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## Site suitability analysis for kiwi fruit plantation in Uttarakhand using GIS

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### Abstract

The present study has been conducted to analyze the suitability of Kiwi fruit in Uttarakhand state. The study area is located between latitude 28°43'N and 31°27'N and longitude 77°34'E and 81°02'E and covers approximately 53,485 sq km. A suitability resulting from the overlay process of the identified theme layers considering the requirement of kiwi on which the suitability is based exhibits the regions where kiwi could be grown. The identified theme layers include temperature (maximum, minimum, average temperature, altitude). All thematic layers with their associated attribute data were encoded in GIS database. Overlay operation was performed on these layers through raster calculation after giving different conditions related to the kiwi fruit in Quantum GIS (2.12.0) the analysis was a result of the crop requirements and the range of input variables in the state. Calculation was applied to formulate the suitability classes. The results indicate that height ranges from 400-1100m is unsuitable, 1100-1800m is highly suitable however 1800-2500 is suitable for the plantation of kiwi fruit. On the basis of the results, it can be recommended that kiwi fruit can be grown on the larger area of Uttarakhand state, most of the area of Uttarakhand state is highly suitable for growing the kiwi except District Udham singh nagar, Haridwar, and some part of Dehradun while district Chamoli, some part of Tehri Garhwal and some part of Nainital are suitable for growing Kiwi.

**Keywords:** Kiwi fruit, GIS, land suitability, site suitability

### Introduction

The kiwifruit, native to northern China, was first brought to and cultivated in New Zealand at the turn of the 20th century and was then known as the Chinese Gooseberry. Kiwi is one such species on which several local level livelihoods are dependent. As a plant, Kiwi is used as a horticultural crop and also have some nutritional properties Collagen, the skins support system, is reliant on vitamin C as an essential nutrient that works in our bodies as an antioxidant to help prevent damage caused by the sun, pollution and smoke, smooth wrinkles and improve overall skin texture. The fiber and potassium in kiwis support heart health. In particular, GIS has been used extensively for spatial analysis and land suitability as GIS functions could be employed for several forms of information including point, line and area. The geospatial technology can be very efficiently used in analyzing the suitability of agricultural and horticultural crops. Geographic information systems (GIS) and geostatistics are tools that are becoming progressively more suitable in fields of research like agriculture (Basso *et al.* 2001) [1]. Geostatistics are statistical methodologies that use spatial coordinates to help formulate models used in estimation and prediction. The spatial information resulted from this study could be utilized the wastelands for plantation which will not only help to increased income of villages but also minimize environmental problems.

### Materials and Methods

#### Study Area

The area of present study has been considered the state of Uttarakhand which is surrounded by Himachal Pradesh in the north-west and Uttar Pradesh in the south and shares its international borders with Nepal and China. This area is located between latitude 28°43'N and 31°27'N and longitude 77°34'E and 81°02'E. The plan of work shows in (Fig. 1).

