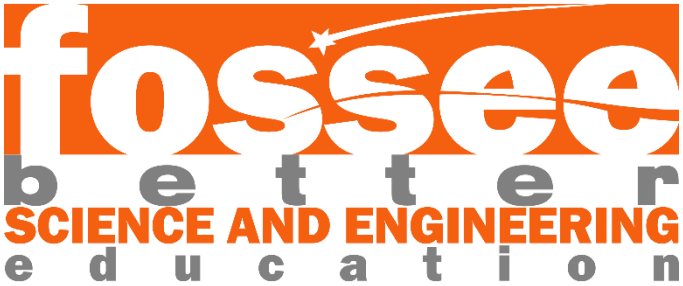

Fossee Summer Fellowship Report

On

Quantum GIS (QGIS)

Submitted by

Kalyani Mawale

Under the Guidance of

Prof. Pennan Chinnasamy

Center for Technology Alternatives for Rural Areas

IIT Bombay, India

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Acknowledgement:

I sincerely express my gratitude to IIT-Bombay and FOSSEE for providing the platform to learn and explore open source software. The online internship to work for FOSSEE project was a great opportunity to learn about the software and its widespread applications in such a pandemic situation.

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With Regards,

Kalyani Vasudeo Mawale,

College Of Engineering, Pune.

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ABOUT

QGIS

Introduction to QGIS

QGIS is a free and user friendly Open Source Geographic Information System (GIS). It is licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo) (QGIS - The Leading Open Source Desktop GIS, n.d.).

QGIS is a volunteer driven project. It runs on Linux, UNIX, Mac OSX, Windows and Android (QGIS - The Leading Open Source Desktop GIS, n.d.).

Figure 1 - QGIS Logo

QGIS supports both vector and raster layers. Vector data is stored as point, line, or polygon features. Multiple formats of raster images are supported, and the software can georeference images (QGIS, 2020).

Properties of QGIS

- Open source and completely free software.
- Easy access to source code.
- Source code can be modified and improved by developer or volunteer.
- User friendly and customizable.
- No need for expensive hardware or software to run it.

Applications of QGIS

QGIS has a wide range of applications in all the fields.

I. Precision Agriculture
II. Mining
III. Forestry
IV. Hydrology
V. Medical science

List goes on.

QGIS features used for current study

In the current study, I have used following QGIS features for accurate conclusions:

I. Georeferencing
II. Raster calculator
III. Vector/Raster styling
IV. Raster extraction

RESEARCH WORK ON AGRO-CLIMATIC ZONES OF INDIA

SPATIAL AND TEMPORAL ANALYSIS OF AGRO-CLIMATIC ZONES OF INDIA DEFINED BY PLANNING COMMISSION FROM 1961 TO 2018

Abstract

An Agro-climatic zone (ACZ) is a land unit delineated in terms of major climate and growing period, which is climatically suitable for certain range of crops. Several efforts have been taken for delineation of agro-climatic zones in India. In 1964 the Planning Commission categorized the zones based on physical conditions, topography, geomorphology, rainfall, cropping pattern, development of irrigation and land resources at the district level regionalisation and delineated 15 agro-climatic zones. In 1989 the planning commission redesigned these zones into 73 sub-zones. Over the time period, several changes in Climate patterns have been observed in India.

This project aims to analyse 15 Agro- climatic zones of India temporally and spatially from 1961 to 2018 using average annual rainfall, mean temperatures of the months of January and July with the help of Quantum Geo-Informatics system (QGIS). Study shows that there is a need to redefine agro-climatic zones based on rainfall, mean January temperature and mean July temperature.

Problem statement

Majority of the working population of India is engaged in agricultural activities. Agriculture is one of the most important sectors in India. The climate is one of the most effective factors for agriculture. The Planning Commission after examination of earlier studies on regionalization of agricultural economy has recommended 15 agro-climatic regions based on climatic parameters. Several climatic changes have taken place in India over the time period i.e. from 1964 to 2018.

This study uses remote sensing and GIS techniques to estimate decadal changes in mean January temperature, mean July temperature and average precipitation of 15 agro-climatic zones.

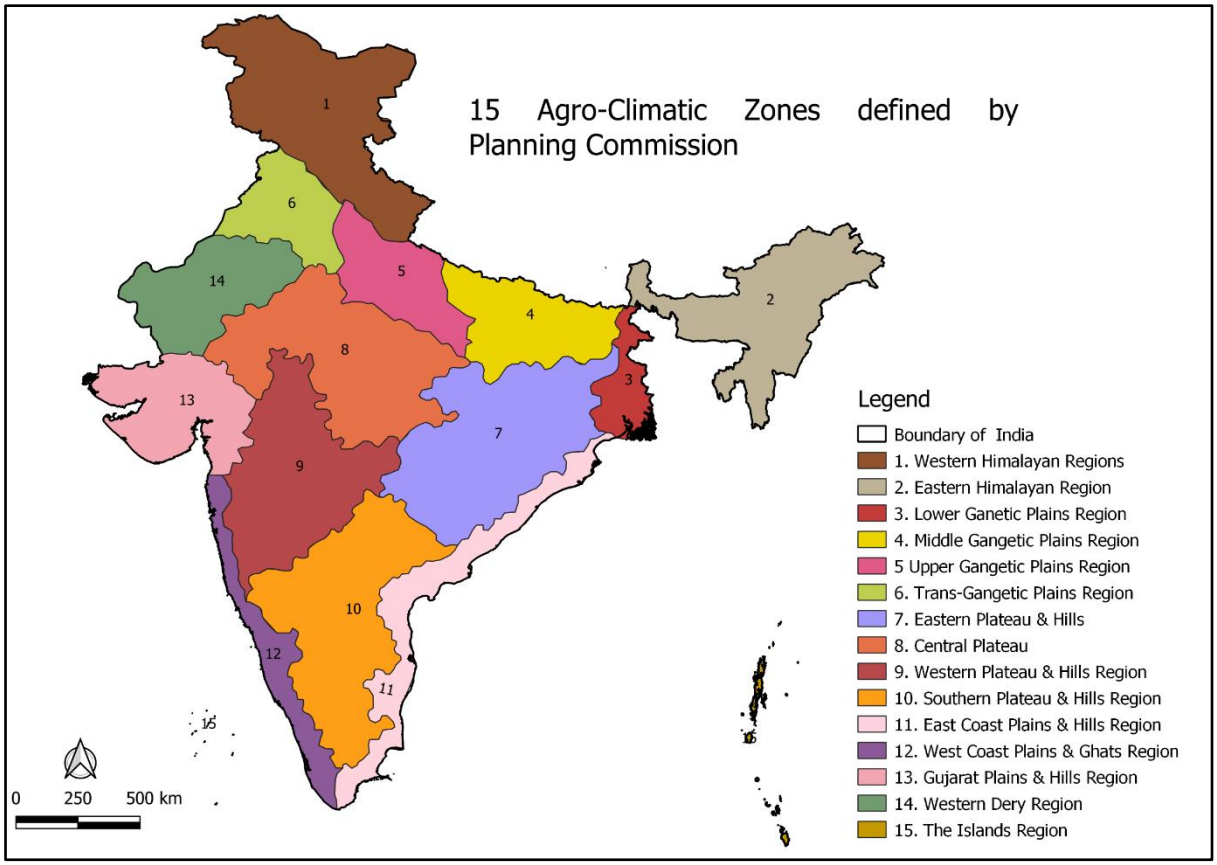


Figure 2 - 15 Agro-Climatic Zones defined by Planning Commission

An "Agro-climatic zone" is a land unit in terms of major climates, suitable for a certain range of crops and cultivars. The planning aims at scientific management of regional resources to meet the food, fibre, fodder and fuel wood without adversely affecting the status of natural resources and environment. Agro-climatic conditions mainly refer to soil types, topography, rainfall, temperature and water availability which influences the type of vegetation (Ahmad *et al.*, 2017).Several organisations have defined agro-climatic zones differently.

