Arth Ganga Project: District Dehradun
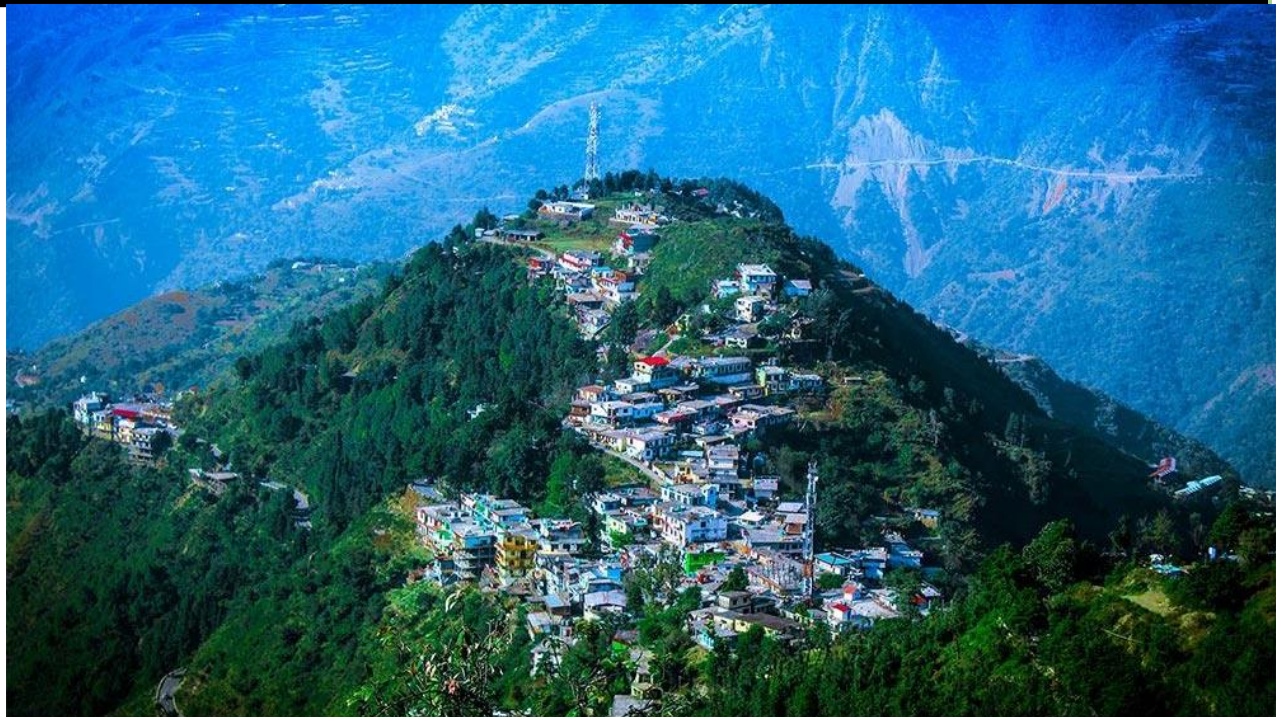

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EXECUTIVE SUMMARY

Dehradun, the capital city of the state of Uttarakhand is one of the educational, military, and research hubs of India. Located in the Doon Valley, the rivers Ganga Yamuna and Son traverse the city.

The total geographical area is 308800 ha, out of this cultivable area is 49900 ha whereas cultivable wasteland 63400 ha. The gross sown area is 66300 ha with 145.7% cropping intensity. The gross irrigated area is 34200 ha. The chief crops are sugarcane, barley, mustard, potato, wheat, etc. Amongst the horticulture crops are mango, apple, peach, citrus, potato, tomato, vegetable pea, etc. Different cropping systems have been adapted in the district. The total fodder crop area is 3200 ha. The livestock includes indigenous and crossbred cattle, buffalo, goat, sheep, etc along with poultry. In the year 2016-17, the agriculture sector showed a decline whereas fisheries and livestock showed an increase in share to economy of the district. The tertiary sector had shown an increase from 2011 to 2017 and has been dominant whereas the primary sector had fluctuated during this period. Also, the area under non-agriculture purposes along with fallow and wasteland increased. The net sown area showed a decrease but irrigation and the cropping intensity had increased. The trend of organic farming is fluctuating whereas the use of chemical fertilizers is high. The share of the agriculture sector went down approximately from 50% to 44% during the whereas the share of livestock rose from 23.69% to 31.4% during 2011-17. Mining and quarrying recorded a growth of 7.74% per year. The share of primary and secondary sectors in GDDP went down from 11.85% in 2011-12 to 10.01% and 41.12% in 2011-12 to 39.97% respectively, in 2016-17. The tertiary sector's share went up from 47.02% to 50.01%. the district's annual growth rate was 6.45% per annum.

Out of the total forest cover of the district (52.09%); areas covered by very dense forest moderately dense forest and open forest are 659.77 Km^2, 601.56 Km^2, and 347.36 Km^2 respectively. The forest plantations, water bodies, etc. have shown a decrease in 2020 in comparison to 2010. An evident increase in forest cover was seen in 2020; open forest area increased from 29.81% in 2010 to 31.02% in 2020, and dense forest area increased from 27.54% to 27.56 % during the period yet the share of forestry and logging decreased from 26.05% to 24.41% during 2011-17. Under *Green India mission*, on 5515 ha plantation was carried out till 2021. The district has high biodiversity. According to the Umbrella project, 4,856 flora and fauna have been observed. Mostly small-sized tanks/ponds and rivers/streams, around 136 wetlands are present where natural wetlands are more than man-made ones. There are many tourist places of religious importance as well as natural places like parks, wildlife, etc. in and around the city. The district is well connected with roads, railways, and airways to nearby and far places whereas accommodations are well established.

The main source of lightning is electricity (96.29%) whereas the major power source for cooking is LPG/PNG (72%) followed by lightning (22%). Different solar appliances and panels have been

installed in the district but more measures should be taken to enhance solar energy usage. The amount of biomass produced is high due to ample production of agriculture and animal waste, thus biogas production has high potential in the district which accounts for approximately 4 crore m^3/year and 60 lakh m^3/year respectively. There are many proposed and ongoing hydro-power projects in the district.

There have been many active measures taken to support and promote sustainable development. Urban city forest- Anand Van, cycling tracks to promote forest-tourism, development of Centre for Aromatic Plants, Mukhayamantri Saur Swarojgar Yojna, various research centers and institutes for exploring new technologies for enhancing use and development of renewable energies, etc. shows government's strenuous efforts to comply with green and clean strategies along with economic development yet lack of monitoring, local participation, expansion of measures like agroforestry, etc. are some of the barriers that are needed to be overcome. Also, tea plantations, sericulture, adapting to advanced technologies, proper monitoring, and maintenance of places and forests, shifting cultivation, promoting beekeeping, floriculture, drip, and sprinkler irrigation, etc., are a few measures that might be adapted in the district.

1 DISTRICT OVERVIEW

1.1 INTRODUCTION

Dehradun also spelled Dera Doon, is the capital and the largest city of the Indian state of Uttarakhand. It is also the most populated city in the stateThe city of Dehradun mainly lies in Doon Valley and is at a varying height from 410 m (1,350 ft) in Clement Town to above 700 m (2,300 ft) at Malsi which is 15 km (9.3 mi) from the city. However, the average elevation is 450 m (1,480 ft) above sea level. The district is situated in the North-Western part of the state. The district lies between 290 57' and 310 2' north latitudes and 770 35' and 790 20' east longitudes. It is bounded in the east by Tehri Garhwal, Pauri Garhwal and Uttar Pradesh, Himachal Pradesh is in the west, Uttarkashi is also in the north while its southern boundary is formed by Hardwar and Saharanpur districts of Uttarakhand and Uttar Pradesh respectively. The district is endowed with rich forests chiefly stocked with Sal. Total area under forests in the district is 203659 hectares which is 55.8 per cent of the total reported area of the district. The flora of the district includes a vast range varying from tropical to alpine species owing to the variation in altitude. Administration wise, the district comprises 6 sub-districts, 22 towns and 748 villages.

In the total population of the district of 1,696,694 as much as 34.3 per cent are workers and rest of 65.7 per cent are non-worker. Among workers 83.8 per cent are main workers and rests of 16.2 per cent are marginal workers of total population. In the district among workers about 13.2 per cent are cultivators and 76.3 per cent other workers. 23.7 per cent of female workers are engaged

as cultivators.In the district about 84.2 per cent population is literate. The literacy is about 88.3 per cent in urban areas and about 79.1 per cent in rural areas.As per 2011 Census sex ratio of 902 females per 1,000 males has been recorded in the district. The economy of the district is mainly dependent on agriculture. The chief agricultural products in the district are sugarcane, mango, guava, mustard, potato, wheat, maize, etc.
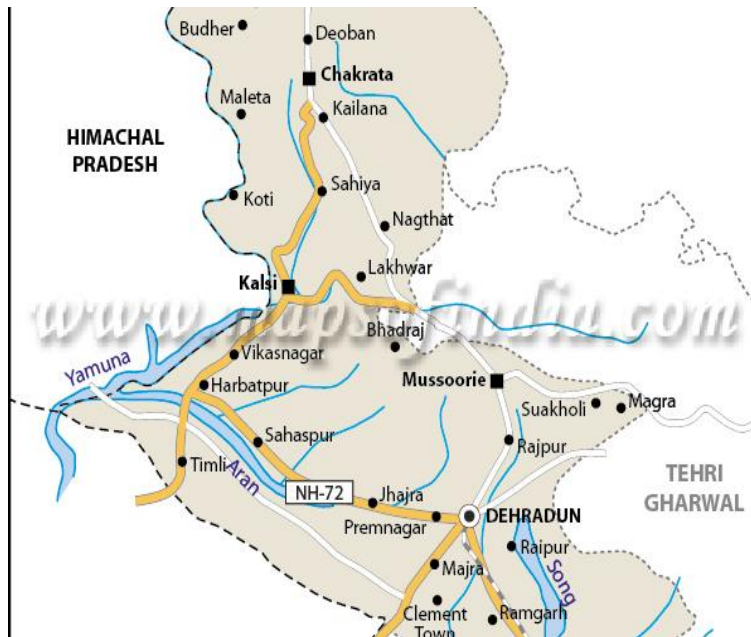

Figure 1 Map of the district

1.2 DEMOGRAPHIC PROFILE OF DEHRADUN

Geographic area: 3088 Km^2
Altitude: 435 m
Rainfall: 1262.4 mm
Forest area: 1608.69 Km^2
Major Rivers: Yamuna, Ganga, Song

Administrative Divisions:

District Headquarter	Dehradun
No. of Blocks	6
No. of Municipalities	6

No. of Villages	748

Demographic and Socio-economic Parameters:

Population	16,96,694
Population Density	550 / Km^2
Sex Ratio	902
Literacy	84.25
Occupation/Livelihood	Agriculture

Agriculture is primary and main constituent of the district economy. The chief agricultural crops are sugarcane, mango, guava, peach, grape, strawberry, barley, mustard, potato, wheat, etc. Because of presence of industries in the district, people have adopted new technologies in the agriculture also. District also has various establishment of software technology parks and defence production factory which produces ordnance for the Indian Armed forces. Massive amount of revenue generation is done through these industries. In year 2016-17 the gross domestic product was Rs. 40,57,583 lakh at current price and Rs. 32, 91,255 lakh at constant prices in year 2011-2012. District also known as 'city of schools' as variety of educational institutions are present in the district. Total 6 municipalities are present in the district as: Dehradun, Rishikesh, Doiwala, Herbertpur, Mussoorie, Vikasnagar.

Table 1 demographic overview

1.3 AGRO CLIMATIC PROFILE OF THE DISTRICT

1.4 ECONOMIC PROFILE OF DEHRADUN

The primary sector of the district economy has constantly been declining in terms of its share in the GDDP. The share went down from 11.85% in 2011-12 to 10.01% in 2016-17. The primary grew at 4.69 percent per annum during this period. The share of the secondary sector declined about two percent point from 41.12% in 2011-12 to 39.97% in 2016-17. However, it recorded a higher average annual growth rate (7.14%) than the primary sector. The tertiary sector's share went up from 47.02% to 50.01% during the same period, with an annual growth rate of 9.09%. Overall, the district economy grew at the rate of 7.75 percent per year during the period under study. The real per capita income in the district went up from Rs.129902 in 2011-12 to Rs.177514 in 2016-17, with an annual growth rate of 6.45% per annum. A perusal of the table reveals that all the three sectors of the district economy have achieved significant growth with relatively a higher growth rate in the tertiary and secondary sectors.

Table 1: Trends in Gross District Domestic Product and Per Capita DGDP in Dehradun at Constant Prices (base 2011-12) in Rs Lakhs

Year	Sector Wise GDDP (Rs Lakh)				Annual Growth Rates				Per Capita DGDP (Rs)	Growth Rate
	Primary	Secondary	Tertiary	Total GDDP	Primary	Secondary	Tertiary	Total		
2011-12	231177	802072	917131	1950381	-	-	-	-	129902	-
	(11.85)	(41.12)	(47.02)	(100)						
2012-13	218278	868139	998313	2084730	-5.57	8.23	8.85	6.88	136556	5.12
	(10.47)	(41.64)	(47.88)	(100)						
2013-14	210315	931683	1090083	2232082	-3.64	7.31	9.19	7.06	145368	6.45
	(9.42)	(41.74)	(48.83)	(100)						
2014-15	217269	972480	1212791	2402540	3.30	4.37	11.25	7.63	154070	5.98
	(9.04)	(40.47)	(50.47)	(100)						
2015-16	271053	1059435	1310224	2640712	24.75	8.94	8.03	9.91	167627	8.79
	(10.26)	(40.11)	(49.61)	(100)						
2016-17	283618	1132099	1416565	2832282	4.63	6.85	8.11	7.25	177514	5.89
	(10.01)	(39.97)	(50.01)	(100)						
Annual Growth Rate					4.69	7.14	9.09	7.75	-	6.45
Source: UKDES										
Note: Figures in Parentheses are percentage share in the total GDDP										

Since our focus is on agriculture and allied activities, we further disintegrate the primary sector GDP to know which sub-sector is laggard and which one is driving the growth of the primary sector. Table 2 shows the sub-sectoral trends in the primary sector. The sector is divided into agriculture and allied activities and mining & Quarrying (M&Q). M&Q recorded an impressive growth of 7.74% per year, though the growth shows ups and downs across years. As far as sub-sectoral growth of agricultural and allied sectors is concerned, we observe that agriculture, including horticulture, declined by 0.33 percent per year during 2011-12 and 2016-17. Consequently, the share of the agriculture sector went down approximately from 50% to 44% during the period. Contrary to this, the share of livestock rose from 23.69% to 31.4% during the same period. Livestock evinces a positive growth of 7.95% per year. The share of forestry and logging decreased from 26.05% to 24.41% during the same period, with an annual average growth rate of 0.84%. Though Fishery has a negligible share in the total GDP of agriculture and allied

sectors, it is the second-highest growing sub-sector in the district economy as it grew at the rate of 5.77% per year. Thus, livestock and Fishery are the growth drivers of the primary sector.

