The Economics of Ecosystem and Biodiversity – TEEBAgrifood Initiative in Uttarakhand

Scoping Report: Demonstration Plot Study

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Submitted to:

The Economics of Ecosystems and Biodiversity, UNEP

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Acronyms

ANOVA	Analysis of variance
BMI	Body Mass Index
CAP	Centre for Aromatic Plants
CED	Chronic Energy Deficiency
ENT	Ear Nose Throat
FCO	Fertilizer Control Order
FLDs	Front Line Demonstrations
FYM	Farm Yield Manure
GBPAU	G B Pant University of Agriculture and technology
Ha	Hectares
HDR	Human Development Report
IAA	Indole acetic acid
INR	Indian National Rupee
KVK	Krishi Vigyan Kendra
MMR	Maternal Mortality Rate
NPOP	National Programme for Organic Production
PGS	Participatory Guarantee Scheme
PKVY	Pradhan Mantri Krishi Vikas Yojana
RCOF	Regional Centre for Organic Farming
SSFA	Small Scale Funding Agreement
TEEB	The Economics of Ecosystem and Biodiversity
U.S. Nagar	Udham Singh Nagar
UCOB	Uttarakhand Organic Commodity Board
UKHDR	Uttarakhand Human Development Report

1. Executive Summary

TEEBagrifood India: Promoting Sustainable Agriculture and Biodiversity Conservation

TEEB - The Economics of Ecosystems and Biodiversity is an international effort aimed at acknowledging, showcasing, and assessing the worth of ecosystems and biodiversity in both monetary and non-monetary terms. TEEBagrifood India, a specific initiative under TEEB, is currently underway in twelve countries. Its primary goal is to safeguard biodiversity and foster a more sustainable agricultural and food sector. Within the Indian context, this project is focused on promoting organic farming and agroforestry in the states of Uttarakhand and Uttar Pradesh. The end goal of this initiative is to inform decision-making within the public and private sectors involved in the agricultural and food industry.

GB Pant University of Agriculture and Technology is commissioned to conduct the assessment focusing on organic agriculture and agroforestry in Uttarakhand through Small-scale funding agreement (SSFA). The core objectives of the project are to inform policy on organic farming's impact, support spatial planning, evaluate economic case, and provide insights for sustainable food production policies. In addition to these, after refining the scope with GBPAU, the TEEBagrifood framework assessment incorporated the demonstration plot study as one of its activities. The objective of this study is to establish an on-farm demonstration of organic inputs and technologies that are related to organic agriculture to boost farmers confidence and build linkages with natural, human, social and produced capitals. This report presents the scope of the demonstration plot study which will be undertaken in two villages of Uttarakhand – Sunkiya and Bidaura situated in Nainital and Udham Singh Nagar respectively to examine the impact of organic farming in both hilly regions and plains.

The Green Revolution and its Environmental and Social Impacts

Post-Independence, to ensure food security, a series of initiatives and enhancements in agricultural technology took place primarily around 1960s. India embraced the “Green Revolution” – a term coined by William Gaud in 1968 to describe the significant increase in agricultural productivity. Green revolution provided modern agricultural protocols such as use of high yielding crop varieties, fertilizers and irrigation to boost crops in a short span of time aimed to alleviate hunger and poverty in the country.

While green revolution resulted in various positive impacts such increasing the agricultural productivity, reduce hunger, improve livelihoods and development of agricultural infrastructure, on the flip side, environmental degradation, increased water consumption and increased inequalities became a major concern. Environmental degradation associated with intensive use of chemicals and irrigation in order to maximise the yield resulted in soil degradation, reduced water quality and loss in biodiversity. Furthermore, unequal distribution of resources resulted in increased inequalities, with small farmers struggling to afford inputs and facing displacement due to widespread uptake of agricultural technologies.

Green revolution emphasized the need for a holistic approach that considers environmental sustainability along with ensuring social equity and involvement of small-scale farmers. This includes cost-effective cultivation methods that promote ecological interactions to ensure soil fertility, nutrient cycling and retention, water storage, control of post and diseases, pollination. Sustainable farming methods such as organic farming and agroforestry are regimes that are ecosystem friendly; promotion of chemical free agricultural practices, etc. Studies suggest, organic farming practices are more effective that conventional farming methods when judged on important parameters such as species diversity and abundance, soil fertility, crop nitrogen update, water infiltration rate and energy use efficiency. (Qiao, Yuhui, et al.2018; Meemken et al. 2018; Reganold & Wachter 2016; Chopra et al. 2013; Fileβbach et al. 2007).

Considering economic, social and environmental angles, organic farming provides a holistic strategy that can maximise crop production per unit area. In India, organic farming was officially introduced in 2000s. Since then, various policies and schemes have been introduced that promote organic farming practices including making compost and green manure, biofertilizers and biopesticides available etc.

Demonstration Plot Study: Boosting Farmer Confidence in Organic Agriculture

The TEEB Agrifood assessment in Uttarakhand includes study of two demonstration plots that are chosen to evaluate the impact of organic farming over time. The two plots that are chosen for this study are Sunkiya and Bidaura situated in Nainital and Udham Singh Nagar respectively. This component of the project will be pivotal in understanding the empirical linkages of scaling up organic farming with the natural, social, human and produced capital stocks. One of the major objectives of this study is to use the data generated for soil parameters such as such as soil health, crop provisioning, carbon sequestration, water retention quality, etc., and yield parameters such as plant biomass, fruit size, disease incidence, etc. will be crucial while drawing the future scenario for scaling up organic farming and agroforestry in the state of Uttarakhand. The production potential of the input system used in organic farming routines is vital in character and holds the foundation for trust-building among new-age farmers. The demonstration studies at each site will be performed with the assistance of Krishi Vigyan Kendra (KVK) for the trust-building process and to understand the cropping system prevalent and followed by local farmers.

2. Study Area Profile – Uttarakhand

Located in the north, Uttarakhand is predominantly mountainous known globally for its natural beauty. The plain region of the state is known as the Tarai-Bhabar region comprising of Haridwar, Udham Singh Nagar, and parts of the Nainital and Dehradun districts. Whereas, the hill region consists of Chamoli, Rudraprayag, Almora, Bageshwar, Uttarkashi, Tehri, Pauri, Champawat, Pithoragarh, and parts of the Dehradun and Nainital districts. Administratively the district is divided into Kumaun and Garhwal regions. The state's diverse agro-climatic conditions divide it into 12 distinct agroclimatic zones. The farming conditions vary in the hilly and plain regions. Farmers in Plains are involved in commercial farming practices, while those in hilly areas are majorly involved in subsistence agriculture.

Most farmers belong to the small and marginal landholder category in the state**.** Out of the total cultivable land, a large area, about 89 percent, are small and sub-marginal farms. The total number of land holdings is 0.9 million out of which 71.0 percent are marginal farmers (land holdings below 1.00 hectares), 18 percent are small farmers (land holdings between 1.00-2.00 hectares) 11 percent of farmers hold land above 2 hectares. The average size of land holding in the state is 0.95 hectares as against the National Average of 1.57 hectares. Also, in the hills, the average land holding size is as low as 0.35 hectares and approximately three-fourths (74 percent) of the holdings are marginal. The State is having about 61.1 percent area under forests. The share of the net sown area is only about 12 percent; of this 33 percent area is organically certified by different certifying schemes. It is prominently said phrase that 'Uttarakhand is Organic by default' which only indicates the popularity of traditional agricultural practices followed in hill districts since ancient times using only the natural resources on the farm, however looking at the plain area districts, such as Udham Singh Nagar, Haridwar and parts of Nainital, and Dehradun, the agriculture pattern is drastically different from the trends followed in the hills and is more intensive, uses heavy mechanization and application of chemical compounds commercially available to curb the pest problem.

3. Impact of Chemical Inputs

Numerous negative effects are associated with the excessive use of chemical fertilizers and pesticides posing significant risk to human health and the environment. Chemical inputs in agriculture produce disturb and disrupt biodiversity, contaminate groundwater, and cause a variety of severe diseases such as cancer, asthma, diabetes, cognitive effects, and so on. (*He et al*., 2005; Sarwar, 2015; Government of India, 2016a).

Impacts of Fertilizer Use

A summary of impacts on human health and environment of chemical fertilizer use is provided in Table 1 below.

Table 1: Effects of fertilizers on human health and environment

Fertilizers and its by-products	Health Impacts	Environment impact
Urea	Skin disease (Bremner 1990)	Disease in soil pH, acidification and adverse effects on seed germination (Bremner 1990; Savci 2012)
Ammonium and nitrogen oxides	Respiratory illness, asthma methaemoglobine, infant disease and premature death etc. (Savci 2012; Loukil et al., 2015; Bishnoi 2018).	Ozonedepletion,global warming and acid rain etc. (Motavalli et al., 2008; Savci 2012).
Phosphorus	Hyperphosphatemia, renal failure, heart disease, arthritic syndromes, atherosclerosis, and osteoporosis (Sharpley and Menzel 1987).	Increase the concentration of cadmium in soil. Eutrophication in lakes and ponds (Sharpley and Menzel 1987, Bennett et al., 2001).
Potassium Chloride	Gastric disease and stomach pains, dizziness, and bloody diarrhea (Loukil et al., 2015).	Disrupt the balance of nurtrients in soil (Sharplet and Menzel 1987).

Impacts of Pesticides Use

The continuous, uncontrolled, unscientific, and exaggerated use of agrochemicals is adversely affecting human life, the environment, and the biosphere. The use of pesticides in India has seen a significant rise going from 154 metric tonnes in 1954 to 88,000 metric tonnes in 2000 (Kumar et al., 2016; Bonvoisin et al., 2020). Although there was a decline in pesticide consumption by the year 2015–16 to about 58,634, it has been steadily increasing and has reached about 62,193 metric tonnes in the year 2020–21 (Figure 1).

In Uttarakhand, between 2017-18 to 2021-22, the state recorded a 45.7% decline in the pesticide consumption, from 210 Mt to 114 Mt (DAC & FW). The knowledge and awareness levels of the retailers regarding the distribution pattern of pesticides have a direct impact on their usage by the farmers. Appropriate advice on the pesticide choice is lacking.

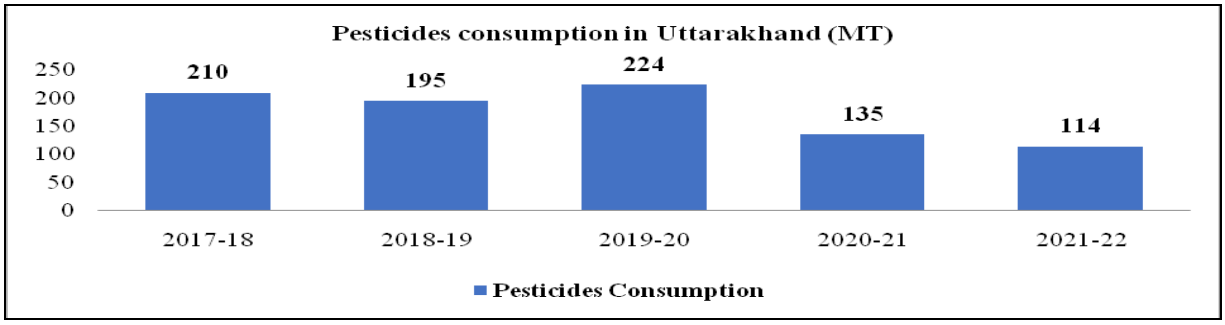


Figure 1: Pesticide consumption rates in Uttarakhand

In terms of the pesticide absorption by the pests, studies indicate, that less than 0.1 percent of the pesticide applied is consumed by the targeted pests. While the rest 99.9 percent ends up in the environment, posing risk to the beneficial organisms including natural enemies and leading to contamination of soil, water and the atmosphere (David Pimental, 1995). Furthermore, in India, there are a total of 85 pesticides registered for use that are banned in other parts of the world. As of 2020, six of these, including dichlorvos, and phorate, are banned. Currently, there are about 20 highly hazardous, 36 moderately hazardous and 17 slightly hazardous pesticides that are banned for use in India (WHO, 2010, Government of India, 2016b, PAN-International 2018, PMEP 2018). These banned pesticides pose serious health risks to living organisms due to their ability to rapidly dissolve in fats and accumulate in non-target organism (Agrawal *et al.*, 2010). The toxic effects and consumption of banned pesticides are summarised in Annexures No 1 and 2.

