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Changing Cropping Patterns in the Central Himalaya: Causes and Implications

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Abstract
The Himalaya is experiencing significant changes in land use and cropping patterns. This paper examines the major causes and consequences of these changes in the Central Himalaya, focusing on two districts: Dehradun (Garhwal region) and Nainital (Kumaon region). Data on land use and cropping patterns for both districts were collected from the district statistical diaries and, subsequently, were analyzed. The analysis reveals that cropping patterns are undergoing substantial changes in both districts, although the change is not uniform across the regions. Various factors contribute to the shifting cropping patterns. In the recent past, there has been a notable increase in climate variability and change, with a persistent warming observed in the river valleys and mid-altitudes. Other significant factors influencing the changing cropping patterns include decline in the area and production of crops, alterations in food habits, population growth, and out-migration in the Central Himalaya.

Keywords
Cropping patterns; Land use; Climate change; Food habits; Central Himalaya

1. Introduction

The crop races/cultivars in the Himalayan region are cultivated based on agroecological conditions (Singh, 2019), and traditional agricultural practices are followed (Singh and Rana, 2019). These practices encompass subsistence cereal farming, fruit and vegetable cultivation, as well as livestock farming (Goswami, 2013; Negi *et al*., 2013; Sati, 2012). A distinctive crop rotation system known as the *Sar/Sari* system is employed, where agriculture is conducted in two *Sars* at different intervals (Kumari, Tewari and Singh, 2009). In the *Sar* system, one *Sar* is cultivated with a specific crop while, simultaneously, another *Sar* is used for growing a different crop. After six months, the roles are reversed, and one *Sar* is left fallow, with this cycle continuing (Pande *et al*., 2016; Ravera *et al*., 2019; Sati, 2005, 2009; Sen, 2015). These farming systems are tailored to the environmental conditions of the specific locality (Martin and Sauerborn, 2013; Thrall, Bever and Burdon, 2010). Over the past decades, there has been a noticeable decrease in the cultivated area (Joshi and Palni, 2005). Fallow land

has increased, attributed to out-migration, and the number of people engaged in farming has decreased by 2.6% (Pathak, Pant and Maharjan, 2017).

The agriculture in the Central Himalaya has experienced significant changes in terms of cropping patterns, cultivation practices, crop production, and productivity. This region is characterized by rich agrobiodiversity, diverse bio-physical resources, and varying weathers, offering opportunities for cultivating a wide range of crops. In the past, cropping patterns were primarily determined by agronomic considerations and the consumption needs of farmers. However, recent trends suggest a shift towards more market-oriented practices. Additionally, changing cropping patterns may be influenced by shifts in food consumption habits. Despite agriculture being the main occupation and a major source of income in rural areas, its contribution to the State Domestic Product (SDP) is relatively low (approximately 6%).

The cropping pattern in the Central Himalaya underwent a significant transformation in the 1970s when a substantial amount of arable land was converted into fruit belts, primarily for the cultivation of temperate fruits. The state government took initiatives to establish several fruit belts along the temperate climatic zones. Initially, the output from fruit plants, especially apples, was considerable, and farmers were able to export apples to regional and national markets. However, in the 1980s, the fruit plants were affected by a flyspeck and Sooty Blotch disease, leading to a decline in production. Another challenge was the marketing of apples. Due to the perishable nature of apples and the absence of cold storage facilities in apple-growing areas, farmers did not reap the benefits of apple cultivation, even though the income generated was less than the cost incurred. Consequently, the cultivation of apples witnessed a substantial decline. The production of other fruits, such as citrus[1], also decreased; and in many areas, the cultivation of fruits has completely vanished.

Subsequently, the arable land in the Central Himalaya shifted towards cash crops, predominantly in the river valleys and middle altitudes. However, over time, the cultivation of cash crops also experienced a significant decline. Following this trend, there was an attempt to introduce medicinal plants, but this initiative did not prove successful. Eventually, farmers reverted to traditional agricultural practices, recognizing its importance in providing livelihoods for rural communities. At present, the primary agricultural activities in the region revolve around the cultivation of paddy and wheat, signifying a return to more conventional farming methods. This shift in focus back to traditional agriculture reflects the resilience and importance of practices that sustain the livelihoods of the rural poor in the Central Himalaya.

The Central Himalaya, primarily consisting of the state of Uttarakhand, became a separate state of the Republic of India in 2000. In the past, millets, pulses, and oilseeds served as the main crops and staple foods. However, the present scenario sees a shift towards wheat and paddy as staple foods. The region has experienced climate change marked by high variability in temperature and rainfall, leading to noticeable alterations in cropping patterns. Temperature trends are increasing, while rainfall is observed to decrease in highland areas. Changing food habits over time, coupled with the challenges of an increasing population and low production and productivity of millets, have further contributed to shifts in cropping patterns in the Central Himalaya. The hilly and

[1] Category of fruits, such as oranges and lemons

mostly infertile soil, prone to erosion from heavy monsoon rainfall due to the steep slopes and undulating terrain, adds to the agricultural challenges. Most crops are rainfed, except in plain areas and river valleys, resulting into nominal production and productivity levels.