Can crop and horticulture sectors be the growth drivers of the district rural economy? Or should a sustainable development model for the growth of the district economy rely more on livestock, forestry and Fishery? Can organic farming initiatives by the government through PKVY and Namami Gange programmes revitalize agriculture and provide a decent livelihood to the rural workforce engaging the agriculture? Or should we think of an integrated model of sustainable development focusing on horticulture, livestock, agroforestry, bio-energy and tourism? How can these activities be integrated into the system and re-enforced each other? To answer these questions, we need to get feedback from the district administration.

Table 2: Trends in GDDP from Agriculture and allied activities in Dehradun at Constant Prices in Rs. Lakhs (Base 2011-12)

Year	Agriculture	Livestock	Forestry & Logging	Fishery	Total Agriculture & Allied	Mining & Quarrying	Primary Sector
2011-12	52778	24954	27436	163	105332	125845	231177
	(50.11)	(23.69)	(26.05)	(0.15)	(100)		
	-	-	-	-	-	-	-
2012-13	52474	26335	27872	170	106851	111427	218278
	(49.11)	(24.65)	(26.08)	(0.16)	(100)		
	[-0.58]	[5.53]	[1.59]	[4.29]	[1.44]	[-11.46]	[-5.58]
2013-14	50709	29248	28125	124	108205	102110	210315
	(46.86)	(27.03)	(25.99)	(0.11)	(100)		
	[-3.36]	[11.06]	[0.91]	[-27.06]	[1.27]	[-8.36]	[-3.65]
2014-15	52959	32651	27216	186	113012	104258	217269
	(46.86)	(28.89)	(24.08)	(0.16)	(100)		
	[4.44]	[11.63]	[-3.23]	[50]	[4.44]	[2.10]	[3.31]
2015-16 RE	51132	35654	28070	186	115041	156012	271053
	(44.45)	(30.99)	(24.40)	(0.16)	(100)		
	[-3.45]	[9.20]	[3.14]	[0]	[1.80]	[49.64]	[24.75]
2016-17 PE	51798	36481	28570	189	117038	166580	283618
	(44.26)	(31.17)	(24.41)	(0.16)	(100)		
	[1.30]	[2.32]	[1.78]	[1.61]	[1.74]	[6.77]	[4.64]
Average Growth	-0.33	7.95	0.84	5.77	2.14	7.74	4.69

Source: Compile from UKDES
Note: 1. Figures in () are percentage share in the total agriculture & allied GDDP
   1. Figures in [ ] are annual growth rates.

Table 3 demonstrates the percentage share of sub-sectors within the secondary and tertiary sectors. Within the secondary sector, manufacturing contributed 69.94 to72.12% share, while construction's share ranged from 16.97 to 20.04%. The average annual growth rate is observed highest in manufacturing (7.85%), followed by electricity gas and water supply (6.59%) and construction (5.44%). Within the tertiary sector, trade, hotels and restaurants constituted the highest share (29.54%) in 2016-17, followed by transport, storage and communication (28.89%) and real estates & professional services (17.15%). The average annual growth rate is observed highest (12.89%) in other services, followed by transport, storage and communication services

(11.35%), financial services (8.51%), public services (8.26%), and trade, hotels and restaurants (8.03%). Overall, the district economy is driven by the growth of non-agriculture sectors as agriculture achieved lower growth.

Table 3: Trends in percentage share of non-agriculture sub-sectors in DGDP at Constant Prices (base 2011-12)

Year	Manufacturing	Electricity, gas, water supply	Construction	Secondary	Transport, storage, communication	Trade, repair, hotels and restaurant	Financial services	Real estate, & professional services	Public administration	Other services	Tertiary
2011-12	69.94	11.02	19.04	100	26.11	31.01	8.77	19.41	4.15	10.55	100
2012-13	72.09	10.95	16.97	100	26.00	31.19	8.69	19.37	2.71	12.03	100
2013-14	69.67	10.29	20.04	100	26.40	31.03	8.72	17.35	3.56	12.95	100
2014-15	69.89	10.66	19.45	100	27.28	29.85	8.70	17.88	3.82	12.46	100
2015-16	71.43	10.55	18.02	100	28.97	29.50	8.73	17.33	3.70	11.77	100
2016-17	72.12	10.72	17.15	100	28.89	29.54	8.54	17.15	3.51	12.38	100
Av. Annual Growth (%)	7.85	6.59	5.44	7.15	11.35	8.03	8.51	6.56	8.26	12.89	9.09

Source: Estimated from statistical handbooks

1.5. THE LIVELIHOOD STATUS

Table 4 shows the livelihood status of the workforce in Dehradun district and Uttarakhand. In 2017, approximately 45% of workers were self-employed, while the corresponding figure for the state is 56.9%. The major difference is observed in the case of regular employment, which was much lower in Uttarakhand (24.2%) than in Dehradun district (38.4%). Casualization of the workforce is higher in Dehradun (20.8%) than the state average (18.9%). Thus, the quality of livelihood is good in Dehradun when compared to the state as a whole.

Sectoral distribution of employment reveals that in terms of workforce, the district economy is dominated by non-farm activities as only 15.2% workforce of the district are engaged in agriculture while the corresponding percent is 39.3% in the state. Contrary to this, secondary and tertiary sectors contributed 30.04% and 54.4% of the total workforce of the district.

The distribution of workers by their skills-set indicates that only 14.4% of workers in the district and 9.6% in the state come under the high skills category. The majority of them fall under the medium and low categories of skills. Poverty and inequality are lower in the district than in the state.

Table 4: Livelihood Status in Dehradun (2017)

Employment Status			Sectoral distribution of employment			Distribution of workers by Skills		
	Dehradun	Uttarakhand		Dehradun	Uttarakhand	Skill	Dehradun	Uttarakhand
Self-employment	45.4	56.9	Primary	15.2	39.3	Low	23.9	24.9
Regular	38.4	24.2	Secondary	30.4	25.4	Medium	61.8	65.5
Casual	20.8	18.9	Tertiary	54.4	35.3	High	14.4	9.6
Total	100	100		100	100	Total	100	100
Poverty Status	7.1	15.6	Inequality (Gini Coeff.)	0.307	0.308			

Source: Uttarakhand Human Development Report

Highlights-1

The primary sector does not play a major role in the district economy as it contributed only 15% to the total workforce and about 10% to the GDDP.

The crop sector recorded negative growth during 2011-2017, while livestock, forestry and Fishery achieved positive GDP growth during the same period.

Mining & Quarrying recorded impressive growth during the period, thus implying environmental sustainability of the ecologically sensitive district of the state.

Within the secondary sector, manufacturing recorded the highest average annual growth (7.85%), followed by electricity, gas and water supply (6.59%).

In the case of the tertiary sector, other services recorded the highest growth (12.89 %), followed by transportation, storage, communication (11.35%).

Manufacturing contributes about 70% of the secondary sector's GDP

2 QUANTITATIVE DATA ANALYSIS

2.1 Agriculture and Allied Activities

2.1.1 Trend in Land Use and Land Cover

To understand the trends in land-use and land-cover, we analyze two types of data--GIS-based and statistical data compiled from the District statistical handbooks of Dehradun. As per the GIS-based data (see Figure 1 and Table 5), between 2010 and 2020, the area under Built-up land as a percentage of the total geographical area has increased from 1.87 in 2010 to 2.35 in 2020. Moreover, the decreasing areas under cropland, forest plantation and waterbodies also indicate degradation in the district's ecosystem services. Cropland area decreased from 19.69% in 2010 to 18.91% in 2020. In 2020, forest plantation was less than 20 percent of the total geographical area of the district. Open forest area marginally increased from 29.81% in 2010 to 31.02% in 2020, and also small increased in the share of dense forest area from 27.54% to 27.56 % during the period. It is significant to note that area under Scrub land has reduced from 2.01% to 1.61% during the period. This indicates that the district administration and community have made some interventions in converting the barren land into productive uses. However, it is difficult to get any conclusive evidence in this regard

Table 5: Land use/ Land cover statistics classes of Dehradun district

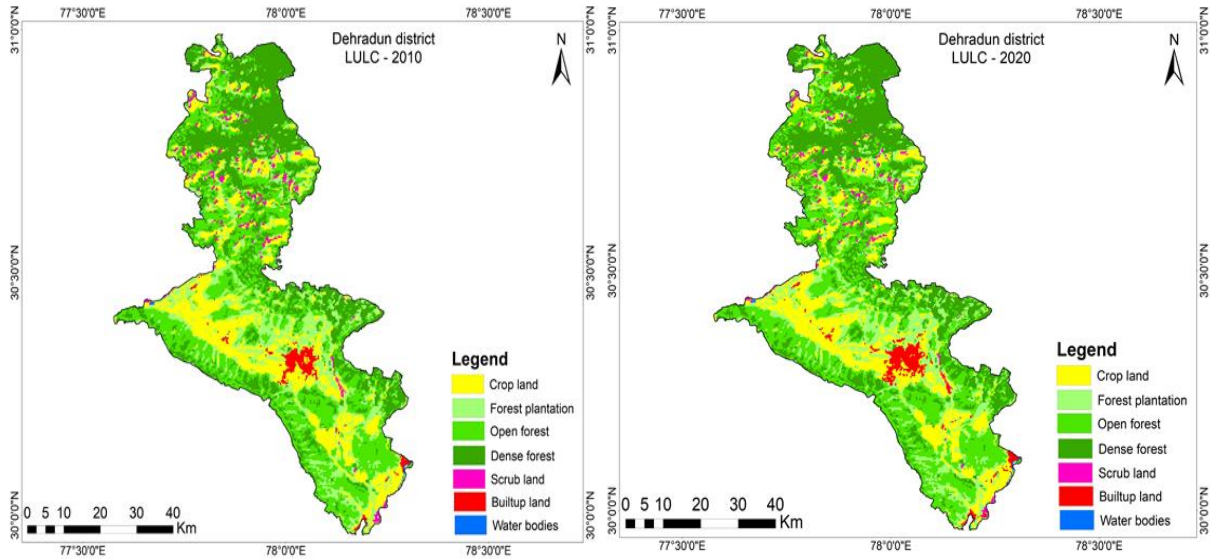| LULC classes	Area(km^2) Year-2010	Area(km^2) Year-2020
Crop land	637.21 (19.69%)	612.03 (18.91%)
Forest plantation	614.44 (18.99%)	597.00 (18.45%)
Open forest	964.60 (29.81%)	1004 (31.02%)
Dense forest	891.40 (27.54%)	892.01 (27.56%)
Scrub land	64.91 (2.01%)	52.2 (1.61%)
Built-up land	60.37 (1.87%)	76.00 (2.35%)
Water bodies	3.32 (0.10%)	3.01 (0.09%)
Total Geographical area	3236.25 (100%)	3236.25 (100%)

Figure. 1. Land use Land cover change in Dehradun district

We notice some discrepancies when the GIS-based data are compared with the data compiled from the district statistical handbooks. The GIS-based map shows 3236.25 square kilometres geographical area of the district, while the handbook shows 3648 sq. km reported area of the district. Forest area constituted 55.46% of the total reported area and it remained constant during the period. The share of barren and uncultivable land has decreased from 1.08% in 2009-10 to 0.55% in 2017-18. Areas under permanent pastures and under trees and gardens also reduced in 2017-18. The net sown area has constantly been declining during the period. It went down from 12.46 in 2009-10 to 10.09 in 2017-18 (Table 6). Overall, the land-use pattern does not evince any visible change during the last eight years, except the gradual increase in area under non-agriculture uses and gradual decline in the net sown area. In 2017-18, cultivable wastes and fallow land constituted 21.10 percent of the total reported area of the district. It implies scope for bringing more area under cultivation and agroforestry.

Table 6: Trends in Land-use Pattern in Dehradun (as % of the total reported area)

Year	Total Reported Area (ha)	Area under forest	Cultivable wasteland	Current Fallow	Other Fallow	Barren and uncultivable land	Land other than agriculture	Pasture Land	Area under trees and gardens	Net Sown Area
1	2	3	4	5	6	7	8	9	10	11
2009-10	364830	55.46	12.60	1.92	2.61	1.08	5.90	3.98	4.00	12.46
2010-11	364830	55.46	12.65	1.12	3.98	1.08	5.92	3.98	3.99	11.83

2011-12	364830	55.46	12.66	0.92	4.31	1.08	5.93	3.98	4.00	11.68
2012-13	364830	55.46	14.65	1.38	3.24	0.68	5.97	2.68	4.10	11.42
2013-14	363196	55.57	14.76	1.53	3.22	0.64	5.99	2.69	4.12	11.47
2014-15	363371	55.54	14.76	1.09	3.22	0.64	6.28	2.69	3.88	11.09
2015-16	363371	55.54	14.90	1.70	3.52	0.67	6.29	2.69	3.84	10.85
2016-17	363371	55.54	14.91	1.71	3.53	0.67	6.30	2.69	3.83	10.82
2017-18	363371	55.54	15.14	2.40	3.56	0.55	6.36	2.51	3.85	10.09

Source: Prepared from District Statistical Handbooks of Dehradun

2.1.2 Trends in Operational Land Holdings

In Dehradun district, the total number of operational holdings has declined from 62920 in 2010-11 to 52882 in 2015-16, a net decrease of 15.95 percent, while in the state, the number has declined from 912650 in 2010-11 to 881305 in 2015-16, a net decline of 3.43%. The majority of land holdings in the district are marginal and small. These categories of holding together constituted 88.55% in 2015-16, while the corresponding percentage in the state was 91.67% (Table 7).

Table 7: Distribution of Operational Holdings by Size-categories of farms (in %)

	Agri, Census	Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10 ha)	Large (10 & above, ha)	Total (Nos.)
Dehradun	2010-11	78.44	12.00	7.07	2.31	0.18	62920.00
	2015-16	75.02	13.53	8.43	2.80	0.22	52882.00 [-15.95]
Uttarakhand	2010-11	73.65	17.24	7.1	1.9	0.12	912650
	2015-16	74.78	16.89	6.59	1.64	0.1	881305 [-3.43]

Source: Compiled from Statistical Handbook 2018-19, UKUES. Figures in [ ] are percentage increase/decrease in 2015-16 over 2010-11.

2.1.3. Trends in Area, Production and Yield of Principal Crops

i. Trends in Cropping Pattern

The agriculture of the district economy is dominated by food grains. Table 8 shows the trend in the area under principal crops during the last 9 years. Rice, wheat, and maize comprise the largest share in the gross cropped area (GCA). The area under these crops marginally declined from 63.85 percent in 2009-10 to 59.79 percent in 2018.19. Maize is high nutritious cereal and is in high demand by consumers. All cereals (rice, wheat, barley, maize, ragi and saava) have a little over 64 percent of the GCA of the district. Pulses consisted of about 6 percent share in the total cropped area. Overall, food grains shared over 70 percent of GCA in 2018-19. The share of oilseeds is a little over two percent of the GCA. In addition to food gains and oilseed, sugarcane and Potato are other important crops. Sugarcane is an annual crop and it comprise about 7 percent of the GCA.

