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TECHNOLOGICAL INTERVENTIONS FOR LIVELIHOOD DEVELOPMENT AND CLIMATE CHANGE MITIGATION IN INDIAN NORTH-WESTERN HIMALAYAS

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ABSTRACT

The technology transfer for rural livelihood development had greater impact to protect microclimatic conditions which further affects the microflora and microbial activities to larger extent in the Indian Himalayan Region (IHR). The technological interventions were made by the Himalayan Research Group organization which helped in economic upliftment of rural poor, women empowerment and in environment protection in hill region. The major activities are Passive Solar Retrofitting (namely, Thermosyphoning Air heat Panel (TAP), Trombe Wall (TW), and Sun Spaces (SS)) fodder development, vermicompost biotechnology, button mushroom cultivation and protected cultivation for climate change mitigation and adaptations. The solar retrofits reduced estimated 4.97 tones carbon emission per household during six winter months which helped in reducing the fuel wood consumption. Improved varieties of different fodder spp. were introduced for year round green fodder availability and reduce soil erosion and reduction in tree lopping. Fodder choppers and silage preparation was popularized to contain the fodder wastage. Vermicompost biotechnology was popularized among farmers to reduce the use of chemical fertilizers for improving the quality of soil. The button mushroom cultivation was used for conversion of agriculture residue into compost making by reducing crop residue burning which increases carbon emission. Protected cultivation in local made polyhouse was popularized to generate maximum returns from small piece of land through cut flower and vegetable cultivation and by raising plant nurseries.

Keywords: Solar passive retrofitting, thermosyphoning air heat panel (TAP), trombe wall (TW), sun spaces (SS), carbon emission, fodder species, button mushroom cultivation, vermicompost, polyhouse.

1. Introduction

The Himalayan ranges are the youngest and loftiest among the mountain systems of the world (Khoshoo, 1992). The Indian Himalayan Region (IHR) with geographical coverage of over 5.3 lakh Km^2 comprises of the vast mountain range. As the world's highest mountain chain, they represent a highly complex and diversified system both in terms of biological and physical attributes and is one among 34 global biodiversity hotspots. The region is largely inhabited by indigenous societies. Living in biodiversity rich areas of the country, the mountain people are largely dependent upon biodiversity for meeting with their livelihood needs. Therefore, sustaining biodiversity in the region also means protecting the interests of the people. Industrial emissions, fuel wood use, household emissions, burning of crop residues; hydropower constructions are destabilizing the system of cozy living in the hill state of Himachal Pradesh situated in the heart of Himalayas.

More than 90% of the population in Himachal Pradesh resides in rural areas. Most of its population depends upon agriculture and allied activities like horticulture and cattle rearing. As a result pressure on natural resources such as forest, land, water etc. is increasing enormously. With every passing day, there is pressure on the local communities to cope up with the changing climatic conditions. Because climatic variables are adversely affecting their routine chores as agriculture or cattle rearing because both are interdependent age old traditions. The technology transfer for rural livelihood development had greater impact to protect microclimatic conditions which further affects the microflora and microbial activities to larger extent (Klett *et al.*, 2011) and further helping the local communities to adapt the changing climatic scenario by adopting new technologies without disturbing the existing environment set up (Kaur, 2002).

The Himalayan Research Group (HRG) is a non government organization working in the rural areas of Himachal Pradesh for livelihood development programmes through technology transfer to improve the economic conditions of the marginal farmers (owning less that one Hac. agriculture land). There are many activities which are taken to field implementation but the main activities are passive solar retrofits, button mushroom cultivation, popularization of protected cultivation , fodder development programme and vermicompost biotechnology (Kaur, 2002) as an alternate to existing traditional technologies to lessen the pressure on the environment without altering their existing set up.

I. Passive solar retrofits

In Himachal Pradesh consumption of fuel wood for cooking, water and space heating is very high and only during 4 months of winter around 4000-5000 kg fuel wood is required per household which constitute almost 75% of the total annual consumption. Himachal Pradesh has 250-300 sunshine days varies from 7-8 sunshine hours per day. Thus, solar energy is best alternate to warm the houses during winters. The maximum energy is required for space heating as the villages experience heavy snowfall during winter months. The high consumption of fuel wood is a serious concern as the forests are receding and people are finding it difficult to collect a huge quantity of fuel wood year after year. The fuel wood use is a major cause of carbon emission which can be reduced through passive solar retrofitting.