This article investigates the changing cropping patterns in the Central Himalaya, focusing on two districts – Dehradun and Nainital, by analysing two years of data (2011-12 and 2021-22) encompassing the area, production, and productivity of crops. It aims to discern changes in these parameters over the specified period and elucidate the major causes and implications of altering cropping patterns. The central hypothesis posits that climate change and evolving food habits have played a significant role in driving the changes observed in cropping patterns in the Central Himalaya. To address these issues, the study considered two main research questions: firstly, what are the primary causes and consequences of the observed changes in cropping patterns? And, secondly, how can the production and productivity of crops be enhanced to ensure sustainable livelihoods in the region? Through a comprehensive analysis of the gathered data and exploration of these research questions, the study aims to contribute valuable insights into the dynamics of agricultural practices in the Central Himalaya.

2. Study Area

The Central Himalaya, an integral part of the larger Himalayan region, shares borders with Nepal to the east, Tibet (China) to the north, Himachal Pradesh to the west, and Uttar Pradesh to the south. Characterized by its mountainous terrain, the region exhibits varied altitudes ranging from 200 m to over 7,000 m (Figure 1). About 93% of the area is mountainous mainland, with approximately 16% covered by snow-capped peaks. The Central Himalaya features three-dimensional landscapes: the river valleys, the Middle Himalaya, and the High Himalaya. In this study, two districts of the Central Himalaya – Dehradun and Nainital - were selected. Both districts exhibit a mix of plain and mountainous terrain, with the Doon Valley, a part of the Dehradun district, being notably fertile. Historically, the Doon Valley was renowned for cultivating Basmati rice; however, contemporary trends show a transformation of agricultural fields into densely population settlements. The Tarai (wet) region in the Nainital district boasts extensive fertile tracts where paddy and wheat are cultivated. The river valleys are narrow, offering limited arable land, yet crops are irrigated in these areas. The Middle Himalaya boasts extensive arable land and a high population concentration, with cropland relying on rain-fed agriculture. The highlands comprise lower highlands, alpine pasturelands, and the perpetual snow-clad Himalaya. Human settlements practicing agriculture are limited to the lower highlands, where crops are grown only during the summer season. Alpine grasslands in the highlands also support the growth of medicinal plants during the summer. Overall, the arable land constitutes only 18%, while 64% of the region is covered by forests showcasing diverse ecosystems, from monsoon deciduous forests to pine forests, mixed oak forests, coniferous forests, and alpine meadows. The Ganga River, along with its numerous sub-tributaries, originates and flow through the Central Himalaya, providing abundant water resources. However, despite the ample water supply, irrigation facilities are insufficient. The agro-climatic conditions are favourable, contributing to rich

crop diversity. Nevertheless, marginal farmers predominantly engage in subsistence agriculture with low output. In recent times, there has been a decrease in both the area and production of crops, accompanied by changes in land use patterns in the Central Himalaya.

