AGROCLIMATIC CHARACTERIZATION OF SOUTHERN DRY ZONE OF KARNATAKA (NARP AGROCLIMATIC ZONE - 6)

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FOREWORD

Climate is changing. Scientific information at local scale is largely uncertain with significant disagreement among climate models with regard to the magnitude and direction of change at global or regional scale. This has been evident in sub-continent simulations worldwide. Infact, the most fundamental contextual limitation identified by the evaluated councils was a lack of scientific information at a scale relevant to inform local planning. At this scale, vulnerability to climate change is not the only issue of concern, but also the non-climate determinant viz. socio-economic situation of farmer and current resource accessibility are the hidden issues to be addressed. Analysis of climate determinants, along with local knowledge and history, play an important role in projecting vulnerabilities to change, and yet, these are largely absent in the evaluated plans.

"In the real world, we garden in microclimates, not hardiness zones". As quoted, the strategic environmental assessment and development of alternative climate adaptation solutions that are site specific is the need of the hour. Scientific community should step ahead with long term vision of conserving resources under altered climates including on how the farming community will adapt to climate impacts.

Editors have made a sincere attempt to document the behavior of the climate over thirty three years. This book with historical weather data forms the baseline for understanding the trends that can be used to address challenges from designing the research to inferring the research results. Water balance considering Potential Evapo Transpiration (PET) describes crop water requirements. Length of Growing Period (LGP), delineation of zones as per the changing climate and crop weather calendars developed help in tackling weather aberrations. This documentation is found to be very useful to the academicians, technocrats as well as policy makers to take necessary steps in mitigating the changing scenario of climate in the interest of farming community. Thus, I congratulate the authors for taking a step towards prioritization of alternative climate adaptation solutions.

May, 2018
Bangalore

Dr. Y.G. SHADAKSHARI
Director of Research
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PREFACE

It is important to know the climate type of your area before choosing the trees to plant

(Quoted by Wayne Teel In 1984).

Certain issues cut across all the disciplines involved in climate research. Among them are the nature of our available climate information, modeling efforts, prediction efforts, detection and attribution issues, and linkages across time scales. Progress in these areas will go far to advance our understanding of climate change and variability over decade-to-century time scales. A census of local climate is the first step. Having said this, an attempt has been made to document the climate of the Agro met Field Unit (AMFU) located at Naganahally, Mysore under Zone-6.

Karnataka being grouped into ten zones, details on cropping season and the crops that are preferable along with safe growing period for each zone is discussed in Chapter - 1. Monthly and seasonal normal over the districts of the state are also mentioned. Length of growing period for each taluk mentioned in this Chapter acts as a base for crop planning. An attempt has also been made to delineate the zone boundaries by considering the changing rainfall situation.

Southern dry zone (SDZ) being the point of interest, an in depth in site with respect to delineation, physiography, climate, irrigation along with its agro ecological situations is discussed in Chapter -2. The Length of Growing Period (LGP) is highly varying within and among the NARP zones. An attempt has been made to develop and present normal LGPs for different districts of SDZ. After identifying the LGP, an attempt has been made to identify the suitable crop growing season, sowing window and crops for the different seasonal conditions. All of the above said information is pooled and crop weather calendar is developed for Mandya, Mysore, Tumkur and Hassan districts based on the weekly mean weather.

District specific details on demography and the agriculture profile are presented in Chapter-3. This chapter provides the details viz., land use pattern, major soils, soil map, agriculture land use, area under major crops and their production and productivity, livestock, poultry and fisheries. Besides these, irrigation and its source, ground water usage and availability have also been highlighted. Monthly normal rainfall over 114 years (1901 - 2014) and in the last decade along with latest 30 years normals are provided at the district level. Rain gauge station specific normal’s and trends in rainfall and rainy days for the last thirty years are also presented for each district.

Climate variability in general, weather and climate information in particular are very important for scientific research. In view of this, the climate data of a region plays a vital role in deciding the ways of life, crops of the region and other developmental plans. The AMFU and Organic Forming Research Station (OFRS), Naganahally, Mysore, of UAS, Bangalore which came into existence during 1968 has been conducting the research for southern dry zone, which are designed to meet the changing needs of agriculture. With time, the emphasis on sectoral approach has now been shifted to systems approach to solve the location specific problems. Keeping in mind, the importance and necessity of this meteorological data, an attempt has been made to pool and create the data bank of weather of AMFU, Naganahally, Mysore in Chapter - 4. This document contains the information on mean daily, weekly, Nakshatra-wise, monthly, seasonal and annual rainfall. It also includes the information on behavior of monthly mean of other weather parameters. This information could be used by various categories of users, such as students, teachers, researchers, administrators, policy makers, planners and mainly farmers.

Information compiled in this book would have not been possible without the kind support and help of staff of Naganahally AMFU / OFRS, Mysore.We are highly indebted to the staff. The project scientists of this centre expresses their profound gratitude to Dr. M. S. Nataraju, Vice-Chancellor and Dr. H. Shivanna, Former Vice-Chancellor, Dr. Y. G Shadakshari, Director of Research, Dr. R. C. Gowda, Associate Director of Research (ZARS of Zone-5), Dr. S. N. Vasudevan, Associate Director of Research, Mandya (ZARS of Zone-6) for their guidance, professional and administrative support. Agrometeorology team of this centre is thankful to Dr. P. Vijaya Kumar, Project Coordinator, AICRP on Agrometeorology and his team at CRIDA, Hyderabad for their guidance and constructive criticism. We are very much grateful to Dr. K. K. Singh, Head Agromet, IMD, New Delhi and his scientific community of IMD and GKMS, New Delhi for their technical guidance and financial support through Ministry of Earth Science, Govt. of India, New Delhi.

May, 2018 **Authors**

Bangalore

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CHAPTER - I

AGROCLIMATE OF KARNATAKA

The fatigue in the post-green revolution era has now attained serious dimensions. For achieving the required production targets to feed more than 1.5 billion in 2050, it is imperative to develop strategies that can sustain higher levels of production without an adverse affect on the environment. In order to maximize the production from the available resources and prevailing climatic conditions, need-based, location specific technology needs to be generated. Delineation of agro-climatic zones based on soil, water, rainfall, temperature etc. is the first essential step for sustainable production.

With 329 million hectares of the geographical area, the country presents a large number of complex agro-climatic situations. Several attempts have been made to delineate major agro-ecological regions in respect to soils, climate, physiographic and natural vegetation for macro-level planning on a more scientific basis. They are as follows.

- Agro-climatic regions by the Planning Commission
- Agro-climatic zones under National Agricultural Research Project (NARP)
- Agro-ecological regions by the National Bureau of Soil Survey & Land Use Planning

An "Agro-Climatic Zone" is a land unit in terms of major climate, suitable for a certain range of crops and cultivars. Agro-climatic conditions mainly refer to soil types, rainfall, temperature and water availability which influences the type of vegetations. An agro-ecological zone is the land unit carved out of agro-climatic zone superimposed on landform which acts as modifier to climate and length of growing period.

1.1 Normal monthly rainfall in different districts of Karnataka State (1901-2014)

State on an average (1901-2014) receives about 1269 mm rainfall. Udupi district receives highest of 4252 mm annual rainfall where as Bagalkote and Vijayapura receives the lowest of 555 mm rainfall. Coastal districts receive higher annual rainfall. The seasonal mean rainfall of all the districts is given in table 1.1. The monthly mean rainfall of all the districts is given in table 1.2.

1.2 Re-delineation of different agroclimatic zones

Its high time that the present classification of LGP is checked and delineated as per the changing climatic trends. As a pilot study, considering changing rainfall trends, an attempt has been made to check if Tiptur and Koratagere taluk of Tumakuru district and Arasikere taluk of Hassan district belongs to the presently grouped central dry zone. The central dry zone (CDZ) has hot, dry, semi-arid climate with low rainfall pattern ranging from 450 to 715 mm. CDZ is characterized by low cropping intensity (114%) and subsistence level. Length of growing period (LGP) is around 90 to 150 days so that mono cropping system of short duration millets and pulses prevails in large. As the soils of CDZ are almost same as that of Southern Dry Zone (SDZ) rainfall and the cropping pattern were considered as deciding factors. K mean cluster analysis on rainfall pattern and cropping system classified these two taluks into a separate group (Table-1.3 and Figure-1.1). Higher Ratio (0.644) of between sum of squares to total sum of squares clearly explains that these three taluks does not match to the criteria of CDZ. Tovinakere hobli of Koratagere taluk has the potentiality for three crops a year while the rest of the taluk has two crops. Tiptur and Arasikere have growing period of 150-180 days with potentiality of double cropping system. Nonavinakere and Tiptur hoblis of tiptur taluk (Table-1.4) have summer crop while other areas of the taluk take up both *kharif* and *rabi* crop. Most of the Arasikere (Table-1.4) area has double cropping system. Average (1980 to 2013) annual rainfall of Tiptur and Arasikere is 770mm and 960 mm. Rainfall of SDZ ranges from 700 to 890 mm. SDZ has hot, moist, semi arid climate. Considering district borders and other soil characteristics, results from k-mean cluster analysis and field data on cropping systems implies that Koratagere has to be grouped to EDZ while Tiptur and Arasikere have to be grouped under SDZ. Newly delineated zone boundaries are presented in Figure-1.2.

1.3 Length of growing period of different agroclimatic zones of Karnataka state

National Agricultural Research Project (NARP) in 1989 has demarcated the Karnataka state into 10 Agro-climatic zones based on soil and climatic conditions. The National Bureau of Soil Survey & Land Use Planning came up with 7 agro-ecological sub regions based on the growing period as an integrated criteria of effective rainfall, soil groups, delineated boundaries adjusted to district boundaries with a minimal number of regions. Further by superimposing soil maps and length of growing period (Higgins and Kassam, 1981), 10 zones were grouped into subzones. Two to four crop growing situations exist in each NARP zone which needs site specific varietal recommendation to ensure better performance. Hence there is a need to identify homogenous land management units within each NARP zone and refine agro technologies in tune with the prevailing natural resources for better management to minimize degradation of soil resources. With this view, zonal agricultural research station (ZARS) is set up in each agro-climatic zone for generating location specific, need based research targeted for specific agro-ecological situations.

The assessment of LGP in the state showed wide variation in each zone i.e. 120 to 180 days (North Eastern transitional, North Eastern dry, Eastern dry zone and Northern transitional zone), <90 to 180 days (Northern dry and central dry zone), 90 to 150 days (Southern dry zone and North Eastern dry zone), 150 to 210 days (Southern transitional zones), 180 to 240 days (coastal zone) and150 to 270 days (hilly zone). Zone wise details are presented below.

Table-1.1: Normal seasonal rainfall (mm) at different districts of Karnataka (1901-2014)

Districts	PM	SWM	NEM	Annual
Bagalkote	83	342	130	555
Bengaluru (Rural)	148	398	208	754
Bengaluru (Urban)	151	409	212	772
Belagavi	84	374	138	596
Ballari	84	338	137	559
Bidar	68	647	100	815
Vijayapura	64	368	123	555
Chamarajanagar	261	1863	307	2431
Chikkaballapur	121	318	137	576
Chikkamagalur	174	1488	231	1893
Chitradurga	109	319	160	588
Darwad	135	528	161	824
Davangere	115	374	162	651
DK	225	3396	343	3964
Gadag	110	346	144	600
Kalaburagi	67	553	109	729
Hassan	176	788	226	1190
Haveri	130	510	163	803
Kodagu	244	2043	279	2566
Kolar	120	364	204	688
Koppal	77	353	141	571
Mandya	172	274	221	667
Mysuru	200	323	220	743
Raichur	62	423	128	613
Shimoga	118	2160	191	2469
Tumakuru	123	325	180	628
Udupi	197	3731	324	4252
UK	647	2665	195	3507
State Average	**152**	**929**	**188**	**1269**

PM= Pre Monsoon SWM=South-West Monsoon NEM=North-East Monsoon

Table-1.2: Normal monthly rainfall (mm) at different districts of Karnataka (1901-2014)

Districts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bagalkot	2	3	6	21	51	70	64	72	137	94	29	7
Bengaluru (Rural)	2	5	11	37	93	61	80	108	149	146	51	11
Bengaluru (Urban)	3	6	10	38	95	62	83	112	152	146	54	13
Belagavi	2	2	5	22	52	70	85	91	128	101	31	6
Ballari	2	3	5	21	53	60	66	84	128	99	31	7
Bidar	4	6	11	21	26	118	178	171	181	73	21	5
Vijayapura	3	3	6	17	35	77	70	75	146	92	24	8
Chamarajanagara	4	6	19	84	147	439	756	462	205	203	85	19
Chikkaballpur	0	8	9	24	80	60	52	85	122	110	21	7
Chikkamagalur	3	4	14	54	99	323	608	384	173	158	60	13
Chitradurga	2	3	7	25	71	57	72	80	110	110	41	8
Darwad	1	2	8	45	79	120	170	116	122	110	43	8
Davangere	2	4	6	33	71	72	105	89	109	110	43	9
DK	3	2	12	43	165	931	1158	773	325	241	87	16
Gadag	2	2	7	33	66	77	71	72	126	102	33	8
Kalaburagi	5	5	10	17	30	101	137	139	176	82	23	3
Hassan	4	4	12	53	102	167	297	198	126	151	63	12
Haveri	2	2	8	41	78	112	183	115	100	111	43	9
Kodagu	4	5	23	73	138	493	816	517	216	189	74	16
Kolar	5	5	10	28	73	56	77	92	139	127	63	14
Koppal	1	1	5	20	50	64	71	91	127	111	24	6
Mandya	3	5	11	45	108	48	46	66	114	150	59	12
Mysuru	3	5	14	59	118	66	86	74	98	145	61	14
Raichur	2	2	6	15	35	78	95	108	141	99	25	4
Shimoga	1	1	8	32	76	482	900	578	200	139	44	8
Tumakuru	3	4	9	30	78	53	63	83	126	126	46	8
Udupi	2	1	8	31	154	1073	1346	910	401	228	81	14
UK	1	1	5	22	78	142	1005	621	256	146	42	8

CHAPTER - II

AGROCLIMATIC CHARACTERISTICS OF SOUTHERN DRY ZONE

The Southern dry zone agro climatically classified as Zone- 6, covers 2 taluks of Hassan district, 3 taluks of Tumakuru district, 4 taluks of Mysuru district and all the taluks of Mandya and Chamarajanagar district. Taluks of each district are:

- Mandya: Nagamangala, Srirangapatna, Malavalli, Maddur, Mandya, Pandavapura and K.R.pet
- Chamarajanagar: Chamarajanagar, Yelandur, Kollegal and Gundlupet
- Mysuru: K.R.Nagar, T.Narasipur, Mysuru and Nanjangud
- Tumakuru: Kunigal, Tiptur and Turuvekere
- Hassan: Channarayapatna and Arasikere

2.1 Physiography

Zone is spread over a geographical area of 1.73 Mha, covering 9.13% of the total geographic area of the State. It is geographically located between $12^{o}45'$ to $13^{o}57'$ North latitude and $76^{o}27'$ East longitude in the Deccan peninsula. In general, altitude ranges from 450 to 900 m above sea level while certain parts of Yelandur and Chamarajnagar have a lower elevation of 450-800 m and higher elevations of more than 960 - 1500 m are seen in hilly regions of Kollegal and Channarayapatna taluks.

The origin of the river Cauvery is traditionally placed at Talakauvery, Kodagu of the Western Ghats in Karnataka. It flows generally South and East through Karnataka and Tamil Nadu and across the Southern Deccan plateau through the South-Eastern lowlands, emptying into the Bay of Bengal through two principal mouths. The Cauvery river basin is estimated to be 27,700 square miles (72,000 km^2) with many tributaries including Shimsha, Hemavati, Arkavati, Honnuhole, Lakshmana Tirtha, Kabini, Bhavani , Lokapavani, Noyyal and Amravati. Rising in South-Western Karnataka, it flows South-East some 475 miles (765 km) to enter the Bay of Bengal. East of Mysuru it forms the island of Shivanasamudra, on either side of which are the scenic Shivanasamudra falls that descend about 320 ft (100 m). The river is the source for an extensive irrigation system (parts of Mandya and Mysuru district) and for hydroelectric power. The river has supported irrigated agriculture for centuries and served as the lifeblood of the ancient kingdoms and modern cities of South India.

River Hemavathi being the main tributary of Cauvery joins Krishnaraja Sagar (KRS) at Srirangapatna. River Kabini (also called as Kapila) originates in Heggadadevankote flows through Nanjangud and joins cauvery at T. N. Pura (Thirumalakoodala Sangama). It provides irrigation to parts of Krishnarajpet before joining cauvery near KRS Shimsha, a seasonal river provides irrigation to limited area in parts of Maddur and Malavalli taluks and finally joins Cauvery near Bluff (Panditehalli) in

Malavalli taluk. A Hydro-electric generating station is located at Hilakul provides irrigation for parts of Channapatna taluk.

2.2 Bioresource status

The Southern dry zone has a bioresource status of 0.93, and hence is a bioresource deficient zone. The net cropped area is about 0.27 Mha, the ratio of the net irrigated area to the net-cropped area being 32.99%. The total agro residues available for this zone are 4.18 million tons, having an energy equivalent of 4385019.5 Mkcal. Forests contribute to 53% of the available energy (8362610.25 Mkcal) followed by agriculture residues-28% and horticulture-19%. This zone has the lowest energy potential from plantations amounting to 1141.29 Mkcal. 3.14 lakh ha of wastelands are available in this zone, capable of being used as energy plantations. The rural population of this zone is 4132307 persons. Of all the agro-climatic zones this is the most populated with a population density of 2.38 persons/ha. The calculated average rural energy demand is about 16772136.8 Mkcal.

2.3 Climate

District wise normals provided by the IMD, Bangalore is being used in obtaining the normals for this zone. Table 2.1 has monthly normals of number of rainy days, minimum and maximum Temperature, relative humidity at both morning and evening hours, vapour pressure at both morning and evening hours and Wind speed. Average its variance and CV along with the minimum and maximum rainfall recorded over months and seasons in the districts of Southern dry zone is being presented in Table 2.2.

2.4 Irrigation

The zone has network of canal system (Cauvery / Krishnarajasagar and part of Kabini and Hemavathi). KRS is the main source of irrigation in Zone-6 which is a confluence of three rivers. KRS canal system consists of a left bank called as V. C. Canal and on right bank a command achkat area. Other details of the dam are presented in Table 2.3. Various taluks covered and areas irrigated by KRS canal system are: Mandya, Srirangapatna, Pandavapura, Malavalli, Maddur, Nagamangala, Mysuru and T. Narasipura. River Kapila/ Kabini provide irrigation for achkat area. River Hemavathi provides irrigation to parts of K. R. Pet while Shimsha covers parts of Maddur and Survanamukhi provides water to Yelandur taluk. Wells and filter points are the principle sources of ground water. Maximum ground water potential availability in this zone is found at Mandya and exploitation is maximum at Chamarajanagar taluk. Open wells and bore wells also serve as source of irrigation in most of the taluks. The number of wells/tanks and other sources are being presented in the profiles of each district in the next section.

Table-2.1: Monthly normals for the Zone-6

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainy Days	0.2	0.3	0.7	3.2	6.0	6.4	7.7	7.4	7.8	8.0	3.6	1.0
Max. Temp (^{o}C)	28.6	31.0	33.5	34.5	33.1	29.2	27.8	27.6	28.8	28.7	28.0	27.5
Min. Temp (^{o}C)	15.3	17.0	19.1	20.8	20.6	19.8	19.4	19.3	19.2	19.1	17.8	16.0
RH (I hr) (%)	74.8	70.5	69.5	75.0	78.8	83.3	84.8	85.8	85.3	83.5	79.8	78.5
RH (II hr) (%)	43.3	38.5	34.8	41.8	54.3	69.3	73.0	73.0	68.5	67.5	62.3	55.0
VP (I hr) (mmHg)	16.7	17.6	19.9	23.3	24.2	23.6	22.9	22.7	22.8	22.7	20.6	18.2
VP (II hr) (mmHg)	15.4	15.6	16.3	19.6	22.3	23.4	23.0	23.1	23.1	22.5	20.4	18.0
Wind speed (Km/hr)	5.1	5.2	4.8	4.9	5.4	7.2	6.9	6.3	5.3	4.1	4.6	5.1

Table-2.2: Monthly and seasonal rainfall (mm) of the Zone-6

Period	Mean	Variance	Maximum	Minimum	CV (%)
Jan	1.5	1.4	15.6	0.0	108.3
Feb	4.8	1.1	16.9	0.0	62.9
Mar	20.6	44.5	50.6	0.0	42.5
Apr	64.2	312.4	258.9	11.2	26.8
May	97.5	229.9	246.8	35.5	20.5
PM	188.7	1015.6	356.8	65.0	18.7
Jun	55.1	171.6	136.4	22.3	24.6
Jul	74.0	550.5	216.7	20.5	28.8
Aug	97.8	482.6	263.7	33.4	22.7
Sep	114.9	678.5	292.8	14.8	25.3
S W M	341.8	5351.8	797.0	148.7	20.3
Oct	182.1	947.2	400.7	58.5	21.0
Nov	54.8	461.8	191.4	12.2	25.2
Dec	9.1	65.6	54.0	0.0	48.2
N E M	245.9	2702.0	469.3	75.8	20.3
Annual	776.4	18704.1	1613.4	338.3	18.0

Note: - PM: Pre Monsoon; SWM: South -West -Monsoon; NEM: North -East- Monsoon

Table-2.3: Details of KRS dam and its catchment area

1. Name of the Reservoir	Krishnarajasagar Reservoir Project
2. Location	Across River Cauvery near Kanambadi Village
a)Latitude	12^{0} 25' 30" N
b)Longitude	76^{0} 34' 30" E
c)Sub-basin	C-1 Upper Cauvery
3. Catchment area(insq.kms)	10619
4. Design yield (in TMC)	189 TMC ft at 50% dependability
5. Storage (in TMC)	
i) Gross	49.452
ii) Dead	4.401
iii) Live	45.051
iv) Carry over	Nil
6. Reservoir evaporation losses (TMC)	5.6
7.i) Filling period	From June to September
ii) Depletion period	From October to May
8. Submersion (in acres)	
i) Forest area	Nil
ii) Cultivable area	26,640
iii) Fallow land	Nil
Total	**26,640**
iv) No.of villages / Hamlets	25
9. Level of Storages.	
i) Full reservoir level (FRL)	124.80 Feet
ii) Minimum drawdown level (MDDL)	74.00 Feet
iii) Dead storage level	60.00 Feet
iv) Cill level of canal sluices	
a) Right bank low level	Canal Sluice 60.00 Feet
b) Left bank low level	Canal Sluice 60.00 Feet
v) Cill level of river sluice	12.00 Feet
10. Silt charge per year	(Mcft/Sq.km of C.A)
i) Designed	Not available
ii) Actual	0.0003
11. Ayacut (in acres)	
i) L.B.C. (V.C)	1,90,753
ii) L.B.L.L.C.	1,430
iii) R.B.L.L.C.	3,789
Total	**1,95,972**
12.General characteristics of soil in the command area	55% of the area is of course and fine sandy loams and remaining 45% are red loams, chocolate brown loams, sandy clays and clay loams

Particulars of dam	
1. Type of dam	Gravity dam of size stone masonry
2. Length of dam (in ft)	8597
3. Height of dam (in ft)	130.80 above river bed level
4. Length of spillway	There is no overflow spillway. The floods are disposed off through 152 sluice gates situated at different elevation in the body of the dam. The gates are rectangular
5. Capacity of the spill way	3, 45,868 cusecs through sluice gates.
6. Outlets (canal and river)	LBC (VC) LBLL RBLL RIVER
a) No.	3 1 1 11
b) Capacity in cusecs	2383 70 250 3,45,868
Description of canals	
(Main & Branch Canals)	
1. i) Length of LBC (in Kms)	45.92 Kms
ii) Length of RBC (in Kms)	32 Kms
iii) Length of LBLLC	20.8 Kms
2. i) Length of branch canal under LBC	303 Kms
ii) Length of branch canal under RBC and LBLLC	Nil
Whether perennial / one seasonal / two seasonal and **lined or unlined**	
a) Left bank canal (Vishweshwarayya canal)	Perennial and Unlined
b) Right bank canal	Perennial and Unlined
c) Left bank low level canal	Perennial and Unlined
Authorized Capacity	
a) L.B.C.(VC)	2383 Cusecs (Exclusive of 70 cusecs for LBLLC)
b) R.B.C.	250
c) Left bank low level canal	70 Cusecs

Source: http://waterresources.kar.nic.in/salient_features_krs.htm

2.5 Agro-ecological situations

National Agricultural Research Project, status report, (1993) classifies agro-ecological situation in Southern dry zone into two classes. Since the soil and the elevation are more or less similar, the major criteria considered to group the situation is rainfall. Though majority of the soils are red sandy loam, black soils are also seen in patches in the taluks of Gundlupet, Nanjangud, Chamarajanagar and Yelandur to a limited extent and thus has not been warranted to consider as a separate farming situation. Crop calendar for major crops of Southern Dry Zone (Agro Climatic Zone-6) is presented in table-2.4. Irrigated farming is yet another major situation in this zone where the irrigation is provided mostly by canals and to a certain extent by wells and tanks and these are scattered all over the zone. This has been identified as farming situation though not as an agro-ecological.

