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Impact of Ecophysiology on Productivity of Fruit Crops in Kumaun Himalaya, Uttarakhand, India

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ABSTRACT
Production level is determined from area and various allied supportive factors which assist in increasing it rapidly or not. After the separation of Uttarakhand from Uttar Pradesh the state has progressed in various sectors. To increase the horticultural production rapidly it has not been easy in the non-facilitated regions where there are many restricting factors, such as, physiographical and no-physiographical challenges which hamper the cultivation of fruit crops or horticultural production. Kumaun Himalaya has favourable climatic conditions for temperate and subtropical fruit crops rather than agricultural crops. Uttarakhand is ranked third in production of Apples in the country and accounts for 4.7% of the total production of apples in the country. The state produces about 0.14 m. MT of apples from an area of 0.033 m. ha having yield of 4.1 MT/ha which is the second highest after J&K. The significance the research paper is to find out the productivity of fruit crops in administrative block development wise under the 06 districts in Kumaun Himalaya on the bases of soil, climatic conditions and physiographic parameters which has differ productivity index level high or low. Productivity Index is being determined for first time ever in Kumaun Himalaya for horticultural crops for and also for regionalization of productivity. This research will relevant to agrarians, planners, government agencies and climate change and food security studies and the classifications for productivity index are as follows: more than 125 for very high productivity region, 101 to 125 index for high productivity regions, 101-99 index for medium productivity regions, 99-75 index for low productivity region, and last one below 75 index represents very low productivity regions of the Kumaun Himalaya. Himalayan region has imbalances in the level of agricultural productivity or performance and hence a combined overall picture of the selected crops is necessary as it will help in the delimitation of horticultural production typologies and identify the weak areas for entire Kumaun Himalayan region. Productivity index is like a ranking method that puts in descending or ascending order the regions according to their capability or potential for the cultivation of agriculture and horticultural crops, and then delineates the region that are suitable for a particular crop.
Keywords: Kumaun Himalaya, Fruit Crops, Productivity, Ecophysiology

INTRODUCTION
'Productivity' is regarded as "A ratio of the output to input in relation to land, labour, capital and overall resources employed in agriculture." Agricultural efficiency is defined as, "The aggregate performance of various crops in regard to their output per acre." Bhatia [1]. Singh talking about productivity considers it as, "the quantity of returns from arable land". R. Singh [2], and Singh and Dhillon [7] defined it thus, "Productivity is the order whose origins, economic, technical and cultural variables are able to take advantage of biological resources of the field for agricultural production." The agricultural productivity period is also dynamic, relative and complex. Many scholars have considered various methods of measurement of productivity [4, 6]. M. Shafi [3] used the standard nutrition units as an approach to measure agricultural productivity.
Agriculture plays the most valuable role in the economic activities of the humans. India is a large developing country that has a dominance of agricultural activity along with large population. In Uttarakhand, as most of the area is under hilly terrain, it is necessary to demarcate the spatial variations of horticultural regions along with the spatial organization of agriculture. Moreover, some of the regions in the hill state are more developed than others, while some are still backward in agriculture. For better planning, management and development of any region it is necessary to find and know about the productivity of that region. Study in agriculture has been done by many scholars [3-9]. Whittelessy [3] first talked about regionalization, and based on the nature of crops, animals, soil processes, the production of agricultural products, the sale of agricultural products, mechanization agricultural

settlement etc., various agricultural categories and land use of the world The classification has been decided. Based on the assessment, he has given thirteen agricultural areas of the world to different standards from a subjective perspective.

MATERIAL AND METHODS

The focus of the present research is on computing the crop productivity of horticultural crops. The six districts Kumaun region having diverse ecophysiology i.e., relief, soil types, climate and irrigation systems. Secondary data taken from various district horticultural department in Kumaun region and validated the secondary data from field survey or in-situ data. In the present study, the administrative block development units have been taken to find productivity because these form the basic unit of data collection and investigation at government level also. Fruits, vegetables flowers and spices are the main crops that were studied for computing the productivity of horticultural crops. The productivity index is shown in the productivity index tables that have been developed after reviewing all the relevant methods. Enyedi's method is generally used for finding the crop productivity and productivity of regions and for determining an index of productivity coefficient. Shafi [3] applied same approach to determine the productivity index for twelve food crops in India. This technique applies nationally, however, in some cases, the productivity index does not fit this with the magnitude of the area under any particular crop. Besides, when the district yield is less than the national yield, its productivity index is higher than the national level. Therefore, we have applied Enyedi's formula that is modified by Shafi's [3] for determining the crop productivity and regionalization of productivity regions of horticultural crop regions for Kumaun Himalaya regions. Shafi's [3] modified format of this formula, which we have applied in the current calculations of productivity is as follows:

Productivity Index (PI)

$$\Sigma\frac{y1}{t1} + \frac{y2}{t2} + \cdots n : \Sigma\frac{Y1}{T1} + \frac{Y2}{T2} + \cdots n$$
$$\Sigma\frac{yn}{tn} : \Sigma\frac{Yn}{Tn}$$

Where:

$y_1, y_2 \ldots n$ = Total Production of the selected crops in an unit area i.e., Administrative Blocks

$t_1, t_2, \ldots n$ = Total cropped area under those crops in the unit area i.e., Administrative Blocks

$Y_1, Y_2 \ldots n$ = Total Production of the selected crops at national level i.e., the Kumaun region

$T_1, T_2 \ldots n$ = Total cropped area under those crops at national level i.e. Kumaun region

n = The selected crops.

In the present work, Shafi's modified formula has been adopted and applied on the basis of average index of area and production in terms of data of horticultural crops of administrative block-wise in Kumaun Himalayan regions. The present data comprises of production and whole area of the horticultural crops, such as fruit, vegetable and aromatic plants, which represent an average output from the data crops of the period from 2012 to 2015.

This paper regionalized the whole study area into five categories of productivity regions into very high, high, medium, low and very low. Productivity calculated of average production in time series data by 08 years from 2003-2011. The classifications for productivity index are as follows: more than 125 for very high productivity region, 101 to 125 index for high productivity regions, 101-99 index for medium productivity regions, 99-75 index for low productivity region, and last one below 75 index represents very low productivity regions of the Kumaun Himalaya. Himalayan region has imbalances in the level of agricultural productivity or performance and hence a combined overall picture of the selected crops is necessary as it will help in the delimitation of horticultural production typologies and identify the weak areas for entire Kumaun Himalayan region. Productivity index is like a ranking method that puts in descending or ascending order the regions according to their capability or potential for the cultivation of agriculture and horticultural crops, and then delineates the region that are suitable for a particular crop. An example shows as below table for computation of the productivity index.

Productivity index is like a ranking method that puts in descending or ascending order the regions according to their capability or potential for the cultivation of agriculture and horticultural crops, and then delineates the region that are suitable for a particular crop. An example shows as below table for computation of the productivity index (Table 1). All maps are generated through GIS software like ArcGIS and QGIS at IIRS Lab Dehradun, Uttarakhand during the various training courses.

Table: 1:Ranking for Productivity regions, Kumaun Himalaya.