Table 8: Trends in Cropping Pattern (as % GSA) and Cropping Intensity

Crop/Year	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Rice	16.86	17.23	16.80	16.73	16.32	15.56	17.95	17.77	17.50
Wheat	31.40	32.25	29.02	33.06	32.02	31.91	31.20	30.47	30.00
Barley	1.24	1.15	1.17	1.06	0.02	1.06	1.15	0.92	0.78
Maize	15.59	14.68	14.84	14.63	14.52	14.19	12.55	12.73	12.19
Ragi	0.00	0.00	2.72	1.91	2.71	2.01	2.00	1.84	2.11
Saava	0.79	0.92	0.78	1.41	0.76	0.79	0.47	0.35	0.46
Total Cereals	68.61	69.15	66.78	64.04	67.03	65.52	65.32	65.48	64.22
Urad	0.85	0.88	1.34	1.32	0.89	1.07	1.03	1.03	1.34
Masoor	0.65	0.63	0.68	0.62	0.75	0.68	0.62	0.49	0.59
Matar	0.65	0.29	0.18	0.71	0.66	0.56	1.25	0.08	0.50
Arhar	0.33	0.36	0.43	0.68	0.80	0.61	0.62	0.40	0.55
Total Pulses	2.24	2.23	6.54	3.34	3.11	2.97	3.55	5.58	5.83
Total Food Grains	70.86	71.38	73.32	72.14	70.14	68.49	68.86	71.06	70.04
Mustard	0.42	0.54	0.48	1.44	1.54	0.60	0.46	1.53	1.47
Groundnut	0.12	0.20	0.15	0.12	0.09	0.13	0.13	0.08	0.02
Total Oilseeds	0.87	0.97	2.42	1.64	1.77	0.89	0.79	1.80	2.29
Sugarcane	6.88	7.01	7.29	7.21	6.56	7.98	6.89	7.02	7.01
Potato	2.27	1.03	1.05	1.81	1.68	1.53	1.58	1.17	1.33
Net Sown Area	45459	43144	42623	41671	41671	43223	39443	39321	36655
Gross Sown Area (ha)	66239	64976	63435	62307	59533	58983	57134	57323	55351
Cropping Intensity	145.71	150.60	148.83	149.52	142.86	136.46	144.85	145.78	151.01

Source: Estimated from District Statistical Handbooks

ii. Trends in Per Hectare Yield of Principal Crops

The per hectare yield of rice ranged from 19.04 qtls/ha in 2009-10 to 21.05 qtls/ha in 2017-18. Similarly yield of wheat ranges between 21.22 to 23.4 qtls/ha during 2009-10 to 2017-18. A more or less similar pattern is also observed in the case of barley. The table depicts that maize yield has improved in recent years. Average productivity maize has been at par with rice and wheat. It can raise the farmers' income if proper marketing support is provided to the farmers. Dehradun is famous for export-quality aromatic basmati rice, which provide premium prices to the farmers.

Among pulses, per hectare yield is higher in Arhar than other crops. Arhar constituted 0.50 percent of GCA and also has the potential for raising farmers' income. Among oilseeds, groundnut is important crop. Its yield ranges between 8.54 to 14.17 qtls/ha. Since per quintal prices of groundnut are higher than that of rice and wheat, its cultivation can provide a better return to the

farmers. Sugarcane is another high-value crop in the district. Its yield ranges between 587 to 675 qtsl/ha. Thus, sugarcane, urad, groundnut, mustard, and Potato are promising crops.

Table 9: Trends in Per hectare productivity of Main Crops (in Quintals)

Crop/ Year	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Rice	19.04	19.5	21.06	20.47	21.3	19.25	21.57	20.36	21.05
Wheat	21.22	23.24	24.53	22.68	24.75	15.63	18.82	24.31	23.4
Barley	17.05	19.99	18.99	22.69	22.69	11.33	14.56	15.75	15.53
Maize	15.91	18.37	14.7	11.92	11.92	24.14	21.72	22.07	27.47
Ragi	13.9	16.78	15.71	13.92	15.94	18.02	14.23	15.84	16.6
Saava	10.75	14.24	13.92	14.65	14.06	14.79	14.02	13.27	13.43
Total Cereals	18.99	20.83	21.35	19.78	19.78	20.9	19.68	22.04	22.86
Urad	6.71	6.47	6.62	6.62	6.52	10.06	9.52	7.88	10.67
Masoor	6	6.98	6.6	7.33	9.08	8.43	7.24	8.48	6.54
Matar	7.2	7.02	6.79	6.91	6.8	6.89	6.76	6.96	6.8
Arhar	9.41	8.85	8.86	9.03	9.46	7.84	7.32	8.34	8.82
Total Pulses	7.02	7.08	7.06	7.85	7.33	9.46	9.159	9.77	10.27
Total Food Grains	18.61	20.4	20.79	18.65	19.85	17.41	18.68	21.03	21.76
Mustard	9.21	5.98	6.35	8.87	7.9	6.64	7.51	6.21	9.73
Groundnut	8.54	10.78	10.52	11.25	11.3	10.94	10.96	12.98	14.17
Total Oil Seeds	6.35	6.2	9.16	7.48	7.96	5.9	6.154	6.18	7.98
Sugarcane	587	585.71	600	609	652	658	647.999	648	675
Potato	133	221	209	203	132	104	111	120	138
Source: District Statistical Handbook									

iii. Trends in Production of Principal Crops

Table 10 depicts that among the individual cereal crops, wheat consisted of the highest production (39432 tons), followed by rice (19562 tons) and Maize (18535 tons). These three crops had 59.69 percent share in the total cereal production in 2017-18. Urad had the highest share (17%) in the total pulses production among pulses. In the case of oilseed production, mustard is the main crop which comprised about 93.8 percent share in the total oilseed production in 2017-18. Sugarcane is another important crop in the district. Its production was highest (19943 tons in 2010-11 and lowest in 2016-17 (8053 tons).

Table 10: Trends in Production of Principal Crops for Dehradun district (in metric tonnes)

Crop/ Year	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Rice	21268	21827	22441	21364	21537	17672	22126	20738	19562
Wheat	44126	48703	45152	46719	47191	29415	33559	42467	39432
Barley	1403	1491	1413	1335	1739	706	957	835	896
Maize	16427	17522	16084	13399	10442	20199	15568	16100	18535
Ragi	2525	3191	2710	1652	2568	2139	1627	1668	1941

Saava	559	847	692	1283	634	692	373	268	341
Total Cereal	86308	93581	88492	85752	84289	71370	74975	82787	81345
Urad	378	372	561	541	346	634	561	466	
Masoor	259	286	283	285	403	339	255	239	212
Matar	177	134	76	284	266	226	482	32	187
Arhar	208	208	241	382	451	280	260	191	270
Total Pulses	1042	1024	1199	3289	1833	3733	3669	3309	3516
Total Food Grains	87350	94605	89691	87248	87726	75103	78653	86096	84861
Mustard	255	211	224	796	723	233	196	546	790
Groundnut	70	138	138	102	61	81	80	61	17
Total Oil Seeds	364	391	529	915	812	550	560	941	842
Sugarcane	267437	266850	277440	433170	254607	309721	255247	260690	261968
Potato	19943	14721	13849	22876	13172	9431	9970	8053	10146
Source: District Statistical Handbook									

We have calculated crop-wise average, standard deviation (SD) and coefficient of variation (COV) in the area, production and yield to understand variability across years. In the case of area under different crops, the lowest variability is observed in rice (6.60%), closely followed by wheat (8.22%), total cereal (9.12%) and maize (14.35%). It is observed highest in matar (61.79%), ragi (60.93%) and mustard (52.77%). Overall, the area under oilseeds and pulses has more variability than the area under cereals (Table11).

Table 11: Variability in Area, Production and Yield of Principal Crops (2009-10 to 2017-18)

Crop/Year		Area			Production			Yield	
	Average	SD	COV	Average	SD	COV	Average	SD	COV
Rice	10273	678	6.60	20948	1488	7.10	20.40	0.88	4.34
Wheat	18949	1558	8.22	41863	6566	15.68	22.07	2.88	13.04
Barley	580	244	41.99	1197	355	29.66	17.62	3.59	20.37
Maize	8514	1222	14.35	16031	2837	17.70	18.69	5.19	27.79
Ragi	1008	614	60.93	2225	555	24.93	15.66	1.33	8.51
Saava	459	207	45.13	632	310	48.98	13.68	1.14	8.31
Total Cereal	40212	3668	9.12	83211	6749	8.11	20.69	1.18	5.72
Urad	655	119	18.13	482	107	22.26	7.90	1.62	20.51
Masoor	385	55	14.22	285	57	19.98	7.41	0.98	13.19
Matar	325	201	61.79	207	132	63.83	6.90	0.13	1.93
Arhar	319	91	28.36	277	87	31.25	8.66	0.67	7.70
Total Pulses	2357	939	39.85	2513	1206	48.00	8.33	1.24	14.93
Total Food Grains	42863	3308	7.72	85704	5780	6.74	19.69	1.35	6.83
Mustard	561	302	53.77	442	268	60.78	7.60	1.33	17.48
Groundnut	71	32	45.66	83	39	46.44	11.27	1.48	13.16
Total Oilseeds	899	374	41.57	656	223	34.06	7.04	1.08	15.29
Sugarcane	4298	350	8.14	287459	57158	19.88	629.19	31.77	5.05
Potato	908	278	30.56	13573	5013	36.93	152.20	42.89	28.18
Source: District Statistical Handbooks									

Overall, variability in the production of different crops is higher than in the area under these crops. Variability in production depends on the variability in the area under the crop and variability in the yield. In some crops, variability in yield is higher than that in the area, while in some crops, it is lower than that in the area. Several factors, such as market prices and rainfall patterns, affect the variability in agricultural production.

2.1.4 Consumption of Chemical Fertilizers

Table 11 shows that nitrogen use ranges between 20.95 kgs/ha to 93.77 kgs/ha of GCA. Phosphorous use ranges between 5.65 kgs/ha to 39.98 kg/ha of GCA. The use of potassium ranges between 0.47 kgs/ha to 6.0 kgs/ha of GCA. Total fertilizers use ranges from 28.23 to 131.90 kgs/ha of GCA (Table 12).

Table 12: Trends in Use of Chemical Fertilizers in Agriculture (Kgs/per ha GSA)

Trends in Use of Chemical Fertilizers in Agriculture (Kgs/per ha GSA)									
Fertilizer/Year	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Nitrogen	20.95	43.06	21.66	37.36	40.88	24.85	71.69	93.77	58.63
Phosphorous	5.65	13.30	7.58	9.57	11.91	8.41	39.98	36.62	16.73
Potasium	1.63	6.00	0.66	0.67	1.41	0.47	1.73	1.52	2.51
Total	28.23	62.36	29.90	47.60	54.21	33.74	113.40	131.90	77.87

Source: District Statistical Handbooks

2.1.5 Irrigation Structure and Status

Being the valley region, the possibility of groundwater extraction for irrigation is higher as compared to the hilly region. Table 13 shows that there is good progress in the addition of length of canals during the first four years and then progress decreased during last two years. The length ranges between 1004 to 2410 kilometres. The number of water tanks has increased from 1902 in 2010-11 to 2492 in 2018-19, a net increase of 590 tanks. The number of Govt. tube well has increased from 136 in 2010-11 to 203 in 2018-19, a net increase of 67 tube wells. The number of bore-well pumps has decreased from 529 in 2010-11 to 203 in 2018-19, a net decrease of 326 pumps. Length of *Gool* has increased from 2997 Kms in 2010-11 to 4307 Kms, a net increase of 1310 kms during the period. The number of high-drums was 168 during 2010- 2017 and zero during the last two years. There has not been any increase since 2012-13 (Table 13).

The net cultivated area under irrigation ranges from 48.68 to 65.11 percent. There is much progress in bringing more area under irrigation. Gross irrigated areas as a percentage of GCA is also high (47.41-50.52%)

Table 13: Types of Irrigation Systems and percentage of the net and gross Irrigated Area

Name/Year	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Length of Canal (KM)	1004	1016	1039.06	1757	1794	2410	1041.01	1045	1045

No. Of Govt. Tube-wells	136	156	163	182	182	187	199	200	203
No. Of Ground level Pump-sets	103	103	112	121	121	187	199	200	203
No. Of bore-well Pump-sets	529	529	163	182	182	187	199	200	203
No. Of private Tube wells	266	700	700	700	700	700	737	788	836
Bandhi (Hectare.)	1343	1343	1343	1343	1343	0	0	0	0
No. Of Tanks	1902	1929	1944	2017	2169	2256	2336	2397	2492
Gool in KM	2997	3208	3407	3538	4079	4170	4231	4257	4307
No. Of High drums	168	168	168	168	168	168	168	0	0
% Of NIA	49.65	50.75	65.12	50.37	50.18	48.68	53.17	49.03	-
% Of GIA	47.99	49.81	50.77	47.41	51.16	50.32	51.35	50.52	-
Source: Compiled from District Statistical Handbook									

2.1.6 Out-Migration and Agriculture

Agriculture is a key growth driver of the district economy. It can be integrated with the promotion of high-value crops (HVCs) such as vegetables, fruits, mushrooms, flowers and medicinal crops. If HVCs are promoted, hotels and dhabas, largely driven by tourists, may get fresh vegetables and fruits and other food items from the local farmers. It may be relevant to mention that the floating population in the district may be quite high. This population needs different kinds of agro-products that the local market can supply. Diversifying agriculture and allied activities toward low volume and high-value agro-products would work as a multiplier in the local economy, generating additional employment avenues in the non-farm activities. The possibility of evolving an economically viable model of convergence of MGNREGA activities with the concerned line departments would be explored to promote HVCs and improve people's livelihood. Uttarakhand Human Development Report (2018) shows that about 92.7% of the total first-time migrant in Dehradun migrated alone and about 7.3 percent with family members (Table 14).

