

## **CHANGING TRENDS OF AGRICULTURAL DEVELOPMENT AND ITS EFFECT ON ENVIRONMENT OF UTTARAKHAND HILLS (A CHALLENGE)**

**Prakash Vir Singh, Ph. D.**

(Sr. Asst. Professor), Deptt. of Geography, Tilak P.G. College, Auraiya, C.S.J.M.University, Kanpur, U.P, INDIA

### **Abstract**

*Agricultural development has been sluggish, and has failed to keep pace with population growth. In recent years the yields of major food crops in Uttarakhand have been lower than other South Asian countries and Uttarakhand is now dependent on food imports. Land holding size per family and field sizes has both decreased markedly during recent years. If hill regions are considered independently, all cereal crops yields have stagnated in the last 30 years and gains in production that have been made. Crop productivity in the hills has declined due to land degradation. Agricultural development has been sluggish, and has failed to keep pace with population growth. In recent years the yields of major food crops in Uttarakhand have been lower than other South Asian countries and Uttarakhand is now dependent on food imports. Land holding size per family and field sizes has both decreased markedly during recent years. If hill regions are considered independently, all cereal crops yields have stagnated in the last 30 years and gains in production that have been made. Crop productivity in the hills has declined due to land degradation. Changes in agricultural practices (including changes in crops and crop production, impacts of livestock overgrazing) are having major and far reaching impacts on natural environment.*

**Keywords:** Agriculture, farming, environment, conservation, impact, degradation.



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### **Introduction**

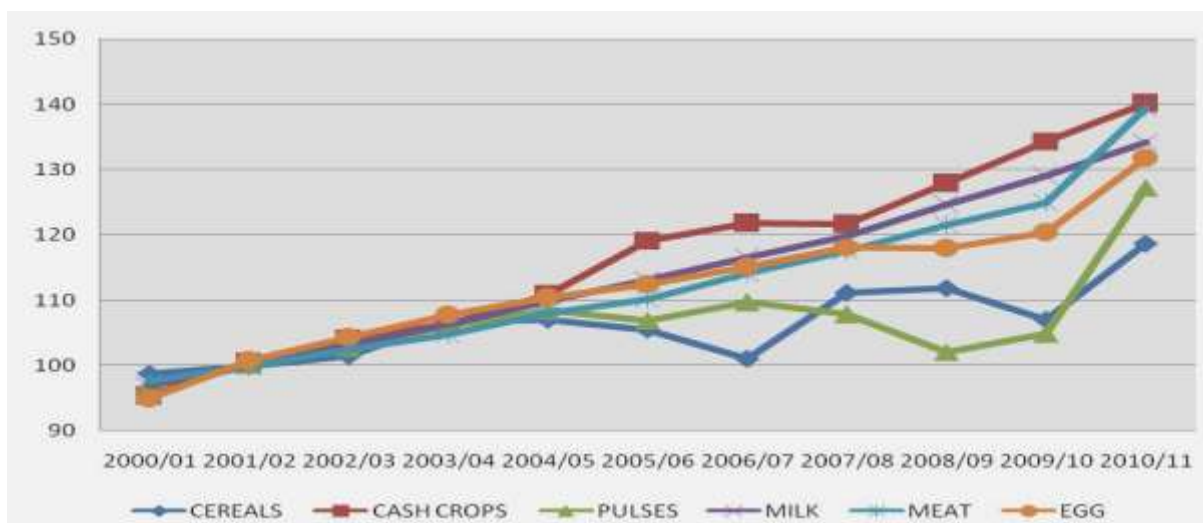
Uttarakhand, the 27th State of the Union of India was carved out of the 13 north Western districts of Uttar Pradesh on 9th November 2000. The state comprising of the central Himalaya, is spread over 53, 483 square kms. And inhabits 84.8 lakh population (Census, 2001). The state is known for its scenic beauty and is also known as “Devbhoomi” due to its shrines, temples & places of worship and meditation. Uttarakhand is included in the National Agroclimatic zone No.-9 and 14. The plain region of the state known as Tarai-Bhabar region comprises of Udham Singh Nagar, Haridwar and parts of Dehradun and Nainital districts. The hilly region of the state consists of Uttarakashi, Tehri, Pauri, Chamoli, Rudraprayag, Almora, Bageshwar, Champawat, Pithoragarh and parts of Dehradun and Nainital districts. The entire state is rugged mountainous terrain except Udham Singh Nagar, Haridwar, Doon