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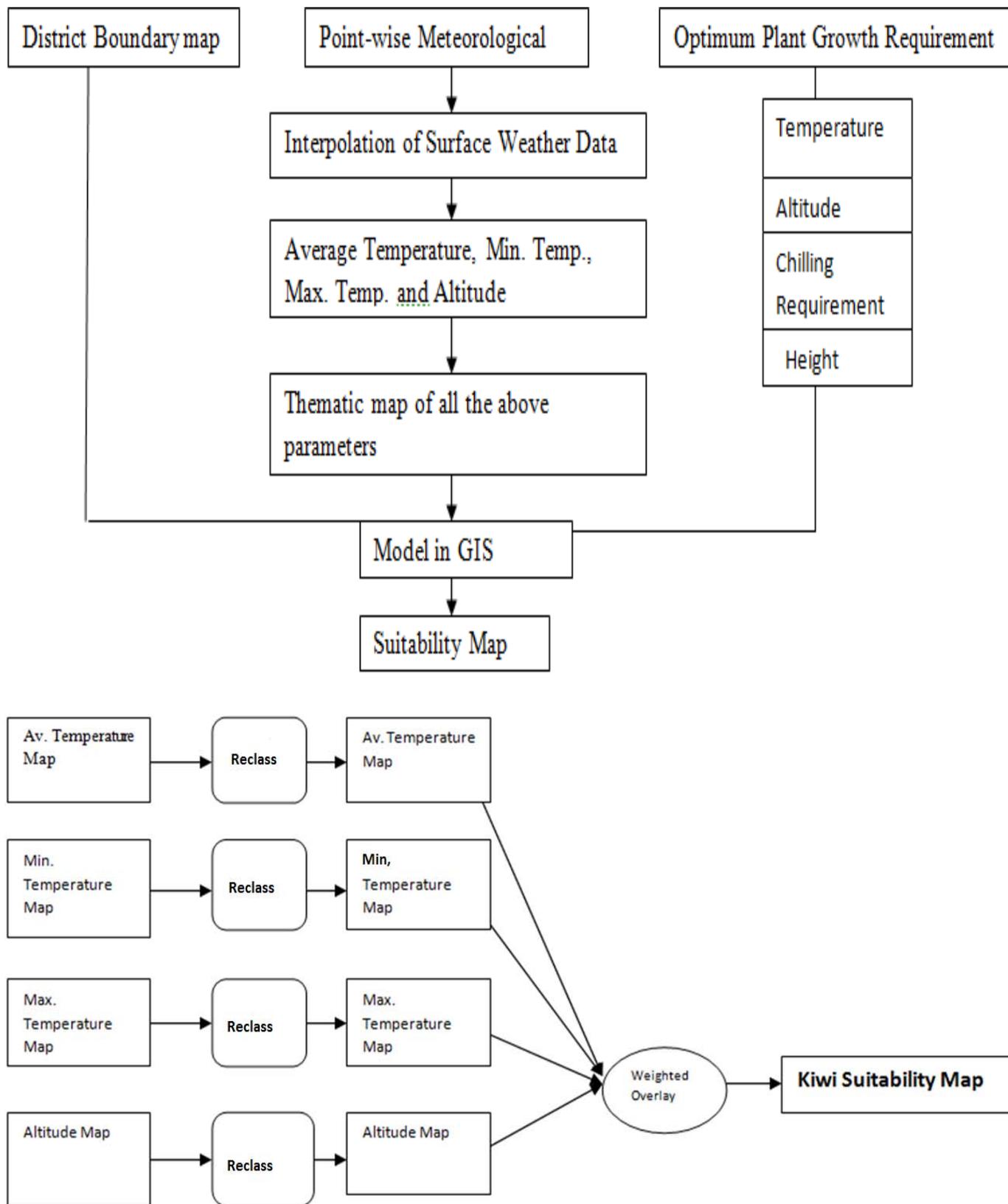


Fig 2: Model for Suitability

The methodology of Suitability analysis included the digitization of the map. Then the weather data were added to the project. The layers of different meteorological parameters were generated using the spatial analyst Extension of. aux.xml &. tif. Suitability model was developed using raster calculator in Q-GIS. The interpolated data related to climate converted

into raster format. The reclass function was added and reclasses of data was done. Then all these reclass data were combined to the inverse weighted overlay function and an inverse weighted overlay model was developed (Fig. 2) after this model was run and suitability map was generated.

