

# AGRICULTURAL DIVERSIFICATION AND FOOD SECURITY IN THE UTTARAKHAND HIMALAYA

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## Abstract

*Food security has become a prime concern over the globe, partly due to increase in population and food scarcity. In the Indian Central Himalayan Region, cereal crops dominate the agricultural systems, occupying about 80% of the total cropped land. Farming of traditional cereal crops is the main occupation of the people. Meanwhile, the output from the traditionally grown cereal crops is insufficient. It does not meet the daily food requirement of the people. Therefore, food scarcity prevails everywhere. In addition, the expansion and modernization of agricultural land cannot be carried out because of the high fragility and high slope gradient of the landscape. Crop land comprises of the small and narrow patches of terraced fields. However, the agro-climatic conditions are quite suitable for agricultural diversification and cultivation of cereals, pulses and cash crops in all the altitudinal zones. This paper examines the current potential of agricultural diversification to achieve food security in the Uttarakhand Himalaya. It reveals that if these agro-climatic conditions are harnessed optimally for agricultural diversification, keeping slops aspects and altitudes in mind, food security can be achieved. Data were gathered from the primary sources through case studies of the villages. Secondary data were also gathered from the published and unpublished records of the government's institutions. Participatory observation approach was well adopted after spending number of days in the villages during the two agricultural seasons in 2008-2009.*

**Keywords:** Agricultural diversification; Food security; Cereal crops; Cash crops; Livelihood.

## Introduction

Agricultural diversification is a key aspect to attain food security. It is more relevant in the countries where economy is directly and indirectly dependent on agriculture and its allied practices. Diversity in growing various crops, in spatio-temporal perspectives, enables the populace to cope with the adverse circumstances such as crop failure due to prolong droughts and floods. In the Uttarakhand Himalaya, the phenomena of high growth of population (19.17%: 2001-2011), low production and low per ha yields of cereal crops, traditional modes of farming (69.45% population is engaged: Census of India 2011) and of course, the phenomena of climate change has together led to food insecurity. As a result, food scarcity and malnutrition is very common phenomenon. The agro-climatic conditions, on the other hand, in the four different altitudinal zones – the valleys (300 m to 1,200 m), the mid-altitudes (1,200 m to 1,800 m) and the highlands (1,800 m to 2,400 m) are very suitable for growing various cultivars/crop species.

Cultivation of traditional subsistence cereal crops is the main occupation of the populace in the montane mainland of the Uttarakhand Himalaya. It is based upon the centuries old practices and carried out on the narrow patches of the terraced fields (Sati, 2004a). Production and per ha yields from these traditionally grown cereal crops is considerably low. Further, the possibility of expansion and modernization of agricultural land in the mountain niche is extremely limited. It is because of high landscape fragility and slope gradient. The practices of cultivating cereal crops along with rearing draught animals in a mixed crop- livestock farming systems have limited potential to maintain the food security. Thus, the people of the region have been struggling to achieve food and nutritional security. Over the time, a considerable increase in population and climate change took place. It has further accelerated food insecurity. Consequently, leading out-migration of the people to the other parts of country.

In the Uttarakhand Himalaya; cereal crops, wheat and paddy and all varieties of cash crops – fruits and off-season vegetables are grown. Cereal crops are grown in the highlands. Wheat and paddy crops are grown in the mid-altitudes and the valley regions. Apple in the highlands; nut, stone and citrus fruits in the mid-altitudes and mango, guava and papaya are grown in the valley regions. In seasonal and off-season vegetables – onion, potato, tomato, cauliflower, beans and other leafy green vegetables are grown. In spices – chili, ginger, turmeric, coriander and garlic are the main cash crops. They are grown across different altitudes. However, the present scenario of growing crops is different. Diversity, production and productivity of the

crops have been decreased during the last decades. The agricultural lands have either been left abandoned or used for construction of settlements. In the valley regions, the proportion of transformation of agricultural land is high (about 30%). The changes in the cropping pattern can also be noticed in the valleys and the mid-altitudes. However, agricultural diversification through cultivating cereals, paddy, wheat and cash crops together in all the altitudinal zones is highly feasible. It can improve the livelihoods and can attain the food security. This paper examines the potential of agricultural diversification to attain the food security in the Uttarakhand Himalaya.