Climate is one of the key factors in agricultural production, right from the field preparation to marketing. However, the success or failure in farming is closely associated with the prevailing weather conditions. Hence it is possible to optimize farm production by adjusting the cropping patterns and agronomic practices to suit the climate of an area, if fairly good knowledge about the agro-climatic regions (based on physiography, soils, geological formation, climate, cropping patterns and irrigation and mineral resources for broad agricultural planning and developing future strategies) of a country is readily available (Chattopadhyay *et al.*, 2019). Climate change affects the variability and seasonality of temperature and humidity. Impact of climate change on Indian agriculture could be amplified because of the warmer temperature of Indian sub-continent. Since climate is an important input in agricultural production, studying the trends of temperature and rainfall is important (Paul *et al.*, 2015). This study focuses on climatic factors such as mean temperature and average rainfall.

Earlier efforts

- 1964 - In 1964 the Planning Commission categorized its regionalization on physical conditions, topography, geomorphology, rainfall, cropping pattern, development of irrigation and land resources at the district level.
- 1971 -The National commission on agriculture (1971) classified the country into 127 agro climatic zones.
- 1977 - Mitra (1977) divided the country into 7 natural regions, 31 sub regions and 89 divisions.
- 1978 - Murthy and Pandey (1978) demarcated the country into 8 regions on the basis of physiographic, soils, rainfall and water balance, and agricultural practices. This regionalization suffered was broadly generalized and agro-climatic indicators were over emphasized.
- 1979 - The launching of the National Agricultural Research Project in 1979 by the Indian Council of Agricultural Research (ICAR) initiated experimental programmers on agricultural research. Agro climatic zonation or ecological land classification was undertaken on the basis of parameters like soils, climate, topography, vegetation, crops etc. for delineation of 126 zones.
- 1992 - The National Bureau of Soil Survey and Land Use Planning (NBSS-LUP) made a comprehensive attempt at agro-ecological regionalization and the country was divided into 20 regions following the Food and Agricultural Organisation (FAO) methodology of sequential layering of information on maps (NBSS Publication, 1992). The regions were aggregated on the basis of uniform climatic factors, physiography, natural vegetation, soils and length of growing period. The major emphasis of this regionalization was on the bio-climatic factors and length of growing period.
- 2004 - Krishna (2004) prepared 40 soil climatic zones (areas falling in the same climate and water balance class and having similar soil types) on the basis of soil types and moisture index. The moisture index was based on Thornthwaite-Mather moisture index (MI) approach (where P is Precipitation): MI = (P – PET) / PET. Thus 9 climatic classes were superimposed on 13 zone soil maps to evolve 40 soil climatic zones. The basic criticism of this approach was that, although soil types were included in the zonation, however, soils were not classified on the basis of their water retention capacity.
- 1988 - In 1988 the Planning Commission came up with a growth strategy based on a holistic approach of area planning for long-term resource efficiency and sustainability. The motivation behind this was that resource based planning became feasible once homogeneous regions with respect to natural resource endowments (agro-climatic factors) were delineated and their utilization of available natural resource endowments was related to requirements of output and employment. These included soil type, climate (temperature, and rainfall and its variation), relevant meteorological characteristics, water demand and supply, including quality of water and aquifer conditions. It was also decided that, at this stage, it was better to concentrate on agro climatic characteristics (Ahsan Siddiqui, no date).

Benefits of Agro-Climatic Zones

Following are the benefits of Agro-climatic zones:

I. To optimize agricultural production;
II. To increase farm income;
III. To generate more rural employment;
IV. To make a judicious use of the available irrigation water;
V. To reduce the regional inequalities in the development of agriculture (Ahsan Siddiqui, no date).

Aim

Access temporal and spatial changes in temperature and precipitation for 15 Agro-climatic zones defined by the Planning Commission from 1961 till 2018.

Objective

- To detect the effect of climate change on average precipitation of agro-climatic zones formed by the Planning Commission from 1961 to 2018.
- To detect the effect of climate change on mean January temperature and mean July temperature of agro-climatic zones formed by the Planning Commission from 1961 to 2018.

Data used

WorldClim –

- WorldClim is a set of global climate layers (gridded climate data in GeoTiff format) that can be used for mapping and spatial modelling.
- The variables available are average minimum temperature (°C) and average maximum temperature (°C)
- The spatial resolution is 2.5 minutes (~21 km². Each downloaded "zip" file contains 120 GeoTiff (.tif) files, for each month of the year (January is 1; December is 12), for a period of 10 years.

WRIS (Water Resources Information System)-India –

- India-WRIS Web GIS is a 'Single Window' solution for comprehensive, authoritative and consistent data of India's water resources along with allied natural resources in a standardized national GIS framework with tools to analyse, access, visualize, understand and search the data for assessment, monitoring, planning, development and finally Integrated Water Resources Management (IWRM) (cwc.gov.in, 2019).
- The project has been jointly undertaken by CWC, MoJS and NRSC, ISRO, DoS in theyear 2009 (cwc.gov.in, 2019).

Formulae

- For calculating mean January and July temperature :

- Mean temperature = (Min Temp + Max Temp)/ 2
- Decadal Mean temperature = (Sum of Mean temperature for 10 months)/10

