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Utilization of Simple Technologies for the Development of Some Hill Areas of Kumaun Himalaya

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Abstract
Uttarakhand, a newly formed state in the Indian Himalayan region state has thin population, undulating terrain, distantly located small villages with difficult approach, terraced cultivation, small and scattered land holdings, scanty irrigation facility, concomitant with little use of modern technology, low productivity, degraded land, and several other difficulties. Over the years many technologies although simple but effective and having the potential to promote socio-economic development and ensure regeneration of degraded mountain lands, have been adopted in the region. Some of these technologies, namely (a) Water Harvesting Technology, (b) Apiculture, (c) Plant nursery techniques, (d) Agroforestry, (e) Vegetable cultivation, (f) Protected cultivation, (g) Floriculture, (h) Horticulture, (i) Bio composting, (j) Vermi-composting, (k) Pisciculture, (l) Integrated fish farming (IFF), and (m) Preparation of decorative items have been discussed in this report. Based on a survey conducted in 5 villages in Almora district of Uttarakhand state, namely Katarmal, Matela, Khunt, Manan (Nagoria) and Basoli, assessment was made on the economic conditions of the people following adoption of these technologies and some case studies reported.
Vermicomposting has been adopted in villages Katarmal, Matela, Khunt and in Basoli. In most of the villages the farmers reaped considerable profit following vegetable cultivation; in some cases like Katarmal and Matela the production was not sufficiently high, nevertheless sufficient for own (internal) consumption. Only selected persons took up Horticulture in the villages Katarmal, Khunt, Manan and Manan-Basoli, and all through support from organisations. Only a few persons had the courage of adopting Pisciculture and IFF. Floriculture has also been taken up as a new initiative by a few.
Source of income of majority of the villagers is through job and labour work; agriculture and allied activities constitute a small fraction, and among the villages studied maximum number of households in Manan-Nagoria and Basoli, i.e. 25 and 18%, respectively take up this activity. While different organizations have been involved in supporting the villagers in terms of physical and technical support to implement technologies, however, only a limited number of households have received help. Further, it must be mentioned that villagers do possess land but own efforts are not sufficient enough and expectations from external sources often prevail. Hence people prefer job where income is assured and regular. A major percentage of people of Matela (53%), Basoli (42%) and Manan-Nagoria (32%) earn their living through job, however, working as labour force was found highest in Katarmal (70%), followed by Khunt (42%), Basoli (31%) Matela (30%) and Manan-Nagoria (27%).
The results indicate that development is slow in these villages. Therefore, some workable solutions have been suggested and discussed for development and improvement of the region. These include consolidation of land holdings, solving water scarcity and fuel wood need, improving marketing of produce, involvement of women, awareness & updating knowledge, and setting up of demonstration models. It is hoped that such concerted approaches can help in improvement in the quality of life of the local inhabitants.

Keywords: hill, Kumaun, Himalaya, simple technologies

Introduction
The Himalaya constitutes a vast and diverse mountain system comprising of varied social, cultural and environmental setup. The Indian Himalayan Region (IHR) extends over 2,800 km in length and 220-300 km in width, and covers partially or completely, twelve states of the Indian Republic (Figure 1). It has a total geographical area of approximately 591, 000 km^2 (18% of India) inhabited by about 3.7% of the total population in the country. Forest cover in the country is gradually reducing and currently is 21.23%. In the Himalayan states it ranges from 10.14% (Jammu & Kashmir) to 90.38% (Mizoram); adequate forest cover of 67% or above is not present in many states, including that of Uttarakhand which has only 45.82% (Forest Survey of India, 2013) [11].

Hill areas are of special importance to the overall development of the country because they contribute a lot in terms of forest and horticultural produce, minerals, water, power, other biological resources, scenic beauty, etc. It has been observed that while each specific area has unique features in terms of natural resources, geophysical settings, fragile and sensitive ecosystems, yet the problems faced by their inhabitants are common (Papola *et al*. 1983, Singh & Singh 1987, 1992, Rao & Saxena 1994)[21, 28, 30, 23]. The region is characterised by thin population, undulating terrain, distantly located small villages with difficult approach, terraced cultivation, small and scattered land holdings, scanty irrigation facility, use of primitive methods of ploughing, little use of modern technology, low productivity and several difficulties (Anonymous 1992) [2]. Most of the areas are rural and people live in very small and scattered settlements; quite a few of these settlements are difficult to access, with poor transportation and communication facilities (Singh & Singh 1992) [30]. Scope of work or job is limited and as a consequence there is out migration, particularly of males. In addition, large scale felling of forests for human settlements, plantation of orchards, obtaining fuel wood, initiation of hydroelectric projects, etc. has led to ecological imbalance and loss of biodiversity (Singh & Singh 1992, Agrawal & Rikhari 1998) [30, 1].

It is desirable that an integrated approach be worked out for identification of problems, priorities for solution and optimal use of resources to bring an overall improvement in the quality of life of inhabitants (Papola *et al*. 1983; Martins & Nautiyal 1988, Singh & Singh 1991, Anonymous 1992, Rao and Saxena 1994, Rao 1997, Papola 2014) [21, 17, 29, 2, 23, 24, 20]. The strategy for development of hill areas should, however, be different and varied depending upon the place and situation, but with the primary aim of fulfilment of the basic needs along with economic benefits (Anonymous 1992, 2000, Joshi *et al*. 2006, Papola 2014) [2, 3, 12, 20]. Therefore, the development programmes for the hill region need to have a sound life supporting system which would judiciously utilize land, water and biotic resources. However, in the hill region, life supporting activities are limited and agriculture and allied activities still remains the basic livelihood for majority of its population; the methods, however, are carried out on traditional basis and rely on unpredictable rainfall. Due to low education level and weak economic status the people are unaware of the advancements in agriculture and/or new technologies suitable for their region and potential supplementary resources for income generation. The average farm size is going down and more than 80% of the farm families belong to small and marginal farmer category. Besides, small sub-divided and fragmented land holdings, declining soil fertility, scanty or absence of irrigation facilities, non-adoption of improved varieties and technologies, low risk bearing capacity of the farmers are important factors accounting for low productivity, which have thwarted the economic development of hill societies.