Table-2.4: Crop calendar for major crops of Southern Dry Zone (Agro Climatic Zone-6)

Sl. No.	Crops	Variety	Sowing period
Rainfed			
1.	**Jowar**(*Kharif*)	CSH-5, CSH-9, CSV-4, DSV-2	April-June
2.	**Maize**	Ganga-11, Deccan-103,Vijaya composite	May-July
3.	**Ragi** (*Kharif*)	Indaf-8	June-July
		MR-2	July-August
		Indaf-5	August
		PR-202	July
		HR-911	July-August
		GPU-28	Late *kharif* to *rabi*
4.	**Redgram**		
	Kharif	Hyderabad-3C, TTB-7, IGPI-87	May-July
5.	**Greengram**		
	Kharif	PS-16	April-May
		PDM-84-178	June-July
	Summer	PHR krilekl, PS-16	January-February
		PDM-84-178	February-April
6.	**Avare**		
	Kharif	Hebbal-3	August
	Rabi		October
	Summer		February-March
7.	**Black gram**		
	Kharif	Karagaon-3	April-May
8.	**Groundnut**		
	Kharif	TMV-2, JL-24	May-July
9.	**Sunflower**		
	Kharif	Morden	June-August
		KBSH-1, BSH-1	June-July
	Rabi	Morden, KBSH-1, BSH-1	September-October
10.	**Castor** (*Kharif*)	Rosy	May-June
11.	**Cotton** (*Kharif*)	Jayalakshmi	May-June
		DHS-105	May-July
12.	**Tobacco**	VFC special, Bhavya	May-June

Sl. No.	Crops	Variety	Sowing period
Irrigated			
1.	**Paddy**		
	Kharif	Jaya	June 2nd fortnight
		Mandya Vijaya, IR-20	June fortnight
		Rasi	June fortnight and July 1st fortnight
		KRH-2	July 1st and 2nd fortnight
		Mangala	July 2nd fortnight and august 1st fortnight
		Mukti	August 1st and 2nd fortnight
	Summer	Rasi, Mangala, KRH-2	January 2nd fortnight and February 1st fortnight
		Jaya and Mandya Vijaya	January 2nd fortnight.
2.	**Ragi**		
	Kharif	HR-911	July- August
		Indaf-8 & MR-1	June- July
		GPU-28	June- August
		Indaf-9	August- September
	Rabi	Indaf-7 and Indaf-15	September - October
	Summer	Indaf-5	January- February
		Indaf-9	February -March
3.	**Maize**		
	Kharif	Ganga-11, Deccan-019, Vijaya composite	May-June
	Rabi		September-October
	Summer		January-February
4.	**Sunflower**		
	Kharif	Modern, BSH-1, KBSH-1	May-June
	Rabi		September-October
	Summer		January 15th- February 15th
5.	**Groundnut**		
	Kharif	JL-24	June-May
		TMV-2	June-July
	Summer	ICGS-11	December-January
6.	**Cotton**		
	Kharif	Bharada	June-July
		Jayalakshmi	August 15th
		DHB-105	June 30th
7.	**Sugarcane**		
	Kharif	CO-419, CO-62175, CO-7804, COO-671	June-August
	Rabi	CO-419, CO-62175, CO-7804, COO-671	October-November
	Summer	CO-419, CO-7804, COO-671	January-February
		B-37172	January-March

2.5.1 Red loamy soils with rainfall of 650 – 750 mm

2.5.1.1 Delineation and Composition

This situation exists in all the districts that fall under this zone. Taluks under this situation are,

- Mandya: Nagamangala, Srirangapatna, Malavalli, Maddur, Mandya and K.R.Pet
- Chamarajanagar: Chamrajnagar and Gundlupet
- Mysuru: K.R.Nagar, T.Narasipur and Nanjangud
- Tumakuru: Turuvekere
- Hassan: Channarayapatna

2.5.1.2 Physiography

This situation has an elevation of 450 to 500 m. It is located between the latitude of $12^{o}48'$ to $13^{o}57'$ and longitude $76^{o}45'$ to $78^{o}24'$ E. There are small to medium hillocks and hills in this track. The upland area is plain to slightly undulating with slope upto 2.5 per cent. There are thick forests in Chamarajanagar, Gundlupet and Malavalli taluks and very limited forests in K. R. Nagar and K. R. Pet. This situation has a large uncultivable area, which is highest in Nagamangala, K. R. Pet, Gundlupet, Chamarajanagar and Turuvekere taluks.

2.5.1.3. Climate

We note arid and dry climate for most of the year except during winter which is slightly cool but mild. It experiences bimodal rainfall with one peak at May/June and the other in September/October. Nagamangala, Gundlupet, Chamarajanagar and Srirangapatna receives lowest rainfall. South West monsoon showers occupy the major part of annual rains. They are very much erratic and scanty. Dry spells prevails from the 2^{nd} week of July and extend up to end of August, sometimes even up to first fortnight of September. This causes severe moisture stress to early sown crops and affects the crop growth and yields. Mean minimum temperature ranges from 14^{o} to 30^{o} C, but occasionally touches 11^{o} C during December. Mean maximum temperature ranges from 27^{o} to 39^{o} C which is mostly noted in May month. This track has relatively low humidity. Wind velocity is high during July/August and February/March months

2.5.1.4 Soils

Soils in this track are shallow to medium in depth. There are coarse to very coarse sandy loams and loamy sands, which are red to light red in color. Patches of black soils are also seen in taluks of Chamarajanagar, Nanjangud and Gundlupet. Soils are neutral in reaction with calcareous kankar in deeper layers and non-saline. Soils are highly permeable and well drained with low water retentive capacity. These soils are generally low in organic carbon and are deficient in P and Zn in general.

2.5.1.5 Crops and cropping systems

During the years of normal and well distributed rainfall, the common crops and cropping systems followed are being presented in Figures: Fig.2.1, Fig.2.2 and Fig.2.3.

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

/-------------FINGER MILLET--------------/

/------------------------------------SORGHUM-------------------------------------/

/--------------------PEARL MILLET--------------------/

/-------------------------------------REDGRAM--/

/-----------------------GROUNDNUT-------------------------/

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

Fig. 2.1: Mono cropping system for situation – I

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

/--------------SESAMUM--------------//------------FINGER MILLET--------------/

/------------SESAMUM-------------//----------------SORGHUM-----------------/

/------------------SORGHUM-----------------//---------------HORSEGRAM------------------/

/---------------GROUNDNUT---------------//---------HORSEGRAM--------/

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

Fig. 2.2: Double cropping system for situation – I

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

/--------------------------FINGER MILLET + DOLICHOS -----------------------------/

/----------------FINGER MILLET + COWPEA -----------------/

/------------------FINGER MILLET + DOLICHOS + REDGRAM -----------------------/

/---------------FINGER MILLET + DOLICHOS + REDGRAM + NIGER----------------/

/------------FINGER MILLET + DOLICHOS + REDGRAM + MUSTARD-------------/

/----------------------------GROUNDNUT + REDGRAM ------------------------------/

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

Fig. 2.3: Mixed cropping system for situation – I

2.5.2 Red sandy loam soils with rainfall above 750 mm

2.5.2.1 Delineation and composition

This situation exists in all the districts that fall under this zone. Taluks under this situation are,

- Mandya: Pandavapura
- Chamarajanagar: Yelandur and Kollegal
- Mysuru: Mysuru
- Tumakuru: Kunigal and Tiptur
- Hassan: Hassan and Arasikere

2.5.2.2 Physiography

There are small hillocks, hills and scattered rocky portions in patches. The land is flat and plain in most of the parts of the taluks belonging to this situation. Still there exist slightly undulating lands with slope values ranging from 0.5 to 2 per cent. Elevations are around 800 to 900 m.

2.5.2.3. Climate

South West monsoon showers occupy the major part of annual rains and it forms the major source in *kharif* season. Rainfall is distributed between May and October months. April/May receives thunder showers, which is of much help for taking short duration crops before main crop. Up to September this track receives 65 per cent of rainfall while 25 per cent in September and October months. This excess rainfall within short period causes water logging condition, inundation and floods affecting the yield. Long dry spells prevails from the 2^{nd} week of July and extend upto end of August, sometimes even up to first week of September. This causes severe moisture stress to early sown crops and vegetative stage of normally sown crop growth. It has an adverse effect on rainfed crops. In addition to this there will be wind with high velocity during July to August causing desiccating effect either affecting germination or crop growth if normal rains are not received. Mean minimum temperature ranges from 12^o to 28^o C and mean maximum temperature ranges from 28^o to 30^o C. During summer temperature may rise upto 40 ^oC in Pandavapura and Kollegal taluks. Winters are moderate and cool for shorter period during December and January months.

2.5.2.4 Soils

Soils are sandy loams with coarse to very sandy loams, light in texture with neutral pH. They are low in organic carbon, medium in available P, high in K content and varied fertility. Soils in some taluks are deficient in Zn and Fe. As they are shallow to medium in depth, they have poor water holding capacity, but the soils are well drained and often prone to run off and erosion. Lime concentration and quartzite fragments are spread on surface with rock in the profile.

2.5.2.5 Crops and cropping systems

During the years of normal and well distributed rainfall, the common crops and cropping systems followed are being presented in Figures: Fig.2.4, Fig.2.5 and Fig.2.6.

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

/-------------FINGER MILLET--------------/

/------------------------------SORGHUM---------------------------------/

/-----------------MINOR MILLET------------------/

/---------------------------------REDGRAM--------------------------------------/

/--------------------GROUNDNUT---------------------/

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

Fig.2.4: Mono cropping system for situation – II

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

/------------SESAMUM------------//-------------FINGER MILLET---------------/

/------------SESAMUM--------------/ /---------------SORGHUM---------------/

/-----------SESAMUM-----------/ /-----------------HORSEGRAM------------------/

/------------COWPEA------------//-------------FINGER MILLET---------------/

/-------------GROUNDNUT-------------//-----------------HORSEGRAM-----------------/

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

Fig. 2.5: Double cropping system for situation – II

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

/------------FINGER MILLET + REDGRAM or DOLICHOS -------------/

/--FINGER MILLET + REDGRAM or DOLICHOS + FODDER JOWAR--/

/-FINGER MILLET + DOLICHOS or REDGRAM + NIGER +MUSTARD-/

/---FINGER MILLET + DOLICHOS or REDGRAM + NIGER + CASTOR---/

/---------------SORGHUM + DOLICHOS or REDGRAM -----------------/

/-----------------------GROUNDNUT + REDGRAM -----------------------/

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

Fig. 2.6: Inter cropping system for situation – II

2.5.3 Irrigated farming

This zone has enough source of irrigation in almost all taluks. Sources of irrigation are canals, wells, tanks and bore wells. Details of which are given in the district profiles in the next chapter. Physiography, soils and climate are as described in both of the situations. However, saline and alkaline soils do exist and is a production constraint in Rice. Common crops and cropping systems followed are depicted in Fig.2.7.

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

--------------------/ /-----------------------------RICE--------------------------------/ /-------------------RICE-------------

------------/ /--------------------------------RICE---------------------------------/ /-------------------RAGI-------------

------------/ /------------------------------RICE------------------------------/ /------------------GROUNDNUT---------

-- SUGARCANE FOR 2 YEARS ---

-- MULBERRY --

-- COCONUT or HORTICULTURE CROPS--

/------------------------------RICE--------------------------------/ /---------------VEGETABLES------------------

----------/ /-----------------------------RICE----------------------------/ /---------------MELON or VEGETABLES------

--FRUIT ORCHARD or FLOWER CULTIVATION------------------------------------

------RICE or RAGI------/ /-----------------------------------SUGAR CANE 1 YEAR-----------------------------------

----------------------SUGARCANE----------------------/ /-----------------------RATOON SUGARCANE------------------

---------------------------------SUGARCANE----------------------------------/ /-------RICE + RAGI + GROUNDNUT----

/---------------------------VEGETABLE----------------------------//-----------------------VEGETABLE------------------/

/--------------------VEGETABLE------------------------//-----------------------VEGETABLE or RAGI--------------- ---/

APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR

Fig. 2.7: Irrigated Farming

2.6 Length of growing period

The present blanket recommendation of varieties (short/medium/long duration) will have critical moisture limitation in some pockets of NARP zones where crop growing period is shorter than the duration of the varieties as seen in many of the zones. This prevailing variation in LGP across the zone necessitates site specific varietal recommendations for successful crop production. The length of growing period (LGP) is highly varying within and among the NARP zones. Having said this we have made an attempt to develop and present normal LGPs for different districts of SDZ in table 2.5 to 2.9 and Figure 2.8 to 2.12.

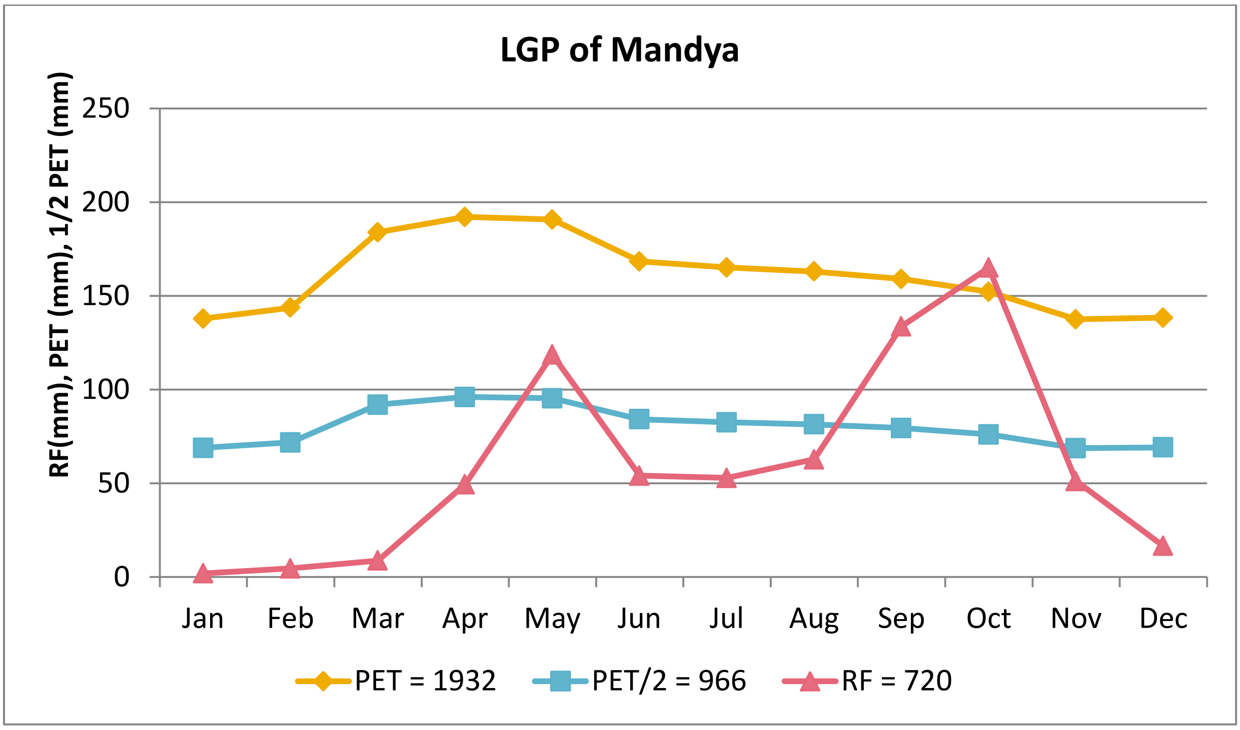

Fig-2.8: Normal LGP of Mandya

Table-2.5: Data for normal LGP of Mandya

Month	RF(mm)	PET(mm)	PET/2(mm)
Jan	2.0	137.8	68.9
Feb	4.6	143.8	71.9
Mar	8.8	184.0	92.0
Apr	49.5	192.2	96.1
May	118.7	190.8	95.4
Jun	54.1	168.4	84.2
Jul	52.9	165.2	82.6
Aug	62.8	163.0	81.5
Sep	133.8	159.0	79.5
Oct	165.1	152.2	76.1
Nov	51.2	137.5	68.8
Dec	16.7	138.4	69.2
Grand Total	**720.2**	**1932.4**	**966.2**

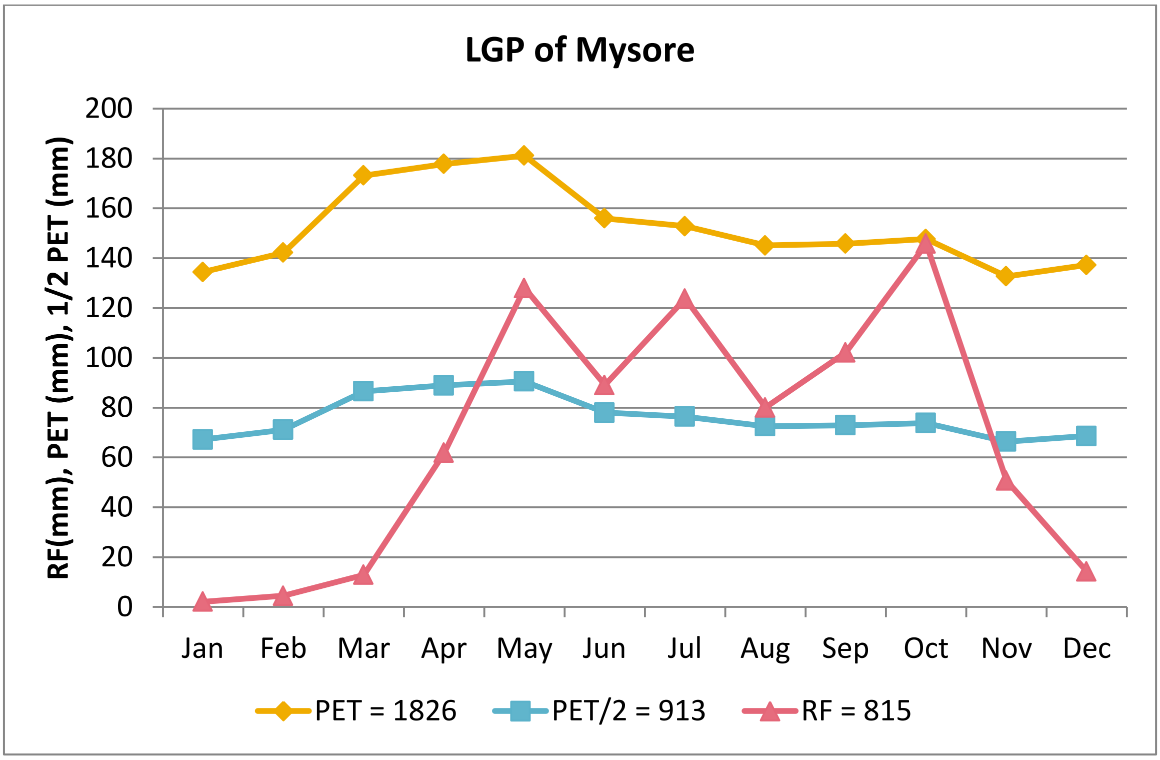

Fig-2.9: Normal LGP of Mysuru

Table-2.6: Data for normal LGP of Mysuru

Month	RF(mm)	PET(mm)	PET/2(mm)
Jan	2.1	134.4	67.2
Feb	4.5	142.2	71.1
Mar	12.9	173.2	86.6
Apr	61.9	177.8	88.9
May	128.0	181.1	90.6
Jun	89.1	156.0	78.0
Jul	123.8	152.8	76.4
Aug	80.1	145.1	72.6
Sep	102.2	145.8	72.9
Oct	145.8	147.7	73.9
Nov	50.7	132.7	66.4
Dec	14.2	137.2	68.6
Grand Total	**815.3**	**1826.2**	**913.1**

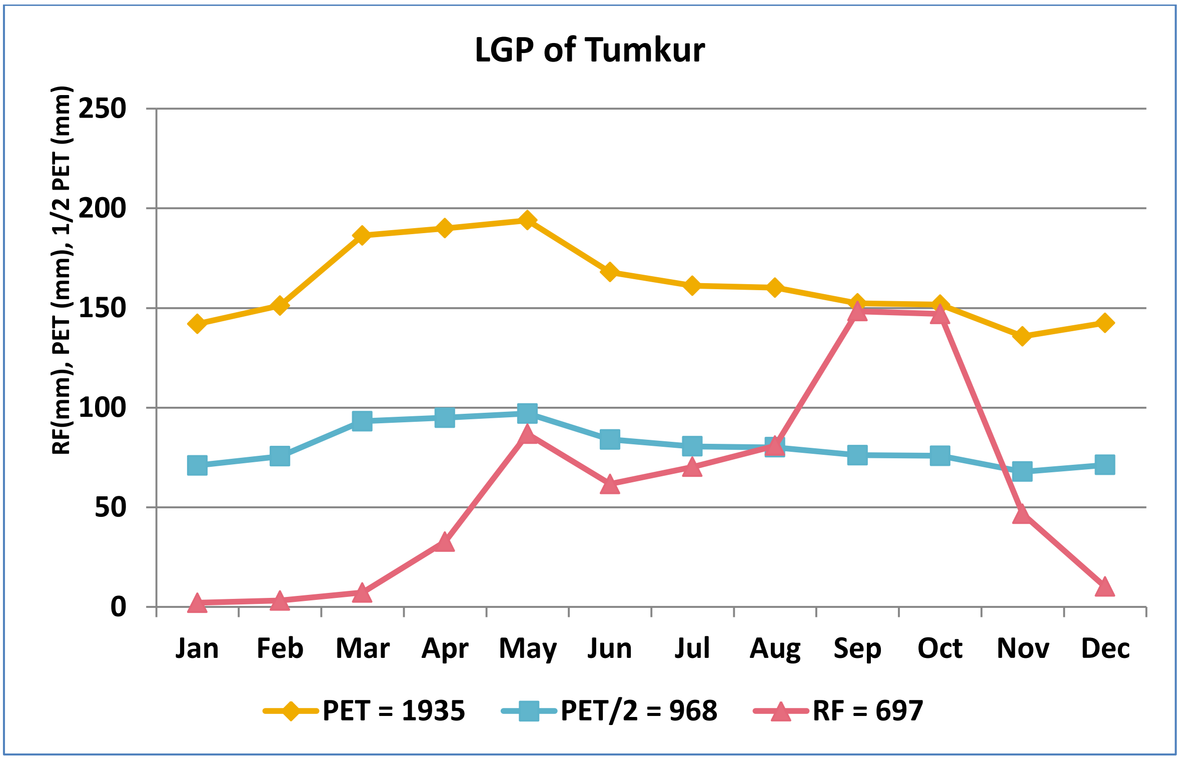

Fig-2.10: Normal LGP of Tumakuru

Table-2.7: Data for normal LGP of Tumakuru

Month	RF(mm)	PET(mm)	PET/2(mm)
Jan	2.1	142.0	71.0
Feb	3.2	151.2	75.6
Mar	7.2	186.3	93.2
Apr	32.8	189.9	95.0
May	86.8	194.0	97.0
Jun	61.7	168.0	84.0
Jul	70.3	161.1	80.6
Aug	80.9	160.2	80.1
Sep	148.4	152.3	76.2
Oct	147.0	151.7	75.8
Nov	46.7	135.8	67.9
Dec	10.2	142.5	71.3
Grand Total	**697.3**	**1935.1**	**967.6**