Table 14: Process of Migration (First Migration) in Dehradun (in %), 2017

District	Migrated alone	Migrated with family members	Migrated with members of community/ Village	With acquaintances/ friends (other than community village)	Middle men/ contractor	Any other	Total
1	2	3	4	5	6	7	8
Dehradun	92.7	7.3	0	0	0	0	100
Uttarakhand	72.1	18	6.6	2.6	0.1	0.6	100

Source: Uttarakhand Human Development Report

2.1.7 Status of Organic Farming

To promote sustainable agricultural practices and improve the farmers' livelihood, the Government of India launched PKVY and Namami Gange schemes. Under these schemes, farmers are incentivised to form groups to do organic farming and sell their products with PGS certification. The state set up the Uttarakhand Organic Commodity Board (UOCB) in 2003 as a nodal agency to facilitate organic clusters and provide technical support to promote organic farming. The area

under organic farming in the state was about 18% of the NSA in 2019 (https://www.downtoearth.org.in/blog/agriculture/how-indian-states-are-promoting-organic-natural-farming-73306). Uttarakhand is the first state of India which enacted Organic Farming Act in 2020 and declared 7 of its blocks fully organic. Chakrata Block of Dehradun district is one of such blocks in the state. The foothill districts of the state, including Dehradun have the natural advantage of organic farming as per hectare use of chemical fertilizers is quite high.

Table 15 shows the status of organic farming PGS groups constituted under PKVY and Namami Gange schemes. As on June 30, 2021, there are 231 organic farming groups with 9942 registered farmers in the district. All these groups were constituted under the PKVY. The median number of farmers group is 48 under PKVY. High value of SD in the case of organic farmers of PKVY groups indicates that the number of farmers per group has higher variability. Block-wise data show that under PKVY, the highest number of groups and number of farmers are in Chakrata (113 and 4679), followed by Kalsi (66 and 2792) and Raipur (18 and 819) and lowest in Doiwala (7 and 403).

Table 15: Status of Organic Farming PGS Groups under PKVY and Namami Gange Schemes in Dehradun (as on June 30, 2021)

S.No.	Block	Scheme	No. of Groups	No. of Farmers in the Groups			
				Total	Average	Median	SD
1	Chakrata	PKVY	113	4679	41.41	50.00	12.25
		Namami Gange	0	0	0.00	0.00	0.00
2	Doiwala	PKVY	7	403	57.57	55.00	7.35
		Namami Gange	0	0	0.00	0.00	0.00
3	Kalsi	PKVY	66	2792	42.30	45.00	10.74
		Namami Gange	0	0	0.00	0.00	0.00
4	Raipur	PKVY	18	819	45.50	49.00	6.92
		Namami Gange	0	0	0.00	0.00	0.00
5	Sahaspur	PKVY	11	550	50.00	50.00	0.00
		Namami Gange	0	0	0.00	0.00	0.00
6	Vikasagar	PKVY	16	699	43.69	50.00	13.69
		Namami Gange	0	0	0.00	0.00	0.00
7	District	PKVY	231	9942	43.26	48	11.53
		Namami Gange	0	0	0.00	0.00	0.00

Source: Compiled from https://pgsindia-ncof.gov.in/

Since economies of scale in both production and marketing matter in organic farming, possibilities of some institutional framework may be in the forms of SHGs/ farm cooperative/PFOs/contract farming, etc. be designed. Organic farming could be an economically viable option in the district if the government builds strong marketing networks linking farmers, processors, and distributors with easy certification processes and minimizing farmers' risk by protecting their farm income through payments of ecosystem services. Organic farming Act is a good initiative and its provisions should be effectively enforced. A long-term system of incentive as well as regulation may be evolved to retain the existing farmers and motivate others to move towards the sustainable farming system in the district.

2.2 Trends in Livestock

Livestock has an important place in the rural economy. Table 16 shows that the total number of cattle (cows and bulls) has increased from 133954 in 1998 to 194043 in 2019. The increase was mainly due to a substantial rise in the exotic female cattle population, which went up from 9800 in 1998 to 99172 in 2019. However, the number of indigenous cows declined from 58888 to 57482 between 1998 and 2019. The number of indigenous male cattle has drastically declined, probability due to lack of demand for animal power. Comparing 1998 and 2019 data, we observe that total numbers of buffaloes have increased from 48152 in 1998 to 52185 in 2019, mainly because of female buffaloes as male buffaloes drastically declined in 2019 over the preceding census. Declining make cattle and male buffaloes population implies that their demand in agriculture is reducing due to farm mechanization and rising demand for meat. The number of sheep shows ups and downs during the entire period. It was highest in 2003 (22176) and then declined to 6222 in 2019. However, the number of goats has increased during the period. The number of pigs in the district also declined in 2019 over the preceding census. Between 1998 and 2012, the number of poultries has increased.

Table 16 Trends in Livestock Population (in numbers) in Dehradun during 1998-2019

	Category	1998	2003	2007	2012	2019
Indigenous Cattle	Total Male	60665	72258	63320	43542	30271
	Total Female	58888	75868	72864	66714	57482
	Total	119553	148126	136184	110256	87753
Exotic Cattle	Total Male	4601	10645	12431	9409	7118
	Total Female	9800	29146	34368	61242	99172
	Total	14401	39791	46799	70651	106290
Total Cattle		133954	187917	182983	180907	194043
Buffalo	Total Male	11056	15049	13913	6260	3831
	Total Female	37096	56636	51538	46585	48354
	Total	48152	71685	65451	52845	52185
Sheep	Total Indigenous Sheep	12700	20837	11476	10622	6040
	Total Exotic Sheep	194	1339	4009	1099	182
	Total Sheep	12894	22176	15485	11721	6222
Goat	Total Male	-	-	-	43274	58095
	Total Female	-	-	-	93455	100219
	Total	87543	116672	126852	136729	158314
Pig	Total Indigenous Pig	5778	6457	3664	2844	923
	Total Exotic Pig	561	816	439	1608	769
	Total Pig	6339	7273	4103	4452	1692
Total Livestock		295379	4499003	443879	390846	
Total Poultry		259264	359300	416597	400940	
Source: Compiled from District Statistical Handbook and http://dahd.gov.in/						

Table 17 shows animal hospitals and development centres in the district. The number of cattle hospitals and cattle development centres remained almost identical over the period. The

number of man-made production centres increased from 65 in 2010-11 to 70 in 2018-19. There has not been any change in the number of cattle reproduction centre and Sheep development centres. Poultry units, Sheep and Pig Development Centres and cattle reproduction farms remained the same over the period.

Table 17 Year-wise number of Cattle Hospitals and Development Centres

Category	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Cattle Hospital	31	32	33	33	29	29	29	29	30
Cattle Development Centre	46	46	49	49	50	50	50	50	52
Man-Made Reproduction Centre	65	70	29	68	68	68	68	68	70
Cattle Reproduction Farm	1	1	1	1	1	1	1	1	1
Sheep Development Centre	2	2	2	2	2	2	2	2	2
Pig Development Centre	1	1	1	1	1	1	1	1	1
Poultry Units	2	1	-	1	1	1	1	1	1
Source: Compiled from District Statistical Handbook									

2.3 Trends in Horticulture Crops

The district has a high potential for horticulture development. With policy support and a well-designed action plan, this sector can be the growth driver for the agriculture sector. Table 18 shows the percentage share of major fruit crops in the total cropped under fruits. In 2018-19, Mango constituted the highest share (23.33%), followed by Apple (18.16%), and Litchi (14.30%). The total area under fruits shows low variation across years.

Table 18: Trends in percentage share of principal fruit crops in total area under fruits

Crop/Year	2010-11	2011-12	2014-15	2015-16	2017-18	2018-19
Apple	17.98	27.49	18.17	18.17	18.29	18.16
Pear	5.16	7.91	5.23	5.23	5.23	5.21
Peach	1.82	2.80	1.85	1.86	1.87	1.88
Plum	3.72	5.54	3.66	3.67	3.67	3.65
Apricot	4.36	6.48	4.29	4.29	4.29	4.28
Walnut	10.39	15.43	10.20	10.19	10.22	10.16
Lemon	9.58	14.98	9.90	9.90	9.92	9.86
Mango	22.99	35.48	23.44	23.42	23.48	23.33
Litchi	14.41	21.84	14.43	14.43	14.43	14.30
Other Fruits	8.38	13.36	8.84	8.84	8.97	9.17
Total of Fruits (ha)	25642 (100)	17429 (100)	26390 (100)	26408 (100)	26986 (100)	27273 (100)
Source: Compiled from District Statistical Handbooks						

Production of Mango ranges from 10284 tons in 2018-19 to 6373 tons in 2010-11. Its production has declined in recent years. Production of almost all fruits declined in 2018-19 when compared to 2010-11 except in litchi fruit (from 6599 tons in 2018-19 to 5735 tons in 2010-11) and Walnut fruits (from 4095 tons in 2018-19 to 2003 tons in 2010-11). Total production of fruits has declined from 38962 tons in 2011-12 to 43091 tons in 2018-19 (Table 19).

Table 19. Production under Horticulture Crops in Dehradun District (in Metric Tonnes)

Crop/Year	2010-11	2011-12	2014-15	2015-16	2016-17	2017-18	2018-19
Apple	8226	12831	12386	7342	16085.2	7797	7777.79
Pear	2505	5198	1380	2003	966.46	2148	2160
Peach	1860	2037	2001	744	250.66	794	814.93
Plum	1682	2984	2943	1395	49.28	1475	1481.6
Apricot	1456	3047	1131	1610	296.1	1749	1772.86
Walnut	2003	3015	3016	3822	287.06	4083	4095
Lemon	4880	7705	7465	3766	138.84	3934	3948
Mango	6373	18443	6185	9774	23347.5	10267	10284
Litchi	5735	8642	8409	6287	1937.32	6579	6599
Other Fruits	4242	4816	4539	3316	1387.1	3564	3075
Total of above Fruits	38765	43388.65	66775.3	40059	44745.48	42390	42008.18
Source: Compiled District Statistical Hand Books							

Table 20 shows that per hectare yield of almost all crops has low declined during 2011-12 and 2018-19. The productivity of Mango accelerated from 1.08 tons in 2010-11 to 1.62 tons in 2018-19. The yields of Pear, Apricot and plum evince ups and downs during the period. Per hectare yield of all fruits (peach, plum, apricot, walnut, lemon and Mango) declined during 2010-11 and 2018-19. The above analysis indicates the dismal scenario of fruits production in the district. The reasons for this dismal condition of horticulture in the district need to be explored.

Table 20. Yield under Horticulture Crops year-wise data for Dehradun District (in Metric Tonnes per hectare)

Crop/Year	2010-11	2011-12	2014-15	2015-16	2017-18	2018-19
Apple	1.78	2.68	2.58	1.53	1.58	1.57
Pear	1.89	3.77	1.00	1.45	1.52	1.52
Peach	3.98	4.17	4.09	1.52	1.57	1.59
Plum	1.76	3.09	3.04	1.44	1.49	1.49
Apricot	1.30	2.70	1.00	1.42	1.51	1.52
Walnut	0.75	1.12	1.12	1.42	1.48	1.48
Lemon	1.99	2.95	2.86	1.44	1.47	1.47
Mango	1.08	2.98	1.00	1.58	1.62	1.62
Litchi	1.55	2.27	2.21	1.65	1.69	1.69
Other Fruits	1.97	2.07	1.95	1.42	1.47	1.23
Total of above Fruits	1.51	2.49	2.53	1.52	1.57	1.54
Potato	8.42	10.85	65.67	5.82	5.80	5.85
Vegetables	10.04	10.62	10.50	7.32	7.29	7.15
Total fruits	1.54	2.61	2.53	1.52	1.57	1.58
Source: Compiled from District Statistical Handbook						

2.4 Trends in Area, Production and Yield of Vegetable Crops

Table 21 shows the trends in the area, production and per hectare yield of total vegetable crops. It is evident from the data shown in the table that the area, production and yield of vegetables in the district have declined during 2010-11 and 2018-19. The per hectare yield has gone down from

11.94 tons/ha in 2012-13 to 7.15 tons/ha in 2018-19. Similarly, total production steeply declined from 102270 tons in 2011-12 to 73023 tons in 2018-19, a net decline of 28%. The decline is driven largely by the reduction in yield as the area declined by 27%. The area under Potato has increased from 2309 ha in 2010-11 to 2678 ha in 2018-19, but the production went down from 19443 tons in 2010 -11 to 15672 tons in 2018 -19. The yield of Potato also declined from 8.42 tons/ha in 2010-11 to 5.85 tons/ha in 2018-19.

Table 21: Area, Production and Yield of Vegetables (area in ha, and production and yield in tons)

Crop/Year		2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Total Vegetables	Area	8791	9630	2711.21	3594.35	9654	9669	3728.88	10013.82	10215
	Production	88295	102270	32363.28	39856.16	101409	70755	36979.85	72953	73023
	Yield	10.04	10.62	11.94	11.09	10.50	7.32	9.92	7.29	7.15
Potato	Area	2309	2546	450.66	419.39	419	2552	464	2655	2678
	Production	19443	27629	3809.73	4841.12	27515	14853	5359	15402	15672
	Yield	8.42	10.85	8.45	11.54	65.67	5.82	11.55	5.80	5.85
Source: Compiled from District Statistical Handbook										

Agriculture and allied sectors can improve rural livelihood through diversification into areas such as horticulture, aromatic and medicinal plants, animal husbandry, including dairy, fisheries, sericulture, beekeeping, mushroom production, etc. Fruits, vegetables, potatoes, mushrooms, spices, medicinal plants, and flowers can provide remunerative returns to farmers as their demand is income-elastic

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Highlights-3

Livestock has an important place in the rural economy. Its contribution to agriculture has been gradually rising. Livestock census data indicate that the total number of cows and female buffaloes has increased from 1998 to 2019.

The district has a high potential for horticulture development. With policy support and a well-designed action plan, this sector can be the growth driver for the agriculture sector.

In 2018-19, the area under mango crop constituted the highest share (23.33%), followed apple (18.16%), and litchi (14.30%). The total area under fruits shows variation across years.