Impact of Pesticides on Human Health

Exposure to pesticides is hazardous to the health of agricultural workers and the consumers of the agriculture produce. A report by All-India Network Project on Pesticide Residues revealed that pesticide residues were detected in 18.7 percent of samples, unapproved pesticides were found in 12.5 percent of samples, and residues above the maximum residue level (MRL) recommended by FSSAI were noted in 2.6 percent of samples. The intake of food containing pesticide residues is reported to result in the highest exposure, which is estimated to be 10^3 -10^5 times higher than that from contaminated drinking water or air (Nayana Sharma, 2017). The Punjab region of India is particularly affected by pesticide poisoning. In a study, traces of pesticides like DDT, HCH, profenofos, monocrotophos, etc were detected in 35% of the 111 samples of human blood, with some samples detecting levels as high as 34.90 ng ml−1 (Sharma et al., 2020). Prolonged pesticide exposure can lead to liver malfunction, immune malfunction, neurologic impairment, and reproductive effects, although results regarding there effectives are inconclusive. Agricultural poisoning ranks second among various methods of suicide and records 23,172 deaths per year due to self-poisoning in India.

Impact on Natural Resources

Water Resources

Agriculturally rich states have reported above-average levels of nitrate pollution in their groundwater. In addition to nitrates, several other metals such as aluminium, lead, chromium, zinc, copper, cobalt, cadmium, etc. are also found to be present above permissible limits due to excessive use of chemical fertilizers. The continuous consumption of fertilizers is considered a possible cause for various life-threating and life-altering diseases such as cancer, diabetes, arthritic syndromes, diabetes, kidney malfunction and improper cognitive & physical growth, low haemoglobin levels, hair loss and skin diseases. Reproductive health issues such as low sperm counts, impotency in males and reduced fertility in women are also

found to be associated with the consumption of fertilizers. (Loukil *et al*., 2015; He *et al.,* 2005).

Pesticides can enter water through surface runoff or through leaching. Suspended sediments of these pesticides can change water quality and affect many life forms. They are toxic to aquatic organisms and cause various diseases in humans and other animals (Stevenson *et al.,* 1997).

Soil

Excessive fertilizer consumption impacts the soil fertility and exposes soil to high nitrogen levels that consist of carcinogenic substances such as nitrosamines (crops like spinach and lettuce showed harmful accumulation of NO_3 and NO_2) (Savci, 2012). Vegetables accumulate toxic substances such as nitrogen fertilisers, which lower soil pH and potassium fertilisers, which disrupt nutrient balance. These substances have negative effects on humans and animals.

Excessive use of pesticides in soil results in a decline in populations of beneficial soil microorganisms and disrupts the biological processes that are carried out by these microorganisms. For instance, the common landscape herbicides Triclopyre inhibits soil bacteria that convert ammonia to nitrites. They can block nitrogen fixation, inhibit the growth of mycorrhizal fungi, and reduce the general biodiversity in the soil. Additionally, pesticides can directly affect non-target vegetation and are also responsible for soil erosion.

Air

Excessive use of nitrogen fertilizers causes air pollution by nitrogen oxides (NO, N_2O, NO_2), which along with the other atmospheric gases contribute to the greenhouse effect, ozone depletion, acid rain, etc. (Savci, 2012). The release of Nr (reactive nitrogen) into the atmosphere from industry, cities, and agriculture contribute to the increase in levels of particulate matter (PM 2.5), ground-level O_3 and NO_2 in the air we breathe, causing premature death and other serious health consequences (Bishnoi, 2018).

Frequent exposure to toxic pesticides is considered to be harmful to humans and other living organisms causing life-threatening risks associated with exposure to air contaminated with harmful chemical pesticides. Dermal and ENT exposure are some of the common routes through which pesticides can enter the body of animals and humans.

Pesticides can cause several severe human diseases such as cancer, asthma, diabetes, Parkinson’s disease, leukaemia, cognitive effects, and infertility, etc. (Sarwar, 2015).

4. Organic Farming in Uttarakhand

4.1. Implementation Status

Pradhan Mantri Krishi Vikas Yojana, Organic Certification Board, Rashtriya Krishi Vikas Yojana are some of the key schemes promoting organic agriculture practices in the state. Government spending of approximately 1.3 million INR every 3 years is deployed for the promotion of organic farming practices. Under the various schemes, farmers receive organic inputs (biofertilizers and biopesticides) and other natural farming inputs such as Beejamrit, Ghanjeevamirt, Neem cake, etc. Other inputs include vermicompost, and phosphate-rich organic manure. Support for successful organic value chain development including provisioning of agricultural implements, infrastructure development through Gokul scheme, availability of packing material and trainings are also provided. Despite witnessing various efforts, farmers continue to prioritize intensive farming.

Pradhan Mantri Krishi Vikas Yojana – Uttarakhand

One of the key policy priorities considered under the TEEBagrifood assessment is the of implementation Pradhan Mantri Krishi Vikas Yojana to analyse the potential for scaling of organic farming interventions in the state. As of 2018-19, the scheme is being implemented in 23 districts and 3900 clusters of Uttarakhand. Among these, as seen in Tehri Garhwal has the highest number of clusters with a total of 600, followed by Pauri Garhwal, Uttarakashi, and Almora, each with 450 clusters (Figure 2).

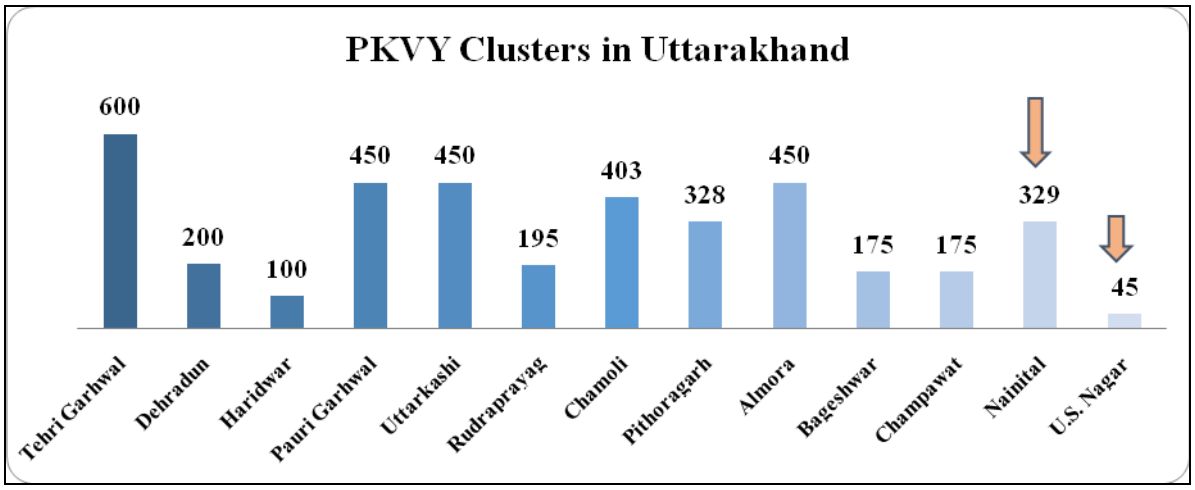


Figure 2: Number of clusters in each district in Uttarakhand

The Agriculture Department, Horticulture Department, Sericulture Department, Centre for Aromatic Plant Board (CAP), and Uttarakhand Organic Commodity Board (UOCB) work in close collaboration to implement PKVY at the district level. These departments work together to cultivate various important crops using organic methods, with each department overseeing its respective area. The information provided by the office of Chief Agriculture

Officer of U.S. Nagar, majority of the clusters are under the agriculture department (55%), followed by horticulture department (32%), UCOB (10%), sericulture department (2%) and CAP (1%) (Figure 3)

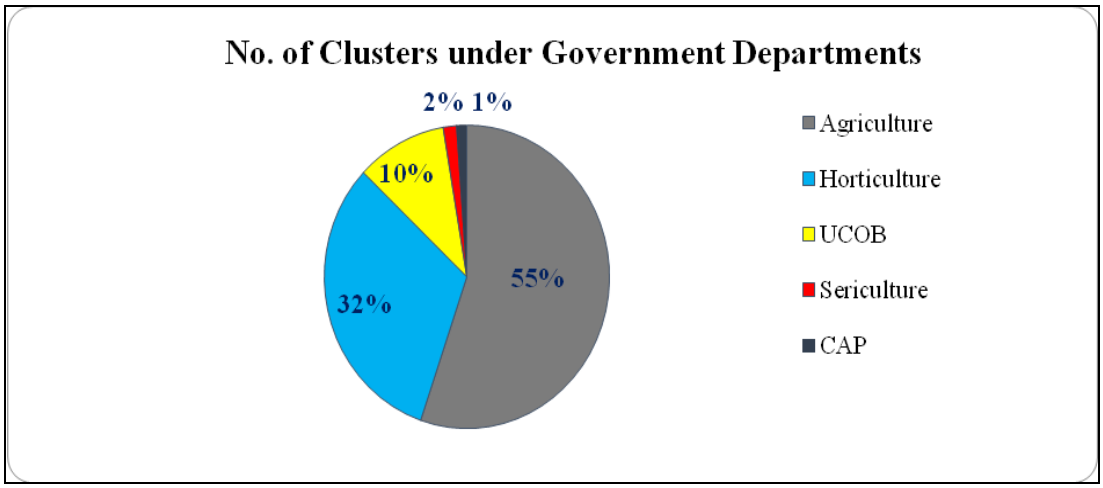


Figure 3: Number of PKVY clusters allocated to each department – Uttarakhand

PKVY Implementation in U.S. Nagar

The district of U.S. Nagar consists of a total of 45 clusters, with clusters dedicated to major agricultural crops, 14 clusters of sericulture, and 23 clusters for horticulture crops. Among the blocks within U.S. Nagar, Bajpur has the highest number of clusters, with a total of 15, followed by Kashipur and 8 clusters, and Gadarpur with 7 clusters as shown in Figure 4

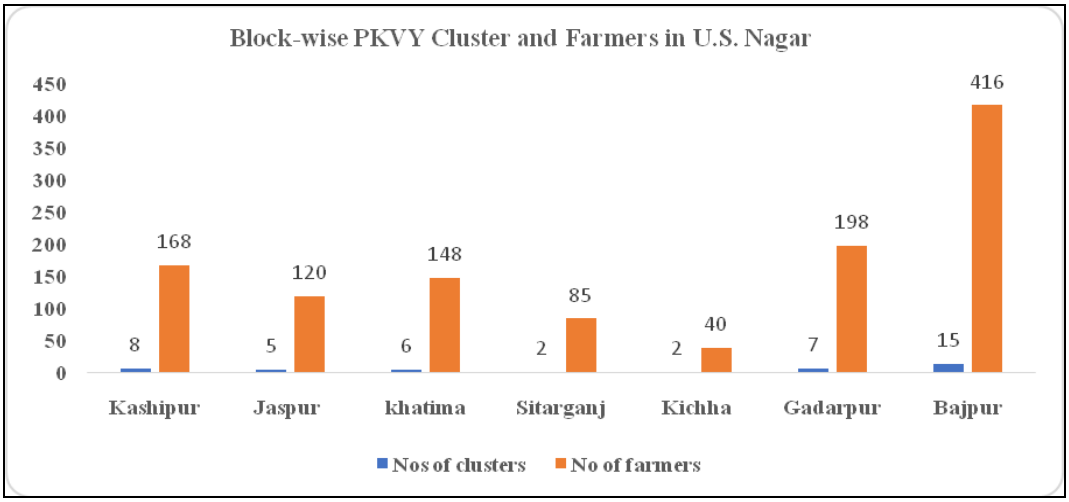


Figure 4: Block-wise number of PKVY clusters in U.S. Nagar

A total of 1175 farmers are covered under the Participatory Guarantee Scheme certification in the district. The highest number of farmers come from the Bajpur block, followed by Gadarpur and Kashipur with 198 and 168 farmers, respectively. Under PKVY, a total of 1020 ha of land is dedicated to organic farming in Udham Singh Nagar. Among these, 460 ha is

used for horticulture crops, of which 280 ha each are assigned to agriculture and sericulture clusters.

