terms of production and expenditure to analyze and explore possible technology multiplier model for promoting growth and employment opportunities in mountain rural economies. The study covered impact analysis of field level intervention made 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 and to evaluate household level technological interventions made for improved livelihood through effective use of mountain resources and traditional knowledge system. Data was collected and studied about the involvement and adoption of technological interventions covering all 19 households in the study village. A detailed impact analysis to evaluate the viability of such interventions was done for three years in the study area i.e. village saldhar located at 2100m asl keeping in view the survey findings and livelihood assessment as described in chapter 4, and potential of non-farm technological intervention in terms of cost-benefit and technology adoption by the community as compared to traditional practice.

5.1.5.2. Technological Interventions: Impact Analysis

Agriculture has been a subsidiary occupation of tribal communities in mountain areas. The area under cultivation is smaller even than the area inhabited thus, not much could be cultivated on the high reach as also can be seen from land use pattern image (Figure 4.7) in Saldhar study area. The crop produced by the Bhutia tribals of Saldhar village are Phaphra (*Fagopyrum tataricum*) and Ogla (*Fagopyrum esculantum*), Vajao and Jao (beardless and common varieties of barley), Wheat and Marsa (*Amaranthus*). The high hill communities had two sets of residences. The winter residence (usually from November to April) is used for trade in India and the summer residence (May to October) for trade in Tibet, the neighboring province. The winter residence is in the middle
Himalaya and the summer in the high Himalaya. Families with cattle moved in caravans from the winter to summer residences and vice-versa. While, the male members were engaged in trade, their families were involved in rudimentary cultivation, cattle rearing and spinning and weaving clothes. The production of woolen goods is the only cottage industry of the tribal population. Wool spinning and weaving is a part of every day routine in family and all members of the family participate in spinning. The wool is spun generally by men folk into different grades of yarn, while, women used to do weaving part. It was observed that these inhabitants have been engaged traditionally throughout the region for manufacturing the woolen materials like Thulma (blanket), Pattus (coarse woolen serge), Pankhis (woolen wrappers), Chutka (a thick woolen blanket or coarse rug), Dann (carpet), Asan (Prayer rug) etc. The marketing of these woolen materials are generally done in the trade fairs. Due to lack of any S & T based processing and production unit in the area, the wool produced by them is taken by the middle men who fetch them very low prices of raw wool. The articles produced by them utilizing their wool produce were found very rough because all the processing operations i.e. winnowing, carding, spinning, dyeing, weaving and finishing were carried out by hands only as time consuming job. Thus, despite the tedious processing activities with low market demand, need emerged to look for alternatives solutions to improve the quality of products with better efficiency in production and reduced drudgery. During the survey and discussion with local inhabitants it was found that the high cost of available processing machines and weaving equipments were not viable options to solve the problem of these isolated communities because of limited supply of raw material, and power shortage in non grid areas located at the fringe of Nanda Devi Biosphere Reserve (NDBR) to sustain and meet the cost for higher scale of operation. Thus, for the survival of these tribal communities and to make effective and sustainable use of available resource and knowledge wisdom in tough terrain, it was urgent need of the area to think and explore about the enhance livelihood opportunities with appropriate and viable technological inputs.

Base line survey in the study village revealed that each family has an average of 70 – 80 sheep. On an average, 1 kg of processed wool may be obtained from raw wool produced by a single sheep in a year. Sheep rearing is one of the occupations of Bhotia tribe. They use Sheep wool for making woolen clothes and carpets. Weaving is their traditional work. During winter they all got engaged in weaving because due to heavy snowfall they cannot do other works. Traditionally, they use bamboo sticks for carding the wool. Hand cleaning and winnowing of wool is carried out manually. Then spinning of the wool is carried out on wooden simple charkha by village women in their houses which is utilized for making shawls, pankhi, carpets etc. for local market. Mostly the carpet weaving (normally 3 x 4 ft size) was carried out using wooden loom that has no adjustment device,
traction device for thread, small in size and no modern design. They weave only with old design, but, interestingly using natural dyes only for coloring.

To address problems of quality products and processing operations, an intervention was made by HESCO, Dehradun, a science based civil society to improve the quality of one major product i.e. carpet weaving among the Bhutia tribal women groups of village Saldhar to improve and sustain their livelihood. Through skill development programme and innovative process of technology intervention of small scale, women were trained on product diversification, color combination, design up gradation, efficiency increase and market avenues. The technical component included finishing and finalization of the products for market, cutting, beating, pasting, knotting, and boundary finishing, washing and beating of the carpet for increasing their softness. Upgraded and user friendly loom and tools were introduced in the village for making good quality carpets and other wool based products (Figure. 5.18 and 5.19). It was found that the new loom made up of very heavy iron rails with adjustment device and traction device was easy to operate and with other advantage in terms of long life and saving of wood used to make traditional loom from sp., *Tuna ciliate* (Tun). This type of upgraded loom can weave any size of carpet at a time and four women can work together on single loom. Table 5.37 shows tangible and intangible benefits of this small scale technological intervention tuned to local requirements leading towards economic empowerment with less drudgery involved in simple operation of upgraded loom and using natural dyes from local plant material for coloring and designing of carpets. As compared to single framed traditional loom, women were able to make on an average six carpets using double framed improved loom instead of five carpets of same size within same working hours during winter period. This has helped to increase average household income by two fold per annum by fetching better market price for quality products. Thus, with improved production efficiency for carpet weaving having 64 knots per sq inch instead of 32 knots in traditional methods, average annual household income increased substantially in addition to agriculture and horticulture based activities. Besides, these trained women were able to earn more income by making smaller articles like Thulma (blanket), Pattus (coarse woolen serge) and Pankhis (woolen wrappers) etc. more efficiently with better design to meet the local demand.

5.1.5.3. Emerging Technological Intervention Model (TIM) for Livelihoods Gain

i. Inducing Economic Potential and Community Empowerment: Adopting Technology to Improve Livelihoods through Local Enterprise

Thus, findings of above technological interventions shows its utility at house hold level application particularly in high altitudinal hilly areas whereby rural households in isolated
and remote locations can maintain their livelihoods with backward and forward production linkages supported through institutional mechanism of support (as local NGO that govern economic relations) with intermediaries (organized women’s groups). Such linkage support is essentially required to motivate and influence local capacity in organized way with improved market knowledge by facilitating and improving relationship in terms of supply inputs in the form of credit and technical assistance, production, and assured marketing. This certainly has helped to overcome market and organizational failures in traditional system of carpet or wool based production system for providing substantial benefits to tribal community and the rural economy as a whole in a village probably due to positive income effects of need based technological change. Impact analysis also suggests that intervention outcomes 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 (Table 5.37).

Thus, it is worth noting that such resources of non-farm rural livelihoods have to be recognized in policies and programmes for their support to make the long-term sustainability in remote mountain areas, hence access to employment by the poor isolated mountain communities. In this approach, attention needs to be given for creation of micro-enterprise based on alternative forest resources (AFRs) as important sources of rural incomes and livelihoods as illustrated in the present findings and by others to increase economic efficacy showing positive correlation between a higher diversification of non-farm activity with higher income level of rural households leading towards better access to credit and infrastructural facilities etc (Reardon et al. 1998; Bright et al. 2000; Davis and Pearce, 2000; Johri and Yadav, 2006). In the case of households, present findings indicate 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. The study also shows strong linkages between the agricultural growth and the rural non-farm economy as a promising and collective way depending mostly on locally available raw materials for inclusive growth and to cut poverty with secure income flows as reported by Mellor (1976) and Thapa (2004). At the same time, promoting good governance, civil society, policies and institutions that create enabling conditions to promote rural livelihoods for the poor were found to be important factors to make the long-term sustainability as reported by Messerschmidt and Hammett (1998) and Rahman and Westley (2001) for successful AFRs based intervention in Nepal and Bangladesh. Therefore, present technology based institutional model with decentralized area based approach on these lines is clearly relevant to the ‘special conditions’ of adaptive research with dynamic indigenous process of technology refinement and adaptation suited to
location specific conditions and requirements to enhance rural incomes and sustainable livelihoods.

ii. Technology and Institutional Success Factors: The Process Approach and Innovative Elements

Above study as discussed above in non-farm sector shows the application of an innovative developmental approach with customization of technology matching the local needs. Replication effect of this technological intervention was seen in Block Doda, District Uttarkashi, another study area where Bhutia as well as Jaunsari and Rawanita tribal communities have adopted above discussed improved loom technology with additional refinement of initial processing operations. It is interesting to note here that for wool winnowing and carding of wool, hydro-power of two improved gharats (i.e. watermill discussed as potential technology intervention model – TIM -1 in present study) is utilized in innovative way to operate and run wool winnowing machine and two carding machines to card 50 kg washed wool in eight hours cycle locally as central facility located in village Mukhaba, Uttarkashi and another village Bhatar, a typical village of Jaunsari tribal population in district Dehradun. In this improved system, the traditional water mills are improved for getting full efficiency of hydro-power. Two pulleys are attached to the shaft of watermill for running the carding machine and another counter shaft which is attached with various pulleys for running the wool teasing machine, the grain grinder, the rice huller and other attachments they require using electricity alternator. While, Ball bearings are utilized at the end of shaft for increasing its speed efficiency.

It was noted that the cost of carding of wool locally through developed technology using improved watermill energy and mini carding machines was found to be Rs.10/- per kg including the maintenance of machines and watermill as compared to charging of Rs. 25/- per kg by privately owned carding machines run on diesel or grid electricity at far off places. Besides, such process innovation as common facility and community level model has helped to save time of women who were traditionally able to winnow only two kg wool per day by hands. These findings reflect more widely on inception and subsequent relationships of technology intervention, innovation and activities associated at the grassroots level for wool based micro-enterprise with an attempt at a new type of partnership in the mountain context, i.e., amongst a research organization, local institution and local community for promoting non-farm and village level activity to sustain and nurture local livelihoods.
5.1.5.4. Future Prospects and Possibilities of Replication: Development of Policies for Non-farm Sector and Social Empowerment

Rural enterprises for primary value addition based on such innovative technologies and field model evolved (TIM -5) for processing and carding of wool as discussed above indeed have the potential to make significant impact in terms of job creation or generating additional income to uplift local mountain economies. This will lead to two - way flow between the people and the technologies to benefit the Himalayan people particularly Bhotia tribal community scattered in small size settlements in high altitude areas of Pithoragarh, Almora, Chamoli, Uttarkashi and Dehradun Districts of Uttarakhand for whom sheep rearing and wool processing has been a traditional activity. At the core of livelihoods strategies support through such technological intervention approach model to enhance access to skills, information and resources on innovative production method and products will help to reduce negative externalities i.e. afforestation etc. which could effectively help to reduce inequality and improve the economic and social positions of the poor in such upland areas.

It is, therefore essential for the policy makers to effectively address the needs of the rural non-farm sector by providing suitable environment to enable households in poor rural areas to take advantage of technological opportunities as “demand pull livelihood diversification model” as a part of upward livelihood trajectory (Islam, 1997; Swift, 1998; Davis and Pearce, 2000). What is needed is the delineation of such technologies for the rural areas and dovetailing the local institutional support system for their optimization and widespread adoption including credit delivery and training to set up new enterprises (household level, self help groups or cooperatives) by adding value to products in small villages. Complementary policies to encourage such small scale enterprises - not only in wool based activity but also in artisanal based activities like blacksmithy, basket and mat making based on locally available raw material will be quite critical for their viability and success in high and middle altitude areas. The significance of such initiatives in the non-farm sector becomes even more pronounced in the agriculturally backward and low productivity upward mountain regions. Such endeavors and convergence to reshape various policies and programmes and implementation mechanisms to promote rural non-farm sector involving different stakeholders would simultaneously upgrade local skills to protect the interests of indigenous population. It will create and demonstrate new avenues for self-sustaining enterprises through application of S & T for sustainable rural livelihoods in mountain areas by building upon traditional knowledge base with judicious use of local resources.
Table 5.37. Cost Benefit and Impact Analysis for making Wool based Products by Bhutia Tribe of Saldhar village using Upgraded Loom Technology (19 households)

<table>
<thead>
<tr>
<th>S.N</th>
<th>Improved Loom Technology</th>
<th>Traditional Loom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; yr.</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; yr.</td>
</tr>
</tbody>
</table>

### A. Weavers’ Investment

1. **Fixed cost (Rs.) of improved loom**
   - Improved Loom: 2800
   - Traditional Loom: 1000

2. **Recurring Cost (Rs.)**
   - Cost of processed wool 8 kg @ 250/kg
     - Improved Loom: 2000
     - Traditional Loom: 2000
   - Cotton thread 3 kg @ Rs 60/-per kg
     - Improved Loom: 180
     - Traditional Loom: 180

### B. Returns

1. **Average days involved (working time 5 hrs/day)**
   - Improved Loom: 20
   - Traditional Loom: 25

2. **Average total working months/yr.**
   - Improved Loom: 6
   - Traditional Loom: 6

3. **Average production of carpets* (Average Size: 3’’ x 6’’)**
   - Improved Loom: 6
   - Traditional Loom: 5

### C. Gross return (Rs.)

- Income from unit sale @ Rs. 3500 for carpet weaving from improved loom and Rs. 2800 for traditional loom
  - Improved Loom: -1480
  - Traditional Loom: -380

### D. Net Profit/annum/hh (Rs.)

- Improved Loom: 5120
- Traditional Loom: 2100
## Intangible Benefits

### Techno-Economic

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loom with adjustable devises to make products of desired size. Easy operation.</td>
<td>Not possible - fixed size, single framed. Operation is hard.</td>
</tr>
<tr>
<td>Long life of loom made up of iron rails.</td>
<td>Short life (5 ± 2) of Wooden loom made from local wood sp., <em>Toona ciliata</em> (Tun).</td>
</tr>
<tr>
<td>Improved wool processing, product diversification, color combination, design development with better market acceptability.</td>
<td>Poor design and low market acceptability.</td>
</tr>
</tbody>
</table>
| Natural dyeing using local resources:  
  - Walnut fruit coat: Brown color  
  - Turmeric and saffron: Red and Yellow  
  - *Prinsepia utilis*: Green  
  - *Berberis and Leh berry*: Yellow | |
| Income generated /day > twice as compared to traditional loom | |

### Ecological

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment friendly: made up of iron – saving of wood and reduced pressure on forest; using locally identified natural dyeing coloring material.</td>
<td>- Using wooden loom</td>
</tr>
</tbody>
</table>

### Social

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced drudgery in winnowing, carding and spinning process with improved efficiency of women.</td>
<td>Low efficiency, operation hard and time consuming process.</td>
</tr>
<tr>
<td>Saving of time. Empowerment and capacity building for better decision making and marketing skill.</td>
<td>More workload on women</td>
</tr>
<tr>
<td>Check on Migration</td>
<td>Temporary migration to meet livelihood needs</td>
</tr>
</tbody>
</table>

* 70-80 sheep/hh with average production of 1kg wool/sheep/yr.
<table>
<thead>
<tr>
<th>Winnowing Tool For Wool Winnowing</th>
<th>Winnowing By Water Mill Operated Winnowing Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Wool Carding By Bamboo Sticks</td>
<td>Wool Carding By Water Mill Operated Carding Plant</td>
</tr>
<tr>
<td>Spinning By Gandhi Charkha</td>
<td>Spinning By Ambar Charkha</td>
</tr>
</tbody>
</table>

**Figure 5.18.** Traditional (left side) and Improved (Right Side) Tools and Methods used for Wool Winnowing, Carding and Spinning Operation by Bhutia Tribes in Saldhar Village, Chamoli.
Plants used for Natural Dyeing

<table>
<thead>
<tr>
<th>Plants used for Natural Dyeing</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walnut fruit coat</td>
<td>Brown color</td>
</tr>
<tr>
<td>Turmeric and saffron</td>
<td>Red and yellow</td>
</tr>
<tr>
<td><em>Prinsepia utilis</em></td>
<td>Green</td>
</tr>
<tr>
<td><em>Berberis</em> and Leh berry</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Figure 5.19. Showing Traditional and Improved Loom to make Carpet and Other Wool based products by Bhutia Tribes using Natural Dyes from local Plant Material.
B. Impact Analysis and Emerging Technology Models: Himachal Himalayas

**Water Resource Management:** In continuation of technology intervention (TI-1) for Improved watermill studied and described earlier under this chapter (item no. 5.1.1), technology intervention (TI-6) related to water harvesting and conservation essentially on technology based watershed management was studied in identified village of Sirmour Dist., Himachal Pradesh. Results and impact assessment details about TI-6 are described as under.

5.1.6. Water Harvesting and Conservation (TI-6)

Natural resources can not be viewed in isolation – its linkages with the habitat where it is available, the human resources in terms of skills and traditions which are in co-existence, need to be taken care of. In recent past, an inter-play of geographical and climatic factors, patterns of resource use and socio-economic conditions have led to severe natural resource degradation and associated environmental consequences in the Himalayan region. This requires a development planning with an in-built environmental concern focusing on protection and optimum utilization of natural resources viz: Soil, Water and Biomass management by adopting an integrated watershed development approach, and their rejuvenation as far as possible to improve the livelihoods of the local community.

From an increasing number of reports and scientific literature, it is now clear that developmental agencies and governments are continuously advancing in the watershed management strategies that are more sustainable in nature to improve land use and the productivity of agriculture with water use efficiency. Watershed has been recognized towards poverty alleviation in the various government programmes as useful vehicle of rural development in Indian context. Though watershed development was emphasized in the Five-Year Plans of Government of India, but, it was more specifically concerned with soil and water conservation. Subsequently, increasing concern for environment and development has led to the shift in watershed programmes from essentially a resource-based approach towards livelihood enhancement, both at National and International levels. It was in the 1993 that the Hanumantha Rao Committee constituted to evaluate watershed programmes recommended for a community-based watershed management (CBWM). This marks a significant step towards integrated resource management with participatory approach realizing in the importance of inter-linkages between improving productivity of natural resources and sustained increase in rural income (Anonymous, 1994 and 1995). In this shift of approach, participation and involvement of community has been emphasized to promote the management of water supply services at the village level. That is, local self-governance of available water resources on demand and
allocation management ensuring the sustainable access of all people, particularly weaker section of the society, to a basic minimum to cover domestic and small scale productive needs, and to progress towards ecological and livelihood security. In semi-arid tropics, watershed management initiatives have been viewed to capture water during rainy periods for subsequent use in dry periods to raise rain fed agriculture production, conserve natural resources and reduce poverty (Farrington et al. 1999; Kerr, 2002).

However, to achieve the desired concept of sustainable use of resources, need is now being felt for scientific planning and appropriate mechanisms for technology driven watershed management and rural development, using not only technical inputs but also local knowledge and perceptions, without losing their comparative advantage of cost-effectiveness and simplicity. The government is also emphasizing involvement of voluntary organizations and local institutions in applying such synergistic approach through appropriate mechanisms for watershed management and rural development to benefit deprived sections of the society. It should be ensured that the technologies introduced into the village system must be internalized by the community through training and experience as best technological options to enhance efficient water use with demand management, introduction of water-saving measures and to manage and nurture local natural resource base. In this approach, low yields of subsistence farming particularly in mountain areas present a great opportunity for improvement with appropriate technological interventions.