Valley, Garhwal and Nainital districts. Administratively, it comprises of the divisions of Kumaon and Garhwal, which are further composed of thirteen districts. Kumaon division comprises of districts of Almora, Nainital, Pithoragarh, Champawat, Bageshwar and Udham Singh Nagar while the Garhwal division consists of districts of Uttarakashi, Chamoli, Tehri, Pauri, Dehradun, Haridwar and Rudraprayag. The state has 95 development blocks and 48 tehsils.

### Hypothesis

This paper is the review of agricultural degradation and its impacts on environment and economy. More than two third population of the country has been depending upon the labour and production of agriculture sector. But in the recent years the per capita land holding has rapidly been reduced and the production system has been converted from organic to chemical, most of the ignorant farmers of remote rural areas are using chemical fertilizers haphazardly, they don't know either their land has needed particular fertilizer or not. Having this background, this paper contains the following major hypotheses.

1. There is inseparable relationship between agricultural degradation, economy and environment.
2. Agricultural production has been reduced in comparison to population growth.
3. The reduced agricultural production system has negatively contributed to the overall economy of the country.
4. Existing agricultural production system has been degraded the quality of environment.



### Index of Major Agricultural Production

Source: Statistical Information on Uttarakhand Agriculture, 2010/2011

## **Agriculture Profile of Uttarakhand**

Agricultural development has emerged as a major subject of development discourse in livelihood improvement and environment degradation in Asia. Shifting cultivation, the first stage of agricultural development was the most widespread agricultural system in South and Southeast Asia until the mid-20th century. It involved basic tools and techniques low level of inputs and subsistence level of production and consumption which was unable to support growing population and their subsistence needs. The food security situation was worse in developing countries where the colonial power invested very little on food production systems. After independence, their situations were much worse. The increasing population combined with government control over common property resources was putting pressure on shifting cultivators to reduce the fallow period. Meantime, shifting cultivators deserve improved lifestyle which was not possible from the low return being provided by their practice of cultivation. Such circumstances forced farmers to seek for more productive agricultural system which otherwise could have brought a hunger and malnutrition situations in Asia. Nowadays in Uttarakhand, the heavy use of chemical fertilizers and pollutant technologies, the most common farmlands are degraded. These advances including high yielding varieties, more use of chemical fertilizers, haphazard irrigation and other chemical inputs led to a remarkable environmental degradation. The increasing number of livestock and overgrazing over the pasture lands has created environmental deterioration. Growing population has challenged to produce more but because of the traditional production system production has not been increased rather it has been degraded the environment and recorded loss on economy.

## **Agricultural Development in Uttarakhand**

Agricultural advancement is the most important challenge in Uttarakhand due to natural constraints. This is urgent since agriculture sector employs more than 55 per cent of workers and provides livelihood security to the major proportion of population in the rural areas. At the outset, we will discuss land use pattern, which is manifestation of combined effect of various physio-climatic conditions in the region. As per the information of Directorate of Agriculture, around 30 per cent of forest area is in the category of degraded forests. There are plans to promote cultivation of *Jatropha* and bamboo on significant proportion of area under degraded forests. This will help to remove rural poverty in these