## Material and Method

### The Study Area

The Uttarakhand Himalaya is located in the centre of the Himalayan Mountain Regions. Himachal Pradesh in the northwest, Haryana in the west, Uttar Pradesh in the south, Nepal in the east and Tibet in the north delimit its national and international boundaries. It occupies an area of 51,125 sq km. The total population is about 10.12 million and density of population is 189 per km<sup>2</sup> (Census of India 2011). This state lies between 28° 53' 24" - 31° 27' 50" N and 77° 34' 27" - 81° 02' 22" E. Of its total geographical area, about 47,325 sq km (92.6%) is covered by mountains, which is the mainland of Uttarakhand. *Tarai* plains and *Doon* valley occupy about 3800 sq km (7.4%) area. The *Tarai* plains and *Doon* valley are 150 km long and 40 km wide, and they are located upto 250 m above the sea level. The total arable land is only 12%. Agriculture is characterized by cultivating subsistence cereal crops dominated by millets. Horizontally, it comprises of the two distinct geographical entities i.e., Garhwal and Kumaon Himalayas. Similarly, the socio-economic and cultural aspects of both the geographical entities are varied and they are reflected on the livelihoods of the people. Agro-climatic conditions are very suitable for cultivating various crops in all the altitudinal zones. It is more suitable in the mid-altitudes (where the concentration of population is high) and the highlands (where crop diversity is high). Alpine meadows are known for the repository of herbs and medicinal plants. Livestock farming and non-timber forest products (NTFPs) constitute a major part in livelihood enhancement.

### Methodology

This study was carried out mainly through the collection of primary and secondary data. Case study of the selected villages was carried out through the household's level survey using structured questionnaire. Questions were raised on the various cropping systems; variety of crops – agricultural and horticultural and their suitability in the different agro-climatic zones – horizontal and vertical. Agro-climatic conditions for growing crops and agricultural diversification was illustrated largely. A participatory observation approach was adopted to assess the agricultural diversification and economic viability of the crops. The entire study area was visited in a number of times during 2008-2009. The stakeholders – marginal farmers, agricultural extension workers and the employees of agricultural and horticultural departments were interviewed for further strengthening of data. Secondary data were gathered from various sources – government records – published or unpublished, and from the statistical diaries. A case study of 12 villages of the Khanda Gad Sub-Watershed (KGSW) of the Alaknanda River was carried out in 2008 (Sati, 2009). A comparative study on the production and per ha yields, and area and income from the traditionally grown cereal crops and recently introduced cash crops was conducted. Except some small patches of arable land along the banks of the Khanda Gad, where off-season vegetables are grown largely, the farmers of all the case study villages produce paddy, wheat and cereals. Statistical Package for Social Sciences (SPSS) was used to correlate agricultural diversity and altitudes. Similarly, correlation between altitudes and occupation was illustrated. Secondary data on number of crops grown in an agricultural season were gathered and crop diversity index (CDI) was calculated.

### Agro-Biodiversity in Uttarakhand Himalaya

The Uttarakhand Himalaya is a hotspot of agro-biodiversity. Diversity varies according to variations in the altitudes. Here, 86 agricultural and 11 horticultural crops have been growing from time immemorial (Mehta *et al.* 2010). Under the traditional system of cultivating 'Barahnaja' (literally, '12 crops') together in cropped land is a centuries-old practice (Singh and Tulachan, 2002; Sati, 2009a). This is practiced under a 'Sar system' (Sati, 2009b) of crop rotation. It characterises the cropping pattern together with a vertical distribution of crops – in valley regions, mid-altitudes and highlands. It also supports the maintenance of agricultural diversity. The traditional agricultural systems are the repository of many crops and cultivars. Most of them are still little known to mainstream societies and are better adapted than modern agricultural systems to environmental and social conditions (Altieri, 1995; Ramakrishnan and Saxena, 1996). *Mandua* (finger millet), *ramdana/chua* (*Amaranthus*), *rajma* (common kidney beans), *ogal* (buckwheat), *urad* (black gram), *moong* (green gram), *naurangi* (mix of pulses), *gahath* (horse

gram), *bhat* (soybean), *lobiya* (French beans), *kheera* (cucumber), *bhang* (*Cannabis*) and other crops are grown together in a mix-cropping pattern. It optimises productivity, maintains soil fertility, conserves crop diversity and meets the diverse household requirements. The farmers grow about 100 varieties of paddy, 170 varieties of kidney beans, eight varieties of wheat, four varieties of barley and about a dozen varieties of pulses and oil seeds each year (Zardhari, 2000). Various pulses and oilseeds are grown in the intercropping system during the monsoon season. Dry and wet paddy, taro, pumpkins, beans, corn, ginger, chili, cucumbers, leafy vegetables and tobacco are also grown. Potatoes have become an important cash crop, grown in areas unsuitable for other plants. About 80% cropped area is rainfed. However, crops are grown almost all the seasons in a year.