Problem in the Hill region

The strategy for development in hill areas need to have a firm basis involving an ecological system comprising of both land and water, which are obviously critically related to each other. Therefore, it has been suggested to initiate development activities in an integrated manner simultaneously improving the economic status of the people (Anonymous 1992, 2000, Valdyia 1997, Joshi *et al*. 2006, Papola 2014) [2, 3, 31, 12, 20]. Since agriculture supplemented by forest resources are the major sources of income of the region, one strategy is to improve or find new systems of management to increase productivity of land and forest resources, and allowing the rural people to participate in the benefits while simultaneously preserving the ecology of the region. Although one of the major bottlenecks in the development of the IHR has been the vast gap between technology developers/managers and the actual users living in the rural areas, nevertheless, several technologies, simple and effective for the region have been adopted by the locals in the recent past. Over the years they have acquired skills and obtained technical knowledge on these technologies which have gradually become popular and benefited them. The technologies that are generally adopted by the villager/hill people (Palni 1996, Anonymous 2000, Joshi *et al*. 2006) [18, 3, 12] are: (a) Water Harvesting Technology, (b) Apiculture, (c) Plant nursery techniques, (d) Agroforestry, (e) Vegetable cultivation, (f) Protected cultivation, (g) Floriculture, (h) Horticulture, (i) Bio composting, (j) Vermi-composting, (k) Pisciculture, (l) Integrated fish farming (IFF) & (m) Preparation of decorative items. The importance of these technologies is documented below.

Water Harvesting Technology

Drinking water is scarce in the hills. Furthermore, water for irrigation is also a problem. Since the area is rain fed and rivers, rivulets and small springs are only source of water, it needs to be conserved (Kamra *et al*. 1985, Maikhuri *et al*. 1998, Anonymous 2003) [14, 16, 5]. The undulating topography of the hills makes it difficult and costly affair to lift water. To cope up with the problem it is necessary to harvest water (rain, unused spring water, etc.) and store them in simple above ground places like polyponds and storage tanks. Water can also be harvested from houses using proper drainage system and collected in appropriate places, and utilized during need, particularly during summer for minor irrigation needs, and livestock use, etc. Moreover, these ponds can be utilized for fish farming. However, in order to ensure proper storage, the walls of the tank must be strong; generally good quality polythene is used for lining the pond walls to avoid seepage.

Apiculture

Due to the availability of great diversity of floral resources, the hilly regions of the Himalaya provide an excellent environment for developing bee keeping (Apiculture) as a small scale industry. While several species of honey bees have been reported from this area, the native species *Apis cerana* appears to be quite suitable. These bees are large sized, more productive and are less prone to negative traits like frequent swarming and absconding nature generally observed in the plains. In the past, *Apis mellifera*, a native species of Europe was introduced to promote apiculture in the IHR with some success in certain regions. Apiculture is an income generating activity and provides opportunities for developing a small scale industry for the villagers (Pratap 1998)[22]. Since it requires little space and low initial investment, it can be readily taken up by the locals. It would be worth mentioning that mountain honey is considered better in quality than honey produced from lowland areas because honey is produced by bees from diverse flora and less use of inorganic fertilizers to crops; hence it fetches higher price.

Plant nursery techniques

Nursery is essential for development of any plantation programme, be it for forestry, horticulture, floriculture, vegetable cultivation, medicinal plants, conservation, etc. A small nursery comprising of polyhouse and net/shade house with adequate supply of water can be extremely useful for generating income for the local villagers/farmers by the sale of plants/planting material (Anonymous 2000) [3]. While some Government nurseries are located in the hills, they generally cater for forestry species and/are not able to meet the full demand of other plant species. Thus there is a great potential to develop suitable nurseries based on the local plant requirement for income generation.

Agroforestry

In the hills agriculture is practiced in small and fragmented land holdings. It is well known that hill agriculture is supported by rain and only three crops are reaped in two successive years. To supplement the agriculture need, it is appropriate to develop forest-like vegetation in the waste, barren and grazing land through the introduction of perennial vegetation using fodder, fruit and multipurpose trees so as to develop appropriate agroforestry models. The introduction of trees not only helps in soil conservation and improving fertility but also in obtaining sustainable harvesting of biomass and the plant produce. Over the past decades various agroforestry models have been developed in different altitudinal ranges (Maikhuri & Semwal 1997) and some are working extremely well.

Vegetable cultivation

Due to small land holdings and lesser man powers in the hills, vegetable cultivation appears to be lucrative. The availability of quality seed material supported by organic fertilizers like biocompost, vermicompost and farm yard manure, and polyhouses would greatly help in increasing yield for commercial cultivation. During a particular season, the type of vegetables that can be grown in the hills would be different from that in the plains; hence the produce would be highly remunerative for supply in the plains. At places villagers have undertaken this job which has markedly improved their economic condition.

Protected cultivation

Due to the harsh climatic conditions prevailing in the hilly regions, particularly during the winter and rainy seasons, growth of crops/plants get severely affected. Thus the farmers/growers are unable to raise nursery and/or grow the desired plants resulting in low productivity. Low temperature and frost delay seed germination and subsequent seedling growth resulting in poor quality of plants, high mortality, lack of uniformity in size and shape, etc. causing overall low productivity in the hills. Such problems can be overcome by setting up protected structures under whose cover the plants can be easily and effectively grown. The structures commonly used are polyhouses, polypits and polytrenches (Palni 1996, Anonymous 2000) [18, 3].