Sl. No.	Ranking for Productivity Regions	Productivity Index
1	Very High (VH)	> 125
2	High (H)	101-125
3	Medium (M)	99 – 101
4	Low (L)	75 – 99
5	Very Low (VL)	> 75

RESULT AND DISCUSSION
Location of the Study Region
The study region lies between 28°44' and 30°49' North latitudes and extends between 78°45' and 81°2' East longitudes. Regions of Kumaun come under considerable tracts of the Himalayas and also comprises of two sub-montane strips of the Tarai and the Bhabar with total geographical area has 21034km²(Table 1). The sub-montane strips go up to 1850 m with almost impenetrable forests at places, giving habitat to wild animals. Below 1850 m altitude, the numerous naturally available clearings attracted a large population from the hills, who cultivated on the rich soil during the hot and cold seasons and returned to the mountains during the monsoons. The climate of Uttarakhand makes it ideal for growing flowers all-round the year. To meet the requirements of domestic as well as foreign markets the floriculture industry is being developed aggressively. To offer incentives and facilities to this industry, Floriculture Parks with infrastructure for sorting, pre-cooling, cold chain, processing, packing, grading, and marketing facilities have been planned. The production of loose flowers in the state has increased from 2,020 tonnes in 2013-14 to 2,760 tonnes in 2014-15. The state government has set up a Horticulture Marketing Board to boost horticulture products in the state. In September 2014, Horticulture Leadership Award at the seventh Agriculture Leadership meet was presented to Uttarakhand. Uttarakhand University of Horticulture and Forestry has also been set up in 2011, and is taking initiatives in the areas of extension, research and certificate level courses for the benefit of staff as well as lay farmers.
Crop Productivity Regions – Based on Fruit Crops Productivity Index
The pattern of horticultural productivity of Kumaun Himalaya regions has been delineated with help of Shafi's method, which is a technique that has also been applied at the national level in India on the basis of Kendall's method. The ranking values of very high, high, medium, low and very low productivity of block development unit wise have been computed given in Table 1,while the resultant patterns of productivity index calculated by table 2 and productivity indices ranking level ofregion-wise have been tabulated by table 3, each of blocks through productivity index value and illustrated byFig. from 2 to 12.The crop productivity of the regions have been computed based on the fruits cultivated in each of the development block region which are under the five ranks. They have been described as below:
Productivity Regions of *Apple* Crop
Highest productivity index for apple has been recorded for Block Lamgara (252.20) of District Almora while the lowest was found at Garur Block (1.09) of Bageshwar district. There are 12 blocks under the very high productivity category, the other blocks being Dhauladevi, Bhaishiyachana, Dwarahat, Galgolihat, Takula, Chaukhutiya, Bhikiyasain, Salt, Hawalbag and Syalde blocks. There are six blocks under low productivity regions such as Okhalkanda, Ramgarh, Dhari, Betalghat, Bhimtal and Kotabag. There are 13 blocks below the index of 75, namely Champawat, Barakot, Lohaghat, Paati, Dharchula, Munsyari, Didihat, Bin, Bageshwar, Moonakot, Kanalichina, Kapkot and Berinag. High and medium productivity regions are not available, and the remaining few blocks of the Tarai, Bhabar and Siwalik such as Ramnagar, Rudrapur and Kaladhungi etc. do not cultivate apple crops due to inappropriate climatic conditions in those regions Fig 2.
Productivity Regions of *Apricot* Crop
Dhauladevi block of Almora district has ranked the highest (150.67) while Block Kapkot of Bageshwar district ranked the lowest in productivity of Apricot cultivation. Under the very high productivity regions there are nine blocks, namely, Dhauladevi, Syalde, Dwarahat, Hawalbag, Chaukhutiya, Bhikiyasain, Tarikhet and Bhaishiyachana. Under the high productivity regions having 101-125 of index values, the blocks besides Kapkot are Lamgara, Salt, Takula, Didihat, Dharchula, Galgolihat, Kanalichina, Moonakot, Bin, Berinag and Munsyari. There is no block under the medium productivity category. Under the low productivity region the thirteen blocks are Kotabag, Okhalkanda, Ramgarh, Dhari, Betalghat, Bhimtal, Paati, Barakot, Lohaghat, Garur, Champawat, Bageshwar and Kapkot, while blocks with a very low productivity index were not found in the region Fig 3.

Productivity Regions of *Aonla* Crop
Aonla fruit crop is not ubiquitous in the whole of Kumaun but is cultivated in regions with subtropical type of climate. This fuit is generally cultivated in Tarai and Bhabar regions, but wherever it is found in the mountains and hilly region, it is a wild species. Highest productivity index value was recorded in Garur block (130.04) while the lowest index was found in Bageshwar block (12.72). The very high productivity regions are Jaspur, Sitarganj, Rudrapur, Khatima, Kashipur, Gadarpur, Bajpur and Garur, and the high productivity blocks are Munsyari, Kanalichina, Moonakot, Galgolihat, Didihat, Berinag and Bin. There are no blocks with medium or low productivity, while there are 04 blocks below productivity index value of 75 for Aonla fruit crops in Kumaun Himalaya, namely, Haldwani, Ramnagar, Kotabag and Bageshwar Fig. 4.

Productivity Regions of *Citrus* Fruit Crops
Cultivation of citrus fruit crops observed commonly in all blocks of Kumaun Himalayan region. The climate, rainfall, soil and physiography, all are suitable for the production of citrus fruits in the region. The highest productivity was recorded in Didihat block (776.67). The productivity in general decreased towards the southern part of Kumaun, Paati block of Champawat district had a productivity of just 25.62. Very high productivity of citrus fruits was recorded for Didihat, Munsyari, Galgolihat, Bageshwar, Garur and Dharchula blocks. Cultivation under the high productivity index value in the range 101-125 was found in Salt, Bhikiyasain, Sitarganj, Hawalbag, Dwarahat, Bhaishiyachana, Chaukhutiya, Bajpur, Gadarpur, Jaspur, Kashipur, Khatima, Rudrapur, Moonakot, Takula, Syalde, Dhauladevi, Lamgara and Tarikhet blocks. However, medium or low productivity regions were not recorded in the Kumaun Himalaya. Very low productivity less than 75 was observed in 13 blocks, namely Kapkot, Okhalkanda, Kanalichina, Berinag, Betalghat, Bhimtal, Bin, Dhari, Ramgarh, Haldwani, Ramnagar, Kotabag, Champawat, Lohaghat, Barakot and Paati.

Productivity Regions of *Guava* Fruit Crops
Guava fruit is an ever-present crop and often found up to 3000 m altitudes in Kumaun Himalayan regions. Udham Singh Nagar has the highest productivity of guava fruits in Bajpur, Gadarpur, Jaspur, Kashipur, Khatima, Rudrapur and Sitarganj blocks are major producers with productivity index value of more than 130. There are seven blocks that come under the very high productivity index value of 125. Paati block in District Champawat has the lowest productivity index value of 32.14. High productivity index was not recorded in the Kumaun Himalaya, however, blocks that had a medium crop productivity index values were Dharchula, Didihat, Berinag, Galgolihat, Bin, Kanalichina and Moonakot. Low productivity was observed only in Munsyari Block. There are 20 blocks that have very low productivity indexes, they are Garur, Salt, Bhimtal, Haldwani, Kapkot, Ramnagar, Kotabag, Tarikhet, Bhikiyasain, Dwarahat, Chaukhutiya, Bageshwar, Bhaishiyachana, Dhauladevi, Hawalbag, Syalde, Barakot, Champawat, Lohaghat and Paati.

Productivity Regions of *Litchi* Fruit Crops
There are 36 blocks that produce litchi fruit, some of them, such as Ramnagar, Tanakpur, Haldwani and Kotabag are famous for Litchi production. The highest productivity index of 342.36 was recorded for Bin block, and the lowest crop productivity index was recorded in Dwarahat block of Almora district. Hawalbag, Lamgara, Takula, Dhari and Ramgarh block did not have any cultivation of litchi fruit crops. High crop productivity was found in Bhimtal, Kanalichina and Betalghat blocks. Medium productivity was not observed, as shown in Table 4.1.7 Low crop productivity with index values in the range of 75-99 values were observed in Dharchula, Jaspur, Sitarganj, Gadarpur, Kashipur, Bajpur, Rudrapur, Khatima and Berinag blocks. Very low litchi crop productivity, below 75 index value, was observed in 16 blocks are Okhalkanda, Barakot, Champawat, Lohaghat, Paati, Bageshwar, Garur, Dhauladevi, Bhaishiyachana, Tarikhet, Syalde, Salt, Bhikiyasain, Chaukhutiya, Kapkot and Dwarahat.