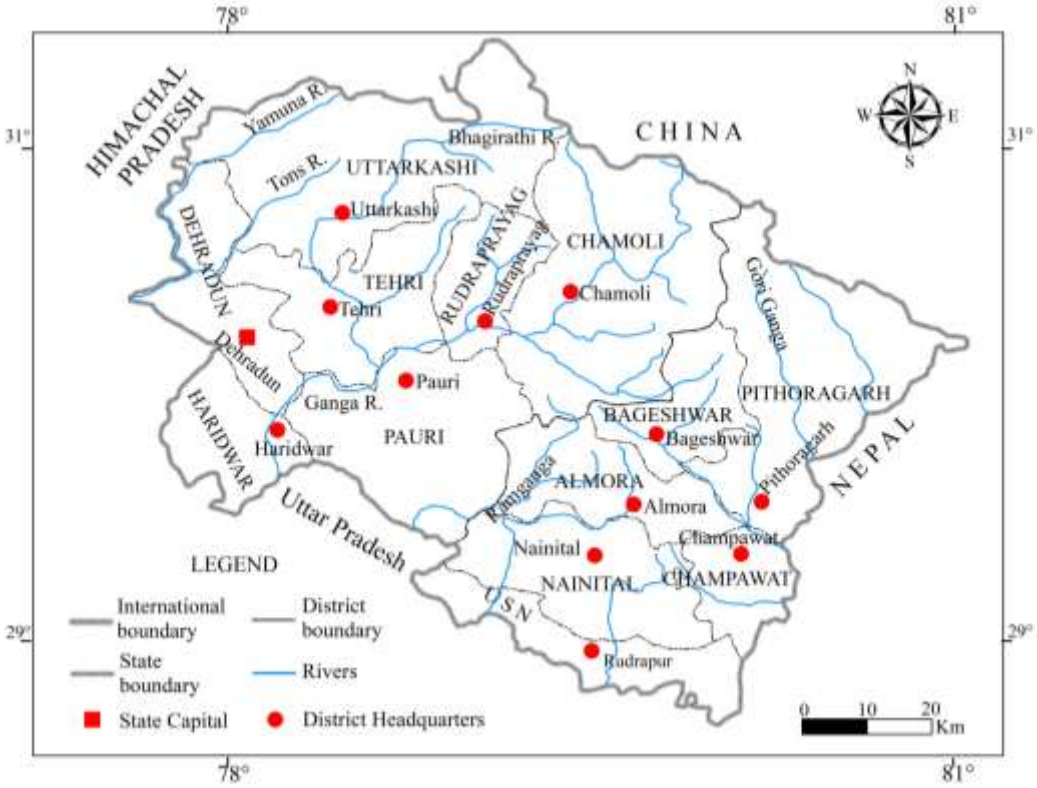

Figure 1: Location map of the Central Himalaya

3. Methodology

This study relies on data compiled from secondary sources, specifically the Statistical Diaries of Dehradun and Nainital districts. Initial data compilation involved obtaining land use data for the years 2011-12 and 2021-22 for both the districts. Subsequently, data on the area and production of key crops, including food grains, pulses, oilseeds, sugarcane, and potatoes were gathered for the same years. Additionally, information on the area and production of fruits and vegetables was gathered for the years 2011-12 and 2021-22. The compiled/acquired data underwent thorough analysis, revealing changes in land use and land cover between 2011-12 and 2021-22. The study also examined alterations in the area and production of various crops, calculating crop productivity. The findings were visually represented through bar graphs to illustrate changes in the area, production, and productivity over the specified time frame. This analytical approach aimed to provide a comprehensive understanding of the evolving agricultural landscape in the study area.

In this study, climate data were analyzed using information gathered from the Meteorological Department based in Dehradun for the two meteorological centres – Dehradun (600 m) and Mukteshwar (2,700 m). These two centres represent the plain regions and the highland areas of the Central Himalaya,

respectively. Specifically, average annual temperature and rainfall data from 2012 to 2022 were examined. The analysis utilized linear regression models to illustrate the variability and changes in temperature and rainfall over the specified period. The findings of the climate data analysis contribute to understanding the evolving climate patterns in the region. Additionally, the study explores the impact of climate change on cropping patterns, shedding light on how shifts in temperature and rainfall may be influencing agricultural practices in the Central Himalaya.

4. Results

4.1 Land Use Patterns and Changes

In the Dehradun district, the forest covered 55.3% of the total area in 2021-22. The land use distribution included 14.9% for cultivable wasteland, 1.9% for current fallow, and 4% for other fallow land. The net area sown accounted for 9.4%, while the area sown more than once and the gross sown area were 4.8% and 14.2%, respectively. Regarding irrigated areas, the net irrigated area constituted 4.7%, and the gross irrigated area was 7.4%. Over the period from 2011-12 to 2021-22, significant changes were observed in land cover. There was a decrease of -0.24% in forest area, -19.3% in net area sown, -18.3% in gross area sown, and -16.5% in gross irrigated area. In contrast, there was an increase in cultivable wasteland by 17.41%, current fallow land by 106%, orchards, trees, and bushes by 13.4%, and net irrigated area by 22.3%. These changes indicate shifts in land use patterns and agricultural practices in the Dehradun district during the specified period.

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Over the decade from 2011-12 to 2021-22 in Nainital district, several changes in land cover were observed. Barren land decreased significantly by 53.4%, and a small portion of forest cover also diminished. Agricultural areas were affected, with a 10.5% reduction in net area sown and a 7.4% decrease in gross area sown. Irrigated land saw declines as well, with a decrease of 11.6% in net irrigated area and 10.1% in gross irrigated area. On the other hand, cultivable wasteland increased by 14.8%, and current fallow land experienced a substantial growth of 67.1%. Pasture land expanded by 102%, while land used for purposes other than agriculture decreased by 11.8%. These changes in land

[2] The land, which was arable but now abandoned and categorized as cultivable wasteland.

cover reflect shifts in land use patterns, likely influenced by various factors impacting the Nainital district's landscape.

4.2 Diversity in Major Crops

The Central Himalaya boasts a rich diversity of crops. Major crop varieties include food grains, pulses, oilseeds, fruits, vegetables, and spices, each comprising several crop races or cultivars as detailed in table 1. The distribution and types of these crops exhibit variations across different climate zones within the region. Altitude and climate influence significantly the area under cultivation and the production of these crops, contributing to the unique agricultural landscape of the Central Himalaya.

Table 1: Major crops and their diversity

Variables	*Major crops*
Food grains	Paddy, wheat, barley, maize, Manduwa (Ragi/finger millet)
Pulses	Urd (black gram), Masur (red lentil), Gram (chick pea), Peas, Tour (pigeon pea, Moth (mat bean)
Oilseeds	Mustard, Til (sesame seed), groundnut, sun flower, soybeans
Sugarcane	Single crop
Potato	Single crop
Fruits	Mango, guava, papaya, litchi (*Litchi chinensi*), lemon, blood orange (malta), orange, Galgal (Hill lemon), elephant citrus, apple, pear, peach, plum, apricot, walnut, almond
Wild fruits	Kafal (box berry), Kilmori (*Berberis asiatica*), Timli (*Roxburgh fig*), Amla (Indian gooseberry)
Vegetables	Capsicum, spinach, pumpkin, cucumber, brinjal, bottle guard, bitter guard, snake guard, beans, Arbi (taro root), potato, onion
Spices	Chili, turmeric, garlic, ginger

4.3 Cropping Patterns – Changing Arable Land

4.3.1 Dehradun District

The Dehradun district exhibits a rich agricultural diversity, as outlined in table 2. A variety of food grains, pulses, and oilseeds are cultivated across the entire district. In the 2021-22 period, the highest area was under food grain (40% of the total crop area), followed by fruits, vegetables, sugarcane, and pulses. Potato and spices had nominal area. In terms of changes in cropping patterns, a notable decrease was observed across all crops under food grains, with a significant overall decrease of 28.5%. Area under oilseeds has decreased by 45%, followed by pulses (42.8%), potato (24%), and sugarcane (16.3%). There was an increase in the area of spices, vegetables, and fruits. Overall, 15.6% decrease was noticed in area from 2011-12 to 2021-22.

