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Use of geographic information and communication technologies (GEO-ICT's) for agro-meteorological management in semi arid zone of Western Maharashtra, India

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Abstract

Geographic information and communication technologies (Geo-ICT's) has a valuable role to play in agro metrological management the techniques, processes and structures through which decisions are made about wise agricultural practices and use of all natural resources. A lot of multifarious challenges the world faces at the moment, such as adjustment to and improvement of climate transform, speedy urbanization, rising food and energy uncertainty and augmented incidence of natural disasters, farmer's suicide, so far no widespread accepting presently exists about the way in which the development and upcoming direction of Geo-ICT for agro-meteorological projects and initiatives should be appraise. At this juncture, i will try to review inter-disciplinary research to present a crisp impression of three exacting inter-disciplinary viewpoints that can be used for the estimate of Geo-ICT for agro metrological management.

Key Words: Geo-ICT, Remote Sensing, Agroclimate, Agro ecology, Agrometerology.

Introduction:

The term **Geo-ICT** (Geospatial and information communication technologies) encompasses synergy and convergence of **technologies** dealing with several aspects of spatial data management including data acquisition, data assimilation, data analysis, **information** generation, decision support, and **information** dissemination. Agriculture is the largest employer on the planet and the most weather conditions dependent. At the same time agricultural practices are under the pressure of changing climate and weather. At present 40% of the earth's land surface is managed for crop land and pasture (Foley. 2005)·In developing countries, around 70% of the total populations are dependent on agriculture. Total annual crop losses in the world agriculture are mainly due to direct weather impacts viz. Droughts, floods, rain, frost, hail, heat and cold waves and severe storms (Hay, 2007). Agri- culture is more dynamic and diverse than any other human activity. Increasing population of the world needs to huge amount of food which will fulfill only by the high potential of agriculture. It is still largely depend on environmental conditions and present wide spatial variation. (Singh & Dhillon S.S, 2008 Agricultural Geography page no.27) Meteorology (A modern dictionary of geography -2007 Page no.304) is the study dealing with the phenomenon of the atmosphere and agriculture.

Study Area:

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

The study area Nashik district situated in the "Deccan trap of Maharashtra" which is partly in the Tapi Basin and partly in the upper Godavari Basin. It lies between 19˚35' 18" North latitude to $20^0$53' 0" North latitude and $73^0$16' 07" East longitudes to $74^0$56' 22" East longitudes. It is surrounded by Dhule district in the North, Jalgaon and Aurangabad district in the East, Ahmadnagar district in the South, Thane district in the South-West and Gujarat state in the North-West. Nashik district has an area of 15530 sq. Km. Population of 6,109,052, as per the 2011census there are 15 Tahsils and 66 block circles are in the Nashik district. (Figure no.01).

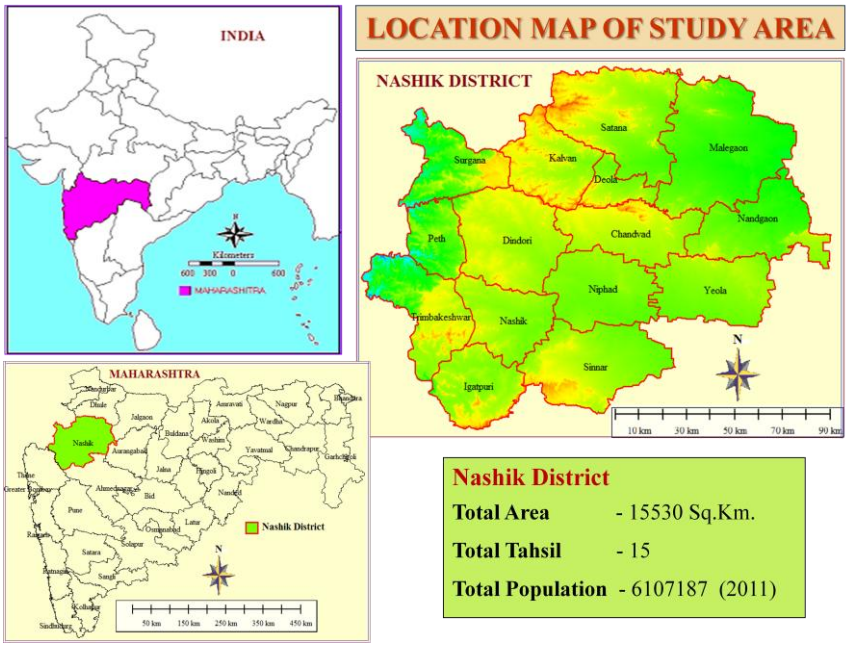

Fig.01 Location Map of Study Area

The study area is with heavy cultural and socio economic diversity. In the western region of the study region mostly people belongs to the tribal community having the low standard of living and they are far away from the modern world of technology with this these people also economically and socially not forward as compare to the rest of the Maharashtra. In the eastern region of the study area is having moderate condition of the socio economic and cultural development.

Objectives:

1. To Use Geo-ICT for detecting crop failure at any stage.
2. Understanding hydro metrological characteristics.
3. Setting up proper agro-ecology.

Hypothesis of the study:

"If Geographic information and communication technologies (Geo-ICT's) used for wise agricultural practices and utilization of all natural resources, then the proper agro- metrological management will

possible"

Data base and methodology: Data base:

Agricultural data was collected by various sources the data is related to the cropping pat- tern, cropping area, types of the crops, net sown area, gross cropped area, Crop yield, crop productivity, agricultural land use this data was collected for the year 1980 to the year 2012, and for the research decadal data was analyzed decades are categories as year 1980- 1981, year 1990-1991, year 2000-2001 and year 201-2012.the data was collected from following sources

1. District Gazetteer of Nashik
2. Agricultural Department of Maharashtra State (www.mahaagri.gov.in)
3. Divisional Agriculture Department, Pune
4. Directorate of Agriculture, M.S. Pune and District Inspector Land Records, Nashik.
5. Socio-Economic Abstract Nashik District

Climatic data was collected by various sources the data is related to the Rainfall pattern, Temperature, Wind System, Potential Evapotranspiration (PET), Rainy Days, Precipitation, Moisture, Relative Humidity ,Thunderstorms, Cloud Cover, Sunshine, this data was collected for the year 1980 to the year 2016, and for the research data was analyzed with the help of various statistical methods in the form of average, variation, standard deviation, skewness, kurtosis etc.details of data collected from following sources are mentioned as below.