Considering the above facts and emerging needs for technology based watershed development and management, present study was carried out to find out factors with appropriate indicators to evolve effective working model of process innovation and technology delivery for natural resource management. With this approach, study has focused to explore the potential and possibility for improved livelihoods through introduction of irrigation system linked with production technologies within micro-watershed carried out by the Rural Centre for Human Interest (RUCHI), a Voluntary Organization, in a sub-tropical area in Himachal Pradesh. The impact study carried out during post intervention period in this watershed area assumes importance in view of the challenging topography for rural population to survive in harsh environment to sustain their livelihood needs.

5.1.6.1. Technological Intervention for Irrigation System and Watershed Management: The Watershed Area

The study area i.e. village Shilanji Dangra falls into the Sub-tropical altitude zone between 914 to 1,523m amsl within the Bagni ka Khala micro-watershed located in
Shilanji Panchayat, Rajgarh Development Block, Sirmour Dist., Himachal Pradesh as described in Table 4.2 (Chapter 4) with respect to location, land utilization pattern etc. It is a village with majority of the population belonging to backward class. The watershed lies approximately 4.5 km north of the town Rajgarh at latitude 77°15’E to 77°20’E and longitude 30°50’N to 30°56’N. It is bordered by the Deothi Dhar hills in the north and Rhoru Dhar hills to the south. With its source at altitude 77°19’30”E and longitude 30°54’30”N, and its convergence with the Pervi Khala River at latitude 77°16’05”E and longitude 30°53’10”N, the river Bagni Ka Khala runs for a distance of approximately 7.75 km in south westerly direction. Availability of water in the stream varies in accordance with the season and rainfall situation in the area. During summer and winters, which is generally dry, the stream becomes thin. The source of water for the river is the rivulets coming down from the crevices of the mountain. The climate is sub humid in nature. Agriculture and labour account for 80 per cent of stakeholders’ occupation indicating high dependence on natural resources for their livelihoods. Out of seven villages in Shilanji Panchayat, study village Shilanji Dangra has average size of land holdings less than or equal to 2 ha signifying that majority of farmers fall in small and marginal category, with average family income of Rs.1,500/month. The main source of drinking water is the natural spring called Bawdi or Chasma.

The watershed with catchments area of 1811 ha has 7 revenue villages around the river Bagni ka Khala which has perennial water source. This area was developed in the form of a watershed by RUCHI during 1998 - 2004 to address the problem of recurring drought, poor agriculture productivity, problem of irrigation water and food security to local inhabitants. The area being mountainous and vegetation cover being sparse, it was badly affected by soil erosion and water loss was intensive before intervention. Soil moisture loss was also reported very high. Land slides and excessive run offs were observed common features in the area. Sedimentation in the lower part of the valley was also observed and there was an increase in wasteland because of depleting vegetative cover. The soil types are clay, sandy and loam, which depends upon how far, the land is from water source. In the upper ridges, soil is found to be rich in organic matter. The soil here was mainly deficient in macro-nutrients. Less area was cultivated by the farmers due to the problem of high run-off rate of water during monsoon period and lack of water storage facilities.

5.1.6.2. Technology Intervention, Promotion and Transfer: Impact Analysis

During initial intervention period in given watershed area, measures were taken for conservation and better management of the primary resources viz. soil and water in arable
land through conservation measures like, contour bunding, contour farming, bench terracing on steep slopes, gully plugging, check dams, establishment of vegetative cover (with grass, shrubs and multi-purpose trees), gully bank plantation, and run-off harvesting and water storage. Other elements of natural resource management were supported with activities like graded bunds, stone bunds and contour trenches on wasteland to improve biomass production and minimize soil erosion. Water harvesting structures like percolation tanks/sunken ponds were constructed. Horticultural and agro-forestry interventions were adopted on farmer’s fields/boundaries as well as in non cultivated land for crop diversification, income generation and fodder production. Special emphasis was given to introduce HYV grasses viz. Napier grass (*Pennisetum purpureum*) which was planted on bunds for stability and fodder production. These interventions at watershed level were made almost eight years earlier with certain level of feasibility and has sustained over the years with good production and livelihood benefits to meet the local requirements even in the recent years observed through participatory assessment (Sutherland, 1998; Dayal, 2000).

The production efficiency and functional system approach of above interventions were further studied at micro level in view of difficult terrain and socio-economic conditions in study area referred as problem zone. It was purposely done to evaluate impact and effectiveness of technological interventions and innovative process approaches applied at organization level during intervention as well as post intervention period from long term sustainability point of view.

The study focused on livelihood related aspects covering total sample size of 40 small and marginal farmers out of total 54 farm households in a study village within the above discussed watershed area. Quantitative and qualitative data on livelihoods assets and strategies related to pre intervention, intervention and post intervention was collected during 2004-2007. Data collection in participatory mode with reflexive control (before and after intervention) was done on biophysical conditions, technological interventions and farmers/villagers estimates of cropping area, crop type, and productivity levels with cost benefit analysis (Rosi and Freeman, 1992; Wilkinson and Bhandarkar, 1999; Lilja and Ashby, 2001; Singh and Padaria, 2005; Singh *et al.* 2005). It also encompasses their perceptions/response in terms of participation during planning, implementation and post intervention period for watershed development and management, and benefit gain on several indicators (tangible and intangible) developed and applied to evaluate related performance covering ecological, economic and social considerations to support and improve local livelihoods (Table 5.41).

To crystallize further, a detailed impact analysis of small scale production technologies
on cash income generation of selected farmers with relevant data was also done for same period (2004-2007) at study site towards feasibility assessment of cost benefit issues keeping in view the latest market scenario. The analysis with descriptive statistical techniques focuses on evaluating technology appropriateness in enhancing production efficiency and diversification process involved in long term viability and adoption by the farming community for local resource utilization and management. Thus, it explores the ‘Process Innovation’ and related factors to find out feasibility and replicability potential of such intervention at macro level application in similar water starved situations with challenging topography in Himalayan region.

i. Soil and Water Conservation Measures

Table 5.38 shows that total agricultural land including cultivable wasteland covered under the Shilanji panchayat in the given watershed area was 184 ha out of total catchments area of 1811ha. The intervention was made at the level of micro-watershed focusing on conserving soil moisture for rain fed agriculture, recharging aquifers to augment groundwater irrigation, capturing stream run-off water in small irrigation tanks and construction of small check dams in drainage lines. During the intervention, seven irrigation tanks measuring 5 x 4 x 3 m size, two check dams, one rain water harvesting (RWH) tank, gully plugging measuring 605 m$^3$ and contour trenching measuring 2750 m$^3$ were constructed within the Shilanji Panchayat area that increases the available total annual irrigation water requirements from 624 to 838 m$^3$ per farmer as reported by the organization by redirecting natural springs, streams and nalahas. RWH was ferro-cement structures with simple sand filter, while, check dams as gabion structures were built across seasonal streams to reduce flood flows and reduce erosion thus supplementing irrigation requirements and also large volumes of infiltration thus aiding aquifer recharge as revealed by villagers during qualitative discussions. Figure 5.20 shows in diagrammatic form the locations of such structures within the whole watershed and in the study village Shilanji Dangra. These interventions have helped to increase the average size of irrigated cultivable land per farmer from 1.38 to 1.45 ha bringing more land i.e. 141ha under irrigation as compared to 21 ha land available for cultivation during pre-intervention period out of total 184 ha land available in Shilanji. The soil conditions were also improved due to introduction of irrigation facility and conservation of top soil layer with application of bio-compost (Table 5.38). The increase in irrigated area is attributed to underground pipeline irrigation system that diverted water from a perennial stream (Sharda et al., 2005) collected and stored in water harvesting structures and irrigations tanks thus mitigating the effect of recurrent drought.
Table 5.38. Impact Analysis of Water Management and Small-scale livelihood related Technologies in Shilanji Panchayat Micro-Watershed Area, Sirmour, HP (40 farm households out of 54)

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Improved System/components</th>
<th>Pre-intervention</th>
<th>Intervention and Post-intervention Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tangible Indicators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Water management and irrigation facilities</td>
<td>Irrigation tanks (5mx4mx3m)</td>
<td>Rain fed condition, small katchi canal</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td>Check dams</td>
<td></td>
<td>01</td>
</tr>
<tr>
<td></td>
<td>Rainwater harvesting tank</td>
<td></td>
<td>01</td>
</tr>
<tr>
<td></td>
<td>Compost pits</td>
<td>Heap method</td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>Gully plugging (m³)</td>
<td>----</td>
<td>605</td>
</tr>
<tr>
<td></td>
<td>Contour trenching (m³)</td>
<td>----</td>
<td>2750</td>
</tr>
<tr>
<td>B. Soil chemistry</td>
<td>Average % Organic carbon</td>
<td>0.76</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>P (ppm)</td>
<td>3.9</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>5.7</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>Conductivity</td>
<td>82</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>% moisture content</td>
<td>23</td>
<td>36</td>
</tr>
<tr>
<td>C. Land details (ha)</td>
<td>Total land</td>
<td>184</td>
<td>184</td>
</tr>
<tr>
<td></td>
<td>Cultivated</td>
<td>74</td>
<td>179</td>
</tr>
<tr>
<td></td>
<td>i. Irrigated</td>
<td>21</td>
<td>162</td>
</tr>
<tr>
<td></td>
<td>ii. Un irrigated</td>
<td>53</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Wasteland(cultivable)</td>
<td>110</td>
<td>05</td>
</tr>
<tr>
<td>D. Average Farm size (ha)</td>
<td>1.38</td>
<td>1.45</td>
<td></td>
</tr>
</tbody>
</table>

2. Intangible Indicators: Benefits as compared to Pre-intervention Period

A. Economic
• Increased level of income generation by the production of cash crops with marked decrease in the areas of staple crops.

B. Techno–ecological
• Irrigation tank with a 24-hour water balance > 100 m³ following daily irrigation cycle except during 2-3 dry months. Essentially through stream flow and effective catchments treatment.
• Rotational cropping with diversification from 4 to 8 crops. Good quality compost for use in agricultural field.
• Optimum utilization of resources through soil conservation and water management and small scale protection cultivation technologies.
• Introduction of new variety of seeds with improved agricultural practices; HYV grasses viz. Napier grass (*Pennisetum purpureum*); and multi-purpose tree species: Fodder (*Morus alba*) and fruit trees.
• Plastic strings thread technology for tomato and pea cultivation reducing pressure on forest to use wooden sticks.

C. Social
• SHG/WMC is able to manage structures and water distribution system with savings and credit facility.
• Improved livelihood and household level food and nutritional security; augmenting income potential for women and unemployed youths.

ii. Crop Diversification

Table 5.39 shows that when irrigation facilities with water distribution system were improved to user group farmers having plot ranging from 0.5 to 3.0 ha, motivated farmers adopted to cultivate diversified cash crops for better income generation. There was a marked decrease in the areas of staple crops such as wheat and maize with an average drop of 0.172 and 0.321 ha/farmer respectively. Farmers reduce the land area under
cultivation of wheat and maize according to their food security demand as overall crop productivity increased, and also started cultivation of various vegetables cash crops in average plantation area. As a system advantage, it was observed that water distribution was done judiciously with flexibility for water supply through impermanent black flexible pipelines allowing irrigation to be carried out as per the requirement during the year to meet the different crops requirement in rotation cropping being practiced in the study area.

iii. Introduction of Small Scale Production Technologies

Besides above, adoption of protected cultivation technologies like poly-house and net-house using locally available bamboo (*Dendrocalamus sp.*), poly-pit and bio-compost resulted in enhancement of overall land productivity of average farmer due to better growth and survival of plantlets in local environment.

| Table 5.40. Cost-Benefit Analysis: Small Scale Technologies for Protected Cultivation and Bio-compost Production (Rs. ± SE/Yr) for Average Farmer |
|---|---|---|---|---|---|---|---|---|
| Technologies | Total Input (Rs) | Total Output (Rs) | Net returns (Rs.) | Total Input (Rs) | Total Output (Rs) | Average Net Return (Rs) |
| | With family labour only | | 1st yr. | 2nd yr. | 3rd yr. | | |
| 1. Bamboo structured Poly house 5mx3mx2m | 3150± 80 | 4155± 110 | 1005± 55 | 4330± 90 | 4550± 120 | 380± 18 | 1690± 72 | 1310± 45 |
| 2. Bamboo structured Net-house 5 mx3mx2m | 3000± 120 | 4080± 195 | 1080± 54 | 4250± 212 | 4395± 224 | 360± 15 | 1650± 65 | 1310± 45 |
| 3. Poly-pit 3mx2.5mx1m. | 1150± 52 | 1920± 65 | 770± 55 | 2130± 80 | 2265± 102 | - In the first year the return was low due to cost involved in construction, whereas in 2nd and 3rd year the net monetary return (Rs.) was obtained reasonably good. |
| 4. Bio-compost pit size 5mx2mx1m | 1200± 60 | 1750± 74 | 550± 35 | 1990± 66 | 2160± 82 | - Calculated based on the prevailing rates / market values. |

It has helped in terms of net monetary return (Maikhuri *et al.* 2007) as can be seen from Table 5.40. This may be due to protected structures to protect plantlets from biotic and abiotic stresses; and improved soil fertility with better nitrogen and phosphorus
availability and organic matter using bio-composting technology, wherein composting period as well as nutrient loss is reduced considerably using farm resources as compared to traditional system of direct farm yard manure (FYM)/cow-dung compost application in the field as evidently reported by Krishna et al. (1998) and Rawat et al. (1998) from Sikkim and Kumaun Himalaya. Such 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 (Sanwal et al., 2004). Although, bamboo structured poly-house/poly-pits may require repairing after 4-5 years, but, bamboo was sufficiently available locally to meet the farmers’ requirements. Adoption of these affordable technologies with less drudgery associated with field work has helped farmers to grow seasonal and off-seasonal vegetables, nursery raising of horticultural and multi-purpose tree species for their own requirements as well as selling the seedlings and plants to other farmers for their economic benefits.

The average net income increase after intervention of above 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 increase as compared to pre-intervention period for average farm size of 1.38 ha thus expanding self employment horizons (Table 5.39). This increase is the cumulative effect of all biophysical and social engineering efforts in watershed management 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. This may be correlated to the interesting finding which shows that in whole watershed area, Shilanjee was the only village Panchayat where irrigation tanks were having water balance of 100m³ after 24 hours refill following daily irrigation cycle including two sessions of irrigation by the user farmers being served by the structure, although this was a minimal excess of <100m³ and so could run dry at some point during the dry period.

5.1.6.3. Technology Adoption: Ecological and Socio-Economic Impact Benefits

A perusal of results based on the response from sample size of 40 farm households about interventions for watershed management and development reveals the changes in terms of various ecological, economic and social indicators developed and applied during study as shown in Table 5.41.
Table 5.41. Differential Achievement of Indicators on the Impact of Water Management and Small-Scale Technologies for Improved Livelihood in Shilanji Panchayat Micro-Watershed Area, Sirmour, HP (N = 40 farm households)

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Indicators</th>
<th>Response</th>
<th>Respondents</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Ecological</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Availability of surface and underground water</td>
<td>Yes</td>
<td>35 (85)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>5 (15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Change in moisture content of soil</td>
<td>Increased</td>
<td>27 (67.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remained Same</td>
<td>10 (25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased</td>
<td>03 (7.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Area of forest cover and plantation</td>
<td>Increased</td>
<td>25 (62.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remained Same</td>
<td>14 (35)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased</td>
<td>01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Area of land under cultivation</td>
<td>Increased</td>
<td>35 (87.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remained Same</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Productivity per unit of land</td>
<td>Increased</td>
<td>29 (72.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remained Same</td>
<td>09 (22.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Availability of fodder and fuel wood</td>
<td>Increased</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remained Same</td>
<td>12 (30)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased</td>
<td>28 (70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>Economic: Livelihood diversification</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>1.1 Livelihood diversification</td>
<td>Yes</td>
<td>34 (85)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>06 (15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Extent of diversification</td>
<td>Food and cash crops</td>
<td>24 (65)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food, cash and horticulture crops</td>
<td>06 (16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food, cash crops and dairy</td>
<td>04 (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food crops and dairy</td>
<td>03 (8)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2.</td>
<td>Annual household income and expenditure</td>
<td>Increased</td>
<td>32 (80)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Remained same</td>
<td>08 (20)</td>
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<tr>
<td>3.</td>
<td>Employment situation</td>
<td>Increased</td>
<td>30 (75)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Remained same</td>
<td>10 (15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social</td>
<td></td>
<td></td>
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<td>---</td>
<td>----------------------------------------------------------------------</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>Source of credit</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased</td>
<td>11 (27.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Remained Same</td>
<td>11 (27.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decreased</td>
<td>18 (45)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SHG functioning: frequency of meeting, participation in decision making etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased</td>
<td>22 (55)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Remained same</td>
<td>18 (45)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Decreased</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Workload on women</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes, Increased by 3 h/day</td>
<td>32 (80)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>No</td>
<td>08 (20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Literacy level about use and application of technologies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>32 (80)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>08 (20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Migration Check</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Yes</td>
<td>40 (100)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Education of Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased</td>
<td>36 (90)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Remained same</td>
<td>04 (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Benchmark used: 0-40 %: Poor; 40 –70 %: Average; Above 70 %: Good.
- Figures in parenthesis indicate % change.
Various indicators 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 as under:

i. Ecological Impacts: Environmental Services

Table 5.41 shows that irrigation facilities such as construction of check dams and irrigation tanks have reduced the dependency on rainwater, and checks on run-off with increased area under cultivation and productivity per unit of land. It shows that a high percentage of population 35 (85 per cent) felt that the water availability in the area has increased in general. This has been the case when there has been intermittent and insufficient rainfall for the last seven years. Regarding water balance, it emerged from the discussion from villagers that water is drawn from check dam on a sharing basis. For drinking purpose, water is sufficiently available from natural springs. Table 5.41 also shows that for more than 60 per cent respondents there was a considerable increase in moisture content, forest cover and productivity per unit of land. This is precisely due to a perceptible shift in the variety of crop grown in the area from food crops grown for ones own subsistence such as wheat, maize, potato and ginger to cash crops such as green vegetables, horticulture and floriculture.

It is interesting finding to note that intervention has performed poorly on the indicator of fodder and fuel wood availability from forests as 70 per cent opined that it has reduced while, 30 per cent felt that it has remained the same probably due to poor rainfall or increase in awareness about the use of alternative sources of fuel. These findings are in consistent with Kerr (2002) showing positive aspect of such environmental services to promote regeneration in common land. This long term benefit visible during post intervention period was also attributed due to mechanical and vegetative soil stabilization measures with plantation of trees specially for fuel-wood, fodder, horticultural and wild edible species during initial intervention period in marginal and degraded portion of the farm land which made the farm families self sustainable and reduces pressure on forests to some extent.