4.3.2 Nainital District

Similar to the Dehradun district, in the Nainital district, the highest area is under food grains (55.5%), followed by fruits (15.3%). The area under other crop was less than 10% (Table 3). Sugarcane and potatoes are also grown in the Nainital district. Comparing changes in cropping patterns, like Dehradun, the Nainital district witnessed a decrease in the area under food grains (15%).

However, the area under pulses increased (22.8%). The area of potatoes has increased by 36.9%, while the area under oilseeds decreased (20.8%). The fruit area has decreased by 57.4%, vegetables by 32.2%, and sugarcane by 31%. Overall, the total crop area in Nainital has decreased by 13.3%. These changes underscore the dynamic nature of agricultural practices in the Nainital district.

Table 2: Cropping patterns, changing arable land 2011-12 to 2021-22 (ha) in Dehradun district

Variables	*2011-12*	*%*	*2021-2022*	*%*	*Change (%)*
Food grain (n=6)	42,362	47.6	30,304	40.4	-28.5
Pulses (n=6)	4,146	4.7	2,371	3.2	-42.8
Oilseeds (n=5)	1,537	1.7	842	1.1	-45.2
Sugarcane	4,624	5.2	3,868	5.2	-16.3
Potato	664	0.7	504	0.7	-24.1
Fruits	25,609	28.8	26,408	35.2	3.1
Vegetables	9,104	10.2	9,669	12.9	6.2
Spices	885	1	1,083	1.4	22.4
Total	8,8931	100	75,049	100	-15.6

Note: n=crop cultivars/races

Table 3: Cropping patterns, changing arable land 2011-12 to 2021-22 (ha) in Nainital district

Variables	*2011-12*	*%*	*2021-2022*	*%*	*Change (%)*
Food grain	46,310	48.5	39,343	55.5	-15
Pulses	2,106	2.2	2,586	3.6	22.8
Oilseeds	6,056	6.3	4,794	6.8	-20.8
Sugarcane	3,952	4.1	2,727	3.8	-31
Potatoes	2,398	2.5	3,282	4.6	36.9
Fruits	25,454	26.7	10,834	15.3	-57.4
Vegetables	8,683	9.1	5,876	8.3	-32.3
Spices	481	0.5	1,425	2	196
Total	95,440	100	70,867	100	-25.7

*Turmeric, potato, ginger, and garlic were reported in 2019-2020.

**Among pulses, black soybean (*Glycine max* (L.) Merrill), kidney bean (*Phaseolus vulgaris* L.) and horse gram (*Macrotyloma uniflorum*), were reported in 2019-2020

4.3.3 Comparison of Changing Cropping Patterns in Dehradun and Nainital Districts

In figure 2, the changes in the area under cultivation in the Dehradun and Nainital districts between 2011-12 and 2021-22 are depicted. Notably, there is a significant decrease in the area dedicated to crops such as food grains, oilseeds, and sugarcane. Potato cultivation witnessed a decline in Dehradun, while it increased in the Nainital district. Meanwhile, there was a substantial increase in the area under pulses in both districts. The trend is evident, highlighting a significant overall decrease in the area under cultivation for all principal crops in both Dehradun and Nainital districts.

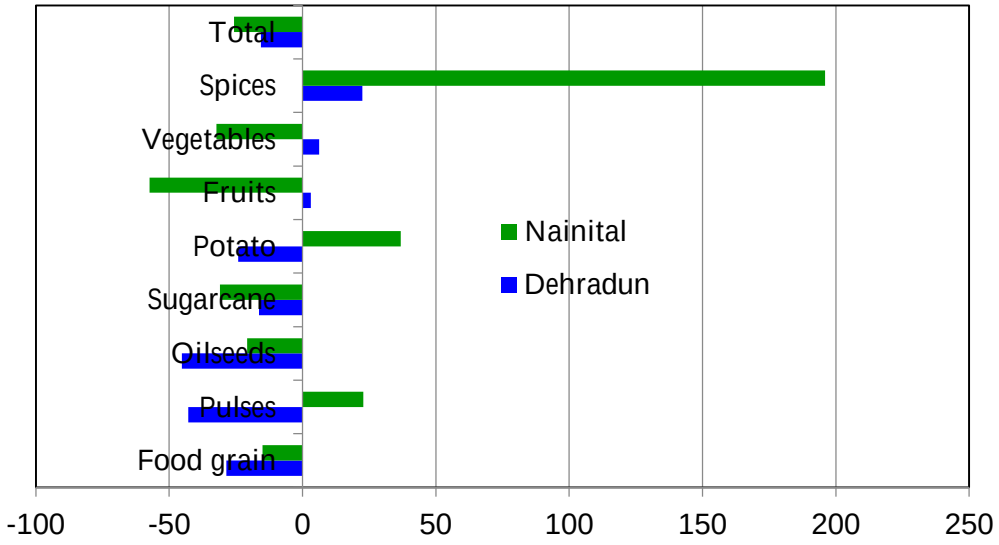

Figure 2: Change in the area (%) 2011-12 and 2021-22

4.4 Changing Production Patterns

4.4.1 Dehradun District

In the Dehradun district, the highest production was observed in sugarcane (58.3%), followed by food grains (16.1%) and vegetables (14%). The production of other crops was less than 10%. The overall decrease in food grain production was 8.4%. However, there was a remarkable increase in pulse production by 74.7%, and a 29.4% increase in oilseed production. Sugarcane production increased by 10.2%, whereas potato production decreased by 55%. Despite the varied changes, an overall 3.4% increase in the production of all crops was observed (Table 4).