1. Data collected from India Meteorological Department (IMD) Shivajinagar, Pune
2. Data Collected from Hydrology Project (SW), Jal Vidnyan Bhawan, Dindori Road, Nashik- 422 004, Maharashtra
3. Satellite Data

Table 01: Satellite data Landsat 5 and Landsat 7 for NDVI calculation

Sr. No	Data used	Resolution(in meters)	Data source
1	Landsat-5 TM, Path 146, Row 048 Years:- **1992 to 1996, 1999**	30	USGS Earth Explorer
2	Landsat-7 TM, Path 146, Row 048 Years:- **2000, 2002, 2003 and 2009**	30	USGS Earth Explorer

Empirical & analytical methodology:

1. Digital image analysis in QGIS software
2. Index of Land Use Efficiency (LUEI) Jasbir Singh's method
3. Index of Crop Diversification BHATIA'S (1965)

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

4. Weaver's method of Crop Combination
5. Potential Evapotranspiration Thornthwaite's method
6. Moisture Availability Index (MAI) Thornthwaite's method

Measuring central tendency(a) Mean values of climatic elements (temperature, precipitation, evapotranspiration, water balance, radiation balance, and the like); (b) Frequencies: number of consecutive days without frost, without thawing, without rain, and so forth; return periods of atmospheric events; (c) Dispersion parameters: standard deviations, coefficients of variation; 8. Relationship between variables a. Correlation b. Regression c.Skewness d.kurtosis

Results and discussion:

Remote sensing for detecting crop failure:

Hyper spectral Remote Sensing is an advanced tool that provides high spatial/spectral resolution data from a distance, with the aim of providing near laboratory-quality radiance (and subsequent related information) for each picture element (pixel) from a distance. This information enables the identification of targets based on the spectral behavior of the material in question mainly absorption features of chromospheres. This approach has been found to be very useful in many terrestrial, atmospheric and marine applications (Clark and20 Roush, 1984; Goetz and Wellman, 1984; Gao and Goetz, 1990; Dekker et al.,21 2001; Asner and Vitousek, 2005).

The BPH damage influenced rice plant reflectance compared to uninfested plants in the visible (VIS), and near infrared (NIR) regions of electromagnetic spectrum under both the conditions. Plot of correlation coefficients (r), between plant reflectance and BPH damage levels, against wavelengths depicted four sensitive wavelengths viz., 1986 nm (r = 0.63), 665 nm (r = 0.58), 1792 nm (r = 0.53) and 500 nm (r = 0.52) in relation to BPH stress detection on plants in glasshouse. In field, the sensitive wave lengths were found to be 961nm (r = -0.706), 1201nm (r = -0.705), 764 nm (r =-0.676) and 1664nm (r = -0.609). Mean plant reflectance as affected by differential BPH damage varied across nine wave bands viz., UV, V, B, G, Y, O, R, NIR and MIR for both glass house and field conditions. Variation in plant reflectance due to BPH damage was smaller at shorter wavelengths (350-730 nm) and larger at longer wavelengths, viz., NIR (740-925 nm) followed by mid infrared (MIR) (926-1800 nm), which indicated the possibility of detection of BPH stress on plants and thereby issuing prompt forewarning to stakeholders. In study area the yield loss due to insect pests in rice has been estimated to 21 to 51 per cent.

Hydro- Agro Meteorological analysis

Agricultural meteorology is concerned with the meteorological, hydrological, pedological and biological factors that affect agricultural production and with the interaction between agriculture and the environment. Its objectives are to elucidate these effects and to assist farmers in preparing themselves by applying this supportive knowledge and information in agro meteorological practices and through agro meteorological services.

Rainfall regime

Rainfall is a phenomenon that always determines all the economic related developments of the region. Agriculture is the most fragile phenomenon that most of the time affecting by the rainfall variation mainly cropping pattern, crop combination and the crop diversification and crop yield, production was affected by the high rainfall or the deficit rainfall. Study region has observes the mean annual rainfall is high in the monsoon period of June to October (figure no.02). Following map (figure no.03) shows the annual average

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

rainfall of the area since 1980 to the 2016 the trend of the high rainfall to low rainfall shows in the west to the

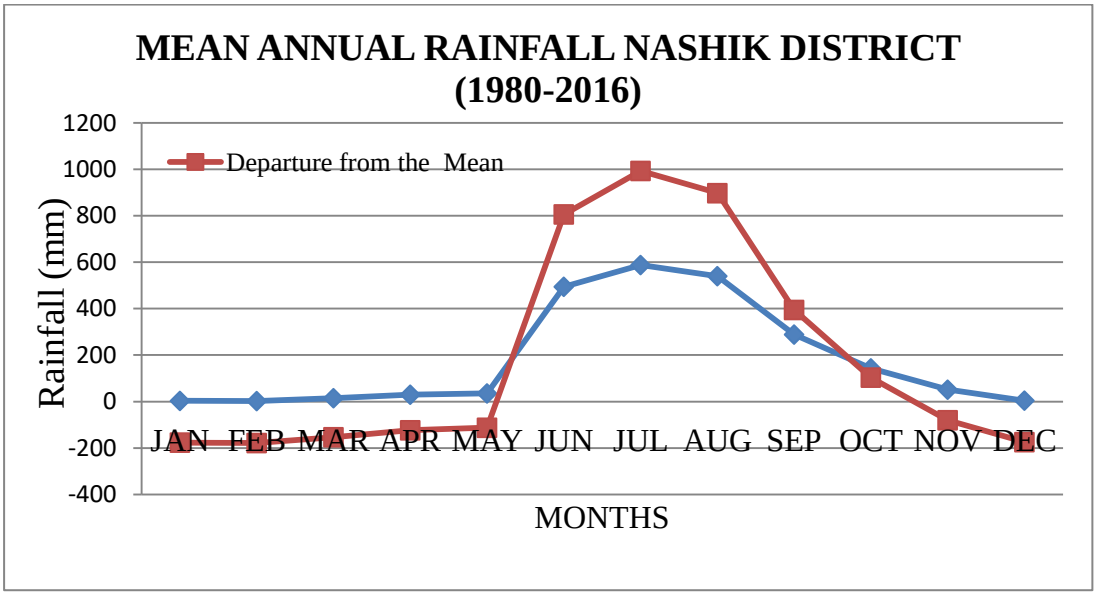

Fig 02: Mean monthly rainfall from year 1980-2016 in the months of June, July, August and September having high average annual rainfall than the rest of the months