II. Mushroom cultivation

Himachal Pradesh in general enjoys a temperate climate with temperature varies between 10 – 30 ^{o}C and precipitation varying from 100 –200 cms, thereby making it a humid region. These conditions are favourable for temperate mushroom cultivation. Though the organization is cultivating button (Kaur, 2005) and shiitake mushroom (Kaur, and Lakhanpal, 1994) but button mushroom is commercially cultivated by women groups (Kaur, 2004). The technology from providing raw material to market the produce was organised by the HRG an implementing agency. The button mushroom needs wheat straw as raw material which is available in plenty in the plains of Punjab where it is burnt due to lack of storage which is add on to air pollution. The wheat straw conversion into compost is the best way to reduce pressure on environment by reducing carbon emission and the spent compost is further used as organic manure to enrich the soil.

III. Fodder development

Fodder was the primary requirement for the rearing of livestock which differed from season to season. No practice of fodder cultivation was observed and only wild grasses grown in the agriculture fields and forests were harvested and fed to cattle. The livestock rearing is one of the oldest professions of the people in the Hill areas and complete agriculture productivity depend on the livestock holding of the households. There is huge shortage of fodder and women are lopping trees by risking their life (Pic.1). This has an adverse impact on forest. The urgent need was felt to establish efficient fodder production systems and to set up fodder bank for assuring the availability of green through out year. Introduction of improved fodder varieties in the existing farming systems enhanced the biomass production and generated additional income and employment opportunities for the resource poor farmers and this is reducing the pressure on the forests. Similarly, whole year green fodder on barren land helped in carbon binding.

Picture 1. Woman lopping fodder tree-risking her life

IV. Vermicompost biotechnology

The excessive use of chemical fertilizers has disturbed the environmental conditions and at the same time affecting human health badly. The introduction of vermicompost preparation in easiest way is the best alternative to the chemical fertilizers. In hills the traditional method of composting is a very slow process takes almost a year in comparison to vermicompost preparation in 2-3 months only. The agricultural wastes like livestock waste, crop residues, tree wastes, agro industrial by-products etc. are generally burnt by the farmers which are now used to produce quality compost i.e. vermicompost. This reduces the use of chemicals in farm practices and helping in the enrichment of natural soil microflora and reduction in chemical pollutants from land, water and environment.

V. Protected cultivation

The introduction of low cost polyhouse by using locally available raw material and expertise with short duration trainings to local artisans gave good results and helped in solving many problems at the same time. The changing environment scenario needs to protect the crops against unfavourable environmental conditions which led to the development of protected agriculture. Polyhouse is the most practical method of achieving the objectives of protected agriculture, where natural environment is modified to achieve optimum plant growth and yield. Green house technology has potential for more produce per unit area. There is lot of pressure on cultivable land due to urbanization, industrialization and expansion of the rural villages. Greenhouses and other technologies for controlled environment plant production are associated with the off-season production of ornamentals and foods of high value in cold climate areas where outdoor production is not possible.

2. Methodology

All the selected technologies were made easily accessible to the people in rural areas of Himachal Pradesh which are replicable to other areas of Himalayan region. The interested people especially women were selected for detailed implementation of each technology. The methodology followed for the selected technologies is defined individually as follows:

I. Passive solar retrofits

i. Survey conducted

A Village hamlet Moolkoti is Gram Panchayat in Block Mashobra in District Shimla of Himachal Pradesh with 68 households was selected for the implementation of 5 different techniques namely, Thermosyphoning Air Heating Panel, Trombe Wall and Sun Space and solar geyser and street lights. The basic data was collected for use of fuel wood during summer and winter seasons. Information on usage of other fuel sources like dung cake, LPG and Kerosene oil was also collected.

ii. Technology Modification

Alteration in basic designs of the retrofitting was done to reduce the cost of construction through use of local materials and skills to make it economically viable for poor people living in villages and to fit into the existing structures.

iii. Engineering Design

Extensive work was done on designing, short listing of material for fabrication and training of the rural artisan. Passive solar retrofitting designs of Thermosyphoning Air Heating Panel, Trombe Wall and Sun Space layouts Fig.1 of the existing houses were designed with advanced software (Auto CAD).These designs vary according to the need in particular house as every house had different layout. The solar geyser and street lights were procured for installation at common place for multiple use by villagers at different places in the village.