Table 4: Production (metric tonnes) of principal crops and change (%) from 2011-12 to 2021-2022 in Dehradun district

Variables	*2011-12*	*%*	*2021-2022*	*%*	*Change (%)*
Food grain	88,492	16	81,056	16.1	-8.4
Pulses	1,199	0.2	2,095	0.4	74.7
Oilseeds	493	0.1	638	0.1	29.4
Sugarcane	266,850	48.3	293,968	58.3	10.2
Potatoes	14,721	2.7	6,628	1.3	-54.9
Fruits	66,566	12	40,059	7.9	-39.8
Vegetables	107,093	19.4	70,755	14	-33.9
Spices	7,551	1.4	9,002	1.8	19.2
Total	552,965	100	504,201	100	-8.8

4.4.2 Nainital District

Sugarcane contributed the highest production among crops (36.5% in 2021-22), followed by food grains (23.2%), fruits (19.4%), vegetables (10.6%), potatoes (7.4%) (Table 5). In terms of change in the production of crops, there was the highest increase in spices (98.6%), followed by pulses (67.9%), and

potatoes (57.4%). On the other hand, the production of some crops decreased with 56.4% of oilseeds, 27% vegetables, and 15.7% sugarcane. Despite these variations, the overall production of all crops has decreased by 4.5%.

Table 5: Production (metric tonnes) of principal crops and change (%) from 2011-12 to 2021-2022 in Nainital district

Variables	*2011-12*	*%*	*2021-2022*	*%*	*Change (%)*
Food grain	117,802	19.9	131,350	23.2	11.5
Pulses	1,698	0.3	2,851	0.5	67.9
Oilseeds	1,1293	1.9	4,925	0.9	-56.4
Sugarcane	245,024	41.4	206,434	36.5	-15.7
Potatoes	26,599	4.5	41,875	7.4	57.4
Fruits	102,214	17.2	109,389	19.4	7
Vegetables	82,711	14	59,700	10.6	-27.8
Spices	4,415	0.7	8,769	1.6	98.6
Total	591,756	100	565,293	100	-4.5

4.4.3 Comparison of Changes in Production in Dehradun and Nainital districts

In terms of production changes, both districts witnessed an increase in pulses production (Figure 3). Notably, the production of potatoes, sugarcane, oilseeds, and food grains increased in the Nainital district, while experiencing a decrease in the Dehradun district. The Nainital district, characterized by a large rural population, demonstrated nominal changes in both the area and production of crops. Conversely, the Dehradun district, with a predominantly urban population and significant in-migration, underwent the conversion of arable land into dense settlements, resulting in a decrease in both area and production. These contrasting dynamics highlight the distinct agricultural landscapes and demographic influences in the two districts.

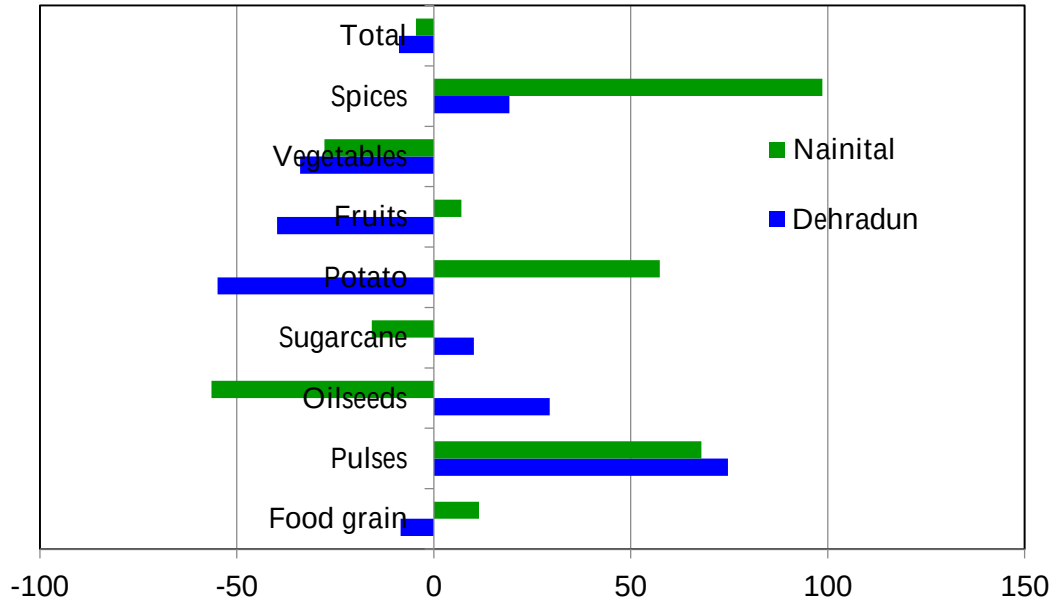

Figure 3: Change (%) in production, 2011-12 and 2021-22

4.4.4 Productivity of Crops and Changes

The change in crop productivity between 2011-2012 and 2021-2022 was observed in both the Dehradun and Nainital districts (Table 6). Notably, crop productivity exhibited both increasing and decreasing trends, and variations were observed between the two districts. There was a noticeable increase in the productivity of paddy and wheat crops in both districts. Moreover, productivity increased for total food grains, total pulses, and total oilseeds. Overall, there was an increase in overall productivity. These trends highlight the complex dynamics influencing crop productivity, which can vary across different crops and districts.