The 'polyhouse' technology is an extremely useful and simple method which has greatly helped farmers, villagers and other people for different purposes, including protection of seedlings and plants during the winters and/or during unwarranted climatic conditions. The size and shape of the polyhouse can be made according to need and availability of space. Besides bamboo structures, which are frequently used in the hills, use of steel or aluminium frames to support the polythene sheets (preferably UV stabilized) have also become popular now-a-days (Anonymous 2000) [3].

Another simple technology is that of 'polypit' which involves digging an appropriate sized pit in the ground and covering with durable and transparent polythene (preferably UV stabilized) fitted on a bamboo frame (Anonymous 2000) [3]. The pit can be made of varying sizes depending on the actual need, and the inner walls can also be cemented if need be, particularly in areas of heavy rainfall and/or snow. Different types of seedlings, saplings or vegetables can be grown. It is completely sealed during night or during day time when temperature is low to maintain warmer temperatures and/or CO_2 levels inside (Palni *et al*. 1994, Vyas *et al*. 1999) [19, 32]. During day time when the outside temperature is normal or high, the polythene cover is opened to allow free exchange of gases. The added effect of carbon dioxide fertilization and lesser need for watering offers distinct advantage in a polypit (Vyas *et al*. 1999) [32].

Floriculture

The hilly tract of the IHR is well suited for growing a number of flowers like gladiolus, lilies, gerberas, tulips, daffodils, roses, chrysanthemum, etc. A number of farmers have taken up this trade to cultivate gladiolus and sell the flowers to make a good source of living (Anonymous 2000) [3]. Efforts can be initiated to increase its area of cultivation up to 2200 m altitude and cultivate a wide variety of species which are in demand. However, one of the major draw backs is that the people of the region must be properly made aware of the appropriate methods of growing and subsequent marketing which are essential components to develop a small scale floriculture industry. In order to promote a small scale industry, the following points are important: (a) demonstration or training for growing flowering plants, (b) organize exhibitions for local people including women to create awareness, (c) providing quality plant material to interested farmers/growers, (d) provide technical support, and (e) making avenues for marketing of the produce (flowers, corms, bulbs, etc).

Horticulture

The climatic condition of Uttarakhand is suitable for growing various kinds of fruits like pear, plum, apricot, peach, pecan nut, walnut, citrus, almond, apple, etc. It is important to mention that plants of several horticultural species were planted in this region following India's independence but due to various reasons (poor road connectivity, lack of processing plants, out migration of males, etc.) people lost interest and finally gave up. Although over the last decade new plantations has arisen, but further and serious initiatives need to be undertaken to make it a lucrative trade. The desired plants can be planted on the terrace risers of less productive agricultural fields, surrounding the waste lands or near farm houses of the villagers under a suitable agroforestry system (Rawat *et al*. 1996) [25]. Different hardy species like walnut, pecan nut and almonds are desired by the villagers since such plants are able to withstand drought and the produce do not really require delicate packing during transport. Other plants like citrus species are also recommended since monkeys and langurs, which cause menace in certain areas, would not prefer these fruits.

Biocomposting

Use of farmyard manure (FYM) or 'cattle dung' is a common and traditional practice in the Indian villages. Normally the FYM of this region takes 5-6 months to completely get decomposed (traditional FYM is not completely decomposed when the farmers put in their crop fields). In addition, it is applied to the fields only before crop sowing is done and, thus the nutrients are not available in required quantity during subsequent period of crop growth. Thus in order to improve the soil fertility and reduce the dependency on traditional FYM, a simple and cheap method of Biocomposting of FYM and other biodegradable matter has been reported to have become very popular (Joshi *et al*. 1998, Anonymous 2000) [13, 3]. These workers demonstrated that a mixture of chopped farmyard weeds, cattle dung, soaked waste paper and sieved soil (all in equal proportion) took about 45 days to obtain good quality compost; when farmyard weed was replaced by chir pine (*Pinus roxburghii*)needles, it took about 110 days to get similar quality compost. The biocompost not only helps to render soil fertility but also substantially improves the physical properties of the soil.

Vermicomposting

Use of earthworms to convert biodegradable wastes into useful manure for the plants is called 'vermicomposting'. The beneficial effect of earthworms is due to the fact that these creatures eat up the vegetable matter, soil and other particles, and excrete small pellets of finely ground soil (called casts) which are rich in nitrogen, phosphorus and potassium, essential nutrients for the plants. Thus they speed up decomposition of the vegetable matter (Anonymous 2000, Singh & Kumar 2002) [3, 27]. This property is being exploited in vermicomposting for the production of rich manure called 'vermicompost'.

A cemented pit is generally constructed depending upon space availability (for example, 8 x 4 x 3 ft). Then different types of waste, cattle dung and appropriate quantity of earthworms are added. The pit is covered lightly either with dried leaves or with jute bags; the contents must be regularly churned and a thatched or tin roof is placed to cover from intense heat and rain. This also ensures proper protection as well as retention of moisture without the need to add much water. This technology has become extremely popular amongst farmers and villagers having small land holdings. Some of the farmers have also started selling vermicompost to different Government organizations, NGOs, individuals or to other user groups including earthworms (*Eisenia foetida*). Its high demand makes this technology further demanding and is being gradually adopted by more villagers.

Pisciculture

Fish culture (pisciculture) is one of the main sources of income in the plains. However, in the hills fish cultures do not appear to be so lucrative due to slow growth of fishes under varying climatic conditions prevailing during the year. Nevertheless, further efforts can be made to involve local people to participate in this activity using the existing resources (Kumar & Kumar, 1998)[15].Generally in hills the ponds need to be dug out near a water source and the inner walls of the tank must be lined with thick polythene to avoid seepage of water. The fish fingerlings are placed particularly during the summer season. Generally Chinese carps (common, silver and grass carp) are cultured since they are easily cultivable.