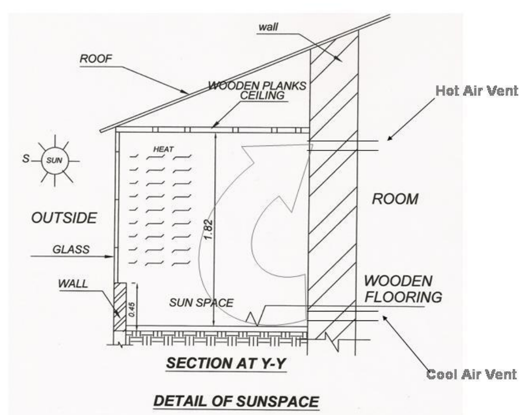

Figure 1. Design for sun space

iv. Data collection

Three temperature data loggers, software and computer connecting lead were installed for recording of temperature. One data logger was installed in room fitted with Thermosyphoning air heating panel another in sunspace and third one was installed to monitoring the temperature of surrounding climate for comparison as control. The data loggers were set to record temperature with 30 minute interval and have battery life of around 600 days.

II. Mushroom cultivation

For mushroom compost preparation wheat straw was the main ingredient and other ingredients were chicken manure, cotton seed cake, gypsum, urea, and wheat bran (Kaur, 2005). Wheat straw was soaked in water. The other ingredients were mixed successively while giving turning to the pile every third day. After 12-15 days the compost was shifted into pasterurisation chamber with 58-60^{0}C temperature for pasteurising the compost. The chamber is of 25 ton capacity. After ten days the compost is ready to spawn. The spawned bags were supplied to growers for button mushroom cultivation.

III. Fodder development

a. Area and beneficiaries selection

Initially the survey was conducted to select out the blocks (Mashobra, Karsog, Sundernagar, Bilaspur Sadar, and Banjar) among selected five districts (Shimla, Mandi, Bilaspur, Solan, and Kullu) for the implementation of the fodder development activity which includes fodder grass and tree species nursery raising, planting material distribution, fodder chopper distribution and silage preparation. During the awareness camps organised interested women were selected for further transferring of the technology, in which master women trainers were selected for further disseminating the technology among fellow villagers and to their adjoining villages.

b. Distribution of planting material

The planting material of 13 fodder spp. of grasses and trees was distributed among the beneficiaries and also sown in HRG nursery to keep a check on the performance of these spp. because none of these were grown by farmers as fodder in their fields. The spp of grasses and trees were tested for cultivationwere *Zea mays, Panicum maximum,* T*all festuca and Setaria, Leucerne sp*, *Trifolium sp., Grewia optiva, Celtis australis, Robinia pseudoacacia, Bauhinia variegate, Morus alba* and *Quercus incana. Quercus incacna, Grewia optiva* and *Celtis australis* raised at HRG nursery by collecting seed from wild. 2550 plants of tree spp of *Grewia* , *Celtis*, oak, *Robinia sp* and *Morus*, and 1,25,000 tufts of grass spp of orchard grass, *Panicum maximum*, *Tall festuca*, and *Setaria* and 200kg seed of African tall *Zea mays*, 10kg barley, 20kg bajra and 5 kg oat were distributed among the beneficiaries.

c. Silage preparation

Technology of silage preparation (Huber, 1980) was modified and simplified by using polybags was introduced and demonstrated among nearing 750 farmers (Pic.2).