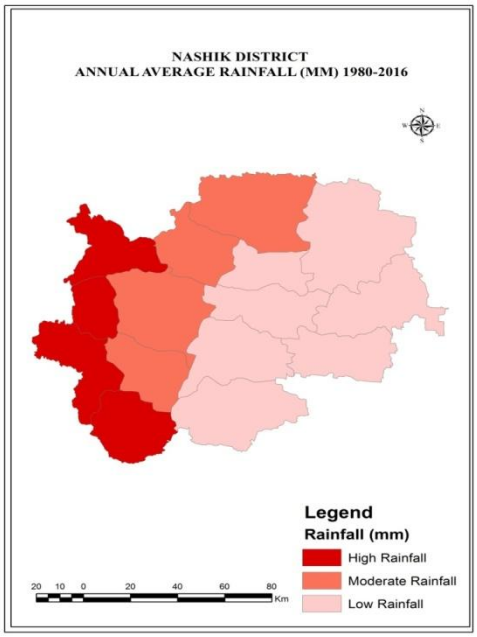

Fig 03: An annual average rainfall from year 1980-2016 high rainfall in the western region of the study area, moderate rainfall seen in the middle part and low rainfall seen in the eastern part of the region.

east direction of the study region. Highest proportion of the study region is under the scarcity of the rainfall. When we discussing about the average monthly rainfall tahsilwise then it would be observed that the tahsils Surgana, Peth, Trimbak, Igatpuri and Nashik having highest rainfall than other tahsils in the last 36 years.

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

(Figure no.04)

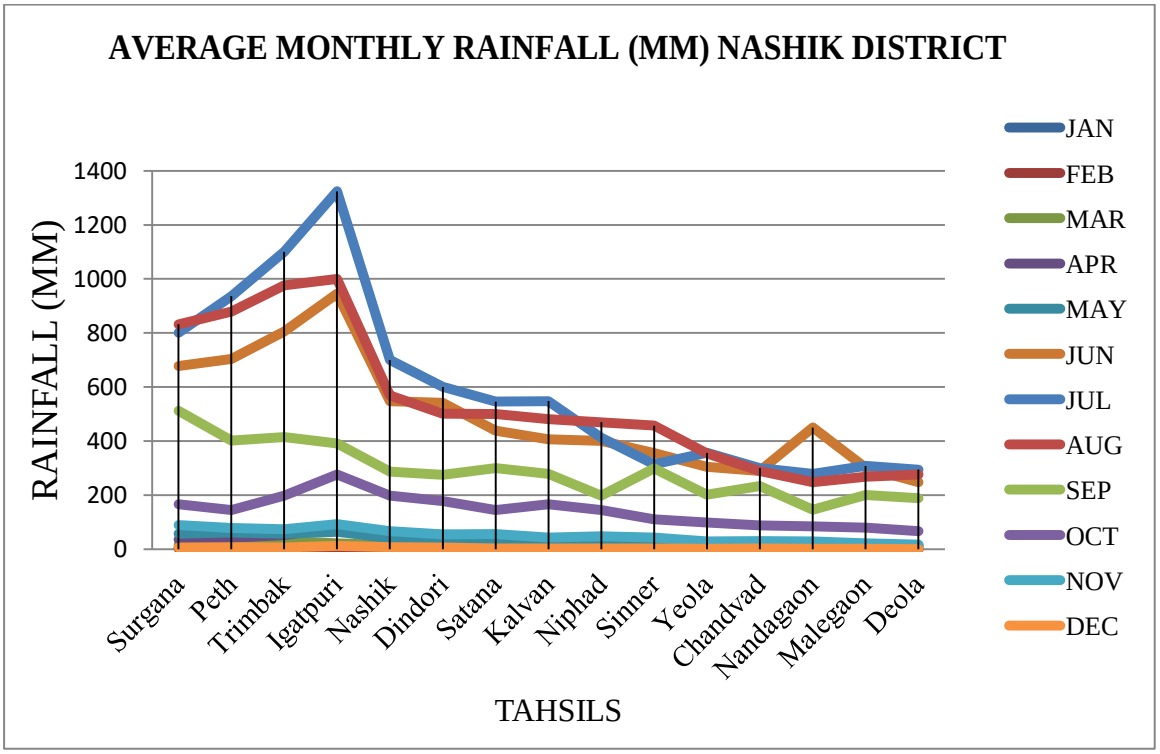

Fig 04: Tahsilwise monthly average rainfall from year 1980-2016

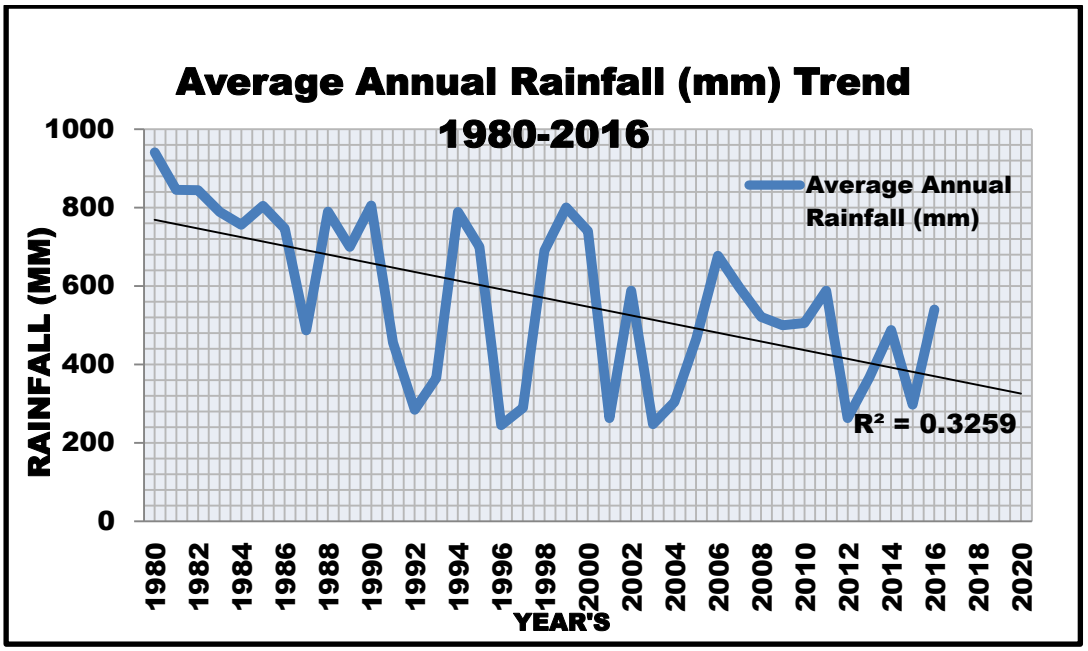

Fig 05: Linear regression & average rainfall from the year 1980-2016

Linear regression of the average annual rainfall shows that the trend of the rainfall is decreasing yearly as well as year wise fluctuations are observed many of the years having normal monsoon distribution while some of that