Horticulture crops are the primary focus for organic farming by majority of the farmers. As seen in Figure 5 among these horticulture clusters, peas are the most prominent vegetable crop grown followed by bottle gourd, ridge gourd, and tomatoes. Mango, guava, and litchi are the main fruit crops, comprising 20 percent, 17 percent, and 6 percent of the total horticultural crops, respectively.

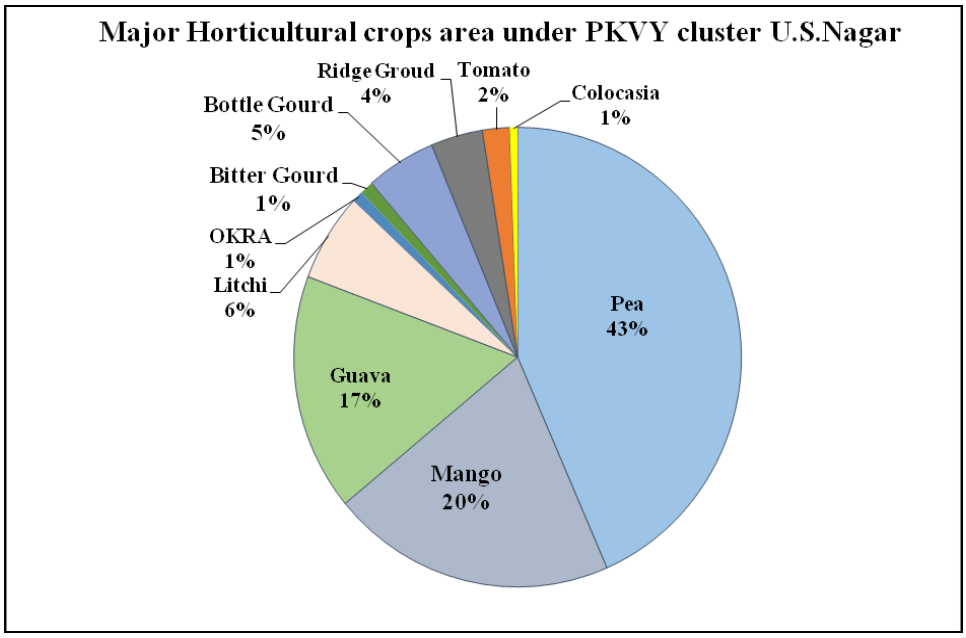


Figure 5: Major horticulture crops grown in U.S Nagar under PKVY clusters

Subsequently, wheat and paddy are the primary crops cultivated in Rabi and Kharif seasons, respectively in the agriculture and sericulture clusters.

Table 2: Major crops and area under agriculture cluster

Kharif 2019		Rabi 2019		Kharif 2020		Rabi 2020		Kharif 2021		Rabi 2021	
Crop	**Area (Ha)**	**Crops**	**Area (Ha)**	**Crop**	**Area (Ha)**	**Crop**	**Area (Ha)**	**Crop**	**Area (Ha)**	**Crop**	**Area (Ha)**
Paddy	280	Wheat	160	Paddy	159	Wheat	160	Paddy	159	Wheat	160

PKVY Implementation in Nainital District

In the Nainital district, Agriculture Department, Horticulture Department, Sericulture Department, Centre for Aromatic Plant Board, and Uttarakhand Organic Commodity Board collaborate together for the implementation of the scheme. Agriculture Department holds the

highest clusters, accounting for 57 percent of the total, with 187 out of a total of 329 clusters. The horticulture department comes second with 20 percent of all clusters. The Uttarakhand Organic Commodity Board has 50 clusters, making up approximately 15 percent, while Sericulture and the Centre for Aromatic Plant Board have 9 and 17 clusters, respectively, contributing around 2 percent and 5 percent.

Horticulture plays a significant role in the Nainital hills as a major source of revenue for farmers. The region is known for the distinctive quality of its fruits and the cultivation of vegetable crops during off-seasons. The Dhari block has the highest number of horticulture clusters of 17, followed by Betalghat, Ramgarh, Bhimtal blocks, which have 16, 14, and 13 clusters, respectively (Figure 6).

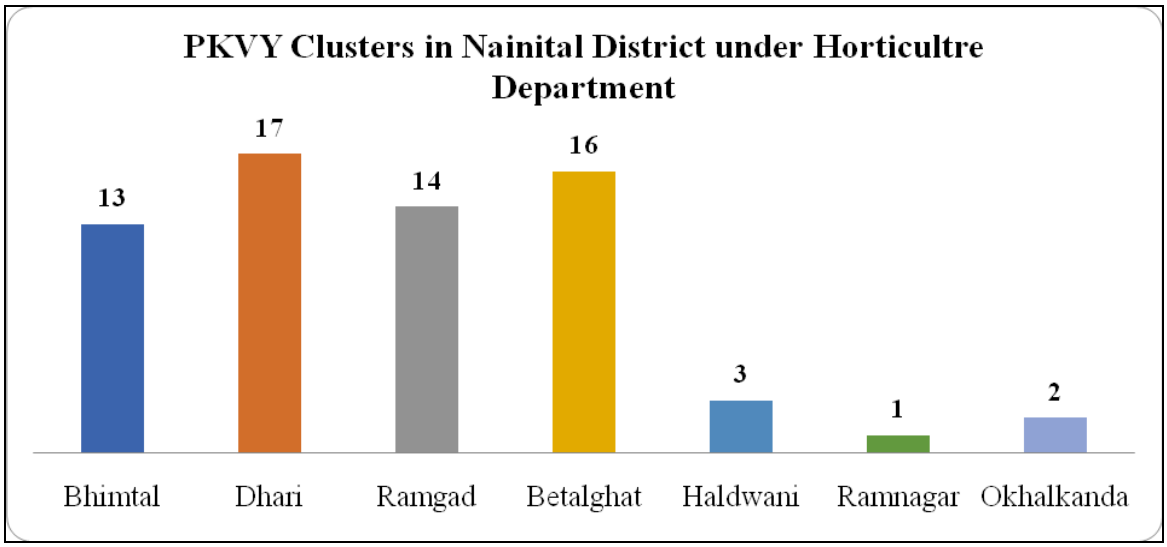


Figure 6: Block-wise information of cluster in Nainital blocks

According to the Chief Agricultural Officer of Nainital, the PKVY scheme involves horticulture clusters spanning an area of 1364 hectares dedicated to vegetable crops. These clusters primarily cultivate organic vegetables such as peas, potatoes, cabbage, cauliflower, beans, tomatoes, capsicum, cucumber, and chilies. Among these crops, peas oppucy the highest share, covering 29 percent of the total cultivated area. Potatoes and cabbage are the next significant crops, accounting for 26 percent and 22 percent of the total area respectively (Figure 7).

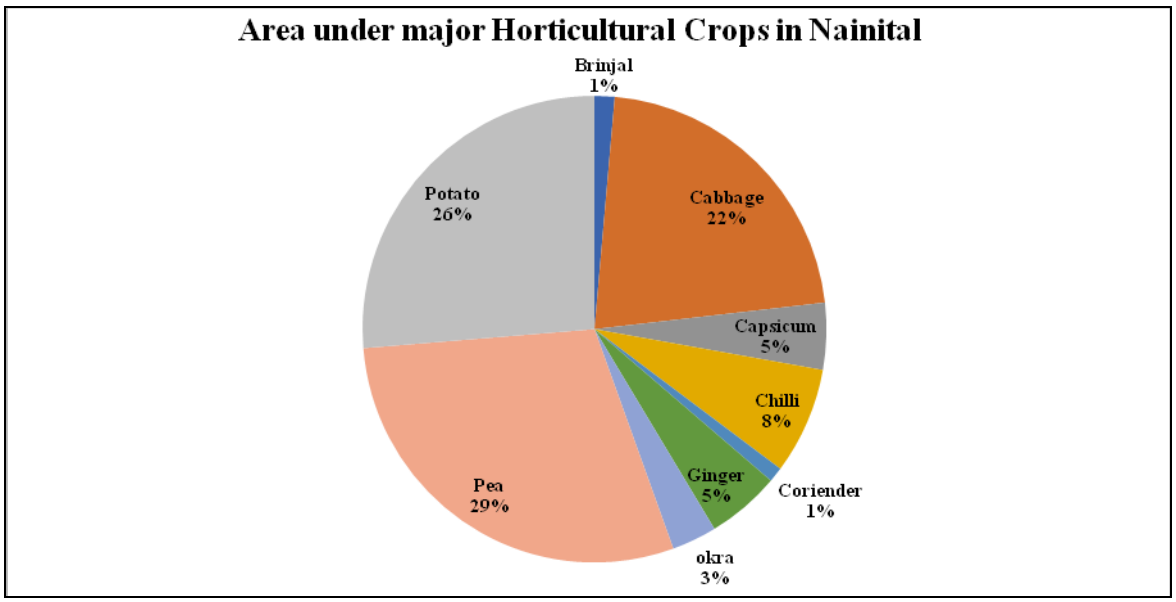


Figure 7: Area under major horticulture crops in Nainital

Paddy is the principal crop cultivated in the agriculture cluster of Nainital during the kharif season. In 2021-22, an area of 1592 ha covered under paddy cultivation received PGS certification. Similarly, horse gram and black gram covered 560 ha and 496 ha of area, respectively Several other crops are grown during the Kharif season including finger millet, rajma, and Amaranthus, with their respective acreages of 286 ha, 256 ha, 206 ha, and 226 ha in 2021-22 (Figure 8).

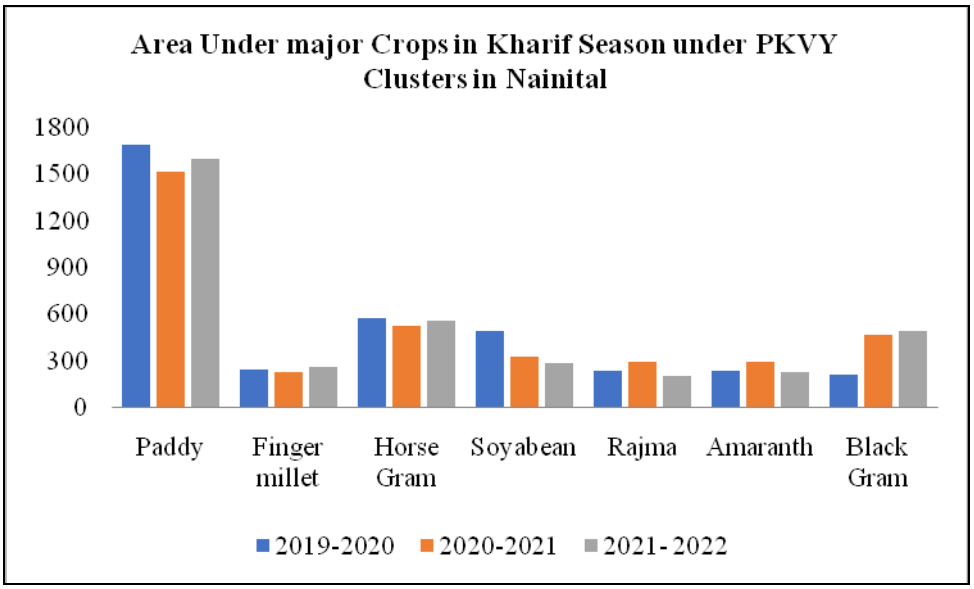


Figure 8: Area under major crops during Kharif season in PKVY clusters - Nainital

During the Rabi season, districts most significant crop in wheat, which encompasses an area of 2260 hectares (as of 2021-22). Following wheat, there are other important crops like mustard, pea, and barley, occupying areas of 788 hectares, 519 hectares, and 98 hectares, respectively (Figure 9).