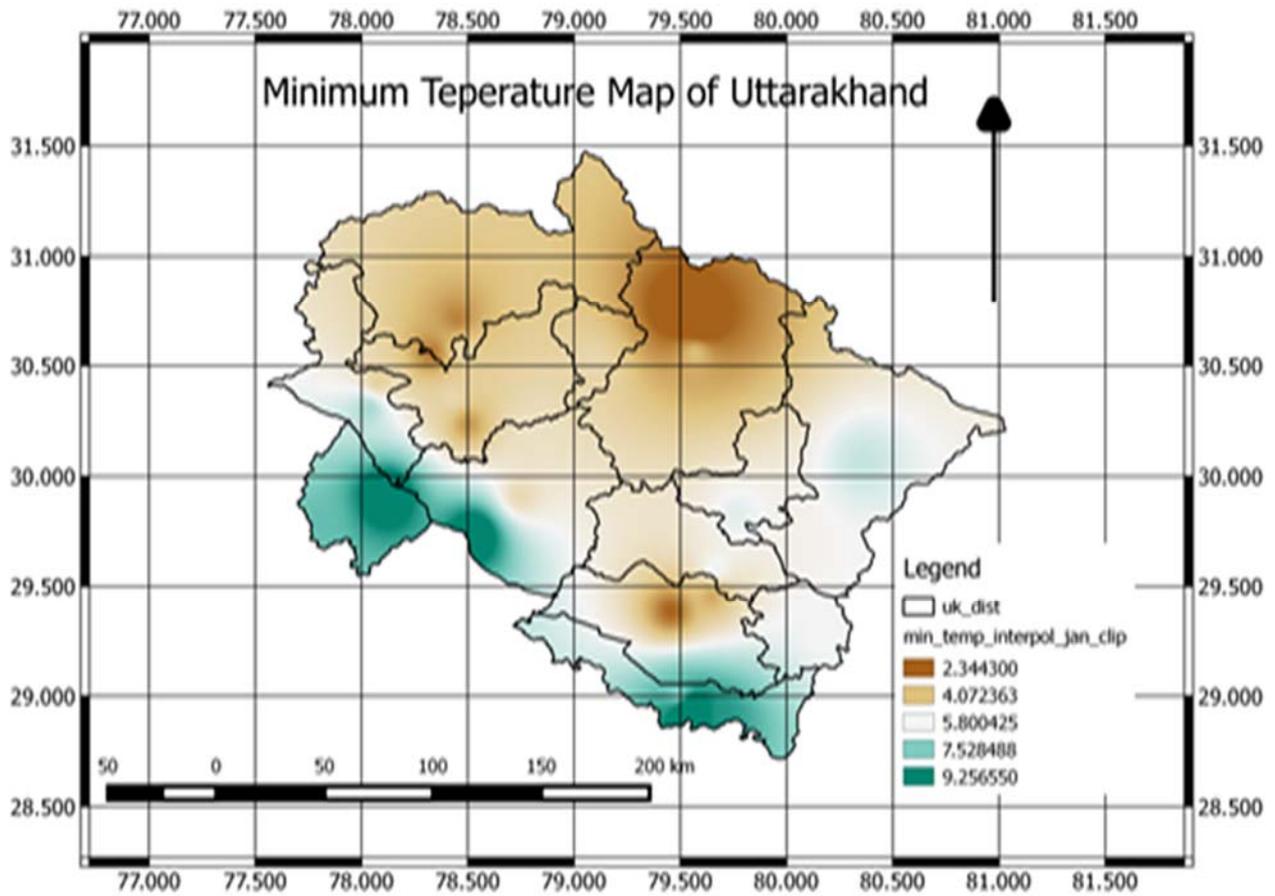


Fig 3: Minimum Temperature Map

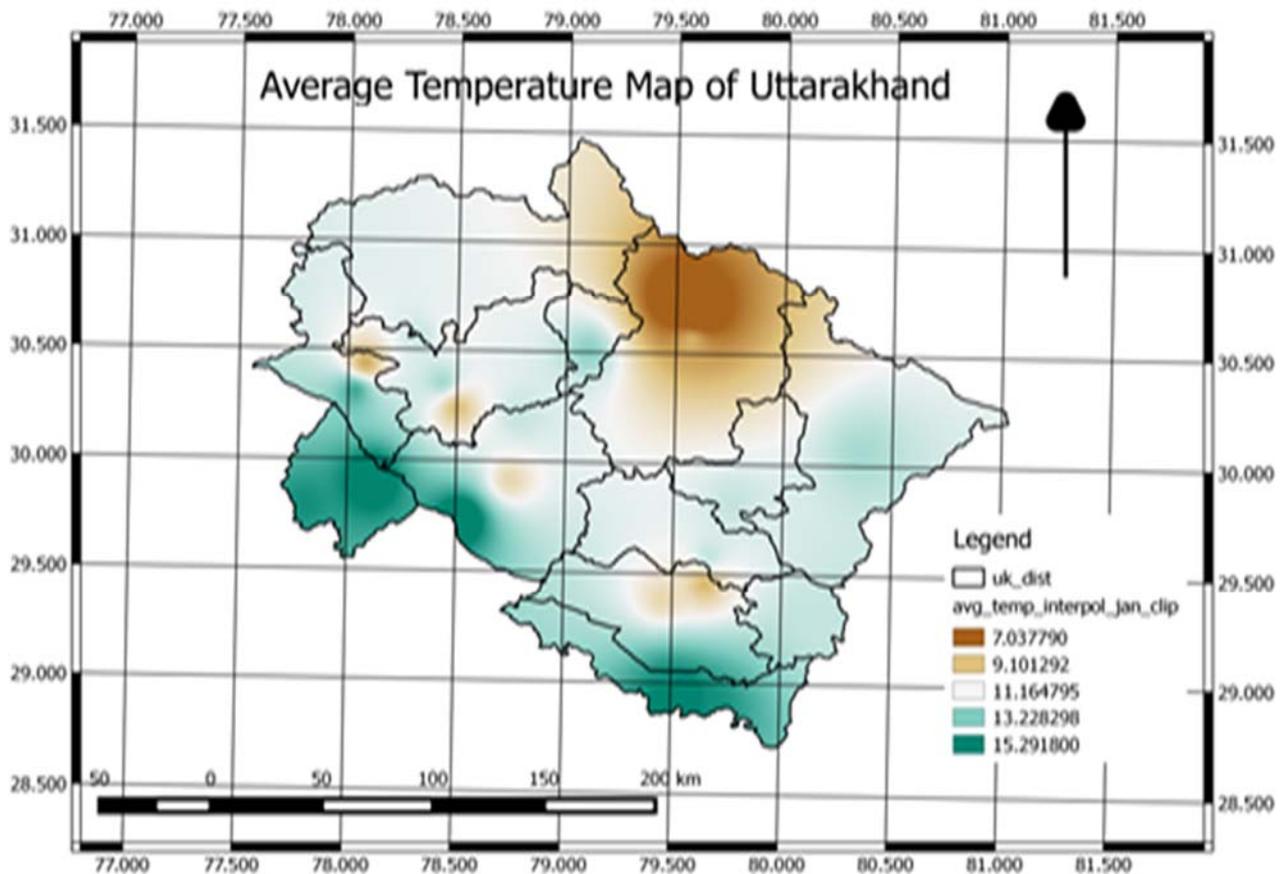


Fig 4: Average Temperature Map

Layers of different parameters i.e. minimum temperature, average temperature, maximum temperature and altitude are

shown in Fig. (3, 4, 5, 6) respectively which were overlaid to generate the suitability map for kiwi fruit.