Methodology

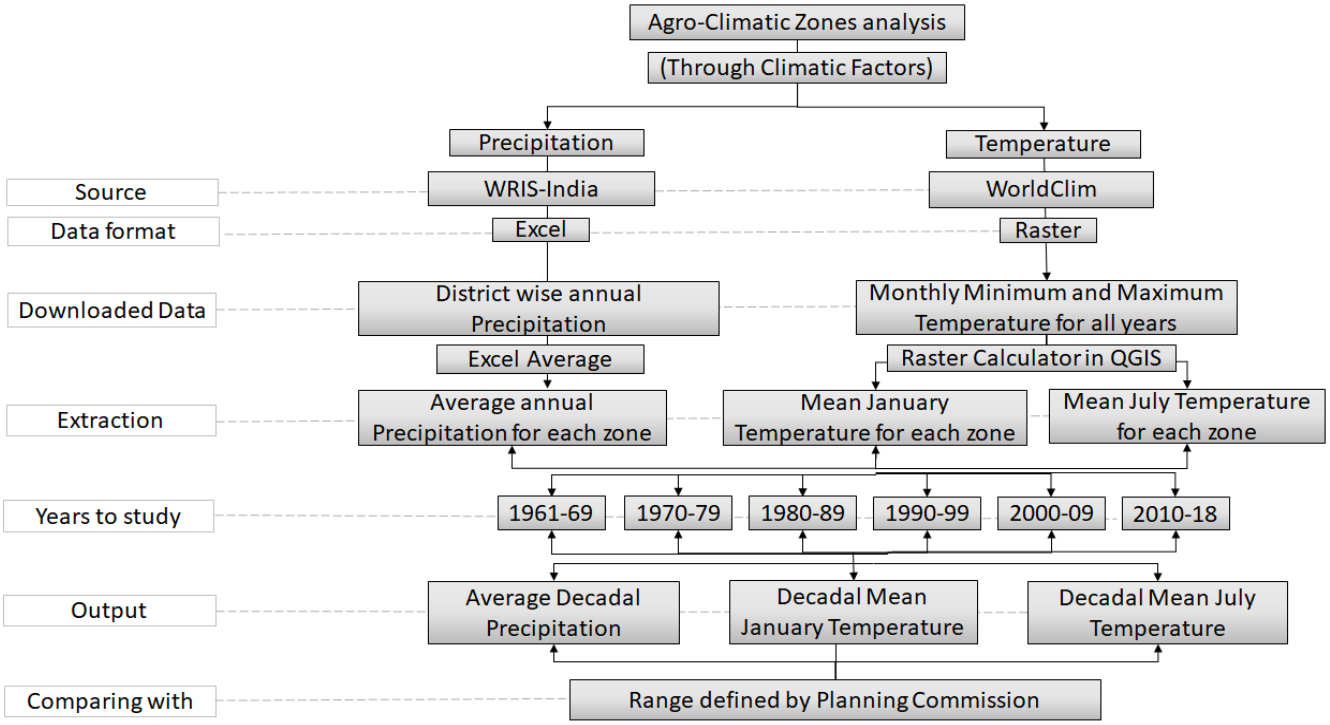


Figure 3 - Detailed Methodology

States covered under 15 Agro-climatic zones:

Zone Number	Name of Zone	States covered under the zones
1	Western Himalayan Region	Jammu and Kashmir, Uttar Pradesh
2	Eastern Himalayan Region	Assam, Sikkim, West Bengal and all North-Eastern states
3	Lower Gangetic Plains Region	West Bengal
4	Middle Gangetic Plains Region	Uttar Pradesh, Bihar
5	Upper Gangetic Plains Region	Uttar Pradesh
6	Trans Gangetic Plains Region	Punjab, Haryana, Delhi and Rajasthan
7	Eastern Plateau and Hills Region	Maharashtra, Uttar Pradesh, Orissa and West Bengal
8	Central Plateau and Hills Region	MP, Rajasthan, Uttar Pradesh
9	Western Plateau and Hills Region	Maharashtra, Madhya Pradesh and Rajasthan
10	Southern Plateau and Hills Region	Andhra Pradesh, Karnataka, Tamil Nadu
11	East Coast Plains and Hills Region	Orissa, Andhra Pradesh, Tamil Nadu and Pondicherry
12	West Coast Plains and Ghat Region	Tamil Nadu, Kerala, Goa, Karnataka, Maharashtra
13	Gujarat Plains and Hills Region	Gujarat
14	Western Dry Region	Rajasthan
15	The Islands Region	Andaman and Nicobar, Lakshadweep.

Table 1 - States or part of states covered under zones

MEAN JANUARY TEMPERATURE (in Degree Celsius)