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

are observed wet monsoon and few are observes scarcity of the rainfall.(Figure 05)

NDVI and Rainfall relation:

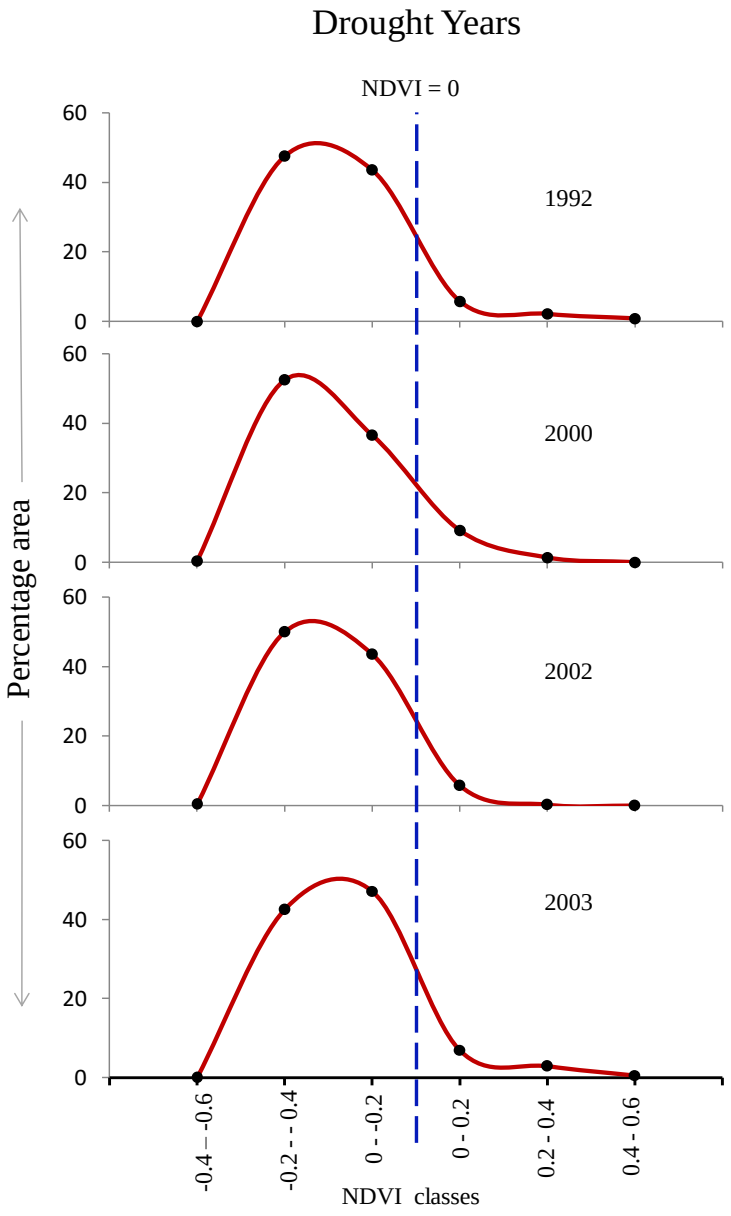

Fig 06: NDVI and Rainfall relation

Occurrence of depressing NDVI values shows weak plant life situation

Above figures shows the NDVI and rainfall relation, Occurrence of depressing NDVI values shows weak plant life condition this situation in the study area occurs in the year 1992,2000,2002 and 2003 (figures 06) and Occurrence of affirmative NDVI values shows good plant life condition this situation in the study area occurs in the year 1996,1999 and 2009. (Figure 07)