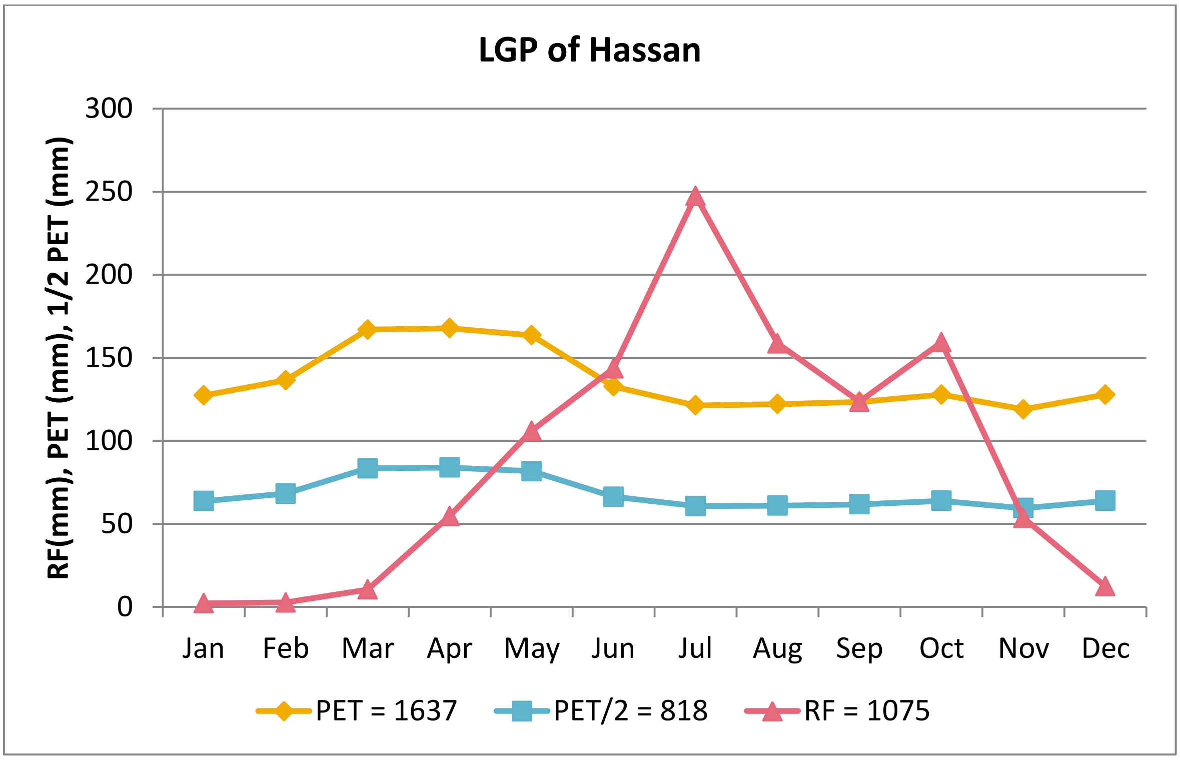

Fig-2.11: Normal LGP of Hassan

Table-2.8: Data for normal LGP of Hassan

Month	RF(mm)	PET(mm)	PET/2(mm)
Jan	2.2	127.4	63.7
Feb	2.7	136.5	68.3
Mar	10.5	166.9	83.5
Apr	54.8	167.9	83.9
May	106.0	163.6	81.8
Jun	143.6	132.7	66.3
Jul	247.5	121.4	60.7
Aug	158.7	122.1	61.1
Sep	123.6	123.5	61.8
Oct	159.3	127.8	63.9
Nov	53.6	119.0	59.5
Dec	12.4	127.8	63.9
Grand Total	**1074.9**	**1636.5**	**818.3**

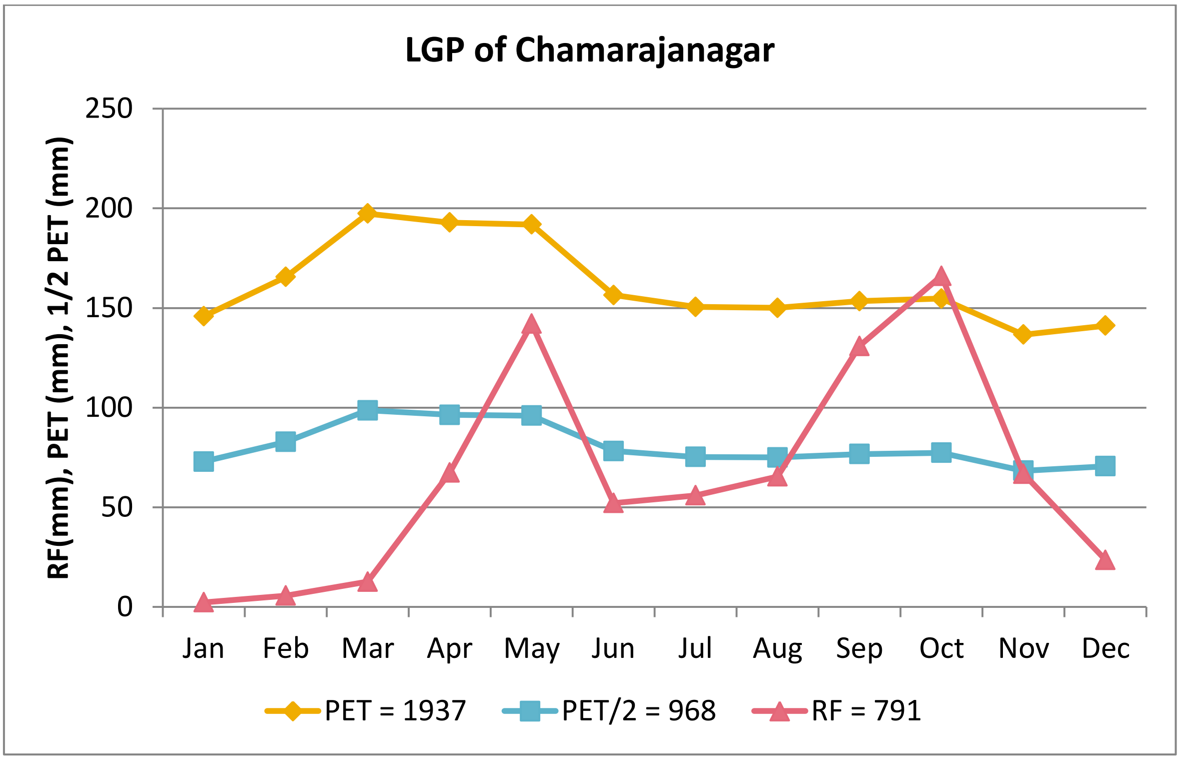

Fig-2.12: Normal LGP of Chamarajanagar

Table-2.9: Data for normal LGP of Chamarajanagar

Month	RF(mm)	PET(mm)	PET/2(mm)
Jan	2.3	145.8	72.9
Feb	5.7	165.6	82.8
Mar	12.7	197.4	98.7
Apr	67.4	192.9	96.4
May	142.1	191.9	96.0
Jun	52.1	156.5	78.3
Jul	56.0	150.5	75.3
Aug	65.5	150.1	75.0
Sep	130.9	153.4	76.7
Oct	166.1	154.7	77.3
Nov	66.8	136.7	68.3
Dec	23.6	141.2	70.6
Grand Total	**791.2**	**1936.6**	**968.3**

2.7 Crop weather calendar

Proper planning of agricultural operations requires relevant and reliable information in timely manner. Information on crop, its stages and the week by week weather during the crop season is essential for proper management of agriculture. Thus, farm operations planned in conjunction with weather information are very likely to curtail the costs of inputs and various field operations. Crop weather calendar is a comprehensive guide for farmers. It also acts as a tool to identify the suitable crop growing season and its sowing window.

Two decades ago, Indian meteorological department has designed the crop weather calendars with components such as weather and crop water component requirements. As per IMD format, crop weather calendars are developed for Mandya (Fig-2.13), Mysuru (Fig-2.14), Tumakuru (Fig-2.15) and Hassan (Fig-2.16) district respectively.

All India Coordinated Research Project on Agrometeorology (AICRPAM) has developed new format for preparing crop weather calendars (V. U. M. Rao et al.). Structure of crop weather calendar designed by AICRPAM consists of three parts.

- The uppermost portion of calendar contains average meteorological data for different months and the respective standard meteorological weeks for the location / station for the entire growth period of the crop. Various meteorological parameters (Maximum & Minimum temperature, rainfall, number of rainy days (rainfall 2.5mm), relative humidity (morning and evening), vapor pressure etc.) are given which can be computed from long term averages (at least 20 years data).
- The middle part shows the typical life history of the crop in the form of a diagram. Important "growth phases" relevant to the crop species like sowing, germination / emergence, transplanting (in case of crops like rice), vegetative growth, flowering, grain formation and maturity period etc. are indicated. These "phases" cover certain time intervals indicated by horizontal bars, which depend on variations in crop variety, sowing date from place to place and from year to year and the nature of the crop itself. In addition to the above information, the middle part of crop weather calendars indicates the favorable meteorological conditions for the crop (stage-wise or whole crop growth period) which will lead towards high yield of the crop.
- The bottom portion of the calendar consists of meteorological conditions conducive for incidence of pests and diseases and the nature of the weather warnings that can be given. The horizontal bars indicate the susceptible periods of the crop during which if the weather is conducive and disease inoculum / insect is present, then, the incidence of that disease / pest may occur.

Finger millet is mainly grown under rainfed situation in Mysuru district of SDZ. So, as per the AICRPAM design, an attempt has been made to develop crop weather calendar for finger millet (Fig-2.17 and Fig-2.18) for two prominent sowing windows.

CHAPTER – III

GENERAL PROFILE OF DISTRICTS IN ZONE – 6

This chapter has two parts with first explaining the demographic details and the second describes the agriculture profile of the district. It provides following district specific details:

- Agroclimatic zone
- Rainfall and its distribution
- Land use pattern
- Major soils
- Agriculture land use
- Irrigation, its source and ground water usage and availability
- Area under major field crops, horticulture crops, plantation and sericulture.
- Livestock, poultry and fisheries
- Production and productivity of major field crops, horticulture crops, plantation
- Sowing window
- Major contingency the district is prone to.
- Soil map

The districts covered are Chamarajanagar, Mandya, Mysuru, Hassan and Tumakuru.

3.1(A). Highlights of 2011 census - Mandya

1. Total population is 1,808,680 compared to 1,763,705 of 2001.
2. Male and female were 909,441 and 899,239 respectively.
3. Population Growth for Mandya District recorded in 2011 for the decade has remained 2.55 per cent. Same Figure for 1991-2001 decade was 7.26 per cent.
4. Total Area of Mandya District was 4,961 with average density of 365 per sq. km.
5. Mandya Population constituted 2.96 per cent of total Karnataka Population.
6. Sex Ratio of Mandya District is now 989, while child sex ratio (0-6) is 934 per 1000 boys.
7. Children below 0-6 age were 162,147 which form 8.96 of total Mandya District population.
8. Average Literacy rate for Mandya District is 70.14 per cent, a change of from past Figure of 61.05 per cent. In India, literacy rate is counted only for those above 7 years of age. Child between 0-6 ages are exempted from this

Description	2011	2001
Actual Population	1,808,680	1,763,705
Male	909,441	888,034
Female	899,239	875,671
Population Growth	2.55%	7.26%
Area Sq. Km	4,961	4,961
Density/km2	365	356
Proportion to Karnataka Population	2.96%	3.34%
Sex Ratio (Per 1000)	989	986
Child Sex Ratio (0-6 Age)	934	934
Average Literacy	11,54,952 (70.14%)	9,51,460 (61.05%)
Male Literacy	6,45,133 (78.14%)	5,51,271 (70.50%)
Female Literacy	5,09,819 (62.10%)	4,00,189 (51.53%)
Total Child Population (0-6 Age)	1,62,147 (8.96%)	2,05,147 (11.63%)

Source: Directorate of Census Operations in Karnataka

3.1(B) District agriculture profile: MANDYA

<table>
<tr><th colspan="4">Agro-Climatic/Ecological Zone</th></tr>
<tr><td>Agro Ecological Sub Region (ICAR)</td><td colspan="3">Eastern Ghats And Tamil Nadu Uplands And Deccan Plateau (8.2)</td></tr>
<tr><td>Agro-Climatic Region (Planning Commission)</td><td colspan="3">Southern Plateau and Hills Region (X)</td></tr>
<tr><td>Agro Climatic Zone (NARP)</td><td colspan="3">Central dry zone, Southern dry zone, Southern transition zone (KA-4, KA-6, KA-7)</td></tr>
<tr><td>List all the districts or part thereof falling under the NARP Zone</td><td colspan="3">Mandya, Maddur, Malavalli, Srirangapatna, Pandavapura, Nagamangala and Krishnarajpet</td></tr>
<tr><td rowspan="2">Geographic coordinates of district</td><td>Latitude</td><td>Longitude</td><td>Altitude</td></tr>
<tr><td>12º31'21.94"N</td><td>76º54'24.16"E</td><td>729 m</td></tr>
<tr><td>Name and address of the concernedZRS/ZARS/ RARS/</td><td colspan="3">Zonal Agricultural Research Station, V.C. Farm, Mandya – 571 405, Karnataka</td></tr>
<tr><td>Mention the KVK located in the district</td><td colspan="3">Krishi Vignan Kendra,V.C. Farm, Mandya-571 405, Karnataka</td></tr>
<tr><td>Normal Onset</td><td colspan="3">Normal Cessation</td></tr>
<tr><td>SWM: 2nd week of June</td><td colspan="3">SWM: 4th week ofSeptember</td></tr>
<tr><td>NEM: 2nd week of October</td><td colspan="3">NEM: 2nd week of December</td></tr>
</table>

Land use pattern of the district (latest statistics)	**Geographical area**	**Cultivable area**	**Forest area**	**Land under non-agricultural use**	**Permanent pastures**	**Cultivable wasteland**	**Land under Misc. tree crops and groves**	**Barren and uncultivable land**	**Current fallows**	**Other fallows**
Area (‘000 ha)	498.2	225.0	24.8	60.9	38.0	42.0	3.4	21.5	30.7	43.0

<table>
<tr><th>Major Soils</th><th>Area (‘000 ha)</th><th>per cent (%) of total</th></tr>
<tr><td>Red gravelly soils</td><td>125.4</td><td>60</td></tr>
<tr><td>Red sandy loam soils</td><td>64.6</td><td>30</td></tr>
<tr><td>Red sandy soils</td><td>21.4</td><td>10</td></tr>
<tr><td>Agricultural land use</td><td>Area (‘000 ha)</td><td>Cropping intensity %</td></tr>
<tr><td>Net sown area</td><td>225.0</td><td rowspan="3">116.8 %</td></tr>
<tr><td>Area sown more than once</td><td>37.9</td></tr>
<tr><td>Gross cropped area</td><td>262.9</td></tr>
</table>

Irrigation	Area (‘000 ha)							
Net irrigated area	126.2							
Gross irrigated area	149.0							
Rainfed area	98.8							
Sources of Irrigation	Number	Area (‘000 ha)			per centage of total irrigated area			
Canals		96.9			74.0			
Tanks	891	19.0			14.5			
Bore wells	10517	11.7			8.9			
Other sources		3.4			2.6			
Total Irrigated Area		131.0			100.0			
Pump sets	10230							
No. of Tractors	1361							
Groundwater availability and use	**No. of Tehsils**	**(%) area**						
		Mandya	Maddur	Malavalli	K. R. Pet	Nagamangala	Pandavapura	S. R. Patna
Over exploited	1	1	29	22	97	2	15	24
Critical	1		2	77				1
Safe	5	99	69	1	3	98	85	75
Ground water quality	Fluoride contamination found in part of Pandavapura& Nagamangala tehsil Nitrate contamination found in Mandya							

(* Data source: State/Central Ground water Department /Board)

Livestock	**Male (‘000)**	**Female (‘000)**	**Total (‘000)**
Non descriptive Cattle (local low yielding)	68.0	130.0	198.0
Crossbred cattle	3.4	148.1	151.5
Non descriptive Buffaloes (local low yielding)	7.1	161.7	168.8
Goat	55.0	189.1	244.3
Sheep	34.9	348.5	383.4
Poultry - Total No. of birds (‘000)		530.2	
Inland (Data Source: Fisheries Department)	**No. Farmer owned ponds**	**No. of Reservoirs**	**No. of village tanks**
	31	4	688
B. Culture	**Water Spread Area (ha)**	**Yield (t/ha)**	**Production (‘000 tons)**
Fresh water (Data Source: Fisheries Department)	15.1	0.5	8.3

	Major Field Crops cultivated	Area ('000 ha)					
		Kharif		*Rabi*		Summer	Total
		Irrigated	Rainfed	Irrigated	Rainfed		
1	Paddy	58.18	-	8.3	-	-	66.48
2	Ragi	0.79	46.5	3.1		-	50.39
4	Sugarcane	27.7		3.6	-	-	31.3
5	Horsegram	-	2.05	-	20.68	-	22.73
6	Cowpea	0.7	4.8	-	0.44	-	5.94
3	Maize	0.1	4.4	0.1	-	-	4.6
7	Field bean	-	2.5	-	0.05	-	2.55
8	Sesamum	0.46	5.17	-	-	-	5.63
9	Niger	-	1.70	-	-	-	1.70
	Horticulture crops - Fruits	**Total area**					
1	Mango	4.2					
2	Banana	2.1					
3	Sapota	1.0					
4	Jack	0.7					
5	Papaya	0.4					
	Horticultural crops - Vegetables	**Total area**					
1	Cucumber	3.3					
2	Tomato	2.3					
3	Brinjal	1.2					
4	Beans	1.0					
5	Okra	0.6					
	Plantation crops	**Total area**					
1.	Coconut	52.3					
2.	Arecanut	1.0					
	Sericulture (Mulberry)	16.6					

Production and productivity of major crops

Name of crop	*Kharif*		*Rabi*		Summer		Total	
	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)
Paddy	252.7	3600			75.0	3750	327.7	3675
Ragi	143.0	1850	10.3	2050	6.8	2250	160.0	2050
Maize	18.3	3650	1.9	3700	0.6	4000	20.7	3783.3
Sugarcane	3250.0	130000	390.0	130000	260.0	130000	3900.0	130000
Sericulture-CB cocoon	30.7	65.7kg/100dfls	45.5	64kg/100dfls	35.91	63kg/100dfls	112.16	64.2kg/100dfls
BV Cocoon	0.9	56.2kg/100dfls	1.8	51.8kg/100dfls	0.196	52kg/100dfls	2.9	53.3kg/100dfls
Horse gram	6.2	575	9.0	600			15.2	587.5
Cow pea	2.8	475	0.1	450	0.3	500	3.1	475
Field bean	2.0	375	-	300	-	375	2.0	350
Sesamum	2.5	550					2.5	550
Niger	0.6	230					0.6	230
Coconut	-	-	-	-	-	-	5885 (lakh nuts)	11242 nuts/ha
Mango	-	-	-	-	-	-	31.3	7480
Cucumber	-	-	-	-	-	-	42.6	1307
Tomato	30.4	2237	8.4	2632	15.2	2515	54.1	2461
Banana	-	-	-	-	-	-	60	2848

Sowing windowfor 5 major field crops	Paddy	Sugarcane	Ragi	Maize	Mulberry
Kharif- Rainfed	-	-	June 2ndweek to July 1stweek	June 1st week toJuly 4th week	-
Kharif-Irrigated	July 2nd week to August 2nd week	June1stweek toAugust 4th week	July 2nd week	July 2ndweek	July1st weekto October 4th week
Rabi- Rainfed	-	-	August 2nd week	August 4th week	-
Rabi-Irrigated	-	October 3rdweekto November 2ndweek	October 3rdweekto November 2ndweek	September 3rdweek to October 1stweek	-
Summer-irrigated	January 2nd week	January 1st week to February 4th week	January 2nd week	January 2nd week	1st to 4th week of January

Major contingency the district is prone to

Extreme Events	Regular	Occasional	None
Drought		✓	
Floods		✓	
Cyclone		✓	
Hail storm			✓
Heat wave			✓
Cold wave			✓
Frost			✓
Sea water intrusion			✓
Pests and Diseases (specify)	✓		

Table-3.1: Categorical spread of monthly rainfall over 114 years in Mandya district

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	2.7	4.6	9.8	45.4	109.1	48.0	45.8	65.1	114.5	150.5	59.1	12.3
Range	0-32	0-53	0-142	3-175	8-252	4-174	9-133	4-222	10-284	4-374	0-556	0-101
2001-2014												
Mean	2.0	5.3	23.0	60.2	90.5	53.2	53.6	79.0	104.9	160.8	58.4	5.1
Range	0-18	0-21	0-142	16-123	16-224	11-98	17-121	25-158	20-216	40-353	6-184	0-22
Low												
Mean	2	0	4	24	83	44	34	33	72	54	41	8
Range	0-7	0-3	0-42	3-45	8-112	4-87	9-98	4-72	10-154	4-174	0-86	0-81
75%	0.0-3.9	0.0-0.7	0.0-11.5	13-35	64-102	22-65	20-49	22-44	40-104	33-74	21-60	0.0-20
65%	0.0-3.1	0.0-0.5	0.0-8.3	18-31	72-94	31-56	26-43	26-39	53-90	42-66	29-52	1.5-15
Medium												
Mean	3	8	9	44	117	54	43	62	127	168	59	15
Range	1-12	5-43	3-41	19-75	73-168	71-162	24-125	38-150	59-216	79-351	41-171	6-68
75%	1.5-4.0	4.0-12.8	4.8-13.2	40-47	110-125	49-60	37-49	55-70	119-135	153-183	51-67	11-19
65%	2.0-3.5	5.0-11.8	5.4-10.6	41-46	113-122	51-58	39-47	58-67	122-132	159176	54-64	13-17
High												
Mean	8	9	11	46	162	59	65	152	132	211	102	18
Range	0-32	0-53	45-142	35-175	80-252	44-174	49-133	64-222	110-284	134-374	90-556	14-101
75%	5.3-10.8	5.1-12.9	9.0-13.0	40-53	151-173	46-72	56-75	136-168	113-151	195-228	82-122	14-23
65%	6.6-9.6	6.0-12.0	9.8-12.2	42-50	156-169	51-67	60-71	143-161	121-143	202-221	90-114	16-21

Table-3.2: Monthly normal rainfall (1983-2013) over different stations of Mandya district

Station Name	Monthly rainfall											
	January	February	March	April	May	June	July	August	September	October	November	December
AKKIHEBBAL	2.1	1.7	16.1	45.9	81.6	51.6	57.0	67.7	90.7	161.7	50.0	7.3
BINDIGANAVOLE	2.7	1.8	5.5	37.7	81.9	42.1	53.2	71.7	132.6	138.9	50.5	6.7
HALAGUR	1.1	5.3	20.7	52.7	94.9	57.4	60.0	88.8	141.6	148.1	49.7	12.8
KIKKERI	2.2	2.3	9.8	48.4	91.9	57.6	68.1	63.0	117.0	159.7	46.3	4.8
KOPPA	5.3	3.0	22.1	46.0	87.0	64.5	63.7	102.6	174.5	186.4	55.6	10.0
KOWDLE	2.3	2.3	19.2	56.3	94.3	65.0	55.9	87.3	140.4	182.0	57.1	8.7
KRISHNARAJPET	3.7	5.7	16.5	61.2	104.1	67.8	68.8	71.9	120.8	180.8	57.5	9.3
KRISHNARAJSAGAR KERS	4.8	5.1	17.9	51.2	104.8	74.7	64.0	74.3	117.6	163.9	58.2	10.5
MADDUR	3.3	2.3	20.6	47.0	95.5	63.5	63.6	84.0	141.7	178.3	57.5	13.2
MALAVALLY	2.0	3.2	17.7	48.4	93.1	63.2	55.3	75.5	128.3	140.2	49.2	11.7
MANDYA TQ OFFICE	2.0	4.0	18.1	46.7	80.4	60.5	55.5	74.4	126.7	152.5	51.3	10.9
MELKOTE	5.1	2.4	18.7	62.7	121.2	66.6	71.4	72.6	135.0	175.1	57.7	8.7
NAGAMANGALA	7.5	4.2	21.4	51.1	106.0	49.7	58.8	93.7	145.7	171.1	64.1	12.2
PANDAVAPURA	4.3	5.8	16.7	57.9	97.2	63.2	51.0	64.8	116.1	166.1	56.2	8.9
SRIRANGAPATNA	3.5	4.2	20.6	59.1	95.2	67.6	53.8	65.8	113.1	139.7	51.0	9.7

Table-3.3: Seasonal and annual rainfall (mm) distribution in Mandya district

Description	PM	SWM	NEM	Annual
1901-2014				
Mean	172	273	222	667
Range	44-325	98-534	29-463	282-1151
Drought (%)	15	19	12	11
Excess (%)	12	17	13	9
2001-2014				
Mean	181	291	224	696
Range	98-325	156-452	117-427	486-1071
Drought (%)	10	10	10	10
Excess (%)	20	20	20	30

Table-3.4: Seasonal normal (1983-2013) rainfall and rainy days over different stations of Mandya district