Productivity Regions of *Mango* Fruit Crops
Crop productivity index of mango fruit shows two dominant extreme ranges, on the one hand is the very high index range with 14 blocks and on the other is the very low productivity regions in 17 blocks of Kumaun, Mango fruit crops commonly observed and with average production in all blocks of Kumaun Himalayan regions. Mango is cultivated in subtropical and tropical climate, but the variety cultivated in the valleys of Kumaun Himalaya, are not a high yield variety. Highest productivity of 208.29 was recorded for Dhauladevi block and the lowest productivity index value of 27.23 at Champawat block. Very high fruit crop productivity regions with index value range of above 125 were observed in Dhauladevi, Lamgara, Hawalbag, Takula, Bajpur, Jaspur, Rudrapur, Kashipur, Gadarpur, Khatima, Sitarganj, Didihat, Tarikhet and Moonakot blocks. High crop productivity regions are namely Kanalichina, Bhaishiyachana and Berinag. Bageshwar block is the only one with medium crop productivity. Low crop productivity index range of 75-99 is found in Bhikiyasain, Salt, Dwarahat, and Munsyari. There are of 13 blocks under the very low crop productivity index value, namely Syalde, Okhalkanda, Betalghat, Ramnagar, Haldwani,

Bhimtal, Kotabag, Chaukhutiya, Kapkot, Dharchula, Garur, Bin, Galgolihat, Lohaghat, Paati, Barakot and Champawat of Kumaun Himalaya (Fig. 4).

Productivity Regions of *Peach* Fruit Crops

Peach fruit is cultivated in middle Himalaya and higher Himalayan ranges of Kumaun. The very high fruit crop productivity index values regions are in the blocks of Munsyari, Didihat, Dwarahat, Tarikhet, Dhauladevi, Galgolihat and Lamgara, Munsyari block has the highest crop productivity index of 375.97, while Barakot block has the lowest crop productivity index of 22.76 for peach. Salt, Syalde, Bhikiyasain, Bhaishiyachana, Chaukhutiya, Takula, Hawalbag blocks are regions of high productivity with indexes in the range of 101-125. Medium crop productivity regions of peach were not found in Kumaun Himalaya. Kanalichina is the only block having a low productivity index. There are 17 blocks, namely Ramgarh, Dhari, Moonakot, Betalghat, Bhimtal, Okhalkanda, Kotabag, Bin, Bageshwar, Berinag, Garur, Dharchula, Kapkot, Lohaghat, Champawat, Paati and Barakot that in the range of very low crop productivity index value of below 75. There are only 07 blocks are under the very high productivity index range as compared to 17 blocks in the very low productivity group. Due to less effort of commercialization of the peach fruit at the national and international level markets, the farmers are not attracted to cultivate this fruit in the Kumaun Himalayan regions. Due to adverse climatic conditions in Udham Singh Nagar there was no peach fruit crop production in the district.

Productivity Regions of *Pear* Fruit Crops

A somewhat similar pattern of productivity, as observed for peach, was observed for pear fruit also. It had very high crop productivity index in the blocks of Munsyari, Didihat, Ramnagar, Haldwani, Syalde, Kotabag, Chaukhutiya, Dharchula and Ramgarh. The highest crop productivity was recorded in the Munsyari block of District Pithoragarh with an index of 195.74, and the lowest crop productivity region was Kapkot block of Bageshwar district. High crop productivity regions are found in Bhaishiyachana, Dhari, Okhalkanda, Betalghat, Bhikiyasain, Salt, Bhimtal, Galgolihat, Tarikhet, Dhauladevi, Takula and Dwarahat blocks of Kumaun Himalaya. Pear is a common fruit crop that is cultivated in all blocks, mostly for use in the manufacture of wine and liquor. Hawalbag block is the only one of the regions under medium crop productivity, while Lamgara, Kanalichina, Khatima, Bajpur, Gadarpur, Jaspur, Kashipur, Rudrapur, Sitarganj and Bin blocks lie in the 75-99 index range of low pear crop productivity region. Berinag, Moonakot, Lohaghat, Paati, Bageshwar, Barakot, Champawat, Garur and Kapkot in Kumaun Himalaya have very low productivity index of pear. There are 21 blocks that have high and very high crop productivity regions of pear crops. There are nineteen blocks under the low and very low crop productivity regions, while the only one remaining block has medium crop productivity of pear.

Productivity Regions of *Plum* Fruit Crops

Due to limitations of sutability of climatic conditions, the plum fruit us cultivated in 32 blocks in the Kumaun Himalaya, and the remaining 09 blocks do not have any cultivation of plum fruit. Main blocks that produce with very high crop productivity index of plum are, Hawalbag, Dhauladevi, Lamgara, Syalde, Bhaishiyachana, Bhikiyasain, Chaukhutiya and Takula blocks. High crop productivity regions of cultivation of plum fruit are located in Tarikhet, Salt, and Dwarahat, Munsyari, Galgolihat, Didihat, Moonakot, Berinag, Bin, Dharchula and Kanalichina blocks. There is no region that has medium crop productivity, and there are only five blocks, namely Okhalkanda, Bhimtal, Dhari, Betalghat and Ramgarh, that have a low crop productivity rank. Kotabag, Bageshwar, Garur, Champawat, Paati, Barakot, Lohaghat and Kapkot are having very low crop productivity regions in Kumaun Himalaya. The highest Plum fruit crop productivity was recorded for Hawalbag with 148.39 index and the lowest crop productivity was at Kapkot block with an index of just 13.62. Besides the medium rank of productivity another very high, high, low and very low crop productivity of plum cultivated in general way.

Productivity Regions of *Walnut* Fruit Crops

Walnut is a rare fruit of nature which is neither a ubiquitous crop nor is found and cultivated everywhere. Walnut plants grow automatically due to sutiabiilty of climatic and altitudinal physiography in the Kumaun Himalaya. It is not commercialized here, therefore production of walnut is found in lesser scale than other of horticultural crops in Kumaun Himalaya. However, the highest productivity was recorded at Tarikhet block (138.28) and lowest was seen at Barakot block, this shows that, productivity decreased towards souther part of the Kumaun. Very high productivity was recorded for Tarikhet, Bhaishiyachana, Hawalbag, Bhikiyasain, Dhauladevi, Syalde, Salt, Dwarahat, Takula and Kanalichina. High value walnut crop productivity regions are Munsyari, Chaukhutiya, Lamgara, Garur, Moonakot, Kapkot, Dharchula and Galgolihat. While medium crop productivity for walnut has not found in the study region. There are three blocks under the low crop productivity, namely, Berinag, Bin and Didihat. Very low crop productivity regions were observed in 10 blocks, namely, Bageshwar, Dhari , Betalghat, Bhimtal, Okhalkanda, Ramgarh, Champawat, Paati, Lohaghat and Barakot. Walnut is now being cultivated in a commercialized