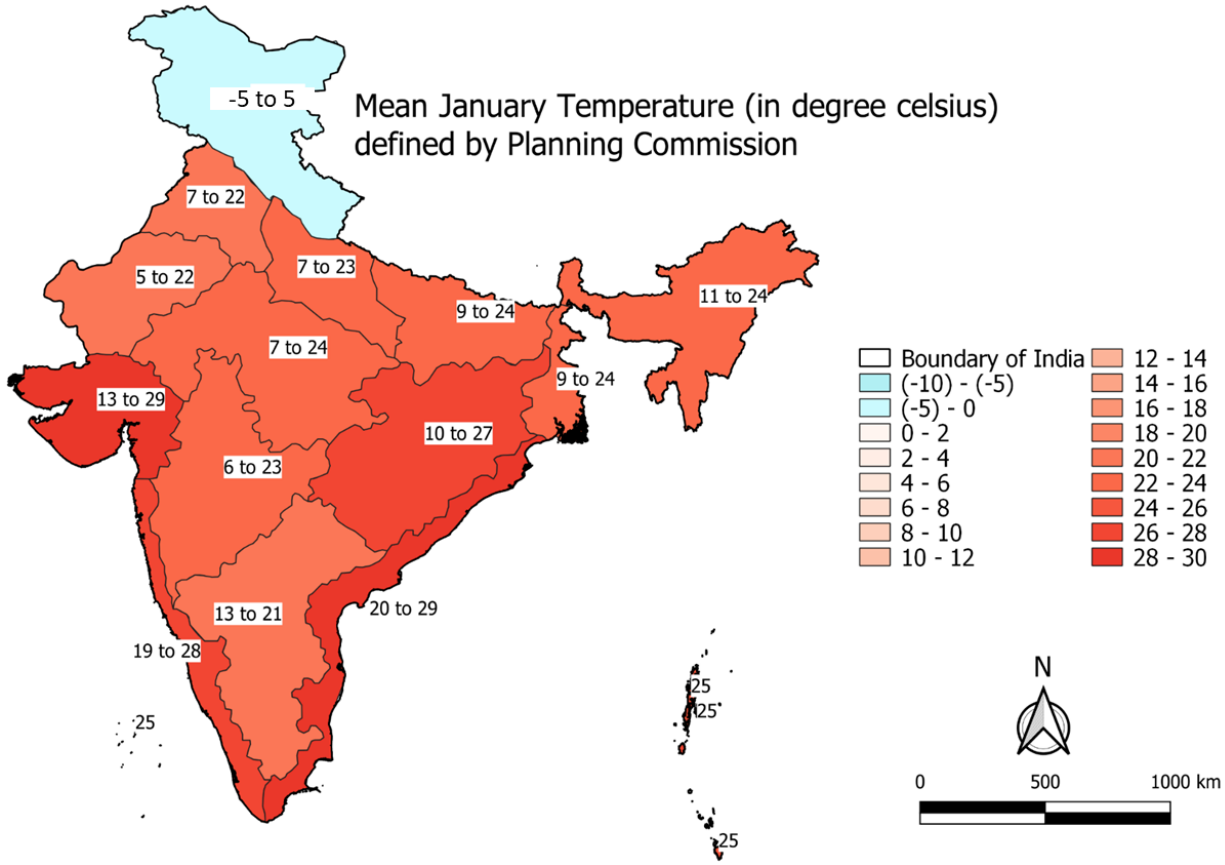


Figure 4 - Ranges defined for Mean January Temperature by Planning Commission

Temporal variation of Mean January temperature from1961 to 2018

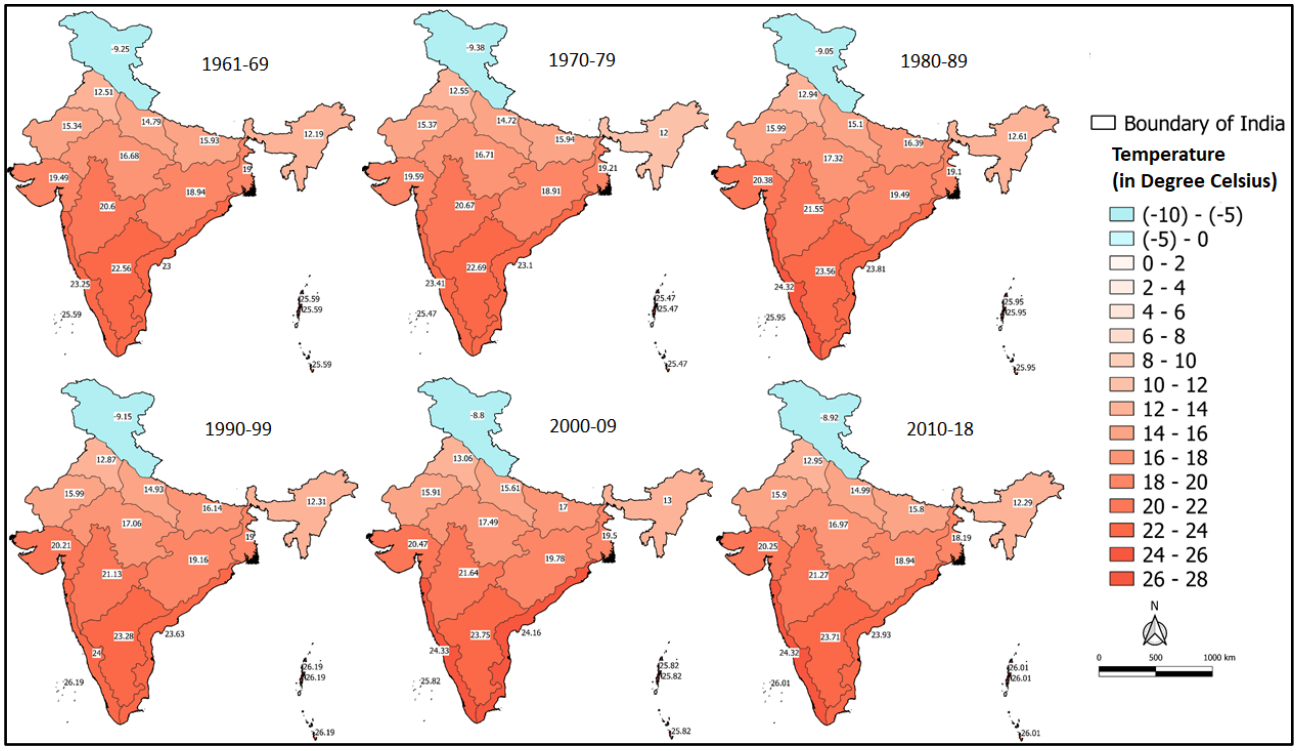


Figure 5 - Temporal Variation of Mean January Temperature

ACZ	1961-69	1970-79	1980-89	1990-99	2000-09	2010-18	AVG_1961 to 2018	Jan Temp. by PC	Deviation
(in degree Celsius)									(in Percentage)
1	-9.25	-9.38	-9.05	-9.15	-8.8	-8.92	-9.09	5 to -5	81.80%
2	12.19	12	12.61	12.31	13	12.29	12.4	10 to 20	
3	19	19.21	19.1	19	19.5	18.19	19	9 to 24	
4	15.93	15.94	16.39	16.14	17	15.8	16.2	9 to 24	
5	14.79	14.72	15.1	14.93	15.61	14.99	15.02	7 to 23	
6	12.51	12.55	12.94	12.87	13.06	12.95	12.81	10 to 20	
7	18.94	18.91	19.49	19.16	19.78	18.94	19.20	10 to 27	
8	16.68	16.71	17.32	17.06	17.49	16.97	17.04	7 to 24	
9	20.6	20.67	21.55	21.13	21.64	21.27	21.14	6 to 23	
10	22.56	22.69	23.56	23.28	23.75	23.71	23.26	10 to 20	16.29%
11	23	23.1	23.81	23.63	24.16	23.93	23.60	20 to 30	
12	23.25	23.41	24.32	24	24.33	24.32	23.94	18 to 30	
13	19.49	19.59	20.38	20.21	20.47	20.25	20.07	25	
14	15.34	15.37	15.99	15.99	15.91	15.9	15.75	5 to 22	
15	25.59	25.47	25.95	26.19	25.82	26.01	25.84	25	3.35%

Table 2 - Mean January temperature of individual zone for each decade

MEAN JULY TEMPERATURE (in degree Celsius)