areas. In addition, 6.81 and 1.25 percent of reported area was under cultivable wasteland and fallow land other than current fallows, respectively in 2008-09. These lands can be brought under cultivation through proper planning and execution. These areas can also be utilized for plantation of fruits, medicinal and aromatic plants. Current fallows comprised less than 1 per cent of the reported area. The net sown area formed only 13.68 per cent of the geographical area. Out of this area, 64.94 per cent was sown more than once during 2008-09. It is found low in comparison to agriculturally developed regions like Punjab and Haryana. The progress on this front in the state is low and an increase at around 6 per cent was noticed in crop intensity in the year 2009-10. The percentage of net irrigated area to net sown area in Uttarakhand was around 45 per cent and it has increased by almost 3 per cent during the referred years. Further share of gross irrigated area in gross cropped area also has risen marginally by around 1 per cent during the past decade. In a nutshell, land use pattern does not show any perceptible change in Uttarakhand between 2000-01 and 2009-10.

### **Effects of Agriculture pattern**

Agricultural sector may be detrimental for environment in many ways. In fact, the growing demand for agricultural products, the increasing domestic food production by fewer individuals because of rural exodus, and the need of non traditional export products as a means of increasing income, and earning valuable foreign currency for the country lead farmers to look for alternative agricultural methods in order to raise their productivity (Andreatta, 1998). One way to address this problem is the excessive use of fertilizer and pesticides, and this has adverse effects in terms of environmental degradation. Fertilizers and pesticides are discharged into the ecosystem by drifting, dripping or leaking into areas surrounding the target area. The deposited chemical is then transformed by living systems, heat, light and water to form a pesticide residue. Another important issue regarding the environmental degradation effect of raw agricultural product exports is the comparison of the environmental impacts of primary production and processing. These residues are dispersed in the ecosystem through natural forces (biologically, physically), and human activities. They can be transported by fluid movements (wind, rain, etc.) in the environment. They can vaporize from falling spray particles and from plant, soil and water surfaces; they can be carried physically as vapour or absorbed in wind-borne particles of soil and dust. Thus, the use of these products in addition to animal feedlots, pastures, dairy farming and aquaculture leads agriculture to provoke soil and water pollution through the discharge of pollutants and

residue (phosphorus, nitrogen, metals, pathogens, sediment, pesticides, biological oxygen demand, trace elements) to the soil as well as surface and groundwater, through net loss of soil by poor agricultural practices, and salinization. Agriculture is also responsible for a large amount of methane emission (second most important greenhouse gas) and nitrous oxide emission (third most important greenhouse gas).

### **Adverse Impact on Physical Environment**

Another way to address the problem of high agricultural product demand is the excessive use of water through irrigation, the use of mechanized agricultural methods rather than labour intensive practices and/or extensive use of land. These methods affect physical environment respectively through water shortage, air pollution (CO<sub>2</sub> emission) and deforestation. Agriculture is the single largest user of freshwater resources, using a global average of 70% of all surface water supplies according to Ongley, (1996). In the specific case of agricultural subsector, some arguments have been developed linking international trade to environmental concerns. The scale, technique and composition effects have been discussed for this sector since agricultural product export obviously leads to economic growth (Antle, 1993).

Trade liberalization also modifies the relative price of agricultural inputs such as fertilizer, pesticide, tractors, and thus, has adverse impact on the physical environment. Given that developing countries generally import these inputs, openness to trade leads to pollution haven in agricultural subsector. Because of data scarcity, few studies investigated empirically this hypothesis. In the areas of semi-commercialized agriculture, farmers are injudiciously using various pesticides for an increased productivity and risk mitigation in crop production. More than 60% of the applied pesticide remains in the soil materials polluting soil environment as a risk to terrestrial as well as aquatic biosphere. The residual effects of some of the chlorinated hydrocarbons like Chlorodane, BHC, DDT and aldrin remain in soil for a period of more than nine years (DOA, 2001). Imprudent disposal of obsolete pesticides is also of serious concern as a considerable quantity of persistent organic pollutants (POPs) stored indifferent warehouses would be detrimental to the prevailing ecosystem in the locality. Average application rate of fertilizers in Uttarakhand is relatively low. Various types of agricultural operations and hazardous effluents from agro-industries and processing plants, slaughter houses and veterinary hospitals and clinics, when not collected and disposed safely (Haung, 2004), are subject to water, air and land pollution in the country. Despite being the