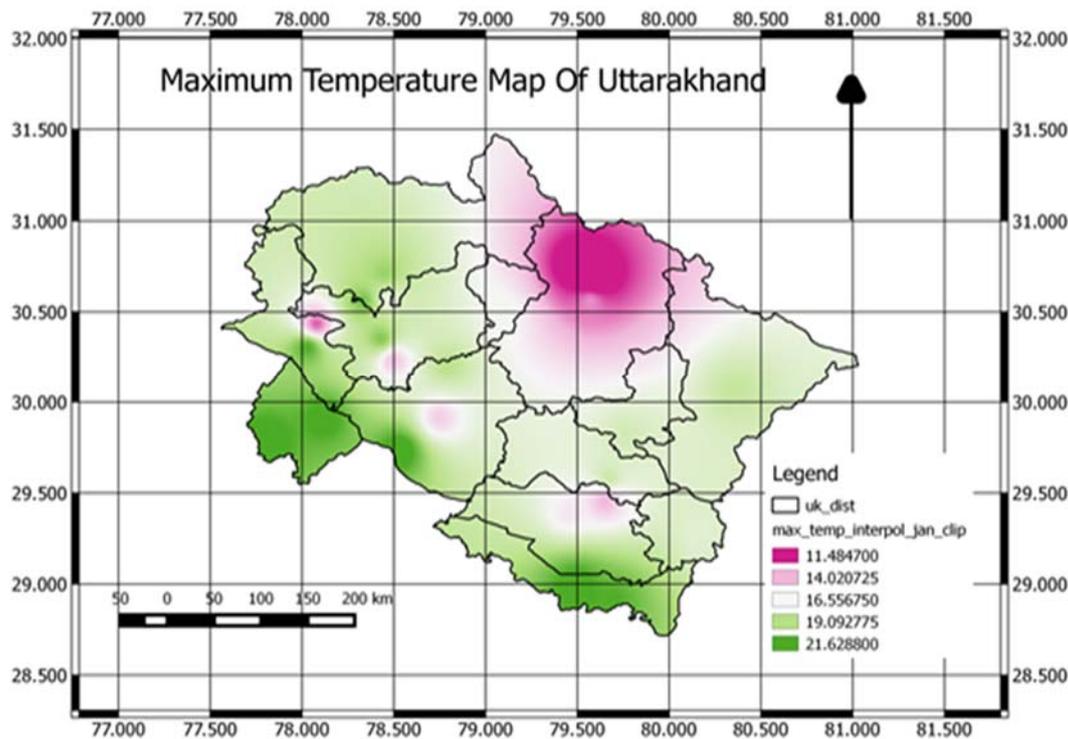


Fig 5: Maximum Temperature Map

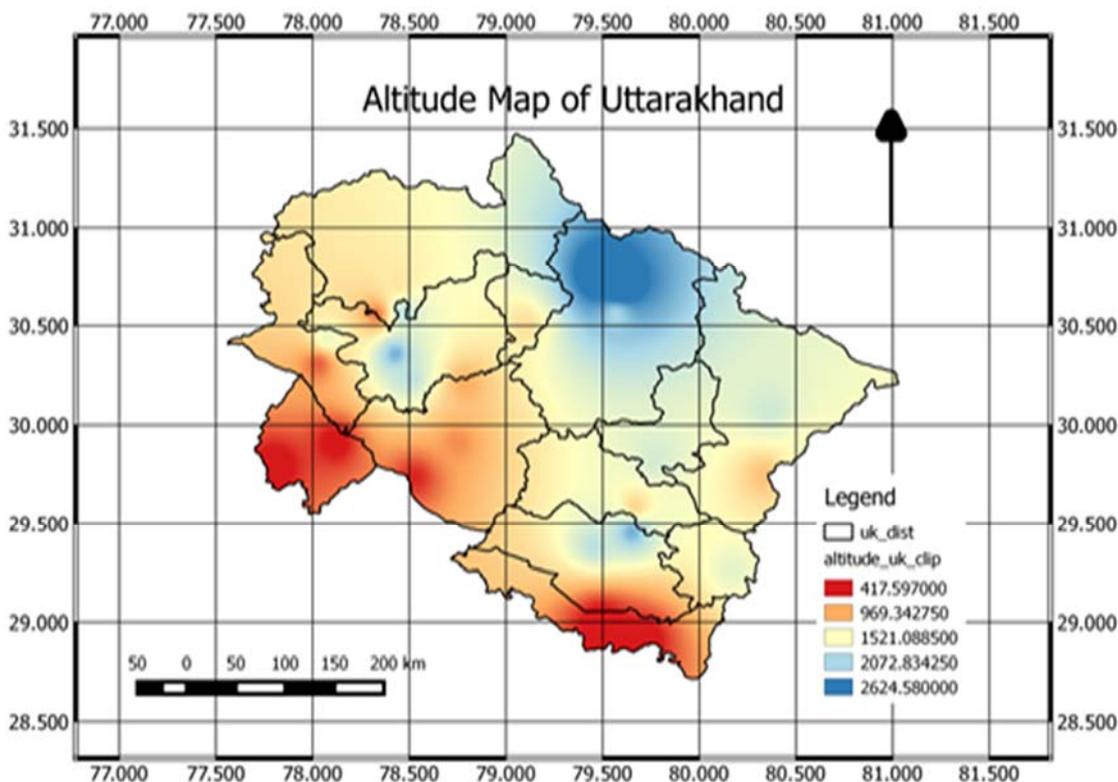


Fig 6: Altitude Map

**Climatic Data**

The data of all weather stations falling within the geographical boundaries of Uttarakhand were collected. Additionally, the data of meteorological observatories of adjoining states of Uttarakhand were also used in the present study.

Data collected from different weather stations which located in Uttarakhand like VPKAS Almora, ARIES Nainital, DEBER Haldwani, CRC Pantnagar, College of Forestry and Hill Agriculture, Ranichauri, FRI Dehradun and data of some

stations covered in UPROBE project of IIT, Roorkee were also considered, while some other stations, data were taken from published IMD periodicals. The complete list of stations of Uttarakhand with number of years has been appended in the Table. 1. The geo-coordinates of all the weather stations were collected recorded with the help of GPS or were collected from literature/published maps. Weather data with geo-coordinates were stored in .csv format in excel the entered in QGIS with geo-coordinates as shown in (Table 2).

**Table 1:** Climatic normals with no. of years for different stations of Uttarakhand

Station	Long.	Lat	Altitude	Total Rain fall	Avg temp	Max temp	Min temp	Years
Almora	79.67	29.6 0	1250.00	998.65	18.36	23.84	12.81	8