It can be inferred from ecological indicators and response from local community that soil and water conservation activities particularly to check the run-off rate of water with vegetative and physical barriers have recharged the ground water significantly. Awareness generated about improved irrigation techniques has also brought changes in this aspect. Use of irrigation systems such as sprinklers and drip irrigation allows water to percolate slowly and also checks soil erosion. Innovative intervention like plastic thread stinging
technology was found cost effective and environment friendly one as traditionally farmers were using 4-5 wood sticks per sapling to hold the plant for tomato cultivation which last for two seasons only. Thus, there was a clear saving of such level of wood use as in each season farmer plants around 5000 saplings.

ii. Economic Impacts: Livelihood Diversification and Enhanced Income Level

The impact has also been significantly favorable with respect to source of livelihood and its diversification, annual household income and improved employment situation because of higher productivity of land due to better availability of water for irrigation purposes as reported by more than 70 per cent respondents. It has helped them in diversifying their source of livelihoods from subsistence level agriculture where they cultivate food crops (mainly wheat and maize) just two times a year to cash crops which they grew almost all the year round. 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. These initial interventions have helped in increase of average annual income of farm household which was found to be 2 fold and more as compared to pre-intervention period with subsequent adoption of protected cultivation technologies leading towards optimized productivity on sustainable basis (Table 5.39). This increase is the cumulative effect of all biophysical and social engineering efforts in watershed management 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 size may also be the contributing factor for improved productivity and income. This may be correlated to the interesting finding which shows that in whole watershed area, Shilanji was the only village Panchayat where irrigation tanks were having water balance of 100m³ after 24 hours refill following daily irrigation cycle including two sessions of irrigation by the user farmers being served by the irrigation structures. The types of crops that can now be planted have also increased and include: peas, tomatoes, potatoes, French beans, ginger and red chilies. Diversification to cash crops and integrating it with horticulture and dairy was also observed with 10 farm households showing the emerging trends to enhance family income with technological empowerment and capacity building which has provided them price stability. Their increase in income helped them in raising the educational standard of their children. Their access to market has increased from close by places such as Solan, Rajgarh, Shimla, and Chandigarh thus expanding self employment horizons. However, for 6 (15 per cent) of the total 40 respondents the source of livelihood has not changed. They still continue to grow food crops or work as marginal farmers or agriculture labourers. It is to be noted that this 15 per cent of the respondents includes 2 (5 per cent) of the people who do not have agriculture land.
iii. Social Impacts: Credit, Gender and Migration Pattern

The impact of the intervention was reasonably favorable with respect to amount and source of credit because of limited institutionalized credit facility which improved subsequently due to formation of self help groups (SHGs). Table 5.41 shows that for 11 (27.5 per cent) of the population the intake credit has increased and for the same percentage it has remained the same. While, 18 (45 per cent) of respondents reported a decrease in dependency on credit. The reason for this variation is understandable. Farm families, which were extremely poor, opted to less credit. However, in order to cultivate cash crops and adopt improved methods of cultivation they looked for more credit. Thus, an increase in credit after their income has increased could be seen as a positive outcome showing effective functioning of village level institution which was able to generate their own resources in the course of time to become self-reliant. The economic situation improved owing to the credit facilities, which gave them purchasing power to invest in economic activities. Thus, there was a change in their social status as they were now empowered not only technologically but also economically.

The study has also found that workload on farm women increased by 3-4 hours per day after technological intervention due to increase in agriculture activities for improved production all around the year and with increase in area of land under cultivation from expanded irrigation. Because employing outside laborers is costly affair, poor farm families prefer to carry these activities themselves and women in the family bear the pressure to enhance the income. Assessing the impact on this indicator it can be inferred that the impact has been moderate, but with opportunistic use to enhance family income.

Table 5.41 also shows that 32 (80 per cent) of the village respondents felt that their awareness level about watershed development and management has increased and they give its credit to awareness generation programmes and process approach during implementation and post intervention period as well. During the discussion with stakeholders, it was revealed that adoption of better agriculture techniques, promotion of related rural technologies such as bio-composting, green house, hydraulic ram pumps, alternative sources of fuel etc. knowledge about micro credit and micro finance exposed the village community to make judicious and effective use of rural technologies and their integration within the natural boundaries of a catchment’s area for local resource management in a sustainable manner. Although, the awareness generation may not have brought direct changes in the life of people but has contributed positively.

The most important factor that contributed to the successful implementation and adoption
of technology intervention initiatives was the high degree of social capital in the community with 100 per cent check on migration, and improved education of children as felt by 90 per cent respondents due to techno-economic empowerment tuned to their location specific needs generating sufficient employment on their own fields. People contributed in cash and through shramdan (self contribution by households for labor) for building of community assets.

Analysis of above ecological, economical and social impact reveals that there has been a rapid adoption of cash crop agriculture and distinct decline in the cultivation of staple crops which was only for self consumption in study area. Realizing the monetary benefit, the use of more land within the watershed for agriculture appears to be future intentions of many farmers of other villages. Thus, in the future, further shift and diversification could cause a reduction in the level of water availability. This suggests that there will be a strain on all the natural resources within the watershed as it emerged from the discussion about the inadequacies of irrigation tanks to meet the water demand due to excessive cultivation of water demanding crops in other villages as compared to Shilanji village in the given watershed area thus rendering many of the planned tanks potentially inadequate or water deficit. To address this, people’s participation and technology inputs were found effective contributing factors in construction and management of all structures with adoption of protected cultivation technologies. This participatory management approach was amply evident in the Shilanji where the water balance of watershed was known and fully understood by all stakeholders involving optimum, non exploitative utilization of natural resources and land initially brought under cultivation during subsequent years. Now, farmers in the adjacent watershed area are willing to adopt this ‘process approach’ for more diverse crop production through effective water management and other resource.

5.1.6.4. Emerging Technology Intervention Model (TIM) for Livelihoods Gain

The findings of impact analysis for above interventions clearly show that proven and relevant technologies suited to geographical conditions of the area were transferred to the farmers. The inbuilt component of social engineering has helped to quicken the process of effective transfer of technologies as evident from adoption and social acceptability by the community in study area due to followings:

i. People’s Participation and Technological Empowerment

On looking at statistical average, Table 5.42 shows that farmer’s participation was about 60 per cent of the total population at planning stage, 75 per cent at implementation stage and 71 per cent at the maintenance stage contributing through shramdan. This is attributed as low in planning stage as learning stage followed by highest participation in
implementation showing establishment of participation with realization of empowerment in terms of technological benefits within the farming community as capacity building process with newly acquired knowledge. It leads towards confidence building and leadership development within the community to manage resources and support development (Saxena, 1998). During maintenance stage, people have contributed in repairing the structures such as cheek-dams in case of silt deposition. It was noted that people’s contribution was highest for small production systems particularly for vegetable cultivation followed by horticultural plantation and fodder development since they were directly linked to their livelihood. They have taken voluntary effort in preserving the soil and water resources of the area. This demonstrates the ability of local institutional arrangements (WMC) and management systems to manage natural resources collectively in harsh climate and challenging topography with major involvement of small and marginal farming community.

It clearly established that success, sustainability and replicability of watershed approach for rural development of rain fed areas largely depend upon people’s participating in planning, implementation and maintenance phases for social, economic, and ecological gains (Samra 1998, 2000 and Sharda et al. 2005) which can substantially improves the living conditions. Moreover, innovative process of participatory and technology driven watershed interventions addresses the location specific complexities instead of externally imposed systems which ensures that elite do not dominate management systems and net benefits are broadly distributed and reaches to weaker sections in terms of conservation and productivity (Agarwal and Gibson, 1999).

<table>
<thead>
<tr>
<th>S. No</th>
<th>Scale (1-10)</th>
<th>Role of people in Implementation and Management stages: Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Planning</td>
</tr>
<tr>
<td>1.</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>2.</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>8.</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>9.</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>11.</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total Respondents</td>
<td>40</td>
</tr>
</tbody>
</table>

Weighted on a scale of 10

<table>
<thead>
<tr>
<th>Weighted on a scale of 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.03</td>
</tr>
</tbody>
</table>

People’s participation (%)

<table>
<thead>
<tr>
<th>People’s participation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
</tr>
</tbody>
</table>
ii. Technology and Institutional Success Factors: The Process Approach and Innovative Elements

It was observed that two-tier organizational mechanism was adopted in the process of use and management of natural resources in micro-watershed area leading towards local livelihood security. One was at the organizational level and the other was at watershed level. At the organizational level, there was a natural resource management with technical inputs on soil and water conservation for capacity building and skill development, while, at the watershed level there was a watershed committee, which consisted of 15 members including three women who represented Shilanji Panchayat Area. As an innovative process approach, it was observed that RWH and irrigation tanks were constructed by careful selection of suitable sites near to available water source considering the size of land to be brought under cultivation to benefit the sizable number of farm households who were willing to contribute labour for construction and managing usage of the tanks. The study also reveals that vegetable seeds of improved varieties were supplied from central seed bank facility managed by local WMC to farmers on interest free loans for a period of six months. Repayment was scheduled to coincide with the harvesting season, allowing the farmers to repay their loans after the sale of their crops. It also supervised the extensive plantation of cash crops, fodder and fruit plants. As a result of these measures - made possible by the villagers’ shramdan - every field in the area now has access to irrigation water. Thus, the most important factor that contributed to the successful intervention was the high degree of social capital in the community by creating and building upon local institutions. Almost all the decisions were taken in consensus. WMC is also responsible for the maintenance of created community assets, decision-making, post-intervention follow-up activities and coordinating linkages with government departments for watershed maintenance and development. Members of the WMC are part of the local SHG, who are responsible for both his/her village’s share as well as his/her own personal monetary contribution. SHG members each contribute Rs.100/- per month thus contributing to various community development initiatives. Loans were approved only for agricultural expenses - buying seeds and livestock issued against a member’s share of the kitty.

Though, rough terrain and low awareness level of the people was a hindrance in the initial phase of the intervention. But, a great deal of institutional effort for customization and appropriate technological intervention; and social engineering with bottom up approach had a catalytic effect to create awareness and empowerment benefit about technology based watershed management for livelihood gains (Figure 5.21 and 5.22). Other Institutional factors which contributed to ‘Process Innovation’ are:
• Innovative use of proven technology to minimize risk of adoption and maximize productivity in the context of mountain topography and weather.
• Decentralization of appropriate technologies extension services and management at the local level.
• Sharing of resources, information and technology.
• Recognition and respect towards role of women as catalysts for community development.
• Develop the technical and managerial capabilities of women by entrusting them with the operation of a savings and credit system.
• Optimal utilization of local resources for economic self-reliance.
• People-centered development and community empowerment.
• Promotion of social change via economic change.
• Capacity of people to improve their own condition when supported by appropriate infrastructure and interventions.

iii. Economic and Technological Interventions as Catalysts for Social Empowerment

Above findings through qualitative and quantitative analysis illustrate the catalytic effect and role of science based civil society on people’s participation and contributions by arranging forward and backward linkages. This led to multiplier effect and horizontal spread of technologies also in nearby areas by constructing 121 irrigation tanks in 85 villages of Sirmour and Solan districts of Himachal Pradesh under rain fed conditions with chronic water shortage, increasing the irrigated land by 40 per cent, thus, benefiting 750 families. In a region of scarce resources, unforgiving topography and harsh climactic conditions, micro-watershed management approach in present study sought to conserve and develop natural resources through the careful and innovative application of technology to improve agricultural techniques, increase the cultivable land, expand the crop range and, in so doing, improve local standards of living. As a systems approach, it can be inferred that enabling access the new hill specific technologies was partly about making more productive technologies available and partly providing opportunities (Institutional, financial, social, micro-credit and skill etc.) that support access to marginalized people in study area to these technologies and addressing their organizational capacities as a complete technology package to achieve economic, livelihood and ecological security (Figure 5.21).

Further, impact analysis suggests that during pre-intervention period forest resources were in declining stage threatening the livelihoods of farmers and sustainability of agricultural land use over a period of time due to long term fallowing of agricultural land with water scarcity (Rao and Saxena, 1996; Sen et al. 1997). Such trend analysis of natural resource in study area as deduced from participatory discussions justifies the
intervention strategy/initiatives taken towards improvement in productivity with irrigation facilities which were sustained during intervention and post intervention period (Table 5.38). These intervention strategies are right responses to address the scarcity of forest resources required to sustain farming in the Himalayan region (Schweik et al. 1997; Semwal, 2004) showing positive impact on local livelihoods.

5.1.6.5. Future Prospects and Possibilities of Replication: Development of Policies for Technology driven Micro-Watershed Management

It is evidently clear from present findings that innovative technological intervention approaches with institutional arrangements are major contributing factors to sustain and improve the livelihoods in given watershed area for long beyond the intervention period as reported in some village level projects namely, Sukhomajri in Haryana, G.R. Hills in Karnataka and Fakot in Uttarakhand by Dhyani et al. (1997), Farrington and Lobo (1997) and Salunkhe (2000) addressing the growing concern for sustainability, benefit sharing and trickle down approach (GOI, 2000; Shah, 2001; Kerr, 2002). But, the conservation and socio-economic indicators examined in this research study also suggests that “process innovation” should continued to be carefully designed/scaled up in such efforts. To make it effective and workable, it is essential to recognize the catalytic role of civil society and people’s institutions (local user’s groups) for designing and customization of simple and affordable technologies like protected cultivation technologies to sustain the watershed development efforts in agriculture dependent areas to further develop natural resources and nurture livelihoods of small and marginal farmers. This is where the success in above discussed technology intervention model (TIM-06) lies in its participatory, need-based and environmentally responsible approach by making institutional arrangements at local level such as formation of local Watershed Management Committee (WMC) to sustain livelihood security in the long term. Self-sustaining watershed institution with element of technology and commitment towards society were able to take over and sustain the intervention activities beyond implementation phase.

Therefore, policy initiatives to promote such technology intervention model to nurture livelihoods of small and marginal farmers should find prominence in S & T and natural resource policies of hilly states as they comprises 22 per cent of the Indian area under cultivation, of which 18 per cent is irrigated, severely limiting the cultivation period, types and quantity of crops that can be sown. Such intervention becomes more pertinent to manage resources in an optimum manner to ensure food and livelihood security of rural folk in the context of Himachal Pradesh where agriculture is the primary source of income for 92 per cent of Himachal’s population depending on limited rainfall i.e. 70 per cent occurs during June, July and August.
To conclude, it has been clearly established that success and sustainability for natural resource management depend upon people’s participation in planning, implementation and maintenance phase as per new paradigms of rural development. Study also suggests that development interventions are only effective to the degree that they respond to local needs and can be sustained by the community to whom they are directed and the natural environment of which they are a part. Empowerment of community, gender neutrality, equity and management of common property resource by village level institutions met the requirements of new guidelines for participatory watershed management (Sharda, 2002). This was widely visible in study area using economic and technological measures as important elements of ‘process innovation’ which eventually – and inevitably serve as the impetus for broader social progress with food and livelihood security. Sharing of benefits and costs, involvement of women and other disadvantaged sections of society were found to be other important factors for holistic and sustainable development of rain fed areas by adopting technology driven micro-watershed development approach. Thus, it enables the local community to look beyond the immediate short term gains through the careful and innovative application of appropriate technologies for conservation and management of local resources. This calls for a greater commitment for success in micro-watershed development by sharing benefits and improving the technology delivery systems starting with water, which is the most valuable common property resource in ecologically fragile landscape of the Himalayan region.
Table 5.39. Impact of Crop Diversification and Technology Inputs on Production and Cash Income of Average Farmer

<table>
<thead>
<tr>
<th>Crop Sown</th>
<th>Area (ha)</th>
<th>Production (Qtl)</th>
<th>Net Return(Rs.)</th>
<th>Area (ha)</th>
<th>Production (Qtl)</th>
<th>Net Return(Rs.)</th>
<th>Area (ha)</th>
<th>Production (Qtl)</th>
<th>Net Return(Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Interv</td>
<td>Post Intervention</td>
<td>Post Intervention</td>
<td>Post Intervention</td>
<td>Post Intervention</td>
<td>Post Intervention</td>
<td>Post Intervention</td>
<td>Post Intervention</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>0.377</td>
<td>4.647±0.985</td>
<td>4414</td>
<td>0.205</td>
<td>2.953±0.782</td>
<td>2805</td>
<td>3.125±0.966</td>
<td>2969</td>
<td>3.139±0.744</td>
</tr>
<tr>
<td>Maize</td>
<td>0.534</td>
<td>2.712±0.149</td>
<td>1764</td>
<td>0.213</td>
<td>2.638±0.774</td>
<td>1714</td>
<td>2.715±0.426</td>
<td>1761</td>
<td>2.847±0.764</td>
</tr>
<tr>
<td>barley</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0.022</td>
<td>0.369±0.079</td>
<td>295</td>
<td>0.412±0.025</td>
<td>329</td>
<td>0.462±0.226</td>
</tr>
<tr>
<td>peas</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0.128</td>
<td>3.113±0.877</td>
<td>3113</td>
<td>3.179±0.877</td>
<td>3179</td>
<td>3.287±0.588</td>
</tr>
<tr>
<td>potato</td>
<td>0.124</td>
<td>1.528±0.244</td>
<td>1528</td>
<td>0.267</td>
<td>3.239±0.766</td>
<td>3239</td>
<td>3.354±0.078</td>
<td>3354</td>
<td>3.415±0.788</td>
</tr>
<tr>
<td>tomato</td>
<td>0.103</td>
<td>1.824±0.133</td>
<td>1641</td>
<td>0.140</td>
<td>2.767±0.854</td>
<td>2490</td>
<td>2.814±0.129</td>
<td>2532</td>
<td>2.978±0.455</td>
</tr>
<tr>
<td>buffalo’s nose</td>
<td>0.047</td>
<td>0.822±0.288</td>
<td>1233</td>
<td>0.104</td>
<td>2.739±0.811</td>
<td>4108</td>
<td>2.914±0.017</td>
<td>4371</td>
<td>3.122±0.977</td>
</tr>
<tr>
<td>chilies</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0.028</td>
<td>0.769±0.052</td>
<td>3076</td>
<td>0.843±0.028</td>
<td>3372</td>
<td>0.869±0.023</td>
</tr>
<tr>
<td>ginger</td>
<td>0.148</td>
<td>2.834±0.332</td>
<td>4251</td>
<td>0.124</td>
<td>2.768±0.287</td>
<td>4152</td>
<td>2.976±0.136</td>
<td>4464</td>
<td>2.983±0.035</td>
</tr>
<tr>
<td>beans</td>
<td>0.047</td>
<td>1.137±0.128</td>
<td>1705</td>
<td>0.173</td>
<td>4.966±0.984</td>
<td>7449</td>
<td>4.982±0.822</td>
<td>7433</td>
<td>5.012±1.227</td>
</tr>
<tr>
<td>cauliflower</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0.018</td>
<td>0.4124±0.022</td>
<td>494</td>
<td>0.427±0.027</td>
<td>512</td>
<td>0.462±0.017</td>
</tr>
<tr>
<td>cabbage</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0.028</td>
<td>0.639±0.067</td>
<td>894</td>
<td>0.647±0.044</td>
<td>905</td>
<td>0.662±0.034</td>
</tr>
<tr>
<td>Total</td>
<td>1.38</td>
<td>16536</td>
<td>1.45</td>
<td>33829</td>
<td>35181</td>
<td>36154</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

150a
Figure 5.20. Diagrammatic representation of the Study Area showing locations of Soil and Water Conservation Structures constructed in the Shilanji Panchayat within the Bagni Ka Khala Micro-Watershed Area, Sirmour, HP (Not to scale).
Environmental Security
- Optimal utilization and conservation of water, fuel-wood, fodder and land resources
- Innovative use of technology to maximize productivity in the context of mountain topography, weather along with ecological security