way, but still at a small scales. Walnut is cultivated in the Middle Himalayas to Higher Himalayas regions in scattered patches as walnut trees take time to mature bear the fruit after many years.
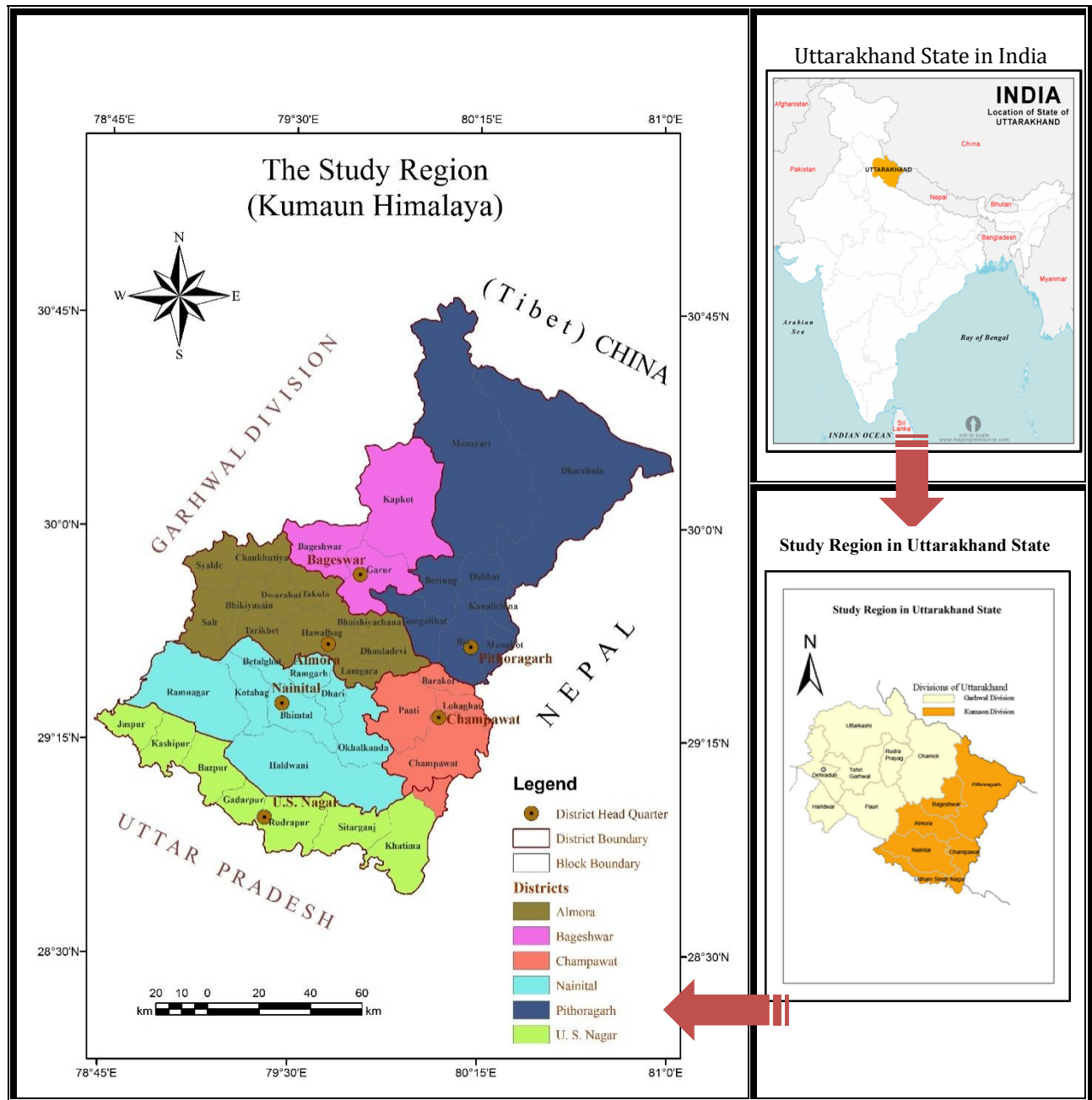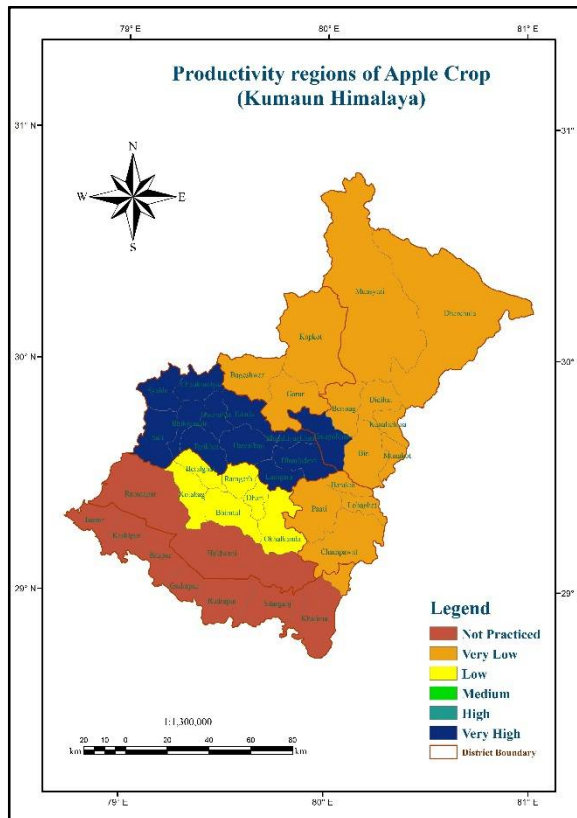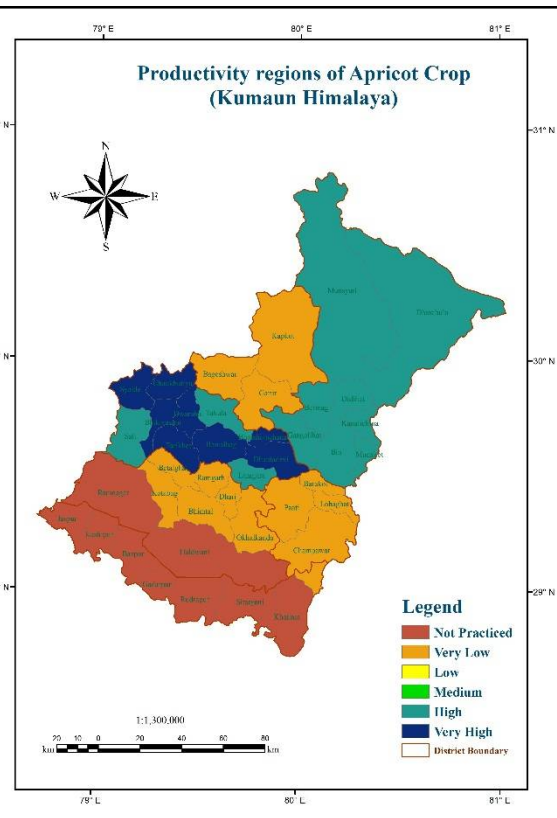