Integrated fish farming *(IFF)*

Integrating some more components to the well-known integrated farming system (IFS), such as, fodder production, dairy, mushroom & vegetable cultivation, biocomposting and vermicomposting can be an excellent means of promoting income generation for small and marginal farmers in the plains of India (Behera and Mahapatra 1998, Singh *et al*. 2006) [9, 26,] and hence has the potential of economic improvement in the Kumaun region also. It has been observed that under this system, recycling of the waste of ducks and/or poultry, the total cost on manure/fertilizers and that of feed required for fish farming is markedly reduced. In some regions of Kumaun hills by adopting fish-duck and fish-poultry, the availability of eggs, meat and fish is maintained (Bisht 2006) [12].

Preparation of decorative items

IHR consists of a great variety of plant wealth which includes trees, shrubs and herbs. These plants produce beautiful flowers and fruits that have attracted tourists from time to time. Other plant parts like small branches, leaves, cones, seeds, roots, mosses, ferns, etc. considered to be of 'little use', can be utilized for making different value added products. These include walking sticks, floral crafts/cards, decorative items, dry flower arrangements, show pieces made out of bamboo/ringal/cane, etc. which contribute to the income generating activities of women and children.

Study site & region

The importance of some of the technologies has been provided above. A study was undertaken in the state of Uttarakhand (area 53, 483 km^2 ; 28º 43' to 31º 27' N and 77º 34' to 81º 02' E),the 27th Indian state carved out of Uttar Pradesh in the year 2000, comprises of 13 districts located in Kumaun and Garhwal region (Figure 1). The Kumaun region consists of 6 districts (Almora, Bageshwar, Champawat, Nainital, Pithoragarh and Udham Singh Nagar) while Garhwal region comprises of 7 districts (Uttarkashi, Rudraprayag, Chamoli, Dehradun, Tehri, Pauri and Haridwar). The state lies mainly in the Indian central Himalaya supports more than 10 million people with 70% people residing in rural area while 30% in urban region (Anonymous 2011a, b) [7, 8]. In hilly region, the life supporting activities are limited and agriculture remains a dominant means of life for majority of the rural people. Although agriculture remains the basic livelihood option for major proportion of the rural population under the poverty line, it is still carried out using traditional methods and is dependent on unpredictable rainfall.

The investigation thus focuses on: (a) to assess the technologies adopted by the locals, and (b) to examine the economic conditions of the people following adoption of these technologies. In this context, 5 villages in Almora district were selected in the state of Uttarakhand, namely Katarmal, Matela, Khunt, Manan (Nagoria) and Basoli for survey conducted during August-September, 2008 and some case studies are described below.

A) Village Katarmal

The village Katarmal is located about approx.16 km from Almora town. Though a relatively larger village amongst the selected ones, with a population of 610 and an area of 325.46 ha, it comprises of 35.66 ha of forest area (Anonymous 2001). Water is scarce in the village, however river Kosi, the

main source of water for Almora town, runs below the village; there is little forest area and no irrigation facility.
Shri Lacchi Ram, who works as a daily wage labourer in Govind Ballabh Pant Institute of Himalayan Environment (GBPIHED), Kosi-Katarmal, Almora has adopted few technologies. These are vermicomposting, vegetable cultivation and growing horticultural crops. It must be mentioned that water source is available at a distance of 0.5 km from his house.

Vermicomposting- Shri Lacchi Ram started vermicomposting in the year 2002 after digging a pit (7 x 5 x 3 ft) with support from GBPIHED. From his house and surroundings area he collects sufficient material for decomposition, for example dung (from 2 buffaloes and 4 goats), farmyard weeds and kitchen waste. Within a year he generated an income of Rs 15,000/- by selling earthworms (Rs 300/- per kilogram) and vermicompost (Rs 12/- per kilogram). In the next four years he earned similar amount; unfortunately from 2007 onwards the market went down and people in Almora and around were not interested in purchasing his produce. Thus lack of market seems to deter the sale. Presently he continues to carry out vermicomposting but for his own use only, and he supplies vermicompost to some interested friends of his village.

Vegetable cultivation-Shri L. Ram do not possess enough land to undertake cultivation of crops, however in the limited land he owns (250 m^2) which includes his house, he grows vegetables for his own use. Vegetables like capsicum, tomato, beans, and eggplant (brinjal) are grown almost round the year (except December to February). He also grows seasonal vegetables like green gourd (zucchini), cauliflower, sweet peas, etc. In the year 2007 an iron framed polyhouse (14 x 7 x 6 ft) was constructed (with UV stabilized polythene) with support from GBPIHED Kosi-Katarmal and this has helped him to generate seedlings and increase vegetable production.

Horticulture- Plantation of fruit trees was carried out by him in 2000, once again with support from GBPIHED who supplied the plants. These include apricot, peach, pear and pomegranate plants. Since only a limited number of plants are grown in a small area, the produce is just sufficient for Shri L. Ram's own use. He works as a daily wage labourer in GBPIHED which is the main source of his earning, use of these technologies do help him in supplementing the food requirement of his family.

B) Village Matela
Matela, a medium sized village with an area of 83.50 ha, 135 households and holding a population of 829, is situated about 10 km from Almora town. River Kosi, the main source of water for Almora town, runs just below the village; there is little forest area and irrigation facility.