Technology Adoption: An Enlightened Community
- Receptive to new ideas and technologies
- Adept at managing natural resources and environment
- Socio-economic empowerment of women to manage resources
- Aware of citizens’ rights and able to negotiate
- Balanced socio-economic development for INCLUSIVE GROWTH

Empowered, Self-reliant and Harmonious Society
- Livelihood and food security
- Desire and ability to facilitate change, improve living standards and social dynamics
- Practicing sustainable and self-reliant development
- Effective functioning of local institutions for organized production and management of resources with value addition: SHGs and WMCs

TECHNOLOGY INPUT PACKAGE:
(based on local need assessment; technology appropriation and field demonstration):
- KNOWLEDGE AND SKILL
- ATTITUDE TOWARDS LIFE
- INFRASTRUCTURE
- LINKAGE SUPPORT FROM S & T INSTITUTIONS

Economic and Technological Interventions
- Natural resource conservation/watershed management
- Technology promotion for crop diversification with water balance
- Income generation
- Women’s participation
- Community health and Environmental sanitation
- Support Services

SOCIAL INPUT PACKAGE:
- AWARENESS
- MOTIVATION
- ORGANISATION
- POSITIVE GROUP DYNAMICS
- FOREWORD AND BACKWARD LINKAGES
- VALUE AND RELATIONSHIP IN A FAMILY AND COMMUNITY

A Harsh Environment
- Natural resource depletion: water, fuel-wood and fodder scarcity; infertile soil
- Challenging topography
- Rough climate
- Drudgery in life
- Increasing aspirations through media glory

An Unaware Community
- Unaccustomed to new ideas
- Unaware of new technologies
- Unable to optimize resource use
- Poor status of women
- Dependant on external aid
- Little knowledge of citizens’ rights

An Impoverished Society
- Struggling to survive in harsh environment
- No knowledge of how to improve their situation and little power to facilitate change
- No direction to improve the situation and facilitate change in contemporary situation

Figure 5.21. Systems Approach: Technological Intervention Model (TIM-6) for Social Empowerment and Livelihood Security (Participatory Action Research in Shilanji Panchayat Micro-Watershed Area, Sirmour, H.P.)
Figure 5.22. Soil and Water Conservation measures with Adoption of Small-Scale Protected Cultivation Technologies led to Crop Diversification and Economic Empowerment at Village Shilanji Danghra, Sirmour, Himachal Pradesh.
Importance and promotion off-farm/non farm activities and their inter linkages for sustainable rural livelihoods have been emphasized in recent years (Lanjouw and Stern, 1993; Estudillo and Otsuka, 1999). It has been reported by Reardon et al. (1998) that rural off–farm activities account for 42 per cent of the income of rural household in Africa, 40 per cent in Latin America and 32 per cent in Asia. However, it is critical to determine how such spin-off activities can be promoted to meet location specific needs vis-à-vis resource availability for rural development considering institutional, organizational and technological aspects in the presence of agricultural growth with a mechanism whereby poor rural households can maintain and improve their livelihoods with backward and forward production linkages (Davis et al., 2002). In the context of mountain development and livelihood needs, it becomes imperative to explore and strengthen such initiative and alternative options for macro level application and promotion.

As discussed in earlier models (item no.5.1.5 :Wool based micro-enterprise -TIM-5) explored in present study, less productive hill agriculture with small land holdings result in migration of male folk to other places for employment opportunities, and women are left to manage agriculture, cattle rearing, household chores and education of children. Poor returns from agriculture and depleting wild resource for collection to augment their daily income make job of women economically less productive with lots of drudgery. New institutional strategies are needed for developing technologies and resource management systems to promote farm/off farm linkages that raise overall productivity and protect or improve the environment needs. Such interventions required to be tailored for use on specific local conditions and climates by optimizing the cost of this off farm/non farm research by linking extension efforts and community based scientific organizations.

5.1.7. Technology: Agriculture based Micro-Enterprise (TI-7)

To give adequate consideration to the importance of above aspects for off-farm sector, related activities like vermiculture biotechnology, mushroom cultivation with linkages for farm based activities like cultivation of high value medicinal plant was evaluated during study period in terms of production and expenditure to analyze and explore possible technology multiplier model for promoting growth and employment opportunities in mountain rural economies. The study covered impact analysis of field level intervention made at Village Dhangiara (Kandhi), District Mandi, H.P. focusing particularly on the technological, institutional and organizational aspects and exploring the linkages between farm and off-farm sector in remote and high altitudinal mountain areas to evaluate
household based technological interventions (TI-7) for development of sustainable livelihood in an eco-friendly manner. Data was collected and studied about the involvement and adoption of technological interventions 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. A detailed impact analysis to evaluate the viability of such interventions was done for three years in the study area located at 1820 amsl keeping in view the survey findings and livelihood assessment as described in chapter 4, and potential of such technological intervention in terms of cost-benefit and technology adoption by the community as compared to traditional livelihood system relying mostly on agriculture.

5.1.7.1. Technological Interventions: Impact Analysis

1. Vermiculture Biotechnology

Vermiculture Biotechnology has been reported environment friendly and viable method for the preparation of vermicompost by earthworms. Several studies have reported it as an alternative technique for the efficient management of organic solid wastes (Hand et al., 1988; Logsdson, 1994). The use of vermicompost as an alternative to chemical fertilizers in the normal farm practices is one of the most easy and cost effective source of nutrients to increase productivity and soil livingness in any agriculture system. It can be prepared in lesser time in comparison to the traditional compost as an off-farm activity for income generation. In remote mountain areas, it may help to reduce women’s drudgery involved in collection of biomass for composting and transportation of compost to the agriculture fields. In this technique, Vermibeds are created into the fields or in house depending upon the handling of the beds or the availability of space and quantity of biomass to set the cycle of regular production of vermicompost. Vermiculture is released in the bed depending upon the biomass quantity used or vermiculture can be multiplied in smaller quantities of biomass, which can be further released on the larger beds. Loading and watering are carried out for further 25-30 days to achieve the bed height of 70-75 cm, and then the beds are left as such for biomass conversion.

The data was collected from 77 low income households group (farmers with land holding below 0.5ha) related to vermicompost production, sale and self use in the agriculture production and is presented year wise in Table 5.43. The cost-benefit analysis of vermicompost production technology (using *E. foetida* species in vermibeds with layers of mixture of cow dung, soil, agricultural residues and leaf litter biomass) was calculated based on actual basis and market value/rates of vermicompost. The net income generated through the intervention was analyzed in terms of tangible benefits, while, ecological and social benefits to local community in study area were analyzed as intangible benefits.
Table 5.43. Cost Benefit (Rs./yr./hh) and Livelihood Impact Analysis for Vermicompost Production Technology (Biomass and cow dung treatment capacity 1000-1200 kg/cycle - 77 households out of total 104)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Detail</th>
<th>Value/quantity 1st Year</th>
<th>Value/quantity 2nd Year</th>
<th>Value/quantity 3rd Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Investment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Cost of shed Construction (5mx3m) with 3 beds</td>
<td>Rs.120/-</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>Cost of 5 kg Vermiculture (Earthworms)</td>
<td>Rs.2500/-</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Total Investment</td>
<td>Rs.2620/-</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>B. Returns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Total No. of cycles/year</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Average Vermicompost yield/year (800Kg/cycle) from treatment of 1000-1200 Kg biomass and dung</td>
<td>2400 Kg</td>
<td>2360 Kg</td>
<td>2400 Kg</td>
</tr>
<tr>
<td>3</td>
<td>Average earthworm yield (25% earthworm increase in each cycle)</td>
<td>7.71 Kg</td>
<td>12.10 Kg</td>
<td>23.64 Kg</td>
</tr>
<tr>
<td>4</td>
<td>Average sale of vermicompost/ annum/ household</td>
<td>600 Kg</td>
<td>560 Kg</td>
<td>600 Kg</td>
</tr>
<tr>
<td>5</td>
<td>Income from sale of 600 kg vermicompost (Rs. 5/kg)</td>
<td>Rs.3000/-</td>
<td>Rs.2700/-</td>
<td>Rs.3000/-</td>
</tr>
<tr>
<td>6</td>
<td>Average Saving in chemical fertilizers through use of vermicompost</td>
<td>Rs.1200/-</td>
<td>Rs.1800/-</td>
<td>Rs.2500/-</td>
</tr>
<tr>
<td>C. Gross returns form vermiculture technology</td>
<td>Rs. 4200/-</td>
<td>Rs. 4500/-</td>
<td>Rs. 5500/-</td>
<td></td>
</tr>
<tr>
<td>D. Net Returns /household</td>
<td>Rs.1580/-</td>
<td>Rs. 4500/-</td>
<td>Rs. 5500/-</td>
<td></td>
</tr>
<tr>
<td>E. Intangible Benefits as compared to normal composting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Economic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Market Value of Earthworms in first year</td>
<td>Rs.3855/-</td>
<td>Rs. 6050/-</td>
<td>Rs.11820/-</td>
<td></td>
</tr>
<tr>
<td>1.2 Market value of vermicompost used in own fields (1800 Kg/yr)</td>
<td>Rs. 9000/-</td>
<td>Rs. 9000/-</td>
<td>Rs. 9000/-</td>
<td></td>
</tr>
<tr>
<td>2. Techno-Ecolological</td>
<td>Soil Improvement; check on pollution and health hazard, no looping of trees for biomass, natural resource conservation high, reduced time (1/4) for composting as compared to traditional heap method.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis of Vermicompost, Farmyard manure and Cow Dung</td>
<td>Parameters</td>
<td>Moist (%)</td>
<td>pH Value</td>
<td>Fungi (x10^4)</td>
</tr>
<tr>
<td></td>
<td>V.C.</td>
<td>49.0</td>
<td>7.8</td>
<td>86.1</td>
</tr>
<tr>
<td></td>
<td>FYM</td>
<td>40.2</td>
<td>6.9</td>
<td>20.6</td>
</tr>
<tr>
<td></td>
<td>C.D.</td>
<td>81.8</td>
<td>6.03</td>
<td>28.5</td>
</tr>
<tr>
<td>3. Social</td>
<td>Reduced drudgery of women with less time investment and distance covered for collection of biomass, employment generation and improved livelihood to small farmers and unemployed youths.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 1st year, with average yield of 2,400 kg vermicompost 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 2\textsuperscript{nd} and 3\textsuperscript{rd} 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 as shown in Table 5.43.

<table>
<thead>
<tr>
<th>Table 5.44. Correlation Matrix for Vermicompost Production Technology in terms of Gross Return and Input Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gross Returns</strong></td>
</tr>
<tr>
<td>Gross Returns</td>
</tr>
<tr>
<td>Input cost</td>
</tr>
<tr>
<td>Production</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>SD±</td>
</tr>
</tbody>
</table>

Factors affecting gross returns with reference to input cost and Production
Input cost =0.489
Production =24.93

**Correlation and Regression Analysis:** Matrix table 5.44 shows that Gross return and input cost has negative correlation. Further 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. However, one unit increase in digestion of the raw dung and biomass with the existing model and material to increase the production is expected to increase the gross returns by 24.93 units. Therefore, in vermicomposting emphasis should be on increase in digestion of biomass to increase the benefits of the beneficiaries.

Techno-ecological benefits and analysis of vermicompost for various chemical and biological parameters as compared to traditional use of farm yard manure and direct application of cow dung which was widely prevalent in the study area, clearly shows utility and potential of vermicompost biotechnology as viable and cost effective soil conditioner technique to improve the farm productivity as also evident from INFARM model in the present study as well as by others (Hartenstein, 1989; Edwards and Bater, 1992; Logsdson, 1994; Gaur and Singh, 1995). This may be attributed due to reduction in organic carbon with nitrogen enhancement, moisture contents, and stimulation of microbial flora influencing higher level of nutrient contents like potassium and phosphorous probably due to mineralization and mobilization generated during ingestion and excretion process by the earthworms (Edwards and Lofty, 1972; Veil et al., 1987). Indirectly, it will immensely help to improve forest productivity as well with reduced dependency of local households for lopping of trees to make compost, thus, helping in the conservation of biodiversity and maintaining environmental balance.
The reduction in the use of chemicals in farm practices will certainly help in the conservation of biodiversity and maintaining establishment of natural flora and fauna species and reduce the level of land, water and environmental pollutants. Thus, lot of positive ecological changes will take place in the soil after continuous use of vermi-composting as observed by Edwards (1998), Ismail (2000) and Garg et al. (2006) as a suitable alternative technology of shorter duration for the decomposition of organic waste into value added compost. Analysis of data and discussion with the technology users and villagers during study clearly indicates adoption and utility of such off-farm activity leading towards reduced drudgery of women with less time investment and distance covered for collection of biomass; employment generation by selling the vermi-compost as well as worms; and improved livelihood option to other small farmers and unemployed youths.

2. Button Mushroom Cultivation

Developed countries have achieved tremendous progress in the cultivation of Button mushroom (Agaricus bisporus) and contribute more than 40 per cent of the world production of mushrooms. Cultivation of button mushroom in India was started in 1961 with the development of mushroom cultivation project at Solan in Himachal Pradesh. India could not make much progress in popularization and production of button mushroom and according to an estimate hardly produces 20,000 tones of mushroom annually and stands no where in the world statistics of mushroom production. Despite favorable climate of mountainous states like Himachal Pradesh, Jammu and Kashmir and Uttarakhand, and availability of agriculture waste in the adjoining state of Punjab, button mushroom cultivation could not pick up to the desired level. Analysis of the situation revealed that button mushroom cultivation was hindered due to lack of awareness and popularization of technology in a very complex manner only for high investment clients as industrial units. In addition, non availability of raw material like compost, spawn and market linkages are the main constraints for small farmers in mushroom cultivation. Governments of different states in India have made efforts to solve these problems by setting up of composting units and linkages with state agriculture Universities and National Research Centre for Mushroom, Chambaghat, Solan, H.P. for the supply of spawn and technical back up. But all these efforts in mountainous states remained restricted to the urban and semi urban low lying areas in the vicinity of compost and spawn supplying units for winter months only. Broadly, button mushroom cultivation failed to reach rural areas where climate is congenial for natural growing and people could cultivate button mushrooms for 8-9 months without any investment for
infrastructure and keeping the capacity to feed the plain areas during peak summer season.

Keeping in view the above situation, study was done precisely to evaluate viability of a mushroom production and span preparation unit setup by the Himalayan Research Group (HRG), Shimla in a study village Dhangiara, Mandi, H.P. Data related to involvement of 21 trained women households linked to central collection point for their produce with this unit was collected for three years to analyze the cost-benefit impact, adoption and spread of the mushroom production activity and institutional mechanism involved as presented in Table 5.45.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Detail</th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Growers Investment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Average Mushroom Compost reared/annum/household (Kg.)</td>
<td>3000</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>2.</td>
<td>Cost of 3000 Kg mushroom compost (Rs.)</td>
<td>12,000</td>
<td>13,500</td>
<td>13,5000</td>
</tr>
<tr>
<td>3.</td>
<td>Cost of Minor changes in household room 10’X10’X10’ with four tier wooden racks, insecticides etc. (Rs.)</td>
<td>1540</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>4.</td>
<td>Transportation cost of compost (Rs.)</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>5.</td>
<td>Total investment (Rs.)</td>
<td>13,690/-</td>
<td>13,890/-</td>
<td>13,890/-</td>
</tr>
<tr>
<td>B.</td>
<td>Growers Returns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Total No. of cycles/year</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>Average yield of mushroom in three cycles (Kg.)</td>
<td>600</td>
<td>640</td>
<td>670</td>
</tr>
<tr>
<td>3.</td>
<td>Sale Price of fresh Mushrooms - ungraded, unwashed, unpacked (Rs./kg)</td>
<td>41</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>C.</td>
<td>Gross Returns (Rs.)</td>
<td>24,600/-</td>
<td>27,520/-</td>
<td>28,810/-</td>
</tr>
<tr>
<td>D.</td>
<td>Net profit/annum/household (Rs.)</td>
<td>10,910/-</td>
<td>13,630/-</td>
<td>14,920/-</td>
</tr>
<tr>
<td>E.</td>
<td>Intangible Benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Economic:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Spent compost produced /annum/household (Kg.)</td>
<td>3000</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>1.2</td>
<td>Value of spent compost @Rs.1/-kg</td>
<td>3000</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>2.</td>
<td>Ecological</td>
<td>Good quality compost for use in agricultural field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Social</td>
<td>Improved livelihood and household level food and nutritional security; augmenting income potential for women and unemployed youths.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.46. Correlation Matrix for Button Mushroom Cultivation Technology in terms of Gross Return and Input Cost

<table>
<thead>
<tr>
<th></th>
<th>Gross Returns</th>
<th>Input cost</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Returns</td>
<td>-</td>
<td>0.954</td>
<td>0.990</td>
</tr>
<tr>
<td>Input cost</td>
<td></td>
<td>-</td>
<td>0.904</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>26976.66</td>
<td>13823.33</td>
<td>636.66</td>
</tr>
<tr>
<td>SD±</td>
<td>2156.95</td>
<td>115.47</td>
<td>35.11</td>
</tr>
</tbody>
</table>

Factors affecting gross returns with reference to input cost and production of mushroom
Input cost = 5.97
Production = 43.00

**Correlation and Regression Analysis**: Examination of figures in matrix table 5.46 clearly shows that maximum correlation is between gross return and production followed by input cost and minimum between input cost and production. Best fit regression equation analysis exhibited that one unit increase in input cost will result in 5.97 unit increase in gross returns and explains further need of refinement and technological input in the existing model of mushroom cultivation. However, the one unit increase in production is expected to increase gross returns by 43 units which is very close as per the available data as presented in Table 5.5.3 that one Kg mushroom is sold for Rs. 41-43/Kg. It can be inferred from regression analysis that total viability is dependent variable from input factors namely quality spawn, compost and other cost. Similar results on economic feasibility and factor productivity of mushroom farming by mushroom growers have been reported by Chandel and Suman (1996), Sigh et al. (2004) and Rani et al. (2006) showing economies of scale of production with average pay back period of one year.

A perusal of results in Table 5.45 indicate 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 (with gross return more than 2 - fold) 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 (Dhar and Verma, 2001) 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. It was also found that people from the adjoining areas are coming forward to undertake button mushroom cultivation activity as a self employment venture for educated youths and women self help groups organized by the Department of Social Justice and Empowerment. It shows that button Mushroom cultivation technology can help in
generation of employment opportunities in a big way and is a matter of taking a right initiative at a right place. Areas in different mountainous states above 2000 meters altitude are most suitable for growing of button mushroom barring few months of winter season when temperature is extremely low.

3. Medicinal Plants Cultivation: *Swertia* sp.

Utilization of plant based drugs for prevention and cure of various kinds of ailments in the country is practiced since time immemorial. This has lead to severe scarcity of many medicinal plant species including those required by traditional healers for common use. In view of the high demand, during past few decades their extraction is far more than their re-venerability in nature (Khosoo, 1993) creating a lot of pressure on the natural flora. Around 70 per cent of India's medicinal plants are found in the tropical forests and remaining 30 per cent comprising 1748 plant species are found in temperate and alpine areas constituting IHR (Samant *et al.* 1998). Western Himalayas contains 50 per cent of the plant drugs mentioned in the British Pharmacopoeia (Nautiyal *et al.*, 1998). Reports on the use of wild medicinal plants in Eastern and Central Himalayas are those of, Gangwar and Ramakrishnan (1990), Bhatt and Gaur (1992) and in Western Himalayas by Badola (2001). Hence, there is an urgent need to stop the exploitation and protect the existing species through conservation and their cultivation on farmer's land. It is reported that India is importing herbs like *Swertia chirata* Buch-Ham., *P. kurrooa*, *Nardostachys grandiflora* DC. (*syn. jatamansi*), and *Aconitum spicatum* (Bl.) Stapf from different parts of the Nepal (Edward, 1993) which, were found abundantly in the Indian Himalayas.