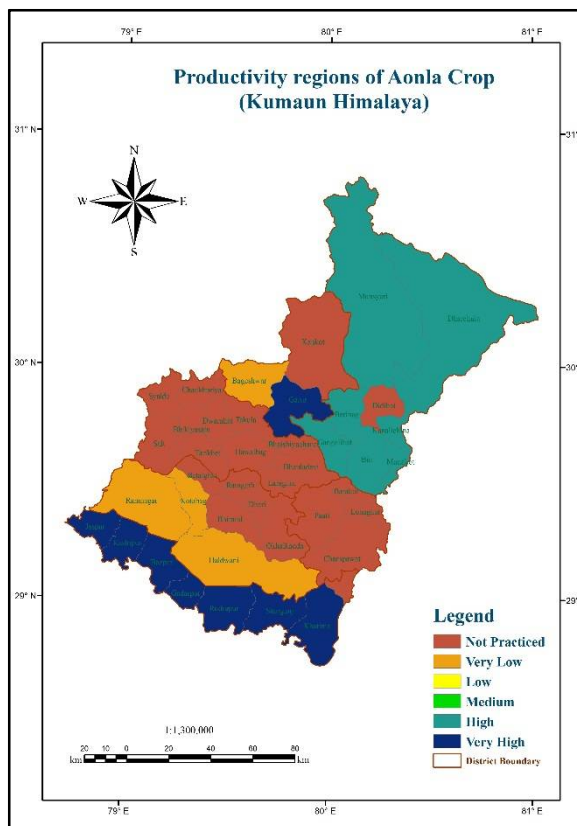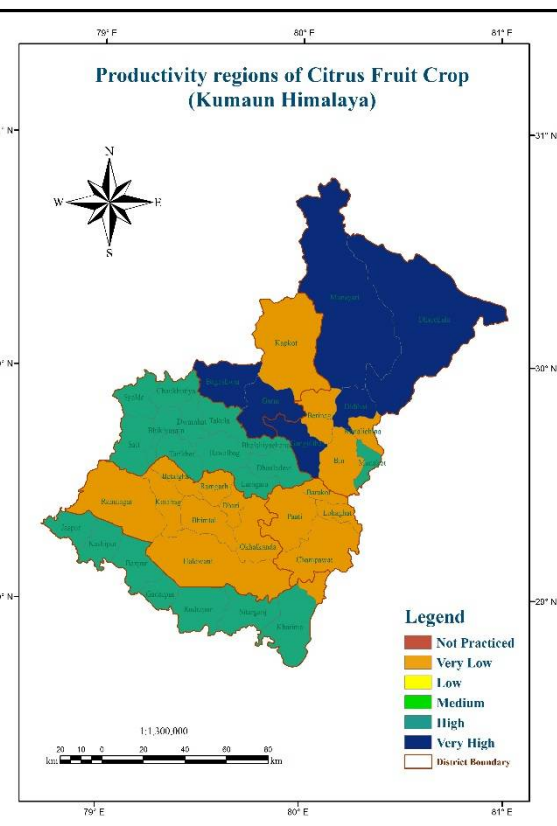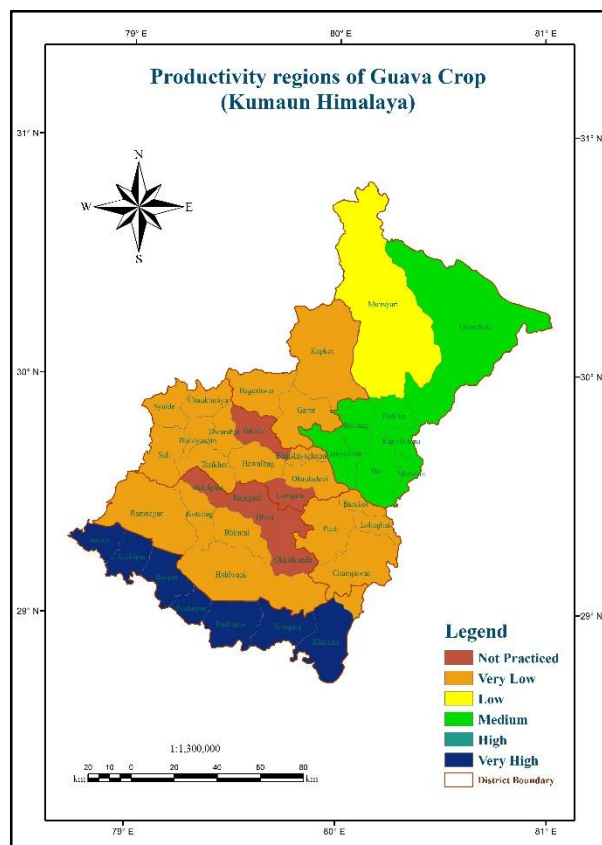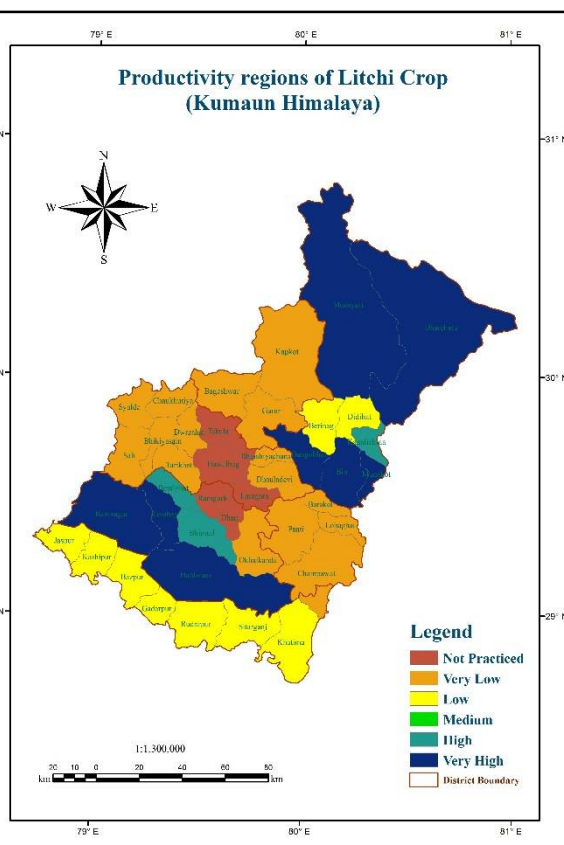**Fig. 1 Location Map: The Study Region (Kumaun Himalaya)**

Fig. 2:

Fig. 3

Fig. 4

Fig. 5

Fig. 6
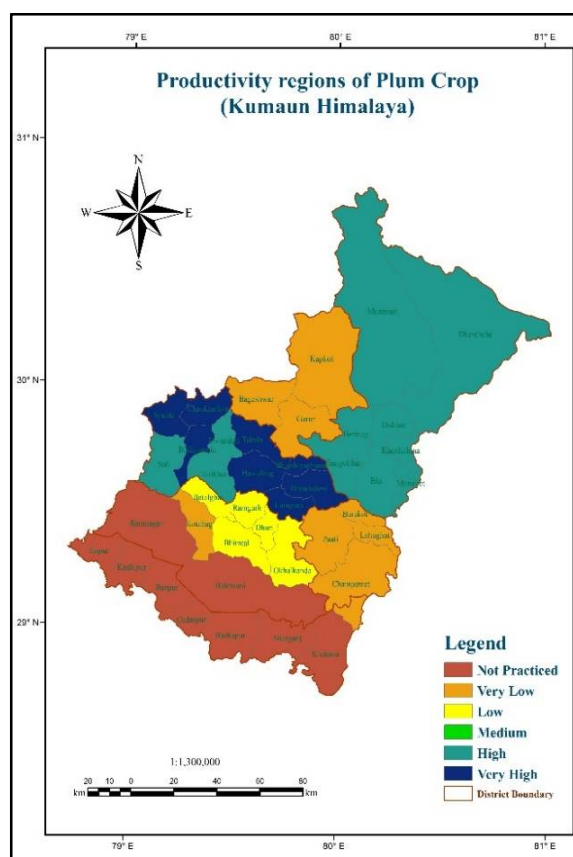

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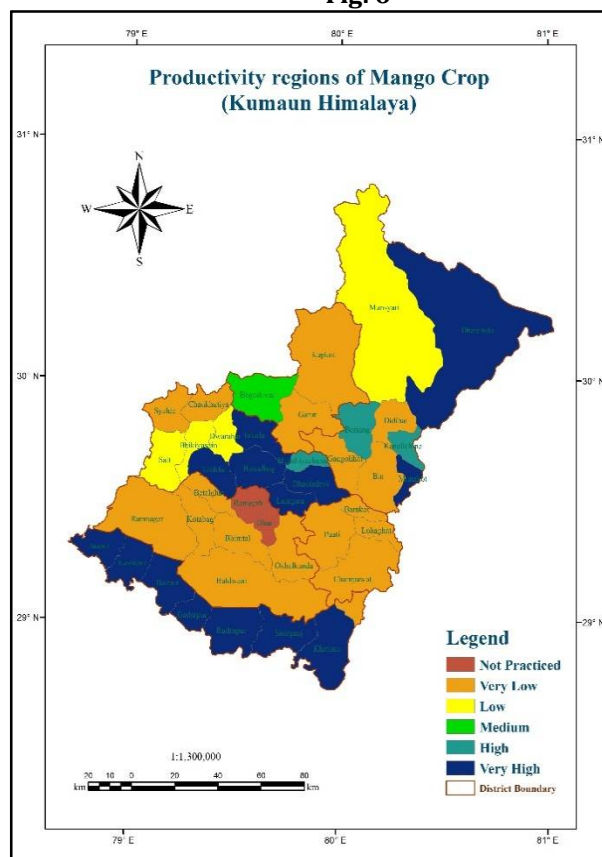
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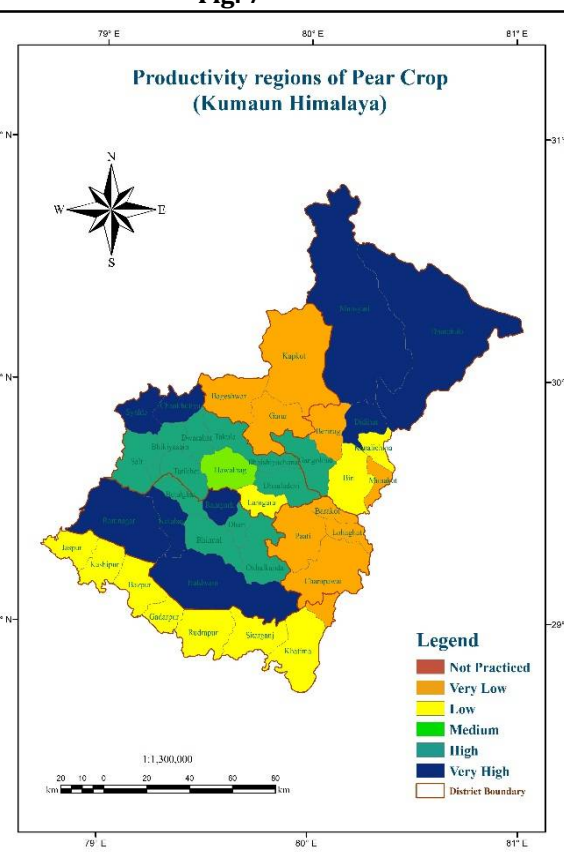
Fig. 9