Production of almost all fruits declined in 2018-19 when compared to 2010-11 except in Litchi fruit (from 6599 tons in 2018-19 to 5735 tons in 2010-11) and Walnut fruits (from 4095

2.3 Forestry

Total geographic area of the district is 3088 Km^2. As per 2019 Forest survey of India assessment, district has total 52.09% of forest area of total geographic area, which fulfils the target of 33%. The total forest cover in the district is 1608.69 Km^2. From this total area 659.77 Km^2 comes under very dense forest (VDF) category, 601.56 Km^2 is moderately dense forest (MDF), and 347.36 Km^2 area is open forest (OF). Dehradun district forest area has increased by 3.69% since the last assessment of 2017 survey. (FIS, 2019).
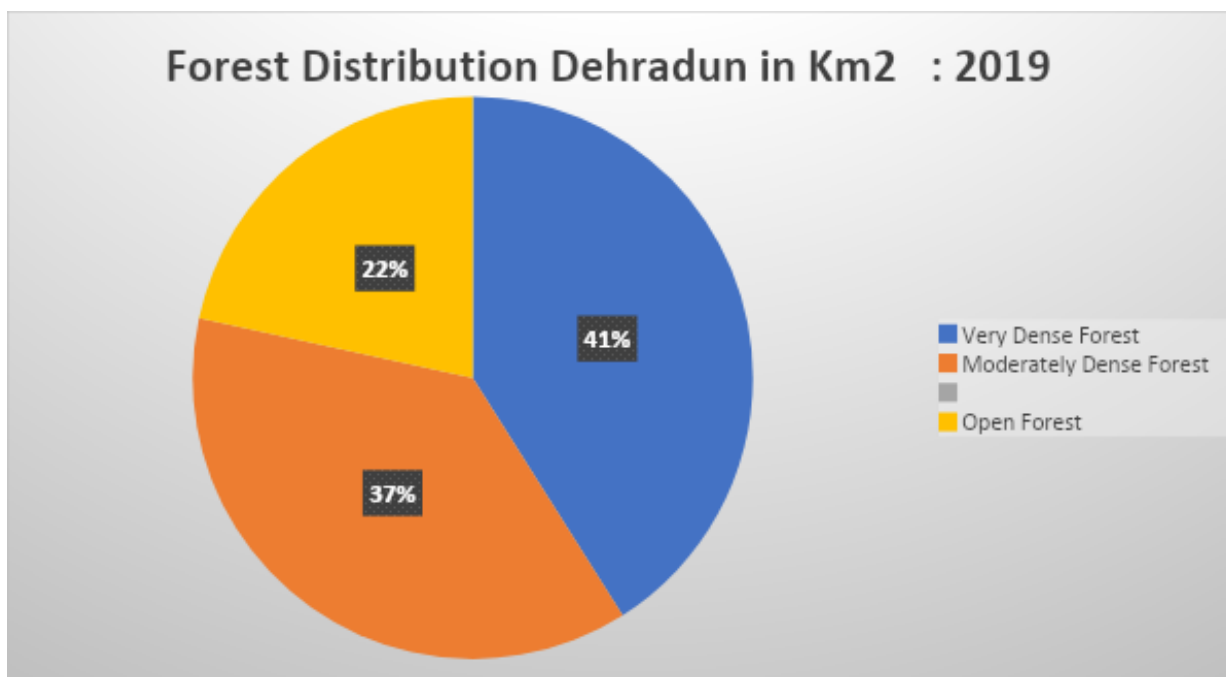
Forest Survey of India 2019 Uttarakhand vs Dehradun District Comparative Assessment						
Area	Geographical Area	Very Dense Forest	Moderately Dense Forest	Open Forest	Total	%of Geographical Area
Dehradun	3088	659.77	601.56	347.36	1608.69	52.09%
Uttarakhand	53483	5046.76	12805.24	6451.04	24303.04	45.44%

Green India mission is one of the missions that come under the umbrella of the National Action Plan on Climate Change (NAPCC). Under this green india mission, a total of **5515 ha**. plantation has been carried out from the year **2018-19 to December 2021**. In addition, Alternate Energy devices has been made available to **5923** number of beneficiaries under this mission. All these activities are carried out with public participation. (Uttarakhand forest website)

2.3.1. Biodiversity:

The district's biodiversity data includes crop production, livestock population, bird species, and forest cover. Assan barrage bird sanctuary is home to 53 different bird species, 19 of which migrate from Eurasia during the winter months. Umbrella project biodiversity of Uttarakhand reports the biodiversity data of the Dehradun district. As per the data 4,856 flora and fauna has been observed till now. A total of 1486 species are present in the district in which 42.08% are insect, 30.48% plant species, 4.32% fungal species, 1.69% mammal species, 15.04% birds, and 1.2% reptiles.

Table 1 Bird species recorded in the district.

Number of species	673
Number of rare/accidental species	7
https://avibase.bsc-eoc.org/checklist.jsp?region=INwhukdd	

Forest cover (in sq. km.)

Geographical area	Very dense forest	Mid dense forest	Open forest	Total	% of Geographical area `	Change with respect to 2017 assessment	Scrub
3088	659.77	601.56	347.36	1608.69	52.09	3.69	86.28
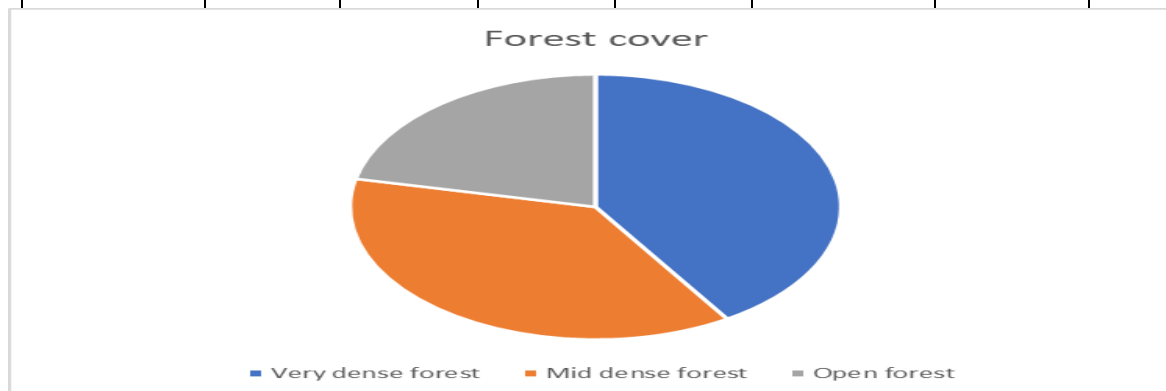
2.4 Tourism

2.5 Wetlands

The district is not comprised of a large number of wetlands. The district consists of barrage like the Asan Barrage (54.04 Ha), some of the large size lakes present in the district. Table 1 represents the number of wetlands and their area representation in the district. Around 32 wetlands sized greater than 2.25 Ha and 104 less than 2.25 Ha areas. The region consists of small wetlands, generally less than 10 Ha in area.

Table 1: Wetland Data of Dehradun District

Wetland Types	Total Number of												Aquatic Vegetation
	Wetlands:			Area (ha)									
Natural Wetlands	NRCD	NWIA	Diff.	<2.25	<5	<10	<20	<50	<200	<500	<1000	>1000	
Lake/ponds	0	0	0	0	0	0	0	0	0	0	0	0	0
Ox-bow lakes/cut off meanders	0	0	0	0	0	0	0	0	0	0	0	0	0
High altitude Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Riverine Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Waterlogged	0	0	0	0	0	0	0	0	0	0	0	0	0
River/Stream	0	27	27	0	0	0	0	0	0	0	0	0	0
Man-made Wetlands	NRCD	NWIA	Diff.	<2.25	<5	<10	<20	<50	<200	<500	<1000	>1000	AV
Reservoirs/Barrages	1	2	1	0	0	0	0	0	1	0	0	0	1
Tanks/ponds	3	3	0	0	1	2	0	0	0	0	0	0	1
Waterlogged	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt pans	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (136)	4	32	28	104	1	2	0	0	1	0	0	0	2

Source: (National River Conservation Directorate, 2008), (Space Application Centre-ISRO, 2007)

- The district comprises 136 wetlands; most are tanks/ponds and rivers/streams.
- The wetland size is small-sized in general.
- The number of natural wetlands is more than man-made.
- Fewer wetlands have aquatic vegetation.

2.6 Energy

2.6.1. Solar Energy

In Uttarakhand, operation and execution of various schemes based on non-conventional energy resources is handled by Uttarakhand Renewable Energy Development Agency (UREDA) through local panchayats, volunteer organizations and district administrations.

The graph represented by Fig. 1 represents the percentage of households using different sources for lightning. This data is according to the 2011 census. It is very clear that solar energy is used by even less than 1% households. Majority of people use electricity for lightning purpose.
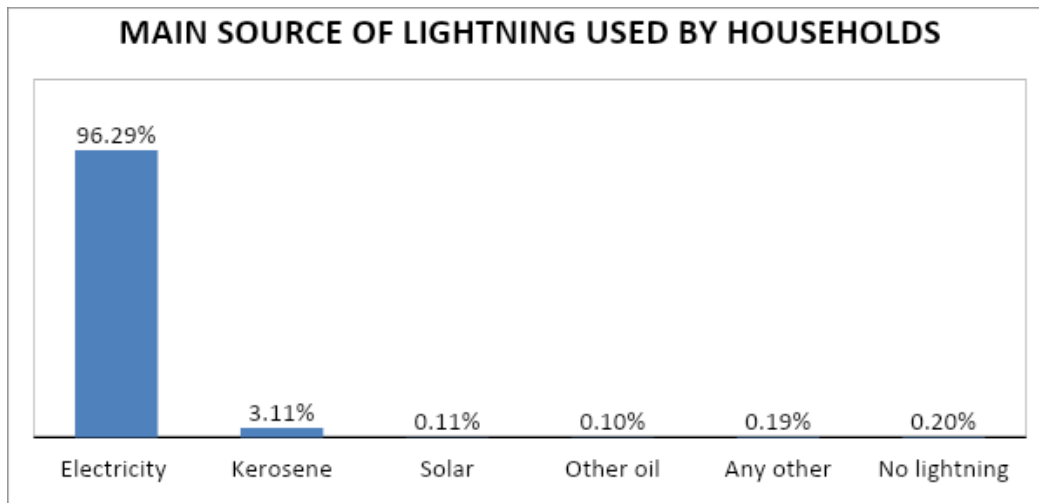

Fig. 1

The district website gives an account of the installed units mainly under the Solar Thermal Scheme. Under the solar thermal program, the district provides various options of utilizing the thermal energy of sun which are- Solar water heating systems, Solar cooking systems, Solar cooking systems and Parabolic Concentrator Solar Water Heating Systems are provided.

In Dehradun, Girls Hostel at Kalsi and Girls Hostel at Tyuni, were installed with Solar water heating systems of 2000 LPD each in 2019-2020.

Also special Residential Hostel at Rajpur Road and Special Residential Hostel at Nabha House (Rishikesh), Solar water heating systems were installed of 2000 LPD and 1000 LPD respectively in 2019-2020.

435 Solar Dish cookers under the Mid Day Meal and Market Mode programme in 2015-16 were installed in the district.

CST is a device which can concentrate solar radiation using mirrors to produce temperatures in the range of 100 to 450˚C or more. These are very useful in medium and high temperatures required for various applications. In 2013-2014 CST systems were installed at Unique Hotel and Restaurant Pvt. Ltd., 97 Rajpur Road, Dehradun for water heating of 80 sq. km. capacity and Swami Ramtirth Mission, Rajpur, for cooking of 16 sqm. capacity.

A 400 kW Solar Power Plant has been installed at village Dunga, post Bidholi. The project has cost 187.35 lakh and has given employment to 2 persons.

2.6.2.Biomass Energy

In Uttarakhand, operation and execution of various schemes based on non-conventional energy resources is handled by Uttarakhand Renewable Energy Development Agency (UREDA) through local panchayats, volunteer organizations and district administrations.

Majority of population in Dehradun is mainly dependent on agriculture as their primary occupation. Rice, wheat, sugarcane maize, etc. are some of the major crops and enterprises engaged in agriculture.

The net sown area of the district is 52667 ha with the cropping intensity of 148%. The district has a 211691 ha of forest land. 13889 ha of area is under agricultural fallow and 2076 under usar and agricultural waste land.

CROPS	PRODUCTIVITY (kg/ha)
Wheat	2376.1
Rice	1968.9
Barley	1957.0
Barnyard millet	1594.6
Finger millet	1294.9
Sugarcane	58700
Maize	1833.9

Table 1

Table.1 gives an account of productivity of some of the major crops in the district. The productivity of the crops appears to be good consequently a good amount of crop residue would be produced.
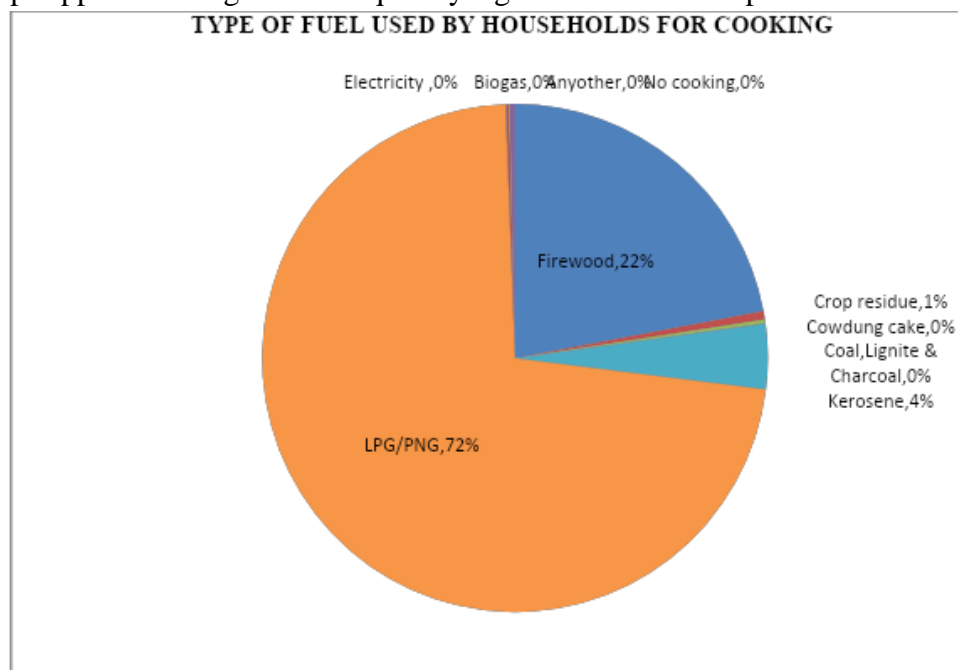
Fig. 1

Fig. 1 depicts the data taken from the 2011 census about the percentage of households using the type of fuel for cooking. It is clear that majority of households use LPG for cooking purpose. Only 22% use firewood, 4% kerosene and 1% crop residue. This is a good indication that people in the

district are probably aware of the harmful effects of burning firewood, crop residue etc. and are able to afford LPG/PNG.

2.6.3.Biogas Energy

Eight hundred twenty nine family sized biogas plants has been installed in the district between year 2009 to 2019. Five biogas power generation plant of capacity 60, 25, 35, 25, 60 m^3 has been installed in the district. Biogas potential from animal and agricultural waste calculated approximately as sixty lakh m^3/year and four crore m^3/year respectively.

2.6.4.Hydropower Energy

Dehradun is situated in the Doon Valley, in the Himalayan foothills, between the Song river, a tributary of the Ganga, on the east and the Asan river, a tributary of the Yamuna, on the west.