The major ingredient for silage preparation are green fodder (crop residue with 70% moisture) chopped, urea(0.2-0.5%), molasses(2-5%) and salt (0.1%) as per quantity of green fodder. Additives should be used according to needs and silage properties. All the ingredients were dissolved in water and mixed thoroughly. The ingredients either mixed thoroughly with green fodder before filling into the polythene bags or sprinkled on fodder while filling into bags in layers and pressed properly to create anaerobic conditions. After filling, the bags were packed tightly and kept in dark. The green fodder includes wild grasses, maize, cabbage or any other edible grasses available.

e. Urea treatment to roughages

To enhance the nutritive value the dried fodder (roughages), was treated with 4% urea (dissolved in water) for ensiling treatment. The treated roughages was packed in polythene bags. It has shown that nutritive value of urea treated straw was quite comparable to non legume forages.

IV. Vermicompost preparation

The vermicompost technology was popularized among all the beneficiaries wherever HRG demonstrated its other technologies to reduce the use of chemical fertilizers. The earthworms (species *Eisenia foetida*) are used as versatile natural bioreactors for efficient biodegradation of organic solid wastes for making of farmyard manure known as vermicompost. Technology was demonstrated in the simplest way. Being a temperate zone there was no problem of termites or other diseases which were being faced in hot climates. To see the conversion rate of biomass by Vermiculture, different materials available were used. 24 different plots of 1X1m had been drawn (Pic. 3).

Picture 2. Silage demonstration

Picture 3. Vermicompost bed making

The locally available biomass of the needles of different pine species namely *Pinus wallichiana* (Blue pine), *Picea smithiana* (Spruce), *Cedrus deodara* (Deodar), oak leaves of *Quercus incana* were used in dry as well as in green form, *Populus ciliate* (Popular), Grasses, mushroom spent compost, mixture of all and pure dung were tried. Different material were used in three different percentages like 25:75, 50:50, 75:25 i.e. if 25% are leaves then the quantity of dung was 75%, equal quantities of both, then 75% of leaves and 25% was of dung.

V. Protected cultivation

Cut flower cultivation has good scope in the market with better economic returns in comparison to the traditional crops and also an alternate to diversify. The Indian market of cut flowers is increasing 20% every year. Since the climatic conditions are favourable for Lilium cultivation but fluctuating climatic conditions makes this crop difficult to grow under natural conditions. The Lilium cultivation was a new activity to the farmers in the selected area. 40 farmers in four blocks in Shimla, Kullu, Mandi were selected to cultivate Lilium under polyhouse (Pic.4).

For soil preparation, vermicompost /farm yard manure was used to enrich the soil before planting and make soil porous and soft for better growth and emergence of Lilium shoot. All beneficiaries were trained in crop harvesting, grading, packing for marketing and maintenance of seed after harvesting till uprooting the bulbs and sowing. The bulbs of quality material of Asiatic and Oriental Lilium were imported from Holland which was further multiplied for further distribution.

Picture 4. Lilium crop under polyhouse

3. Results

I. Passive Solar Retrofits: Energy requirement was studied to an average family size of 6 members in the Moolkoti village and summary is presented in the following table.

Table 1. Estimation of household energy needs in village Moolkoti, Mashobra, Shimla, H.P.

S.No.	Detail	Summer	Winter	Cost
1	Quantity (Kg) of fuel wood required/day	16.45	39.45	Free of cost
2	Time (in hrs.) for collection/visit for collection of fuel wood (Total visit/annum 140)	1.57	1.59	Opportunity cost is Rs. 12.50/hr
3	Distance (in Km.) covered/visit for collection of fuel wood	1.62	1.57	On foot
4	LPG Cylinder consumed/month	1.09	1.59	Rs. 370/cylinder
5	Electricity (kwh/month)	23	68	Rs. 2.83 Kwh (subsidized)

All 68 household were provided with one or the other type of passive solar retrofitting for space heating keeping in view the engineering and location layout of the house. 45 Thermosyphoning air heating panel were installed one in each house by using aluminium sheet and thermocoal along with siphoning pipes. 6 sun spaces were created by using glass with frames. Three water heater (200lt) and 8 street lights were installed in the villages for collective use. Data from Data loggers was transferred after 6 months to evaluate the thermal performance of the solar passive retrofitting only. It is observed that Thermosyphoning panel was able to heat the air at 58 °C when room temperature was around 18 °C. Similarly, the Trombe Wall and Sun Space were able to increase the Temperature of living space/room 18 °C to 27 °C when outside temperature was recorded at 12 °C. For the study winter season of six month was considered from October- March.