Integrated fish farming (IFF) - Shri H.S. Negi has initiated IFF in June 2008 with support from GBPIHED. One cemented pond (40 x 12 x 5 ft) was constructed and lined with polythene. Just next to the pond a small pen (6 x 6 x 5 ft) for hens has been constructed (Figure 1A).Full support (fencing & construction material, fish fingerlings and chicks) and labour for pond and pen construction was provided by GBPIHED. From this technology Shri Negi's income has increased considerably, and he gets regular supply of fish and eggs. Moreover, at times he is able to sell poultry for meat. In addition, Shri Negi carries out vermicomposting, vegetable cultivation and has planted fruit trees.
The economic condition of the people of this village is relatively better and most of the adult males are earning members of the family. During the survey it has been observed that several people in this village grow crops and vegetables all through the year.

C) Village Khunt
Khunt, a medium sized village (167.14 ha) has a population of 467. This place is well known in the hills of Uttarakhand, being the birth place of Bharat Ratna Pandit Govind Ballabh Pant, situated about 24 km from Almora town on way towards Sitlakhet. The village has the highest literacy rate amongst the 5 selected villages taken up in the study.
In general only a limited number of people have shown interest in adopting technologies but due to low income they did not take up. Nevertheless, Shri Madavanand Joshi, one among the experienced persons of this village, has shown tremendous zeal and effort in adopting many of the abovementioned technologies and over the years, since 1982, has developed a rapport with many agencies (Government & non-Government) to implement them and demonstrated generation of income.
Shri M. Joshi has adopted a number of the above mentioned technologies, namely, apiculture, pisciculture, vermi-composting, vegetable cultivation along with polyhouse facility, horticulture, floriculture, agriculture, animal husbandry and mushroom cultivation near his residence, in an area of about 1 ha. The methods adopted in making some of these technologies workable are given as under.

Apiculture- This was initiated in the year 2005 with support from Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora. Four wooden boxes were received and installed (Figure 1B) along with honey bees (*Apis cerana*). While production of honey is not large enough and little processing is being done to improve the quality, the produce is consumed by the family. The production is also based on the season and the type of crops growing in that area. Efforts are being made to increase production and involve more number of villagers to take up this activity.

Pisciculture - This was started in the year 2000 by digging up of one pond (18 x 6 x 4 ft) with walls lined with polythene. Subsequently with support from several agencies like Central Himalayan Environment Association (CHEA) - Nainital and GBPUAT, three other ponds were constructed, which included a cemented one (12 x 8 x 4 ft). The walls were lined with black polythene sheets and then silver and grass carp were cultured. To avoid attack by birds and accidents, the ponds were covered with iron nets. Although the exact data on fish production from these ponds and income were not provided, it was indicated that the production do commensurate with the local demand. The growth of fishes, however, was slow and not as fast compared to that of the plains.

Vermicomposting - Vermicomposting has become very popular in most of the villages in Kumaun Himalaya. Shri Joshi started this as early as in 1990 with one pit (8 x 5 x 3 ft) dug in the soil. Impressed with the faster method of decomposition by the earthworms, compared to ordinary biocomposting method, and production of quality fertilizer,

for his vegetable and crop growth, and support from CHEA, he prepared six cemented pits (8 x 5 x 3 ft), placed side by side (Figure 1C). Subsequently a small structure with tin roof top was placed over it to protect from rain and heat of the sun, and at the same time maintaining high humid and cooler atmosphere for decomposition. The material used for decomposition included kitchen waste, leaf litter, cow dung and even chopped twigs of trees. Following appropriate decomposition, the material is sieved to remove the earthworms and clumps (Figure 1C, inset), and subsequently sun dried for own use or for making packets.

Vegetable cultivation - Cultivation of vegetables has been carried out by Shri Joshi since long. However, since 1982 he took it very seriously and increased production started with the availability of superior quality seeds. The extra produce is being sold in Kosi/Almora market. Subsequently the area under vegetable cultivation was increased along with construction of one polyhouse (20 x 9 x 6 ft); this ensured timely production of seedlings of vegetables. Moreover, production is possible under harsh climatic conditions. Further, in the year 1993 Shri Joshi made another polyhouse of the same size; this further improved seedling production for vegetable cultivation. Currently with the availability of hybrid seeds and organic fertilizers like vermicompost obtained from his household, the production has further increased. Moreover, under polyhouse off-season and highly priced vegetables could be grown resulting in higher income. At the moment vegetable cultivation is being complemented by two polyhouses and different vegetables, namely, potato, sweet peas, cauliflower, cabbage, beans, eggplant (brinjal), tomato, broccoli, capsicum, chillies, etc are being grown (Figure 1D).

Agriculture, Animal Husbandry & Mushroom cultivation – Since the Joshi family possess sufficient land (1 ha) in close proximity to his house where all these technologies have been adopted and demonstrated, he utilized the land for growing crops also. These include rice, wheat, pulses and finger millet (‘mandua’; *Eleusine coracana*). They have also kept cattle (cows) which provide milk and dung (used as manure). In addition, he has started mushroom (Button mushroom) cultivation in 2008 and during the same year more than 100 kg was sold in Almora market (at Rs 100/- per kilogram).Since there is good market round the year in Almora and Kausani (both tourist centres) Shri Joshi has concentrated on increasing the production to generate more income.

D) Village Manan (Nagoria)

This small village located in a valley is about 30 km from Almora town, and 10 km from Someshwar, an important market centre. It is well connected and situated on the Almora-Kausani highway. The area is fertile and the place is rain fed. A small stream flows through some parts of the village and hence this area is well suited for growing crops/vegetables. Initial support from different agencies, namely, IFFCO, GBPIHED-Kosi Katarmal and VPKAS-Almora has helped few villagers in adopting some of the simple technologies for generating better economic benefits. The technologies include vegetable cultivation supported by setting up polyhouses and/or taking up integrated fish farming (IFF).