Bageshwar	79.77	29.84	1800.00	1397.27	18.81	24.16	13.46	37
Champawat	80.17	29.28	1675.00	1303.19	15.9 0	22.57	8.84	5
Chinyalisaur	78.33	30.57	755.00	1044.74	20.05	28.23	11.69	3
Dehradun	78.03	30.32	682.00	2222.23	21.67	27.96	15.38	38
Ghangaria	79.59	30.7 0	3049.00	1956.51	9.17	13.64	4.70	7
Joshimath	79.57	30.57	2073.00	1150.55	14.65	19.04	10.25	16
Jwalapur	78.12	29.93	300.00	1584.90	24.51	29.56	19.13	3
Kotdwar	78.53	29.75	454.00	1937.01	25.82	29.97	21.57	5
Mana	79.50	30.77	3219.00	1157.19	8.25	12.59	3.92	6
Mukhim	78.47	30.58	1944.00	1588.57	15.21	21.39	9.03	37
Mukteshwar	79.65	29.47	2311.00	1296.56	13.64	18.71	8.58	37
Mussoorie	78.08	30.45	1642.00	2036.42	13.90	17.64	10.15	17
Nainital	79.46	29.4 0	1953.00	2131.46	15.63	19.37	9.07	14
Pantnagar	79.49	29.02	216.00	1581.43	23.25	29.68	16.82	32
Pauri Garhwal	78.75	29.93	847.00	1100.14	18.88	23.13	14.64	7
Pithoragarh	80.36	30.08	1833.00	2013.19	19.41	24.79	14.02	37
Ranichauri	78.5 0	30.25	1950.00	1170.20	14.65	19.81	9.68	11
Roorkee	77.81	29.81	274.00	985.60	23.78	30.08	17.33	30
Shantipuri	79.54	28.95	246.00	1090.30	24.58	29.06	19.51	5
Sitarganj	79.7 0	28.93	211.00	1754.30	22.54	28.35	16.28	5
Srinagar	78.79	30.22	973.00	1289.45	22.13	29.24	14.84	3
Tehri Garhwal	78.43	30.37	2286.00	888.38	20.43	27.06	13.80	18
Ukhimath	79.1 0	30.52	1311.00	1861.61	19.63	24.35	14.76	3
Uttarkashi	78.45	30.73	1352.00	1458.55	18.19	26.43	9.95	13