STATION NAME	Mean rainfall					Rainy days				
	Annual	SWM	NEM	Winter	Summer	Annual	Winter	Summer	SWM	NEM
AKKIHEBBAL	633.5	267.1	219.0	3.8	143.6	47	0	10	23	13
BINDIGANAVOLE	625.1	299.6	196.0	4.5	125.0	34	0	7	17	10
HALAGUR	732.9	347.7	210.5	6.4	168.3	46	0	10	23	13
KIKKERI	671.0	305.7	210.8	4.5	150.1	44	0	10	22	12
KOPPA	820.7	405.3	252.0	8.3	155.1	43	0	9	21	13
KOWDLE	770.8	348.6	247.8	4.6	169.8	45	0	11	21	13
KRISHNARAJPET	768.2	329.3	247.7	9.5	181.8	51	0	11	25	14
KRISHNARAJSAGAR KRS	746.9	330.6	232.5	10.0	173.8	50	1	11	26	13
MADDUR	770.5	352.8	249.0	5.6	163.1	48	0	10	23	14
MALAVALLY	687.7	322.3	201.1	5.2	159.2	46	0	10	23	13
MANDYA TQ OFFICE	683.0	317.0	214.7	6.0	145.3	46	0	10	23	13
MELKOTE	797.1	345.6	241.6	7.4	202.5	41	0	9	20	11
NAGAMANGALA	785.3	347.9	247.3	11.7	178.5	46	1	10	21	14
PANDAVAPURA	708.1	295.0	231.2	10.2	171.8	45	0	10	22	13
SRIRANGAPATNA	683.3	300.4	200.3	7.6	175.0	47	0	11	24	13

Table-3.5: Trendsin South-Westmonsoon (SWM) rainfall (RF) and extreme events (RF above 75 mm) over different stations of Mandya district

STATION NAME	RF TrendSWM		SWM RF Event 75-100		SWM RF Event >100	
	Slope	Trend	Slope	Trend	Slope	Trend
AKKIHEBBAL	0.682	NS	0.949	NS	_	_
BINDIGANAVOLE	-1.453	NS	-0.356	NS	-0.326	NS
HALAGUR	-0.756	NS	-1.156	NS	0.148	NS
KIKKERI	-0.978	NS	-0.563	NS	-0.519	NS
KOPPA	0	NS	0.237	NS	-0.178	NS
KOWDLE	0.296	NS	0.356	NS	0.682	NS
KRISHNARAJPET	-1.393	NS	-0.148	NS	_	_
KRISHNARAJSAGAR KRS	-0.415	NS	0	NS	0.904	NS
MADDUR	-0.267	NS	-0.222	NS	-0.415	NS
MALAVALLY	-0.549	NS	-0.445	NS	0.089	NS
MANDYA TQ OFFICE	-0.86	NS	-0.86	NS	0.089	NS
MELKOTE	-0.534	NS	0.415	NS	0	NS
NAGAMANGALA	-0.178	NS	0.296	NS	0.385	NS
PANDAVAPURA	-0.267	NS	-0.919	NS	-0.208	NS
SRIRANGAPATNA	-1.097	NS	-0.356	NS	0.356	NS

Table-3.6: Trends in annual rainfall (RF) and extreme events (RF above 75 mm) over different stations of Mandya district

STATION NAME	Annual		Annual RF Event 75-100		Annual RF Event >100	
	Slope	Trend	Slope	Trend	Slope	Trend
AKKIHEBBAL	0.801	NS	1.423	NS	-0.267	NS
BINDIGANAVOLE	-1.186	NS	-0.534	NS	-0.326	NS
HALAGUR	-1.097	NS	-1.557	NS	0.178	NS
KIKKERI	0.059	NS	-0.712	NS	-0.756	NS
KOPPA	1.008	NS	0.282	NS	-0.756	NS
KOWDLE	2.016	PT (0.05)	0.756	NS	0.889	NS
KRISHNARAJPET	-0.563	NS	0.445	NS	-0.489	NS
KRISHNARAJSAGAR KRS	0.682	NS	-0.593	NS	1.69	PT (0.1)
MADDUR	0.741	NS	0.03	NS	-0.356	NS
MALAVALLY	-0.296	NS	-0.889	NS	-0.163	NS
MANDYA TQ OFFICE	0.623	NS	-0.593	NS	-0.415	NS
MELKOTE	0.148	NS	0.949	NS	-1.008	NS
NAGAMANGALA	-0.089	NS	0.415	NS	0.267	NS
PANDAVAPURA	1.038	NS	-0.059	NS	-0.445	NS
SRIRANGAPATNA	0.949	NS	-0.267	NS	1.468	NS

Table-3.7: Trends in annual, South-Westmonsoon (SWM) and north east monsoon (NEM) rainy days over different stations of Mandya district

STATION NAME	Annual		SWM		NEM	
	Slope	trend	Slope	trend	Slope	trend
AKKIHEBBAL	0.074	NS	0.682	NS	0.593	NS
BINDIGANAVOLE	-1.823	NT (0.1)	-2.105	NT (0.05)	0.03	NS
HALAGUR	0.326	NS	0.208	NS	0.311	NS
KIKKERI	0.282	NS	-0.993	NS	0.682	NS
KOPPA	2.313	PT (0.05)	1.453	NS	1.453	NS
KOWDLE	0.786	NS	-0.934	NS	1.364	NS
KRISHNARAJPET	-0.652	NS	-1.26	NS	0.726	NS
KRISHNARAJSAGAR KRS	0.83	NS	0.059	NS	1.986	PT (0.05)
MADDUR	0.815	NS	0.326	NS	1.349	NS
MALAVALLY	-0.549	NS	0.119	NS	0.593	NS
MANDYA TQ OFFICE	0.46	NS	-0.815	NS	0.964	NS
MELKOTE	1.141	NS	0.252	NS	1.156	NS
NAGAMANGALA	-0.282	NS	-0.83	NS	-0.252	NS
PANDAVAPURA	1.127	NS	0.015	NS	1.053	NS
SRIRANGAPATNA	0.86	NS	-0.208	NS	1.497	NS

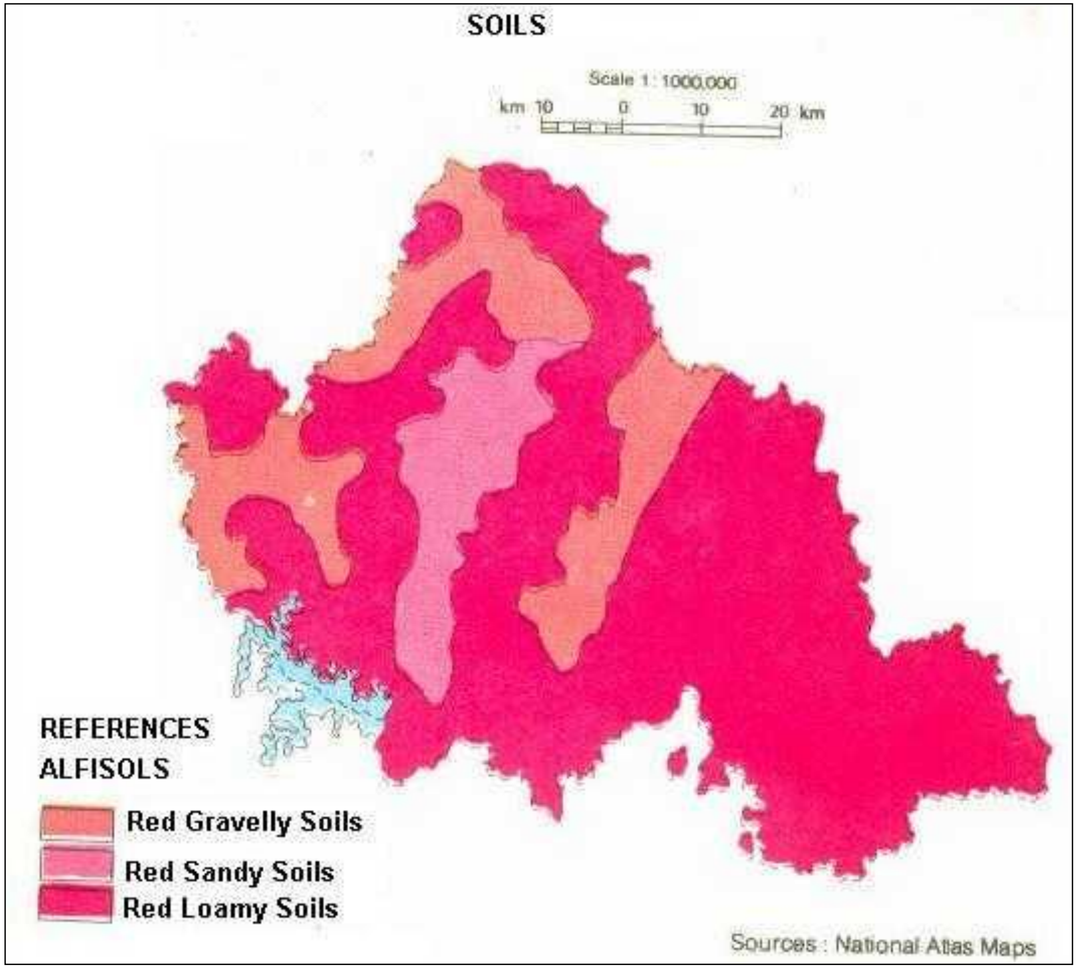

Fig-3.1: Soil map of Mandya district

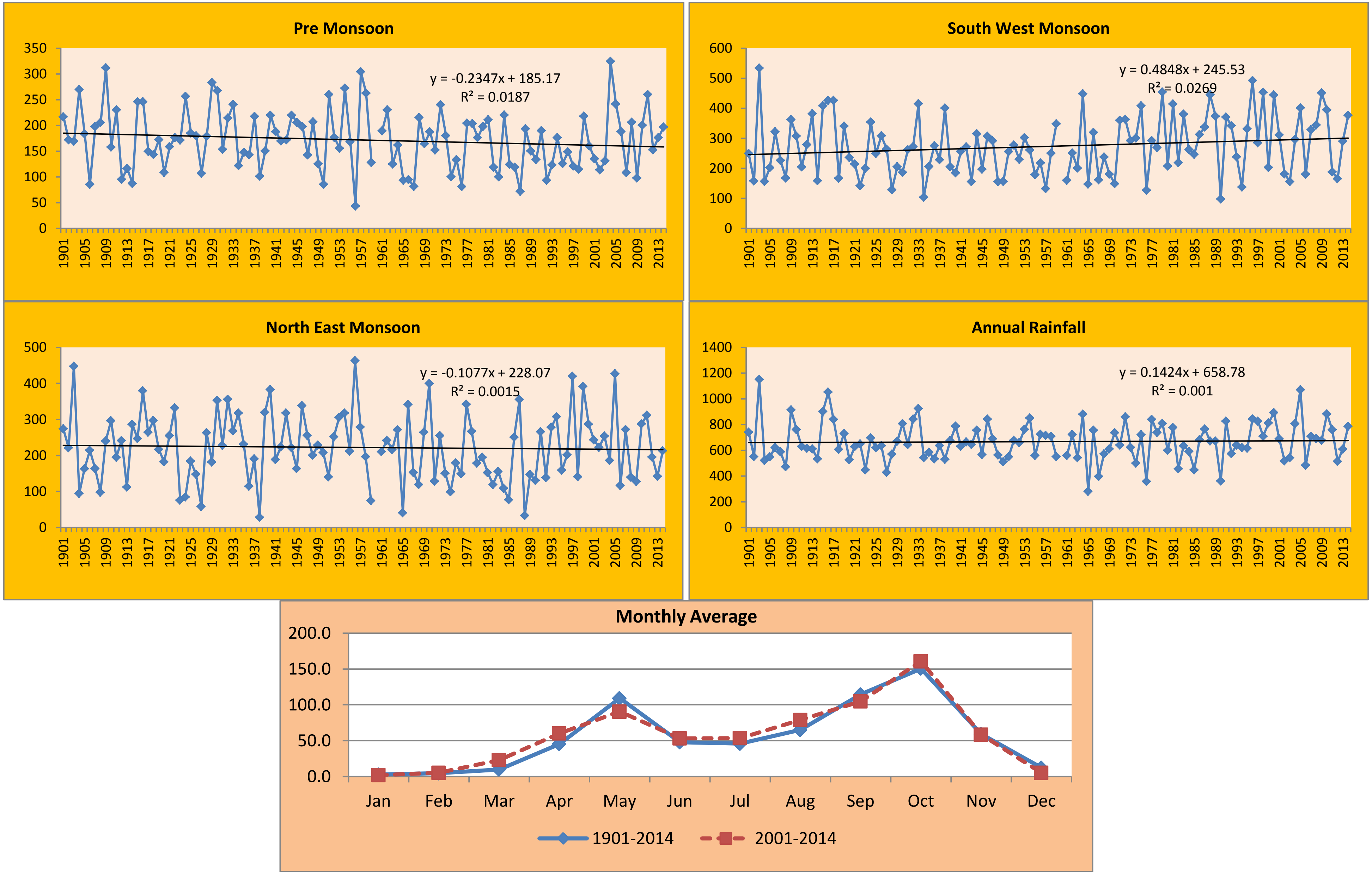

Fig-3.2: Rainfall at Mandya

3.2(A). Highlights of 2011 census: Mysuru District

1. Total population is 2,994,744 compared to 2,641,027 of 2001.
2. Male and female were 1,511,206 and 1,483,538 respectively.
3. Population Growth for Mysuru District recorded in 2011 for the decade has remained 13.39 per cent. Same Figure for 1991-2001 decade was 15.75 per cent.
4. Total Area of Mysuru District was 6,854 with average density of 437 per sq. km.
5. Mysuru Population constituted 4.90 per cent of total Karnataka Population.
6. Sex Ratio of Mysuru District is now 982, while child sex ratio (0-6) is 956 per 1000 boys.
7. Children below 0-6 age were 285,956 which forms 9.55 of total Mysuru District population.
8. Average Literacy rate for Mysuru District is 72.56 per cent, a change of from past Figure of 63.48 per cent. In India, literacy rate is counted only for those above 7 years of age. Child between 0-6 ages are exempted from this.

Description	**2011**	**2001**
Actual Population	29,94,744	26,41,027
Male	15,11,206	13,44,670
Female	14,83,538	12,96,357
Population Growth	13.39%	15.75%
Area Sq. Km	6,854	6,854
Density/km2	437	385
Proportion to Karnataka Population	4.90%	5.00%
Sex Ratio (Per 1000)	982	964
Child Sex Ratio (0-6 Age)	956	962
Average Literacy	19,65,492 (72.56%)	14,71,155 (63.48%)
Male Literacy	10,70,649 (78.44%)	8,36,195 (70.88%)
Female Literacy	8,94,843 (66.59%)	6,34,960 (55.81%)
Total Child Population (0-6 Age)	2,85,956 (9.55%)	3,23,555 (12.25%)

Source: Directorate of Census Operations in Karnataka

3.2(B). District agriculture profile: MYSURU

Agro-Climatic/Ecological Zone			
Agro Ecological Sub Region (ICAR)	Central Karnataka plateau,hot, moist, semi-arid eco-subregion (8.2)		
Agro-Climatic Region (Planning Commission)	Southern Plateau And Hills Region (X) West Coast Plains And Ghat Region (XII)		
Agro Climatic Zone (NARP)	Hilly Zone (KA-9); Southern Transition Zone (KA-7)		
List all the districts or part thereof falling under the NARP Zone	KA-9 : Uttara Kannada, Mysuru, Kodagu, Shimoga, Chikmagalur KA-7: Chikmagalur, Hassan, Mandya, Mysuru		
Geographic coordinates of district	Latitude	Longitude	Altitude
	12º18'11.02" N	76º38'45.71" E	821 M
Name and address of the concernedZRS/ZARS/ RARS/ RRS/ RRTTS	ZARS, VC Farm, Mandya, UAS, Bangalore		
Mention the KVK located in the district	JSSKVK, Suttur-571129, Nanjangud Taluk, Mysuru District		
Normal Onset	**Normal Cessation**		
SWM: June 1st Week	SWM: September 4th Week		
NEM: October 1st Week	NEM: November 3rd Week		

Land use pattern of the district (latest statistics)	Geographical area	Forest area	Land under non-agricultural use	Permanent Pastures	Cultivable wasteland	Land under Misc. tree crops and groves	Barren and uncultivable land	Current fallows	Other fallows
Area (‘000 ha)	676	62	67	55	21	6	45	35	4

Agricultural land use	Area (‘000 ha)	Cropping intensity %
Net sown area	341.3	170
Area sown more than once	238.4	
Gross cropped area	579.7	

Sowing window for 5 major field crops	Paddy	Ragi	Maize	Pulses	Cotton
Kharif- Rainfed	-	May 3^{rd} week – July 4^{th} week	May 4^{th} week– June 4^{th} week	April 2^{nd} week–June 2^{nd}week	April 2^{nd}– May 2^{nd} week
Kharif-Irrigated	July 3rdweek	July 3^{rd} week– July 4^{th} week	-	-	-

Irrigation	Area (‘000 ha)		
Net irrigated area	159.1		
Rain fed area	182.2		
Sources of Irrigation	**Number**	**Area (‘000 ha)**	**per centage of total irrigated area**
Canals		108.7	
Tanks	648	22.48	13.05
Open wells & Bore wells	14,022	24.11	14.00
Lift irrigation	-	0.1	-
Total Irrigated Area	-	159.1	-
Groundwater availability and use	**No. of blocks/ Tehsils**	**(%) area**	
Over exploited	6 taluks	H D Kote (12%), T N Pura(32%),Hunsur(27%),K R Nagar(3%), Mysuru(73%)	
Critical	One taluk	T N Pura	
Semi- critical	3 taluk	H D Kote,(19%)T N Pura(18%) and Nanjangud(3%)	
Safe	One taluk	Periyapatna	
Ground water quality	Suitable for all purposes in major parts of district		

Name of crop	*Kharif*		*Rabi*		Summer		Total	
	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)
Paddy	475.9	4380	-	-	84.1	4624	560	4502
Ragi	104.0	1620	15.7	797	3.8	1676	133.6	1256
Maize	103.4	4078	8.6	3170	5.0	1548	117.1	3624
Pulses	55.2	464	-	-	-	-	55.2	464
Cotton	50.4	164(lint)	-	-	-	-	50.4	164(lint)
Tomato	57.3	19559	-	-	-	-	57.3	19559
Banana	44.5	12988	-	-	-	-	44.5	12988
Chilli (dry)	2.5	2456	-	-	-	-	2.5	2456
Turmeric (dry)	14.1	1319	-	-	-	-	14.1	1319
Coconut	49.3	2698	-	-	-	-	49.3	46.94 nuts/palm/year

Major Field Crops cultivated	Area ('000 ha)					
	Kharif		*Rabi*		Summer	Total
	Irrigated	Rainfed	Irrigated	Rainfed		
Paddy	107.40	-	-	-	-	107.40
Ragi		31.92	-	15.37	0.9	47.38
Maize	0.83	26.9	1.9	3.2	-	32.83
Pulses		119.0	-	-	-	119.0
Cotton		44.89	-	-	-	44.89

Horticulture crops - Fruits	**Total area**
Mango	5.96
Sapota	1.7
Banana	3.66
Horticultural crops - Vegetables	**Total area**
Tomato	3.52
Chilli	0.075
Brinjal	1.10
Medicinal and Aromatic crops/spices	**Total area**
Ginger	1.9
Plantation crops	**Total area**
Coconut	14.2
Fodder crops	**Total area**
Improved grasses (Napier, Para)	2.1
Total fodder crop area	2.1
Grazing land	5.5
Sericulture etc	2.4

Livestock(2007-08)	Male ('000)	Female ('000)	Total ('000)
Non descriptive Cattle (local low yielding)	204.9	266.5	471.4
Crossbred cattle	17.2	128.0	145.2
Non descriptive Buffaloes (local low yielding)	5.7	60.4	66.1
Goat			196.9
Sheep			257.0
Others (Camel, Pig, Yak etc.)			3.18
Poultry	**No. of farms**	**Total No. of birds ('000)**	
Commercial	120	3194.2	
i) Marine (Data Source: Fisheries Department)	**Storage facilities (Ice plants etc.)**		
	7 ice plants with capacity of 48.40t		
ii) Inland (Data Source: Fisheries Department)	**No. of Reservoirs**		**No. of village tanks**
	3		979
Water Spread Area (ha): 17.6	**Production ('000 tons): 7.0**		

Major contingency the district is prone to

Extreme Events	Regular	Occasional	None
Drought	-	✓	-
Flood	-	✓	-
Cyclone	✓	-	-
Hail storm	-	-	✓
Heat wave	-	-	✓
Cold wave	-	-	✓
Frost	-	-	✓
Sea water intrusion	-	-	✓
Pests and diseases Sheath blight and stem borer in paddy	✓	-	-
Others	-	-	✓

Table-3.8: Categorical spread of monthly rainfall over 114 years in Mysuru district

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	3	5	13	60	118	66	86	73	98	145	61	14
Range	0-36	0-74	0-142	8-152	12-309	9-190	26-206	20-186	9-255	9-382	1-234	0-150
2001-2014												
Mean	2	4	24	74	91	74	94	97	90	147	63	6
Range	0-18	0-16	0-142	16-152	12-194	31-118	29-171	53-156	15-165	66-251	4-221	0-29
Low												
Mean	1	2	10	35	88	47	69	48	60	94	35	1
Range	0-10	0-17	0-24	8-86	30-193	9-76	26-98	20-132	9-126	9-212	1-125	0-26
75%	0.9-1.9	0.5-2.5	8.4-11.3	30-40	79-97	43-51	64-74	42-54	53-67	84-104	27-43	0.3-1.7
65%	1.1-1.7	0.9-2.1	9.0-10.7	32-38	83-93	45-49	66-72	44-52	56-64	88-100	30-40	0.6-1.4
Medium												
Mean	3	3	22	56	121	75	95	66	100	138	64	9
Range	0-28	0-15	0-42	19-90	29-219	20-126	27-151	19-156	37-154	39-324	6-145	0-90
75%	1.7-3.8	2.3-3.7	16-28	50-61	112-131	69-81	89-102	60-72	93-106	128-148	56-71	5.4-12.6
65%	2.2-3.4	2.6-3.4	19-26	52-59	116-127	72-78	91-99	62-70	96-103	132-144	59-68	6.9-11.1
High												
Mean	5	14	34	78	156	98	116	97	140	247	93	24
Range	0-36	0-74	0-142	22-148	68-309	24-190	40-206	30-185	68-255	81-382	14-234	1-150
75%	3.7-6.3	9.1-18.9	31-37	73-83	143-169	90-106	106-126	87-108	128-153	225-268	80-106	14-34
65%	4.2-5.8	11.2-16.8	32-36	75-81	148-164	93-103	110-122	91-104	133-148	234-259	85-100	18-30

Table-3.9: Monthly normal rainfall (1983-2013) over different stations of Mysuru district

Station Name	Monthly rainfall											
	January	February	March	April	May	June	July	August	September	October	November	December
ANECHOWKUR	1.3	0.8	24.3	69.4	99.7	169.1	177.5	123.4	114.8	141.8	55.2	9.1
BETTADAPURA	1.0	2.3	13.1	59.5	96.6	86.1	106.9	85.3	87.9	146.8	51.9	10.1
BILIGERE	2.7	3.4	14.2	63.2	96.5	65.7	71.7	71.3	103.7	142.5	58.3	9.0
BIRWAL	4.4	7.5	20.8	70.4	85.5	100.7	120.1	88.4	81.3	124.2	48.3	14.9
BYLAKUPPE	3.6	2.4	23.9	63.7	97.0	120.8	171.8	129.7	105.4	121.4	38.7	13.7
H D KOTE	3.5	6.6	25.1	86.5	113.2	103.0	127.0	94.1	97.6	133.5	55.8	13.2
HAMPAPURA	2.1	5.7	19.3	78.1	106.9	79.6	111.9	91.2	108.1	128.0	58.1	9.8
HUNSUR ARS	1.7	5.7	17.0	63.7	97.1	86.5	105.1	82.3	122.0	154.2	50.1	11.6
HUNSUR TRS	3.8	3.4	18.4	73.7	96.8	87.5	101.2	81.6	120.1	151.8	56.3	11.6
K R NAGAR T.O	4.1	3.6	15.8	53.3	90.6	70.3	62.4	71.9	100.4	135.0	57.6	10.7
MUGUR	0.2	2.2	18.8	62.2	84.3	52.4	60.8	72.0	106.5	146.8	56.4	8.2
MYSURU OBSY	6.0	2.3	16.7	68.3	114.9	72.9	79.4	80.7	106.5	155.9	61.1	11.5
NAGANAHALLY	3.2	3.1	20.1	70.3	95.1	66.2	81.9	86.9	106.9	146.3	62.2	10.7
NANJANAGUD	6.6	3.9	15.0	51.6	94.4	63.5	52.8	61.4	111.0	141.5	43.8	11.3
PERIYAPATNA	0.6	4.3	24.8	74.1	100.1	126.8	129.2	91.5	112.6	152.5	57.3	12.7
RATNAPURI	3.3	4.6	16.5	77.3	91.3	86.1	102.8	82.4	123.1	143.6	58.0	11.2
SALIGRAMA	1.8	2.3	20.4	55.1	110.6	74.1	77.4	65.3	91.0	148.8	53.3	7.8
SARGUR	1.8	4.6	16.7	74.8	100.5	117.8	133.7	96.6	80.2	126.7	61.5	9.2
T NARASIPUR	1.3	4.3	18.0	60.1	92.2	78.2	73.2	84.6	120.8	159.8	60.4	9.9
ELIWALA	5.4	2.5	14.0	56.4	104.2	79.0	77.0	79.3	119.4	152.6	58.4	12.0