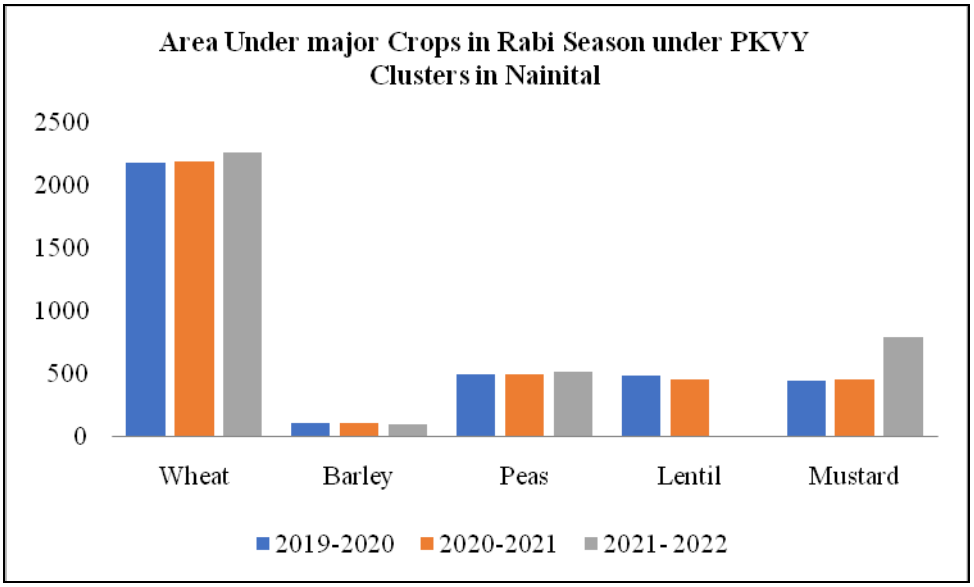


Figure 9: Area under major crops during Rabi season in PKVY clusters - Nainital

4.2. Challenges in Organic Farming

The Ministry of Agriculture, Government of India has identified Uttarakhand, Jharkhand, Rajasthan and North-eastern states as states with lowest consumption of chemical fertilizers compared to the rest of the country. Consequently, the government decided to transform these states into organic states. Uttarakhand, in particular, has a promising future in organic farming owning to its reserve of natural resources and widespread government initiatives aimed at achieving sustainable development while preserving ecosystem and biodiversity. While Uttarakhand is making significant progress in this direction, several constraints are in its way to achieve "Organic state status". Some of these with respect to development across natural, human, social and produced capital which the TEEBagrifood framework assessment will evaluate.

High Input Costs

Traditional farming practices followed by small and marginal farmers align with the organic standards as they predominantly rely on on-farm inputs derived from livestock, forest and cattle waste which is environmentally friendly. However, the costs associated with organic inputs has risen and now is higher compared to industrially produced chemical fertilizers, pesticides and other inputs used in conventional farming. A study conducted by the Directorate of Economics and Statistics, Uttarakhand (2016-17) analysed the cost of cultivation of conventional crops like Basmati rice, non-basmati rice, wheat, and sugarcane is higher by 1.50 percent, 2.56 percent, 25.20 percent, and 1.90 percent, respectively in comparison to organic cultivation practices in plains (in this case Haridwar).

Low Yields

Experiencing low yields in a single season can be disheartening for farmers. In majority of these cases, farmers face a temporary loss in yields as they transition from conventional to organic ways of farming, eliminating the synthetic inputs. Restoration of the full biological activity takes time, including growth of beneficial insect populations, nitrogen fixation from legumes, pest suppression, and restoration of soil fertility. This interim period can result in decreased yield rates. Analysis of the same study cited above by the Directorate of Economics and Statistics, Uttarakhand (2016-17) for Haridwar district also revealed that the returns from conventional crops were higher in Basmati rice, wheat, and sugarcane by 13.78 percent, 27.71 percent, and 3.11 percent, respectively, in comparison to organic cultivation.

Lack of Adequate Supporting Infrastructure

Even though the National Programme for Organic Production (NPOP) was introduced in 2000, state governments have not yet developed comprehensive schemes, policies, and reliable processes for their implementation. The establishment of a trustworthy framework is still pending. Currently, there are only a few accreditation agencies available, and their expertise is primarily focused on fruits, vegetables, tea, coffee, and spices production.

Marketing Problems of Organic Inputs

The adoption of commercial organic products such as bio-fertilizers and bio-pesticides has not gained widespread popularity in the country. This can be attributed to weak marketing, limited cold chain supply, and distribution networks. Additionally, Retailers are hesitant to deal with these products, as the demand is low. The inconsistent quality of such bioproducts and limited awareness of the cultivators further contributes to the problem as doubts arise regarding their performance on field. Furthermore, higher retail profit margins in chemical fertilizers and pesticides coupled with high short-term performance benefits in terms of yields provides better cost/benefit ratios to the farmers which become major challenge to address on the ground level.

Among specific districts, Udham Singh Nagar, Haridwar, Nainital, Champawat, and Dehradun have prominent markets, with three of them located in the plains. However, in the hilly districts, the markets do not function efficiently, and the state also lacks regulated markets for agricultural produce.

Knowledge gaps

The farming community, due to gaps in knowledge, raises doubts about the ability of on-farm inputs to adequately replenish the necessary nutrient levels in the soil. Farmers believe that organic matter alone is insufficient to fulfill the crop's nutritional requirements and that chemical fertilizers are necessary to meet those needs.

Availability of Farm Biomass

One of the main challenges for organic farming is the availability of farm biomass, as the required amount cannot be sourced externally. Even currently, farmers are unable to meet the organic matter requirements from their own resources. The success of organic farming relies on landowners embracing it without skepticism. One significant drawback is the lack of quality inputs, which should be addressed by dividing the supply into two categories. Farmers can arrange one portion from their own resources, while the other portion can be supplied by the industry.

Subsidy on chemical fertilizers

The parameters for biofertilizers are monitored through Fertilizer control Order (FCO) 1985 as regulatory confines, which was brought under the Union Ministry of Agriculture and Farmers' Welfare, in 2006. As of now, 11 bacterial and fungal biofertilizers are approved under FCO, which include nitrogen fixing, phosphate-solubilizing and potassium-mobilizing biofertilizers. Available in liquid as well as solid forms as packaged biofertilizer product. Government of India has launched several programmes to promote the biofertilizer production, one of the most prominent of all is PKVY (Paramparagat Krishi Vikas Yojana) to create awareness among farmers. In 2020-21, 1,34,323 tonnes of carrier-based solid biofertilizer and 26,442 kilolitres of liquid biofertilizer were produced in India marking tremendous increase in comparison to previous years. Unfortunately, the total sum amount of money spent on these schemes through government is still dwarfed by the subsidy schemes on chemical fertilizers.

Poor quality organic inputs

There are 26 FCO approved laboratories authorized to perform quality assurance tests on biofertilizers and other organic inputs. These labs have combined capacity of testing 14000 sample per year, these include Regional Centre of Organic Farming (RCOF). However, many states in India still do not have their own authorized centres for testing the biofertilizer samples. Indicating widespread availability of inferior quality and spurious biofertilizers in local markets due to lack in quality assurance Procurement of these biofertilizers through low priced tenders by state governments is another major reason for distribution of inferior quality product among farmers under various schemes.

U.S. Nagar and Haridwar are plain districts of Uttarakhand. While Nainital and Dehradun have half of their land in plain areas. These plain areas of the state are predominantly irrigated, as a result, large-scale intensive farming practices are carried out here. On the other hand, the hilly areas that practice rainfed agriculture have a greater potential for organic farming, but the level of awareness about these farming methods is significantly low. It is crucial to assess the impacts of conventional or intensive agricultural practices, considering the sector has gone through commendable technological advancements, from crude chemical fertilizer technologies to the introduction of nanotechnology. However, the rate of scientific

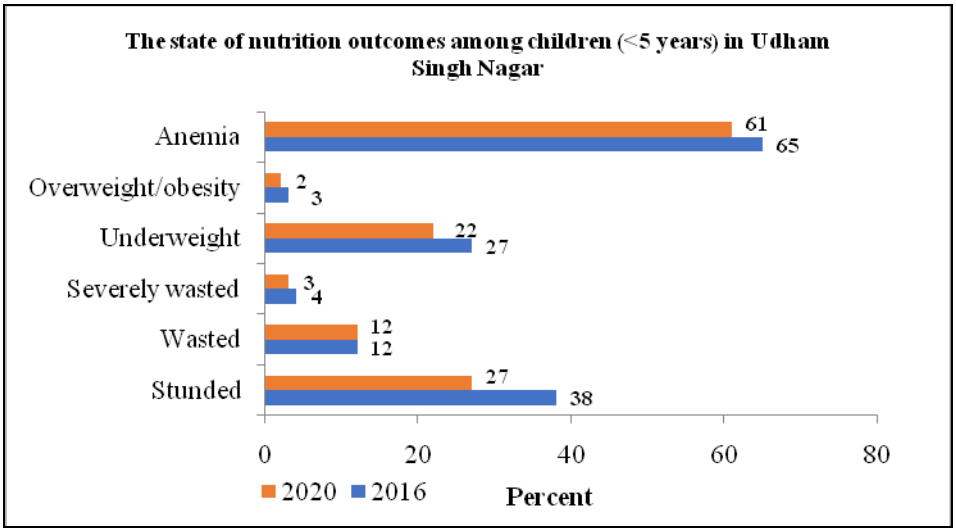
innovation surpasses the level of education and innovation among hardworking farmers in countries like India.

Demonstration studies serve as clear examples, showcasing how technology is disseminated from research centres compared to the actual farming practices of the farmers. In addition to data collection for establishing baselines, these studies are key to identifying factors at grassroots level that influence the current agricultural methods.

5. Status of Social and Human Capital Indicators in Uttarakhand

5.1. Health

38 and 32 percent of the children under five years of age in Udham Singh Nagar and Nainital respectively are experiencing stunted growth in height indicating long term undernourishment. Additionally, 12 percent of children in Udham Singh Nagar and 9 percent in Nainital are wasted, indicating recent inadequate food intake or weight loss due to illness. About 3-4 percent of children are severely wasted. Underweight rates are also concerning, with 27 percent of children in Udham Singh Nagar and 17 percent in Nainital falling into this category. Underweight includes both chronic and acute malnutrition. Moreover, more than half of children aged 6 to 59 months are anaemic, with rates of 65 percent in Udham Singh Nagar and 58 percent in Nainital (Figure 10).