There are total five ecological sub-regions (Table 1). The altitudes vary from 250 m (*Doon* valley and *Tarai* plains) to 3,600 m (alpine meadows). Crop diversity changes according to changes in the altitudes. The valleys regions comprise of low crop diversity while, it is high in the highlands. In the *Doon* valley and *Tarai* plains (250 m – 600 m), mostly three crops – wheat, paddy and sugarcane are grown. Here, irrigation facilities are adequate. Major cultivars in the Lesser Himalaya, Shivalik ranges and river valleys (600 m – 1,200 m) are wheat, barley and mustard in the *rabi* season and paddy in the *kharif* season. In the mid-altitudes (1,200 m – 1,800 m), during *rabi* season, wheat, barley and mustard are grown while during *kharif* season, paddy, *koni*, *jhangora* and millets – *kodo*, pulses and oilseeds are grown. In the highlands (1,800 m – 2,400 m) many cultivars grow. The highest agro-biodiversity has been noticed in the highlands, mostly during the *kharif* season. It is because of heavy rainfall that occurs during this season and assists in growing many cultivars. The alpine meadows remain snow-clad upto eight months. Only during summer (from June to September), medicinal plants and flowers are naturally grown in these alpine meadows.

**Table 1:** Ecological sub-regions and agricultural diversity

Ecological sub-region	Altitude (M)	Crop seasons	Agricultural diversity	Changes in crop diversity
<i>Doon</i> valley and <i>Terai</i> region	250-600	Rabi	Wheat and sugarcane	No change in crop diversity but agricultural land has been reduced
		Kharif	Paddy and sugarcane	No change in crop diversity but agricultural land has been reduced
Lesser Himalaya, Shivalik hills and river valleys	600-1,200	Rabi	Wheat, mustard and onion	No change in crop diversity but land has left abandoned
		Kharif	Paddy (First <i>sar</i> ); maize and pulses (Second <i>sar</i> )	The production of maize and pulses has been reduced
Mid-altitudes	1,200-1,800	Rabi	Wheat, barley and mustard	The production of barley has been reduced
		Kharif	Paddy <i>koni</i> and <i>jhangora</i> (First <i>sar</i> ) millets – <i>mandua</i> , <i>cheena</i> ( <i>Panicum miliaceum</i> ), pulses and potato (Second <i>sar</i> )	Mostly paddy and potato are grown
Highlands	1,800-2,400	Rabi	Summer crops – wheat, barley and mustard	The production of barley has been reduced

		Kharif	Twelve grains ( <i>barahnaza</i> ) paddy, potato, <i>phaphra</i> , <i>chaulai</i> , <i>ogal</i> , millets – <i>kodo</i> ( <i>Fagopyum esculentum</i> ), <i>uva</i> ( <i>Hordeum himalayense</i> ) and nine pulses ( <i>naurangi</i> )	Mostly paddy and potato are grown
Alpine Zone	2,400-3,600	Oct to May	Snow covered (8 months in a year)	No change
		Autumn season	Naturally grown medicinal plants and flowers	Medicinal plants are highly exploited

Source: Modified and adapted from Sati (2004c & 2009b)

## Results

Correlation between altitudes and agro-biodiversity for the KGSW was calculated through using SPSS. The hypothesis was 'higher the altitude, higher the crop diversity' and vice-versa. The significance value was found 0.1. A new trend of cropping pattern was noticed in Khanda Gad villages (800 m). Here, about 40% of the cropped land is devoted to cultivating cash crops. Mainly tomato, potato, cauliflower, cucumber, beans and capsicum are grown. Thus, diversity in cash crops is high.