Fig. 10
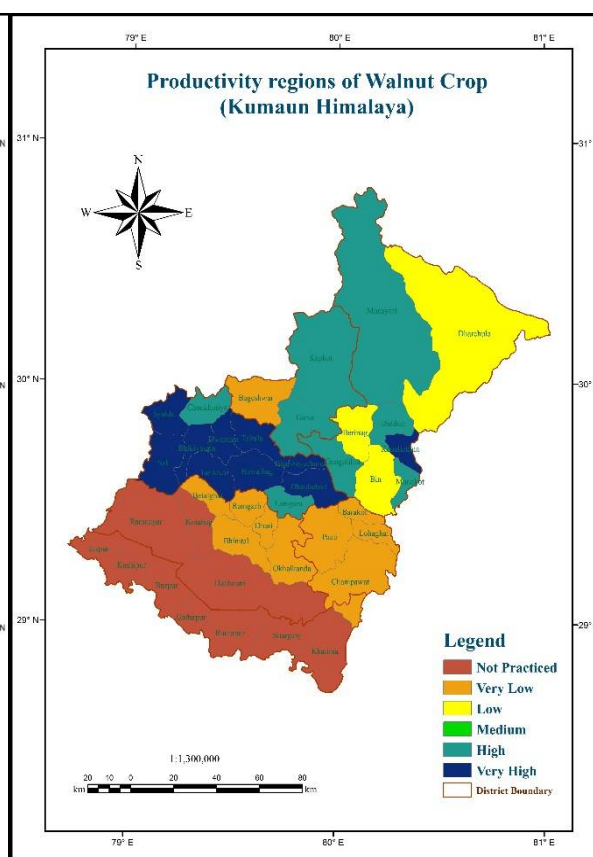
Fig. 11
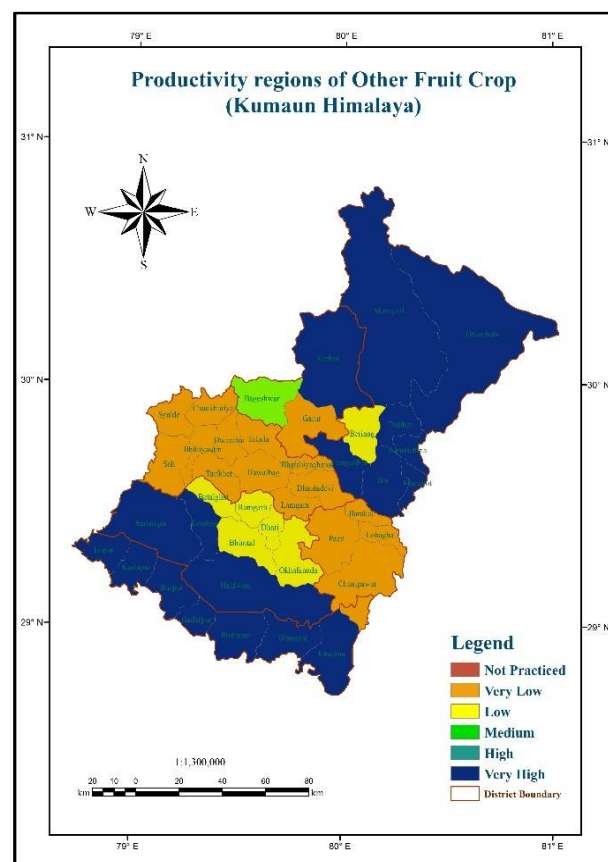
Fig. 12
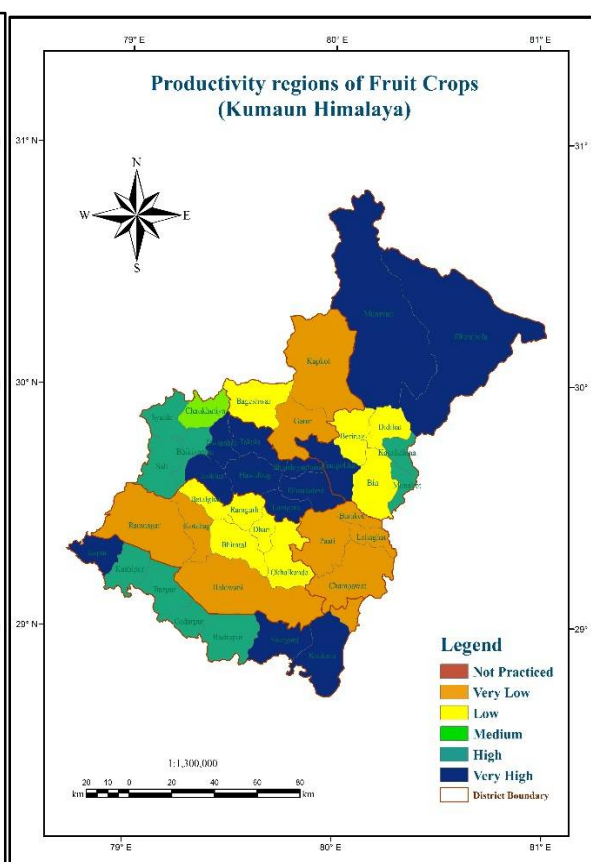
Fig. 13

Table 2: Crop Productivity Index of Fruit crops, Kumaun Himalaya (Average 2003-11)

SI. No.	Block Regions	Apple	Apricot	Aonla	Citrus	Guava	Litchi	Mango	Peach	Pear	Plum	Walnut	Other Fruits	Total Fruits
A	Almora (1-11)	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value
1	Bhaishiyachana	192.03	126.28	0.00	118.53	47.81	19.66	109.57	110.55	124.46	128.22	135.72	53.36	126.12
2	Bhikiyasain	136.65	132.91	0.00	119.76	55.49	13.30	86.25	110.82	119.74	128.15	129.90	63.75	109.79
3	Chaukhutiya	136.91	133.66	0.00	118.53	48.78	13.07	59.01	110.02	131.53	127.01	123.47	49.02	100.93
4	Dhauladevi	205.12	150.67	0.00	111.36	42.68	29.21	208.29	201.06	108.80	129.48	129.81	52.56	158.49
5	Dwarahat	168.69	137.37	0.00	118.56	51.22	10.22	82.26	250.03	103.02	112.92	129.36	52.37	137.33
6	Hawalbag	131.11	134.31	0.00	118.59	42.68	0.00	203.85	109.50	100.83	148.39	132.35	63.54	140.35
7	Lamgara	252.20	120.93	0.00	105.36	0.00	0.00	204.86	152.34	96.62	129.05	123.20	50.62	151.10
8	Salt	133.86	117.49	0.00	119.94	68.29	14.05	83.53	111.60	119.32	123.40	129.53	62.84	112.21
9	Syalde	129.88	138.86	0.00	115.75	37.56	14.98	71.86	111.37	139.27	128.81	129.70	65.46	108.08
10	Takula	150.15	117.21	0.00	116.13	0.00	0.00	203.33	110.02	107.79	125.47	129.20	54.46	134.69