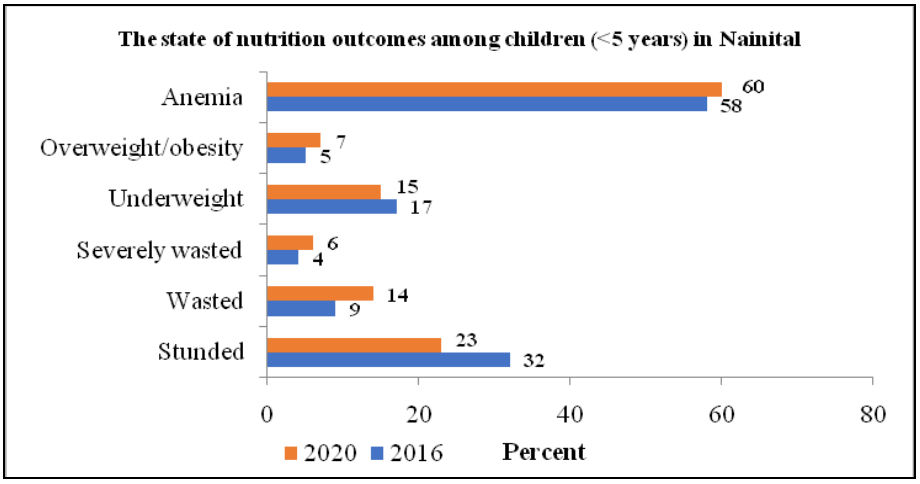
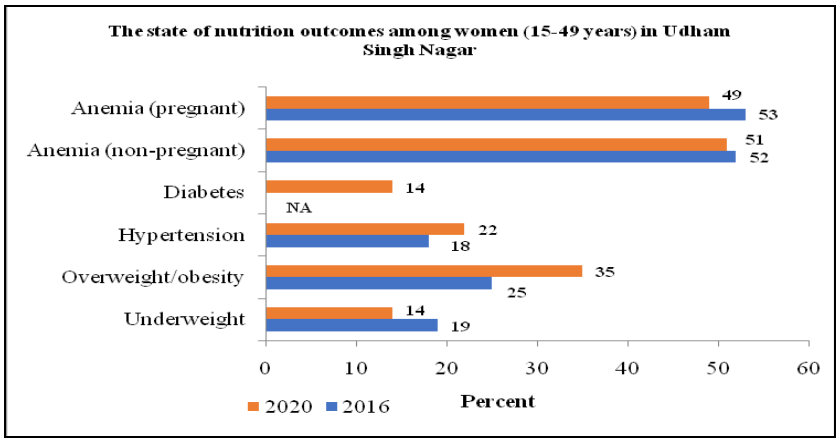


Figure 10: State of nutrition outcomes among children (U.S. Nagar and Nainital)

In Udham Singh Nagar, 25 percent of women and in Nainital, 27 percent of women are classified as overweight or obese. Additionally, over half of the women in the district are affected by anemia. Anaemia is a significant health concern in the region, particularly among women and children. The prevalence of undernutrition tends to decrease as factors such as the mother's education level, her overall health, the birth weight of the baby, and the spacing between births improve (Figure 11).



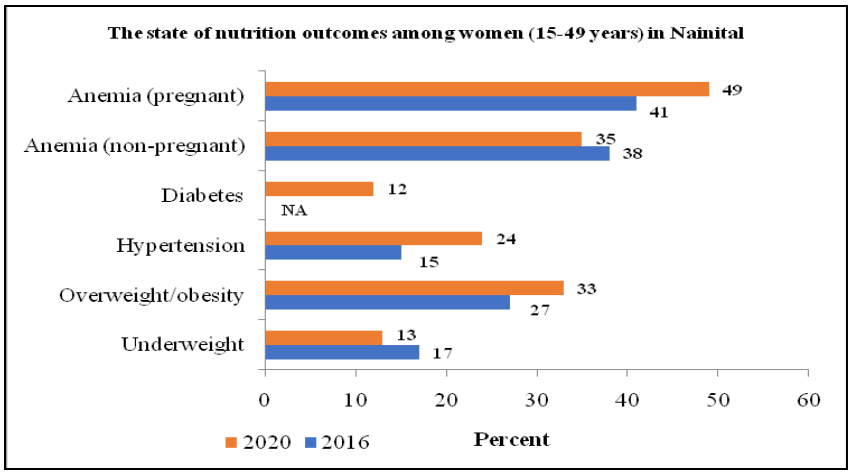
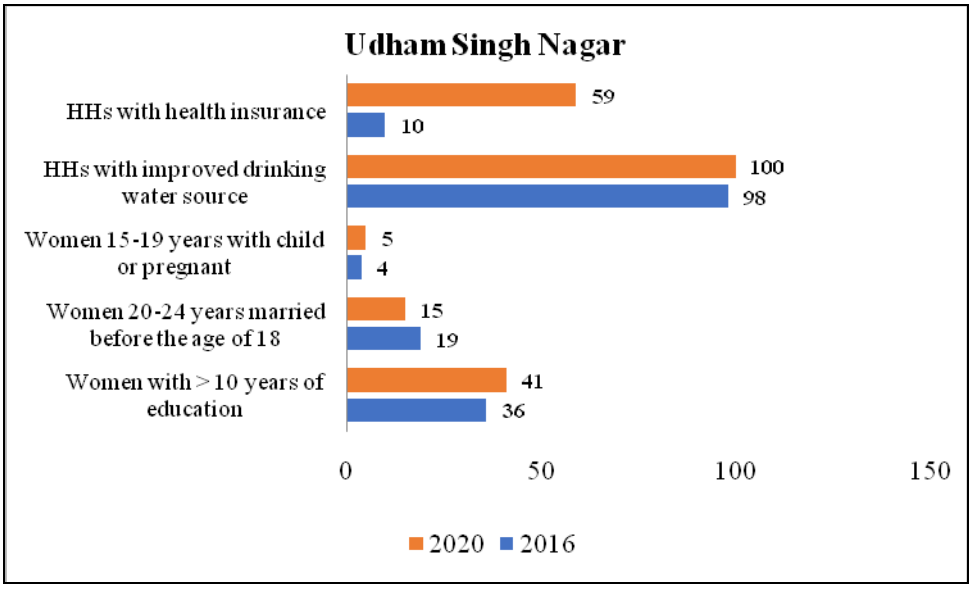


Figure 11: The status of nutrients outcomes among women (U.S. Nagar and Nainital districts)

Status of Human health schemes

Emergence of several health insurance programmes and health schemes in U.S. Nagar and Nainital districts has resulted in an increased uptake of insurance plans by the residents from 10-13 percent in 2016 to 59-61 percent in 2020 (Figure 12). The average healthcare costs in the state is INR 3,741 per capita per year i.e. 9.4 percent of the total household expenditure. Healthcare spending in urban areas is observed to be more at INR 4,203 compared to rural areas at INR 3,518. In addition, healthcare expenditure in plains is more compared to the expenditure by residents in hilly areas (INR. 4,369 and INR. 2,932 respectively) (Uttarakhand Human Resource Development report 2018).



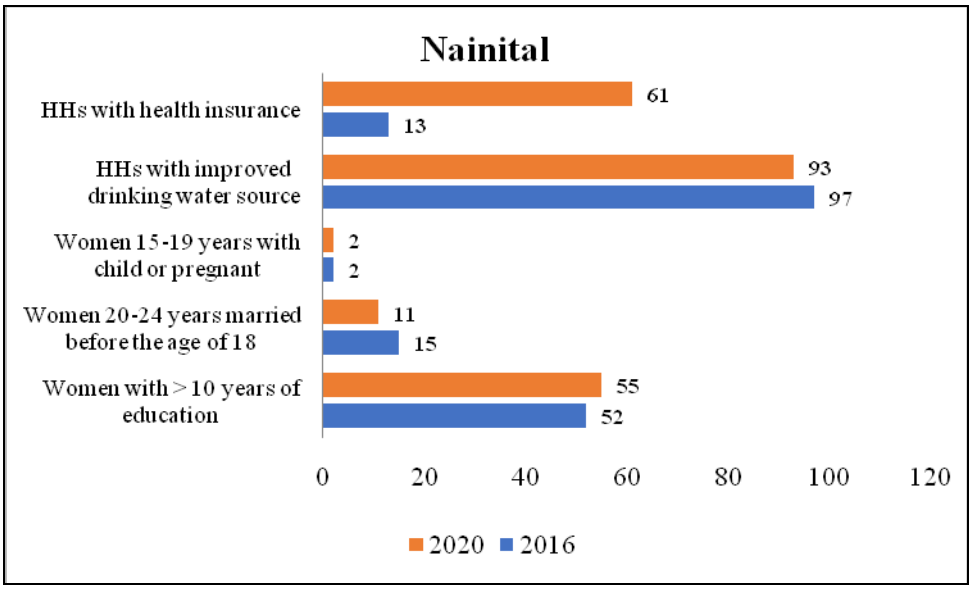
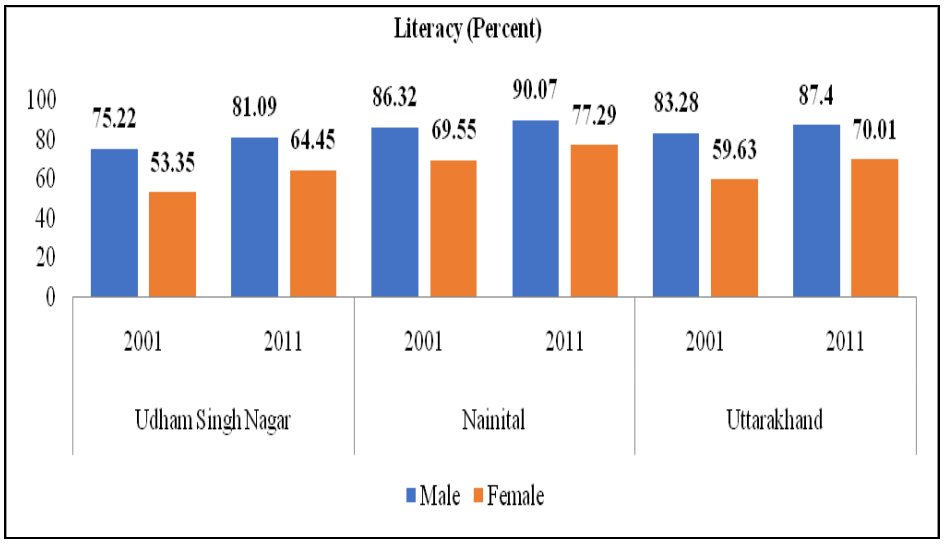
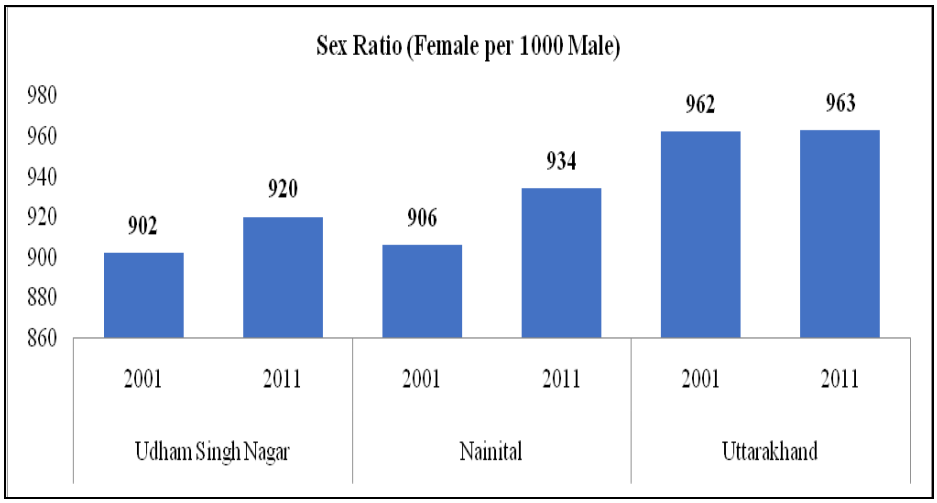


Figure 12: Status of health schemes and health related indicators (U.S. Nagar and Nainital)

5.2. Women Empowerment

Gender inequality persists in Uttarakhand, where women face disparities and limitations compared to men. The disparity in literacy rates between males and females is significant, with a gap of 17.39 percentage points. The literacy rate among males stands at 87.4 percent, while the corresponding rate among females is 70.01 percent (Figure 13). Particularly alarming is the decline in the child sex ratio, which dropped from 948 in 1991 to 908 in 2001 and further declined to 890 in 2011. Uttarakhand has a high maternal mortality ratio (MMR) of 285 per 100,000 live births, second only to Assam, which has the highest reported rates of MMR (HDR Report, Uttarakhand, 2018). As per the 2011 Census, the state's overall literacy rate was 78.82 percent, with males having a literacy rate of 87.40 percent and females having a literacy rate of 70.01 percent.