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

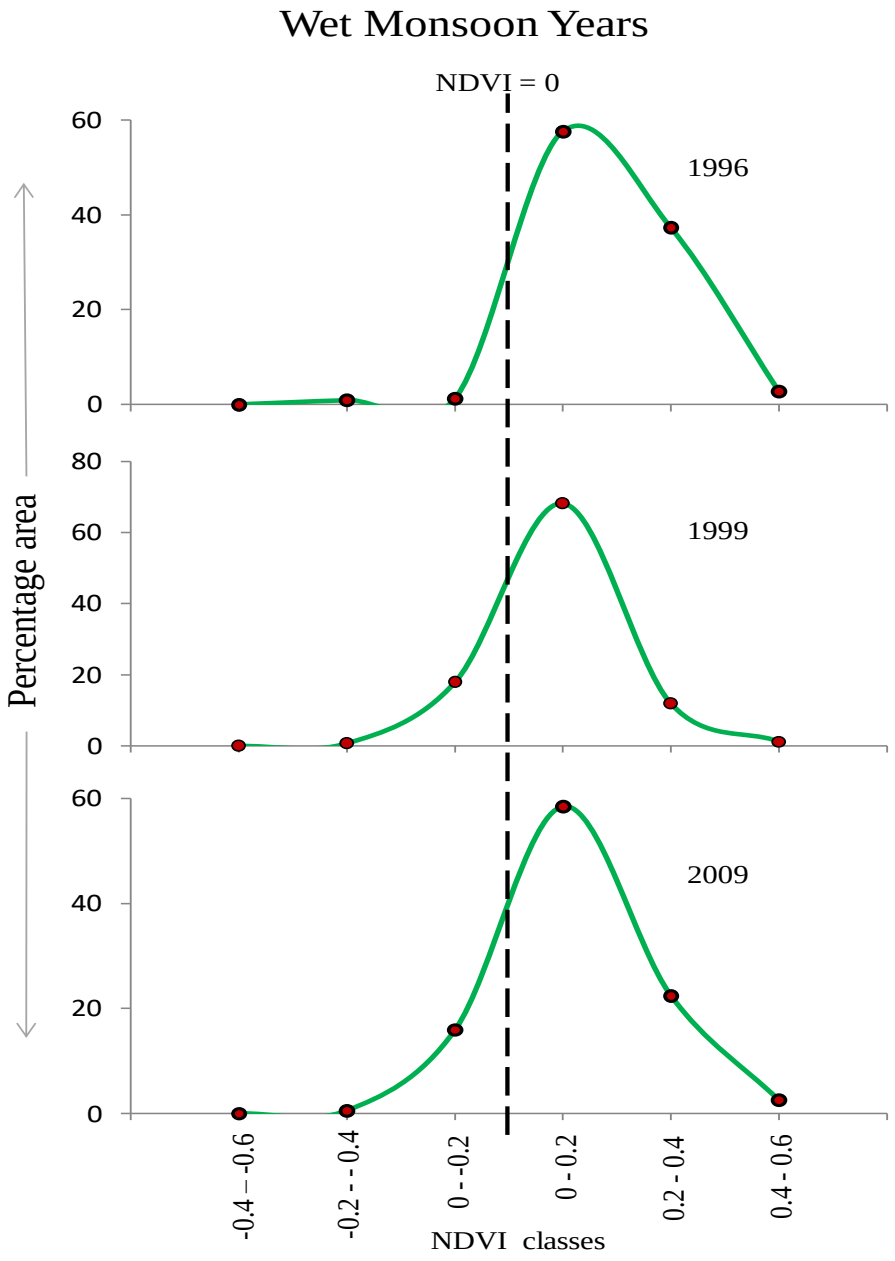

Fig 07: NDVI and Rainfall relation

Occurrence of affirmative NDVI values shows good plant life situation

Classification of climate

Climate classification of the study area is categorize by the Thornthwaite's method for this we considered the temperature and potential evapotranspiration. Seasonal mean temperature variation is computed form the year 1980-2016**.** Season wise in the Cold Season (Dec- Feb) average temperature is around 17 to 19 ºc, in the Hot Season (Mar - May) average temperature is around 24 to 26 ºc, in the Southwest Monsoon season (Jun - Sept) average temperature is around 26 to 28 ºc, in the Post Monsoon season (Oct - Nov) average temperature is around 22 to 26 ºc. (Table 02)

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

Table 02: Seasonal mean temperature average, Standard deviation and coefficient of variation tahsilwise in the study area from the year 1980 to 2016

Sr. No.	Tahsils	Seasons											
		Cold Season (Dec- Feb)			Hot Season (Mar - May)			Southwest Monsoon (Jun - Sept)			Post Monsoon (Oct - Nov)		
		Avg.	SD	CV	Avg.	SD	CV	Avg.	SD	CV	Avg.	SD	CV
1	Surgana	18.7	0.5	3.19%	26.0	1.9	7.56%	27.3	0.8	3.12%	23.4	1.6	7.16%
2	Peth	19.3	0.7	3.68%	26.4	1.8	7.08%	27.1	0.8	3.25%	22.8	1.5	6.65%
3	Trimbak	18.8	0.7	3.72%	25.4	2.2	8.90%	27.3	0.8	3.24%	22.7	1.8	7.93%
4	Igatpuri	18.6	0.6	3.60%	25.8	2.0	8.09%	26.8	0.7	2.66%	22.7	1.6	7.24%
5	Nashik	17.9	0.5	3.06%	24.9	2.6	10.70%	27.5	0.8	3.10%	24.1	2.0	8.48%
6	Dindori	18.7	0.8	4.73%	25.9	2.8	10.91%	27.1	0.6	2.48%	23.3	1.4	6.04%
7	Satana	19.0	0.4	2.21%	25.5	2.4	9.68%	26.8	0.5	2.20%	23.4	1.3	5.57%
8	Kalvan	18.7	0.7	3.75%	26.0	2.2	8.55%	26.9	1.0	3.79%	22.6	1.5	7.04%
9	Niphad	18.7	0.5	2.96%	25.7	1.8	7.26%	26.5	0.7	2.94%	23.1	1.1	5.09%
10	Sinner	18.6	0.7	4.12%	25.7	2.2	8.68%	26.8	0.6	2.34%	22.3	1.6	7.42%
11	Yeola	18.8	0.2	1.45%	25.5	2.6	10.47%	27.1	0.6	2.41%	22.8	1.7	7.60%
12	Chandvad	19.2	1.0	5.68%	25.8	2.2	8.56%	27.1	1.0	3.70%	22.7	1.7	7.57%
13	Nandagaon	18.9	0.7	3.95%	25.5	2.4	9.70%	26.9	0.6	2.50%	22.6	1.7	7.58%
14	Malegaon	19.1	0.3	2.07%	25.5	2.2	8.99%	27.1	0.8	3.06%	22.9	1.0	4.58%
15	Deola	18.4	0.4	2.41%	26.5	2.0	7.66%	27.6	0.6	2.34%	26.1	1.6	6.27%

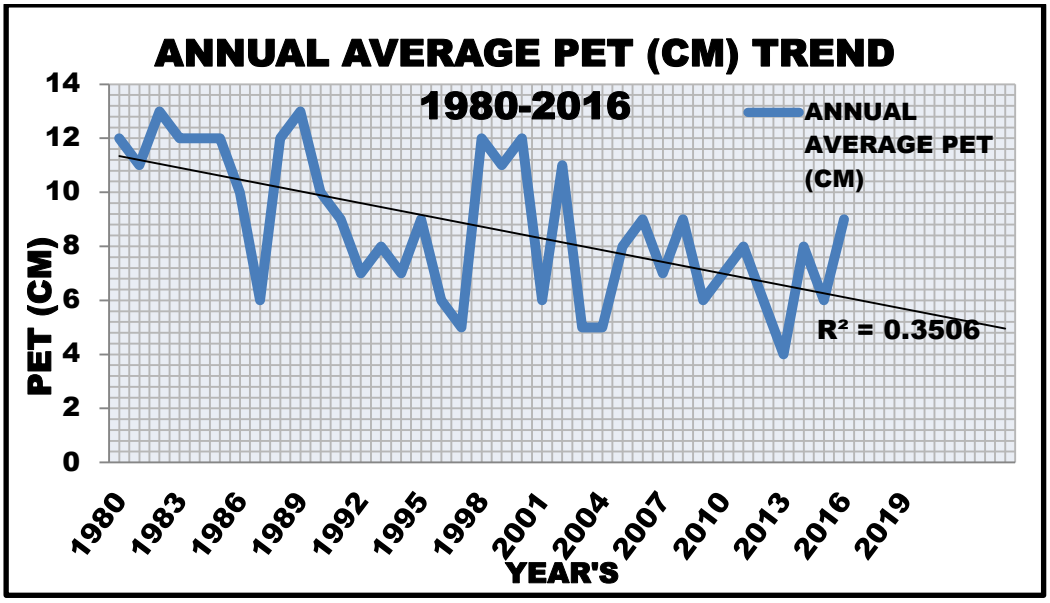

Fig 08: Annual average PET (cm) trend from 1980-2016 shows decreasing trend with regression equation $R^2 = 0.3506$.