S.No	Block	Index Values												
11	Tarikhet	149.98	138.28	63.63	123.76	110.18	242.49	159.37	15.33	58.05	105.31	0.00	132.33	215.99
B.	**Bageshwar (12-14)**	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value
12	Bageshwar	80.00	99.24	36.40	59.58	32.08	31.78	41.25	100.18	48.18	48.48	136.59	12.72	15.88 / 6.13
13	Garur	56.00	36.40	120.98	31.34	21.28	32.98	55.70	46.36	73.88	131.76	130.04	16.47	1.09
14	Kapkot	58.33	196.51	114.56	13.62	15.53	26.43	57.50	12.58	67.57	71.14	0.00	6.56	2.16
C.	**Champawat (15-18)**	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value
15	Barakot	30.05	39.85	8.38	18.04	30.73	22.76	29.26	64.25	33.40	28.11	0.00	19.26	22.74
16	Champawat	28.76	42.00	9.12	19.00	27.18	25.47	27.23	64.01	33.25	28.36	0.00	16.07	22.84
17	Lohaghat	30.44	37.32	8.44	17.48	32.71	25.64	29.31	63.89	33.25	28.27	0.00	17.01	22.72
18	Paati	30.52	40.65	8.62	18.69	32.09	24.89	29.28	55.76	32.14	25.62	0.00	19.53	20.85
D.	**Nainital (19-26)**	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value
19	Betalghat	84.47	80.87	29.70	76.39	121.65	64.44	66.14	104.11	0.00	65.08	0.00	53.95	85.80

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No.	Block													
20	Bhimtal	85.77	52.92	0.00	63.21	68.29	118.31	65.29	63.78	119.20	78.24	28.40	97.27	95.16
														83.83
														66.83
21	Dhari	85.86	54.31	0.00	61.14	0.00	0.00	0.00	71.86	122.50	77.05	29.91	82.09	83.83
22	Haldwani	0.00	0.00	38.59	60.55	68.29	140.37	65.40	0.00	153.00	0.00	0.00	183.29	66.83
23	Kotabag	84.71	74.09	23.25	59.83	58.98	137.11	65.06	52.90	133.53	74.45	0.00	214.89	63.37
24	Okhalkanda	86.15	57.08	0.00	70.66	0.00	73.82	68.17	62.32	121.88	78.58	27.12	84.69	86.90
25	Ramgarh	85.88	56.40	0.00	60.57	0.00	0.00	0.00	72.61	127.12	75.92	26.12	83.44	81.89
26	Rannagar	0.00	0.00	30.32	60.55	65.32	137.23	65.61	0.00	167.51	0.00	0.00	252.90	64.48
E.	Pithoragarh (27-34)	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value
27	Berinag	1.91	104.19	112.46	69.82	99.03	76.12	104.95	34.57	60.59	101.63	87.87	95.42	81.94
28	Bin	12.17	104.19	112.46	61.61	99.02	368.92	51.77	50.49	82.24	101.62	84.58	202.30	92.25
29	Dharchula	20.28	104.20	0.00	129.28	99.03	94.92	57.48	28.64	130.72	101.62	107.94	210.33	98.80
30	Didihat	16.50	104.21	112.47	776.67	99.03	342.86	175.71	362.41	184.96	101.63	83.94	246.05	361.88

No.	Place	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value
31	Gangolihat	152.93	104.19	112.47	143.00	99.03	297.69	45.83	149.29	112.92	101.63	104.55	189.41	102.91	146.90
32	Kanalichina	4.89	104.19	112.49	70.17	99.02	112.31	111.32	92.48	96.25	101.57	127.50	215.88	114.09	
33	Moonakot	5.59	104.19	112.48	117.55	99.02	341.18	140.61	69.50	52.58	101.63	120.58	177.93	340.10	
34	Munsyari	16.93	103.89	112.49	527.15	98.99	305.55	78.88	375.97	195.74	101.64	123.85	155.62		
F.	U.S. Nagar (35-41)	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value	Index Value
35	Bajpur	0.00	0.00	198.48	118.53	136.59	76.66	177.58	0.00	94.97	0.00	0.00	171.89	124.10	
36	Gadarpur	0.00	0.00	198.48	118.53	136.59	76.80	177.56	0.00	94.97	0.00	0.00	171.86	123.61	
37	Jaspur	0.00	0.00	209.50	118.53	136.59	77.00	177.58	0.00	94.97	0.00	0.00	171.87	140.66	
38	Kashipur	0.00	0.00	198.48	118.53	136.59	76.78	177.56	0.00	94.97	0.00	0.00	172.02	122.98	
39	Khatima	0.00	0.00	198.48	118.53	136.59	76.44	177.56	0.00	95.09	0.00	0.00	172.06	132.70	
40	Rudrapur	0.00	0.00	198.48	118.53	136.59	76.61	177.58	0.00	94.97	0.00	0.00	171.77	123.03	
41	Sitarganj	0.00	0.00	198.48	118.88	136.59	76.81	177.56	0.00	94.97	0.00	0.00	171.60	127.57	

Table 3: Productivity index level of Regions of Fruit Crops, Kumaun Himalaya

Sl. No.	Fruit Crops	Very High (>125)	High (101-125)	Medium (99-101)	Low (75-99)	Very Low (< 75)
1	Apple	Lamgara, Tarikhet, Dhauladevei, Bhaishiyachana, Dwarahat, Galgolihat Takula, Chaukhutiya, Bhikiyasain, Salt Hawalbag, Syalde	N.A.	N.A.	Okhalkanda, Ramgarh, Dhari, Betalghat, Bhimtal, Kotabag	Champawat, Barakot, Lohaghat, Paati Dharchula, Munsyari, Didihat , Bin, Bageshwar, Moonakot, Kanalichina, Kapkot, Berinag, Garur
2	Apricot	Dhauladevi, Syalde, Dwarahat, Hawalbag, Chaukhutiya, Bhikiyasain, Tarikhet, Bhaishiyachana	Lamgara, Salt, Takula, Didihat , Dharchula, Galgolihat, Kanalichina, Moonakot, Bin, Berinag Munsyari	N.A.	Kotabag, Okhalkanda, Ramgarh, Dhari, Betalghat, Bhimtal, Paati, Barakot, Lohaghat, Garur, Champawat, Bageshwar Kapkot	N.A.
3	Aonla	Jaspur, Sitarganj, Rudrapur, Khatima, Kashipur, Gadarpur, Bajpur, Garur	Munsyari, Kanalichina, Moonakot, Galgolihat, Didihat, Berinag, Bin	N.A.	N.A.	Haldwani, Ramnagar, Kotabag, Bageshwar
4	Citrus	Didihat, Munsyari, Galgolihat, Bageshwar, Garur, Dharchula	Salt, Bhikiyasain, Sitarganj, Hawalbag, Dwarahat, Bhaishiyachana, Chaukhutiya, Bajpur, Gadarpur, Jaspur, Kashipur, Khatima, Rudrapur, Moonakot, Takula, Syalde, Dhauladevei, Lamgara, Tarikhet	N.A.	N.A.	Kapkot, Okhalkanda, Kanalichina, Berinag, Betalghat, Bhimtal, Bin, Dhari, Ramgarh, Haldwani, Ramnagar, Kotabag, Champawat, Lohaghat, Barakot, Paati
5	Guava	Bajpur,Gadarpur, Jaspur, Kashipur, Khatima, Rudrapur, Sitarganj	N.A.	Dharchula,Didihat ,Berinag, Galgolihat , Bin, Kanalichina, Moonakot	Munsyari	Garur, Salt, Bhimtal, Haldwani, Kapkot, Ramnagar, Kotabag, Tarikhet, Bhikiyasain, Dwarahat, Chaukhutiya, Bageshwar, Bhaishiyachana, Dhauladevei, Hawalbag, Syalde, Barakot, Champawat, Lohaghat, Paati
6	Litchi	Bin, Didihat , Moonakot, Munsyari, Galgolihat, Haldwani, Ramnagar, Kotabag	Bhimtal, Kanalichina, Betalghat	N.A.	Dharchula,Jaspur, Sitarganj, Gadarpur, Kashipur, Bajpur, Rudrapur, Khatima Berinag	Okhalkanda, Barakot, Champawat, Lohaghat,Paati, Bageshwar, Garur,Dhauladevei, Bhaishiyachana, Tarikhet, Syalde, Salt, Bhikiyasain, Chaukhutiya, Kapkot, Dwarahat