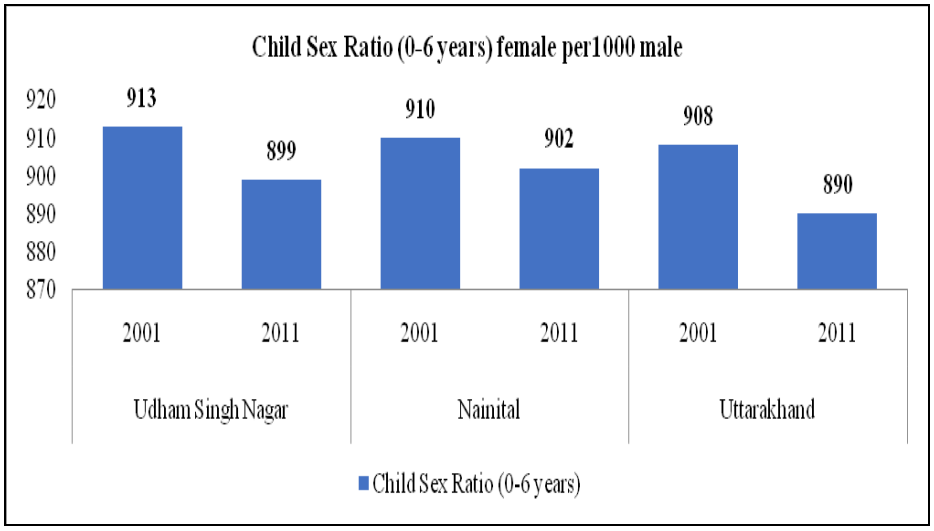
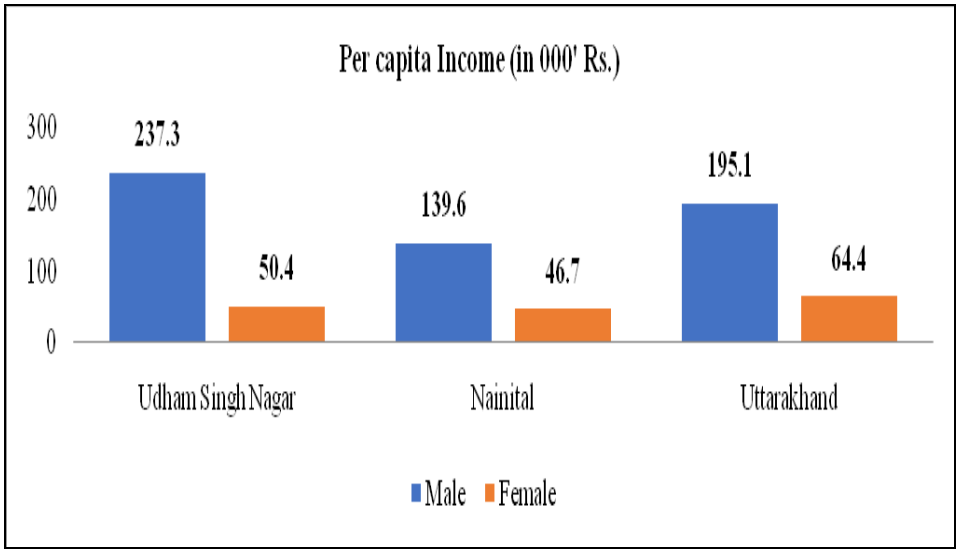
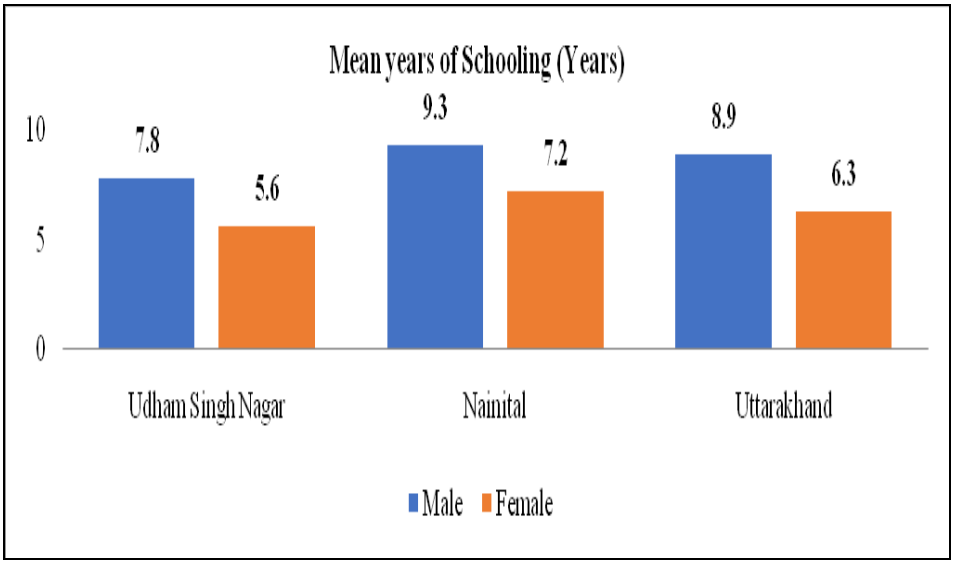


Figure 13: Literary, sex ration and child sex ration (Uttarakhand, U.S. Nagar and Nainital)

Women participation in the labour force has been declining since 1994, with a large gender gap in the labour force employment rate. Between 2005-2012, Uttarakhand ranked lower than most of the states in terms of job creation. The non-farm sectors of Uttarakhand's economy have not generated enough jobs to absorb the growing size of the workforce displaced from agriculture. In terms of per capita annual earnings, males (INR 195,100) earn three times more than females (INR 64,000). This divide in annual per capita earnings is significantly high in the plain's possibly due to low female participation in economic activities. Across the state and districts, females have a lower average number of years of schooling compared to males, with males having an average of 8.9 years and females having 6.3 years. On the other hand, women have a higher life expectancy of 74.3 years compared to men's life expectancy of 68.8 years.





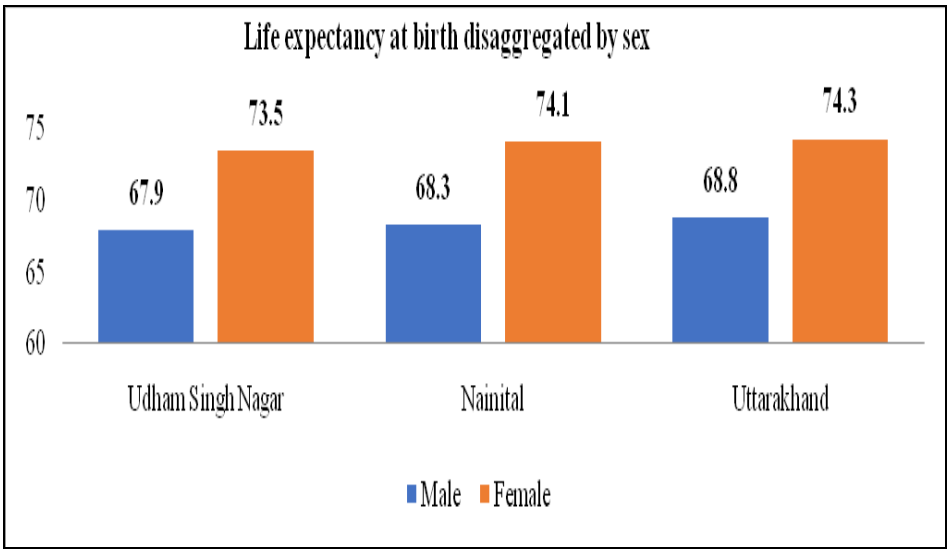


Figure 14: Per capita income, mean years of schooling, life expectancy at birth (U.S. Nagar, Nainital and Uttarakhand)

5.3. Employment and Literary

The employment structure of the Uttarakhand has witnessed a transformation in the past couple of years from primary to tertiary sector and, to some extent, the secondary sector. Agriculture, however, continues to play an important role in the state, with approximately 70% of the rural population relying on it for a living. It is true that agriculture sector employs a higher percentage of female workers in the state. Female workers constituted a higher share of the agriculture workforce (52.2 percent) compared to 47.8 percent of males. In Uttarakhand, the distribution of occupations based on gender reveals that women are primarily engaged in medium-skilled occupations and agricultural activities, accounting for 57.8 percent of their employment. In contrast, men are more commonly employed in low-skilled occupations, comprising 29.2 percent of their workforce. According to the UKHDR, regular workers earn significantly higher average daily wages at INR. 545 compared to casual

workers who earn Rs. 303. In rural areas and hilly regions, skilled agriculture, crafts, and related trades provide greater employment opportunities, while urban areas and plains have a higher concentration of employment in services such as retail sales and professional activities. It is essential to quantify the wages of regular and casual workers based on their educational level, taking into account both rural and urban areas as well as plains and hilly regions of the state.

5.4. Migration

Results from data presented in the report by Migration Commission suggests that the main occupation of the people living in different villages of the state is agriculture, followed by labour and government service. Migration from rural to urban areas in the state poses a significant challenge. Between 2001 and 2010, a total of 3,83,726 individuals across 6338-gram panchayats have migrated on a semi-permanent basis, while 1,18,981 individuals have permanently migrated from 3,946 gram-panchayats. As a result of which, 564 villages that have witnessed an over and above 50% decline in the population in the last 10 years. The hills are witnessing long-term outmigration in much higher proportions compared to plains.
The increasing unsustainability of income and livelihoods in hill agriculture may be a contributing factor to this phenomenon. Furthermore, the lack of infrastructure in the hilly regions has hindered the emergence of new job opportunities in the industrial sector. According to the Uttarakhand Human Development Report Survey conducted in 2017, approximately 8 percent of the sampled population were recorded as migrants, with the proportion being higher at 10.7 percent in the hill districts. Migrated households accounted for around 28 percent of the total. Notably, out-migration from the hill districts of the state was significantly higher at 38.5 percent. It is worth mentioning that rural out-migration (9.1 percent) was three times higher than urban out-migration (3 percent).

5. Demonstration Plot Study

6.1. Overview

By demonstrating the advantages of organic inputs, which not only promote plant growth but also enhance resilience of the plants, farmers can be convinced of the potential of organic farming without experiencing significant losses in crop yield. Furthermore, implementing agroforestry practices at a demonstration site is considered valuable in showcasing the advantages of the intervention, not just in terms of financial gains but also in terms of maintaining a balanced ecosystem and addressing soil-related concerns. It is widely believed that crop yield decreases during initial three years of organic farming implementation, demonstration plot study will help instil confidence in the farmers and dispel their misconceptions about organic farming. The key lies in farmers being proactive in carrying out timely operations while utilizing high-quality inputs in their fields.

This on-farm demonstration trial, also known as Front-Line Demonstrations (FLDs), represents a unique approach that facilitates direct interaction between scientists and farmers. It also provides an opportunity for showcasing the strategies, inputs, and technologies developed in research institutions. This allows scientists to adapt and improve their research programs based on the data collected and analyzed during the demonstrations. In the context of scaling up organic agriculture and Agroforestry in Uttarakhand, the FLDs provide valuable insights into the impact that can be achieved through small-scale interventions, such as enhancing the quality of inputs used in organic farming. These interventions have the potential to address issues like low crop yield, income, and overall poor health within the farming community.