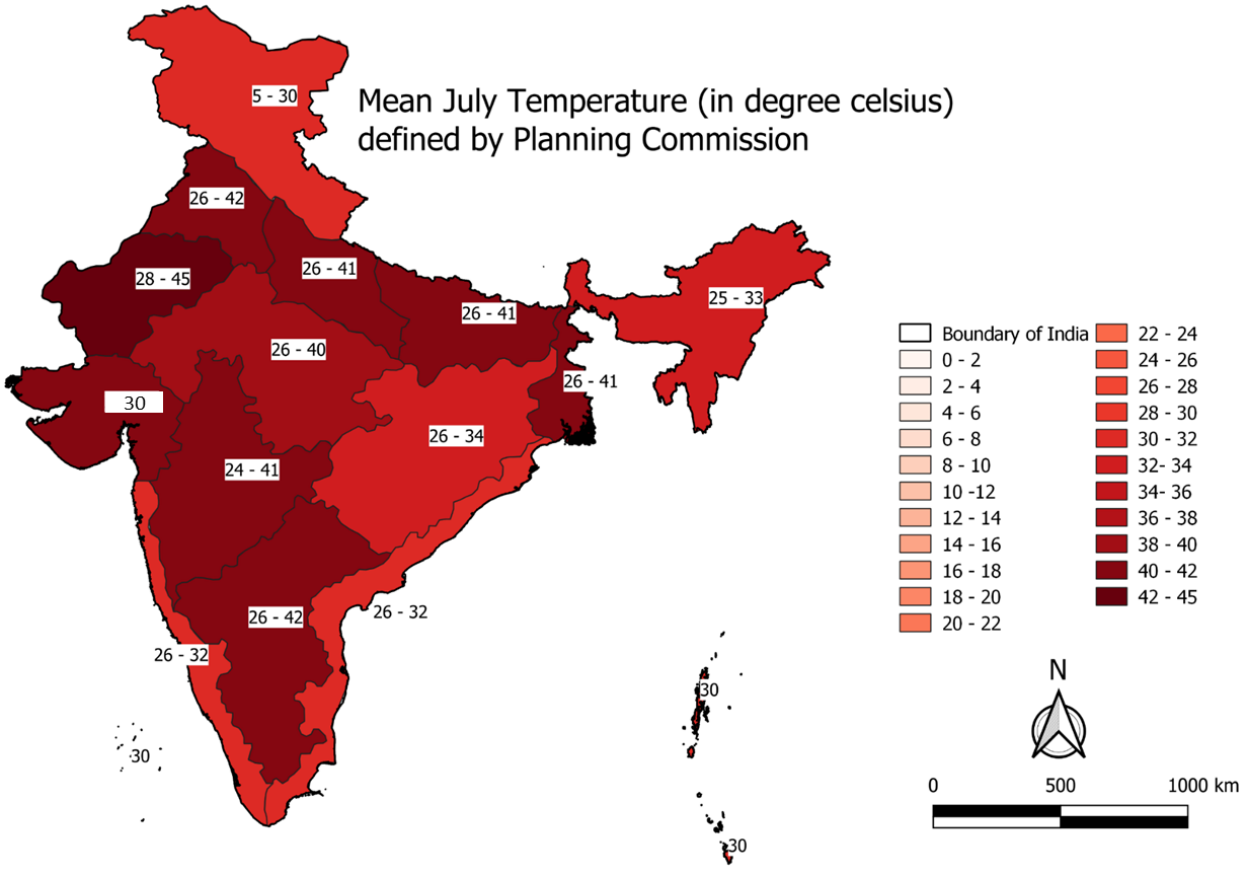


Figure 6 - Ranges defined for Mean July Temperature by Planning Commission

Temporal variation of Mean January temperature from1961 to 2018

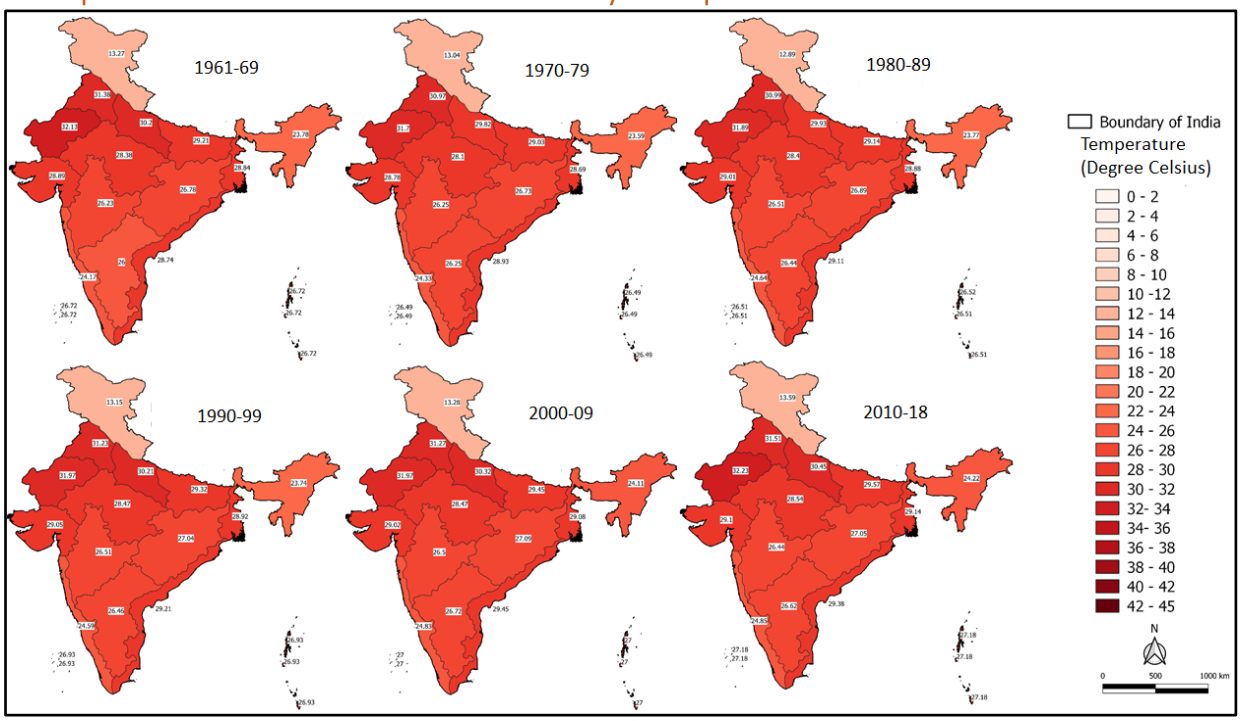


Figure 7 - Temporal Variation of Mean January Temperature

ACZ	1961-69	1970-79	1980-89	1990-99	2000-09	2010-18	AVG_1961-2018	July Temp. by PC(in degree Celsius)	Deviation in %
1	13.27	13.04	12.89	13.15	13.28	13.59	13.20716	5 to 30	
2	23.78	23.59	23.77	23.74	24.11	24.22	23.8688449	25 to 30	-4.52%
3	28.84	28.69	28.88	28.92	29.08	29.14	28.9275185	26 to 41	
4	29.21	29.03	29.15	29.32	29.45	29.57	29.289344	26 to 41	
5	30.2	29.82	29.93	30.21	30.32	30.45	30.15691967	26 to 41	
6	31.38	30.97	30.99	31.22	31.27	31.51	31.22577583	26 to 40	
7	26.78	26.73	26.89	27.04	27.09	27.06	26.93222883	26 to 34	
8	28.38	28.1	28.41	28.47	28.46	28.54	28.39738933	26 to 40	
9	26.23	26.25	26.51	26.50	26.50	26.44	26.408148	24 to 41	
10	26	26.25	26.44	26.46	26.72	26.62	26.4164985	25 to 40	
11	28.74	28.93	29.11	29.21	29.45	29.38	29.13647383	25 to 30	
12	24.17	24.33	24.64	24.59	24.83	24.84841	24.56942233	25 to 30	-1.72%
13	28.89	28.78	29.01	29.05	29.02	29.10655	28.97557533	30	-3.41%
14	32.13	31.7	31.89	31.97	31.98	32.23102	31.98421383	28 to 45	
15	26.72	26.49	26.51	26.93	27.01	27.18124	26.80777533	30	-10.64%

Table 3 - Mean July temperature of individual zone for each decade

AVERAGE ANNUAL PRECIPITATION (in mm)