Sl. No.	Fruit Crops	Very High (>125)	High (101-125)	Medium (99-101)	Low (75-99)	Very Low (<75)
7	Mango	Dhauladevei, Lamgara, Hawalbag, Takula, Bajpur, Jaspur, Rudrapur, Kashipur,Gadarpur, Khatima, Sitarganj, Didihat, Tarikhet, Moonakot	Kanalichina, Bhaishiyachana, Berinag	Bageshwar	Bhikiyasain, Salt, Dwarahat, Munsyari	Syalde, Okhalkanda, Betalghat, Ramnagar, Haldwani, Bhimtal, Kotabag, Chaukhutiya, Kapkot, Dharchula, Garur, Bin, Galgolihat, Lohaghat, Paati, Barakot Champawat
8	Peach	Munsyari, Didihat, Dwarahat, Tarikhet, Dhauladevei, Lamgara, Galgolihat	Salt, Syalde, Bhikiyasain, Bhaishiyachana, Chaukhutiya, Takula, Hawalbag	N.A.	Kanalichina	Ramgarh,Dhari, Moonakot, Betalghat, Bhimtal, Okhalkanda, Kotabag, Bin, Bageshwar, Berinag, Garur, Dharchula,Kapkot, Lohaghat, Champawat, Paati, Barakot
9	Pear	Munsyari, Didihat ,Ramnagar, Haldwani, Syalde, Kotabag, Chaukhutiya, Dharchula, Ramgarh	Bhaishiyachana, Dhari, Okhalkanda, Betalghat, Bhikiyasain, Salt, Bhimtal, Galgolihat, Tarikhet, Dhauladevei, Takula, Dwarahat	Hawalbag	Lamgara,Kanalichina, ,Khatima, Bajpur, Gadarpur, Jaspur, Kashipur, Rudrapur, Sitarganj, Bin	Berinag, Moonakot, Lohaghat, Paati, Bageshwar, Barakot, Champawat, Garurm, Kapkot
10	Plum	Hawalbag, Dhauladevei, Lamgara, Syalde,Bhaishiyachana, Bhikiyasain,Chaukhutiya, Takula	Tarikhet, Salt, Dwarahat, Munsyari, Galgolihat, Didihat, Moonakot, Berinag, Bin, Dharchula, Kanalichina	N.A.	Okhalkanda, Bhimtal, Dhari, Betalghat Ramgarh	Kotabag, Bageshwar, Garur, Champawat, Paati, Barakot, Lohaghat, Kapkot
11	Walnut	Tarikhet, Bhaishiyachana, Hawalbag, Bhikiyasain, Dhauladevei, Syalde, Salt, Dwarahat, Takula, Kanalichina	Munsyari, Chaukhutiya, Lamgara, Garur, Moonakot, Kapkot, Dharchula, Galgolihat	N.A.	Berinag, Bin, Didihat	Bageshwar, Dhari, , Betalghat, Bhimtal, Okhalkanda, Ramgarh, Champawat, Paati, Lohaghat, Barakot
12	Other Fruits	Ramnagar, Didihat , Kanalichina, Kotabag, Dharchula, Bin, Kapkot, Galgolihat, Haldwani, Moonakot, Khatima, Kashipur, Bajpur, ,Jaspur Gadarpur, Rudrapur, Sitarganj, Munsyari	N.A.	Bageshawar	Bhimtal, Berinag, Okhalkanda, Ramgarh, Dhari, Betalghat	Syalde, Bhikiyasain, , Tarikhet, Hawalbag, Salt, Takula, Bhaishiyachana, Dhauladevei, Dwarahat, Lamgara, Chaukhutiya, Champawat, Paati, Barakot, Lohaghat, Garur

CONCLUSION
This study indicate of the future of the significance of fruit cultivation in Kumaun Himalaya by the computation of productivity index. Some of the regions have more potential and agro-climatic zones for the fruit crops i.e., most favourable conditions like ecophysiological features as relief, temperature, soil and climate for cultivation of temperate fruit crops regions are Dhauladevei, Dwarahat, Chaukhutiya, Ramgarh, Hawalbag and Syalde and for the subtropical fruit crops regions Ramnagar, Kashipur, Rudrapur and Jaspur. Which regions have favourable condition by the ecophysiology they grow more fruit crops simultaneously productivity index have very high or high as well ranking. This study help to local agrarians, government planner and stakeholders for the better help to selection choice the regions for fruit crops cultivation for low input and high return in fruit cultivation in Kumaun Himalayan regions. Horticultural crop production and productivity of study region are a temporal phenomenon, and a multi-dimensional concept, which is related to many dimensions, such as effective management of available resources, technological advancement, organizational setup and community's perception of the crop production. All these factors affect the relative crop production of a region. Although it may be argued that agricultural development should be assessed by evaluated by applying various inputs in agricultural sectors both institutional and non-institutional, such as, the extent of cultivated area, the provision of irrigation, fertilizers, improved varieties of seeds and labour availability, etc. This activity not only provides fruits, vegetables and flowers to all but also help in expanding the secondary and tertiary sectors, increases the income levels and provide a boon to the population living in the rural areas. Secondary data was collected in order to assess crop productivity on average basis in each of the 41 Development Blocks belonging to the six districts of Kumaun Division of Uttarakhand for the period of 2012-2015. The eleven major fruit crops which are grown in the region, namely, apple, plum, apricot, citrus fruits, peach, walnut, mango, litchi, aonla, pear and guava, were considered for the productivity analysis.

CONFLICT OF INTEREST
The authors declare that there is no conflict of interest

REFERENCES
1. Bhatia, S.S., (1967). "A New Approach to Measure Agricultural Efficiency in Uttar Pradesh", Economics Geography Vol.43, pp.224-260
2. Noor Mohammdad and Singh, R., (1981). "Measurement of Crop Productivity", perspectives in Agricultural Geography, Vol. IV, Concept Publishing Company, p. 159.
3. Shafi, M., (1990)."Measurement of Agricultural Efficiency in Uttar Pradesh", Economic Geography, Vol.36, pp.296-305.
4. Whittlesey, D.,(1936). "Major Agricultural Regions of the Earth", Annals of the Association of American Geographers, pp. 199-240.
5. Patil, A.A., (2002). "Changes in Agricultural Productivity in Upper Bhima and Upper Krishna Basins in Maharashtra: A Geographical Analysis," Ph. D. Thesis, Shivaji University, Kolhapur.
6. C. Arul Kumar and G. Manimannan, (2014). "Spatial Pattern of Agriculture Productivity of Crops in Cauvery Delta Zone of Tamilnadu", Agriculture and Veterinary Science, Journal, (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 7, Issue 11 Ver. II, pp 01-07 .
7. Singh Jasbeer and Dhillon S.S., (2000). "Agricultural Geography", Tata McGraw-Hill Publication Company Limited, New Delhi, Second Edition, ISBN 0-07-462421-0, Text book, pp. 240-245.
8. Naik B.Hemla and D. Thippesh, (2014). Fundamentals of Horticulture & Production Technology of Fruit Crops, HRT. 101: Fundamentals of Horticulture and Production Technology of Fruit Crops; (2+1),14-15
9. Tuteja Usha, Baseline Data on Horticultural Crops in Uttarakhand, Research Study No. 2013/02,Agricultural Economics Research Centre University of DelhiDelhi -110 007, (2013)