Table-3.10: Seasonal and annual rainfall (mm) distribution in Mysuru district

Description	PM	SWM	NEM	Annual
1901-2008				
Mean	199	323	221	743
Range	66-342	60-556	48-505	440-1181
Drought (%)	13	125	13	10
Excess (%)	14	16	14	10
1999-2008				
Mean	195	356	217	768
Range	101-307	216-494	132-371	527-991
Drought (%)	20	10	10	20
Excess (%)	20	30	20	10

Table-3.11: Seasonal normal (1983-2013) rainfall and rainy days over different stations of Mysuru district

STATION NAME	Mean rainfall					Rainy days				
	Annual	SWM	NEM	Winter	Summer	Annual	Winter	Summer	SWM	NEM
ANECHOWKUR	986.3	584.7	206.1	2.1	193.4	68	0	12	44	12
BETTADAPURA	747.5	366.2	208.8	3.4	169.2	57	0	11	33	13
BILIGERE	702.2	312.4	209.9	6.1	173.9	50	0	10	28	12
BIRWAL	766.4	390.5	187.3	11.9	176.7	62	1	13	37	13
BYLAKUPPE	892.2	527.7	173.9	6.0	184.7	65	0	11	43	11
H D KOTE	858.9	421.6	202.4	10.1	224.8	66	1	14	38	13
HAMPAPURA	798.7	390.8	195.8	7.8	204.3	61	0	12	35	13
HUNSUR ARS	797.1	396.0	215.9	7.4	177.9	55	1	10	32	12
HUNSUR TRS	806.3	390.4	219.7	7.2	189.0	62	1	12	35	14
K R NAGAR T.O	675.9	305.1	203.3	7.7	159.8	50	1	10	26	13
MUGUR	670.8	291.7	211.5	2.4	165.3	44	0	10	21	12
MYSURU OBSY	776.2	339.5	228.5	8.3	199.9	55	0	11	29	14
NAGANAHALLY	656.7	288.7	196.6	10.5	160.9	47	1	10	25	12
NANJANAGUD	752.8	341.8	219.2	6.3	185.5	56	1	11	31	13
PERIYAPATNA	886.5	460.1	222.5	4.9	199.0	68	0	13	40	14
RATNAPURI	800.2	394.5	212.8	7.9	185.1	58	1	12	33	13
SALIGRAMA	707.9	307.8	209.9	4.1	186.1	51	0	11	27	12
SARGUR	824.0	428.3	197.3	6.4	192.0	59	1	12	36	11
T NARASIPUR	763.0	356.9	230.2	5.6	170.3	52	0	12	27	14
ELIWALA	760.1	354.7	223.0	7.9	174.6	50	0	10	28	12

Table-3.12: Trends (1983-2013)in South-Westmonsoon (SWM) rainfall (RF) and extreme events (RF above 75 mm) over different stations of Mysuru district

STATION NAME	RF TrendSWM		SWM RF Event 75-100		SWM RF Event >100	
	Slope	Trend	Slope	Trend	Slope	Trend
ANECHOWKUR	-3.0	NT (0.01)	-1.5	NS	-1.2	NS
BETTADAPURA	0.9	NS	_	_	_	_
BILIGERE	1.4	NS	_	_	-0.2	NS
BIRWAL	-1.2	NS	0.0	NS	_	_
BYLAKUPPE	-4.0	NT (0.01)	-1.8	NT (0.1)	-0.5	NS
H D KOTE	0.1	NS	0.1	NS	_	_
HAMPAPURA	-0.7	NS	0.0	NS	0.1	NS
HUNSUR ARS	-0.9	NS	0.0	NS	-0.4	NS
HUNSUR TRS	-0.1	NS	0.1	NS	-0.2	NS
K R NAGAR T.O	0.4	NS	0.4	NS	0.1	NS
MUGUR	-1.4	NS	-0.4	NS	-0.7	NS
MYSURU OBSY	-1.5	NS	-0.1	NS	_	_
NAGANAHALLY	-2.2	NT (0.05)	0.3	NS	-0.3	NS
NANJANAGUD	-1.2	NS	0.3	NS	-0.5	NS
PERIYAPATNA	0.3	NS	-0.7	NS	-0.4	NS
RATNAPURI	-1.0	NS	0.4	NS	0.1	NS
SALIGRAMA	0.0	NS	-1.6	NS	_	_
SARGUR	-1.2	NS	-0.2	NS	-0.5	NS
T NARASIPUR	-0.1	NS	-1.1	NS	-0.4	NS
ELIWALA	-0.1	NS	-0.8	NS	0.3	NS

Table-3.13: Trends (1983-2013) in annual rainfall (RF) and extreme events (RF above 75 mm) over different stations of Mysuru district

STATION NAME	Annual		Annual RF Event 75-100		Annual RF Event >100	
	Slope	Trend	Slope	Trend	Slope	Trend
ANECHOWKUR	-2.2	NT (0.05)	-0.4	NS	-0.9	NS
BETTADAPURA	0.7	NS	0.3	NS	-0.5	NS
BILIGERE	0.9	NS	-1.3	NS	-1.2	NS
BIRWAL	0.0	NS	0.9	NS	-0.3	NS
BYLAKUPPE	-4.4	NT (0.01)	-1.8	NT (0.1)	-1.6	NS
H D KOTE	1.4	NS	0.3	NS	0.4	NS
HAMPAPURA	-0.7	NS	-0.1	NS	-0.2	NS
HUNSUR ARS	0.1	NS	0.5	NS	-0.6	NS
HUNSUR TRS	0.6	NS	-0.5	NS	-0.7	NS
K R NAGAR T.O	2.1	PT (0.05)	0.0	NS	-0.2	NS
MUGUR	-1.2	NS	-0.7	NS	-0.6	NS
MYSURU OBSY	-0.1	NS	-0.6	NS	-0.1	NS
NAGANAHALLY	0.0	NS	-0.3	NS	0.8	NS
NANJANAGUD	0.0	NS	0.3	NS	-0.1	NS
PERIYAPATNA	0.4	NS	-0.2	NS	-0.1	NS
RATNAPURI	0.0	NS	0.5	NS	-0.1	NS
SALIGRAMA	-1.3	NS	-1.2	NS	-0.8	NS
SARGUR	1.7	PT (0.1)	-0.5	NS	0.0	NS
T NARASIPUR	-0.3	NS	-0.3	NS	-0.3	NS
ELIWALA	0.1	NS	-2.0	NT (0.05)	-0.3	NS

Table-3.14: Trends (1983-2013) in annual, South-Westmonsoon (SWM) and North-Eastmonsoon (NEM) rainy days over different stations of Mysuru district

STATION NAME	Annual		SWM		NEM	
	Slope	trend	Slope	trend	Slope	trend
ANECHOWKUR	-1.0	NS	-1.9	NT (0.1)	0.2	NS
BETTADAPURA	0.9	NS	1.1	NS	-0.1	NS
BILIGERE	1.8	PT (0.1)	1.5	NS	1.9	PT (0.1)
BIRWAL	-0.1	NS	-0.6	NS	0.4	NS
BYLAKUPPE	-1.8	NT (0.1)	-2.2	NT (0.05)	-0.3	NS
H D KOTE	1.8	PT (0.1)	0.5	NS	1.3	NS
HAMPAPURA	-0.3	NS	-0.4	NS	0.4	NS
HUNSUR ARS	2.0	PT (0.05)	1.6	NS	1.4	NS
HUNSUR TRS	2.9	PT (0.01)	2.9	PT (0.01)	2.2	PT (0.05)
K R NAGAR T.O	1.8	PT (0.1)	0.8	NS	1.9	PT (0.1)
MUGUR	1.2	NS	0.9	NS	1.2	NS
MYSURU OBSY	-0.1	NS	-0.8	NS	0.0	NS
NAGANAHALLY	-0.2	NS	-1.3	NS	1.0	NS
NANJANAGUD	0.5	NS	0.0	NS	0.2	NS
PERIYAPATNA	1.3	NS	0.6	NS	1.7	PT (0.1)
RATNAPURI	0.3	NS	-0.1	NS	0.4	NS
SALIGRAMA	0.1	NS	0.1	NS	0.7	NS
SARGUR	0.9	NS	-0.1	NS	2.2	PT (0.05)
T NARASIPUR	1.3	NS	1.3	NS	0.8	NS
ELIWALA	1.8	PT (0.1)	1.1	NS	1.8	PT (0.1)

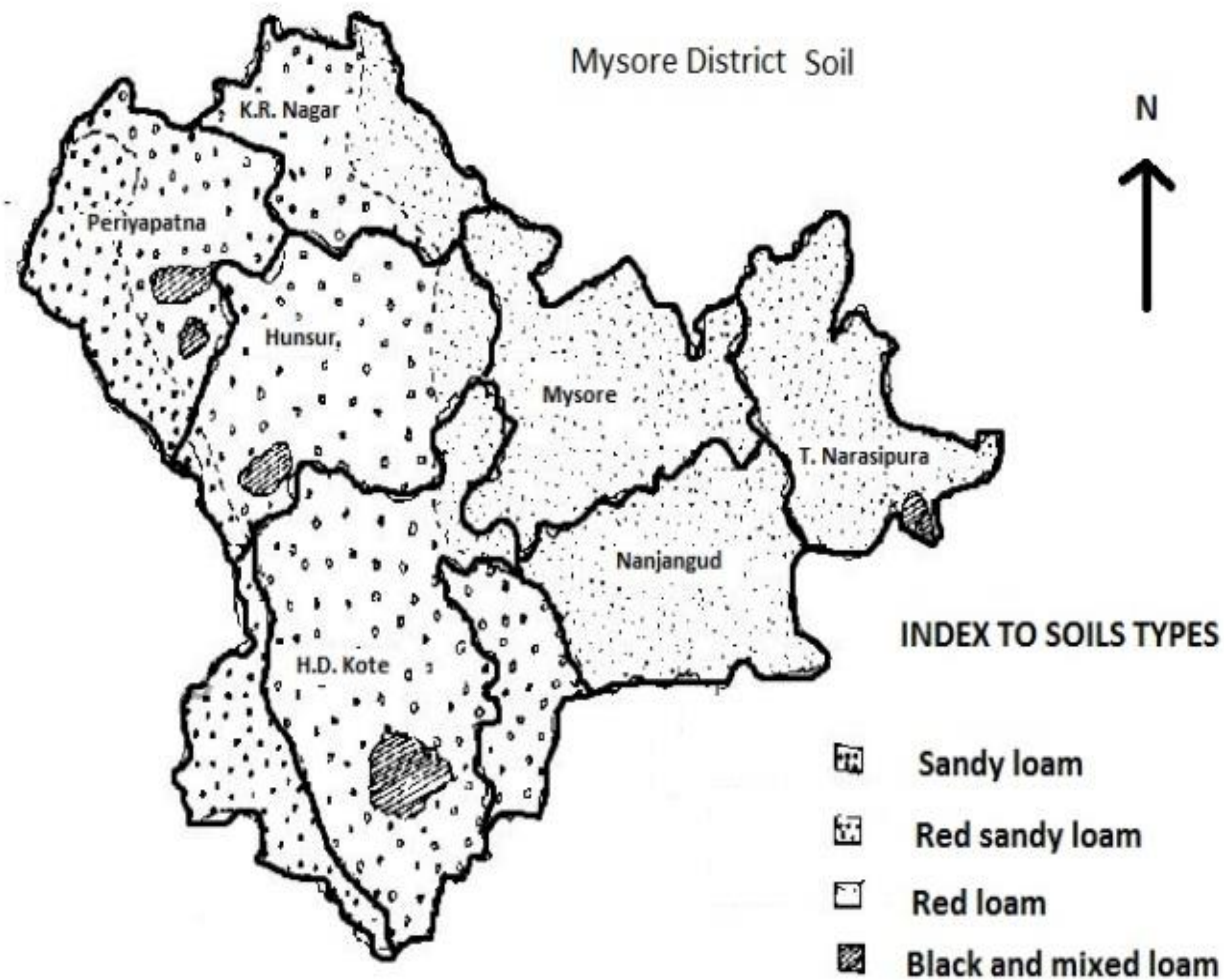

Fig-3.3: Soil map of Mysuru district

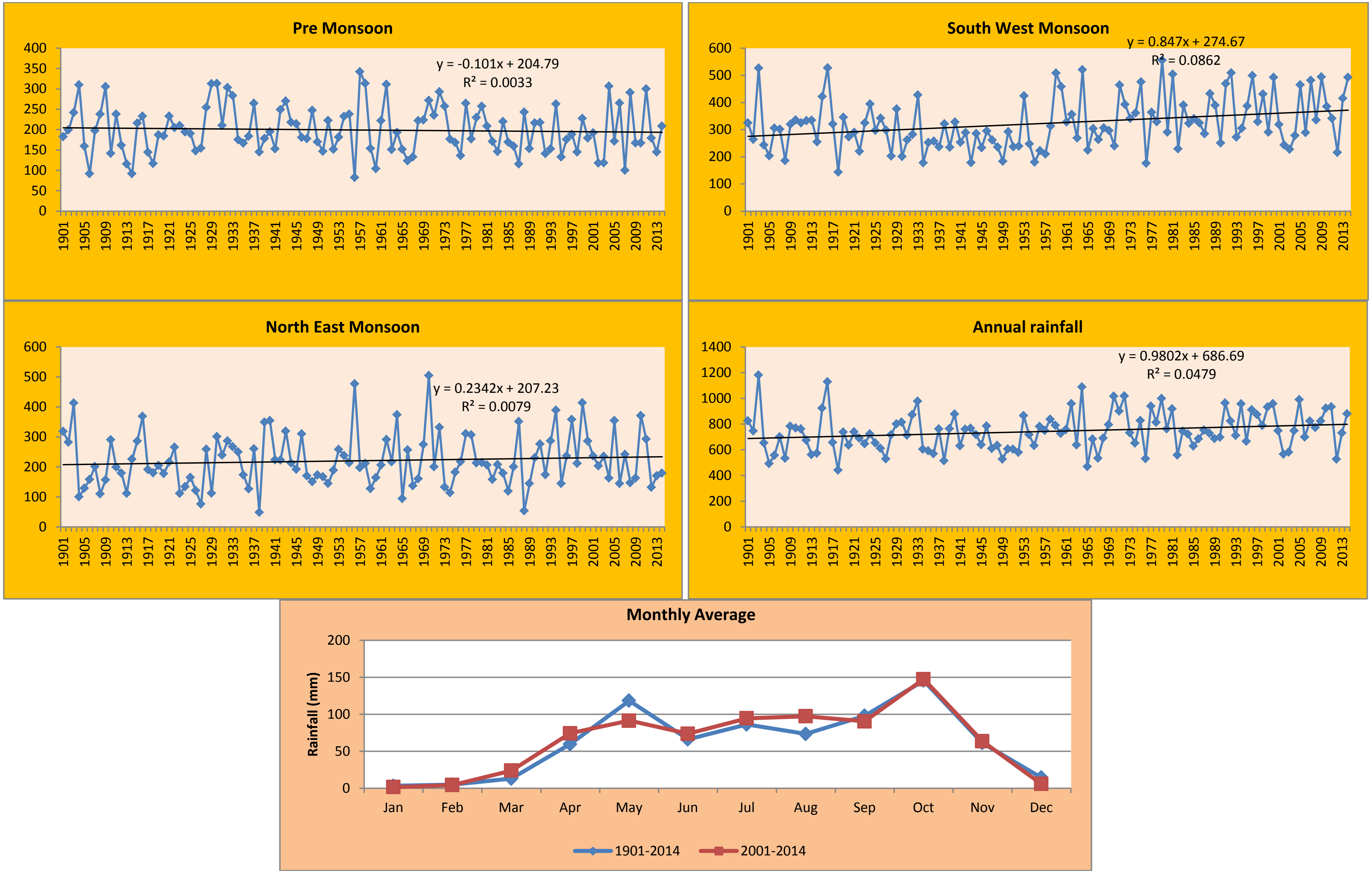

Fig-3.4: Rainfall at Mysuru district

3.3(A). Highlights of 2011 census:Tumakuru

1. Total population is 2,681,449 compared to 2,584,711 of 2001.
2. Male and female were 1,354,770 and 1,326,679 respectively.
3. Population Growth for Tumakuru District recorded in 2011 for the decade has remained 3.74 per cent. Same Figure for 1991-2001 decade was 12.10 per cent.
4. Total Area of Tumakuru District was 10,598 with average density of 253 per sq. km.
5. Tumakuru Population constituted 4.39 per cent of total Karnataka Population.
6. Sex Ratio of Tumakuru District is now 979, while child sex ratio (0-6) is 952 per 1000 boys.
7. Children below 0-6 age were 252,307 which forms 9.41 of total Tumakuru District population.
8. Average Literacy rate for Tumakuru District is 74.32 per cent, a change of from past Figure of 67.01 per cent. In India, literacy rate is counted only for those above 7 years of age. Child between 0-6 ages are exempted from this.

Description	2011	2001
Actual Population	26,81,449	25,84,711
Male	13,54,770	13,13,801
Female	13,26,679	12,70,910
Population Growth	3.74%	12.10%
Area Sq. Km	10,598	10,598
Density/km2	253	244
Proportion to Karnataka Population	4.39%	4.89%
Sex Ratio (Per 1000)	979	967
Child Sex Ratio (0-6 Age)	952	949
Average Literacy	18,05,361 (74.32%)	15,25,485 (67.01%)
Male Literacy	10,05,570 (82.05%)	8,87,341 (76.78%)
Female Literacy	7,99,791 (66.45%)	6,38,144 (56.94%)
Total Child Population (0-6 Age)	2,52,307 (9.41%)	3,08,162 (11.92%)

Source: Directorate of Census Operations in Karnataka

3.3(B). District agriculture Profile: TUMAKURU

Agro-Climatic/Ecological Zone			
Agro Ecological Sub Region (ICAR)	Central Karnataka plateau, hot, moist, semi-arid eco-subregion (8.2)		
Agro-Climatic Region (Planning Commission)	Southern Plateau And Hills Region (X)		
Agro Climatic Zone (NARP)	Central Dry Zone (KA-4)		
List all the districts or part thereof falling under the NARP Zone	Chitradurga, Mandya, Tumakuru, Davanagere		
Geographic coordinates of district	Latitude	Longitude	Altitude
	13'20^{0} 34.82" N	77'06^{0}07.45" E	894.6 M
Name and address of the concerned ZRS/ZARS/ RARS/ RRS/ RRTTS	ZARS, Hiriyur, Chitradurga- 572 143		
Mention the KVK located in the district	Krishi Vigyan Kendra, Konehalli, Tiptur, Tumakuru - 572 202		
Normal Onset	**Normal Cessation**		
SWM: 1st week of June	SWM: 2ndweek of October		
NEM: 3rdweek of October	NEM: 2ndweek ofNovember		

Land use pattern of the district	Geographical area	Forest area	Land under non-agricultural use	Permanent pastures	Cultivable wasteland	Land under Misc. tree crops and groves	Barren and uncultivable land	Current fallows	Other fallows	Net area sown
Area (Lakh ha)	1064.7	45.2	83.8	79.4	62.6	20.1	67.5	86.4	36.8	582.6

Agricultural land use	Area ('000 ha)	Cropping intensity %
Net sown area	582.6	106.5
Area sown more than once	39.0	
Gross cropped area	621.6	

Major Soils	Area ('000 ha)	per cent (%) of total geographical area
Black soil	32.04	0.048
Red soil	386.531	0.58
Sandy soil	37.975	0.056
Sandy loam	209.743	0.314

Irrigation	Area (‘000 ha)	
Net irrigated area	117.8	
Rainfed area	464.8	
Sources of Irrigation	**Number**	**Area (‘000 ha)**
Tanks	1,642	1.661
Open wells	1,40,924	0.969
Bore wells	75,209	120.790
Lift irrigation	7	0.032
Total Irrigated Area		148.165
Pump sets	1,38,600	
No. of Tractors	20,468	

Major Field Crops cultivated	Area (‘000 ha)					
	Kharif		*Rabi*		Summer	Total
	Irrigated	Rainfed	Irrigated	Rainfed		
Paddy	17.99	0.4	0.3	-	10.4	29.09
Ragi	2.0	178.6	0.36	-	1.1	182.06
Maize	6.7	19.9	0.45	-	-	27.05
Redgram	0.9	14.16	-	-	0.4	15.46
Groundnut	0.4	99.9	-	-	-	100.3
Horsegram	-	4.7	-	-	-	4.7
Horticulture crops - Fruits	Total area					
Mango	10.6					
Banana	4.6					
Sapota	0.4					
Pomegranate	0.6					
Horticultural crops - Vegetables	**Total area**					
Vegetables	2.5					
Horticultural crops - Flowers	2.2					
Medicinal and Aromatic crops	0.1					
Plantation crops	**Total area**					
Coconut	122.5					
Arecanut	19.0					
Fodder crops	**Total area**					
FodderJowar	0.3					

Livestock	Male ('000)	Female ('000)	Total ('000)
Non descriptive Cattle (local low yielding)	180.8	267.2	448.0
Crossbred cattle	4.9	136.2	141.1
Non descriptive Buffaloes (local low yielding)	19.0	222.7	241.7
Graded Buffaloes	-	-	241907
Goat	-	-	517763
Sheep	-	-	1061383
Others (Camel, Pig, Yak etc.)	-	-	7718
A. Capture			
Inland (Data Source: Fisheries Department)	**No. Farmer owned ponds**	**No. of Reservoirs**	**No. of village tanks**
	96	4	1285
B. Culture			
Fresh water	**Water Spread Area (ha)**	**Yield (t/ha)**	**Production ('000 tons)**
	10	2.2	22.

Name of crop	*Kharif*		*Rabi*		Total	
	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)
Paddy	846.9	3715	-	4577	84.7	4,146
Ragi	392.7	2063	1.2	1925	393.9	1,994
Redgram	6.2	615	-	-	6.2	615
Maize	66.3	3186	7.4	1850	7.4	2518
Groundnut	48.6	560	-	-	48.6	560
Mango	-	-	-	-	186.2	-
Banana	-	-	-	-	129.7	-
Sapota	-	-	-	-	4.7	-
Guava	-	-	-	-	3.7	-
Vegetables	-	-	-	-	54.3	-
Flowers	-	-	-	-	2.1	-
Medicinal plants	-	-	-	-	0.1	-

Sowing windowfor 5 major field crops	Finger millet	Groundnut	Redgram	Paddy	Vegetable
Kharif- Rainfed	June 1st week to July 2nd week	June 1st week to July end	2nd fortnight of May to 1stfortnight ofJuly	June 1st week to July end	June-July
Kharif-Irrigated	June 1st week to August 2nd week	June 1st week to July end	2nd fortnight of May to 2ndfortnight ofJuly	June 1st week to August 2nd week	June-July
Rabi- Rainfed	-	-	-	-	Oct -Nov
Rabi-Irrigated	-	December 2nd week to January 2nd week	-	-	Oct.-Nov.