The quality of plant material will be the prerequisite to compete in the export market under the changed scenario of WTO regime and Globalization. Cultivation of medicinal plant is, therefore, imminent and can meet these requirements and fill the gap between demand and supply on one hand and conservation of natural resource on the other to sustain the livelihood of poor people. Cultivation can lead to the improvement in conservation as noticed in certain villages of Central Himalayas for *Arnebia stracheyi* and *Carum carvi* Linn. (Uniyal *et al.*, 2002). Dhar *et al.* (2002) have emphasized the need to cultivate medicinal plants in the Himalayas as an income generating activity. Another viewpoint is that cultivation will be fruitful only in natural habitat i.e. *in situ* cultivation to avoid any competition with the food crops. Medicinal plants propagation under forest land was popularized under Joint Forest Management in the sate but has not yielded the desired result as no harvesting from the planted plots has been done till now and may be hampered due to the involvement of many stakeholders. Therefore, cultivation on individual revenue land as *ex situ* cultivation is the need of hour.
Table 5.47. Cost Benefit (Rs./yr./hh) and Livelihood Impact Analysis for Medicinal Plants Cultivation (*Swertia sp*) on one Bigha* (18 households out of total 104)

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Detail</th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Farmer’s Investment</td>
<td>800</td>
<td>880</td>
<td>880.00</td>
</tr>
<tr>
<td>1.</td>
<td>Land preparation</td>
<td>8000</td>
<td>8000</td>
<td>----</td>
</tr>
<tr>
<td>2.</td>
<td>Cost of seed material ( 80 gm.) @ Rs. 100/gm.</td>
<td>600</td>
<td>740</td>
<td>700</td>
</tr>
<tr>
<td>3.</td>
<td>Maintenance of Crop</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>4.</td>
<td>Quality testing charges</td>
<td>10600</td>
<td>10820</td>
<td>2780</td>
</tr>
<tr>
<td>B.</td>
<td>Returns</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>1.</td>
<td>Duration of cropping cycle (months)</td>
<td>-----</td>
<td>184</td>
<td>192</td>
</tr>
<tr>
<td>2.</td>
<td>Total quantity of crop harvested (Kg.)</td>
<td>-----</td>
<td>190</td>
<td>190</td>
</tr>
<tr>
<td>3.</td>
<td>Selling price of plant material (Rs./Kg)</td>
<td>-----</td>
<td>34,960</td>
<td>36,480</td>
</tr>
<tr>
<td>C.</td>
<td>Gross returns (Rs.)</td>
<td>-----</td>
<td>13,540</td>
<td>33,700</td>
</tr>
<tr>
<td>D.</td>
<td>Intangible Benefits</td>
<td>0.250</td>
<td>0.250</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Economic: Seeds harvested (Kg.)</td>
<td>-----</td>
<td>25,000</td>
<td>25,000</td>
</tr>
<tr>
<td>2.</td>
<td>Ecological: Conservation of Species in the nature: Complete plant of <em>Swertia</em> is harvested at the flowering stage before seed setting and excessive harvesting has threatened the existence of this species in the nature. Large-scale cultivation will provide characterized material to the industry and help in the conservation of this species in the nature.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Social: • Livelihood diversification with technology inputs, improved income with backward and forward linkages. • Utilization of uncultivated land, less run-off, environment friendly. • Education to children, Reduced drudgery and migration</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Cropping cycle = 18 months duration. Cultivation of *chirata* is done in rotation on two plots one bigha each planted successively to set the annual harvesting cycle. Investment of first two sowings is recouped from the return of first crop in 2nd yr., and return of the subsequent crop from 3rd yrs. onwards account for better return only. The farmers keeping few plants till seed ripening in the field produce quality seed for further cultivation – saving in seed cost from 3rd yr. onwards. * 12.5 Bigha = One ha

Many initiatives have been taken in recent years by the Departments like Environment and Forests, Indian System of Medicines through their field implementing agencies, universities, institutes and NGO's for the conservation and sustainable utilization of medicinal plants throughout the country. The progress of all these efforts is still restricted
to the floristic, categorization of species in different conservation categories and small-scale cultivation trials of identified species under natural and polyhouse conditions (Nautiyal and Purohit, 2000; Badola, 2001; Badola and Pal, 2002; Dhar et al., 2002; Manjkhola and Dhar, 2002). Though, sporadic studies exist on the agronomic practices of only few other Himalayan species of medicinal plants which are further limited to the experimental plots or controlled conditions. Either these efforts are contradictory to each other and are lacking any particular methodology to be followed or the involvement of beneficiaries to realize the goal of maintaining, managing, preserving and enhancing biodiversity.

Keeping in view the above facts, a field level technology intervention made for cultivation of one of the high value Himalayan medicinal plants Swertia (Chirata) used by pharmaceutical industry for liver tonic was identified in study area during survey for impact study which appropriately fit in local social matrix benefiting the poor farmers. HRG provided quality planting material by establishing mother nursery as central facility with polyhouse right in the valley near to farmland of women beneficiaries. 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 as presented in Table 5.47.

**Correlation and Regression Analysis:** Matrix Table 5.48 shows that there is a perfect correlation between gross returns and production. When gross return was regressed against input cost it was found that gross return in Chirata cultivation becomes independent of input cost in 3rd year onwards. However, gross return is reflected to increase by 190 units with one unit increase in production. This explains the data as presented in the above table that one Kg Chirata cost Rs.190/- in the market.

| Table 5.48. Correlation Matrix for Medicinal Plants Cultivation (Swertia sp.) in terms of Gross Return and Input Cost |
|--------------------------------------------------|------------------|------------------|
|                                   | Gross Returns  | Input cost | Production |
| Gross Returns                      | -               | (-) 0.511   | 1          |
| Input cost                         | -               | -           | (-) 0.511  |
| Production                         |                 |             | -          |
| Mean                               | 23813.33        | 8066.66     | 125.33     |
| SD                                 | 20636.95        | 4579.70     | 108.615    |

Factors affecting gross returns with reference to input cost and production
Input cost =0.00 (This is on the basis of opportunity cost for the beneficiaries and supply of planting material by the developmental agency in the beginning of intervention stage)

Production =190.00
A perusal of results also indicates that the total average investment cost/household was amounting to Rs.10,600/- to Rs.10,820/- to meet the cost of seed material etc. in 1st year and 2nd year due to cropping cycle of 18 months duration as described in Table 5.47. Investment of first two sowings is recouped from the return of first crop in 2nd year with net monetary benefit of Rs.13,540/-, and significant return of the subsequent crop from 3rd year onwards account for better return amounting Rs.33,700/- with saving in seed cost from 3rd year onwards for further cultivation. Thus, there is an incremental benefit (3-fold) in terms of average gross returns as compared to traditional farming which was found to be Rs.11,970/-/annum/bigha. 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. Similar findings about the profitability have been reported by Nautiyal et al. (1998) about the eight plant species cultivated with the conservation oriented land use at similar altitude by Bhotia tribes in the buffer zone village of Nanda Devi Biosphere Reserves showing total monetary output as well as net return very high in all the species studied. The net return as exhibited in the data presented was found more than 3-4 times than the agriculture crops.

Since life cycle of most of the Himalayan medicinal plants varies from 2-3 years and therefore it is the main constraints in putting these plants under cultivation regime as in the present case of *Chirata*. The women who have started cultivation of *Chirata* on their farmland have to forgo 2-4 agriculture crops. To sustain such a long-term crop, they need some other economic activity to meet with their day to day expenses until and unless the annual cycle of harvesting is not set. Therefore, cultivation package was designed in the manner that each woman grower planted 1/12th of a hectare (locally measured as one bigha) every year for three years. So that a cycle of one unit (One bigha) harvesting and planting is done every year after 3rd year onwards to generate regular annual income. To supplement the income, they were also involved in above discussed off-farm activities for short-term income generation from vermicompost production and button mushroom cultivation supported with relevant technology backup and buy back arrangement. In such an innovative process, it was interesting findings in terms of time saved and used by women for off-farm activities as medicinal plant fields are cultivated and harvested only once in three years considering minor operation of wedding etc. whereas in agricultural operation, field needs to be cultivated 12 times in 3 years for Rabi and Kharif crops. The commitment and interest of women beneficiary was determined in terms of saving of Rs.1/- per day and Rs.30/- month in their group account opened in the nationalized bank. It is evident from this study that cultivation of such high value medicinal plants such as *Picrorrhiza kurrooa*, *Aconitum heterophyllum*, *Nardostachys grandiflora*, *Valeriana jatamansi*, *A. acuminate Royle* can play a prominent role for employment generation,
particularly in rural sectors, if undertaken properly with systems approach as adopted for *chirata* and marketing arrangements integrating the objectives to benefit the farmers/tribal population for improvement in rural economy and reduction in exploitation pressure in the natural forests in the mountain areas (Dobriyal *et al.*, 1997). The perennial nature of these crops will further contain the soil run-off experienced in extensive cropping of cash crops like potato and pea which was widely prevalent in terraced field of the study area. Since active principles of the plant are generally secondary metabolites and their biosynthesis, though controlled genetically, is strongly affected by environmental and cultural factors, it is therefore, suggested to undertake cultivation of medicinal plants nearer to their natural habitats. As a future potential, organic cultivation using vermicompost shall ensure sustainable development not only in terms of the farm output but also in socio-economic and ecological parameters.

5.1.7.2. Emerging Technology Intervention Model (TIM) for Livelihoods Gain

Thus findings of above technological interventions as potential Technology Multiplier Model for rural application clearly shows and justify large scale utility for macro level application particularly in high altitudinal hilly areas to benefit and empower group of small growers especially women and rural youths due to followings:

i. Inducing Economic Potential and Community Empowerment: Adopting Technology to Improve Livelihoods

As a result of above efforts at village level, a cluster level agro-enterprise model has emerged with economies of scale for production of vermi-compost, mushroom and *Chirata* with local support by S&T based field group providing technical back-up as well as managerial services to local growers and farmers in participatory mode for promoting strategic linkages between the farm and off-farm sectors. In case of Button mushroom cultivation, which mainly involves preparation of compost in bulk as a labour intensive activity, it has innovative elements for production of compost through a small scale central facility. This was set up by HRG through bank loan and margin money scheme of Khadi and Village Industries Board, Shimla for production of 20-25 tons/lot pasteurized compost with active participation of about 15-18 trained women working 4-5 hours/day. Preparation of compost, spawning, bag filling and packaging of compost was managed at organizational level through organized women groups’ members and generated cash for monthly savings. Organized women groups accomplish these activities by rotation in decentralized way and almost every member gets an opportunity to earn. A system has been developed by all growers to market their crop in group to avoid any spoilage and promoted a group of educated youths to market the produce in nearby towns.
At the same time all the members of these organized women groups also got trained in preparation of vermicompost primarily uses as casing soil in mushroom culture, thus, providing a direct benefit of Rs.8.90 Lakh to 77 women in three years. Involvement of organized women groups in all these activities generated interest in some women members as shown in Table 5.45 and 5.47 in mushroom production and medicinal plant cultivation with potential monetary benefits. It was found that to make the activity popular among poor women, provision was made for providing spawned compost without cost initially and recoup the cost within 3 months after the sale of mushrooms. This helped the activity to reach the poorest among poor. On an average each women started cultivation on 1000 kg compost which was provided in batches to avoid the glut in the market shows the multiplier effect for technology adoption. On an average, under natural condition 18-20 per cent average yield of mushroom on compost weight per annum was achieved to harvest the benefit of economics of scale of production and marketing efficiency as reflected in Table 5.45. Thus, finding of present study are in agreement with others who suggest that profitability increases with the increase in the size of mushroom farm and vice versa (Singh, 2001). But, it is interesting in present enterprise model from long term sustainability point of view that it is based on cluster level intervention rather than large farm owned by individual - to empower, benefit and generate self confidence amongst small growers for better livelihood opportunities.

Further, it was observed that trained women organized in the form of producer organizations have become proactive and playing significant role in forming farmer-to-farmer extension linkages by imparting training and technical know-how to other women of the catchment’s area as on-going activity having multiplier effects and horizontal flow of technologies. The successful demonstration and adoption of technologies has initiated a under current for adoption by others. This has helped to decentralize the activity and develop the leadership qualities among the rural people. During the study and discussion with growers, it was found that they have benefited directly individually or in a group to have all year round production from vermi-composting and mushroom production technology for self use and sustained income under limited conditions of land and space availability. However, in case of Chirata cultivation, in terms of availability of quality planting material and considering cost benefit analysis for cultivation with extraordinarily long gestation period, contract cultivation on cooperative basis will be the only viable proposition to provide quality medicinal plants for the industry as is also observed by Chominot (2003). The cooperative action will minimize the risk and maintain the traditional cropping cycle till the date lucrative return out of medicinal plants cultivation are not exhibited.
The impact assessment and statistical analysis of data through correlation matrix depicted above for all three activities (Table 5.43 to 5.48) 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. Adoption for cultivation of medicinal plant was also attributed due to non availability of agriculture labor for repeated cultivation of cash crops year after year in study area. Moreover, with initial short term gain achieved in first two years, women’s group have developed a clear business vision in third year for long term gain that involves grading and packaging of produce by improving quality and linking to potential buyers. It was observed that there was a net monetary income in 3rd year to 21 household who adopted both vermicompost 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. vermicompost 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. Hence, farm and off-farm linkages impact with small scale step-by-step diversification shows visible synergistic effects as potential emerging technology intervention model (TIM-7) for economic, ecological as well as social benefit within village economy to meet local livelihoods needs (Figure 5.23). It can also be inferred that such small scale off farm activities linked with agriculture and medicinal plant cultivation with systems approach (Figure 5.24 and 5.25) could be more remunerative in cluster based decentralized approach in subsequent years as it got stabilized in 3rd year to benefit group of small growers collectively for better efficiency and profitability on large scale as shown in Table 5.49 and Figure 5.25.

ii. Technology and Institutional Success Factors: The Process Approach and Innovative Elements

Commercial activity can not be successful until and unless there are strong backward and forward linkages of production and marketing. In case of button mushroom cultivation sustained production as per the market demand is very difficult as the crop takes 5-7 days to mature after every flush is harvested. Therefore, it is not possible for the couple of farmers to sustain the market on long term basis. If farmers start cultivating on larger quantity of compost the risk is very high and maintenance is also cost intensive and failure of even one crop may prove disastrous and it is not possible to restart the activity again. Therefore, the cluster approach and linkages made between off-farm and farm activities clearly shows improved collective net monetary benefits minimizing the risk.
associated at individual level and to sustain the market for products viz. vermicompost, mushroom and *Chirata*. Using participatory approach, women as the primary stakeholders were organized into small saving and credit groups of 10-15 women in each group with total 77 women. During the study, it was found that process of establishing and / or supporting self-reliant groups is not easy. It should not be rushed into or forced on local people. Technology should meet initial requirements of planting material, training and marketing to develop the women groups and build their capacity during the intervention period which lead to direct economic benefits for many rural people. As the confidence grows with the success, groups automatically evolve new roles and responsibilities and cater to the left over people even after the post intervention period.

Therefore, it is critical at policy level to recognize how such spin-off activities can be promoted in the off-farm sector as a mechanism whereby rural households can maintain their livelihoods from backward and forward production level in the presence of agricultural growth. Success of this technology intervention and multiplier model is promising as it focuses on institutional linkage (as local NGO that govern economic relations) with intermediaries (organized women’s groups) and arrange/provide technological support mechanism and other services initially through by government assistance as also reported by Davis *et al.* (2002) in a study carried out in villages of Latin America and three Sub-Saharan Africa regions. It is interesting to note that high value output and significant cash income through off-farm activities has created numerous local linkages as in the present case of vermi-compost production and its use in mushroom production, agricultural field and for cultivation of *Chirata* as compared to traditional agricultural production system leading to development of integrated agro-enterprise technology intervention model (TIM-7). This justify the role of science based civil society for institutional innovation to influence local capacity in organized way with improved market knowledge to invest in driving non-farm economy under local conditions by 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. This certainly helps to overcome market and organizational failures and link between small farmers with agri-business to provide substantial benefits to farmers, growers and the rural economy as a whole in a village probably due to positive income effects of technological change for rural producers/growers (Lundy *et al.*, 2002). The study and discussion with women’s growers also confirmed that poor rural households resort to off-farm activities not only to increase total income, but also to offset the effect of sharp fluctuations in income flows from traditional farming, which is one of the characteristic of rural poverty as also reported by Reardon *et al.* (2000). Thus, findings illustrate farm/off-farm diversification and linkages are important which are mostly with markets outside rather than within villages.
supporting Adleman (1984) for “agriculture-demand-led-industrialization” and in tune with the findings of Taylor and Naude (2002) in a study carried out in micro-region of rural Mexico. Thus, present technology intervention model tried to capture the complex inter linkages among production, institution – including rural households- and the nearby market with village-town relationship. Further, as compared to this, INFARM model - TIM 2 evolved in present study in Garhwal region where on farm diversification occurs - is mostly relying on endogenous production linkages essentially to satisfy household consumption demand and increasing demand for intermediate inputs which may generate important backward and forward production linkages to consumption and expenditure linkages with rest of the economy in surrounding villages as was evident from third year input-out put analysis. Whereas, in the present agro-enterprise based model (TIM-7), exogenous linkages are visible from first year onwards driven by identified market demand/opportunities for specific produce from nearby rural town Mandi and Kullu in Himachal Pradesh. Thus, both models tries to explore and reveal the impact effect of appropriate technological intervention as per location specific needs considering village to village and village-town micro region relationship in shaping and strengthening local livelihood needs as well as village economy with technology linked income multiplier approach. Frequent observation and Impact analysis also suggests that intervention outcomes have addressed the problem of enabling environment for the poor and gender concern in study area by reducing vulnerability to drudgery which is crucial in maintaining subsistence lifestyles of traditional mountain societies particularly inhabiting the high mountain areas with huge economic and ecological potential.

**iii. Future Prospects and Possibilities of Replication: Development of policies for organized Promotional Activities and Linkages Support**

Designing of policies at government level to encourage diffusion of such technology intervention and multiplier model (TIM-7) that brings initial financial support and credit are needed as stimulus to understand and promote the rural farm and off-farm linkages and related production changes with technological inputs and institutional support. This is critical to explore in shaping the changes in rural households incomes and to promote economic growth in rural economies by forming growers groups and integrating producers’ organization to improve the efficiency of resource use and providing for economies of scale (Relio and Morales, 2002). Certainly sincere efforts are needed to streamline the activity initially for diversification of rural livelihoods. Such mechanism and process model to effect local production system and linkages becomes important for generation of employment as it is being realized that agriculture is no longer the primary occupation or income source of most rural inhabitants particularly in remote mountain areas for the survival of poor rural producers and low income inhabitants of marginal
zones where support services are insufficient. On policy level, important issue like organic certification of such products is to be settled to provide such kind of services in the IHR in near future to fetch better price to growers and farmers especially for women folk on ready cash basis at the production site certifying that produce is from cultivated field. Such an approach towards ecological and organic production with value adding activities linked to niche markets will provide the opportunity to generate both farm and off-farm income to poor growers. All these efforts will help in the biodiversity conservation and sustainable development of the rural areas with effective human as well as natural resource use and management. Organized groups of local people can be linked to the Forest Department for joint cultivation on the patch of forestland in case of non-availability of land and keeping agriculture cropping cycle intact. The household members can also use time saved in agricultural operations of the medicinal plant cultivation for some other economic activity.

