Paper/Poster Title	Crop Diversification and Nutritional Security in Paddy-Wheat Dominated Cropping Pattern Areas: Extent and Relationship

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Abstract	200 words max

Since green revolution, the cropping pattern in northern India which includes Uttarakhand State, has been dominated by paddy and wheat. Crop diversification is said to have positive relationship with food and nutritional security. It is important to answer that where have such dominant cropping patterns or crop diversification have brought us in terms of food and nutritional security. This study examines the extent of district-level crop diversification in Uttarakhand by the use of Simpson index of diversification and the extent of district-level nutritional security by the use of nutritional diversification index for the period 1990-2017. This research is novel for it devises 'Nutritional Diversification Index' to measure nutritional security. Quadratic (nearly U-shaped) relationship has been found between nutritional diversification index and crop diversification index. Average values of crop diversification index and nutritional diversification index for the periods, 1990-99, 2000-09 and 2010-17 were calculated. There was largely crop specialization in plain districts of Uttarakhand, namely, Udham Singh Nagar and Haridwar whereas in remaining 11 hilly districts, there has largely been crop diversification. In these two plain districts, nutritional diversification was observed over first two decades after which nutritional specialization was observed. The results of nutritional diversification were mixed for hilly districts.

Keywords	Crop diversification, Nutritional security, Uttarakhand
JEL Code	P42, Q1

Introduction	100 – 250 words

There is a predominance of rice–wheat cropping systems especially in Haryana, Punjab and Uttar Pradesh (UP); winter maize in Bihar; groundnut in Gujarat; chickpea in South; sugarcane in the north; soybean in Madhya Pradesh and its adjoining states; and pigeonpea in north-western states like Punjab, Haryana, Gujarat and Rajasthan. It is an important question to answer that where have such specialised cropping systems brought us in terms of food and nutritional security.

Crop diversification is a dynamic tool that can ensure food security in a way that is sustainable. There is a positive relationship between crop diversification and household food security status. It is an important question here that what could be the relationship between crop diversification and food and nutritional security at district-level and what could be the determinants of the same. Uttarakhand is a state

that comprises of 13 districts out of which 2 are plain districts while 11 are wholly hilly or a mix of plains and hills. It is characterized by poor development of agriculture which is majorly due to poor irrigation facilities, small land holdings, soil-erosion-and-landslide-prone geography and many other problems that have pushed agriculture to act as a meagre income generator for the residents of the state. In this backdrop, the present study has analyzed the trends and extent of crop and nutritional diversification at district level in Uttarakhand along with identification of the relationship between crop and nutritional diversification and their determinants. Nutritional diversification index developed here has been considered indicative of nutritional security at macro level.

Methodology	*100 – 250 words*

To assess crop diversification, Simpson index of diversification was used as Crop Diversification Index (CDI). It provides clear dispersion of crops in a geographical region. The CDI is given by the following equation:

$$CDI = 1 - \sum_{I}^{n} P_i^2$$

where, P_i is the proportionate area under i^{th} crop in the gross cropped area. CDI ranges from 0 to 1. The value closer to 1 indicates high diversification and the value closer to 0, indicates zero or no diversification. The CDI has been measured for foodgrains, oilseeds and sugarcane for each district of Uttarakhand state of India for the period 1990-91 to 2017-18.

To assess nutritional diversification, a Nutritional Diversification Index (NDI) was developed which is indicative of the level of nutritional security ensured by major crops (foodgrains, oilseeds and sugarcane) that are part of dominant cropping patterns. The NDI has been developed on the lines of Simpson index of diversification and is given by the following formula:

$$NDI = 1 - \sum_{I}^{n} P_i^2$$

where, P_i is the proportion of nutrient (protein, fat, minerals, fibre or carbohydrate) to the total grams of nutrients obtained through production of different crops. The NDI ranges from 0 to 1. The value closer to 1 indicates high diversification of nutrients and the value closer to 0, indicates specialization.

By using different curve equations (linear, logarithmic, inverse, quadratic, cubic, compound, S-curve, growth and power functions) the relationship between NDI

(dependent variable) and CDI (independent variable) has been described.

To discern the determinants of crop diversification and nutrient diversification, fixed effect model (FEM) and random effect model (REM) were used.

Results	*100 – 250 words*

It was found that over the years CDI has increased in majority of the hilly districts. In the plain districts, Udham Singh Nagar and Haridwar, there has been specialization.

In Almora, nutritional diversification showed slight specialization over the first 2 decades after which the NDI reached the same level as it was in the first decade. In Bageshwar and Haridwar, NDI showed specialization over first 2 decades after which it stabilized. In Chamoli, Pauri Garhwal, Pithoragarh and Uttarkashi, there was specialization towards second decade after which diversification slightly more than the first decade was observed. Champawat clearly showed diversification in nutritional diversification whereas Dehradun clearly showed specialization over the period. In Nainital and Udham Singh Nagar districts, there was slight diversification towards second decade after which nutritional diversification slightly less than the first decade was observed. In Rudraprayag, nutritional diversification index showed slight diversification over first 2 decades after which it stabilized. In Tehri Garhwal, the average NDI was constant over first 2 decades after which it showed slight diversification.

The overall relationship between NDI and CDI was found to be nearly U-shaped indicating that NDI first decreased with increase in CDI as diversification was happening but with further diversification, NDI increased. This indicates that in Uttarakhand, slight nutritional specialization was found to happen until a threshold value of CDI was reached after which nutritional security was enhanced with increase in crop diversification. This implies that until the attainment of threshold level, crop diversification was happening in crops that are rich in a particular nutrient.

Cropping intensity and gross irrigated area were found to be the statistically significant determinants of CDI and NDI

Discussion and Conclusion	*100 – 250 words*

This study involved examination of the extent of district-level crop diversification and

nutritional diversification in Uttarakhand over the period 1990 to 2017, their relationship and identification of their determinants. Crop diversification was examined using Simpson index of diversification whereas nutritional diversification index was developed on the lines of Simpson index. It was found that there has been crop specialization in plain districts whereas in hilly districts there has largely been crop diversification. The results of nutritional diversification have been mixed. However, only Champawat and Dehradun districts clearly showed diversification and specialization respectively in nutritional diversification. The relationship between nutritional diversification index and crop diversification index has been found to be quadratic. The statistically significant determinants of crop diversification index and nutritional diversification index were gross irrigated area and cropping intensity and both showed negative relationship.

In districts of Uttarakhand, especially in plain districts where crop specialization is increasing, marketing and extension facilities should be provided for crops other than paddy-wheat dominant cropping –pattern-crops also. Ensuring food and nutritional security through crop diversification requires actions that include development of bio-fortified varieties, ensuring access of all people to safe and nutritious food, boosting of eco-friendly and region-specific production, shifting to consumption patterns that are sustainable, advancing of equitable livelihoods and building resilience that combats shocks, vulnerabilities and stress.

This research is based on district-level data. Future research could use farm-household-level data on crop diversification and diets of farmers to study the linkage between crop diversification and food and nutritional security.