In this regard, the demonstration plot study will be carried out in the Bidaura village of Udham Singh Nagar and Sunkiya village of Nainital districts of Uttarakhand. The broad scope for this demonstration study includes the folloing:

- The farmers will be trained at creating organic inputs like quality FYM, vermicompost, Amripani, Panchgavya, etc. In addition, they will be trained at the storage procedure and tackling their shelf life.
- Quality biofertilizers/biopesticides will be distributed and farmers will be given hands-on training on the methods for their application

While relying solely on the government is not a comprehensive solution, it is important for the government to invest in training programs and establish initiatives that ensure farmers have access to quality products. Marketing also presents a significant challenge, particularly for rural communities. Therefore, an effective system is necessary, although it falls beyond the scope of the demonstration study.

Linkages with TEEBagrifood Valuation

Heavy deforestation activities, soil erosion, dried water bodies, soil acidity, high-intensity irregular rainfall, increased risk of snow and frost, lack of infrastructure to curb animal damage, hostile topography, and poor transportation for market access are some of the major factors affecting agriculture in the hilly areas. The economic valuation of the eco-agri-food system through the demonstration trials will help generate evidence that could support policy formulation, development of growth pathways, specifically focusing on the marginalised farmer communities which are the dominant social group in the region. The demonstration trials have the potential to develop customized solutions tailored to specific locations, benefiting marginalized farmers by promoting economic growth and facilitating sustainable development.

These trials have the potential to assess the historical and future connections between environmental, social, and economic outcomes. Even small-scale changes can have significant impacts on all four capital stocks (Natural, Social, Human, and Manufactured), particularly in terms of farmers' income, which is directly linked to improved access to nutritious food. This can play a crucial role in addressing malnutrition, particularly among women and children. The trial studies can also account for the externalities associated with

the transition from conventional agriculture to organic practices, including the generation of ecosystem services and disservices. Additionally, they can evaluate the social structure of the community and its impact on human development.

6.2. Demonstration Sites

The demonstration sites were shortlisted based on study area surveyed and listed in the project scoping report (Deliverable 1). The Kosi and Kailash watershed selected for the study of biophysical modelling consists Nainital and Udham Singh Nagar. During this phase of the study, one village in one block is selected from these two districts. Sunkiya village from Dhari block in Nainital district and Bidaura from Sitarganj block in Udham Singh Nagar selected for demonstration plots and Social and human capital analysis. The demonstration trials will be set up on the agricultural land of the voluntary farmers. The Bidaura village consists of 435 numbers of households and Sunkiya consists 274 numbers of households in the village. For each selected village 30 numbers of households will be selected randomly for the study.

6.2.1. Bidaura-Majhola, Udham Singh Nagar

Bidaura village, located in Sitarganj block of Udham Singh Nagar district in Uttarakhand, India, is a gram panchayat situated 8 km away from the sub-district headquarter in Sitarganj and 93 km away from the district headquarter in Rudrapur (Figure 15). The village spans a total geographical area of 360 hectares and has a population of 2,629 individuals, with a female population of 47% based on the 2011 census. There are approximately 435 houses in Bidaura village, and the literacy rate stands at 73%, with a female literacy rate of 30%. The village consists of a 40% scheduled tribe population (Tharu tribe) and a 3.5% scheduled caste population. It falls under the Nanak Matta assembly and Nainital-Udham Singh Nagar parliamentary constituency. The village has been identified through primary survey, revealing a small number or absence of organic farmers. Agriculture work in this village is primarily managed by the women population, and households with lower income relying on agriculture as their main source of income will be selected as beneficiaries for the study. The project will provide inputs based on the farmer's crop plan, which is subject to change according to market trends (the specific crop plan is not provided here). The major crops cultivated in the village include wheat, rice, pulses, and vegetables.

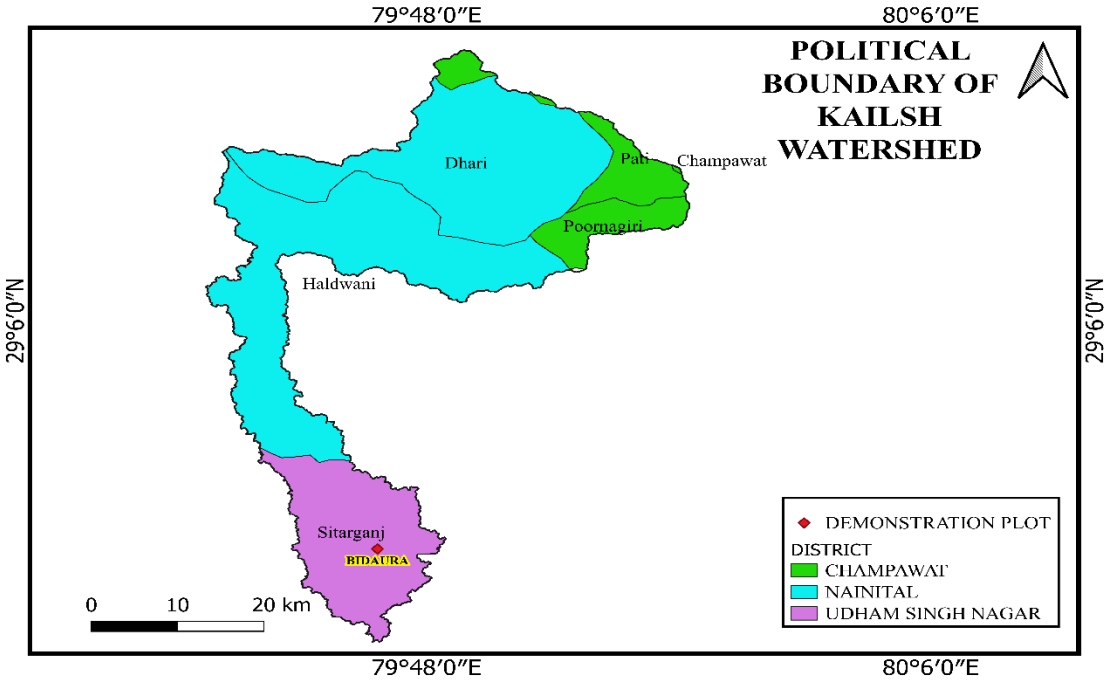


Figure 15: Kailash watershed map showing village Bidaura - Majhola

Sunkiya, Nainital

Sunkiya village is located in Dhari block 20 kms east of district headquarters Nainital, Uttarakhand. Bhimtal is the nearest town at 40 kms (Figure 16). The nearest town is Bhimtal at 40 km, and the State capital Dehradun is 213 Km away from the village. According to the Population Census of 2011, Sunkiya village has a population of 1524, with 791 males and 733 females. The village's child population (ages 0-6) accounts for 14.11% of the total population, amounting to 215 children. The female population represents 48.1% of the village, and the average sex ratio is 927, lower than the state average of 963 in Uttarakhand. The child sex ratio in Sunkiya is 838, also lower than the state average of 890. The village boasts a higher literacy rate compared to the overall state literacy rate. In 2011, Sunkiya village had a literacy rate of 77.3%, while Uttarakhand's literacy rate was 78.82%. Male literacy in Sunkiya stands at 81.78%, while female literacy is 72.44%. The village has 927 females per 1000 males among the total population and 838 girls per 1000 boys under the age of six. The scheduled caste population makes up 14% of the village, while the scheduled tribe population is minimal. The cropping patterns in the area are based on indigenous knowledge, incorporating crop rotation and diversity to maintain soil fertility and reduce risks. During the Kharif season, the main crops cultivated in Sunkiya include potato, maize, capsicum, coriander, pea, cabbage, tomato, and chilies.

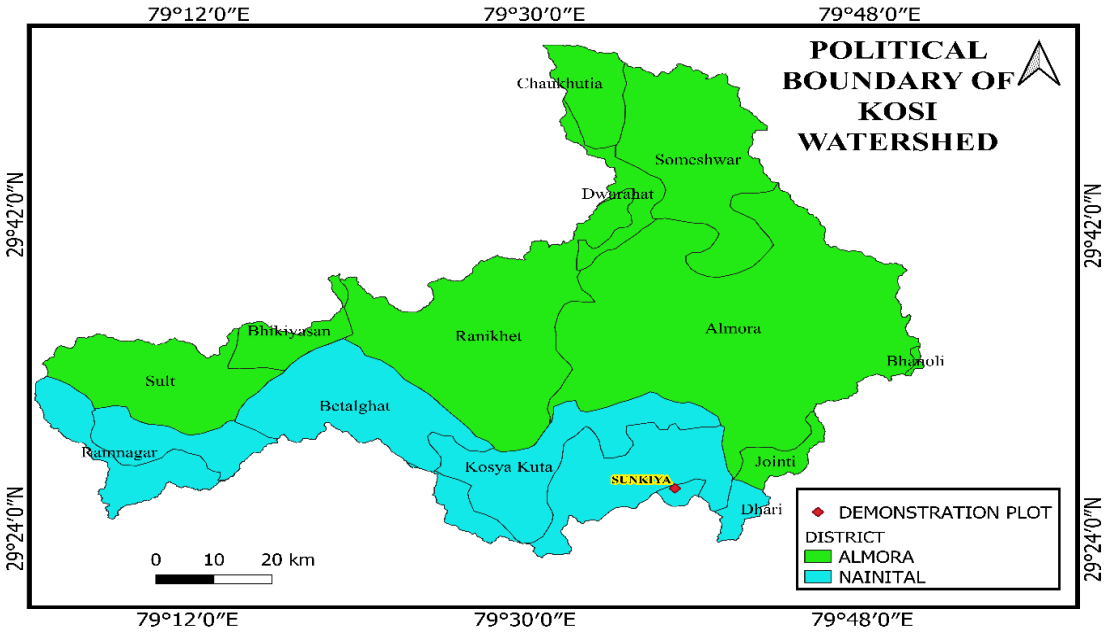


Figure 16: Kosi watershed map showing Sunkiya village, Nainital

6.3. Experimental Trial and Data Collection Methods

The experimental trials will include identification and prediction of long-term impacts of organic farming in the study region. Voluntary participation by farmers will be encouraged in the two villages – Sunkiya and Bidaura for the study. Bioinoculant inputs and recommendations on dosage will be provided from the PIs laboratory. Other inputs considered, will be prepared on-farm at the demonstration sites. The parameters described in section 6.4 below will be used to measure the impact of interventions through experimental trial. Each experiment will be conducted on farmers' fields, where data on previous crops and farmers' practices will be recorded. The experiment will be carried out during the Rabi and Kharif seasons between 2021-2022.

Data collection: Both primary and secondary data collection methods will be used for this study:

- Primary data on social and human capitals will be collected using structured questionnaires. The data collected will be regarding education level, income, employment types, agriculture production, training attended, etc. In addition, community interaction methods such as Participatory Rural Appraisals (PRAs) and Key Informant Interviews (KIIs) will be undertaken to collect data on farm activities pertaining to agriculture

- Secondary data will be collected from various published and unpublished sources, such as reports, journals, official records of government department, websites, etc.

6.4. Assessment of 4 capitals

The following indicators described in Table 3 below will be used for the demonstration plot study across the 4 capitals – Natural, produced, human and social. The approach and methodology for these assessments is explained in the subsequent sections. Additional qualitative information that will be assessed through structed questionnaires include level of on-field training on organic farming, constraints in production and marketing of organic produce, etc. that will provide valuable inputs across the 4 capitals.