Temperature tends to fall below 10 °C minimum in morning hours from mid of October and till mid of February. TAP (Pic. 5) and SS provided 8-10 °C increase in temperature of living space in comparison to the outside climate temperature. Fig.2 is showing the comparison between different temperatures recorded at different retrofits at the same time for six months. Blue line showed outside climate temperature, while ink line depicts increase in temperature rooms where TAP technology used and third is yellow line depicts the temperature raised in sun space areas. The retrofit has drastically reduced the use of fuel wood and pressure on the forests which helped in reduction of carbon emission manifolds. The main purpose of the implementing agency was to popularize the technology at the grassroots level for poor villagers and also to make them aware of clean and green environment for their health too.

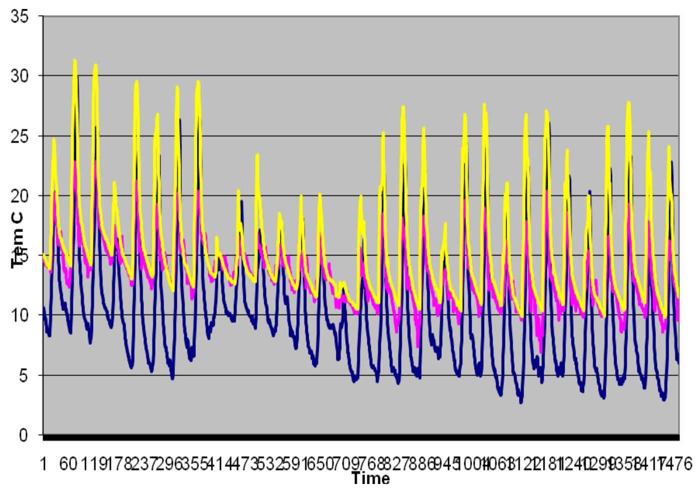

Figure 2. Temperature recorded at different retrofits. Blue line-climate

Table-2. Six Months Winter Season Carbon Projections for households with Solar Passive Retrofitting and solar water heater

1	Average monthly (Winter) per capita consumption of fuel wood in Mashobra Block of Shimla) Kg	236.7
2	Winter season (6months) per capita consumption-Kg	1420.2
3	No. of Households with Solar Passive Retrofitting and solar water heater	82
4	Average Household Population	6
5	Total average population of 82 households	492
6	Total Winter season consumption of fuel wood of 82 households -Kg	6,98,738.4
7	Carbon conversion @ 1.46/kg	10, 20,158.06
8	40% efficiency during 6 months winter season through Solar Passive Retrofitting = savings (Kg)	40,80,63.22
9	Saving in Tonnes	408.06
10	Average/ Household Carbon Saving in Tonnes (6 month winter)	4.97

II. Mushroom cultivation

150 ton of wheat straw is annually consumed for the button mushroom compost preparation by HRG. Wheat straw is mixed with other ingredients and total 300 ton compost is produced which is sold to beneficiaries. On average with 20% biological efficiency 60 ton of mushrooms are produced and sold into the market giving the beneficiaries 100% return. Button mushroom cultivation is considered as the best alternative to stop wheat straw burning to reduce air pollution.