Name of project	Installed capacity (MW)	Stream/river	Developer	Status
Chibro	240	Tons	UJVNL	In operation
Dhakrani	34	Yamuna	UJVNL	In operation
Dhalipur	51	Yamuna	UJVNL	In operation
Galogi	3	Bhattafall	UJVNL	In operation
Khodri	120	Tons	UJVNL	In operation
Kishau	660	Tons	THDC	Under construction
Kulhal	30	Yamuna	UJVNL	In operation
Lakhwar vyasi	420	Yamuna	NHPC	Under construction
Tuni plasu	42	Tons	UJVNL	Under construction
https://www.iitr.ac.in/wfw/pdf/Hydropower_stations_in_operation_and_under_construction_in_uttarakhand.pdf				

3 QUALITATIVE DATA ANALYSIS

3.1 AGRICULTURE, ALLIED ACTIVITIES,

SWOT Analysis for Organic Farming

Based on the data analysis related to the cropping pattern, production, yields, and use of chemical fertilizers, we find that the district has ideal conditions for sustainable agricultural practices, including natural and organic farming. Organic farming in high-value crops such as basmati rice, Potato, mustard, sugarcane, mushrooms, can be promoted on a cluster basis under the PKVY and Namami Gange schemes within the crop sector. Within horticulture, vegetables, including Potato, cabbage, and the production of fruits such as leechi, Mango, Pear, Peach, etc. can be developed. Technology transfer through KVK and horticulture and agricultural universities of the region can help the organic farmers reduce the cost of cultivation and enhance productivity per unit of land, labour, and other resources. To understand the potential of up-scaling of organic farming in the district, we conduct the SWOT analysis as given below:

SWOT Analysis of Organic Farming in the District

Strengths	Weaknesses
- Suitability of agro-ecology for horticulture and livestock - Agro-biodiversity and multiple cropping System - The abundance of organic manure (forest leaves and cattle urine & Dung) - Community-based certification system (PGS) - Less dependence on external inputs - Agriculture and Horticulture Universities in the region - Market Proximity (capital city Dehradun, Delhi NCR) - Famous for Basmati Rice and Leechi	- Small and scattered land holdings - Lower productivity during the transition period - Inadequate marketing infrastructure and market linkages - Knowledge and skills-deficit in OF - Lack of effective monitoring - Inadequate testing and certification system - Lack of effective farmers' Organisation
Opportunities	Threats
- Consolidation of agricultural holdings - Income-elastic demand for organic products - Crop-livestock integrated farming system - Tourists flow and scope for agro-tourism - Common "Namami Gange" brand - Possibility of Convergence with MGNREGA - Local livelihood generation through production and sales of bio-fertilizers & Bio-pesticides	- The intrusion of wild animals - Vulnerability to natural factors (landslides) - The declining number of cattle and buffaloes - High transaction cost - Market risks - Shortage of labour in agriculture

● Huge scope for Agro-processing Government Institutional and policy support ● Patanjali Ayurvedic University and Food parks	

Highlights-2

NSA in the district about 10% of the total reported area and it has been gradually shrinking due to due rising land demand for non-agricultural uses.

Area under forest is about 55.46% of the total reported area. Forest-based livelihood activities have the potential for income generation in the district.

Marginal and small farmers constituted about 91% of the total farmers of the district.

The agriculture of the district is dominated by food grains which comprise 70% of the GCA. Together, three cereal crops- wheat, rice and Maize constituted about 60% of the GCA.

Sugarcane, basmati rice, mustard, urad, and Potato are promising crops in the district. Marketing support and R&D intensification can make these crops more remunerative for farmers.

Variability in the production of different crops is higher than in the area under these crops. Variability in production depends on the variability in area and variability yield. In some crops, variability in yield is higher than that in the area, while in some other crops, it is lower than that in area

The net cultivated area under irrigation ranges between 48.68

3.2 FORESTRY

The 2019, Forest Survey has enlisted most abundant tree species in the urban as well as rural region. Pinus roxburghi, Grewia oppositifolia, Mangifera indica, Quercus leucotrichophora, Ficus species are some of the most occurring species in the rural region. Urban region includes trees like Quercus leucotrichophora, Mangifera indica, Cedrus deodara. Some commercially important medicinal and aromatic plants (MAPs) of the state are Aconitumsp, Acorus calamus, Adhatoda vasica, Swerita chirauita, Nardostachys grandiflora, Berberis aristata, Hedychium spicatum,

Juniperus communis, Picrorhiza kurrooa, Podophyllum emodi, Rauvolfia serpentina, Emblica officinalis, Aegle marmelos, Terminalia chebula, Terminalia bellir-ica, Cedrus deodara, Sapindus emarginatus, Rheum emodi, Saussurea lappa,Swertia chirayitaandValeriana jatamansietc (Sundriyal, 2021). Sonapatha, Talispatra, Giloe, Chirata are some of highly acclaimed medicinal plants found in the state.

School Nursery Yojana by the government of India is another great initiative to involve educational institutions as stakeholders. This scheme aims to provide an environment for the students to understand and appreciate the significance of plants in maintaining and sustaining the natural eco-systems. Each school will receive **Rs. 50,000/-** as grant under this scheme. Out of this, Rs. 40,000/- will be used by the school for creation of a nursery. Balance Rs. 10,000/- will be utilized for miscellaneous activities. Under the School Nursery Scheme, thirty Nurseries (Single Nursery per School) are to be developed in the State. The implementation of this scheme has not yet started in the state. Under this scheme **76** proposals related to 10 districts have been sent to the Govt. of India in the 1st phase. **Dehradun** district has **9** proposed school nurseries.

Last year Government announced Nagar Van Scheme on World Environment Day, this scheme aims to develop 200 Urban Forests across the country in the next five years. Under this scheme Dehradun district has developed urban city forest known as **'Anand Van'.** This Anand Van Forest has been developed at Jhajra Forest Range Complex in 2020. The forest has been developed to reduce the severe levels of air pollution in the region. It will provide detailed information regarding the fauna and flora of the state. Developed in three years at a cost of Rs 43 lakhs, Anand Van is spread on 50 hectares of land (Hindustan Times, 2020).

Dehradun city is also getting **new cycling tracks through forests as part of forest-tourism**. This will help safeguard the **existing greenery, planting more productive trees and developing bird watching zones**. A set target of three years has been marked to complete the project (Times of India, 2021).

Ministry of Tribal affairs had announced Inclusion of 23 additional Minor Forest Produce (MFP) items and stipulation of their Minimum Support Price (MSP) under the Centrally Sponsored Scheme titled "Mechanism for Marketing of Minor Forest Produce (MFP) through Minimum Support Price (MSP) and development of value chain of MFP".

Some of the important MFP that can be included in the city forests.

Minor Forest Products(MFP)	Minimum Support Price (Rs. Per kg)
Van Tulsi seeds (Ocimumgratissimum)	16
Van Jeera (Vernonia anthelmintica)	70
Tamarind Seed (Tamarindusindica)	11
Bamboo Brooms (Thysanolaena maxima)	60
Dry Anola (Phyllnthusemblica) (Dry)	60
Kachri Baheda (Terminalia bellerica)	20

Kachri Harra (Terminalia chebula)	23
Seed lac (Kerria lacca)	677

Dehradun District also has **Centre for Aromatic Plants (CAP).** This organisation is primarily focuses on aromatic plants and its products. CAP provides required interventions as incubator to very small enterprises, small to medium enterprises and industries dealing with essential oil sector. CAP has high tech nursey, training, and demonstration facilities. CAP provides following services:

- Survey & selection of land
- Awareness and Training
- Counselling for cultivation of aromatic crops
- Extension in cluster approach
- Quality assessment & certification
- Agro Techniques & Technical Literature
- Quality planting material & seeds of aromatic crops
- Marketing of essential oil/aromatic produce
- Interaction with Industries
- Processing & Value Addition

As of now from the information available on CAP website, it also sells products such as **rose water and Lemon grass oil** (Centre for Aromatic Plant Website).

3.2.1 Biodiversity

During the winter, in Assan barrage bird sanctuary more than 10 migratory species dominate the bird population, including the Common Pochard, Pintail, Brahminy Duck, Gadwall, Mallard, Red Crested Pochard Tufted Duck, Wigeon, Common Teal, and Shoveller.

The Shivaliks, amid the Himalayan foothills, are home to Rajaji National Park, an Indian national park and tiger reserve. It spans 820 square kilometres in three Uttarakhand districts: Haridwar, Dehradun, and Pauri Garhwal. There are over 500 elephants, 12 tigers, 250 panthers, and a diverse prey base that includes Spotted Deer, Sambhar, Wild Boar, Barking Deer, and Goral. Rajaji National Park is a fantastic wildlife and bird watching site, with two types of bears, Himalayan Black and Sloth, and over 400 bird species.

3.3 ENERGY
5.5.1. Solar

The state government has two types of schemes one is solar energy schemes and the other are solar thermal energy schemes. The quantitative data collected gives a glimpse of solar energy

development in Dehradun. It seems that the district has more installations for thermal energy as compared to photovoltaic types.

The Mukhayamantri Saur SwarojgarYojna (MSSY) Scheme is an ambitious scheme of the state government for providing employment to people through solar energy. According to a news article in Mongabay, delays and glitches are snagging Uttarakhand's solar self-employment scheme. The delays are due to unavailability of the required infrastructure and hence the scheme is not able to fulfill its aim.

The state also has launched a Grid connected solar rooftop program, phase –II in 2020 according to The Pioneer. The CM said that the State is focusing on solar power for electricity generation in government buildings. Stating that this has been started in the government buildings in Dehradun and Haridwar, he exhorted citizens to also use their rooftops for power generation.

A news article in The Times of India reads Solar Panels and rainwater harvesting soon to be must for Uttarakhand homes. The same article reads that in Dehradun alone there are 104 residential welfare societies and if all of them adopt these two green features then it would help the district conserve water and electricity.

It seems that the government is trying its best so that people adopt solar energy, probably it is the people who are not aware or do not understand the importance of this clean and green energy.

5.5.2. Biomass

In Dehradun most of the people use LPG, only a few of them use firewood and crop residue, which is good. The state Government has various projects for biomass energy production.Co-Generation/Waste to Energy Type Captive /Grid Connected Biomass Based Power Generation Projects which can be bagasse based, rice husk based, starch based etc. are encouraging bioenergy in the district.The district has a lot of scope for such kind of biomass based energy plants as it cultivates wheat, rice, sugarcane, etc. on large scale.

A report in The Economic Times states that the three state-owned research bodies include the Indian Railways' alternate fuel arm Indian Railways Organisation for Alternate Fuels (IROAF), Indian Institute of Petroleum (IIP) Dehradun and National Institute of Solar Energy (NISE)to develop a solar-assisted biomass paralysis plant in the first stage and eventually look at the possibility of obtaining methanol.

A report in Times of India read RUCO express launched in Dehradun, to collect used cooking oil and convert it to biofuel. With an aim to collect used cooking oil and convert it into biofuel, a Repurposed Used Cooking Oil (RUCO) van runs in the city. The RUCO Express is a joint initiative of Council of Scientific and Industrial Research, Indian Institute of Petroleum (CSIR-IIP), Food Safety and Standards Authority of India (FSSAI), Food and Drug Administration (FDA), and GATI Foundation. The RUCO van will collect used cooking oil from residents, bakers, restaurants, and sweet shop owners of the city. The collected oil will be sent to IIP where scientists will convert the same into bio-fuel. IIP has announced to purchase the used cooking oil at Rs 20 per kilogram. Notably, IIP is the only organisation in the world that converts cooking oil into biofuel at room

temperature. Within three months from its launch 20 participating F&B outlets have joined and are producing 1000 L per week.

The district is appreciably progressing in biofuel generation and has time and again come up with efforts encouraging people to indulge in it.

5.5.3. Biogas

UREDA has commissioned 2 Institutional biogas based power generation project at village Shyampur and Kalshi of Dehradun under a scheme "Biogas based distributed / grid power generation" of Ministry of New and Renewable Energy (MNRE), Govt. of India with a view to promote biogas based power generation project in the farms where large quantity of animal wastes are available.

5.5.4. Hydropower

Hydropower data of the district shows that nine hydroelectric plant are there, out of which six are operating and producing electricity while other three are under construction. The Government of Uttarakhand (GoU) is planning to build a hydroelectric power plant along the border between Uttarakhand and Himachal Pradesh, India, through its Uttarakhand Jal Vidyut Nigam Ltd (UJVNL) and the Government of Himachal Pradesh (GoHP) through its Himachal Pradesh Power Corporation Ltd (HPPCL). A 660MW (4X165MW) power plant with a 680m long and 236m high concrete gravity dam is being built as part of the project.

3.4   TOURISM

3.5   WETLAND

The wetlands are the source of many ecosystems and habitats for various species. The wetlands create a unique ecosystem that supports many species simultaneously like aquatic, terrestrial, and human beings. The district has many potential sources and opportunities to harness valuable products using the scheme and start the pilot project. Local stakeholders directly or indirectly depend on the wetland for their income and small-scale business. These businesses can be a great opportunity can be turned into a large-scale production hub using the right approach. The region has a good amount of production of litchi and rice. The region is known for the early bearing variety of litchi and basmati rice. The data collected and analyzed shows the region's production and possible product derived from the raw product. The list of sources and the possible products are mentioned below:
● Rice production is recommended as commercial crops in the region, leading to products like product-related like rice water, rice, rice flour products.
● Production of litchi is reasonably high, which can turn into the products like juice, jam products.

- Forest products play an essential role in the economy of the district. Besides supplying fuel, fodder, bamboos and medicinal herbs, they also yield various products like honey, lac, gum, resin, catechu, wax, horns and hides.
- The district is famous for its basmati rice products
- Sal forest and coniferous forests are predominant in the western part of tehsil Dehra Dun. Chir is the only coniferous species in the old reserved forests.

4 ACTION PLAN DEVELOPMENT

4.1 AGRICULTURE

4.3. Trends in Horticulture Crops

The district has a high potential for horticulture development. With policy support and a well-designed action plan, this sector can be the growth driver for the agriculture sector. Table 18 shows the percentage share of major fruit crops in the total cropped under fruits. In 2018-19, Mango constituted the highest share (23.33%), followed by Apple (18.16%), and Litchi (14.30%). The total area under fruits shows low variation across years.

Table 18: Trends in percentage share of principal fruit crops in total area under fruits

Crop/Year	2010-11	2011-12	2014-15	2015-16	2017-18	2018-19
Apple	17.98	27.49	18.17	18.17	18.29	18.16
Pear	5.16	7.91	5.23	5.23	5.23	5.21
Peach	1.82	2.80	1.85	1.86	1.87	1.88
Plum	3.72	5.54	3.66	3.67	3.67	3.65
Apricot	4.36	6.48	4.29	4.29	4.29	4.28
Walnut	10.39	15.43	10.20	10.19	10.22	10.16
Lemon	9.58	14.98	9.90	9.90	9.92	9.86
Mango	22.99	35.48	23.44	23.42	23.48	23.33
Litchi	14.41	21.84	14.43	14.43	14.43	14.30
Other Fruits	8.38	13.36	8.84	8.84	8.97	9.17
Total of Fruits (ha)	25642 (100)	17429 (100)	26390 (100)	26408 (100)	26986 (100)	27273 (100)
Source: Compiled from District Statistical Handbooks						

Production of Mango ranges from 10284 tons in 2018-19 to 6373 tons in 2010-11. Its production has declined in recent years. Production of almost all fruits declined in 2018-19 when compared to 2010-11 except in litchi fruit (from 6599 tons in 2018-19 to 5735 tons in 2010-11)

and Walnut fruits (from 4095 tons in 2018-19 to 2003 tons in 2010-11). Total production of fruits has declined from 38962 tons in 2011-12 to 43091 tons in 2018-19 (Table 19).