## Results and Discussion

Kiwi fruit is a temperate fruit which can be grown in most of the temperate climate and Uttarakhand is a hilly region which is suitable for the production of kiwi fruit. For the suitability analysis of kiwi fruit different layers of climatic parameters were generated by the use of interpolation technique provided in the QGIS software and these layers shows variation in minimum temperature ranges from 2 °C to 9 °C, average temperature ranges from 7 °C to 15 °C and maximum average temperature ranges from 11 °C to 21 °C when the temperature layers compared with the altitude layer it reflected that the values of temperature was decreases with increase in altitude as shown in Fig. (3, 4, 5 & 6).

For the proper development and maximum production of kiwi fruit chilling temperature and altitude plays a crucial role. On the basis of above study for the suitability analysis of Kiwi was done by using different climatic layers and thereby making a relationship between the chilling requirements, temperature, altitude by doing this it gives the optimum growth requirement for the cultivation of kiwi fruit and suitability map was developed. As kiwi fruit requires proper temperature which is 7 °C with proper altitude that is 1200-1500m.

The suitability map shows that the places which are present at a height of 400-1100m found unsuitable for the development of kiwi fruit and the lies from 1100-1800m found highly

suitable and the places which are found 1800 to 2500 are suitable for the cultivation of kiwi fruit as shown in Fig. 7. The above results meets the requirements as given in the study that Kiwi fruit can be grown in most temperate climates with adequate summer heat. These are generally equipped with a watering system for irrigation and frost protection in the spring. Ideal soil for Kiwi farming is sandy loam. Soil must be moist, deep, well drained with 5-6 pH. It can be cultivated between 200-2250 m altitudes but its yield is maximum between 1200-1500 m. Kiwi fruit is cultivated mainly in those hilly areas where in winter season temperature 7 °C for 8-15 days (Bisht *et al.* 2012) [2].

All the districts of Uttarakhand are highly suitable for growing the kiwi except District Udham Singh Nagar, Haridwar, and some part of Dehradun while district Chamoli, some part of Tehri Garhwal and some part of Nainital are suitable for growing Kiwi (Table 2). And the heights suitable for growing kiwi are as follows:

**Table 2:** Height suitable for growing kiwi

Sr. No.	Suitability	Height (m)
1	Unsuitable	400-1100
2	Highly Suitable	1100-1800
3	Suitable	1800-2500