Finally, institutional reforms is therefore a central requirement of development policy towards the rural sector to recognize and facilitate such process with specific programme to create an enabling environment and promote related activities for rural off-farm enterprises linked with agriculture within mountain ecosystems by involving public sector as their corporate social responsibility (CSR). This calls for specific attention to built local capacities for macro level application with a need to target vulnerable population explicitly recognizing the importance of women’s role focusing on system level opportunities and constraints to address rural poverty and livelihood issues with technological development. Small growers and farmers have to be involved in appropriate technology mix to provide short and long term income generation opportunities on sustainable basis who in turn will be in position to help others and can provide the multiplication material (planting material, compost etc.) and technical know how to propagate the package of practice as evidently visible in the technology intervention model evolved in the present study.
Table 5.49. Cost-benefit Analysis Rs/yr./hh for Small-Scale livelihood Improvement Technologies for High Altitude Himalayan Region

<table>
<thead>
<tr>
<th>Technologies</th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
<th>System Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Input Cost (Rs.)</td>
<td>Output Cost (Rs.)</td>
<td>Net Return (Rs.)</td>
<td>Input (Recurring Cost)</td>
</tr>
<tr>
<td>Vermicompost</td>
<td>2,620</td>
<td>4,200</td>
<td>1,580</td>
<td>4,500</td>
</tr>
<tr>
<td>Mushroom Cultivation</td>
<td>13,690</td>
<td>24,600</td>
<td>12,210</td>
<td>13,890</td>
</tr>
<tr>
<td>Cultivation of Swertia/Bigha</td>
<td>10,600</td>
<td>--</td>
<td>--</td>
<td>10820</td>
</tr>
</tbody>
</table>
Figure 5.23. Off-farm and Farm linkages for Economic Benefit and Improved livelihood through Vermi-composting (A.1- A.2), Mushroom Cultivation (B.1-B.2) and Chirata Cultivation (C.1-C.4) with Cluster level Approach for Decentralized Production at Village Level.
BIOTECHNOLOGY INPUT PACKAGE (based on local need assessment; technology appropriation & field trial)
• KNOWLEDGE AND SKILL
• ATTITUDE
• INFRASTRUCTURE

SOCIAL INPUT PACKAGE
• AWARENESS
• MOTIVATION
• ORGANISATION
• POSITIVE GROUP DYNAMICS

COST-EFFECTIVE CULTURE TECHNIQUES - SUSTAINABLE USE AND MANAGEMENT OF RESOURCES FOR VALUE ADDITION

RURAL PEOPLE

INTERMEDIATE OUTPUT: Capability for Organizing production, development and management of composting/mushroom units and medplant cultivation.

MARKET CHAIN

Service spin off: Quality production of Vermicompost/Mushroom/Plantlets and group certification

• Improved Health
• More income
• Additional Employment
• Sustainable Growth

GOAL
- BALANCED SOCIO ECONOMIC DEVELOPMENT
- CULTURAL IMPROVEMENT
- ENVIRONMENTAL SECURITY
- SUSTAINABLE GROWTH

Specific S & T output

Specific Social output

Figure 5.24. Institutional Framework: Systems Approach and Adoption factors for Effective Technology Transfer customized to local Needs.
Fig. 5.25. Farm and Off-farm Linkages for Diversification of Rural livelihoods: Technology driven Model (TIM-7) for Rural Business Development in High Altitude Himalayan Region.
Integrated Resource Management

5.1.8. Integrated Village Development (TI-8)

Development is a process and a result of change induced by planned programs aimed at improving the condition and conduct of everyday human life in society. The pace of development of a village depends on various inherent characters such as location, nature of land, availability of water, other natural resources, means of communication and ultimately human resource. These factors sometimes limiting and vary from village to village and are more in case of mountains. The holistic approach for development of a village therefore would be a location specific to meet livelihood needs. Besides individual need, common necessity is also one of the essential variables in the pace of village development. It is, therefore, to strike and effect holistic development process for village in the hills.

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 studied covering farm, off-farm and particularly artisanal sectors and their inter-linkages that raise overall productivity and protect or improve the environment needs. In continuation of technology intervention (TI-4) for Integrated resource management studied and described earlier under this chapter (item no. 5.1.4) it was purposely done to understand especially the role of non-farm sector in hill economy for providing income diversification opportunities and to analyze possibility of model of integrated planning and development and its sustainability to address livelihood needs in mountain areas. 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 keeping in view the survey findings and livelihood assessment as described in chapter 4, and potential of such technological intervention strategy for replication as compared to traditional livelihood system relying mostly on rain fed agriculture. Impact assessment in participatory mode for pre and post intervention with reflexive control of same beneficiaries was done for expression of results as described in Chapter 3 to evaluate the micro-level feasibility and livelihood benefits.
5.1.8.1. Technology: Decentralized Technologies for Value Addition and Income Generation

The study revealed that during pre-intervention period, most of the poverty and livelihood related problems in the village were due to mismanagement of the local natural resources indicating the inadequacy of the developmental strategies with soil erosion, resulting into low land productivity. The other major problem was found about the lack of proper irrigation facilities in the village. Since there was no village forest, people were more dependent on private lands for meeting fuel wood and fodder requirements and to a large extent on the government forestland. Due to lack of quality fodder and irrigation facilities people were unable to fetch good returns from their farms produce and livestock. There was also lack of livelihood opportunities within the watershed. The main source of livelihood for the people was daily wage labor (primary source of livelihood for 80 per cent of the households) and agriculture to fulfill their basic needs. The dearth in local employment opportunities resulted into a high level of out-migration. Participatory discussions revealed that availability of water for domestic and agricultural use was the topmost priority for the villagers.

To address above with decentralized approach in mind, intervention was made by Society for Technology and Development (STD), a science based field group in Mandi, HP with introduction of suitably de-scaled and appropriate technologies in farm as well as non-farm and off-farm sectors. The integrated and holistic approach was devised to strengthen and revive traditional artisans to compete with organized system and to provide new income generating opportunities to augment the income of households with introduction of improved farming practices. A visible impact with simple intervention was made by constructing gravity water channel (Kuhl) to canalize 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 reflected in Figure 5.26 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.

Thus, the initial interventions were directed at raising agricultural productivity through better land and water management, better input management, sustainable practices including organic inputs linked with better marketing strategies facilitated by STD. Post harvest preservation and processing including storage techniques also
found favor within the community at small scale secondary activity. Upgrading traditional skills, diverse forms of organized production activities, better use of local resources and markets were attempted at individual as well as community level by revival of artisanal trades (leather, pottery and black smithy) with upgraded technologies and supportive environment for micro-enterprise related livelihoods as shown in Table 5.50. Besides technology component, intervention was also directed to improve local habitat, assist in improving social sector components like sanitation, water availability, health-care etc. thereby contributing to the overall improvement in quality of life with holistic approach.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Technology/support Activity</th>
<th>Pre-Intervention</th>
<th>Post-Intervention</th>
<th>Impact Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kulh (Cemented water channel) and hydram</td>
<td>Only rainfed agriculture</td>
<td>Land (65 ha.) irrigated</td>
<td>Shifting to off-seasonal vegetable besides staple crops benefiting 57 farmers</td>
</tr>
<tr>
<td>2</td>
<td>Training and awareness on Crop Diversification, vermicomposting, Fuel wood and Fodder grass plantation Barseem (<em>Trifolium alexandrinum</em>), Maize (<em>Zea mays</em>) and Barnyard millet</td>
<td>Only rice, wheat and maize</td>
<td>Green peas, cabbage, tomato, and capsicum production</td>
<td>Slowly replacing chemical fertilizers with vermi-compost; availability of fodder for livestock. Adoption of vermin-composting by 25 households.</td>
</tr>
<tr>
<td>3</td>
<td>Pottery (introduction of improved Kiln, and motorized wheel); and black smithy (introduction of mechanical hammer)</td>
<td>Declining traditional trade</td>
<td>Revival of livelihood support to 16 artisanal families.</td>
<td>Employment generation skill up gradation, reduction of drudgery with increased production efficiency. -Diversified product range. Artisanal group formed with collective production centre. -Systems provided economies of scale and substantially higher productivity in organized way (10-15 potters) not available to individual potter.</td>
</tr>
<tr>
<td>4</td>
<td>Backyard Poultry and Integrated fishery</td>
<td>Nil</td>
<td>14 families involved</td>
<td>New avenues of income generation with livelihood diversification at village level</td>
</tr>
<tr>
<td>5</td>
<td>Handloom weaving</td>
<td>Traditional loom used by 3 women</td>
<td>9 women are involved</td>
<td>New product range with better market linkages; enhanced family income</td>
</tr>
<tr>
<td>6</td>
<td>Awareness on health, literacy and habitat improvement</td>
<td>Frequent School drop outs</td>
<td>Dropouts checked, awareness about personal health increased</td>
<td>Saving of money on medicines, Girls also given proper education, gender sensitivity increased.</td>
</tr>
</tbody>
</table>
5.1.8.2. Technological Intervention with integrated Approach: Impact Analysis

The study revealed that select S & T based intervention/support services were undertaken to evolve enabling environment through community participation and sustainable institutional system to create a model village having following elements for improved livelihood. The intervention with integrated and holistic approach has been directed both for human resource as well as natural resource management to strengthen village economy with following systems approach:

- Location-specific, need-based and affordable technological solutions covering different sectors (farm, off-farm and non-farm) for livelihood diversifications bridging the existing gaps of basic requirements (food, fodder, fuel-wood, water and livelihood).
- Linkages with suitable resource agencies for sourcing various technologies that were sought to be infused.
- Involvement of Panchayat, State Govt. departments and other developmental agencies to take up corresponding measures (like fisheries and installation of Hydram) which are needed though not covered under the IVLD.
- Participation of the village community was ensured in all stages of the programme i.e. in conceptualization, planning, implementation and maintenance with complete transparency: the villagers were able to 'own' the programme.
- Enhance food grain production levels by providing irrigation facilities and introducing improved seed varieties.
- Creation of livelihood opportunities for women and artisans and other disadvantaged section in the village. Groups’ formation of artisans notably among potters, blacksmiths and weavers with introduction of de-scaled technologies.
- Plantation of fuel wood and fodder species in barren land.
- Formation of a village level institution i.e. Village Development Committee so as to undertake implementation of various works and ensure subsequent maintenance of the assets created.
- Empowerment of women through formation of Mahila Mandals and Self-Help Groups.
- Awareness generation for health, nutrition and income generation activities with essential features of physical and social infrastructure.

- Establishment village fund (gramkosh) in the village for promoting self-reliance.

Above intervention strategy with minimum infrastructure support has resulted in formation of 8 SHG to carry out related income generating activity with marketing. It was found that four technology based trained group are functional in non-farm sector i.e. in pottery, weaving, black smithy and in construction technology to make value added products/services with a suitably scaled common facility production centre for each trade with equipment and machinery. While, in farm sector, 2 groups are engaged in growing off-seasonal vegetables and production of vermi-compost. In off-farm activities, 2 groups were formed to carry out Backyard poultry and fishery.

Having met their basic amenities through community participation, villagers are able to bring socio-economic development in the village through natural resource management. The trained youth and women groups are able to organize and implement development plans with the help of block and district administration, identify local resources and their utilization. Study shows that the technology interventions have been directly linked with the local communities and their traditional trades by identifying constraints and gaps through interactions with artisans, farmers and domain experts for adoption of appropriate technologies. It also suggest how rural communities can lift themselves out of poverty web and achieve the goals if they have access to field tested and appropriate technologies that can enhance their farm productivity, health, education, and access to markets – with support of science based field group and local institutional mechanism for participatory community decision making. For each trade and activity, specific group/committee and community members were identified involving local Panchayat to work out a community action plan for implementing and managing related interventions, and sourcing technologies and techniques with the help of STD.

5.1.3.3. Emerging Technology Intervention Model (TIM) for Livelihoods Gain

The findings of above intervention shows that infusion of a multi-sectoral package of innovative technologies has created a cascading effect in the surrounding region of the study village, with people knowing about use of technologies for employment generation and augmentation of income. It has also shown a tangible improvement in awareness regarding utilization of natural resources like water availability with
people-oriented measures to check ecological degradation, especially of forests, pasture land or local water bodies. Study has also revealed that technological orientation was completely lacking and there was typically little mobility out of extreme poverty, and many households remain poor for generations. Therefore, any credible broad-based development strategy must involve public policies aimed directly at promoting asset accumulation by chronically poor households.

Another important criterion to ascertain sustainability of this intervention model is number of SHGs (8) formed and mobilized in 2-3 years for economic enterprises, who in long term now in post intervention period are responsible in executing and spreading the related technology ensuring social acceptance (and hence, sustainability) among the intended end users. Small land holdings and low productivity of lands in study village is evidently found to be the dominating factor with effective alternative strategy for establishment of micro-enterprises in off-farm and non-farm sectors in this NRM model (TIM-8) with reduced pressure and dependency on finite resources.

Such working model of useful technologies in off-farm and non-farm sector with diversification approach considering the limited land availability for agriculture, lack of irrigation facilities in general due to steep and rugged nature of the terrain and poor economic conditions of marginalized families will have rural favour as functional model for economic reforms in the hills. A model village with application of demand based yield increasing and livelihood supporting hill specific technologies, and establishment of common facility centre can act as conduits between technology developers and the end user – a crucial, but missing link in the Himalayan region where it is most needed as also reported by Ragunandan, (2006) and Palni et al. (2006) in Garhwal and Kumaon hills. Thus, improving the existing practices and supplementing these with income generating interventions in holistic and integrated way would go a long way in providing alternative to support livelihood through eco-friendly and yet remunerative activities with risk management capabilities for NRM as also supported by Uphoff (1996) and Ashby et al. (2000).

The state government of hilly states, who have a major role in improving activities in the core infrastructure and social sectors, may take up initiatives for technology based village development which can contribute a lot in the developmental activities leading to economic empowerment of the mountain communities. It was found that unlike other models discussed earlier, for macro level application and replication, IVLD model (TIM-8) approach requires major investment for diverse activities as per location specific needs for holistic and integrated development. This can be taken up
through public-private-NGO (science based) partnership with community as collective social responsibility for generating additional rural employment and incomes, especially in village industries and the unorganized sector of mountain region. Adoption of such technology driven community based model in developmental schemes and programme through inbuilt component of rural marketing and management activities may help to address economic viability associated with implementation of such programme to address the needs of the poor households.

In this process, the role of S&T based voluntary organizations with a good grassroots track record are vital to match the livelihoods need of the diverse community by sourcing and delivering technology as complete package with initial support of donor/financial agencies and subsequent hand-holding of end users to manage activities on their own. Need is to introduce selectively various forms of technologies (knowledge/ skills) into the lives of poor people in mountain villages and also provide them with various forms of connectivity in order that they cut the vicious circle of poverty and further impoverishment.

On the basis of above discussed technological interventions and related models 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. 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. Since agriculture sector has been showing declining trends for livelihood security, it is, therefore must to look for livelihoods diversification by adding value to local rural produce or otherwise through processing in non-farm sector. Keeping above facts in view eight technological interventions models (TI-T8) of different scale identified in non-farm and off-farm sector for conservation and effective use of locally available natural resources for improved livelihoods were studied in selected villages of Uttarakhand and Himachal Pradesh and discussed in details will go a long way in their replication and facilitates effective policy formulation for overall development of the mountains regions in the country. Further results of these technological interventions evolved as a complete model/package for adoption and delivery point of view were also studied in detail from people’s perceptions about their appropriateness and feasibility are presented under item No. 5.2 in the successive pages.
Integrated Village Development

Shalla Village Block-Chachyot, District Mandi (H.P.)

Land Use Pattern before Intervention

Figure 5.26. Land Use Pattern after Technological Intervention
5.2. Technology Intervention Models (TIM) and Effective Delivery Mechanisms for Sustainable Rural Livelihoods (SRL)

Sustainability is a multifaceted challenge for India in its path to development to sustain the economic and social gains made over the last three decades. Due to high population density and India’s rapidly growing economy there is unprecedented pressure on environment and natural resources such as land, water, air, soil and forests. An added challenge for the country especially in mountain regions, economic growth needs to be inclusive; to reach out to the people living on the edge under hostile topography and harsh environmental conditions. Therefore, it is critical to strengthen technology driven multi-sectoral development with active participation of stakeholders to increase capacity and accountability of all of them to facilitate sustainable development and utilization of natural resources. In this context, as discussed earlier under item No. 5.1 of this chapter selected technological interventions for NRM and SRL were studied in detail with techno-economic viability and ecological feasibility considering the livelihood gains to the communities. Results of these technological intervention models which has shown potential as complete packages to address the diversified needs were further studied to understand their scale of appropriateness, and systems approach followed for their adoption and delivery at the field level by the end users and other stakeholders. Further, statistically people participation index, stakeholder perception and role of other socio-economic factors were also analyze for assessment of these models from stakeholders point of view to ensure long term sustainability.

5.2.1. Outcomes: Technology Models at Household and Community Level

Results and outcome of different technological interventions as “technology intervention models” with systems approaches as discussed under item no. 5.1 were crystallized and following technology models of different scales (Table 5.51) found to be effective under field conditions for NRM and improved livelihoods in mountain areas.