second richest country in water resources in the world, chronic shortages of water at various places of the country is a common problem. Farming with no or low use of agrochemicals becomes a strategic destination towards achieving sustainable development of Uttarakhand agri-businesses. Such would help to create low carbon economy in the country. Promotion of alternative energy sources like biogas, improved cooking stoves and solar energy from photovoltaic system is important also in achieving environment friendly agriculture development. The Alternative Energy Promotion Centre has been working on such promotions through a twenty-year master plan to reduce pressures on forest resources mainly due to fuel wood supply.

### **Soil Degradation**

Soil loss through surface erosion from the agricultural land in hills varies from less than 2 tons ha<sup>-1</sup>year<sup>-1</sup> to highest soil loss of 105 tons ha<sup>-1</sup>year<sup>-1</sup> (Acharya, 2007). Thus, the frequent breaking and loosening of soil through regular hoeing and plough had forced soil to erosion. Soil degradation through nutrient depletion is also a serious issue (Lal, 2000). Many studies have shown that soils in mid-hills have very low nutrients especially nitrogen and phosphorous (Shah and Schreier, 1991). In particular, the double and triple annual cropping rotations are more nutrient demanding. Thus in order to fulfill nutrient requirements, increased number of crops per annum has increased the inputs of chemical fertilizers in their farm. As a consequence of increased fertilizer use during intensification process, soils in midhills are becoming more acidic (Westarp, 2004). The intensification also leads to the deterioration of nearby water bodies like rivers. During the monsoon time, heavy rainfall takes away tons of soil with nutrients from hills to the water bodies. It has been found that water bodies near to the intensification area have higher concentration of nitrogen, phosphorous and potassium. This is due to higher amount of chemical fertilizer use for intensive production of crops and the nutrients have been washed down. There are some evidences that the climate has been changing in Uttarakhand. The temperature has been increased by 1.8oC during last 32 years and the average temperature increase was recorded as 0.06oC per year. The rainfall pattern is also experienced as inconsistent with higher intensities of rain and less number of rainy days (Malla, 2008). The emission of methane from rice field supplied with 50% nitrogen fertilizer was 49 kg per hectare which is quite high without irrigation facilities (Malla, 2006). The plains (Terai) of Uttarakhand faced a problem of rain deficit during 2005 and 2006 due to early monsoon which reduced the crop

production by 12.5% on national basis. Around 10% of the country's arable land was left fallow due to rain deficit where as there was flood in mid-western Terai, that decreased production by 30% in the same year (Rauniyar, 1998). Early maturity of the crops due to increasing temperature helps to increase the number of crops per year. But increasing number of crops lead to increase in agricultural activities like tilling and agro-inputs. This has potential implication on soil degradation and emission of greenhouse gases in the fragile landscape of mid-hill region.

### **Uttarakhand Agriculture and Environmental Degradation**

Two third of Uttarakhand people are involved in farming business exploiting only 21% of cultivable land for their livelihood. Majority of the farm families are semi-literate or illiterate and scattered in rural settlements. An increase in population by 2.2% annually is producing additional labour force in the national labour market. Average size of land holding is small (0.5 ha) fragmented in scattered parcels of three thus limiting agriculture commercialization. Forty five percent of the farmers, having less than 0.5 ha, share only 13% of total land. Owing to modern sophistications and ever-increasing population, meeting people's increasing and changing needs and aspirations, on one hand, is a major burden to the country. On the other, crop profitability (particularly on cereals) is declining due to aforementioned agri-business related challenges. The consequence is over exploitation of natural and land resources. Such resulted in degradation of environment deeply connected with permanent loss, depletion or pollution of natural resources, adverse weather, changing microclimates and unbalanced situations in the components of inherent chain in the ecosystems. Excluding adverse physiographical, ecological, geological and meteorological factors resulting in common natural hazards such as floods, earthquakes, droughts, cold and hot waves, hailstones, windstorm and cyclone, landslides, disease epidemics, glacial lake outburst flood (GLOF), avalanches, thunderbolt and fires, the environmental degradations are basically caused by human intervention in various aspects of modern technology adoptions. Ever increasing surplus labour forces are compelled in general to cultivate mountain slopes and other marginal lands in the country in meeting their employment and day-to-day basic needs. The consequence of such practice in long run is land resources and environmental degradation. There is a high and increasing pressure on the forest area because of rapidly growing population and their dependence on fuel wood for major share (77%) of energy required. Besides, encroachment of forest area for cultivation and settlements and thus human