Major contingency the district is prone to

Extreme Events	Regular	Occasional	None
Drought	√		
Flood			√
Cyclone			√
Hail storm			√
Heat wave			√
Cold wave			√
Frost			√
Sea water intrusion			√
Pests and diseases		√	
Others			√

Table-3.15: Seasonal and annual rainfall (mm) distribution in Tumakuru district

Description	PM	SWM	NEM	Annual
Mean	122	322	180	625
Range	40-241	134-620	13-385	292-1007
Drought (%)	17	12	15	12
Excess (%)	13	12	15	12
2001-2014				
Mean	155	359	171	685
Range	44-241	188-570	112-305	426-982
Drought (%)	10	10	-	20
Excess (%)	20	20	30	40

Table-3.16: Categorical spread of monthly rainfall over 114 years in Tumakuru district

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	3	4	8	30	78	53	62	81	126	126	46	8
Range	0-33	0-39	0-104	2-118	4-211	9-143	6-204	9-281	10-308	10-323	0-180	0-80
Drought	0.40	0.35	0.15	0.30	0.15	0.10	0.25	0.35	0.20	0.20	0.25	0.25
Excess	0.10	0.15	0.10	0.10	0.15	0.30	0.15	0.25	0.25	0.20	0.15	0.10
Low												
Mean	0	1	3	13	50	38	33	39	63	67	20	1
Range	0-6	0-12	0-18	2-65	3-69	8-72	5-58	9-80	10-99	10-171	1-60	0-20
75%	0.0-1.1	0.1-2.3	1.3-5.1	9.6-16.4	44-55	32-44	29-38	33-45	56-69	53-81	15-26	0.0-2.3
65%	0.0-0.8	0.5-1.9	2.1-4.3	11-15	46-53	35-41	30-36	35-43	59-66	59-75	17-23	0.0-1.6
Medium												
Mean	1	5	6	29	64	73	62	86	146	131	54	4
Range	0-12	0-29	0-17	3-51	3-142	26-98	35-121	33-112	24-251	48-191	4-105	0-29
75%	0.8-1.6	2.7-7.7	4.5-7.9	25-33	53-76	56-72	55-69	81-91	127-165	118-144	77-65	2.8-5.6
65%	0.9-1.5	3.7-6.7	5.3-7.2	27-31	58-71	58-68	58-66	83-89	135-157	123-138	48-61	3.4-5.0
High												
Mean	2	9	18	41	115	85	106	152	183	162	90	11
Range	0-33	0-40	0-93	4-79	57-180	21-143	22-193	98-281	122-308	117-323	9-175	0-31
75%	2.20-2.44	5.4-12.6	9-27	34-48	104-127	75-95	88-121	138-166	167-202	156-181	73-107	8-13
65%	2.25-2.39	7.0-11.0	13-23	37-45	109-122	79-91	96-116	144-161	144-192	161-176	80-100	9-12

Table-3.17: Monthly normal rainfall (1983-2013) over different stations of Tumakuru district

STATION NAME	Monthly rainfall											
	January	February	March	April	May	June	July	August	September	October	November	December
AMRITUR	1.7	2.2	16.3	46.1	97.0	51.2	75.4	91.4	160.4	162.1	55.2	7.4
BADAVANAHALLI	0.5	3.1	7.6	20.4	62.9	71.9	63.6	81.7	127.9	106.7	32.0	4.3
BILIDEVALAYA	1.6	1.2	21.3	38.8	89.7	57.9	80.9	114.5	149.8	122.2	43.0	4.5
BUKKAPATNA	1.6	2.9	10.6	23.1	57.2	43.9	53.0	75.2	120.0	104.1	44.9	3.4
BYALYA	1.5	6.1	5.9	25.2	69.9	57.6	56.4	76.5	127.2	134.0	43.0	5.6
C N HALLI	3.2	5.3	23.1	44.7	79.6	71.4	76.2	98.0	140.9	120.5	44.3	8.1
CHANDRASEKARPUR	3.7	3.1	11.1	28.4	73.6	74.2	65.9	100.5	155.8	120.7	34.0	4.5
DANDINASIVAR	5.2	2.2	13.3	28.0	96.3	53.0	67.0	110.4	140.4	136.6	38.3	5.2
GUBBI	6.8	5.5	17.4	41.0	71.9	73.7	96.8	127.4	162.3	135.8	47.9	6.2
HEBBUR	3.6	3.4	18.2	34.8	80.6	54.1	69.4	107.3	141.6	115.6	36.0	1.8
HULIYURDURGA	5.2	1.9	13.5	47.7	82.4	48.0	81.9	108.3	154.3	162.9	38.3	5.3
KADABA	6.0	5.3	11.9	32.3	68.8	57.8	69.0	101.3	136.7	121.2	37.2	5.6
KALLAMBELLA	0.7	3.9	14.1	28.0	70.4	59.8	69.8	94.9	158.4	121.6	42.9	4.4
KODEGENAHALLI	1.1	2.0	11.0	21.9	64.7	54.7	59.6	92.8	138.2	131.7	37.3	6.4
KUNIGAL T O	4.8	2.6	22.1	47.1	108.6	70.8	87.5	116.7	160.4	143.0	45.5	7.5
MADHUGIRI	1.9	3.4	13.3	26.1	59.7	78.1	72.6	95.5	146.7	134.9	52.3	8.8
NAGALAMADIKE	0.0	2.9	11.0	20.2	48.2	40.6	48.2	59.9	130.3	86.0	34.1	4.6
NONAVINAKERE	5.1	5.4	10.7	41.8	99.0	58.3	62.4	95.4	142.8	144.9	46.3	7.2
PAVAGADA	1.9	4.0	10.7	27.2	62.1	53.8	60.2	87.1	133.8	103.7	41.9	10.0
SIRA	1.9	5.1	13.4	31.5	66.9	64.3	64.3	98.9	144.5	123.1	46.1	6.2
TAVAREKERE	4.8	5.7	8.1	27.9	60.2	59.7	51.7	101.3	148.4	127.3	33.6	7.4
TIPTUR P O	3.3	5.2	11.8	43.8	99.2	57.5	60.3	90.1	133.4	158.2	43.1	5.4
TUMAKURU RLY	4.2	5.0	14.2	49.1	71.6	83.9	112.5	138.4	177.1	145.6	52.8	10.2
URDIGERE	2.0	8.3	18.0	30.4	79.5	60.9	106.0	122.1	142.0	108.0	46.7	6.8

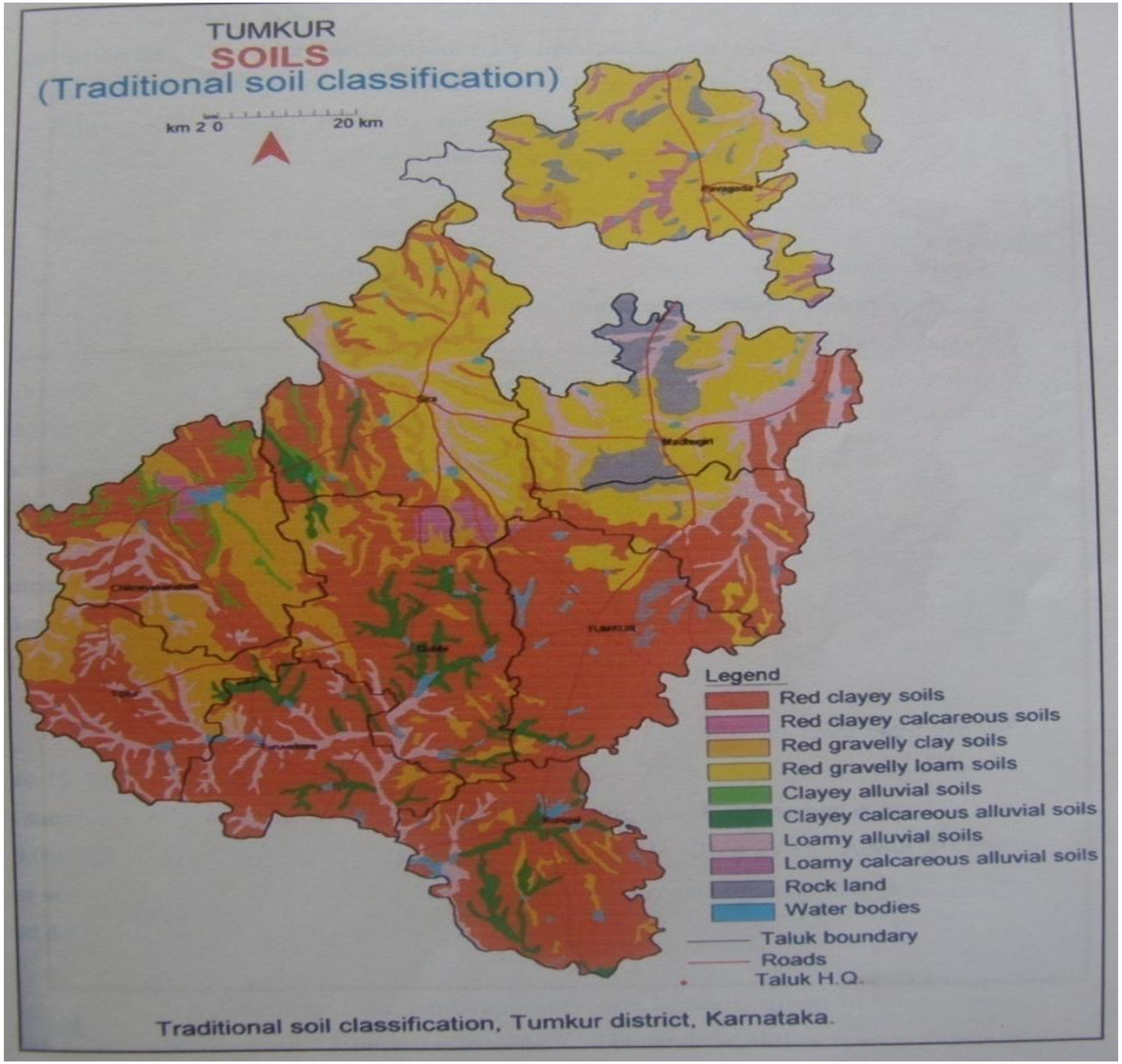

Fig-3.5: Soil map of Tumakuru district

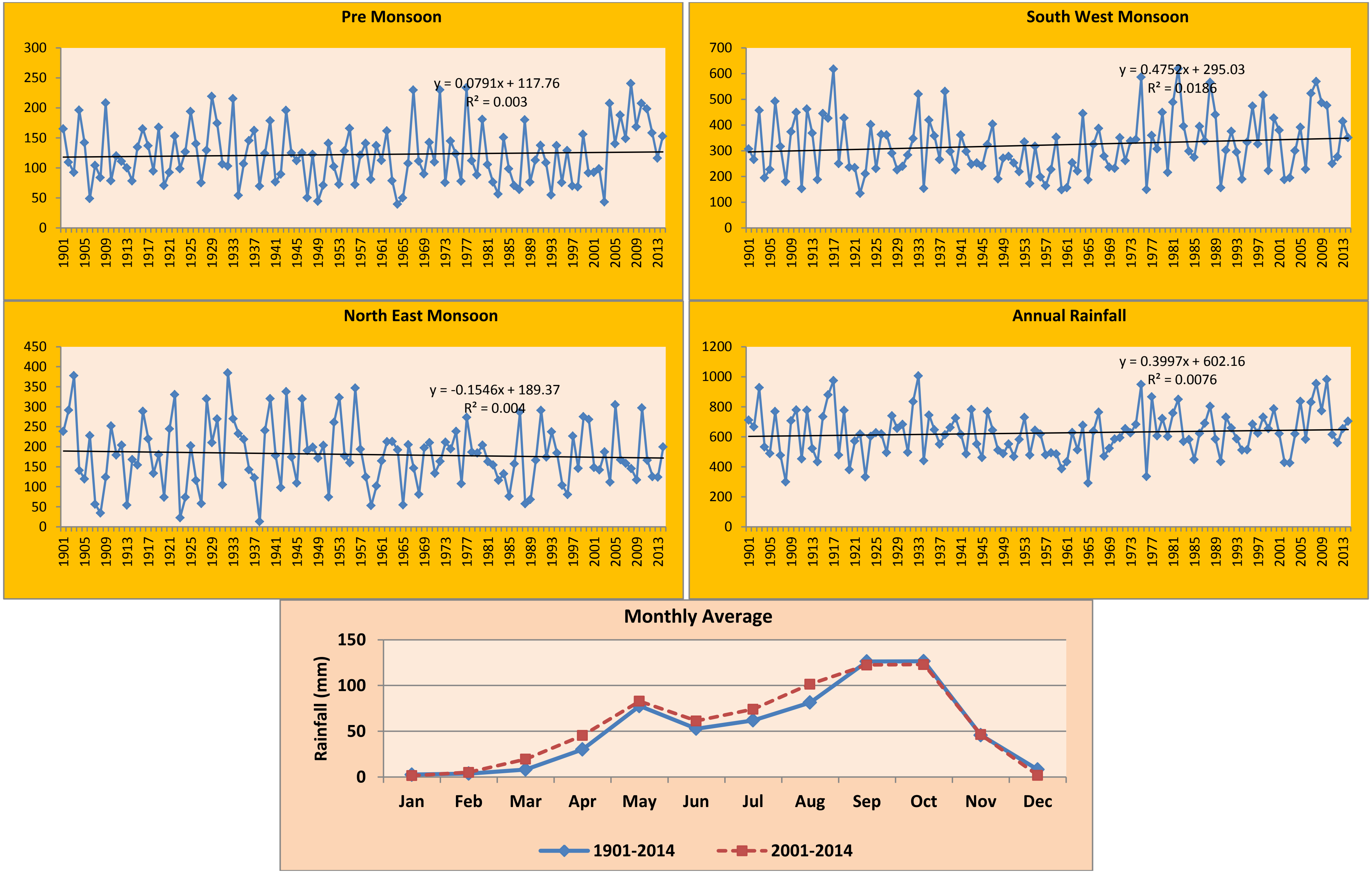

Fig-3.6: Rainfall at Tumakuru district

Table-3.18: Seasonal normal (1983-2013) rainfall and rainy days over different stations of Tumakuru district

STATION NAME	Mean rainfall					Rainy days				
	Annual	SWM	NEM	Winter	Summer	Annual	Winter	Summer	SWM	NEM
AMRITUR	766.4	378.4	224.7	3.9	159.4	42	0	9	21	12
BADAVANAHALLI	582.6	345.2	142.9	3.6	90.9	38	0	6	23	9
BILIDEVALAYA	725.4	403.2	169.7	2.9	149.7	43	0	9	23	10
BUKKAPATNA	539.8	292.1	152.4	4.5	90.9	33	0	5	18	9
BYALYA	608.6	317.6	182.5	7.5	101.0	39	1	7	21	11
C N HALLI	715.4	386.6	172.9	8.5	147.4	48	1	9	27	11
CHANDRASEKARPUR	675.5	396.4	159.2	6.8	113.1	43	1	8	24	10
DANDINASIVAR	695.9	370.8	180.1	7.4	137.6	38	0	8	21	10
GUBBI	792.8	460.2	190.0	12.3	130.4	54	1	10	31	12
HEBBUR	666.2	372.3	153.3	7.0	133.7	42	0	9	23	10
HULIYURDURGA	749.6	392.4	206.5	7.0	143.7	46	0	10	24	12
KADABA	653.0	364.7	164.1	11.3	113.0	46	1	8	27	11
KALLAMBELLA	668.9	382.9	168.9	4.6	112.5	40	0	7	22	10
KODEGENAHALLI	621.4	345.3	175.4	3.1	97.6	35	0	5	19	10
KUNIGAL T O	816.4	435.4	195.9	7.4	177.8	50	1	11	27	12
MADHUGIRI	693.3	392.8	196.0	5.4	99.1	46	0	7	26	12
NAGALAMADIKE	485.7	278.8	124.7	2.9	79.3	30	0	5	16	8
NONAVINAKERE	719.1	358.9	198.3	10.6	151.5	48	0	10	25	13
PAVAGADA	596.2	334.8	155.5	5.9	100.0	42	1	7	23	11
SIRA	666.1	372.0	175.3	6.9	111.8	43	1	8	24	10
TAVAREKERE	636.0	361.1	168.2	10.6	96.2	40	1	7	22	10
TIPTUR P O	711.2	341.2	206.7	8.5	154.8	48	1	10	25	12
TUMAKURU RLY	864.6	511.9	208.6	9.2	135.0	56	1	9	33	13
URDIGERE	730.8	431.1	161.5	10.3	127.9	50	1	8	31	10

Table-3.19: Trends (1983-2013)in South-Westmonsoon (SWM) rainfall (RF) and extreme events (RF above 75 mm) over different stations of Tumakuru district

STATION NAME	RF TrendSWM		SWM RF Event 75-100		SWM RF Event >100	
	Slope	Trend	Slope	Trend	Slope	Trend
AMRITUR	-1.675	NT (0.1)	-1.29	NS	-0.563	NS
BADAVANAHALLI	0.044	NS	-0.03	NS	0.074	NS
BILIDEVALAYA	-2.075	NT (0.05)	-0.03	NS	0.074	NS
BUKKAPATNA	0.534	NS	-0.919	NS	0.474	NS
BYALYA	0.119	NS	0.178	NS	-0.385	NS
C N HALLI	-0.208	NS	0.267	NS	1.082	NS
CHANDRASEKARPUR	-3.113	NT (0.01)	-1.586	NS	-0.385	NS
DANDINASIVAR	-0.222	NS	-0.474	NS	0	NS
GUBBI	0.356	NS	0.712	NS	-0.652	NS
HEBBUR	-1.245	NS	-1.053	NS	0.044	NS
HULIYURDURGA	0.46	NS	-0.252	NS	-0.949	NS
KADABA	0.282	NS	0.193	NS	0	NS
KALLAMBELLA	0.296	NS	0.949	NS	-0.222	NS
KODEGENAHALLI	-0.163	NS	0.667	NS	-1.008	NS
KUNIGAL T O	-0.934	NS	0.326	NS	0.43	NS
MADHUGIRI	0.119	NS	0.371	NS	-0.119	NS
NAGALAMADIKE	-0.682	NS	1.216	NS	-0.385	NS
NONAVINAKERE	-0.593	NS	1.141	NS	0.133	NS
PAVAGADA	-0.623	NS	-0.178	NS	0.089	NS
SIRA	0.089	NS	0.044	NS	0.252	NS
TAVAREKERE	-1.023	NS	1.008	NS	0.089	NS
TIPTUR P O	0.519	NS	0.356	NS	0.267	NS
TUMAKURU RLY	0.311	NS	0.46	NS	0.415	NS
URDIGERE	-0.445	NS	-0.356	NS	-0.03	NS

Table-3.20: Trends (1983-2013) in annual rainfall (RF) and extreme events (RF above 75 mm) over different stations of Tumakuru district

STATION NAME	Annual		Annual RF Event 75-100		Annual RF Event >100	
	Slope	Trend	Slope	Trend	Slope	Trend
AMRITUR	-0.741	NS	-0.563	NS	-0.415	NS
BADAVANAHALLI	0.504	NS	-0.237	NS	0.119	NS
BILIDEVALAYA	-2.224	NT (0.05)	-0.237	NS	0.119	NS
BUKKAPATNA	1.023	NS	-0.445	NS	1.127	NS
BYALYA	0.682	NS	1.067	NS	-0.83	NS
C N HALLI	0.03	NS	0.845	NS	0.697	NS
CHANDRASEKARPUR	-2.995	NT (0.01)	-1.779	NT (0.1)	-0.771	NS
DANDINASIVAR	0.193	NS	0	NS	-0.178	NS
GUBBI	0.919	NS	0.623	NS	-0.712	NS
HEBBUR	-0.03	NS	-0.652	NS	-0.296	NS
HULIYURDURGA	1.764	PT (0.1)	-0.222	NS	-0.563	NS
KADABA	0.993	NS	0.623	NS	-0.356	NS
KALLAMBELLA	1.127	NS	2.016	PT (0.05)	-0.178	NS
KODEGENAHALLI	0.044	NS	0.786	NS	-1.245	NS
KUNIGAL T O	0.059	NS	2.387	PT (0.05)	0.356	NS
MADHUGIRI	-0.208	NS	0.46	NS	-0.949	NS
NAGALAMADIKE	0	NS	1.453	NS	-0.385	NS
NONAVINAKERE	0.326	NS	1.512	NS	0	NS
PAVAGADA	-0.059	NS	-0.608	NS	0.089	NS
SIRA	0.949	NS	0.133	NS	-0.178	NS
TAVAREKERE	-1.957	NT (0.1)	1.038	NS	0.089	NS
TIPTUR P O	1.26	NS	0.356	NS	0.267	NS
TUMAKURU RLY	0.667	NS	0.815	NS	-0.178	NS
URDIGERE	0.86	NS	-1.245	NS	0.771	NS

Table-3.21: Trends (1983-2013) in annual, South-Westmonsoon (SWM) and North-East monsoon (NEM) rainy days over different stations of Tumakuru district

STATION NAME	Annual		SWM		NEM	
	Slope	trend	Slope	trend	Slope	trend
AMRITUR	-0.741	NS	-1.675	NT (0.1)	0.445	NS
BADAVANAHALLI	0.504	NS	0.044	NS	-0.697	NS
BILIDEVALAYA	-2.224	NT (0.05)	-2.075	NT (0.05)	-0.237	NS
BUKKAPATNA	1.023	NS	0.534	NS	1.008	NS
BYALYA	0.682	NS	0.119	NS	0.86	NS
C N HALLI	0.03	NS	-0.208	NS	0.119	NS
CHANDRASEKARPUR	-2.995	NT (0.01)	-3.113	NT (0.01)	-1.067	NS
DANDINASIVAR	0.193	NS	-0.222	NS	-0.015	NS
GUBBI	0.919	NS	0.356	NS	0.148	NS
HEBBUR	-0.03	NS	-1.245	NS	1.601	NS
HULIYURDURGA	1.764	PT (0.1)	0.46	NS	1.379	NS
KADABA	0.993	NS	0.282	NS	1.171	NS
KALLAMBELLA	1.127	NS	0.296	NS	0.712	NS
KODEGENAHALLI	0.044	NS	-0.163	NS	0	NS
KUNIGAL T O	0.059	NS	-0.934	NS	0	NS
MADHUGIRI	-0.208	NS	0.119	NS	-0.119	NS
NAGALAMADIKE	0	NS	-0.682	NS	0.119	NS
NONAVINAKERE	0.326	NS	-0.593	NS	0.726	NS
PAVAGADA	-0.059	NS	-0.623	NS	0.237	NS
SIRA	0.949	NS	0.089	NS	0.504	NS
TAVAREKERE	-1.957	NT (0.1)	-1.023	NS	-0.964	NS
TIPTUR P O	1.26	NS	0.519	NS	-0.015	NS
TUMAKURU RLY	0.667	NS	0.311	NS	0.178	NS
URDIGERE	0.86	NS	-0.445	NS	0.949	NS

3.4(A). Highlights of 2011 census: Hassan District

1. Total population is 1,776,221 compared to 1,721,669 of 2001.
2. Male and female were 885,807 and 890,414 respectively.
3. Population Growth for Hassan District recorded in 2011 for the decade has remained 3.17 per cent. Same Figure for 1991-2001 decade was 9.68 per cent.
4. Total Area of Hassan District was 6,814 with average density of 261 per sq. km.
5. Hassan Population constituted 2.91 per cent of total Karnataka Population.
6. Sex Ratio of Hassan District is now 1005, while child sex ratio (0-6) is 964 per 1000 boys.
7. Children below 0-6 age were 155,579 which form 8.76 of total Hassan District population.
8. Average Literacy rate for Hassan District is 75.89 per cent, a change of from past Figure of 68.63 per cent. In India, literacy rate is counted only for those above 7 years of age. Child between 0-6 ages are exempted from this.