1. **Individual/Household levels**: INFARM activities, Carpet weaving, 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.
4. **Entrepreneurs**: Vermi-composting.
5. **Convergence at multi-sectoral levels**: Micro Watershed Management link up with income generation; INFARM Model and Village Development Programmes.
<table>
<thead>
<tr>
<th>Technology Models</th>
<th>Study Sites (Villages)</th>
<th>Traditional Practice/Technology Gaps/Major Felt Needs</th>
<th>Upgraded Technology/New Components</th>
<th>Scale/Mode of Operation</th>
<th>Technology Adoption/Flow</th>
<th>Impact Benefit for Livelihood Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TIM-1 (Improved watermill)</td>
<td>Dokhwala, Dehradun.</td>
<td>Flour grinding with low efficiency</td>
<td>Change in runner; use of ball bearings; water use for nursery and fishery etc.</td>
<td>Community level</td>
<td>High (extension to other Himalayan state)</td>
<td>• Multi-purpose use for energy needs and income</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Clean technology to compensate CO₂ emission.</td>
</tr>
<tr>
<td>2. TIM-2 (Integrated farming for resource management)</td>
<td>INFARM-1 Ambiwala, Dehradun.</td>
<td>Low agricultural yield; Fodder scarcity</td>
<td>Composting; improved crop varieties (Cash and nutritional); crop diversification; Integration of leguminous crops; integration of livestock (beekeeping and poultry) along with vegetable cultivation.</td>
<td>Household level (for small farms: 0.2-0.3 ha trial plot)</td>
<td>High (farmer to farmer)</td>
<td>60 percent increase in farm productivity; resource integration; Off-farm income generation; enhancing diversity and nutritional security</td>
</tr>
<tr>
<td></td>
<td>INFARM-2 Chaundiyat, Uttarkashi</td>
<td></td>
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<tr>
<td>3. TIM-3 (Post Harvest Processing of Horticultural Produce)</td>
<td>Gagotu, Rudraprayag.</td>
<td>Huge wastage, no processing facility</td>
<td>Setting up of processing unit of proper scale</td>
<td>Network model with cluster approach involving 50 small farmers</td>
<td>High (farmer to farmer)</td>
<td>• Value addition at source itself</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Local market supply</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Product diversification</td>
</tr>
<tr>
<td>4. TIM-4 (Biomass utilization and management)</td>
<td>Use of Lantana Sp. Dokhwala, Dehradun</td>
<td>Invasive or unutilized plant species</td>
<td>Value added products; furniture making; briquetting</td>
<td>Household as well as Enterprise model</td>
<td>High (extension to other villages and Himalayan state)</td>
<td>Decentralized scale of operation; ecologically beneficial with opportunistic use for value addition</td>
</tr>
<tr>
<td></td>
<td>Use of Grewia (Bhimal) Gagotu, Rudraprayag</td>
<td>Multi-purpose family tree</td>
<td>Improved fibre extraction process; products design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. TIM-5 (Carpet weaving and) Saldhar, Chamoli.</td>
<td>Wooden loom with more drudgery and low</td>
<td>Adjustment devise with improved loom, Household level</td>
<td>Medium (extension to local weavers); Product diversification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIM-6 (Water harvesting and conservation)</td>
<td>Shilanji Dangra, Sirmour</td>
<td>High soil erosion and excessive run-off rate of water</td>
<td>Run-off harvesting, storage and recycling; introduction of protected cultivation technologies</td>
<td>Community and individual level</td>
<td>High (extension to other revenue villages in watershed area)</td>
<td>Reduced drudgery and migration</td>
</tr>
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<td>----------------------------------------</td>
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</tr>
<tr>
<td>TIM-7 (Agriculture based micro-enterprise)</td>
<td>Vermi-Culture Biotechnology</td>
<td>Heap method of composting</td>
<td>Reduced time of composting</td>
<td>Decentralized production unit</td>
<td>Household level</td>
<td>Medium (extension to other village at block level)</td>
</tr>
<tr>
<td></td>
<td>Mushroom cultivation</td>
<td>Dependency on traditional agricultural practices with low yield</td>
<td>Establishment of mother nursery</td>
<td>Individual farmer level</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Medicinal Plant (Swertia sp.) cultivation</td>
<td></td>
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</tr>
<tr>
<td>TIM-8 (Integrated village development)</td>
<td>Shalla, Mandi</td>
<td>Rain fed area; poor agricultural growth; dying traditional artisanal trades</td>
<td>Use of Hydram; introduction of de-scaled technology for pottery, weaving, blacksmithy and construction activities; fuel wood and fodder plantation; vegetable cultivation; and fishery</td>
<td>Multi-sectoral Network model – community based</td>
<td>Medium</td>
<td>Improved water management; Revival of artisanal trades; employment generation; supportive environment for enterprise related livelihoods</td>
</tr>
</tbody>
</table>
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 black smithy, pottery covering rural engineering were found to be equally important to secure livelihoods of artisans, landless labourers through cost effective technological interventions to nurture their skills. A close study of all the technology interventions at study areas clearly brings out the following characteristics/modes of technology transfer mechanism specific to each model of different scale.

1. **Technology Transfer at Individual/Household levels:** These are easy to install, operate and maintain technology systems, which can be adopted at individual/household levels. The initial investment level is marginal and the returns are attractive both in the short and long terms (TIM-4, TIM-5, and TIM-7).

2. **Utilizing the Artisanal Network for Technology Transfer:** Rural local economy has a distinct town-village network in terms of market access, availability of raw materials and manufacturing infrastructure for activities based on artisanal skill. Properly scaled technology models can be replicated and transferred through such artisanal network where a large number of artisanal groups support each other for various levels of independent functions. Model of such scale (TIM-4 for use of *Lantana*) was found in the network of Artisans to make use of *lantana* in which they were able to effectively utilize the *Lantana* resources and their own skills for establishing a viable and sustainable production micro-enterprise. Most importantly, the value addition is done at village levels, which brings greater benefits to all the stakeholders.

3. **Networking of Primary Production and Secondary Processing Units:** This is perhaps the best NRM model (TIM -3) for mountain areas by which technology can be effectively transferred. It is based on secondary production systems using agricultural/horticultural products as inputs including secondary processing and backward integration. In this model, a network has been established between small farmers, decentralized processing/ production centers and state-of-art modern mother/nodal unit with all the necessary statutory clearances. This network (NBMS structure - Nodal, Big, medium and small) ensures that small farmers get adequate returns for their
agricultural/horticultural produce – value addition at source itself with quality production. The decentralized unit of proper scale with sub-units produces diversified processed products with year round production. Such decentralized production center can brings in additional income at household level and the mother units takes on the responsibilities of marketing the final product at local and outside markets. This has also resulted in long term sustainability by linking the women from small farmers families in the area with the production and marketing system – involving their full participation at all levels, thus, making them self confident.

4. **Franchising of Technology:** It is often found that an extremely relevant technology developed either by an R&D/technological institution remains grossly underutilized due to inadequate replication efforts. A successful method of large-scale replication of such useful technologies is by franchising the knowledge and skill to an individual or a group of individuals or an NGO. The parent institution provides necessary technical back-up support wherever required and the field work involving actual replication activities are taken up by the franchisee. Under this category, community based model (TIM -1) for improved watermill with three optional modes for multiple use of water was found to be of immense utility to meet the small energy needs like cotton combing and rice de-husking; and village electrification in non grid areas for household needs. This technology model now being replicated in other Himalayan states including HP to upgrade old watermills by Forest Department and State Energy Development Agency like HIMURJA as well as Indian Army in remote North and North–Eastern region.

5. **Entrepreneurship Model:** Very similar to the franchise arrangement, such technology transfer processes are based on young entrepreneurs who pick up and adopt technologies developed by the laboratories (or such other S & T agencies) and pilot tested by field level organizations for successful commercialization. The investment is entirely of the entrepreneur and essentially it is a small business enterprise located in rural area with the local market as its main client. Such entrepreneur model of technology transfer has emerged in the area of at village vermi-composting and mushroom cultivation (TIM-7) with farm and off-farm linkages.

6. **Convergence at Multi-Sectoral levels:**

   a. Micro-Watershed Management link up with income generation: A water harvesting and conservation model (TIM -6) showed the role of local
community in effective post intervention management. With improved irrigation and agricultural diversification, efforts were made to establish a viable replicable system of natural resource management and sustainable production, harvesting, processing, storage and marketing of value added products based on traditional knowledge and scientific methods involving a network of trained farmers and group of youths. Thus, contributing to increased household income and natural resource base.

b. Integrated Farming and Resource management (INFARM) Model: This model was found potential one to benefit the small and marginal farmers. Study of this model reveals a set of packages for small farms which can be used to ameliorate not only the productivity but would also improve the nutritional and livelihood status of the poor farm households. This model is effective for local NRM focusing on whole farm productivity at system level by integration of various components through participatory research to address the issues of economic viability, ecological soundness and social acceptability. Such an intervention with integrated approach assures an increase in the net economic return, compared to that of the conventional approach/method, for a certain unit of land, water, time and capital which is very important from the farmers’ point of view in mountain areas.

Most remarkable feature of almost all these technology models evolved is that they can be designed in the form of standardized mode for replication as per location specific needs with proper scaling. This suggest necessary policy measures are required for development and adoption of such need based replicable models of small scale for technological empowerment of mountain community for NRM and improved livelihoods.

5.2.2. Success Factors and Strategic Issues: Technology Delivery and Adoption

5.2.2.1. Systems Approach: Grass roots’ Innovation, Linkages and Institutional Management

Institutional management and innovations (locally generated or the result of research interventions), people’s participation, NGO-institution partnership and gender issues are important aspects for participatory research at the grass roots level particularly in the context of technology percolation vis-à-vis natural resources management and utilization. During impact study, special emphasis was laid on to isolate and identify the role of local institutions-community organizations to directly articulate people’s
needs and priorities, people’s participation, technological innovations, social engineering and linkages amongst stakeholders. This was necessary 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 (Figure 5.27). 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. Such systems approach involves designing of intervention programme to infuse technical skills in local people and enhance capabilities of artisans/small and marginal farmers/landless labourers through application of S&T inputs for creation of sustainable livelihoods. This bottom-up approach suggests development of a complete process of identifying needs, appropriate technology design and development, systems engineering resulting in creation of systems based on sustainable technology packages and maintenance of assets created (Raghunandan, 1988). The process takes into account the local resources/skills available, the problems of the existing economic structures, gender and environment friendliness of the technology package and long-term sustainability of the intervention made. Thus, focus of technology development and transfer model would be to a problem solving approach rather than merely developing products or processes for the benefit of rural people and society.

The common salient features could be summarized as under for ‘systems approach’ as management tool to modulate, customize and transfer technology as a package to the field as user and environmental friendly so as to have easy adaptability and explicability (Figure 5.27).
Figure 5.27. Systems Approach for Effective Technology Development and Delivery with Participatory Approach
• 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. 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.

• 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.

Steps involve in effective technology development and delivery process should, therefore, involve the following as management strategy for better outreach:

• Need assessment/Problem diagnosis: need identification and technology gaps as perceived by people in the village;

• Identification of technology source (S&T institutions);

• Maximum utilization of local resources which can be sustained economically and ecologically, skills and markets;

• Participatory technology modulation/development which are environmentally compatible and socio-economically sustainable;

• Self-sustaining S&T base in rural areas (S&T based NGO or field groups) for effective technological intervention/ to develop location specific technology package taking into account the perceptions of people.

• Setting up of viable S & T based micro-enterprise involving S&T field groups in remote mountain areas and linking them with nearby S&T institutions/labs for adaptive R&D based on field generated specifications;
• 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.

Therefore, entire technology package as model will have to be developed based on local needs, which, in turn must be evolved through a detailed scientific micro-planning exercise. Thus, appropriateness of technology delivery system through S & T base would revolve around effective education and learning process to facilitate the development of creative, innovative and autonomous capabilities in individual and community as a whole through attitudinal/behavioural changes to promote evolution and transfer of environmentally sound technologies (Khosla, 1991; Agarwal and Kumar, 1993). With ‘Systems Approach’ discussed above based on study of models evolved, it is conclusive that effective technological interventions can be made at the grass-roots level to protect and improve the rural livelihoods of disadvantaged people in mountain areas. Such interventions strategy for technology delivery can brought in visible changes in the lifestyles of local people and can have multiplier effects in other mountain areas through some appropriation as per local needs with technical backup support of its technology generator/provider groups.

5.2.2.2. People’s Participation and Empowerment

Considering the potential of the technologies and favorable perception about them among the sample rural households/end users, it was presumed that they would adopt or intend to adopt them for their benefit. But, it was felt that participatory assessments of representative samples for technological intervention models (TIM) will be particularly useful for policy making because they will provide valuable insights into how handicapped social groups-women, indigenous people, artisans and tribals assess their situation with such technology based interventions from the point of view of appropriate ness and overall feasibility (Chambers and Jiggins, 1986; Singh and Gill, 1993; Singh and Padaria, 2005). It will also help to know 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. Therefore, the study tried to analyze people participation index (PPI) as per method described in Chapter 3 (item No. 3.7.1) during planning, implementation and post intervention period of each livelihood related technology intervention models evolved. A
stakeholders’ analysis for people’s perceptions with respect to 15 indicators of appropriateness which influence feasibility and effective delivery was also done to understand the appropriateness of each model and its impact and utility from users’ perspective. 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 as per detail in Chapter 3 ((item no. 3.7.1). For stakeholder analysis, a sample of 30 respondents with 20 users/intended users and 10 non-users/other stakeholders was taken for each of the technology model and Pearson correlation coefficients for same number of respondents were worked to identify the nature of relation between adoption and the socio-economic characteristics of end users.

i. People’s Participation Index

On looking at statistical average for sample 30 households for each technology intervention in study areas during planning, implementation and maintenance phases, it was found that people’s participation was in increasing order which was highest during maintenance stage (Table 5.52) 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-1, 2 and 3), TIM-2 (INFARM -2), TIM-3 (Hort-processing), TIM-5 (Improved loom) and TIM-7 (Vermicomposting 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 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.
Table 5.52. Scores (Nos.) and People’s Participation Index (%) at different stages of Various Livelihoods related Technological Interventions Models/Packages evolved.

<table>
<thead>
<tr>
<th>S.N</th>
<th>Technology Intervention Models (TIM)</th>
<th>Intervention Stages</th>
<th>Overall People’s Participation Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Planning</td>
<td>Implementation</td>
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<tr>
<td></td>
<td></td>
<td>Total Score Obtained*</td>
<td>Mean Score (N=30)</td>
</tr>
<tr>
<td>1.</td>
<td>TIM -1 IWM -1</td>
<td>100</td>
<td>3.33</td>
</tr>
<tr>
<td></td>
<td>TIM -2 IWM -2</td>
<td>100</td>
<td>3.33</td>
</tr>
<tr>
<td></td>
<td>TIM -3 IWM - 3</td>
<td>100</td>
<td>3.33</td>
</tr>
<tr>
<td>2.</td>
<td>TIM - 2 INFARM -1</td>
<td>92</td>
<td>3.07</td>
</tr>
<tr>
<td></td>
<td>INFARM -2</td>
<td>92</td>
<td>3.07</td>
</tr>
<tr>
<td>3.</td>
<td>TIM -3 Horti-Processing</td>
<td>101</td>
<td>3.37</td>
</tr>
<tr>
<td>4.</td>
<td>TIM - 4 Biomass</td>
<td>90</td>
<td>3.00</td>
</tr>
<tr>
<td>5.</td>
<td>TIM - 5 Improved Loom</td>
<td>96</td>
<td>3.20</td>
</tr>
<tr>
<td>6.</td>
<td>TIM - 6 WM</td>
<td>98</td>
<td>3.27</td>
</tr>
<tr>
<td>7.</td>
<td>TIM - 7 VC</td>
<td>92</td>
<td>3.07</td>
</tr>
<tr>
<td></td>
<td>Mushroom</td>
<td>94</td>
<td>3.13</td>
</tr>
<tr>
<td></td>
<td>Med Plant</td>
<td>88</td>
<td>2.93</td>
</tr>
<tr>
<td>8.</td>
<td>TIM - 8 IVLD</td>
<td>88</td>
<td>2.93</td>
</tr>
</tbody>
</table>

For calculation of mean score, the maximum possible score for all three stages (planning, implementation and maintenance) was 5. The participation level was grouped under categories of low (participation index up to 33.33 per cent), medium (participation index range 33.34 to 66.66 per cent) and High (participation index above 66.67 per cent).
While, in the case of TIM-7 (vermi-composting), TIM-2 (INFARM-1), TIM-4 (Biomass utilization), TIM-7 (Mushroom production and medicinal plants cultivation) and TIM-8 (IVLD), overall people’s participation was found medium and in decreasing order ranging from 66.44 to 59.55 per cent as shown in Table 5.52. This is attributed due to specific nature of such technologies as a package designed to supplement the income through on-farm and off-farm/non-farm intervention with opportunistic use as in the case of TIM-4, TIM-7 and TIM-8. For TIM-2 (INFARM-2), overall participation index as compared to INFARM-1 is high probably due to large land holdings with the households and limited opportunities for income generation at remote high altitudinal location (1700m amsl) of village Chaundiyat, Dist Uttarkashi contributing towards better adoption of technology package to sustain their livelihood needs.

Thus, above trend analysis for 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 (Table 5.53 and Figure 5.28) which is in consistent with Lilja and Ashby (2001). It clearly support effectiveness in process chain innovation for successful delivery and adoption of technology interventions studied and explored - as viable replicable models of various scale in study areas as discussed under item 5.1 to manage local resources in sustainable way.
ii. Stake holder’s Perceptions

To draw the insight of impact of technological interventions from the users’ perspective as major stakeholder, study also carried out to understand their perceptions with respect to 15 indicators of appropriateness for each livelihood related technological intervention models (Table 5.54) explored during the study as discussed under item no.5.1 of present chapter. It is interesting to note that users’ perceptions for all the technological intervention models was high for all fifteen indicators 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). Highest level of appropriateness for no. of indicators (perceived mean score 4.90 and above) was found for Improved loom for carpet making (TIM-5) followed by Improved watermill and multiple use of water - IWM -2 (TIM-1), watershed management with small scale protection technologies (TIM-6), INFARM -2, INFARM-1, horti-processing (TIM-3) and Vermicomposting (TIM-7).

In case of TIM-4, perception was found medium with respect to physical compatibility, cultural compatibility and natural resource compatibility. Such trend was more intense for TIM-8 towards no. of indicators i.e. simplicity, physical compatibility, livelihood security, natural resource compatibility, and feasibility, sense of ownership, adoptability and technological empowerment. 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 people’s participation index discussed above.

Although, perceived overall appropriateness, technology flow, adoptability and economic efficiency at field level was found high in all technology models except for technology intervention related to cultivation of *Swertia sp.*, a medicinal plant (TIM-7) probably due to high cost of initial investment. But, this activity was also found profitable and cost effective intervention after two years as compared to traditional farming practices in study area as discussed earlier under item no. 5.1.7.
<table>
<thead>
<tr>
<th>Technology Intervention Models (TIM)</th>
<th>Participatory Approaches</th>
<th>Technology Stages</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>A= Lab research (scientists alone without organized communication with users)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B= consultative (scientists alone with organized communication with users)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C= collaborative (scientists and users jointly through organized communication)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D= collegial (users in group alone with organized communication with scientists)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E= User’s experimentation (users alone, individually, without organized communication with scientists)</td>
<td></td>
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</tbody>
</table>

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<th>Participatory Approaches</th>
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<tr>
<td></td>
<td>E= User’s experimentation (users alone, individually, without organized communication with scientists)</td>
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<tr>
<td></td>
<td>E= User’s experimentation (users alone, individually, without organized communication with scientists)</td>
<td></td>
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</tbody>
</table>

Table 5.53. Participatory Research Approaches (based on locus of decision-making) for Various Technological Interventions and Technology Delivery at Field Level
Table 5.54. Stakeholders’ Perceptions with respect to Indicators of Appropriateness of Livelihood related Technology Models/Packages evolved (N=30)

<table>
<thead>
<tr>
<th>Indicators of Technology Appropriateness in entire Innovation Process of Delivery</th>
<th>Garhwal Himalayas</th>
<th>Himachal Himalayas</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIM – 1</td>
<td>TIM-2</td>
<td>TIM-3</td>
</tr>
<tr>
<td>Improved Watermill (IWM)</td>
<td>INFARM - 1</td>
<td>INFARM - 2</td>
</tr>
<tr>
<td>IWM - 1</td>
<td>IWM - 2</td>
<td>IWM - 3</td>
</tr>
<tr>
<td>1</td>
<td>Simplicity</td>
<td>4.70</td>
</tr>
<tr>
<td>3</td>
<td>Observability</td>
<td>4.80</td>
</tr>
<tr>
<td>4</td>
<td>Profitability</td>
<td>4.50</td>
</tr>
<tr>
<td>5</td>
<td>Physical compatibility</td>
<td>4.73</td>
</tr>
<tr>
<td>8</td>
<td>Natural resource compatibility</td>
<td>4.80</td>
</tr>
<tr>
<td>9</td>
<td>Feasibility</td>
<td>4.80</td>
</tr>
<tr>
<td>10</td>
<td>Sense of ownership</td>
<td>4.73</td>
</tr>
<tr>
<td>11</td>
<td>Adoptability</td>
<td>4.43</td>
</tr>
<tr>
<td>12</td>
<td>Technological empowerment</td>
<td>4.63</td>
</tr>
<tr>
<td>14</td>
<td>Overall appropriateness</td>
<td>4.47</td>
</tr>
<tr>
<td>15</td>
<td>Technological flow</td>
<td>4.43</td>
</tr>
</tbody>
</table>

On scale: Strongly agree, Agree, Undecided, Disagree and Strongly disagree with corresponding weight age of 5, 4, 3, 2 and 1. The weighted mean score was calculated. The perception score was grouped under categories of low (score up to 1.66), medium (score range 1.67 to 3.33) and High (score above 3.33).
iii. Adoption of Technologies and its Predictors – the Relation between Adoption and Socio-Economic Factors/Characteristics

Rogers (1965) highlighted that socio-economic characteristics of an individual had great role to play in his adoption decision and action. Hence, the socio-economic characteristics of the end users/respondents were studied with respect to variables viz., age, and education, size of farm holding, social participation, extension linkages and innovativeness. For this, Pearson correlation coefficient was worked out for identifying the nature of relation between technology adoption and the socio-economic characteristics of end users. While adoption was taken as the dependent variables, age, education, size of holding, social participation, extension contact and innovativeness of the respondents were taken as independent (predictor) variables.