induced landslides, floods and water erosion have resulted in massive depletion of forest and agricultural land. The annual deforestation rate is highest in Uttarakhand (1.8%) among the South Asian Countries, and more than 100 thousand hectares of forest were reported deforested within a short period of 1997 to 2000. However, forest regeneration to an appreciable level is reported recently upon coming of community forest user groups (CFUGs) into forest management. In the areas of semi-commercialized agriculture, farmers are injudiciously using various pesticides for an increased productivity and risk mitigation in crop production, even though an average application rate of 142 g/ha and annual consumption of 176mta.of pesticides in Uttarakhand is not considered high. According to Palikhe (2006), more than 60% of the applied pesticide remains in the soil materials polluting soil environment as a risk to terrestrial as well as aquatic biosphere. The residual effects of some of the chlorinated hydrocarbons like Chlorodane, BHC, DDT and aldrin remain in soil for a period of more than nine years. Imprudent disposal of obsolete pesticides is also of serious concern as a considerable quantity of persistent organic pollutants (POPs) stored in different warehouses would be detrimental to the prevailing ecosystem in the locality. Average application rate of fertilizers in Uttarakhand is relatively low. It is estimated in Uttarakhand situation that a general pattern of major cereals removed 310kg of plant nutrients from soil annually on a hectare basis. Since, on an average, only 29 kg of plant nutrients per hectare is added to soil through various fertilizers, net loss of plant nutrients from the inherent fertility reserve in the soil alarming.

Likewise, various types of agricultural operations and hazardous effluents from agro-industries and processing plants, slaughter houses and veterinary hospitals and clinics, when not collected and disposed safely (Haung, 2004), are subject to water, air and land pollution in the country. Despite being the second richest country in water resources in the world, chronic shortages of water at various places of the country is a common problem. Impurities in water increase with its scarcity and introduction into water sources of various pollutants because of agricultural operations such as drainage from agricultural lands and processing units. Deforestation, agricultural mechanization, processing plants and crop production such as paddy are responsible for emitting air polluting suspended particles such as CO<sub>2</sub> into the atmosphere. Carbon dioxide (CO<sub>2</sub>) is considered as a very important green house gas (GHG), increasing concentration of which in the air is the threat to maintaining the country with Low Carbon Economy (LCE). The aim of a LCE is to integrate all aspects of manufacturing,



agriculture, transportation and power generation with technologies that produce energy and materials with little GHG emission. Recently, most of the scientific and public opinions have concluded that there is an unreasonable accumulation of GHGs (especially CO<sub>2</sub>) in the atmosphere; over-concentrations of which in the atmosphere would fundamentally change the earth's climate adversely affecting resource bases and lives in the foreseeable future. For which only humankind is blamed, and LCE is globally proposed as a mean to avoid catastrophic climate change and as a precursor to an ideal zero-carbon economy to maintain everlasting cycle of nature. Therefore, LCE is now considered as the necessary condition for modern agriculture as well.

### Inputs

Adequate and timely availability of inputs is essential for agricultural growth. A dynamic and growing, agricultural sector requires seed, fertilizer, plant protection chemicals, bio pesticides, agricultural machinery and credit at reasonable rates to the farmers. Input management has become an important component of modern agriculture. Balanced use of high quality inputs at the appropriate time brings in the much-desired results in terms of both production and productivity. The detrimental effects of imprudent use of chemicals is an area of concern and ways and means have to be found to ensure sustainable agricultural growth by promotion of balanced use of chemicals with an emphasis on organic farming.