Vegetable cultivation-The villagers, besides growing rice, wheat and pulses also undertake vegetable [sweet pea, capsicum, tomato, green gourd (squash), eggplant (brinjal)] cultivation. Support to four of the prospective farmers of the village by setting up polyhouses and supplying quality seed material had helped to improve vegetable cultivation which gradually increased over the last few years (about 4-5 years). While the production varied with each farmer and mainly depended on the cultivable area, location in the village and the available workforce, production was concentrated mainly during five months of the year, i.e. from April to August.

It should be mentioned that initiation of such activity and improvement through different lessons learnt by them resulted in increase in income of the prospective farmers. For example, the Chimwal family was cultivating vegetables in their land since long. However, with support from VPKAS Almora, a polyhouse (35 x12 x 9 ft; steel frame; Figure 1E) was constructed in 2002. Subsequently another polyhouse (18 x 10 x 7 ft) was constructed in 2003 with support from IFFCO. With these two polyhouses, the Chimwals could prepare their planting material/seedlings well ahead in the season (even during harsh climatic conditions) as well grow vegetables during any season, be it summer, rainy or winter (Figure 1E). As a consequence the vegetable production along with income has increased considerably from Rs 3000/- p.m. (in 2001) to Rs 15,000/- p.m. (in 2008) during the months of April to August. Based on the above success and a relatively good selling centre in Someshwar market, Shri M. Chimwal has embarked on a programme on flower cultivation (Floriculture). As a trial they would take up cultivation of *Lilium* spp. in a small area of about 600 m^2 with support from the National Horticultural Board (Ministry of Agriculture, GOI).

The other persons who are carrying out vegetable cultivation in that village supported by polyhouses (with external support) are Shri Bhuwan Pandey (from VPKAS Almora), Shri N.K. Mangoli (from IFFCO) and Shri L.M. Pandey (from IFFCO) with a net profit of Rs 10,000/- p.m., Rs 5,000/- p.m and Rs 3,000/- p.m., respectively. Besides the above mentioned four farmers, the remaining persons in the village possess land and grow vegetables in limited area, for their own consumption only. Discussion with many of these villagers highlight various reasons for them not adopting and/or lack of interest in adopting vegetable cultivation or any of the above mentioned simple hill technologies.

Integrated fish farming (IFF) -Pisciculture (fish culture) is popular in some areas of Kumaun region; in this village the Chimwal family has also initiated IFF in 2004 with support from GBPIHED. Two ponds (72 x 39 x 5 and 35 x 30 x 5 ft) were constructed; next to the bigger pond a small pen (6 x 5 x 6 ft) was made for ducks. At a small distance from the pond, another pen (same size) was constructed for hen. Fingerlings of Chinese carps (common, silver and grass carp) were cultured in these ponds and a regular supply provided during that period by GBPIHED since its initiation. In a preliminary study, a net return of Rs 29,500/- was generated in a year by an initial investment of Rs 6,000/- (Anonymous 2005).

Horticulture -The region is well known for growing horticultural tree species and several species like peach, pear, pomegranate, citrus fruits (lemon and sour lime), guava and apricot. In view of this a fruit processing factory, namely The Himalaya Fruit Products Factory was set up at Patharia, 4 km

from Manan for production of fruit drink/squash. However, over the last decade, there has been a decline in interest amongst the locals and hence production of fruits declined. But recently it has picked up and several households, including Shri Chimwal have taken up plantation and/or revived the orchards of the abovementioned species.

E) Village Basoli

Like Manan, village Basoli is also located in a valley, about 30 km from Almora town, in the Almora-Takula-Bageshwar highway. The area is fertile, however, the region is rain fed. A few small streams are seen flowing in certain parts of the village and hence areas in the near proximity are better suited for plant growth. However, at some places the condition of the streams is extremely dismal, particularly during the summer season. Some Government agencies have come to support some of the villagers in adopting a few technologies for generating better economic benefits. The technologies include vegetable cultivation supported by setting up polyhouses, vermicomposting, horticulture, pisciculture and/or taking up integrated fish farming (IFF).

Vegetable cultivation-It is quite a common practice in the village to carry out cultivation of different seasonal vegetables. While some efforts were made by the residents of the village earlier to take this up in large scale, however due to various reasons (particularly scarcity of water and man power) it has not been so successful. At present only one prospective person in this village, Mr Mohan Singh Dangwal, has taken it up in a large scale. This has largely been possible due to his better financial condition and his ability to approach various agencies. With support from Horticulture Department (Government of Uttarakhand) and VPKAS (Almora) he got constructed a steel structured large size polyhouse (140 x 32 x 8 ft; Figure 1F) in the agriculture field itself where a stream flows. It is important to mention that a cement tank was been constructed next to the polyhouse to collect and store stream water (Figure 1F) which is pumped inside for irrigation. Mr Dangwal judiciously uses his polyhouse to raise seedlings and various types of plants; in addition, seasonal vegetables (beans, tomato, cabbage, cauliflower, brinjal, green and bottle gourd, broccoli, etc) are also cultivated. Mr Dangwal has sufficient land nearby where besides cultivation of crops, vegetables (onion, garlic, potato, etc) are also grown (Figure 1F).Although the production from land as well as polyhouse is quite large and profit was not mentioned, it was clear that sizeable income is being generated. Besides use at home, the produce is either sent to nearby market and/or supplied to hotels in Binsar and the locally established Hotel opened by Club Mahindra.

Vermicomposting-Since waste material is readily available in the farm area, vermicomposting is being carried out. Two large cemented pits (10 x 6 x 4 ft each), side by side, were constructed and a tin roof placed over it. As mentioned earlier, following proper procedures, compost is being prepared and the entire lot is used up in the farm of Mr Dangwal, sufficient for on-farm cultivation of vegetables and raising seedlings under polyhouse condition.