Table 3: Indicators used for demonstration study across 4 capitals

	Indicators	**Parameters**
Natural	Soil health	- Soil health parameter testing to measure the organic content
	Pest and disease incidence	- Impact of biopesticides on pest and disease incidences
Produced	Income	- Changes in financial capital –by assessing the input and outputs
	Stocks	- Assessing assessments in fixed assets such as small farm inputs
Social	Women Empowerment	- Drudgery reduction
Human	Education and Skill Development	- Literacy levels - Training and knowledge capacity building in agriculture and organic farming
	Health	- Estimations of Body Mass Index as a parameter for nutritional health

6.4.1. Assessment of Natural Capital

The study includes analysis of soil microbial population at multiple time intervals providing strong evidence for the benefits of utilizing biofertilizers to enhance soil health. Furthermore, absence of chemical compounds attracts diversity of pollinators, which can be observed during the trial period in different crops. Existing literature suggests that biodiversity benefits

derived from organically managed soil cannot fully offset the biodiversity loss associated with the current land use practices (Gabriel et al. 2013). However, the TEEB framework looks at a holistic ecosystem perspective, allowing for the potential to bring positive changes in the biodiversity pattern in the due course of time.

Methodology Applied

*Application of biofertilizers***:** The Bioinoculants formulation contains four potential microbial candidates namely *Trichoderma sp*., *Fusarium palidoroseum*, *Pseudomonas palleroniana*, and *Variovorax paradoxus*.

Soil sample collection: The soil sample will be collected before and after each trial and will be brought to the laboratory for nutrient status testing. The physicochemical properties of soil such as pH (Beckman Glass electrode pH meter (Jackson, 1973), % Organic Carbon (Modified Walkley and Black method (Jackson, 1973), Total Nitrogen (kg ha-1) (Kjeldahl digestion (Pelican Kelplus Kelvac VA equipment), Available Phosphorous (Olsen's method (Olsen et al., 1954) (kg ha-1), Available Potassium (kg ha-1) using Flame photometer method (Jackson, 1973) and other micronutrients such as Iron, Zinc Sulphur, etc.

The water holding capacity of soil will be tested using the following formula:

WHC of soil (%) *= (Weight of the water contained in the saturated soil) ×100/ (Weight of the saturated soil)*

Where,

Weight of the water contained in the saturated soil = Weight of saturated soil - Weight of dry soil

Weight of the saturated soil = Weight of cup, filter paper, and saturated soil – the weight of the cup and filter paper

Plant Sample Collection for Agronomical Parameters: At the time of harvesting of each crop at each farmers' field, plant shoot was collected from 1x1 Square meter (sq. Mt.) in technical replicates and they will be used to record the data based on agronomical parameters such as Plant height, Shoot weight, Fruit weight, Fruit length, Number of tillers, length of spikes, etc. will be recorded and the data will be statistically analysed using suitable ANOVA (Analysis of variance) based statistical model.

Testing of Soil Health Parameters: The microbial community profile will be tested in vitro using different functional tests in the laboratory before and after each demonstration trial. The bacterial community will be enumerated using Nutrient Agar synthetic medium and the fungal community will be enumerated using Potato Dextrose synthetic medium. Several other functional tests will be performed to assess the functional population such as Phosphorous solubilizers, siderophore producers which help in iron chelation, and Indole acetic acid (IAA) producers which are a critical indicator of soil health. For measuring the soil enzyme activity chromogenic substrate assays such as alkaline phosphatase, Acid phosphatase, Urease, and Dehydrogenase activity will be performed in the laboratory. These assays indicate the

presence of extracellular enzymes in the soil produced by diverse microbial communities that help cleave the phosphate molecule from the organic compounds such as phospholipids and nucleic acids making the phosphate available for the plant root to uptake. These soil enzymes make a crucial indicator of change in soil health upon the application of biofertilizers.

6.4.2. Assessment of Produced capital

The demonstration plot comprises two distinct sites with differing agricultural practices, resulting in variations in the types of crops, including grains, spices, herbs, plantation crops, and livestock, all of which contribute to the agriculture value chain. Additionally, the division between plain and hill agriculture is influenced by the land sizes managed by individual families. The choice of crops grown by farmers is primarily driven by their personal and commercial needs. Similarly, while cattle breeding programs are implemented, their intensity and success rates differ between the plain and hilly regions. In this regard the processing industry also varies widely. Hence, both qualitative and quantitiative assessments will be undertaken to assess the produced capital in the two study area (plain and hilly) to capture representative results.

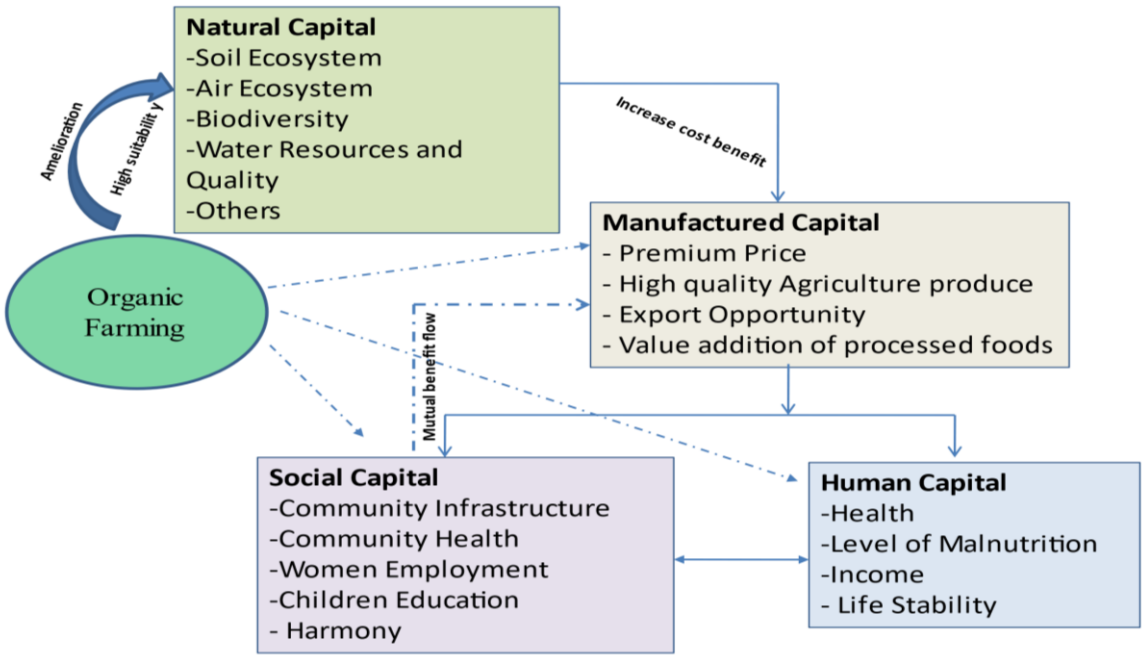


Figure 17: Assessment of produced capital

The proposed methodology for quantification of income and stock (infrastrucutre, equipment, etc) is given below –

Income

To estimate the income generated from agriculture and allied sectors, the calculation of input and output will be conducted using a standardised format specifically designed for agriculture and plantation produce, as well as livestock. Both physical and economic aspects of input and output will be considered.

The equation to be used is as follows-

$$E = \sum_{i=1}^{n} (Mi \times Pi)$$

Where,
E is the value of the material flow
i is the input or output of element i
Mi is the amount of material in the input or output of category I
Pi is the price of the input or output of element i.

Quantification of stock

Field surveys will be conducted to collect data on the stock generated. This will include infrastructure construction, equipment, and financial capital.

$$S = \sum_{i=0}^{n} (Pi \times Ti)$$

Where,

S is the value of the stock of substances
i is the type of stock of substance i,
Fi is the stock of substance i
and Pi is the value of the stock of substance i.

Stocks and flows considered across different sectors:

- Agriculture sector- stocks and flows in terms of seeds, chemical fertilizers, farmyard manure, organic fertilizers, pesticides, etc., infrastructure, production of raw material like straw etc., surplus and marketing of crops, etc.
- Livestock sector-population, cattle feed, vaccines, infrastructure- sheds and barns, storage rooms, manure handling facilities, etc, production and marketing of milk, chicks, goats, manure, etc.
- Processing sector- process food related to agriculture, horticulture, vegetables, and animal products and sales, slaughtering and processing, etc.

6.4.3. Assessment of Social and Human Capitals

Women Empowerment - Drudgery

In Uttarakhand, women in agriculture either work as cultivators or labourers. Majority of the women are dependent on traditional farming equipment that are more labour intensive. While a few small farm inputs are available, their uptake is considerably low. The proposed study aims to evaluate the reduction in physical exertion by providing appropriate tools, which can be beneficial for the planters. The study will examine the extent of women's participation in various agricultural tasks such as land preparation, seed cleaning and sowing, intercultural operations, harvesting, reaping, winnowing, drying, cleaning, and storage. Additionally, it will analyze their involvement in cattle management activities such as cleaning cattle sheds, watering cattle, milking animals, collecting fodder, preparing dung cakes, and gathering farmyard manure. The research will also investigate the health risks faced by women in these activities, utilizing primary data collection methods. This will include assessing ergonomic factors and measuring muscular stresses experienced by women.

Education and Skill Development

Quantification

For the quantity and quality of the workforce, wage level will be used to determine the quantity and quality of the workforce using the following formula

$$L = \sum_{k=0}^{n} (Pi \times Ti)$$

Where,
L is the value of the labour force
i is the ith labour force
Pi is the wage level of the ith labour force
Ti is the hours worked by the ith labour force.

The hourly wage levels for different levels of education are shown in the table below and other information will be obtained from the field survey.

Skills training of the workforce

Improvement in access to education for farmers through training is a major source to capacity building in agriculture sector. Cultivation techniques and essential requirements for farmers include enhanced seeds, intercultural practices, fertilizers, soil testing, irrigation, modern implements, plant protection measures, poultry, animal husbandry, and access to credit information. Majority of the farmers are known to have poor credit awareness, minimal knowledge on extension services and moderate farming expertise.
In the process of acquiring new skills, attitudes, and knowledge to enhance productivity in farming or prepare for a profession, effective training necessitates a clear understanding of how trainees will apply the acquired information in place of their current local practices. The government has been organizing various training programs in diverse agricultural and related fields. While it is challenging to assess and measure the impact, a combination of qualitative and quantitative methods can be employed, including surveys to gather data on the nature, frequency, duration, and level of training received by the workforce.

Health

Nutritional status can be evaluated in many ways; it is an established fact that Body Mass Index (BMI) is a useful anthropometric indicator for measuring nutritional status of the population. Subsequently, the prevalence of Chronic Energy Deficiency (CED) measured through BMI is considered a good enough indicator for not only determining the nutritional status but also to understand poor demographic, socio-economic and environmental conditions of the population. In this regard, the study if health indicators will attempt to evaluate nutritional insufficiencies hills and plain region.

The following standardised equation will be used to calculate the Body Mass Index (BMI)-

$$BMI\ (Kg/m^2) = Weight\ (kg)/Height\ (m^2)$$

Nutritional status will be evaluated using internationally accepted BMI guidelines given by World Health Organisation (WHO, 1995). The following cut off points will be used-

Under nutrition: BMI < 18.5
Normal: 18.5 ≤ BMI ≤ 25.0
Overweight: BMI ≥ 25.0
Obese: BMI ≥ 30

Market Linkages

Marketing Channels: The marketing channel represents the pathway through which products are transferred, either directly or indirectly, from producers to consumers. It encompasses the network of dealers, wholesalers, commission agents, and retailers involved in the marketing of commodities and produce. To analyze the marketing pattern and channels, surveys and personal interviews will be conducted with farmers and intermediaries.

Marketing Cost: The marketing cost refers to the actual expenses associated with the transportation, packaging, commission charges, loading and unloading, mandi fee, and other factors involved in the process of delivering goods and services from producers to consumers. An estimation of the marketing cost will be carried out to determine the incurred expenses in the marketing process.

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