Description	2011	2001
Actual Population	17,76,221	17,21,669
Male	8,85,807	8,59,086
Female	8,90,414	8,62,583
Population Growth	3.17%	9.68%
Area Sq. Km	6,814	6,814
Density/km2	261	253
Proportion to Karnataka Population	2.91%	3.26%
Sex Ratio (Per 1000)	1005	1004
Child Sex Ratio (0-6 Age)	964	958
Average Literacy	12,29,941 (75.89%)	10,44,584 (68.63%)
Male Literacy	6,73,922 (83.55%)	5,93,329 (78.37%)
Female Literacy	5,56,019 (68.30%)	4,51,255 (59.00%)
Total Child Population (0-6 Age)	1,55,579 (8.76%)	1,99,665 (11.60%)

Source: Directorate of Census Operations in Karnataka

3.4(B). District agriculture profile: HASSAN

Agro-Climatic/Ecological Zone			
Agro Ecological Sub Region (ICAR)	Eastern Ghats And Tamil Nadu Uplands And Deccan (Karnataka) Plateau, Hot Semi-Arid Eco-Region (8.2)		
Agro-Climatic Region (Planning Commission)	Southern Plateau And Hills Region (X)		
Agro Climatic Zone (NARP)	Southern Transition Zone (KA-7)		
List all the districts or part thereof falling under the NARP Zone	Hassan, Mysuru, Chikmagalur, Shimoga, Uttara Kannada		
Geographic coordinates of district	Latitude	Longitude	Altitude
	13º00'29.30" N	76º06'13.06" E	943m
Name and address of the concernedZRS/ZARS/ RARS/ RRS/ RRTTS	ZARS, VC Farm, Mandya – 57140; ZARS, Navile, Shimoga – 577204		
Mention the KVK located in the district	KVK, Kandali, Hassan – 573217		
Normal Onset	Normal Cessation		
SWM: 1st to 2nd Week of June	SWM: 2nd Week of September		
NEM: 2nd Week of October	NEM: 1st Week December		

Land use pattern of the district (latest statistics)	**Geographical area**	**Cultivable area**	**Forest area**	**Land under non-agricultural use**	**Permanent pastures**	**Cultivable wasteland**	**Land under Misc. tree crops and groves**	**Barren and uncultivable land**	**Current fallows**	**Other fallows**
Area (000')	662.6	431.6	58.8	78.4	32.9	13.5	0.7	30.4	36.4	2.2

Agricultural land use	**Area ('000 ha)**	**Cropping intensity %**
Net sown area	370	119%
Area sown more than once	71	
Gross cropped area	441	

Major Soils	Area (‘000 ha)	per cent (%) of total
1. Very Deep Red soils in Hilly zone	110.6	16.7 %
2. Very deep Red soils in Plains	206.5	31.2 %
3. Medium Deep Red gravelly soils in plains	4.6	0.73 %
4. Shallow, Calcareous, Gravelly soils in plains	2.6	0.40 %
5. Shallow to medium deep red soils in plains	55.6	8.40 %
6. Deep Red soils with Moderate/ poor drained soils in plains.	80.8	12.2 %
7. Rock out crops	12.6	1.9 %

Irrigation	Area (‘000 ha)		
Net irrigated area	88.6		
Gross irrigated area	97.4		
Rainfed area	255.0		
Sources of Irrigation	**Number**	**Area (‘000 ha)**	**per centage of total irrigated area**
Canals		34.6	39.05
Tanks		28.9	32.68
Open wells		1.07	1.21
Bore wells		22.7	25.48
Lift irrigation		0.185	0.2
Other sources		1.03	1.16
Total Irrigated Area		88.6	
Pump sets	3952		
No. of Tractors	12517		

Major Field Crops cultivated	Area ('000 ha)					
	Kharif		*Rabi*		Summer	Total
	Irrigated	Rainfed	Irrigated	Rainfed		
Paddy	4.03	0	0	0	0.71	4.74
Ragi	1.22	16.97	0.10	0.10	0.07	18.47
Maize	0.75	5.40	0.06	0.39	0.14	6.74
Cowpea	0	1.24	0.07	0.13	0.05	1.50
Greengram	0.05	0.54	0.01	0	0.01	0.61
Horsegram	0	0.35	0	1.90	2.25	6.43
Fieldbean	0	1.11	0	0.06	0	1.17
Sunflower	0.05	0.19	0.01	0.04	0.01	0.31
Groundnut	0.05	0.20	0	0	0.01	0.26
Sugarcane	2.30	0	1.56	0	0.64	4.51
Paddy	4.03	0	0	0	0.71	4.74
Ragi	1.22	16.97	0.10	0.10	0.07	18.47

	Total area		**Total area**
Fruits		French beans	0.5
Banana	3.4	**Plantation crops**	**Total Area**
Mango	2.2	Coconut	61.8
Sapota	0.7	Arecanut	3.9
Lemon	0.4	Cashew	0.1
Guava	0.3	**Spices**	**Total Area**
Vegetables	**Total Area**	Ginger	13.8
Potato	57.5	Cardamom	7.5
Green Chillies	2.4	Pepper	2.7
Tomato	1.7	Turmeric	0.1
Cabbage	0.5	**Flower crops**	**0.8**

Livestock		Male (‘000)		Female (‘000)	Total (‘000)
Non descriptive Cattle (local low yielding)		183.32		290.07	473.39
Crossbred cattle		13.93		126.94	140.87
Non descriptive Buffaloes (local low yielding)		19.96		170.38	190.34
Goat		41.51		7.14	48.65
Sheep		74.41		126.74	201.15
Pig		-		-	2.48
Poultry		**No. of farms**		**Total No. of birds (‘000)** = 516.57	
A. Capture					
Inland (Data Source: Fisheries Department)	**No. Farmer owned ponds**		**No. of Reservoirs**	**No. of village tanks**	
	103		**3**	**3035**	
B. Culture					
Fresh water (Data Source: Fisheries Department)		**Water Spread Area (ha)**		**Yield (t/ha)**	**Production (‘000 tons)**
		33354		60 kg/ha	8425 m

Name of crop	*Kharif*		*Rabi*		Summer		Total	
	Production (000 t)	Productivity(Kg/ha)	Production (000 t)	Productivity(Kg/ha)	Production (000 t)	Productivity(Kg/ha)	Production (000 t)	Productivity(Kg/ha)
Paddy	214.1	4379.0	0.0	-	26474.9	5254	26689.1	5245.59
Ragi	128.2	1716.0	17.8	1856	243.0	2025	389.0	1904.07
Maize	261.4	4459.0	18.1	3790	1979.5	5350	2259.0	5212.3
Cowpea	9.9	1250.0	1.5	950	251.1	1350	262.5	1342.6
Greengram	3.6	1050.0	0.0	-	12.5	1250	16.1	1198.2
Horsegram	5.9	845.0	6.8	720	0.0	-	12.7	773.1
Fieldbean	7.3	1150.0	1.3	940	0.0	-	8.6	1111.2
Sunflower	20.5	1357.0	1.1	1305	20.8	1385	42.4	1369.1
Groundnut	1.3	1550.0	0.0	-	1015.0	1750	1016.3	1749.7
Tobacco	7.8	839.1	0.0	-	0.0		7.8	839.1
Sugarcane	331.3	105000.0	0.0		0.0		331.3	305.32
Potato	135.9	2247.7	1.35	2820.0	-	-	97445	2251.5

Groundwater availability and use	No. of blocks/ Tehsils/ Watershed No.	(%) area
Over exploited	48482	25
Semi- critical	40386	12.50
Safe	48483 & 48484	62.50
Ground water quality	Good	

Situation	Sowing window for 5 major field crops				
	Paddy	Ragi	Maize	Potato	Sunflower
Kharif- Rainfed	July 2nd –Aug 1st	May 4th – June 4th	May 4th – June 4th	June 1st - June 2nd	May 2nd – May 3rd
Kharif-Irrigated	July 4th – Aug 4th	July 2nd – Aug 1st	June 3rd-July 2nd	May 3rd – May 4th	May 1st - May 2nd
Rabi- Rainfed	-	Sept 1st – Sept 2nd	Sept 1st – Sept 2nd	-	Aug 1st – Aug 2nd
Summer	Dec 1st – Jan 2nd				

Major contingency the district is prone to

Extreme Events	Regular	Occasional	None
Drought		√In 2003 (53 % of Normal Rains)	-
Flood			✓
Cyclone			✓
Hail storm			✓
Heat wave			✓
Cold wave			✓
Frost			✓
Sea water intrusion			✓
Pests and diseases		√(Late blight in Potato (2008 and 2009))	
Others			✓

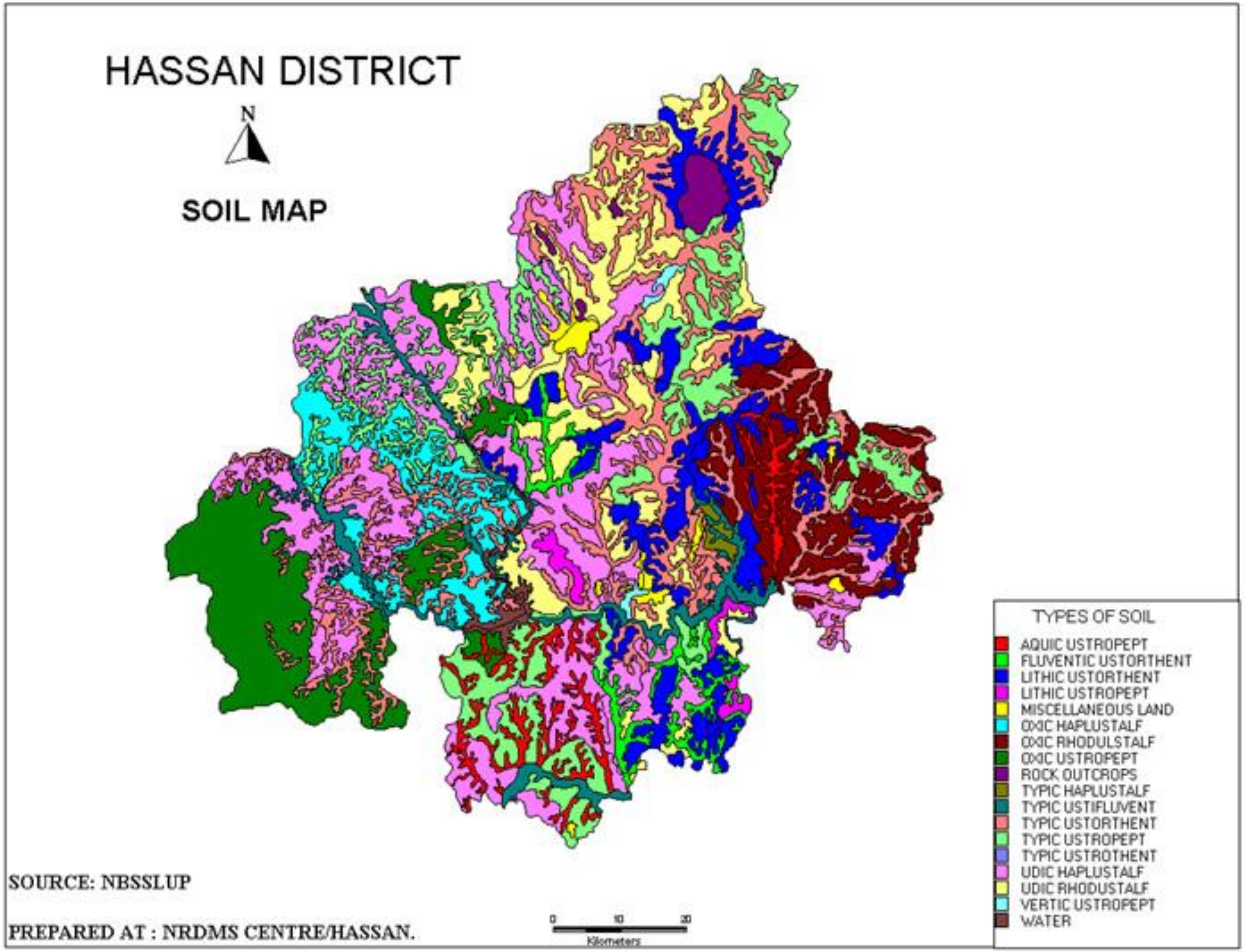

Fig-3.7: Soil map of Hassan district

Table-3.22: Categorical spread of monthly rainfall over 114 years in Hassan district

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	4	4	11	53	102	167	298	198	126	151	64	12
Range	0-49	0-65	0-152	5-200	3-293	33-431	61-794	35-413	21-333	10-474	0-356	0-141
Drought	0.35	0.30	0.15	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.20	0.30
Excess	0.20	0.20	0.20	0.20	0.15	0.20	0.15	0.20	0.20	0.25	0.20	0.15
2001-2014												
Mean	2	6	24	78	101	164	224	200	134	157	58	6
Range	0-17	0-40	1-152	35-150	3-227	40-372	72-663	98-393	44-271	30-328	9-211	0-44
Low												
Mean	0	1	3	27	71	107	210	132	86	93	16	3
Range	0-49	0-12	0-15	55-91	3-144	33-220	61-309	35-244	20-154	10-189	0-89	0-29
75%	0.0-0.9	0.0-1.2	1.2-3.9	20-34	63-80	94-120	190-229	117-147	76-97	79-106	5.6-27	0.0-5.3
65%	0.0-0.7	0.1-1.1	1.4-3.7	21-33	64-78	96-117	194-226	120-144	77-96	82-104	7.5-25	0.3-4.8
Medium												
Mean	2	2	8	53	92	156	311	195	145	165	61	10
Range	1-9	1-15	3-69	19-115	38-185	43-268	160-498	53-331	77-251	47-245	49-142	6-39
75%	0.2-4.4	0.0-5.1	0.0-17	45-60	81-104	140-171	287-334	177-213	132-158	142-188	50-72	5.1-14.1
65%	0.5-4.0	0.0-4.8	1.0-15	46-59	83-101	143-168	291-330	180-210	134-156	147-184	52-70	5.9-13.2
High												
Mean	5	5	13	73	153	235	449	281	177	207	99	14
Range	4-49	3-65	11-152	69-200	66-293	75-431	253-794	135-413	146-323	110-474	70-357	10-141
75%	2.1-8.5	3.7-7.2	8.7-17.8	60-85	136-170	211-258	404-494	258-303	158-195	180-235	77-122	10.9-16.9
65%	2.6-7.9	1.0-6.9	9.5-17.0	62-83	139-167	216-254	412-485	262-299	161-192	185-230	81-118	11.4-16.4

Table-3.23: Seasonal and annual rainfall (mm) distribution in Hassan district

Description	PM	SWM	NEM	Annual
Mean	174	789	226	1189
Range	53-541	310-1614	37-810	622-2965
Drought (%)	14	12	18	9
Excess (%)	15	10	15	10
2001-2014				
Mean	211	723	220	1154
Range	91-363	370-1425	86-420	658-2046
Drought (%)	10	10	10	--
Excess (%)	50	20	30	20

Table-3.24: Monthly normal rainfall (1983-2013) over different stations of Hassan district

STATION NAME	Monthly rainfall											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ARASIKEE TQ OFFICE	4.5	6.7	14.6	42.5	94.6	65.4	68.7	82.2	146.1	153.4	46.6	6.7
AREHALLY	1.6	4.7	24.6	63.8	86.7	339.1	460.1	355.5	169.8	166.3	65.0	8.1
ARKALGUD	2.7	2.9	18.8	44.1	86.3	111.6	165.1	129.6	91.9	130.2	53.8	9.7
BAGUR	5.9	1.3	10.4	61.6	104.6	80.3	70.1	89.8	162.8	163.4	70.5	3.5
BALLUPET	2.6	5.8	17.8	55.8	88.2	301.9	433.7	336.6	160.7	180.9	60.0	12.2
BICCODU	3.4	4.9	20.4	63.9	98.6	206.8	274.8	199.5	133.3	154.2	62.6	6.7
CHANNARAYAPATNA	2.1	1.7	14.3	53.5	89.4	71.0	65.6	73.4	123.4	139.1	48.8	5.3
DUDDAMAGGE	0.6	1.3	21.2	43.5	65.6	85.4	126.1	104.2	85.4	129.2	45.0	4.1
GANDSI	0.6	5.3	6.9	41.9	87.1	59.0	68.9	69.0	132.1	146.9	39.1	6.7
GENDEHALLY	1.9	4.0	25.1	68.2	94.9	237.8	337.2	227.7	139.5	152.0	75.7	10.1
HAGARE	3.7	4.5	15.2	65.1	105.5	111.1	137.8	121.9	128.9	150.1	38.8	8.5
HALLIMYSURU	2.4	3.9	10.8	52.7	92.8	76.9	90.7	85.6	100.9	162.2	45.9	6.9
HANBAL	3.9	3.2	16.4	68.5	83.8	536.3	727.6	524.4	216.7	142.8	50.4	6.6
HIRESAVE	1.9	2.4	18.0	48.1	99.9	59.7	62.0	89.4	143.8	166.9	61.7	5.7
KANAKATTE	4.2	5.3	9.8	40.3	70.9	53.5	58.4	74.5	108.5	140.8	45.7	10.8
KATTAYA	0.9	1.5	19.1	46.8	71.2	91.6	121.1	102.2	84.9	116.5	40.8	5.6
KENCHAMMANA HOSKOTE	4.5	3.5	18.8	73.8	89.1	347.8	560.3	426.2	173.1	187.4	60.1	11.9
KONANUR	1.3	1.8	20.3	48.9	76.3	96.5	132.2	108.1	86.4	154.9	57.5	6.7
MALLIPATNA	2.0	0.4	24.0	52.5	78.3	199.8	313.3	238.3	122.3	158.4	57.4	8.9
NUGGEHALLI	2.6	3.3	10.5	55.0	99.3	57.5	64.9	83.5	140.2	151.6	53.0	5.1
PALYA	1.6	5.0	22.2	67.4	86.0	205.0	338.4	234.5	144.6	170.3	58.1	10.3
SALAGAME	3.2	5.1	15.9	53.6	101.2	102.4	114.8	106.1	129.0	141.8	42.2	4.5
SHANTIGRAMA	1.9	3.3	10.9	38.3	89.9	80.0	85.5	74.8	106.1	131.1	43.7	6.3
SHRAVANABELAGOLA	2.4	2.1	18.6	48.5	97.1	63.3	70.8	84.8	138.8	148.7	54.9	5.9
SUKRAVARSANTHE	1.5	2.5	15.7	58.3	95.3	559.3	861.9	693.4	252.4	169.1	60.0	7.5
UDAYAPURA	1.5	1.0	9.4	47.0	88.6	70.0	69.9	72.0	120.0	140.4	47.0	2.1
YELAWARE	2.6	5.0	13.8	40.1	83.9	56.6	65.3	78.7	119.6	147.2	39.7	7.5
YESLOOR	1.8	4.2	21.4	70.1	78.7	382.6	630.9	458.6	183.2	161.6	61.8	7.5

Table-3.25: Seasonal normal (1983-2013) rainfall and rainy days over different stations of Hassan district

STATION NAME	Mean rainfall					Rainy days				
	Annual	SWM	NEM	Winter	Summer	Annual	Winter	Summer	SWM	NEM
ARASIKEE TQ OFFICE	731.9	362.4	206.6	11.2	151.7	48	1	9	27	12
AREHALLY	1745.2	1324.5	239.3	6.3	175.2	91	0	11	66	13
ARKALGUD	846.6	498.2	193.6	5.7	149.2	64	0	10	43	11
BAGUR	824.1	402.9	237.4	7.2	176.7	41	0	8	21	11
BALLUPET	1656.2	1232.9	253.1	8.4	161.8	95	0	11	70	14
BICCODU	1229.2	814.4	223.5	8.3	182.9	82	0	12	57	13
CHANNARAYAPATNA	687.5	333.4	193.2	3.8	157.1	47	0	10	24	12
DUDDAMAGGE	711.7	401.1	178.4	1.9	130.3	57	0	8	37	11
GANDSI	663.4	329.0	192.6	5.9	135.9	38	0	8	21	10
GENDEHALLY	1374.1	942.2	237.8	5.9	188.2	82	0	12	56	13
HAGARE	891.0	499.7	197.3	8.2	185.7	62	0	12	38	12
HALLIMYSURU	731.6	354.1	215.0	6.3	156.3	52	0	10	30	11
HANBAL	2380.6	2004.9	199.8	7.2	168.7	98	0	11	73	13
HIRESAVE	759.4	354.8	234.3	4.3	166.0	44	0	9	23	12
KANAKATTE	622.6	294.8	197.4	9.5	120.9	39	0	7	22	10
KATTAYA	702.3	399.8	162.9	2.5	137.1	55	0	9	35	11
KENCHAMMANA HOSKOTE	1956.5	1507.4	259.5	8.0	181.6	94	0	11	69	14
KONANUR	790.9	423.2	219.1	3.1	145.5	58	0	9	37	12
MALLIPATNA	1255.7	873.8	224.7	2.4	154.7	80	0	9	58	12
NUGGEHALLI	726.3	346.0	209.6	5.9	164.8	44	0	9	23	11
PALYA	1343.2	922.4	238.7	6.6	175.6	80	0	11	55	13
SALAGAME	819.5	452.2	188.4	8.2	170.7	60	0	10	37	11
SHANTIGRAMA	671.7	346.4	181.0	5.2	139.1	50	0	9	30	11
SHRAVANABELAGOLA	735.8	357.7	209.5	4.4	164.2	48	0	10	26	12
SUKRAVARSANTHE	2776.7	2366.9	236.5	4.0	169.2	104	0	10	80	14
UDAYAPURA	668.9	331.9	189.6	2.5	145.0	43	0	9	24	11
YELAWARE	660.1	320.2	194.4	7.6	137.9	42	0	8	23	11
YESLOOR	2062.4	1655.3	231.0	6.0	170.2	93	0	10	70	12

Table-3.26: Trends (1983-2013)in South-Westmonsoon (SWM) rainfall (RF) and extreme events (RF above 75 mm) over different stations of Hassan district

STATION NAME	RF Trend SWM		SWM RF Event 75-100		SWM RF Event >100	
	Slope	Trend	Slope	Slope	Trend	Slope
ARASIKEE TQ OFFICE	-0.593	NS	0.608	NS	-0.549	NS
AREHALLY	-0.563	NS	0.089	NS	0.667	NS
ARKALGUD	0.741	NS	-0.059	NS	0.326	NS
BAGUR	-2.209	NT (0.05)	-1.216	NS	-1.69	NT (0.1)
BALLUPET	0.623	NS	-0.178	NS	0.267	NS
BICCODU	0.563	NS	0.563	NS	-0.741	NS
CHANNARAYAPATNA	-0.534	NS	-0.341	NS	_	_
DUDDAMAGGE	1.601	NS	-0.593	NS	_	_
GANDSI	-0.371	NS	-0.074	NS	-1.186	NS
GENDEHALLY	1.067	NS	-0.474	NS	0.208	NS
HAGARE	-0.148	NS	-0.534	NS	0.326	NS
HALLIMYSURU	0.208	NS	0.208	NS	-0.387	NS
HANBAL	-0.208	NS	1.571	NS	-1.082	NS
HIRESAVE	-1.038	NS	-1.038	NS	-0.237	NS
KANAKATTE	0.474	NS	-0.549	NS	0.222	NS
KATTAYA	1.393	NS	0.949	NS	0.474	NS
KENCHAMMANA HOSKOTE	-1.097	NS	1.127	NS	-0.578	NS
KONANUR	0.889	NS	0.949	NS	-0.03	NS
MALLIPATNA	-0.415	NS	1.334	NS	-0.86	NS
NUGGEHALLI	0.563	NS	-0.682	NS	0.637	NS
PALYA	-0.682	NS	-1.482	NS	0.326	NS
SALAGAME	0.86	NS	0.445	NS	0.326	NS
SHANTIGRAMA	-1.631	NS	-0.415	NS	-0.356	NS
SHRAVANABELAGOLA	1.186	NS	0.133	NS	0	NS
SUKRAVARSANTHE	0.059	NS	0.608	NS	0.148	NS
UDAYAPURA	-0.534	NS	0.222	NS	0.074	NS
YELAWARE	0.267	NS	0.593	NS	_	_
YESLOOR	1.156	NS	2.535	PT (0.05)	0.771	NS

Table-3.27: Trends (1983-2013) in annual rainfall (RF) and extreme events (RF above 75 mm) over different stations of Hassan district

STATION NAME	RF Trend Annual		Annual RF Event 75-100		Annual RF Event >100	
	Slope	Trend	Slope	Trend	Slope	Trend
ARASIKEE TQ OFFICE	0.623	NS	0.949	NS	-0.059	NS
AREHALLY	0.771	NS	0.311	NS	0.815	NS
ARKALGUD	1.542	NS	-0.015	NS	1.305	NS
BAGUR	-1.557	NS	-1.571	NS	-2.09	NT (0.05)
BALLUPET	0.919	NS	-0.074	NS	0.43	NS
BICCODU	1.201	NS	1.186	NS	-0.741	NS
CHANNARAYAPATNA	0.03	NS	-0.637	NS	-0.652	NS
DUDDAMAGGE	2.461	PT (0.05)	0.267	NS	0.208	NS
GANDSI	1.097	NS	0	NS	-1.038	NS
GENDEHALLY	1.364	NS	0.267	NS	0.178	NS
HAGARE	0.356	NS	-0.385	NS	0.296	NS
HALLIMYSURU	0.445	NS	0.178	NS	-1.393	NS
HANBAL	0.534	NS	1.571	NS	-0.83	NS
HIRESAVE	-0.949	NS	-1.425	NS	-0.949	NS
KANAKATTE	1.364	NS	0.178	NS	0	NS
KATTAYA	2.016	PT (0.05)	1.245	NS	0.474	NS
KENCHAMMANA HOSKOTE	-0.771	NS	0.682	NS	-0.578	NS
KONANUR	1.393	NS	1.957	PT (0.1)	-0.178	NS
MALLIPATNA	1.038	NS	0.919	NS	-0.919	NS
NUGGEHALLI	1.957	PT (0.1)	-1.038	NS	0.549	NS
PALYA	0.148	NS	-0.993	NS	0.889	NS
SALAGAME	1.542	NS	0.964	NS	-0.074	NS
SHANTIGRAMA	-0.504	NS	-0.208	NS	-0.356	NS
SHRAVANABELAGOLA	2.461	PT (0.05)	-0.059	NS	-0.089	NS
SUKRAVARSANTHE	0.563	NS	0.489	NS	0.282	NS
UDAYAPURA	0.697	NS	-0.371	NS	0.074	NS
YELAWARE	1.809	PT (0.1)	0.445	NS	0.282	NS
YESLOOR	1.749	PT (0.1)	2.461	PT (0.05)	0.771	NS