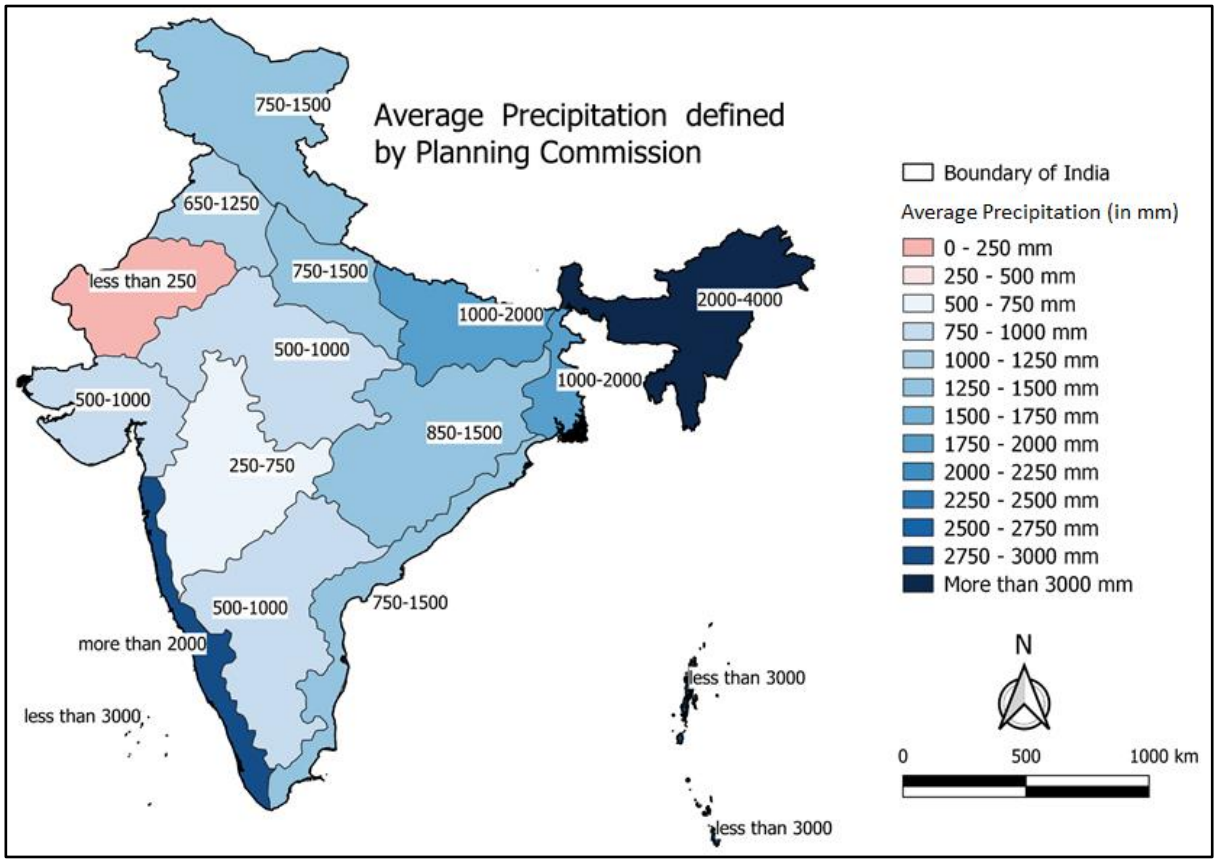


Figure 8 - Average Annual precipitation defined by Planning Commission

Temporal variation of Average Decadal Precipitation from 1961 to 2018

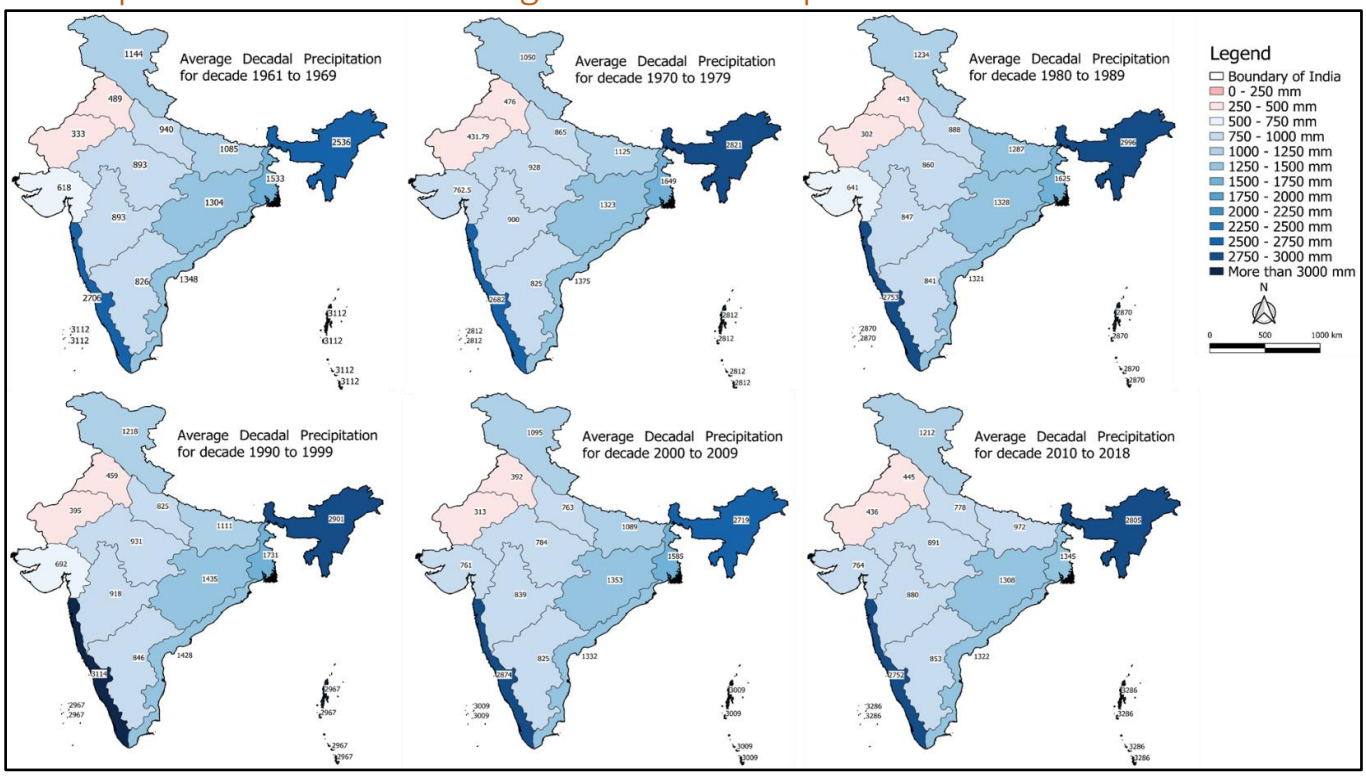


Figure 9 - Temporal variation of Average Decadal Precipitation

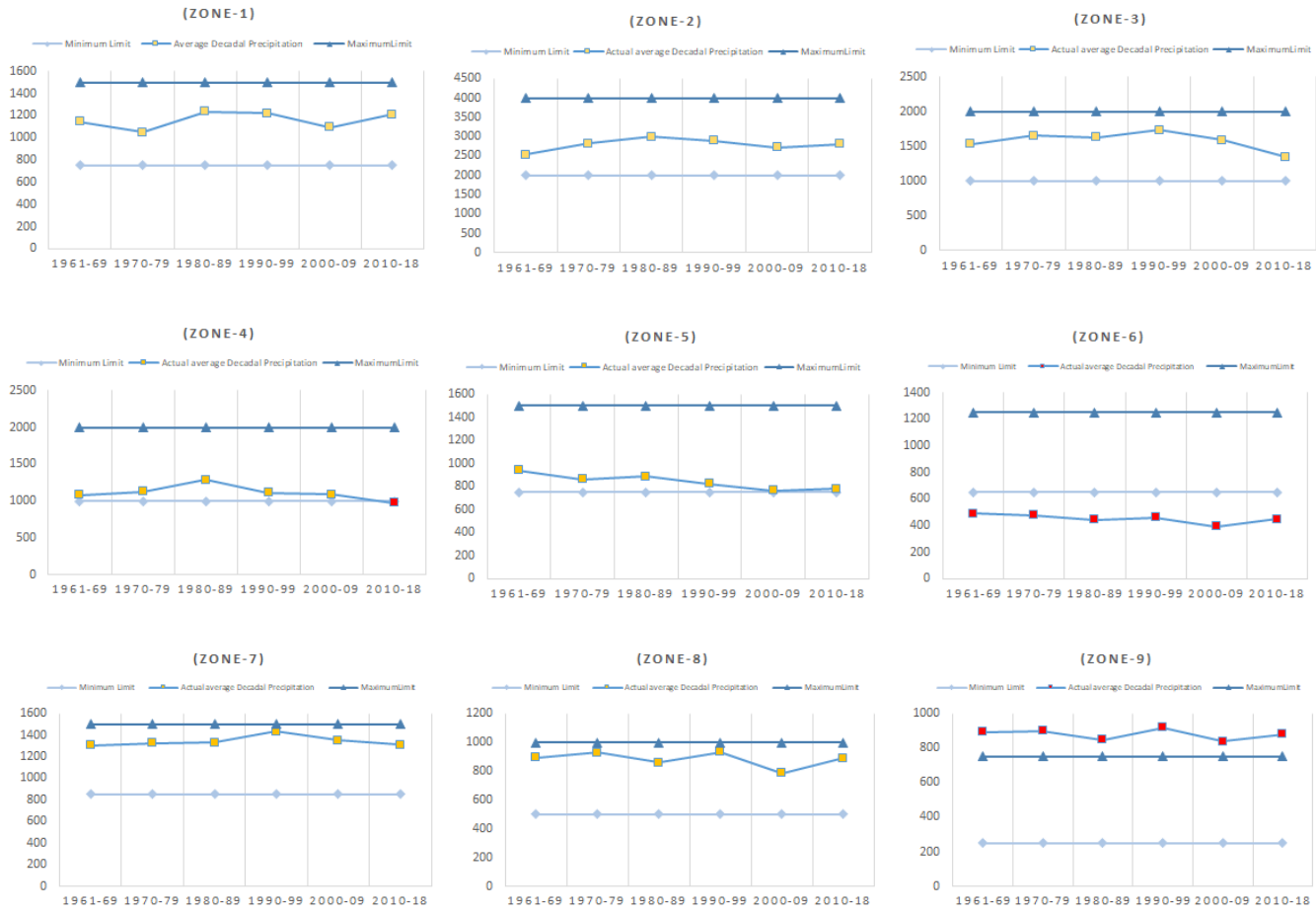
ACZ	1961-69 (in mm)	1970-79 (in mm)	1980-89 (in mm)	1990-99 (in mm)	2000-09 (in mm)	2010-18 (in mm)	AVG_1961-2018 (in mm)	Limits Defined by PC (in mm)	Minimum Limit by PC (in mm)	Maximum Limit by PC (in mm)	Deviation (in percentage)
1	1144.15	1050.253	**1234.513**	1218.56	1095.653	1212.233	1159.227222	750-1500	750	1500	
2	2536.273	2821.316	**2996.99**	2901.24	2719.849	2805.053	2796.786984	2000-4000	2000	4000	
3	1533.289	1649.438	1625.458	**1731.157**	1585.849	1345.827	1578.503	1000-2000	1000	2000	
4	1085.23	1125.662	**1287.707**	1111.022	1089.382	972.0893	1111.848587	1000-2000	1000	2000	
5	**940.4466**	865.1972	888.8397	825.0859	763.0438	778.8869	843.5833333	750-1500	750	1500	
6	**489.905**	476.9683	443.5308	459.2983	392.7917	445.6208	451.3525	650-1250	650	1250	-30.56%