Table 6: Productivity in (metric tonnes/ha)

Crops	*Dehradun*			*Nainital*		
	2011-12	*2021-2022*	*Change (%)*	*2011-12*	*2021-2022*	*Change (%)*
Food grain	2.1	2.7	28.6	2.5	3.3	32
Pulses	0.3	0.9	200	0.8	1.1	37.5
Oilseeds	0.3	0.8	167	1.9	1	-47.4
Sugarcane	57.7	76	31.7	62	75.7	22.1
Potato	22.2	13.2	-40.5	11.1	12.8	15.3
Fruits	2.6	1.5	-42.3	4	10.1	152.5
Vegetables	11.8	7.3	-38.1	9.5	10.2	7.4
Spices	8.5	8.3	-2.4	9.2	6.2	-32.6
Total	6.2	6.7	8.1	6.2	8	29

4.4.5 Comparison in the Productivity in Dehradun and Nainital districts

As depicted in figure 4, the productivity of crops increased in both districts, except for potatoes in the Dehradun district. Remarkably, despite a significant decrease in arable land, productivity experienced a notable increase, primarily attributed to the adoption of intensive agriculture practices. Farmers engaged in agriculture continue to practice intensive farming methods, contributing to enhanced productivity despite challenges such as reduced land availability. This trend underscores the resilience and adaptability of agricultural practices in the face of changing landscapes and land use patterns.

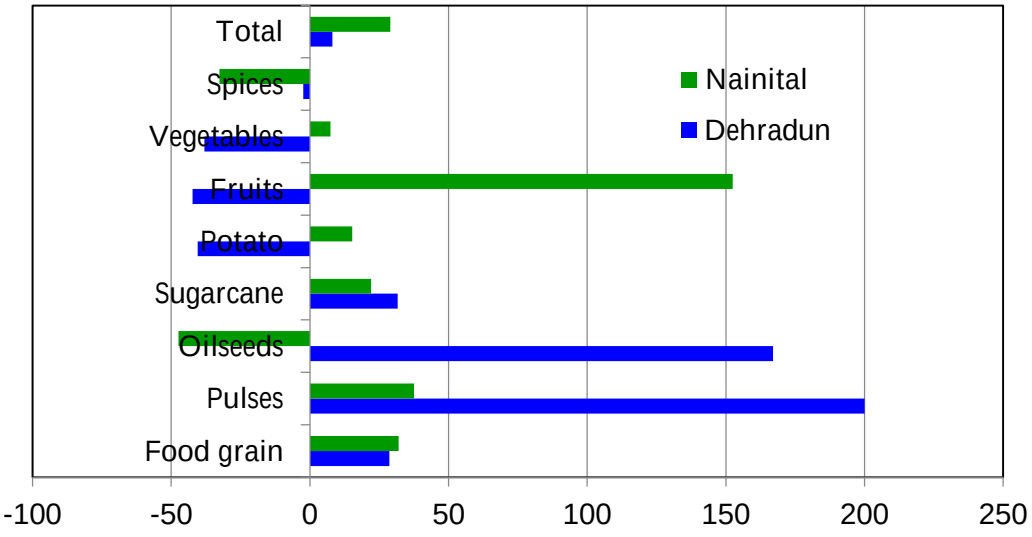

Figure 4: Change (%) in productivity, 2011-12 and 2021-22

5. Factors Affecting Changes in Land Use and Cropping Patterns

The changing cropping patterns in the Central Himalaya are influenced by various factors, among them are the climate change, increasing population, shifting food habits, and land abandonment due to out-migration. These factors are separately described below.

5.1 Climate Change

Climate change, recognized as a global phenomenon, has widespread effects on the Earth system, impacting rainfall and temperature patterns, water resources, glaciers, and biodiversity. The Himalayan region is particularly vulnerable to these changes, with significant consequences for both natural and cultural aspects.

5.1.1 Average Annual Temperature (°C) in Dehradun and Mukteshwar

Figure 5 illustrates the variability and change in average annual temperature from 2012 to 2022 in both Dehradun city and Mukteshwar service centre. Notably, Dehradun city consistently experiences higher temperatures than Mukteshwar, primarily due to differences in altitude. Dehradun city, situated at an average altitude of 600 meters, contrasts with Mukteshwar village, which has an average altitude of 2,500 meters. The temperature in Dehradun exhibits variation, ranging from a lowest recorded temperature of 23°C in 2015 to the highest 28°C in 2022. Despite fluctuations, there is an observable increasing trend with high variability, as indicated by an R^2 value of 0.118. The increasing temperature trend is more pronounced, with an R^2 value of 0.249. In Mukteshwar, where temperature variability is also high, the lowest average temperature was recorded as less than 15°C in 2015, while the highest temperature reached 19°C in 2022. These temperature trends and variations underscore the dynamic nature of climate conditions in both locations, with potential implications for agriculture and cropping patterns.