**Table-I**

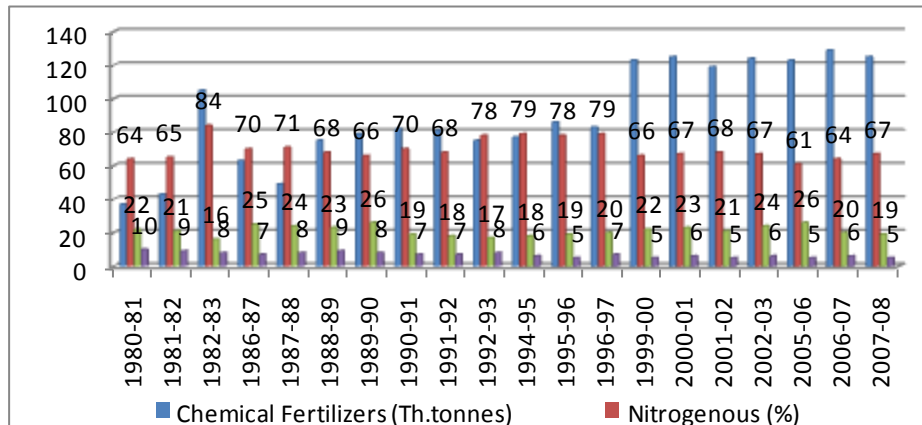
| Item                              | 2005-06 | Use per ha. of GCA (in tonne) |
|-----------------------------------|---------|-------------------------------|
| N ('000 t)                        | 90.45   | 00.073                        |
| P ('000 t)                        | 24.56   | 00.021                        |
| K ('000 t)                        | 10.72   | 00.009                        |
| Micro Nutrients ('000 t)          | 00.74   | 00.001                        |
| Manures ('000 t)                  | 15.51   | 00.013                        |
| Bio-Fertilizers ('000 t)          | 00.021  | 00                            |
| Area under Green Manuring (ha)    | 2550    | 2.06                          |
| Bio-pesticides (MT)               | 9.97    | 00.001                        |
| Pesticides (MT)                   | 492     | 0.398                         |
| <b>Agricultural Mechanization</b> |         |                               |
| Tractor/PowerTillers (No.)        | 144     | 0.12                          |
| Power Operated (No.)              | 330     | 0.267                         |
| Zero till drill (No.)             | 60      | 0.049                         |
| Sprinkler sets (No.)              | 43      | 0.0348                        |
| Water Lifting Pumps (No.)         | 50      | 0.04                          |

*Source: Directorate of Agriculture, Uttarakhand*

The utilization of fertilizer, pesticides, tractors and tube wells plays an important role in boosting the agricultural development of a region. Uttarakhand is lagging behind in the use of these inputs. The consumption of fertilizer was extremely low. However, use of pesticides was found better in cultivation. The nitrogenous fertilizers were preferred over phosphate and potassic fertilizers. The state of Uttarakhand is moving towards agricultural mechanization gradually. But, use of implements per hectare of GCA was found extremely low (Table-I). It was reported that Uttarakhand is ahead of many states in the production as well as distribution of high yielding variety seeds but information on percentage of cultivated area of the wheat and paddy under high yielding variety seeds is not available. Potential of organic farming in Uttarakhand is excellent. In view of rising demand for organic products, state should exploit this opportunity. Lack of physical infrastructure in hills makes distribution of inputs extremely difficult. Massive investment is needed to address this shortcoming. The government should give priority to this aspect in order to boost growth of agriculture in the state.