Occupation changes according to changes in altitudes. The main occupation is agriculture and its allied practices i.e., livestock farming and collection of NTFPs. It is followed by the tertiary activities. The educated people are involved either in teaching profession or recruited in the national army. It was hypothesized that 'higher the altitude more people are involved in agriculture, livestock farming and collection of NTFPs'. The significance value was found 0.2. Occupation and food security has close relationship. Those people, who are involved in tertiary activities, are more secured with food. However, the farming community is still struggling to achieve food security. In the other word, higher the altitude, the level of food security is low and vice-versa.

In the KGSW, during the beginning of the 2000s, some Nepali inhabitants of Rolpa District of Nepal immigrated to the villages of Khanda Gad in the search of job. They acquired land from the owners/farmers of these villages in lease and started cultivating cash crops in the narrow and small patches of cultivable land along the Khanda Gad, a perennial stream. Due to adequate irrigation facility and availability of fertilizers – chemical and organic, high production of cash crops was achieved. Table 2 shows production and per ha yields from off-season vegetables and cereal crops in 2007-08 in twelve villages of the KGSW. Cauliflower, cucumber, tomato, capsicum, beans and potato are the main cash crops grown here. In cereal crops, wheat, paddy, barley, millets, pulses and oilseeds are grown. It shows that per ha yields (in quintal) of cucumber is highest (103.3 q) followed by tomato (89.5 q) and potato (53.3 q). Among cereals, paddy and barley (36.8 q each) recorded highest per ha yield followed by oilseeds (35.4 q). In nutshell, average per ha yields of cash crops is 67.7 quintal/ha, while cereal crops yield was 28.0 quintal/ha. It shows that cultivating cash crops is economically viable.

**Table 2:** Production and per ha yield from cereals and cash crops (2007-08)

Off-season vegetables	Area (ha)*	Production (in quintal)	Per ha yield (q)	Subsistence crops	Area (ha)*	Production (in quintal)	Per ha yield (q)
Cauliflower	15	727	48.5	Wheat	100	1520	15.2
Cucumber	3	310	103.3	Paddy	100	3680	36.8
Tomato	20	1790	89.5	Barley	50	1840	36.8
Capsicum	3	118	39.3	Millets	50	1472	29.4
Beans	3	144	48.0	Pulses	20	368	18.4
Potato	7.5	400	53.3	Oilseeds	10.4	368	35.4
<b>Total</b>	<b>51.5</b>	<b>3489</b>	<b>67.7</b>	<b>Total</b>	<b>330.4</b>	<b>9248</b>	<b>28.0</b>

Source: Primary collection \* Patwari circles Srinagar and Pauri

Table 3 shows that area under cash crops is 51.5 ha and annual income from it is Rs. 1,33,8100 (Rs. 25, 982/ha). Under cereal crops, the area is 330.4 ha with annual income of Rs. 5,02,1600 amounting to Rs. 15, 198/ha. The land-man ratio is 0.8 ha for the cash crops and 0.9 ha for the cereals. Although, the marginal farmers have initiated cultivating cash crops mainly off-season vegetables, yet its pace is slow. It is highly recommended that the places, particularly the valley regions, where irrigation and market facilities are adequate, cash crops can be grown largely. If a sizeable proportion of cultivable land is devoted to cultivating cash crops then, food security can be ensured.

**Table 3:** Area and annual income from off-season vegetables and cereal crops (2007-2008)

Off-season vegetables	Area (ha)	Annual income (thousand Rs.)	Cereal crops	Area (ha)	Annual income (thousand Rs.)
Cauliflower	15	5, 08.9	Wheat	100	1472.0
Cucumber	3	2, 17.0	Paddy	100	2520.0
Tomato	20	1, 79.0	Barley	50	760.0
Capsicum	3	1, 18.0	Millets	50	121.6
Beans	3	1, 15.2	Pulses	20	70.0
Potato	7.5	2, 00.0	Oilseed	10.4	78.0
<b>Total</b>	<b>51.5</b>	<b>13, 38.1</b>	<b>Total</b>	<b>330.4</b>	<b>50, 21.6</b>

Source: Primary collection

### Crop Diversity Index

Table 4 shows crops diversity index (CDI) of traditional and cash crops in the hill districts of Uttarakhand Himalaya. It is shown in the table that CDI of traditional and cash crops is slightly varied. The three districts – Chamoli, Rudraprayag and Uttarkashi have comparatively less diversity in traditional crops i.e., 7.69 CDI while Pauri and Tehri have 7.14 CDI. In cash crops, CDI vary from 6.67 (highest) in Chamoli district to 9.09 (lowest) in Rudraprayag and Tehri districts. Pauri and Uttarkashi districts have 7.14 and 7.69 (moderate) CDI, respectively.