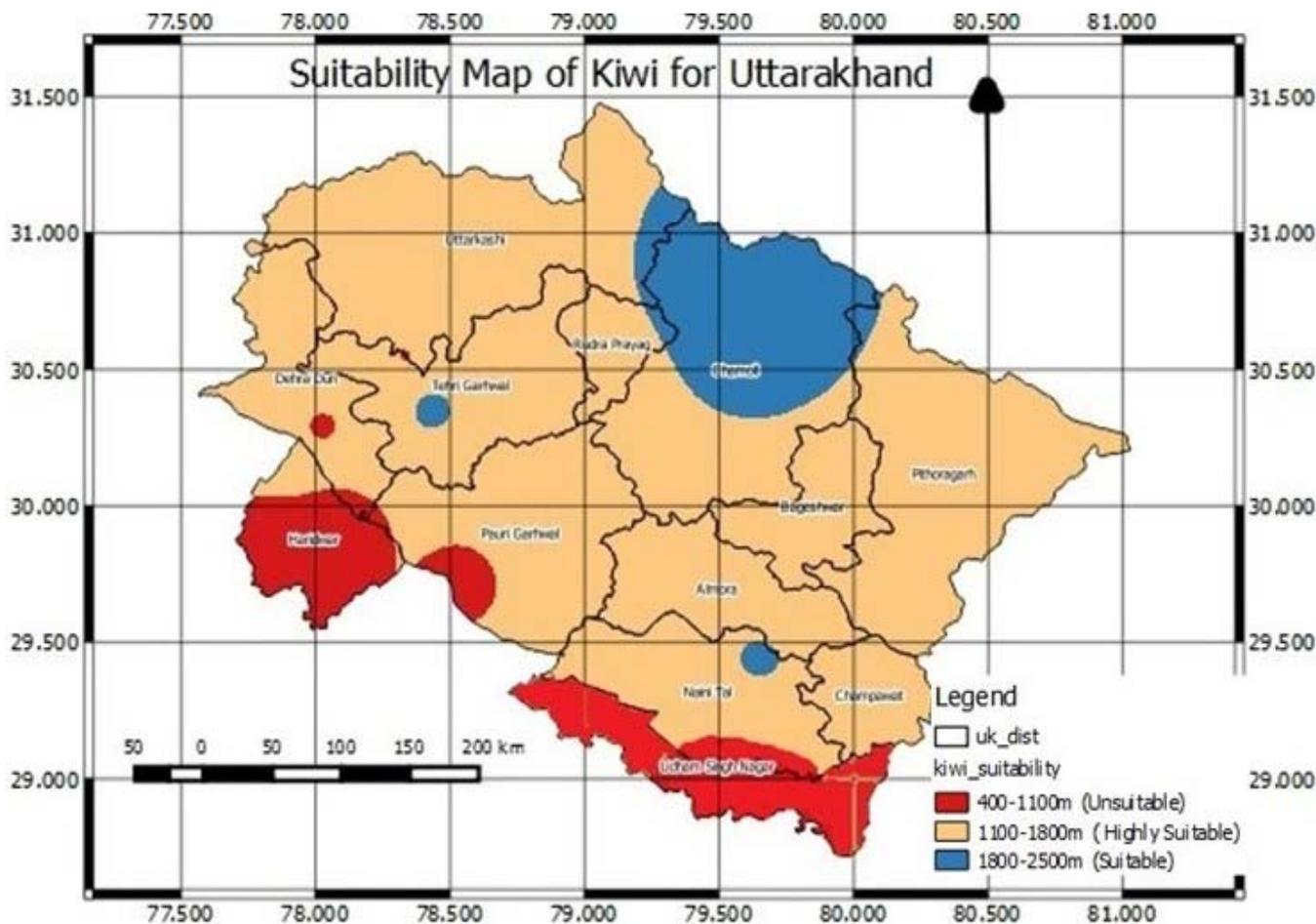


Fig 7: Suitability Map of Kiwi for Uttarakhand

### Conclusion

GIS (Geographic Information System) application in agriculture increasingly plays an important role in crop production throughout the world by reducing costs, managing the land resources more efficiently which helps farmers to increase their production and income. GIS is a modern tool which is incredibly helpful for mapping and projecting the current and future scenarios related to rainfall, temperature, crop yield, suitability analysis of crops. GIS could increase food production in parts of the world that are struggling to produce enough food for the people around by mapping of geographic and geologic features of current (and potential) farmland scientists and farmers can work together to create more effective and efficient farming techniques.

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