Table 19. Production under Horticulture Crops in Dehradun District (in Metric Tonnes)

Crop/Year	2010-11	2011-12	2014-15	2015-16	2016-17	2017-18	2018-19
Apple	8226	12831	12386	7342	16085.2	7797	7777.79
Pear	2505	5198	1380	2003	966.46	2148	2160
Peach	1860	2037	2001	744	250.66	794	814.93
Plum	1682	2984	2943	1395	49.28	1475	1481.6
Apricot	1456	3047	1131	1610	296.1	1749	1772.86
Walnut	2003	3015	3016	3822	287.06	4083	4095
Lemon	4880	7705	7465	3766	138.84	3934	3948
Mango	6373	18443	6185	9774	23347.5	10267	10284
Litchi	5735	8642	8409	6287	1937.32	6579	6599
Other Fruits	4242	4816	4539	3316	1387.1	3564	3075
Total of above Fruits	38765	43388.65	66775.3	40059	44745.48	42390	42008.18
Source: Compiled District Statistical Hand Books							

Table 20 shows that per hectare yield of almost all crops has low declined during 2011-12 and 2018-19. The productivity of Mango accelerated from 1.08 tons in 2010-11 to 1.62 tons in 2018-19. The yields of Pear, Apricot and plum evince ups and downs during the period. Per hectare yield of all fruits (peach, plum, apricot, walnut, lemon and Mango) declined during 2010-11 and 2018-19. The above analysis indicates the dismal scenario of fruits production in the district. The reasons for this dismal condition of horticulture in the district need to be explored.

Table 20. Yield under Horticulture Crops year-wise data for Dehradun District (in Metric Tonnes per hectare)

Crop/Year	2010-11	2011-12	2014-15	2015-16	2017-18	2018-19
Apple	1.78	2.68	2.58	1.53	1.58	1.57
Pear	1.89	3.77	1.00	1.45	1.52	1.52
Peach	3.98	4.17	4.09	1.52	1.57	1.59
Plum	1.76	3.09	3.04	1.44	1.49	1.49
Apricot	1.30	2.70	1.00	1.42	1.51	1.52
Walnut	0.75	1.12	1.12	1.42	1.48	1.48
Lemon	1.99	2.95	2.86	1.44	1.47	1.47
Mango	1.08	2.98	1.00	1.58	1.62	1.62
Litchi	1.55	2.27	2.21	1.65	1.69	1.69
Other Fruits	1.97	2.07	1.95	1.42	1.47	1.23
Total of above Fruits	1.51	2.49	2.53	1.52	1.57	1.54
Potato	8.42	10.85	65.67	5.82	5.80	5.85
Vegetables	10.04	10.62	10.50	7.32	7.29	7.15
Total fruits	1.54	2.61	2.53	1.52	1.57	1.58
Source: Compiled from District Statistical Handbook						

4.4 Trends in Area, Production and Yield of Vegetable Crops

Table 21 shows the trends in the area, production and per hectare yield of total vegetable crops. It is evident from the data shown in the table that the area, production and yield of vegetables in the district have declined during 2010-11 and 2018-19. The per hectare yield has gone down from 11.94 tons/ha in 2012-13 to 7.15 tons/ha in 2018-19. Similarly, total production steeply declined from 102270 tons in 2011-12 to 73023 tons in 2018-19, a net decline of 28%. The decline is driven largely by the reduction in yield as the area declined by 27%. The area under Potato has increased from 2309 ha in 2010-11 to 2678 ha in 2018-19, but the production went down from 19443 tons in 2010 -11 to 15672 tons in 2018 -19. The yield of Potato also declined from 8.42 tons/ha in 2010-11 to 5.85 tons/ha in 2018-19.

Table 21: Area, Production and Yield of Vegetables (area in ha, and production and yield in tons)

Crop/Year		2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Total Vegetables	Area	8791	9630	2711.21	3594.35	9654	9669	3728.88	10013.82	10215
	Production	88295	102270	32363.28	39856.16	101409	70755	36979.85	72953	73023
	Yield	10.04	10.62	11.94	11.09	10.50	7.32	9.92	7.29	7.15
Potato	Area	2309	2546	450.66	419.39	419	2552	464	2655	2678
	Production	19443	27629	3809.73	4841.12	27515	14853	5359	15402	15672
	Yield	8.42	10.85	8.45	11.54	65.67	5.82	11.55	5.80	5.85
Source: Compiled from District Statistical Handbook										

Agriculture and allied sectors can improve rural livelihood through diversification into areas such as horticulture, aromatic and medicinal plants, animal husbandry, including dairy, fisheries, sericulture, beekeeping, mushroom production, etc. Fruits, vegetables, potatoes, mushrooms, spices, medicinal plants, and flowers can provide remunerative returns to farmers as their demand is income-elastic

Highlights-3

Livestock has an important place in the rural economy. Its contribution to agriculture has been gradually rising. Livestock census data indicate that the total number of cows and female buffaloes has increased from 1998 to 2019.

The district has a high potential for horticulture development. With policy support and a well-designed action plan, this sector can be the growth driver for the agriculture sector.

In 2018-19, the area under mango crop constituted the highest share (23.33%), followed apple (18.16%), and litchi (14.30%). The total area under fruits shows variation across years.

Production of almost all fruits declined in 2018-19 when compared to 2010-11 except in Litchi fruit (from 6599 tons in 2018-19 to 5735 tons in 2010-11) and Walnut fruits (from 4095

4.2 FORESTRY

- Dehradun district has total 7 educational institutions of national importance. These institutions are IIT Roorkee, NIT Uttarakhand, IIM Kashipur, AIMS Rishikesh, Forest Research Institute, Indira Gandhi National Forest Academy, Indian Military Academy. With huge amount of land availability and budget, these institutes can start village and tribal adaptation programs for development of NTFP value chain. Technical and Management institutes can provide total platform support and development of market ready products for these tribes and NTFP collectors. These institutions can become outlets for the products to sell. This creates accountability and trust between local tribal people and government.

- Pradhan Mantri Jan Van Yojana launched in 2018, is scheme under which tribal people and local people can sell their collected forest products at certain MSPs.

- There is a huge trust deficit between the tribal communities and the forest department. Local NGOs can act as volunteer and mediator between the government and locals (Mongabay , 2020).

- Dehradun is blessed with great area of sal trees. Sal leaves are famous for making the eco-friendly plates and bowls. Local government needs to push the use of these sal tree plates to the local restaurants, institutions. A complete value chain of these sal plates can be enforced in the district. These sal leaves plate are biodegradable, and also saves huge amount of water and soap.

- To implement agro-forestry in the urban area as well, ready sampling of native plants are required. It is important for the government to take initiative for establishing nurseries at all major towns in the district and same nurseries can be acted as collection centres for the NTFPs. This creates circular economy effect.

- Recently opened urban forest 'Anand Van' included various activities for the visitors and tourists. This is great market opening for the collected and processed forest products to sell through small stalls. Visitors can buy essential oils, forest fruits, Jams, Bamboo artwork etc.
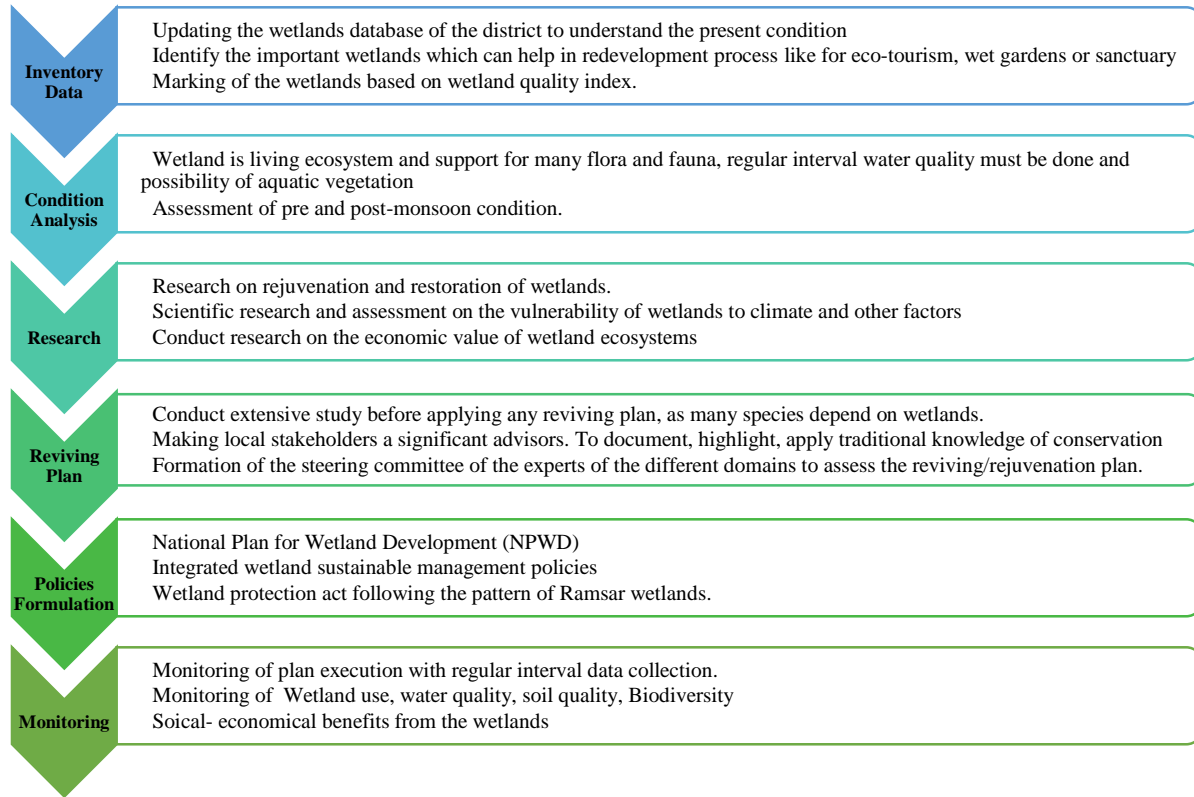
4.2.1. Biodiversity

As forest fire occur every year, the government should not compromise on environmental issues such as forest fire hazard and should allocate more funds for the use of modern technology, the installation of watch towers, and other infrastructure so that not only forest fires but also other forest-related problems can be addressed concurrently.

4.3   TOURISM

4.4   WETLANDS

The district is comprised of some of the healthy and wealthy wetland ecosystems. They directly or indirectly support millions of people and provide goods and services. They support all life forms through extensive food webs. They are habitat to aquatic flora and fauna and numerous species of birds, including migratory species. They mitigate floods and recharge the groundwater. They need to be taken care of, and action on different fronts must be taken. The action plan below gives a glimpse of the action and development required to protect, conserve, rejuvenate the wetlands existing and extinct.

Inventory Data	Updating the wetlands database of the district to understand the present condition Identify the important wetlands which can help in redevelopment process like for eco-tourism, wet gardens or sanctuary Marking of the wetlands based on wetland quality index.
Condition Analysis	Wetland is living ecosystem and support for many flora and fauna, regular interval water quality must be done and possibility of aquatic vegetation Assessment of pre and post-monsoon condition.
Research	Research on rejuvenation and restoration of wetlands. Scientific research and assessment on the vulnerability of wetlands to climate and other factors Conduct research on the economic value of wetland ecosystems
Reviving Plan	Conduct extensive study before applying any reviving plan, as many species depend on wetlands. Making local stakeholders a significant advisors. To document, highlight, apply traditional knowledge of conservation Formation of the steering committee of the experts of the different domains to assess the reviving/rejuvenation plan.
Policies Formulation	National Plan for Wetland Development (NPWD) Integrated wetland sustainable management policies Wetland protection act following the pattern of Ramsar wetlands.
Monitoring	Monitoring of plan execution with regular interval data collection. Monitoring of Wetland use, water quality, soil quality, Biodiversity Soical- economical benefits from the wetlands

4.5 ENERGY
4.5.1 Solar

The data collected from various sources suggests that more and more solar energy units have been installed in schools, institutions etc., the need is to encourage solar energy for domestic and agricultural purposes. Since the district's economy is dependent on agriculture, farmers should be made aware of KusumYojana. Energy requirements for farming should be fulfilled by solar energy, so that there is less burden on the discoms to supply power in the required seasons. A survey should be done and accordingly, the appropriate component of Kusumyojana should be applied in the district. Along with KusumYojana, The Mukhayamantri Saur SwarojgarYojna (MSSY) Scheme should also be brought to the picture. People should be made acquainted with the various types of schemes and educated about the one most appropriate for them.

The urban and the rural households should also be made aware of the benefits of solar energy. The households should be encouraged to install solar rooftop panels under **Grid connected solar rooftop program, phase –II.** Since the winters are severe in the district, solar thermal energy should also be promoted. Use of solar cookers and solar water heaters should be encouraged. Use of solar room heaters should be encouraged in hotels, restaurants and guest houses. Solar water heaters should be used in industries wherever required.

PROJECTION AND MONITORING

Firstly people should be aware about the benefits of solar energy, especially the urban and rural households and the farmers. Not only this, students in schools and colleges should also be taught about the renewable energy capacity of their district. Secondly, a district oriented survey should be conducted to analyze which component of KusumYojana suits best to its people. Also people should be educated about various solar energy schemes in the state. Thirdly, grid connected solar panels should be encouraged in urban areas, which would add to the grid supply supporting the power production. Along with this norms should be made for the hotels, restaurants etc., for using solar thermal energy. Fourthly, industries should be provided with some amount of financial assistance, especially the MSMEs so that they can easily afford clean and green energy. Lastly, the infrastructure development should be done so that it does not curb the schemes.

The agriculture sector needs to adapt using solar energy to fulfill its energy requirements.Hence when improvements will be made and the barriers in expansion of solar energy will be removed, the district will automatically flourish sustainably.

4.5.2   Biomass

The district is ambitiously working on biofuel generation from used cooking oil. Attention is required for the farmers as well, because the district's economy depends mainly on agriculture and hence the large amount of biomass produced as agricultural residue needs to be utilized. Farmers should be made aware of the energy generation from the biomass and encouraged to sell it.

Small start-ups should be encouraged to set up biomass based energy plants, which would provide employment to the people in the area. This would eventually improve the district's economy.

The sugar mills, rice mills, etc. should be encouraged to produce bioenergy not only for themselves but also should try to produce it for the district so that the burden of electricity production on the district is reduced.