The summary of calculated correlation coefficients for adoption and socio-economic characteristics of the end users for each technology are presented in Table 5.55.

**Age:**

It is revealed from the Table 5.55 that age of the respondents had negative relation with the adoption of each of the technology. The relation is highly significant (P<.01) in case of the technologies viz., TIM-2 (INFARM-1), TIM-3(horticultural processing), TIM-4 (biomass utilization) and TIM-8 (IVLD), while, it is significant (P<.05) in case of TIM-2 (INFARM-2). The negative correlation shows that adoption of the technologies was high among the respondents with less age.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Technology Intervention Models</th>
<th>Socio-economic Factors/Characteristics with Correlation Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age</td>
</tr>
<tr>
<td>1.</td>
<td>(TIM-1) IWM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IWM-1</td>
<td>-.268</td>
</tr>
<tr>
<td></td>
<td>IWM-2</td>
<td>-.268</td>
</tr>
<tr>
<td></td>
<td>IWM-3</td>
<td>-.228</td>
</tr>
<tr>
<td>2.</td>
<td>(TIM-2) INFARM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INFARM-1</td>
<td>-.458*</td>
</tr>
<tr>
<td></td>
<td>INFARM-2</td>
<td>-.458*</td>
</tr>
<tr>
<td>3.</td>
<td>(TIM-3) Hort. Processing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-.445**</td>
</tr>
<tr>
<td>4.</td>
<td>(TIM-4) Biomass</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-.435**</td>
</tr>
<tr>
<td>5.</td>
<td>(TIM-5) Improved Loom</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-.231</td>
</tr>
<tr>
<td>6.</td>
<td>(TIM-6) WM</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-.076</td>
</tr>
<tr>
<td>7.</td>
<td>(TIM-7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VC</td>
<td>-.141</td>
</tr>
</tbody>
</table>
Educational Level and Size of land Holding:

The relation of education level with adoption was found to be highly significant (P<.01) for the entire technological intervention model except for improved loom (TIM-5) and IVLD (TIM-8). Similarly, a highly significant (P<.01) relation with adoption was observed in case the size of holding for all the technologies except for improved loom. This may be due to poor accessibility of rural households of Saldhar village in remotely located difficult terrain.

Social Participation:

In case of INFARM-2, the correlation was significant at 0.05 level for social participation. The correlation was highly significant (P<.01) for the technologies TIM-1(IWM-2), TIM-2 (INFARM-1), TIM-3 (Horticultural processing), TIM-4 (improved loom) and TIM-5 (WM), while in case of other technologies it was significant at (P<.05).

Extension Linkages:

Extension contact/linkage though had positive relation with adoption of all the technologies, correlation was significant (P<.05) in case 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, 2 and 3), TIM-3 (Hort-processing), TIM-6 (Micro-watershed Management)

Innovativeness:

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 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, Chamoli, Uttarakhand as compared to the users in other technology intervention areas probably due to lack of basic infrastructure facilities.

These findings evidently suggest that to promote the transfer and adoption of technologies among the end users, besides enhancing attitudinal orientation for technological change and experimentation habit among the end users, social participation and extension contact/linkages, which are medium at present particularly for TIM-2 (INFARM-1 & 2) and TIM-7 (VC, Mushroom and medplant) and low for...
TIM-4 (Biomass utilization) and TIM-5 (improved loom) towards extension linkages, should also be intensified for macro level application which have shown potential as discussed earlier with techno-economic viability and ecological feasibility. Such slow extension of these technological interventions may be due to their utility in remote locations at high altitudinal areas with scattered settlement and particularly due to their introduction as new initiatives in the study areas. But, to protect livelihoods of local community, horizontal spread of such field tested interventions which are found to be techno-economically viable in present study as a replicable technology models should be promoted. This requires systems approach with social engineering as essential elements for promotion and adoption of such technology intervention model(s) at state level with policy level decision for effective NRM to ensure food as well as small level livelihood security in remote mountain areas.

Therefore, it is evident from above findings and Table 5.55 that users (farmers/artisans/women) perceived all related technological intervention models (TIM-1 to TIM-7) appropriate and feasible to address their small scale livelihood needs except TIM-8 for which people’s level of perception was medium and in decreasing order against nine out of fifteen indicators as compared to other models. Thus, analysis for people’s participation index, users’ perception and socio-economic factors for technology appropriateness in entire innovation process of delivery and adoption clearly suggest potential of such models of different scale for macro level application in mountain areas. The above findings are in confirmation with Ghosh et al. (2005) about the importance of people’s participation, their perceptions and socio-economic factors that contribute immensely in the process of technology appropriation and adoption. These findings are also in agreement to support results of techno-economic feasibility for each related technology intervention studied and discussed earlier under item 5.1. 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 2 (Table 5.4 to 5.6) 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 discussed above (Table 5.52, 5.54 and 5.55), thus supporting further it as a viable emerging technology intervention model. This requires stimulus for horizontal flow and spin-off mechanisms for large scale utility and application of these technology intervention models with systems approach and linkages as suggested above under item no. 5.2.2.1. for economic as well as livelihood and economic gains. The outcome emanating from the study suggest to bring in required changes in the policies and procedures related to local human resource development through participatory technological empowerment for natural resources management and sustainable utilization in the mountain areas.
5.2.2.3. Policy Interventions: Decentralized Governance and relevance of Technology Interventions for NRM and SRL

In all the models emerged from the present study, the major partner for the implementation of the technology intervention programmes are the rural poor themselves leading towards sustainable technology adaptation. Such decentralized and multi-sectoral approaches together with institutional arrangements for involving the people in the various phases of the programme planning and implementation for technology transfer can stimulate local economic growth. It will have a direct benefit to catalyze development of large number of population from remote mountain areas for economic as well as ecological gain requiring inter-sectoral interaction with improve knowledge base to strengthen natural resource based livelihoods (Saxena, et al. 2001; Thapa, 2004; Neef et al. 2006). 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 which are in consistent with Lovell et al. (2002) and Campbell and Sayer (2003). Appropriate technology Package transfer should consider socio-economic concerns and size of the population, composition and structure of household, basic and secondary needs of the people to address the problems of unemployment, under-employment, inequalities in income and assets and over-exploitation of natural resources. 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 mentioned above 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. Study also highlights the common nature of replicable technology models which are generated in a decentralized manner by adopting systems approach for technology development and transfer specific to mountain regions by involving small and marginal farmers, women and weaker sections of the society.

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 justify ‘problem based intervention’ rather than ‘solution based thinking’ with systems approach covering managerial and social engineering aspects as well

Study also reveals that related technology package was created with technical back up support from nearby S & T institution and establishing marketing linkages in response of the needs of the rural poor, who have little purchasing power. If proper networking amongst different stakeholders in terms of technology, credit, and social engineering based on location specific need is ensured from planning to implementation stage compatible to mountain production system as seen in TIM-2, TIM-3 and TIM -6, it certainly helps in percolation of technology at the grass-root level and post programme sustainability.

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. The results are providing clear pictures of changes and evaluate the effect of appropriate technological application in individual as well as integrated and holistic development and management work done by voluntary groups for enhancing sustainable livelihoods. In such technology models, local problems were addressed to generate following assets essential for enhancing sustainable livelihoods:

1. **Natural Assets:** Ground water rain water harvesting, storage and its judicious usage; water channels; production plantations for fodder, forages and grasses to fetch quick returns initially and timber for long term benefits ensuring immediate community participation .

2. **Physical Assets:** Check dams; drainage work; gully plugging; horti-processing centre; production cum demonstration training centres for horti- processing; vermi-compost etc.

3. **Human Assets:** New employment opportunities with specialized skill and knowledge about processes, quality production, value addition and marketing in the area organized compost making, nursery raising, glazed pottery items etc. have generated immense confidence amongst local people and self help/artisans groups due to enhanced income level, reduced drudgery and additional off-farm employment leading to sustainable growth.
4. **Financial Assets**: Direct employment and enhanced income through new micro-enterprise; horti-processing; bee-keeping and honey production (INFARM model); power generation for agro-processing through improved watermill etc.

5. **Social Assets**: Formation of local management committee, Women’s/ artisans groups, monetized (thrift, informal and infrastructure bank) and non-monetized (biomass, service and labour bank) banking structure has helped in increased participation and collective decision ensuring social security.

6. **Technology Assets**: Infrastructure and local science based institutions with facilities for technology support at village level, crucial and essential element from technology sustainability point of view.

Technology interventions studied and analyzed in present study clearly illustrate 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 (Carney, 1998; Scoones, 1998; Shankland, 2000), 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 (Figure 5.29 and 5.30). This requires a policy change for adoption of above discussed systems approach regarding needs-identification, choice of technology, appropriate scaling, technology upgradation/innovation, economical and ecological sustainability and optimum use of local resources (Johnson, *et al.* 2000; Guendel, *et al.* 2001) with emphasis on technology literacy amongst rural community to address most important issue of human resource development and natural resource management in Indian mountain region.

**Involvement of Science based Voluntary Organizations- Linkage and Networking**: In order to facilitate effective rural transformation and to manage finite natural resource base, it emerged evidently from all the models strongly that voluntary organizations with scientific and technical expertise can play a crucial role in development and dissemination of sustainable technology along with social engineering and motivation work; by providing a strong communication link between the users and S & T agencies; maintaining forward and backward linkages; standing as a guarantor/facilitator for loan and support services for the end users and providing marketing linkages, thereby can play vital role in improving profitability and aptitude.
to use the technologies for NRM and SRL. Such science based organizations often are local in nature or associated with external groups (S & T institutions, developmental agencies) have a strong linkages and networks for their collective and mutual benefits.

To provide good decentralize governance and to reach majority of the people who live in the remote rural area of IMR, creation of grass-roots level organizations with scientific and technological capabilities can provide crucial link between the emerging new developments in knowledge and technology and also helping to strengthen and diversify the local economy, utilization of local resources, and to upgrade the skills of artisans, land-less labourers and other disadvantaged sections in their geographical catchments area. They can facilitate the articulation of felt needs on one hand, and also match those needs with potential source of technology in developing and delivering viable models of green technologies by adopting above discussed systems management approach for technology absorption with social and managerial inputs. Such interventions in ‘process approach’ with local institutional support for technology delivery will brought in visible changes in the lifestyles in mountain areas with multiplier effects for livelihood gain through effective management of natural resources as also advocated by Allen (2000), Gladwin (2002) and Pound, et al. (2003).
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 foreword linkages from present study as discussed above (Figure 5.28 and 5.31) 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 (Ramakrishna, 2007).

Figure 5.30. Diversification Approach of Natural Resource based Livelihoods

Figure 5.31: Inter-Sectoral Interaction for Natural Resource based Livelihoods
Technology Interventions as People’s Programme and related Issues: Policies seem to be the ultimate factors determining spatio-temporal dynamics of natural resources and livelihoods. Introduction of development interventions as time-bound programme/projects is the major reason behind un-sustainability of many interventions in rural areas and in mountain particular. It requires conceptualization of development interventions with active participation of local communities in policy making and implementation. 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 and discussed above like improved water mill, INFARM model and Improved loom for carpet making with technology element and diversification approach – Table 5.51) 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 (Biggs and Smith 1988; Saxena et al. 2006). Such a coupling will empower people to find out pathways for better livelihood options with reduce dependence on forests and optimum use of available resources. 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. Participatory approach to problem analysis and technology solution with location specific development strategies is found to be the most successful approach to address the problems of livelihoods and natural resources. Though both private and public sector investments in such technology interventions areas for diversified livelihoods remain low particularly in marginal lands, which are critical for sustainable management of natural resources (Jha and Bawa, 2006). It becomes important to minimize heavy reliance of such communities on local ecosystems which often puts them into conflict with those who seek to protect biodiversity (Chapin, 2004) as effectively found in TIM-5 to reduce dependency of local community of Saldhar village on the forest resources in NDBR by introducing improved loom made of iron rails instead of wooden loom with better efficiency and income (Table 5.37).

Thus, need is to build links between innovation, investment and enterprise by scaling up innovation process and by facilitating technology networks on sectoral level, and knowledge may be made public domain to improve sectoral performance as
mentioned in Table 5.56 on the basis of Cost-benefit analysis (CBA) using alternate viability measures.

<table>
<thead>
<tr>
<th>Technology Intervention Models</th>
<th>NPV</th>
<th>NPB</th>
<th>NPC</th>
<th>IRR</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIM-1 Improved Watermill</td>
<td>INR 63837</td>
<td>INR 111370</td>
<td>INR 37409</td>
<td>94%</td>
<td>2.98</td>
</tr>
<tr>
<td>IWM-1a.</td>
<td>INR 120896</td>
<td>INR 226095</td>
<td>INR 84644</td>
<td>85%</td>
<td>2.67</td>
</tr>
<tr>
<td>IWM-1b.</td>
<td>INR 43272</td>
<td>INR 97741</td>
<td>INR 45583</td>
<td>70%</td>
<td>2.14</td>
</tr>
<tr>
<td>IWM-2a.</td>
<td>INR 140354</td>
<td>INR 309044</td>
<td>INR 140596</td>
<td>71%</td>
<td>2.20</td>
</tr>
<tr>
<td>IWM-2b.</td>
<td>INR 69140</td>
<td>INR 124913</td>
<td>INR 44417</td>
<td>91%</td>
<td>2.81</td>
</tr>
<tr>
<td>IWM-3a.</td>
<td>INR 98148</td>
<td>INR 200431</td>
<td>INR 84062</td>
<td>78%</td>
<td>2.38</td>
</tr>
<tr>
<td>IWM-3b.</td>
<td>INR 781035</td>
<td>INR 2568590</td>
<td>INR 1787555</td>
<td>72%</td>
<td>1.44</td>
</tr>
<tr>
<td>TIM-3 Horti-processing</td>
<td>INR 15360</td>
<td>INR 52224</td>
<td>INR 32116</td>
<td>278%</td>
<td>1.63</td>
</tr>
<tr>
<td>TIM-5 Improved loom</td>
<td>INR 50070</td>
<td>INR 95745</td>
<td>INR 36970</td>
<td>78%</td>
<td>2.59</td>
</tr>
<tr>
<td>TIM-7 Medicinal Plants</td>
<td>INR 120896</td>
<td>INR 226095</td>
<td>INR 84644</td>
<td>85%</td>
<td>2.67</td>
</tr>
</tbody>
</table>

- NPV = net present value; NPB = net present benefit; NPC = net present cost; IRR = internal rate of return; BCR = benefit–cost ratio. All values are in Indian Rupees.
- Improved watermill (IWM) components:
  - IWM-1a: (wheat grinding + Power sale) IWM-1b: (wheat grinding + Power sale + Other components for water usage)
  - IWM-2a: (wheat grinding + Power sale + Paddy De-husking) IWM-2b: (wheat grinding + Power sale + Paddy De-husking + Other components for water usage)
  - IWM-3a: (wheat grinding + Power sale + Spice grinding) IWM-3b: (wheat grinding + Power sale + Spice grinding + Other components for water usage)

Cost-benefit analysis (CBA) using alternate viability measures with a cash flow for three years, i.e. Net present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR), the results in Table 5.56 exhibited that if expected full benefits are realized, the benefits net of cost derived from the Improved Watermill (IWM) are quite high, with the IRRs ranging from 70% to 94% for three replicates of IWM -1, 2 and 3. Each replicate from cost benefit analysis point of view was assessed separately for grinding and power sale and with other components for effective water usage. IRR was also found 72% for horti-processing and 78% for medicinal plant (Chirata) cultivation package. On the current interest rate, the IRR in all the cases are much higher and above 10% with positive NPVs and BCR is greater than 1 clearly demonstrate viability of these select technology models of rural enterprise mode. Overall, the analysis carried out taking into account opportunity cost not only for tangible benefits and costs, but also in-tangible benefits and costs in terms of land and environmental cost suggest that these technology intervention models evolved to improve the economy and ecology of mountainous region are economically viable and socially desirable.

Above findings in terms of cost benefit analysis demonstrate that the small scale and tiny sector of our economy, largely unorganized in nature, can be made more innovative. Replication of such local resource based technologies as complete package can in turn help in spawning large number on village based micro-enterprises in IMR. The transaction costs of mentoring such innovations and traditional
knowledge at grassroots level in different parts of the mountain region will be enormous which should be in action plan of state policy (for Uttarakhand and Himachal as well as other hilly states) to augment grassroots innovations and generate vibrance in mountain development to strengthen local economy. The policy should also emphasize to implement programme to valorize innovations by women and for women so that extraordinary drudgery involved in the daily chores of million of women in the IMR can be eliminated. The technology models evolved and discussed in present study such as improved loom (TIM-5), opportunistic use of Lantana (TIM-4) have evidently demonstrated the potential that exists for these kinds of small scale but useful technological innovations which also requires well knit delivery mechanisms at the grassroots level. Testing and certification of technologies; establishment of innovator managed R & D design and fabrication facilities to improve the ergonomic and aesthetic appeal of the products for wider acceptance by consumer; time bound research to add value to grassroots innovations; micro-finance venture promotion fund; small innovation patent systems to file patents on behalf of local communities and individuals; financial support for technological innovations focused especially on women are related issues to be addressed adequately in future programme at policy level for mountain development.

It may be concluded that reversal approach ‘land to lab with social engineering’ will hold the key to transformation of science so as to make it responsive to the urges of farmers, artisans, small scale and tiny scale in rural mountain settings. 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 to ensure economic and ecological sustainability in Indian Mountain Region.