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

Annual average potential evapotranspiration trend form the year 1980 to 2016 shows decreasing trend with the decreasing values of PET from 12 cm to 5 cm also linear regression having declining trend with $R^2 = 0.3506$

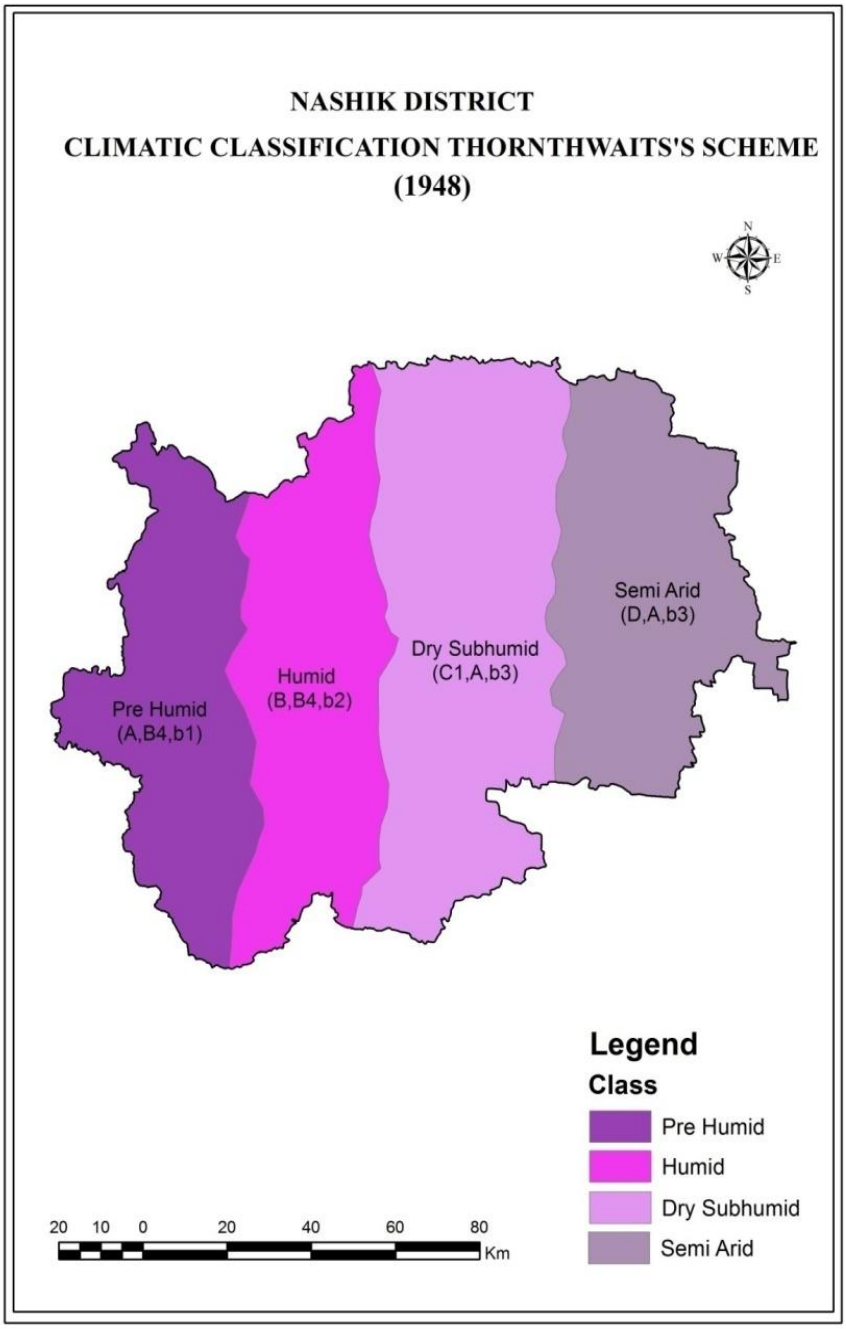

Fig 09: Climate Classification of study area in to pre humid, humid, dry sub humid and semi arid according to Thornthwaite's scheme of classification.

(Figure 08) Climatic classification has done by the Thornthwaite's method according to all parameters used in this method we classify four categories for the study region that is Per humid climate (A,B4,b1) this type of

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

climate is found in the western region of study area with high rainfall and high potential evapotranspiration. Secondly Humid climate (B, B4, b2) this type of climate is found in the next to western region of study area with moderate rainfall and moderate potential evapotranspiration. Third type of climate is Dry sub humid climate (C1, A1, b3) this type of climate is found in the middle part of study area with low rainfall and low potential evapotranspiration. Fourth type of climate is Semi arid climate (D, A, b3) this type of climate is found in the eastern part of study area with very low rainfall and very low potential evapotranspiration. (Figure 09)

Agroclimatic zones

As per climatic and agricultural data and GIS technique we divide the study region in to four Agroclimatic zones with their distinguished characteristics. First Agroclimatic zone is Western assured rainfall zone with high rainfall, high temperature and high humidity having highest production of rice and ragi. Second Agroclimatic zone is Central moderate rainfall zone with moderate rainfall, moderate temperature and moderate humidity having rice; wheat and Jawar are the main crops in the region. Third Agroclimatic zone is Mid Central moderate transitional zone with low rainfall, fluctuated temperature and low humidity having Bajara, Soyabeen and Jawar are the main crops in the region. Fourth Agroclimatic zone is Eastern scarcity zone with very low rainfall, very high fluctuated temperature and low humidity having Bajara and Jawar are the main crops in the region. (Figure 10)

Setting up proper agro-ecology

Agro ecology coalesce elements of conventional farmer's knowledge with elements of current ecological, social and agronomic science, generate a discourse of wisdoms from which ideology for manipulative and managing biodiversity and tough farms are resulting. Agro ecology comprises the features of Agri ecology with Abiotic surrounding, anthropology in the sense of people engaged in the farm activity ,Sociology is also including in agro ecology also biological control, ecological economics, knowledge from basic agricultural sciences, specific technological forms and research in farmers field. These entire elements are active agents in the proper agro ecology for setting up ideal agro ecology we have to consider these entire elements broadly.