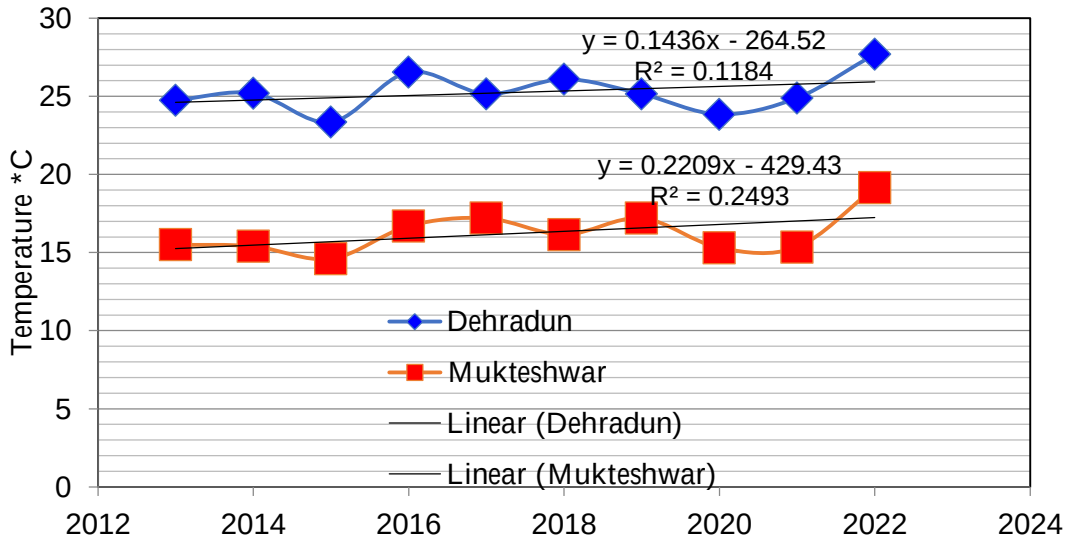

Figure 5: Average annual temperature (°C) in Dehradun and Mukteshwar

5.1.2 Average Annual Rainfall (mm) in Dehradun and Mukteshwar

Figure 6 illustrates the high variability and change in average annual rainfall from 2012 to 2022. The observed trend is not uniform, displaying contrasting patterns between Mukteshwar and Dehradun. While Mukteshwar experienced a decreasing trend in rainfall, Dehradun, conversely, witnessed an increasing trend. In Mukteshwar, the lowest recorded rainfall was less than 10 mm in 2022, and the highest rainfall occurred in 2015, exceeding 115 mm. Dehradun, on the other hand, recorded its lowest rainfall of less than 10 mm in 2013 and 2022, while the highest rainfall was registered at above 80 mm in 2020. These divergent trends in rainfall patterns between the two locations highlight the localized nature of climate variations in the Central Himalaya, emphasizing the need for region-specific analyses when studying the impacts on cropping patterns.

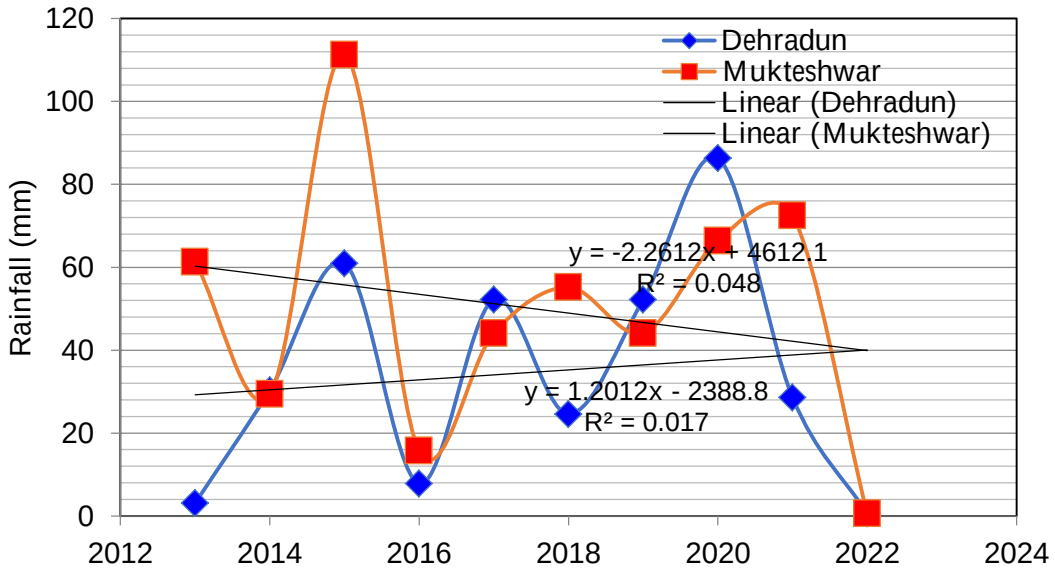

Figure 6: Average annual rainfall (mm) in Dehradun and Mukteshwar

The pronounced variability and changes in temperature and rainfall, as observed in the study of the two districts in the Central Himalaya, have had a significant impact on cropping patterns. The noticeable decreases in the area, production, and productivity of crops, particularly those grown in the highlands, can be attributed to the observed trends of decreasing rainfall and increasing temperatures (DoM, 2023). These climatic shifts are likely influencing agricultural conditions, posing challenges to traditional cropping practices and necessitating adaptations in response to the evolving climate in the Central Himalayan region.