#### **Adverse effect of Fertilizers**

The excessive use of chemical fertilizer, as more than 100 thousand tons of chemical fertilizer were consumed annually by the state during 1980's, contributed in the reduction of natural fertility of the soil, as well as the destruction of soil structure, aeration and water holding capacity. It also contributed in the indiscriminate killing of useful insects, microorganisms, and predators that naturally check excess crop damage by insects and pests; poisoning the food with high toxic pesticide residues; and the change in the natural taste of the produce. Figure-I shows the level of fertilizer consumption and proportion of its constituent during 1980-81 to 2007-08. The graph clearly indicates that there has been a tremendous increase in the consumption of chemical fertilizer in the state from a level of only 37 thousand tons during 1980-81 to about 125 thousand tons during 2007-08. The contribution of nitrogenous among other compositions of the fertilizer has always been higher (more than 65%).



**Fig-I Consumption of Chemical Fertilizer, Uttarakhand, 1980-81 to 2007-08**

Source: Uttarakhand Statistical Diary

### Strategies for Environment Friendly Agriculture

Uttarakhand, a state of villages and townships, is a dwelling of people making their livelihood largely from agriculture. Having a mountainous geography, very little area is cultivable with poor farming facilities. Because of the economic challenges Uttarakhand people is facing, its products cannot compete directly with the commodities of the international trading partners. Presence of plenty of resources with great diversities can be valuable assets to the country for producing agricultural unique products to exploit markets in the international trading arena. In view of the agricultural development situations in the country and environmental concerns aforesaid, Uttarakhand can strategize its agri-businesses promotion and environmental protection through harnessing comparative advantages of diversified agro-ecological areas and microclimate there in producing niche products for the potential niche markets especially in India, China and other south Asian countries. Organic products, popular products associated with specific geography and the products with distinct uniqueness are the possible areas of production promotion for export. Some commodities such as honey, cardamom, tea, coffee, zinger, vegetable seeds, off season fresh vegetables and citrus fruit (especially mandarin) are the areas where Uttarakhand farmers can exploit the opportunity. In such view, Uttarakhand has agri-business promotion policy with import substitution and export promotion instruments. However, agriculture sector in Uttarakhand, though mentioned getting top priority in each of the periodic plans and fiscal years, is subject to low budgetary disbursement. Actual budgetary disbursement does not indicate the above stated scenarios. The state has provided the sector with less than 5% of its total annual budget in every year, while the sector is contributing more than 33% to national GDP. This does not

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coincide with the mission of attaining high economic growth through the intensive and accelerated growth in agriculture sector. Niche products identification, promotion of such productions in value chain approach and quality assurance and certification are prerequisites for an assured international market of such unique products. In the value chain management, quality standards, timely and sizeable supply and competitive prices are also important as basic requirements of the products' movement into the global market system. Regular production of such products and their competitive disposal in the export markets also needs maintenance of consumer-friendly environment, and assurance of no or low creation of environmental (air, water, soil and/or other) pollution in their production and processing, and thus necessitates very low emission of carbon into the surrounding biosphere. Quality concerns of them are also connected with good agricultural/manufacturing/hygienic practices (GAP/GMP/GHP), sanitary and phytosanitary requirements and good record keeping of such practices for the products' quality assurance and proving them free of pesticides and other harmful chemicals residues, certification by an internationally accredited laboratory and free movement to trans-border markets. Thus farming with no or low use of agrochemicals becomes a strategic destination towards achieving sustainable development of Uttarakhand agri-businesses. Such would help to create low carbon economy in the country. Promotion of alternative energy sources like biogas, improved cooking stoves and solar energy from photovoltaic system is important also in achieving environment friendly agriculture development. The Alternative Energy Promotion Centre has been working on such promotions through a twenty-year master plan to reduce pressures on forest resources mainly due to fuel wood supply. Peoples and different devices in use can utilize the energy sources efficiently and recycle the wastes in a way to have a minimal GHGs output. Furthermore, it has been proposed that to make the transition to an LCE economically viable, we should cost on GHGs production through an approach such as emissions trading and carbon taxation based on natural and social justice.