Agricultural waste are available only at the time of crop cultivation hence other sources of biomass such as industrial waste, municipal solid waste, food waste etc should be managed so that the availability of biomass is maintained throughout the year. A district oriented survey should be done to figure out the lands where these plants could be set up. The most suitable place for these plants can be somewhere in between the urban and the rural areas, so that biomass from both the areas can be collected. For this a well-connected collection system needs to be planned by the concerned authorities.

The district's current attempts to utilize cooking oil are appreciable, the requisite improvements should be done and the biofuel production shoud be increased.

PROJECTION AND MONITORING

First and the foremost thing required is to make people aware of biomass energy by campaigning etc. Especially, farmers should be made aware of bioenergy.

Second step should be analyzing the availability of biomass in the specific areas and accordingly lands for setting up the biomass plant should be selected so that transportation of biomass will be easy and will not hinder its continuous supply.Also attention should also be made on storage of biomass during and after the harvest season. This would then encourage the small start ups to set up biomass based plants and hence generate employment.

Third step can be developing a proper transport system for collecting and supplying the biomass. This would also generate employment.

Fourth thing the government can do is provide financial assistance to the people willing to set up biomass energy plants.

The district cultivates sugarcane, rice, wheat, etc.Bagasse based biomass plants and biomass based gasifiers are suggested for the district.These steps together will lead to an overall development of the district in a sustainable manner.

4.5.3 Biogas

Three operational sewage treatment plant are present in the district of capacity 1 MLD, 0.42 MLD and 0.7 MLD. The organic from the plant should be treated in codigestion biogas plant.

4.5.4 Hydropower

The Lakhwar dam is projected to be the highest dam on the Yamuna river (206 metres). The project was announced in 1976, however it has yet to be finished. Government primary aim should be to complete pending project rather than developing new ones.

5 RECOMMENDATIONS

5.1. Agriculture and allied sectors

- The district has the potential for improving the livelihood of local people and regeneration of natural capital through promoting organic agriculture, horticulture and agroforestry, and tourism and educational services. For eco-tourism small cottages on homestead land can be constructed under convergence.

- The government horticulture and forest departments should take uncultivated and barren lands on lease from the absentee farmers. The departments can do large-scale horticulture and agroforestry activities under MGNREGA convergence. These departments can set up horticulture and agroforestry zones and prepare the DPRs under the convergence framework, with detailed techno-economic feasibility and socio-economic and environmental impact analysis. Wire fencing of these zones can be done by the departments

to protect the crops and plantations from the wild animal. Such fencing would be more cost-effective as compared to the fencing of individual farmers' land.

- Sugarcane, basmati rice, mustard, groundnut, urad, and Potato are promising crops in the district. Marketing support and R&D intensification can make these crops more remunerative for farmers.

- The possibility of evolving an economically viable model of convergence of MGNREGA activities with the concerned line departments would be explored to promote HVCs and improve people's livelihood.

- The area under forest is about 55% of the total reported area. Forest-based livelihood activities have the potential for income generation in the district.

- Agriculture R&D and extension services need to be reinvigorated and oriented toward sustainable agricultural practices suited to the hill areas in the case of HVCs, horticulture, livestock, and agroforestry.

- A three-tier framework of agro-processing (primary, secondary and tertiary processing) can be set up to reduce post-harvest losses and generate value addition and local employment. Primary processing can be done at the cluster level, secondary at local town and tertiary at SIIDCUL and be well-integrated with the supply chain network.

- Agriculture production in the district has a high level of variability and is vulnerable to natural factors. Compulsory and subsidised crop insurance should be provided to protect farmers' livelihood and income.

- A new institutional framework needs to be set up at the district level where the concerned line departments' technical, human and financial resources may be pooled or converged together to provide customized solutions to the farmers related to technology, training, marketing needs and other advisory services.

- The Organic Farming Act is a good initiative, and its provisions should be effectively enforced. A long-term system of incentive as well as regulation may be evolved to retain the existing farmers and motivate others to move towards the sustainable farming system.

- The district has enormous scope for commercial cultivation of pomegranate spices, onion, garlic, ginger, chili, capsicum, tomato, bitter guard, and other vegetables that should be promoted under poly house and greenhouse farming. It also has potential for fruit crops such as Litchi, Mango, jackfruits, citrus, peach, walnut, and apple. These vegetables and fruit crops should be promoted through institutional support and processing and marketing infrastructure.

- Poly houses could be used for the cultivation of flowers and orchids, and medicinal plants like tulsi, kalmegh, ashwagandha can be encouraged by providing training and market access. Poultry, Fishery, beekeeping and floriculture can also be incentivized.

- Farmers need to adopt advanced technologies used in the agriculture sector like Hybrids in commercial cereals and vegetable crop production, land leveling, water-soluble fertilizer application, harvesting & thrashing implements, drip and sprinkler irrigation, etc. Modern agro advisory services should be made easy access to the farmers.

- In the hilly part of the district, tea plantations under the cooperative farming model can also be promoted to improve the local livelihood.

- The district has ample scope for tea plantations under the cooperative farming model; besides, there is a need to develop tea processing and marketing infrastructure.
- Processing units for ginger, mango, vegetable pea, and tomato need to be developed.
- Sericulture needs to be encouraged among the local people by providing training and support.
- The district needs to develop storage units for the Preservation of agricultural products.
- Farmers need to adopt advanced technologies used in the agriculture sector like Hybrids in commercial cereals and vegetable crop production, land leveling, water-soluble fertilizer application, harvesting & thrashing implements.
- The district has huge scope to amplify pomegranate's commercial cultivation, which should be encouraged.
- Shifting toward spices cultivation like onion, garlic, ginger, chili could increase the farmer's income, which needs the expand.
- High revenue crops like capsicum, tomato, and other vegetable cultivation should be promoted under poly house and greenhouse farming.
- There is a scope for floriculture, also poly houses could be used for the cultivation of flowers and orchids.
- The district has a huge scope for the Litchi, mango, jackfruits, citrus, peach, walnut, and apple, which should be encouraged among the farmers.
- There is a scope for expanding food processing infrastructure and marketing, especially for litchi, mango, citrus, apple.
- The district has ample scope for cultivating medicinal plants like tulsi, kalmegh, ashwagandha, which should be encouraged by providing training and market access.
- There is a need to encourage poultry farming by providing training and assistance for establishing poultry hatchery.
- Beekeeping needs to be encouraged among the farmers.
- The farmers should follow the agro advisory services.
- Drip and sprinkler irrigation should be used to increase water efficiency and crop yield.

5.2. Forestry

- Dehradun currently holds enough forest area to fulfill the national policy requirement of 33%. But what the district lacks is organizational productivity through the forestry sector.
- It is important for local government and policy makers to establish trust between forest product collectors and organizations.
- District is an important tourist attraction in the country. It also includes important organizations such as Ordnance Factory, DRDO, Survey of India, Oil and Natural Gas. These institutions and tourist destinations can hold monthly exhibitions of NTFP stalls for the visitors and urban people.
- Local governments can invite foreign investors and Indian pharmaceutical companies for collaboration between tribal people and new business opportunities.
- Dehradun District needs a single window institution for buying and selling these forest products. District currently produces essential oils, bamboo-based products and Sonapatha, Talispatra, Giloe, Chirata which are some of the important medicinal plants.
- Tons valley in the district has a variety of NTFP, which includes 53 types of edible plants, 21 types of fodder, 70 species of medicinal plants, and some fibers and fuel. A recent 2016 study enlisted a total 105 types of NTFP in the valley. A commercialisation of these products is a necessity (Rawat, 2016).

5.2.1. Biodiversity

It is recommended to make a separate department for reducing forest fire accidents in different stages, so that fire control measures could be handled independently and effectively.

5.3. Tourism

5.4. Wetlands

The wetlands need to be intact, but at the same time, they need to be planned wisely to support the district economically, socially and environmentally, which will lead to indirectly relieving of stress from the Ganga River to a large extent. It will also lower the local people's dependence on the Ganga River for their small-scale industry or basic daily needs. The following recommendations and interventions are required to get valuable products and solve the issues/ challenges faced by the local people of that region.
- Rice producing farmers need to switch to organic and water-efficient irrigation systems.
- It is recommended to promote animal husbandry, rice, and litchi. This provides a boost to the economic growth of the local people. Sustainable development of industries will lead to minor exploitation of the wetlands as these are water-intensive industries.
- It is recommended to promote forest areas in the region to support the forest-related industry and wetlands can support the water supply for the cultivation.

- It is recommended to promote eco-tourism in the region as the region can develop with flower gardens around the wetlands area and biodiversity. It will attract visitors and help in the economic growth of the region. The economy generated by eco-tourism must be utilized to maintain the hotspot.

5.5. Energy
5.5.1. Solar

- The people in the district should be made aware about the benefits of installing solar rooftop panels so that their inclination shifts towards clean and green energy.
- KusumYojana and Mukhyamantri Saur SwarojgarYojna should be run on a larger scale in the district. So that more and more farmers are benefiting from it.
- A thought needs to be given for providing subsidies to the industries, especially cottage and MSMEs, for their uninterrupted working.
- The households should be encouraged for solar rooftop panels under grid connected solar rooftop program, phase II.

5.5.2. Biomass

- ❖ Farmers should be made aware of biomass energy and they should be demonstrated biomass energy production. This way they will develop interest and willingness to sell their crop residues.
- ❖ There should be norms where the sugar mills, rice mills etc. should have a biomass energy plant.
- ❖ The prices for the crop residues should be fixed in such a way that neither the seller nor the buyer is at loss.
- ❖ Since the district mainly cultivated rice, wheat, and sugarcane, bagasse based power plants and biomass based gasifier plants, co-generation plants should be encouraged to be set up by small start-ups.

5.5.3. Biogas

It is recommended to build more no. of family size biogas plants in the district especially in rural areas.

5.5.4. Hydropower

It is recommended to complete pending projects such as Lakhwar dam and provide rehabilitation areas for villagers.

6. Discussion during the Report Presentation

- Dehradun is known for tourist footfalls and also has a great opportunity for eco-tourism.

- NMCG has sanctioned a biodiversity project to WII, Dehradun.
- The suggestion of utilizing ashrams as Wedding venue was appreciated by the DM and also will be explored further.
- There is a scope of religious tourism.The IIML Report for Arth Ganga should be a regular Agenda item for next 6-8 DGC meetings.
- Hon'ble PM during the post-Budget webinar on Tourism had spoken about market potential of destination weddings. It was suggested that suitable Ashrams in Ganga Basin may be identified for such purpose to promote blissful experience, cost reduction, livelihood opportunities and better upkeep.
- Allocate separate space for Namami Gange Awareness and Jalaj Marketing kiosk in Melas/Congregatios/Fairs for providing better marketing opportunities to the Jalaj products.
- As Dilli Haat Centre – Namami Gange Awareness and Marketing Centre – is being launched soon, it was requested that every district to identify niche products with a creative story and link it with Jalaj in their area.
- To identify Arth Ganga Tourist Trails and organize Ganga Guide training
- Promotion of Natural Farming in Ganga Basin and training workshops should be organized on a regular basis. NMCG is supporting this initiative in coordination with MoA& FW and NCOF.
- Make plans for reuse of treated waste water for agriculture, industrial etc. purpose and also the sludge.
- Training of volunteers for Ganga awareness & Aarti workshops to promote regular aartis on Ghats.

7 REFERENCES

Centre for Aromatic Plant Website. (n.d.). https://www.capuk.in/.

Hindustan Times. (2020). 'Anand Van', Uttarakhand's first urban forest set to open this Navaratri.

Mongabay . (2020). India urgently needs to streamline multi-billion rupees worth NTFP market.

Rawat, M. (2016). Important Plant-Based Non-Wood Forest Products of Tons Valley, Uttarakhand.

Sundriyal, M. (2021). Development of NTFPs Sectorfor Income Generationand Environmental Conservation.

Times of India. (2021). Cycling tracks in forests to enable birdwatching.

https://censusindia.gov.in/2011census/dchb/0505_PART_B_DCHB_DEHRADUN.pdf

https://censusindia.gov.in/2011census/dchb/0505_PART_A_DCHB_DEHRADUN.pdf

https://dehradun.kvk4.in/district-profile.html

https://fssai.gov.in/upload/media/FSSAI_News_RUCO_TOI_09_12_2019.pdf

http://petroleum.nic.in/sites/default/files/WBD_10aug20.pdf

https://economictimes.indiatimes.com/industry/energy/oil-gas/indias-top-energy-research-bodies-come-together-to-develop-next-gen-fuel-resources/articleshow/58836621.cms?from=mdr

https://censusindia.gov.in/2011census/dchb/0505_PART_B_DCHB_DEHRADUN.pdf

https://censusindia.gov.in/2011census/dchb/0505_PART_A_DCHB_DEHRADUN.pdf

https://dehradun.kvk4.in/district-profile.html

https://ureda.uk.gov.in/dpages/solar-tharmal-schemes

https://timesofindia.indiatimes.com/city/dehradun/solar-panels-rainwater-harvesting-soon-to-be-must-for-uttarakhand-homes/articleshow/84799739.cms

https://www.dailypioneer.com/2020/state-editions/grid-rooftop-solar-phase-ii-launched-in-dehradun.html

https://india.mongabay.com/2021/09/delays-and-glitches-mar-uttarakhands-solar-self-employment-scheme/

8 APPENDICES

Table 2 Biogas potential from animal waste.

Livestock	Residue type	Total population as of 2012	Manure yield* (kg/day)	Total manure generation annually (kg)	Average collection (75%)	Dry manure after removing Moisture content	Manure required for biogas* (kg/m³)	Biogas potential (m³/yr)
Cattle	Manure	180907	10	66,03,10,550	495232912.5	99046582.5	25	3961863.3
Buffalo	Manure	52845	15	28,93,26,375	216994781.3	43398956.25	25	1735958.25
Sheep	Manure	11721	1	42,78,165	3208623.75	641724.75	25	25668.99
Goat	Manure	136729	1	4,99,06,085	37429563.75	7485912.75	25	299436.51
Pig	Manure	4452	2.5	40,62,450	3046837.5	609367.5	25	24374.7
Poultry	manure	1,55,643	0.1	56,80,970	4260727.125	852145.425	25	34085.817
Total		5,42,297						6081387.567

Table 3 Biogas potential from agricultural waste.

Crop	residue type	Total crop production (tons) (2017-18)	Residue production ratio	Residue amount (tons)	Average collection (70%)	Moisture content	Residue amount after removing moisture (tons)	Biogas potential [m3/(tons of dry matter)]	Overall biogas potential (m3)
Maize	straw	15509	1.5	23263.5	16284.45	15	13841.7825	800	11073426
Wheat	straw	44780	1.5	67170	47019	30	32913.3	800	26330640
Sugarcane	Bagasse	251878	0.33	83119.74	58183.818	80	11636.7636	750	8727572.7
Total		312167							46131638.7