Pisciculture – Due to scarcity of water in the region, culture of fish is rare, however Mr Dangwal could undertake this work since a small stream flows through his agricultural field. He initiated this programme in 2007 in a large pond (125 x 30-34 x 6 ft) with support from the Department of Fisheries (Govt of Uttarakhand). The inner walls of the pond were lined with thick and black polythene to stop seepage of water. The fish species generally cultured are Chinese carps (common, silver and grass carp). Although the exact data on fish production from the pond was not revealed but it is envisaged that it was large enough to be sold in the nearby market with reasonable profit. But one important point that emerged is that the growth of fishes is slow compared with that of the plains.

Integrated fish farming (IFF) – In this village IFF was initiated by Shri Khurshiv Singh Bisht in 2004 with support from GBPIHED. One cemented pond (40 x 12 x 5 ft) was constructed and subsequently lined with black polythene. Unlike the IFF system set up in Manan, the fish pond here is quite small due to insufficient land and water. A small cemented structure (pen) for hens (6 x 6 x 5 ft) with tin roof has also been constructed. Besides support in the form of material (for construction) and labour for pond and pen construction along with fencing costs, live material (fish fingerlings and chicks) have also been provided by GBPIHED. Generally fish is harvested once a year; the annual income generated from fish production is Rs. 10,000/- to 15,000/-. While the eggs and bird (meat) from the poultry are consumed by the family members, at times live birds are also sold to hoteliers and/or villagers on demand. Shri Bisht has a small area where he cultivates vegetables and grows horticultural trees (lime, apricot, plum and walnut); the produce is consumed by the family only and there is not much left for sale outside.

Conclusions

Vermicomposting has been adopted in most of the villages surveyed, particularly Katarmal (Shri Lacchi Ram), Matela (Shri H.S. Negi), Khunt (Shri M. Joshi) and in Basoli (Shri M.S. Dangwal). In all the villages the farmers reaped considerable profit from vegetable cultivation; for example S/Shri M.S. Chimwal, B. Pandey, L.M. Pandey and N.K. Mangoli of Manan (Nagoria) village, Shri M. S. Dangwal of Basoli and Shri M. Joshi of Khunt village. In a few cases although the production is not sufficiently high, for example production by Shri L. Ram (Katarmal) and Shri H.S. Negi (Matela) was not very high but sufficient for own (internal) consumption. Only a few persons have taken up horticultural activities, namely, Shri L. Ram (Katarmal), Shri M. Joshi (Khunt), Shri M.S. Chimwal (Manan-Nagoria) and Shri M.S. Dangwal (Basoli), all through support from various organisations. A few persons had the courage of adopting Pisciculture and IFF (Pisciculture- two and IFF-three). Floriculture has been taken up as a new initiative. Shri M. Joshi (at Khunt) has initiated cultivation of *Gladiolus* spp. Moreover, Shri M. Chimwal (Manan-Nagoria) plans to plant floricultural crops (namely Lilly) since his field is near a stream and water would not be a problem.

In general it has been observed that all the above mentioned villages have large sized families with over 75% of the households possessing 5 or more family members. The average income per household ranged from Rs 3565/- (Katarmal) to Rs 4375/- (Basoli) during the year 2009; the low income of Katarmal village is possibly due to the fact that the area is rocky and sandy, water scarcity is acute and thus difficult to grow crops. It is also far from the nearest road. Due to the presence of the famous Sun Temple in this village, a Tourist Lodge has been recently constructed by

Kumaun Mandal Vikas Nigam and connectivity by road has improved; this will promote tourism which will bring substantial benefit to the people of this village. During this period the number of families under category of below poverty line ranged from 25.4% (Manan-Nagoria) to 40% (Matela; Table 1). The source of income of majority of the villagers is through job and labour work; agriculture and allied activities constitute a small fraction, and among the villages studied Manan-Nagoria and Basoli had higher levels, i.e. 25% and 18%, respectively of the households taking up this activity. The general reason is due to low soil fertility, water scarcity, less availability of male members and uncertain income. It must be mentioned that villagers do possess land but own efforts are not sufficient enough and expectations for funding/support from external sources often prevail. Hence people prefer job where income is assured and regular. A major percentage of people of Matela (53%), Basoli (42%) and Manan-Nagoria (32%) earn their living through job, however, working as labour force was found highest in Katarmal (70%), followed by Khunt (42%), Basoli (31%) Matela (30%) and Manan-Nagoria (27%; Table 1).

It is also a common practice to keep domestic animals (cows, buffaloes, goats, sheep, etc.) and its number was found to vary. Almost all the households in the villages possessed at least one cow/buffalo; the presence of other animals however, varied. In few villages goat/sheep were kept; all these domestic animals are a source of income too. Most common problems of the villagers, though varied, were mainly water scarcity, availability of fuel wood, job, cultivable land and manpower shortage. In view of the above, some workable suggestions are provided below:

Workable suggestions

(i) Consolidation of land holdings- Most of the villagers have small land area and scattered holdings; many a times the distance between the holdings is far. Thus, efforts need to be made to "consolidate the land", not just between one villager/farmer, but to consolidate land in nearby locations/plots so that activities like vegetable cultivation, plantation of horticultural and agroforestry tree species, and others can be taken up in a somewhat bigger scale. This will not only ensure increased land area for applying the technology but also more inputs in terms of combined wisdom/ideas, work force and resources.

(ii) Solving water scarcity- It has been observed that water is a real and continuous problem in the hills, therefore, emphasis must be given on improving water availability. The hill areas of Uttarakhand are totally rain fed and in order to improve the living condition, and particularly for human and animal consumption, and cultivation, water is of utmost importance. Serious efforts must be made by the Government and other agencies to develop "water harvesting" facilities and such programmes need to be funded on priority basis. Steps need to be undertaken to harvest rain water effectively from all places, like roof tops of houses/buildings, sloping field, etc. Moreover, such facilities must be set up in different villagers as a 'model' so as to make people aware about the exact benefits.