**Table 4:** Crop diversity index in the Uttarakhand Himalaya (figures in parentheses are percentages)

S. No.	District	CDI		Cropped land (ha)	
		Traditional crops	Cash crops	Traditional crops	Cash crops
1	Chamoli	7.69	6.67	51730 (15.1)	3744 (20.8)
2	Pauri	7.14	7.14	124388 (36.4)	3151 (17.5)
3	Rudraprayag	7.69	9.09	32980 (9.6)	745 (4.1)
4	Tehri	7.14	9.09	44143 (12.9)	5582 (31.0)
5	Uttarkashi	7.69	7.69	88953 (25.9)	4780 (26.6)

Source: District Statistical Diary (DSD) 2008, Sati (2012)

### Discussion and Conclusions

Food security can be achieved through high crop diversity in all the altitudinal zones of the Uttarakhand Himalaya. Cultivating cash crops throughout the Himalayan region has put a step forward in terms of generating income and augment employment. This is also with the case of Southeast Asian and Latin American countries where a shift in favour of high value food commodities opened growth opportunities, generate income, augment employment, alleviate poverty and improve sustainability of agricultural systems (Pingali and Rosegrant, 1995a; Von, 1995). Several factors have affected the nature and speed of agricultural diversification. The process of agricultural diversification is triggered by rapid technological change in agricultural production, improved rural infrastructure and changes in food demand patterns (Pingali and Rosegrant, 1995b). In practice, cereal consumption is often used as an indicator for food deprivation, as cereals are the staple food of the poor (Kumar *et al.*, 2009).

In the Uttarakhand Himalaya, cultivating cereal crops dominates in the cropping pattern. Meanwhile, the outcome from these traditionally grown crops is comparatively low. As a result, food insecurity is a common phenomenon. Increase in population on the limited terraced agricultural fields further accelerated this situation. The agro-climatic conditions, on the other hand, are quite suitable for agricultural diversification. Here, crop diversity for food security is more relevant. However, low soil fertility and water scarcity have adversely affected the productivity of paddy and wheat in this region (Kumar *et al.*, 1998).

It was noticed that the implications of agricultural diversification on the food security was tremendous. During the past, when population was less and the farming community was absolutely dependent on the cereal farming, the phenomenon of food scarcity and malnutrition was high. Changes in the cropping pattern from cultivating cereals to paddy, wheat, fruits and off-season vegetables have attained food security. There has been a long debate on the suitability of crops for food security. Saxena and Rao (1994) pointed out that preferences for consumption of wheat and paddy, and more so for paddy, are the recent changes in food habits. Singh and Raghuvanshi (2012) observed that cultivating traditional cereal crops are one of the potential approaches for improving household food security in the Uttarakhand Himalaya. Agricultural diversification towards food-grain, non-food-grain and high value cash crops is inevitable. These crops have potential of income and employment augmentation, poverty alleviation and export promotion (Von Braun *et al.*, 1995; Pingali & Rosegrant, 1995c; Jha, 1996; Chand, 1996; Vyas, 1996; Delgado & Siamwalla, 1999; Ryan & Spencer, 2001 & Joshi *et al.*, 2004b).

It is the common experience that the ecological conditions in the Himalaya are more suitable to agricultural diversification (Atkinson 1882a). Cash crops – fruits, off-season vegetables, medicinal plants and production of tea, will boost up the regional economy (Sati and Kumar, 2004). Here, from the valley region to the north border, sub-tropical humid and bio-climatic conditions change step by step into temperate, sub-temperate and alpine zones (Atkinson, 1882 b), which are very useful for cultivation of off-season vegetables, fruits and medicinal plants. Whatever the study reveals; the general consensus on the agricultural pattern reflects that food security cannot be attained only through cultivating crops individually; it can be attained through agricultural diversification, keeping all ranges of agro-climatic conditions, landscape, altitude and availability of market in view. Community participation along with government assistance should be ensured for cultivating different crops in all the altitudinal zones. If all these measures are taken into account, food security can be achieved.

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