Specific GIS and Remote sensing tools such as hyper spectral remote sensing and GIS mapping of the agricultural resources are play crucial role in the proper agro ecology, side by side we have to provide proper soil and water testing for the farmers and easily provide new agricultural tools and techniques to the farmers is also important .We have to suggest Agroclimatic zone wise cropping pattern to the farmers with proper marketing of their crops. All these things are possible with the proper agricultural, Climatic data and GIS, Remote Sensing techniques.

Relevance and Recommendations:

Knowledge of available environmental resources and the interactions that occur in the area below the soil surface, the soil–air interface and the boundary layer of the atmosphere provides essential guidance for strategic agro meteorological decisions in long-range planning of agricultural systems. This applies to both favorable and unfavorable conditions – and these may vary a great deal. Typical examples are the design of irrigation and drainage schemes, decisions relating to land-use and farming patterns, and within these choices, selections of crops and animals, varieties and breeds, and farm machinery.

Agro meteorological information should be distributed to all users, including: (a) Agricultural administrations; (b) Research institutions and laboratories; (c) Professional organizations; (d) Private crop and weather services; (e) Government agencies; (f) Farmers, ranchers and foresters.

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

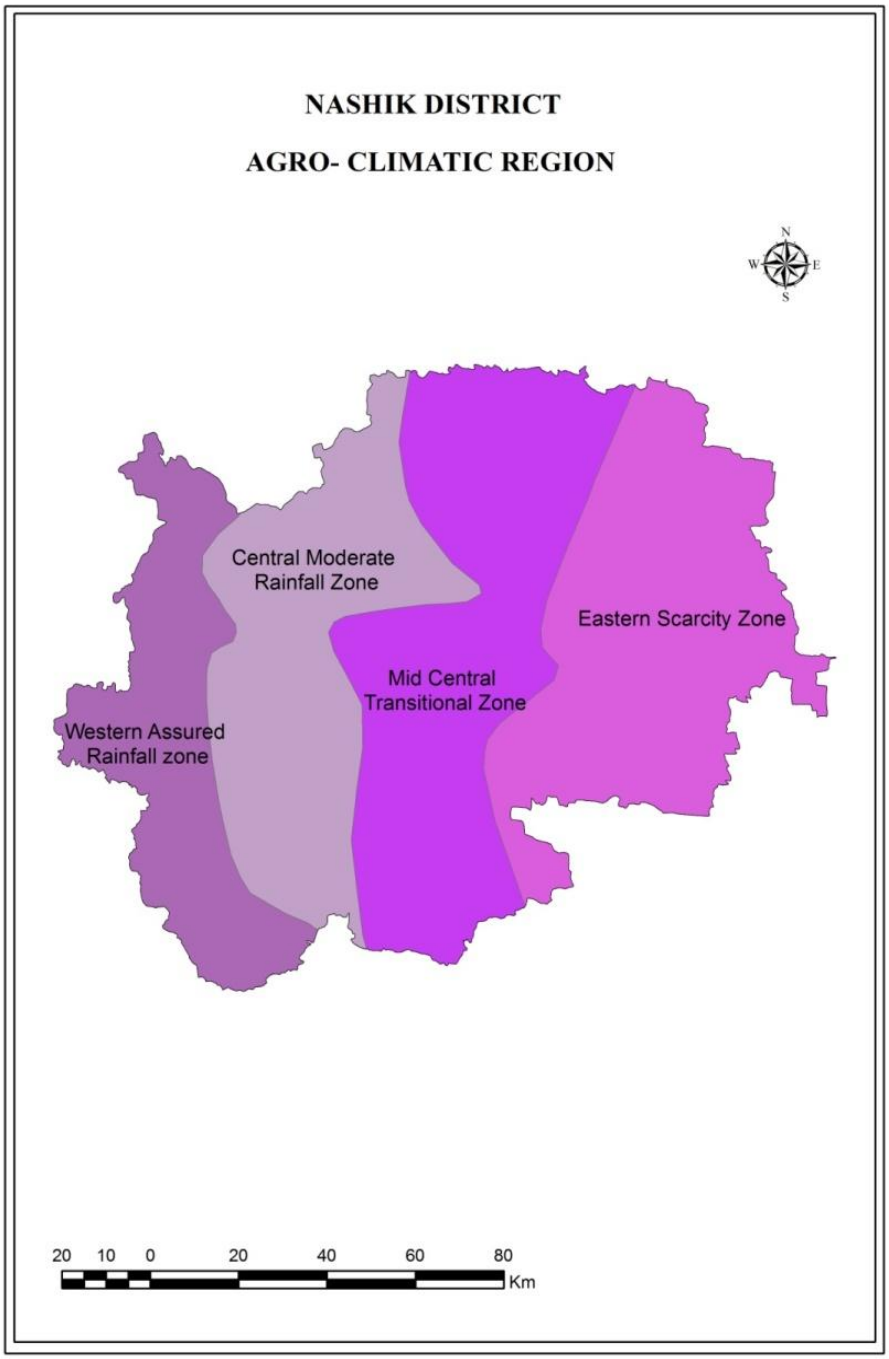

Fig 10: Agroclimatic zones of study area on the basis of climatic and agricultural characteristics