(iii) Solving fuel wood need- The requirement of fuel wood is a continuous need of the villagers. This need must be taken up quite seriously. As observed from Table 1, one of the problems is fuel wood supply; therefore, plantation of fast growing species is absolutely necessary. In this context collaboration of villagers and Forest Department would be essential; many a times due to over-grazing and human interference the planted saplings do not survive. Once again, consolidation of land and involvement of the Van Panchyat are essential to solve this issue.

(iv) Marketing- Marketing of product needs to be improved considerably. Unless it is proper and timely, the small farmers may not be able to sell their produce; this was clearly observed in case of Shri L. Ram of Katarmal village while selling vermicompost and earthworms. Thus setting up a Farmers' Co-operative will not only reduce post-harvest losses but facilitate easy transportation and fetch appropriate price; the cooperative can also cater other basic needs of farmers, like procurement of seeds, planting material, insecticides, make labour available and solve other items.

(v) Involvement of women- In villages most of the household work, including agriculture, is being carried out by women; they appear to be more responsible than men. Thus for adoption of technologies in villages, it would be imperative that more number of women be involved to carry out the actual work and get involved in technical and managerial activities to make the technology successful.

(vi) Awareness & updating knowledge- Although awareness amongst villagers is increasing as far as the technologies and developments are concerned, they need to be updated on newer methods along with management skills. Over time various awareness and training programmes are being provided/organized by the Government and non-Govt. Agencies, such activities need to be more frequent.

(vii) Setting up of demonstration models- It has been observed that various Government and non-Government agencies have supported different farmers/ villagers. But in a real sense nothing much has come out. In most cases, the financial or physical support given by these agencies was to 'so-called relatively better-off farmers', and hence the overall benefits to common people were found to be very less. Moreover, these were provided to individual persons and not to a group of many villagers/farmers. Such kind of support in "bits and pieces" would not make any headway. However, it is felt that in order to really make the technologies successful and improve the economic conditions of the villagers, such organizations should come forward and help to set up a *"model demonstration site"* where some of the relevant technologies are demonstrated and technical know-how is provided including marketing. This should involve villagers/farmers so that the local residents learn from their experiences and subsequently adopted on their own. It must be emphasized that unless such an approach is taken, development in a village will remain in the back seat.

Based on the study and the workable suggestions as provided, if implemented, the problems to a large extent can be solved. All these points can be easily implemented if serious efforts are taken keeping in mind the need for economic upliftment of the farmers/villagers. Even in the villages there is variation in income which is reflected in their living standards. The overall economic condition of villages has improved markedly following efforts by the Government and various agencies. Thus the poverty lines for

the country have also improved; population below poverty line got reduced from 37.2% in 2004-05, to 29.8% in 2009-2010 to 21.92% in 2011-12, while that of Uttarakhand from 32.7%, 18.0% to 11.26% during the same period (Papola 2014) [20]. It is hoped that adoption of these technologies and concerted efforts will help in furthering the livelihood opportunities in these areas, including other hilly regions.

Fig 1: A map of India along with Indian Himalayan region and Uttarakhand state in particular; different sites selected for the study can be approached from Almora town.

Fig 2: Figures depicting some of the simple technologies adopted by villagers for income generation and improving livelihood.
A: A prospective farmer with his integrated fish farm in Matela village; B: A wooden bee hive placed close to the residence of Shri M. Joshi near Khunt village; C: Rows of pits under a shade where vermicomposting is being carried out by Shri Joshi; inset: a close view of the earthworms; D: Cultivation of broccoli in a terrace by Shri Joshi near Khunt village. Inset: a closer view of a broccoli plant; E: Green

pumpkin is being grown under polyhouse condition by the Shri Chimwal family in Manan village; and F: A storage water tank beside a polyhouse used for irrigation of plants inside.

Table 1: A table summarizing the socio-economic condition of villagers, their involvement in agriculture and problems in some selected villages of the study.

Parameter[#]	Katarmal	Matela	Khunt	Manan (Nagoria)	Basoli
No. of members in a household(% of household)					
• 4 or less	14.0	21.0	12.0	17.0	11.0
• 5 or more	81.0	76.0	84.0	78.0	92.0
Average income per household per month (Rs)	3565/-	4135/-	4155/-	4350/-	4375/-
Per cent of families on below poverty line (BPL)	28.2	40.0	26.7	25.4	26.5
Source of income (% of household)					
• Job	10.0	53.0	25.0	32.0	42.0
• Labour work	70.0	30.0	42.0	27.0	31.0
• Agriculture & allied	10.0	2.0	9.0	25.0	18.0
• Other activity	5.0	12.0	18.0	13.0	6.0
Presence of electricity in a house (% of household)	75.6	90.0	76.7	80.0	85.0
Presence of cooking gas in a house (% of household)	45.0	52.0	45.0	65.0	55.0
Land (‘*Nali’)* with each household					
• Agriculture & allied	2.0	1.2	1.5	2.1	2.0
• Other types	0.4	0.2	0.3	0.2	1.0
Animals (nos.) with each household					
• Cow/buffaloes	0.90	1.3	1.2	1.1	1.2
• Goat/sheep	0.45	0.1	0.5	0.3	0.3
• Others	0.1	0.1	0.2	0.2	0.1
Availability of important items (within 2 km)					
• Water	Yes	Yes	Yes	Yes	Yes
• Fuelwood	No	No	Yes	No	No
• Fodder	No	No	Yes	Yes	No

[#] Data were collected in January 2009; BPL= Below Poverty Line; 1 *Nali* = 200 m^2.

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