### **Critical Assessment**

The relationship of agriculture with environment is even more pronounced in case of Uttarakhand, as the agriculture is the major economic activity of Uttarakhand and this sector contributes around one third percent of total GDP. Despite some increase in agricultural production over the years, the population growth in Uttarakhand has outstripped agricultural production resulting into a growing concern about sustainability of agricultural production

system. Although the environmental consequences of agriculture in Uttarakhand have not been alarming, there has been some reporting on the negative environmental impacts due to agriculture sector. Some of the issues of environmental implication reported are environmental effects due to excessive use of pesticides including use and disposal of Persistent Organic Pollutants (POPs) (Rizal and unbalanced use of chemical fertilizers improper agricultural practices in the uplands overgrazing of livestock and methane gas emission by livestock indiscriminate use of veterinary medicine and feed supplements in livestock, erosion of agro-biodiversity. These environmental issues indicate that there is a need for some policy/legal framework to govern such environmentally sensitive activities so that environmental effects of such activities can be minimized and ensure adoption of suitable mitigation measures. The provisions relevant to agricultural sector in the Environmental Protection Act (EPA), 1997 and the Environment Protection Rule (EPR), 1997 are supposed to address these concerns. This paper has attempted to examine the provisions in the EPA, 1997 and the EPR, 1997 and provisions related to agriculture and environment in relevant policy documents of GON such as National Agricultural Policy, 2004; and Tenth Plan, 2002. The paper has also discussed preparedness of Ministry of Agriculture Development (MOAD) to implement such legal and policy provisions. Finally, this paper has discussed mechanisms to facilitate the implementation provisions of EPA under MOAD.

### **Conclusion**

A large part of geographical area in Uttarakhand is hilly terrain having primarily rain-fed subsistence agriculture. Its undulating topography, varied climate, scant cultivated land, overwhelming percentage of small and marginal holdings, difficult working conditions, high input costs and low returns on food grain crops, sparse settlement, soil erosion, land degradation and inadequate infrastructure like transport facilities in remote areas are serious constraints in development of agriculture. Given these circumstances, major challenge is to promote livelihoods to retain work force through local employment and income generation to enhance quality of life of the people living in rural areas of the state. This is possible through holistic development of agriculture. Quality seeds, suited to hill agriculture have to be developed for accessibility and affordability of small and marginal farmers. As soil and topography are not suitable for mono-cropping, mixed agricultural practices need be adopted. This diversified agriculture could be a healthy mix of animal husbandry including cattle rearing, poultry, fishing, beekeeping, etc. There is an urgent need to improve productivity of

crops and livestock, etc. There is good potential for aromatic and medicinal plants in Uttarakhand, which remains untapped due to lack of serious efforts. It is also important to introduce organic farming practices to enrich soil and increase soil depth for sustained development of agriculture in the long run in Uttarakhand.

The intensive use of inputs with green revolution has not only polluted soil, water and environment causing slow degradation but also affected human beings and animals. With this realization, organic agriculture emerged since late eighties as an alternative to reduce such hazards. At present, world market for organic produce is increasing and people are ready to pay the premium for foods raised without the use of chemicals. As majority of farms in Uttarakhand are still in traditional farming, there is a good prospect to adopt organic measures. However, as per the world regulatory functions, Uttarakhand still face challenges in terms of product certification and other relevant infrastructures and policy framework. In the context of WTO, Uttarakhand needs to re-examine existing policies and formulate policies that support for wider adoption of organic agriculture for which research on technological aspects of organic farming relevant to Uttarakhand context needs to be carried out. Organic agriculture can be a sustainable alternative to mitigate the adverse effects of chemicals on human health and environment. Contrary to traditional farming, where farmers use local and indigenous resources, limited organic agriculture with the use of bio fertilizers and pesticides, favours greater production. However, for a developing state like Uttarakhand, lower production in organic farming in the initial years need to be compensated with assured supply of organic manures, pesticides and market assurance. Programs and policies need to support the production and use of organic manures and researches on use of bio-pesticides and other inputs needs to be strengthened.

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