5.2 Increasing Population

The increasing population is a key factor driving changes in land use and cropping patterns in the Central Himalaya. During the given period, population increased by more than 20% (SHB, 2023). However, the increase in population was uneven. The author observed that the limited availability of land for

settlements and agriculture has prompted the use of arable land for construction, leading to the conversion of forest lands into cultivable areas.

5.3 Shift in Food Habits

Traditional food habits in the region revolved around millets, which were staple crops grown in the middle altitudes and highlands, contributing to the region's rich agrobiodiversity. These crops, along with a variety of fruits and vegetables, were cultivated predominantly during the rainy season, relying on rain-fed agriculture.

Owing to modernization and cultural changes, there has been a significant shift in the food habits of the local population. The increased production of wheat and paddy in the river valleys and plains has played a role in altering dietary preferences. This shift has resulted in a substantial decrease in the cultivation of millets, along with a reduction in the cultivation of fruits and vegetables. Many areas have witnessed the abandonment of land previously dedicated to these crops.

5.4 Migration

In-migration and out-migration are crucial drivers of changing cropping patterns, impacting both the areas of origin and destination. Rural areas experience land abandonment due to out-migration, while urban areas receiving migrants witness the conversion of arable land into settlements. Consequently, both sending and receiving areas are undergoing significant changes in land use and cropping patterns due to migration dynamics.

6. Discussion

The study examined the changing land use and cropping patterns in two districts, Dehradun and Nainital, from 2011-12 to 2021-22, with a specific focus on analysing the evolving climate in these regions. Significant changes were observed in land use patterns in both districts during the specified period. There was a notable decrease in forestland, net area sown, gross area sown, and irrigated land in both Dehradun and Nainital districts. Conversely, there was an increase in cultivable wasteland, fallow land, and pastureland. The Dehradun district experienced a decrease in arable land, primarily due to widespread in-migration from rural areas, leading to the construction of settlements instead of agricultural land. A similar trend was observed in the Nainital district, contributing to an increase in barren land and pastureland in both districts. Despite the decrease in forest area in both districts, the extent of reduction was relatively lower, attributed to the presence of two national parks — Rajaji National Park in the Dehradun district and Corbett National Park in the Nainital district. These protected areas have contributed to maintaining the forested areas within the districts.

In the traditional society, dietary habits were predominantly influenced by the production of food grains and millets, leading to a significant allocation of land for food grain cultivation. The rich agrobiodiversity of the region resulted in a substantial area dedicated to fruits and vegetables. The climate and irrigation facilities also favoured the cultivation of sugarcane, primarily in the plain areas, contributing to a considerable area under this crop. However, over time, there has been a substantial decrease in the area under food grains, pulses,

oilseeds, sugarcane, and potatoes. In contrast, the area under fruits, vegetables, and spices has witnessed a nominal increase. The Dehradun district, known for its fertility, is grappling with the issue of shrinking arable land, impacting the overall agricultural landscape. The Nainital district, facing a different scenario, experienced a significant decrease not only in the area of food grains but also in fruits and vegetables. The overall decrease in agricultural areas was more pronounced in the Nainital district compared to the Dehradun district. These shifts underscore the changing dynamics in land use and cropping patterns, influenced by evolving dietary preferences and challenges specific to each region.

Regional changes were evident in the Nainital district, characterized by a decrease in production, particularly for oilseeds, sugarcane, and vegetables. When comparing the production of crops between the two districts, it was observed that the Dehradun district experienced a higher decrease compared to the Nainital district. The productivity trends also displayed variations between the two districts. In the Dehradun district, there was a significant decrease in the productivity of potatoes, fruits, and vegetables. On the other hand, the Nainital district saw a decline in the productivity of oilseeds and spices. Despite these variations, the overall productivity showed an increase. It is noteworthy that the Nainital district exhibited higher productivity levels than the Dehradun district, even though the latter had a larger agricultural area. These findings suggest distinct patterns in production and productivity dynamics, influenced by local factors and agricultural practices in each district.

7. Conclusions

The Central Himalaya has a rich tradition of practicing traditional farming systems, with diverse crop races/cultivars and cropping patterns varying across the river valleys, middle altitudes, and highlands. In the past, the prominent practice of Barahnaja[3] involved cultivating twelve or more traditional cereals and millets on a single cropland. However, over time, and influenced by factors such as climate change, increasing population, changing food habits, and out-migration, there has been a significant shift in cropping patterns. Currently, the staple crops in the region are paddy and wheat, with crop-growing areas gradually moving to higher altitudes due to the warming of river valleys and middle altitudes. The study suggests the necessity of conducting a comprehensive base-level survey to assess the current situation regarding changing cropping patterns and the shifting of crop races to higher altitudes. This assessment could inform the re-delineation of agro-ecological zones, facilitating the selection of suitable crop races for cultivation in different agro-climatic zones. Such an approach could contribute to sustainable agricultural practices in response to the evolving environmental and demographic conditions in the Central Himalaya.

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Author' Declarations and Essential Ethical Compliances

Author' Contributions (in accordance with ICMJE criteria for authorship)
This article is 100% contributed by the sole author. S/he conceived and designed the research or analysis, collected the data, contributed to data analysis & interpretation, wrote the article, performed critical revision of the article/paper, edited the article, and supervised and administered the field work.

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The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

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