7	1304.15	1323.489	1328.961	**1435.176**	1353.633	1308.584	1342.332159	850-1500	850	1500	
8	893.8138	928.743	860.8343	**931.8625**	784.3439	891.9313	881.9214583	500-1000	500	1000	
9	893.1665	900.026	847.661	**918.86**	839.114	880.4473	879.879125	250-750	250	750	17.32%
10	826.9365	825.3171	841.2238	846.0698	825.2681	**853.4783**	836.3822569	500-1000	500	1000	
11	1348.708	1375.007	1321.405	**1428.123**	1332.804	1322.508	1354.759306	750-1500	750	1500	
12	2706.169	2682.408	2753.333	**3114.976**	2874.563	2752.066	2813.918974	more than 2000	2000	-	
13	618.72	762.5	641.91	692.56	761.16	**764.56**	706.9016667	50-1000	500	1000	
14	333.96	431.79	302.45	395.2589	313.2011	**436.2244**	368.8140741	less than 250	-	250	47.53%
15	3112	2812	2870	2967	3009	**3286**	3009.333333	less than 3000	-	3000	0.31%

Table 4 - Average precipitation of individual zone for every decade

Average Decadal Precipitation variation for zone 1 to zone 15

X-axis shows average decadal precipitation in mm and

Y-axis shows decades



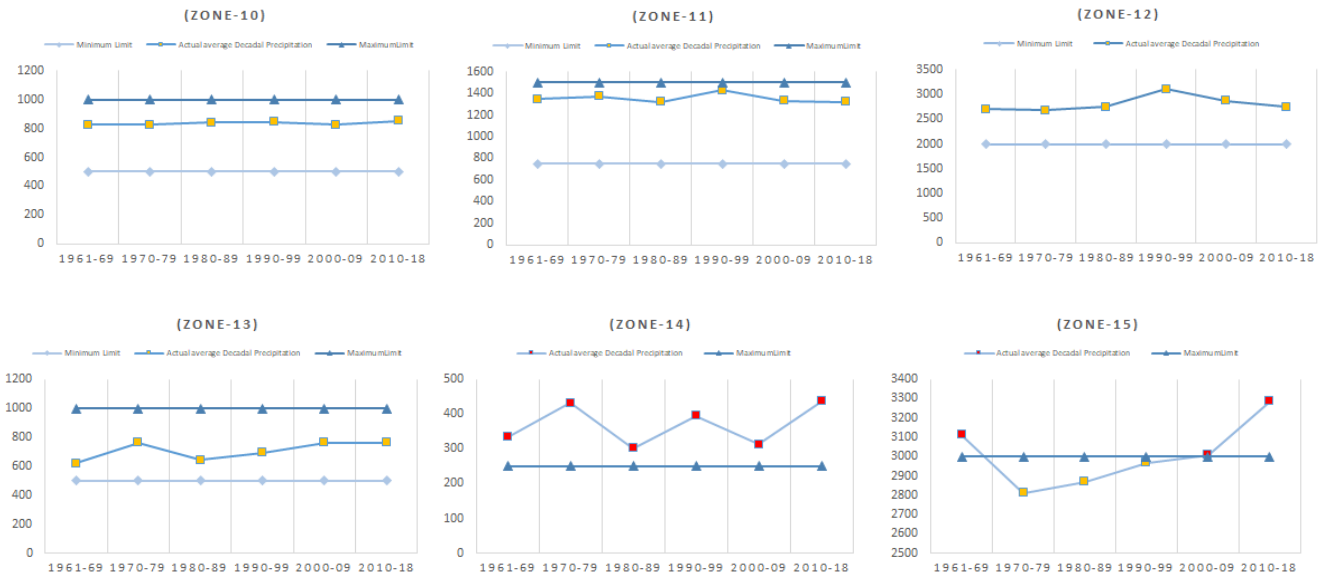


Figure 10 - Temporal variation of individual zones from 1961-2018

Conclusion

Results for Precipitation:

- For zone 1 and zone 2 decadal average annual precipitation shows gradual increase in the period 1980-89 and after that it shows gradual decrease in precipitation in 2000-09 and suddenly it shows increment for the decade 2010-18.
- Zone 3 and zone 4 shows continuous increment in decadal average precipitation in decades 1990-99 and 1980-89 respectively. Afterwards it shows continuous decrement in 2010-18.
- Zone 5 and zone 6 shows an overall decreasing trend.
- Zone 7 shows continuous increment in decadal average precipitation in 1990-99 and afterwards it shows continuous decrement till 2018.
- Zone 15 shows continuous decrement in decadal average precipitation till 1980-89 decade and afterwards it shows continuous increment.
- Rest of the zones i.e. zones 8, 9, 10, 11, 12, 13 and zone 14 shows discrete variation in decadal average precipitation.
- For zone 6 i.e. Trans- Gangetic plains region, the range for average annual precipitation is defined as 650 to 1250 mm. Observations from the data show for all the decades (from 1961 to 2018) that precipitation is lower than the minimum limit decided by the planning commission which is 650 mm. Decadal average precipitation values for all the studied decades are varying in between 390 mm to 490 mm. Overall negative deviation of average precipitation (1961-2018) is 30.56 % for zone 6.
- For zone 9 i.e. Western plateau and hills region , the range for average annual precipitation is defined as 250 to 750 mm. Observations from data shows for all the decades that precipitation is higher than the maximum limit defined by the Planning Commission which is 750 mm. Overall positive deviation of average precipitation (1961-2018) is 17.32 % for zone 9.

- For zone 14 i.e. Western dry region , the range for average annual precipitation is defined as less than 250 mm. Observations from data shows for all the decades that precipitation is higher than the limit defined by the planning commission which is 250 mm. Overall positive deviation of average precipitation (1961-2018) is 47.53 % for zone 14.
- For zone 15 i.e. the Iceland's region, the range for average annual precipitation is defined as less than 3000 mm. Observations from the data shows that, for 3 decades (which are 1961-69, 2000-09 and 2010-18) the decadal average precipitation is higher than the limit decided by the planning commission of 3000 mm. Overall positive deviation of average precipitation (1961-2018) is 0.31 % for zone 15.

Results for January Mean Temperature:

- All the zones except zone 6 shows discrete variation of decadal mean January temperature. No significant increment or decrement have been observed over the timeframe of Zone 6 shows a trend of continuous increment of decadal mean January temperature in 2000-09 and suddenly decreases from 2010-18.
- For zone 1 i.e. Western Himalayan region, the range for mean January temperature is defined as –5 to 5 degree Celsius. Observations from data shows for all the decades that decadal mean January temperature is lower than the minimum limit decided by the planning commission which is -5 degree Celsius. Overall positive deviation of average precipitation (1961-2018) is 81.8 % for zone 1.
- For zone 10 i.e. Southern plateau and hills region, the range for mean January temperature is defined as 13 to 21 degree Celsius. Observations from data shows for all the decades that decadal mean January temperature is higher than the maximum limit decided by the planning commission which is 21 degree Celsius. Overall positive deviation of average precipitation (1961-2018) is 11.48 % for zone 10.
- For zone 15 i.e. the ice lands region, the value for mean January temperature is defined as 25 degree Celsius. Observations from data shows for all the decades that decadal mean January temperature is higher than the value decided by planning. Overall positive deviation of average precipitation (1961-2018) is 3.35 % for zone 15.

Results for July Mean Temperature:

- Zones 3, 4, 5, 6 and 15 shows similar trends for mean July temperature variation. For the 1970-79 decade the temperature was decreasing and afterwards it continuously increased till 2010- 18.
- Zone 10 and zone 11 shows similar trends for mean July temperature variation. Temperature from 1961-69 till 2000-09 is continuously increasing and suddenly shows a decrease for decade 20210-18.
- Zone 14 is showing continuous increment in decadal mean July temperature.
- Rest of the zones (which are zones 1, 2, 7, 8, 9, 12 and 13) show discrete variation in decadal mean July temperature.
- For zone 2 i.e. Eastern Himalayan region, the range for mean July temperature is defined as 25 to 33 degree Celsius. Observations from data shows for all the decades that decadal mean July temperature is lower than the minimum limit decided by the

planning commission which is 25 degree Celsius. Overall deviation of 4.52 % from minimum range value have been observed for zone 2.

- For zone 12 i.e. West coastal plains and Ghats region, the range for mean July temperature is defined as 26 to 32 degree Celsius. Observations from data shows for all the decades that decadal mean July temperature is lower than the minimum limit decided by the planning commission which is 26 degree Celsius. Overall deviation of 1.72 % from minimum range value have been observed for zone 12.
- For zone 13 i.e. Gujarat plains and hills region, the range for mean July temperature is defined as 25 to 30 degree Celsius. Observations from data shows for all the decades that decadal mean July temperature is lower than the minimum limit defined by the planning commission which is 25 degree Celsius. Overall deviation of 3.41 % from minimum range value have been observed for zone 12.
- For zone 15 i.e. the ice lands region, the value for mean July temperature is defined as 30 degree Celsius. Observations from data shows for all the decades that decadal mean July temperature is lower than the value of 30 degree Celsius decided by the planning commission. Overall deviation of 10.64 % from decided value have been observed for zone 15.

ABOUT SPOKEN TUTORIAL PROJECT

Description of project

- The Spoken Tutorial project is funded by the National Mission on Education through Information and Communication Technology (ICT), launched by the Ministry of Human Resources and Development, Government of India.
- The use of spoken tutorials to popularize software learning and its use will be coordinated through this website (Spoken Tutorial, n.d.).

Figure 11 - Spoken Tutorial Logo

Spoken Tutorial Forums is a friendly and free online discussion forum. You can join existing discussions or start new topics and get lots of replies from the Spoken Tutorial community (Spoken Tutorial, n.d.). There are informative tutorials available on this forum which are easily accessible and easy to operate.

Forums are very easy to use. It's very easy to format forum posts with fonts, colours, and many other creative options. You can directly attach files to your posts from your computer. You can give links to webpages or videos from other video websites (Spoken Tutorial, n.d.).

My contribution for spoken tutorial project

The Spoken tutorial project is itself an innovative and impressive idea. It is easier to learn something visually than from books or audios and spoken tutorials are best to learn open source softwares visually.

I have contributed a little in this great work by writing two scripts:

1. Merging and splitting of vector layers

- Merge two or more vector layers into a single vector layer.
- Spit a single vector layer into two or more vector layers using one attribute.

2. Georeferencing

- To georeference a raster image using the Georeferencer GDAL plugin.

References

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