ISSN: 2278-4632
Vol-10 Issue-5 No. 4 May 2020

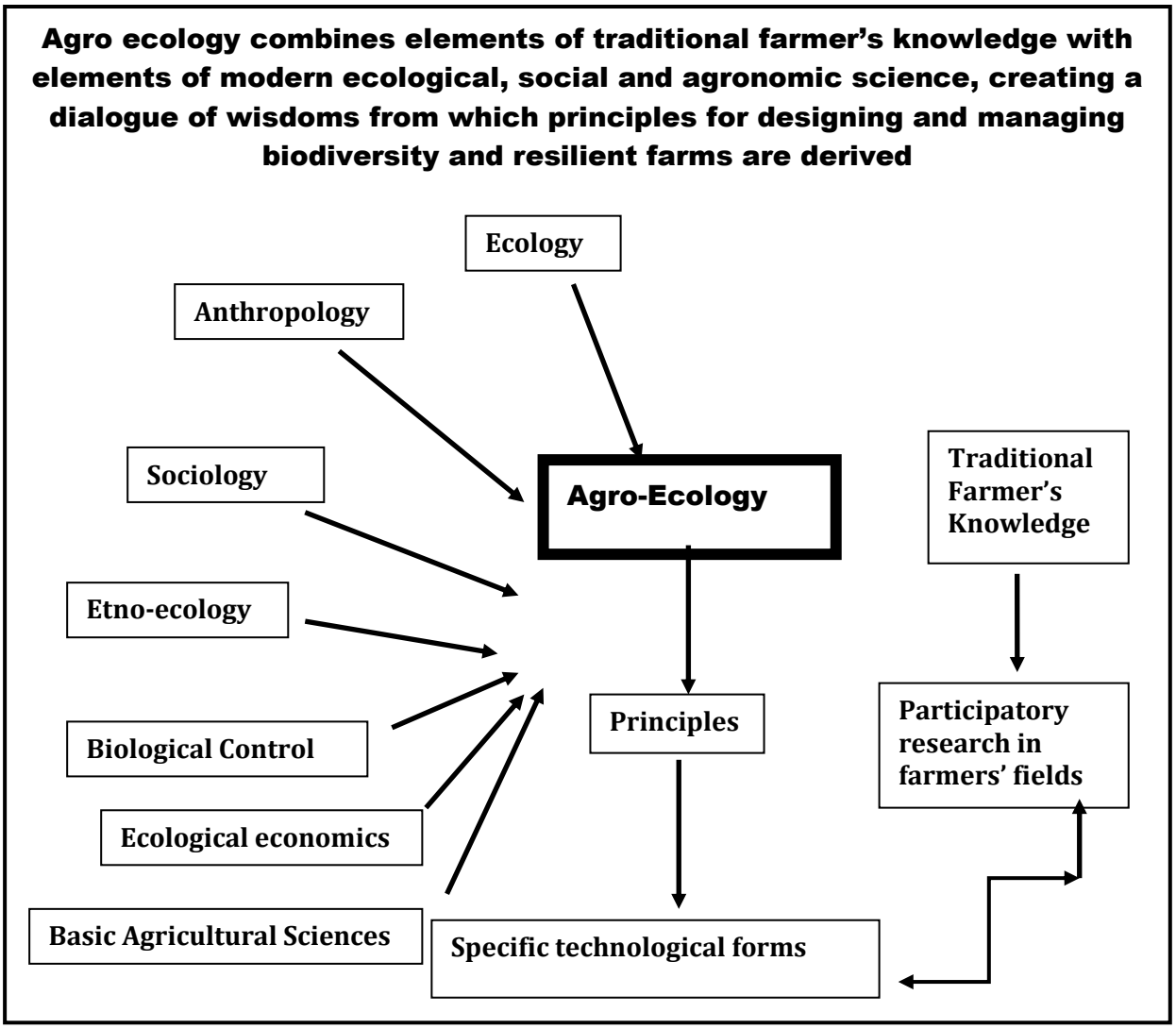

Chart 01: Agro-Ecological expectation by various parameters

Recommendations

- Arrangement of Agroclimatic observatories have to be improved. Currently, the system of surface weather stations of IMD in the district is limited; however it has fine figures of rain gauge locations. Therefore, around is vital need to provide a better depiction of temperature and rainfall changeability over the district climate change situation.
- Primarily crops are extra susceptible to small conditions inconsistency somewhat than lengthy period climate changes, the confrontation of climate inconsistency on crops have to be recognized. Comprehensive analysis is necessitating being aware of the little and extended periods possessions of climate change for the growing of particular crops.

- A number of following explanations will be helpful for enlarge agricultural outcomes in different agro-climatic zones.

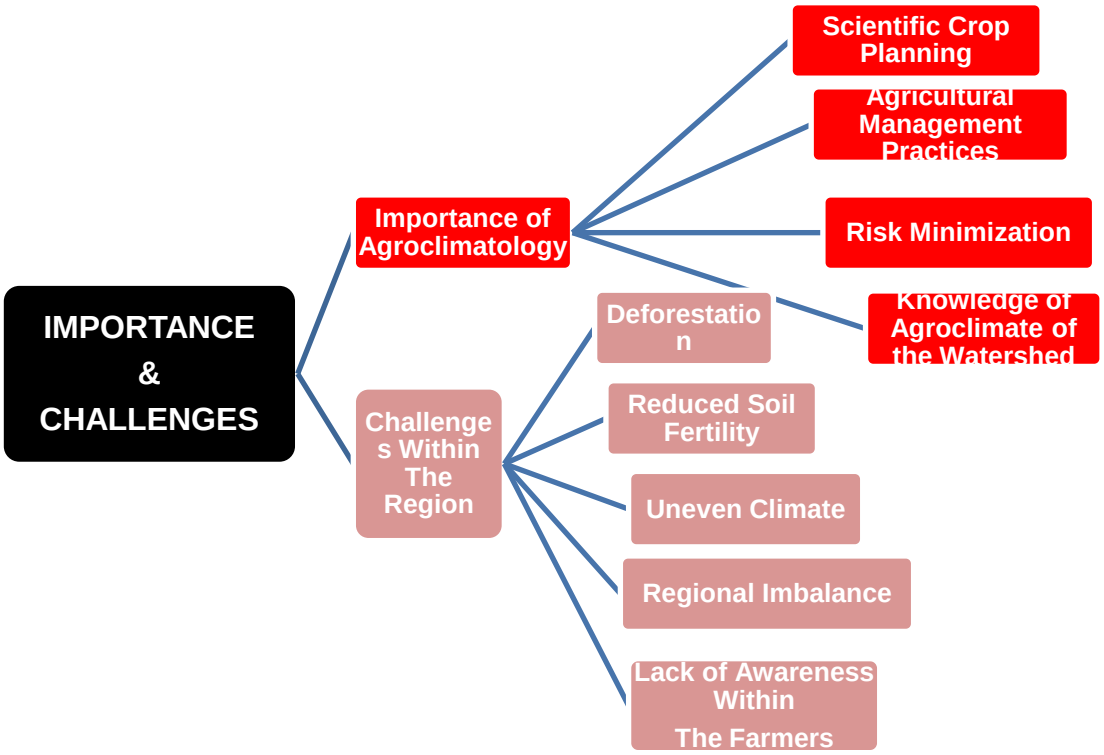

Chart 02: Importance and challenges use of GEO-ICT in agrometeorological study

i) Development and finishing of main and small irrigation amenities within the definite phase of period.

ii) Dry cultivation methods can be practiced in drought prone areas.

iii) The uniformities of land possessions would be approve.

iv) Up gradation in conventional cropping pattern and replacement of crops as per the adaptation of specific agro-c1imatic characteristics.

v) Market and bank amenities, HYV's, and organization of agricultural service centers at tahsil centers would be rewarding to improve up agricultural growth.

vi) Improvement of Floriculture, Horticulture, Greenhouse farming and traditional forest based medical crops plantation.

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