Picture 5. Thermosyphoning air heating panel (TAP) fixed on mud wall

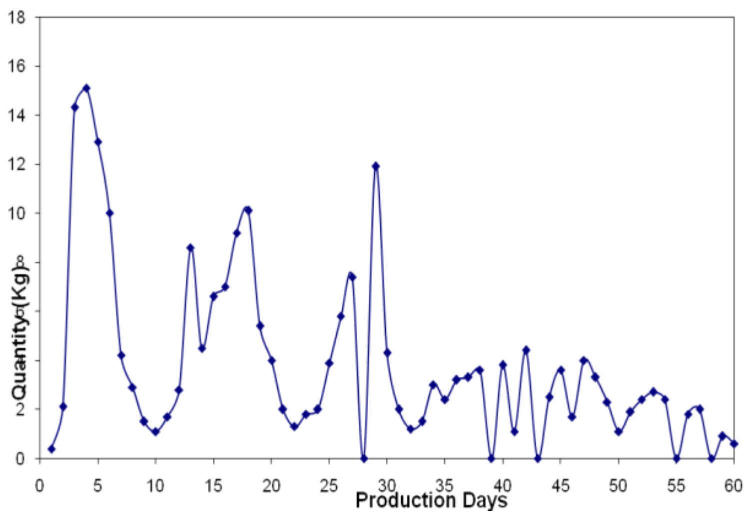

Figure 3. Button mushroom production on daily basis

III. Fodder

The best selected spp of the fodder planting material of grass spp were: *Steria, Pannicum* and *Napier* and tree species were: oak, C*eltis* and *Morus* was distributed to the beneficiaries for further dissemination. The women farmers selected as master trainers to further spread the technology to their fellow villagers by providing them the planting material multiplied by them in their own nurseries. This action spread the technology to larger areas and also barren hill areas to make fodder available throughout the year. Now the beneficiaries have the facility of year round green fodder and take 3-4 cuts of the grasses which usually had one cut in a year and there was no green fodder through out the year otherwise. 30 fodder choppers were distributed among the 30 groups in different villages. Silage preparation (green fodder preservation) and dry fodder preservation through urea treatment was also demonstrated. Polythene bags were made available to the beneficiaries for silage and roughages storage. The introduction of fodder choppers reduced fodder wastage and facilitated silage preparation and reduced their worries of forage storage. The fodder development programme had larger impact on cattle rearing.

VI. Vermicomposting

Vermicompost biotechnology is an alternate to chemical fertilizers. It is an aerobic process and helped in reducing methane production which is hazardous in environment. It was very important to study the local available material for vermicompost preparation. In first experiment where material is 75% and dung used is 25%, maximum conversion rate is in pure dung 90% followed by *Populus* sp i.e. 69.47%. In second experiment where both material and dung were used in equal quantity the maximum conversion rate was in dry grasses i.e. 63.15% in third experiment maximum conversion rate was in *Pinus wallichiana* (green) was 65.68% followed by 61.90 % in grasses. In this case the quantity of dung was more i.e. 75% and material used was 25%. Form these results it is concluded that the conversion rate in grasses and leaves is more in comparison to the needles i.e. of *Pinus* spp. Where there is higher conversion rate moisture %age is also high in that vermicompost. The farmers were made aware of the best material to be used for Vermicoposting on the basis of these results. Almost half the quantity of vermicompost was equal to the traditionally used quantity of FYM, which reduced the women's labour in collection of the organic material and transportation of the FYM to the field by 50%. The use of vermicompost is helping in rejuvenation of soil and its microflora and reduction in soil and water pollutants by providing fresh food crops to the people at large with lesser hazardous chemicals.

V. Protected cultivation

The polyhouse were used by the farmers for the nursery raising of vegetable crops like tomatoes and coriander and medicinal plants like *Taxus wallichiana*, Chirayeta, and aromatic plants lavender, geranium, and rose. The different Lilium varieties were tried and cultivated under the polyhouse conditions. This fetched good market value and economic returns to the farmers. HRG purchased the planting material from the existing farmers for further distribution to the new farmers free of cost with an agreement that the same no. of bulbs will be taken back from them after multiplication of the planting material. This was to continue the farmers interest to take up new technology at the same time to get good economic returns.

4. Discussions and Conclusion

Each technology is given in brief in this paper. The livelihood development programmes were implemented in the rural areas of hill regions in Himalayas. Every technology has its far reaching impacts for sustaining the natural resources. Since these activities are giving good economic returns to the farmers/beneficiaries. Because farmers need alternative technologies to go for diversification than into the traditional crop cultivation which is giving very less economic returns to the farmers. Keeping in view the climatic conditions in the Himalayan it was imperative to the implementing agency to concentrate on introducing existing technologies with little modification and made them applicable at field level to give farmers new and better avenues for which they are unaware and increase their income form the existing land holdings. The new technologies and ideas are welcomed by the farmers with long term sustainable programmes through hand holdings. With the advent of nuclear family system land division has become a major issue.

Acknowledgements

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