Table-3.28: Trends (1983-2013) in annual, South-Westmonsoon (SWM) and North-Eastmonsoon (NEM) rainy days over different stations of Hassan district

STATION NAME	Annual		SWM		NEM	
	Slope	trend	Slope	trend	Slope	trend
ARASIKEE TQ OFFICE	-0.044	NS	-0.326	NS	0	NS
AREHALLY	0.593	NS	-1.141	NS	1.482	NS
ARKALGUD	1.216	NS	0.445	NS	0.726	NS
BAGUR	1.216	NS	1.912	PT (0.1)	1.379	NS
BALLUPET	1.171	NS	0.875	NS	0.934	NS
BICCODU	1.838	PT (0.1)	1.216	NS	1.097	NS
CHANNARAYAPATNA	1.646	PT (0.1)	0.178	NS	0.726	NS
DUDDAMAGGE	2.594	PT (0.01)	1.705	PT (0.1)	2.728	PT (0.01)
GANDSI	3.958	PT (0.01)	2.268	PT (0.05)	2.713	PT (0.01)
GENDEHALLY	2.164	PT (0.05)	2.12	PT (0.05)	0.549	NS
HAGARE	1.082	NS	0.682	NS	1.171	NS
HALLIMYSURU	2.031	PT (0.05)	0.978	NS	1.586	NS
HANBAL	0.875	NS	0.682	NS	0.741	NS
HIRESAVE	0.697	NS	0.133	NS	0.578	NS
KANAKATTE	2.075	PT (0.05)	1.112	NS	0.934	NS
KATTAYA	1.557	NS	0.919	NS	1.883	PT (0.1)
KENCHAMMANA HOSKOTE	-0.771	NS	-2.757	NT (0.01)	0.267	NS
KONANUR	1.512	NS	0.4	NS	1.542	NS
MALLIPATNA	1.038	NS	-0.148	NS	1.883	PT (0.1)
NUGGEHALLI	3.321	PT (0.01)	1.631	NS	2.298	PT (0.05)
PALYA	0.148	NS	-1.675	NT (0.1)	0.489	NS
SALAGAME	2.135	PT (0.05)	1.838	PT (0.1)	1.601	NS
SHANTIGRAMA	-0.504	NS	0.104	NS	0.964	NS
SHRAVANABELAGOLA	3.128	PT (0.01)	2.12	PT (0.05)	1.586	NS
SUKRAVARSANTHE	0.563	NS	0.074	NS	0.904	NS
UDAYAPURA	1.764	PT (0.1)	0.697	NS	1.527	NS
YELAWARE	1.912	PT (0.1)	0.964	NS	0.385	NS
YESLOOR	-0.667	NS	-0.993	NS	0	NS

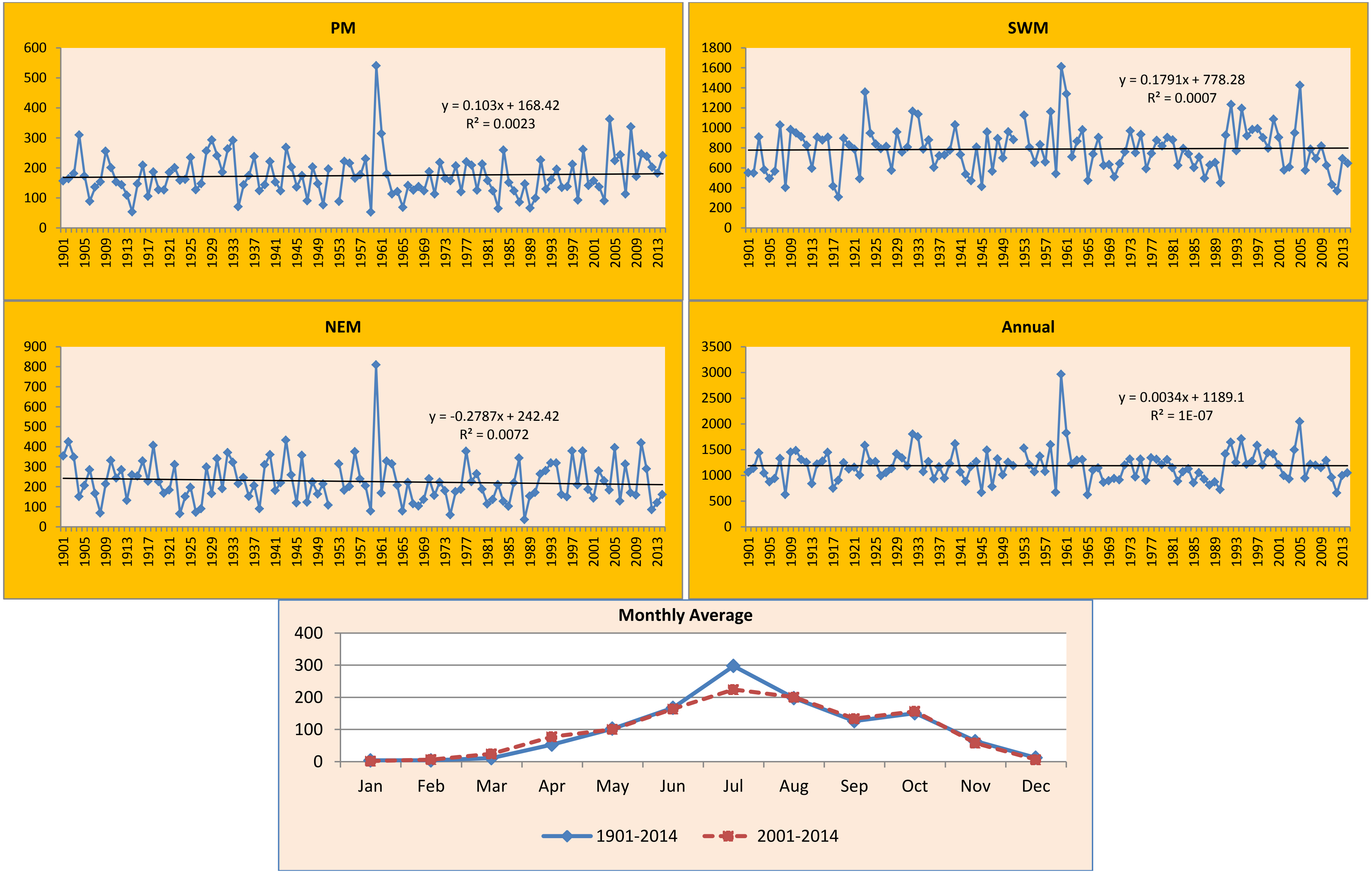

Fig-3.8: Rainfall at Hassan district

3.5(A) Highlights of 2011 census: Chamarajanagar District

1. Total population is 1,020,962 compared to 965,462 of 2001.
2. Male and female were 513,359 and 507,603 respectively.
3. Population Growth for The District recorded in 2011 for the decade has remained 5.75 per cent. Same Figure for 1991-2001 decade was 9.29 per cent.
4. Total Area of The District was 5,102 with average density of 200 per sq. km.
5. The Population constituted 1.67 per cent of total Karnataka Population.
6. Sex Ratio of The District is now 989, while child sex ratio (0-6) is 942 per 1000 boys.
7. Children below 0-6 age were 94,859 which form 9.29 of total The District population.
8. Average Literacy rate for The District is 61.12 per cent, a change of from past Figure of 50.87 per cent. In India, literacy rate is counted only for those above 7 years of age. Child between 0-6 ages are exempted from this.

Description	2011	2001
Actual Population	10,20,962	9,65,462
Male	5,13,359	4,89,940
Female	5,07,603	4,75,522
Population Growth	5.75%	9.29%
Area Sq. Km	5,102	5,102
Density/km2	200	189
Proportion to Karnataka Population	1.67%	1.83%
Sex Ratio (Per 1000)	989	971
Child Sex Ratio (0-6 Age)	942	964
Average Literacy	5,66,076 (61.12%)	4,32,700 (50.87%)
Male Literacy	3,15,321 (67.88%)	2,54,672 (59.03%)
Female Literacy	2,50,755 (67.88%)	1,78,028 (59.03%)
Total Child Population (0-6 Age)	94,859 (9.29%)	1,14,937 (11.90%)

Source: Directorate of Census Operations in Karnataka

3.5(B) District agriculture profile: CHAMARAJANAGAR

Agro-Climatic/Ecological Zone			
Agro Ecological Sub Region (ICAR)	Central Karnataka plateau,hot, moist, semi-arid eco-subregion (8.2)		
Agro-Climatic Region (Planning Commission)	Southern Plateau And Hills Region (X)		
Agro Climatic Zone (NARP)	Southern dry zone (KA-6), Southern Transition Zone (KA-7)		
List all the districts or part thereof falling under the NARP Zone	Chamarajanagar, Mysuru, Mandya, Tumakuru		
Geographic coordinates of district	Latitude	Longitude	Altitude
	11º55'17.40" N	76º56'21.52" E	787.6 M
Name and address of the concernedZRS/ZARS/ RARS/ RRS/ RRTTS	ZARS, V. C farm Mandya - 571405		
Mention the KVK located in the district	Krishi Vigyan Kendra-Haradanahalli, Chamarajanagaram, Karnataka - 571313		
Normal Onset	Normal Cessation		
SWM: Second week of June	SWM: Last week of September		
NEM: 1st week of October	NEM: 2nd week of December		

Land use pattern of the district (latest statistics)	**Geographical area**	**Cultivable area**	**Forest area**	**Land under non-agricultural use**	**Permanent pastures**	**Cultivable wasteland**	**Land under Misc. tree crops and groves**	**Barren and uncultivable land**	**Current fallows**	**Other fallows**
Area (ha)	569.9	191.8	275.6	46.0	22.7	7.6	4.8	21.4	7.7	13.5

Major Soils	Area (ha)	per cent (%) of total
Medium black soils	91.2	16.0
Red loamy soils	81.3	14.2
Red sandy loam soils	27.5	4.8

Agricultural land use	Area ('ha)	Cropping intensity %
Net sown area	191.8	
Area sown more than once	38.7	120
Gross cropped area	230.5	

Groundwater availability and use	(%) area
Over exploited	21.7
Critical	-
Semi- critical	23.50
Safe	54.75

*over-exploited: groundwater utilization > 100%; critical: 90-100%; semi-critical: 70-90%; safe: <70%

Irrigation	Area ('000 ha)		
Net irrigated area	67.6		
Gross irrigated area	142.9		
Rainfed area	124.2		
Sources of Irrigation	**Number**	**Area ('000 ha)**	**per centage of total irrigated area**
Canals		12.9	19.1
Tanks	9112	9.1	13.5
Open wells	6562	6.6	9.8
Bore wells	38500	38.5	57.0
Lift irrigation	500	0.5	0.7
Other sources	16		
Total Irrigated Area		67.6	
No. of Tractors	405		

	Major Field Crops cultivated	Area ('000 ha)					
		Kharif		*Rabi*		**Summer**	**Total**
		Irrigated	**Rainfed**	**Irrigated**	**Rainfed**	**-**	**-**
1	Maize	5.33	32.33	0.60	0.29	5.93	32.62
2	Pulses	0.05	20.27	-	16.9	0.05	37.17
3	Paddy	15.97	-	0.4	-	15.97	-
4	Jowar	-	-	0.15	-	0.15	-
5	Ragi	-	16.67	-	0.2		16.87
6	Groundnut	0.4	18.19	-	-	0.4	18.19
7	Sugarcane	10.5	-	1.8	-	12.3	-
8	Sunflower	0.8	8.84	0.1	-	0.9	8.84
9	Cotton	0.5	6.00	-	0.023	0.5	6.023
	Horticulture crops - Fruits	**Total area**					
1	Banana	8.5					
2	Mango	0.6					
3	Sapota	0.4					
4	Papaya	0.3					
	Horticultural crops - Vegetables	**Total area**					
1	Onion	4.3					
2	Tomato	0.7					
3	Green chilly	1.0					
4	Brinjal	0.4					
5	**Plantation crops**	**Total area**					
	Coconut	8.3					
1.	Arecanut	1.6					
2.	Oil Palm	0.4					
	Spices	**Total area**					
1.	Tumeric	8.5					
	Flower	**Total area**					
1.	Marigold	2.1					
	Sericulture etc	8.6					

Name of crop		*Kharif*		*Rabi*		Summer		Total	
		Production ('000 t)	**Productivity (kg/ha)**	**Production ('000 t)**	**Productivity (kg/ha)**	**Production ('000 t)**	**Productivity (kg/ha)**	**Production ('000 t)**	**Productivity (q/ha)**
Major Field crops (Crops to be identified based on total acreage)									
1	Paddy	68.0	4736	1.4	4364	6.2	4946	75.7	4682
2	Jowar	20.0	849	0.02	212	0.2	20274	20.3	724
3	Maize	59.0	2845	3.4	2638	1.2	63656	63.6	2689
4	Ragi	27.2	1416	0.9	1996	0.8	28845	28.8	1686
5	Groundnut	18.2	705	-	-	0.2	18387	18.4	533
Others	Sunflower	1.1	498	0.1	916	0.2	1511	1.5	731
Major Horticultural crops									
1	Banana	224.5	26.3					224.5	26.3
2	Mango	6.5	11.0					6.5	11.0
3	Sapota	2.9	7.9					2.9	7.9
4	Papaya	23.6	74.9					23.6	74.9
5	Banana	224.5	26.3					224.5	26.3
6	Onion	22.6	5.3	13.0	4.0	8.2	13.4	43.9	5.3
7	Tomato	15.5	21.0	16.9	21.6	7.5	21.7	40.0	21.4
8	Green chilli	77.8	76.8					77.8	76.8
9	Coconut							1723 lakh nuts	0.21 lakh nuts
10	Arecanut							1.2	0.7
11	Oil Palm							4.0	10.7
12	Turmeric	24.2	3.1					24.2	3.1
13	Mari gold	18.7	9.0					18.7	9.0

Livestock	Male	Female	Total
Non descriptive Cattle (local low yielding)	84596	100175	184771
Crossbred cattle	24331	60185	84516
Non descriptive Buffaloes (local low yielding)	9640	28112	37752
Goat	21000	85342	106342
Sheep	20650	96845	117495
Others (Pig, etc.)	45	975	1020 (pig)
Poultry	**No. of farms**	**Total No. of birds (‘000)**	
Commercial	19	2,27,753	

Sowing windowfor 5 major field crops	Paddy	Ragi	Groundnut	Jowar	Maize
Kharif- Rainfed	-	1^{st} WeekMay to 2^{nd} week May	4^{th} week July to 1^{st} week August	1^{st} WeekApril to 2^{nd} WeekJune	2^{nd} Week May to 1^{st} WeekJuly
Kharif-Irrigated	July to August	1^{st} WeekAugust To 1^{st} WeekSeptember	---------	-	August 1^{st} Week to September 2^{nd} Week
Rabi- Rainfed	-	1^{st} WeekSeptember to 1^{st} Week October	-	-	September to October
Summer-Irrigated	2^{nd} WeekJanuary to 2^{rd} Week February	1^{st} Week January To 1^{st} Week February	1^{st} January to 1^{st} Week February	-	1^{st} Week January to 2^{nd} February

. Major contingency the district is prone to

Extreme Events	Regular	Occasional	None
Flood			✓
Cyclone			✓
Hail storm			✓
Heat wave			✓
Cold wave			✓
Frost			✓
Sea water intrusion			✓
Pests and diseases		✓	

CHAPTER - IV

CLIMATIC FEATURES AND TREND ANALYSIS OF AGROMET FIELD UNIT (AMFU) NAGANAHALLY

Location details

Naganahally village is located in Heggadadevanakote Taluk of Mysore district in Karnataka, India. It is situated 5km away from sub-district headquarter Heggadadevanakote and 8 Km away from Mysore city on Bangalore Mysore road (State highway No.17). Its geographical co-ordinates are 76° 39' longitude, 12° 22' latitude and at an altitude of 706 above mean sea level. This research centre is spread over 24 hectares including 17 hectares of wetland.

Formation of the research station

This centre was the visionary product of his majesty Rajashree Naalvadi Krishnaraja odeyar of Mysore and Dr Leslie Coleman, the first Director of Agriculture of Mysore, who recommended to initiate research on crops, development of technologies and to undertake the seed production of sugarcane in the nala catchment region, has come into existence in 1917 and thus celebrating centenary in 2017. Since 1917, Naganahally ARS was operating under the Directorate of Agriculture and later handed over to University of Agricultural Sciences, Bangalore in 1965. Government of Karnataka, in 2005 declared and renamed Naganahally ARS as Organic Farming Research Station (OFRS).

Naganahally Agricultural Research Station (ARS) centre was phenomenal and pioneer in the release of new varieties and hybrid technology, which were popular and covered more than 90 per cent of the then Mysore state. Initially, Naganahally ARS served as seed production unit of sugarcane. In between 1928 to 1965, the centre was instrumental in releasing the many varieties of paddy, collecting more than 2000 varieties from local, other states and other countries (Russia, Burma and Srilanka). The prominent varieties released by this center during the initial stage were Kemboothi, Kaddi Paddy, Patta Somanahalli, Nagapura Sanna, Coimabatore Sanna, Bangarakovi, Aloor Sanna, Maharaja Bhoga, Ratnachoodi, Bangara Kaddi, Alubbalu etc.

The research and innovation conducted on hybrids and high yielding varieties in paddy was exemplary. The center is in the forefront through its excellent performance by releasing the new high yield varieties in sugarcane, banana and maize and is also focused on dry land agriculture and extension activities. Naganahlly ARS has developed the agricultural technologies such as benefit of compost, usage of fertilizers, water management, practices of paddy cultivation of Japan model and recommended for practice to the farmers. It was noteworthy to know that the farmers have implemented the technologies.

Physical and chemical properties of the soils of Naganahally station are as below:

Properties	Values
Physical properties(Mechanical analysis)	
Course sand (%)	45.56
Fine sand (%)	22.50
Silt (%)	12.33
Clay (%)	19.56
Textural class	SCL
Physio chemical properties	
Soil Reaction(pH)	6.66
Electrical Conductivity (dsm^{-1})	0.09
Chemical properties	
Organic Matter (%)	0.80
Cation Exchange Capacity (emol1/kg)	7.08
Available Nitrogen (kg/ha)	215.55
Available P_20_5 (kg/ha)	14.58
Available K_20 (kg/ha)	210.0
Exchangeable calcium (c mol/ kg)	4.96
Exchangeable magnesium (c mol/kg	2.05
Available sulphur (ppm)	8.95

The historical weather data of the station is grouped and analyzed. List of instruments presently available in working condition are: Rain gauge, Wind vane, Maximum thermometer, Minimum thermometer, Evaporimeter, Dry bulb and Wet bulb thermometer and Anemometer. Details of Individual weather parameter is presented below

4. 1 Rainfall

The available daily rainfall data for the period of 1983 to 2015 has been used to compute weekly, monthly, seasonal and annual rainfall. Rainfall time-series generation is used for different purposes:

- To assess the impact of rainfall variability on water resource systems,
- For hydrological modeling and
- Water management issues

4.1.1 Annual rainfall

This station receives mean annual rainfall of about 698 mm. Details of the deviation per cent and drought condition are presented inTable-4.1. Deviation per cent ranging from -26 to -50 is considered as moderately drought. Except for 1985, 1990, 1995, 2002 and 2013 rest all years have normal rainfall. The highest annual rainfall of 1085 mm was received during 2005 and the lowest of 364 mm was received during 2013. Frequency of drought has got reduced by time. In the study period, first drought occurred in 1985successive drought occurred after 4 years, then after six and ten years.Test on trend, correlation and linear regression is presented in Table -4.2. There exists neither any association (Spearman's rho -Non significant) nor any auto correlation (Non-Significant). Non significance results of Mann Kendall test shows that annual rainfall has no significant trend. Still as an attempt linear regression coefficient was developed and the regression coefficient was also found to be Non significant. Maximum rainfall recorded every year is presented in table-4.3. 151.4 mm of rainfall recorded on Tenth of September is till date highest rainfall recorded on a day. Though not significant, an increasing trend (Fig-4.1) is observed in maximum rainfall recoded per day over years (1983-2015).

Table-4.1: Deviation per cent and drought condition of annual rainfall (mm)

Sl No.	Year	Annual RF(mm)	Deviation (%)	Drought Condition
1	1983	731	4.7	No Drought
2	1984	626	-10.2	No Drought
3	1985	493	-29.3	Moderate
4	1986	701	0.49	No Drought
5	1987	662	-5.16	No Drought
6	1988	546	-21.7	No Drought
7	1989	692	-0.80	No Drought
8	1990	462	-33.7	Moderate
9	1991	799	14.5	No Drought
10	1992	753	7.88	No Drought
11	1993	879	26.0	No Drought
12	1994	868	24.4	No Drought
13	1995	492	-29.4	Moderate
14	1996	862	23.5	No Drought
15	1997	953	36.6	No Drought
16	1998	664	-4.86	No Drought
17	1999	833	19.4	No Drought
18	2000	1071	53.5	No Drought
19	2001	656	-5.95	No Drought
20	2002	478	-31.5	Moderate
21	2003	614	-11.9	No Drought
22	2004	909	30.3	No Drought
23	2005	1085	55.5	No Drought
24	2006	623	-10.6	No Drought
25	2007	668	-4.29	No Drought
26	2008	603	-13.5	No Drought
27	2009	528	-24.2	No Drought
28	2010	834	19.5	No Drought
29	2011	645	-7.49	No Drought
30	2012	564	-19.1	No Drought
31	2013	364	-47.8	Moderate
32	2014	678	-2.80	No Drought
33	2015	684	-2.01	No Drought

Table-4.2: Statistical analysis of annual rainfall (mm)

Annual RF	Test statistic	a=0.1	a=0.05	a=0.01	Result
Mann-Kendall	-0.263	1.645	1.96	2.576	NS
Spearman's Rho	-0.467	1.645	1.96	2.576	NS
Linear regression	-0.243	1.696	2.04	2.745	NS
Auto Correlation	1.133	1.645	1.96	2.576	NS

Table-4.3: Highest and lowest rainfall (mm) and temperature events (^0C) recorded every year

Year	Date	Rainfall (mm)	Highest Max. Temp	Month	Lowest Max. Temp	Month	Highest Min. Temp	Month	Lowest Min. Temp	Month
1983	9/12/1983	62.5								
1984	3/6/1984	56.3								
1985	5/16/1985	62								
1986	1/15/1986	60								
1987	11/20/1987	65	37.2	1	25	12				
1988	6/2/1988	48.2	34.4	12	25	7				
1989	9/26/1989	64	36.9	4	25.2	7				
1990	5/24/1990	90	37.7	4	25.2	10				
1991	10/29/1991	134	36.9	4	26	6				
1992	5/28/1992	54	36.1	4	20.5	1	24.9	6	15.7	12
1993	10/5/1993	87	36.5	5	24.9	7	33.9	3	12.8	1
1994	10/27/1994	140	36	4	21.8	12	35.1	3	15.2	12
1995	9/30/1995	51.8	35.6	3	24.1	1	29.7	9	12	12
1996	10/11/1996	66			22.2	12	28.8	7	10.1	12
1997	11/24/1997	87	36.2	5	24.9	8	25.2	5	11.9	2
1998	4/30/1998	61	37	3	23	9	24	4	15.2	1
1999	10/28/1999	54.8	36	3	20.5	11	26	5	12	1
2000	10/23/2000	103.2	36.5	4	21	12	23.5	4	9.5	2
2001	4/23/2001	51	37.5	4	24.5	8	23.5	3	12	1
2002	9/16/2002	84.3	38.4	5	24.5	10	24	3	11	1
2003	10/12/2003	55	39.5	5	25	6	23	4	10.5	12
2004	5/30/2004	69	38	3	23	11	22.5	4	10.5	1
2005	10/23/2005	124	37.5	5	25	10	23	5	10.3	1
2006	3/6/2006	102	38.5	5	26	1	21.5	4	9.5	2
2007	5/2/2007	55	37	3	22	12	20.5	4	9	11
2008	10/24/2008	109.2	37	4	23.9	11	21	4	10	1
2009	10/13/2009	62.2	37.5	4	24.5	11	22.5	5	10	1
2010	11/2/2010	54	38	3	22.5	11	23.5	4	10	1
2011	4/22/2011	52.4	36	5	25	11	22	4	9	1
2012	10/9/2012	151.4	36.8	3	22.8	11	29.5	3	8	1
2013	2/16/2013	40	38.5	4	26	9	23	10	9	1
2014	9/29/2014	57.4	37	4	26	10	22.6	4	14.6	2
2015	9/25/2015	72	35.8	4	25.4	6	22.2	5	15.6	1

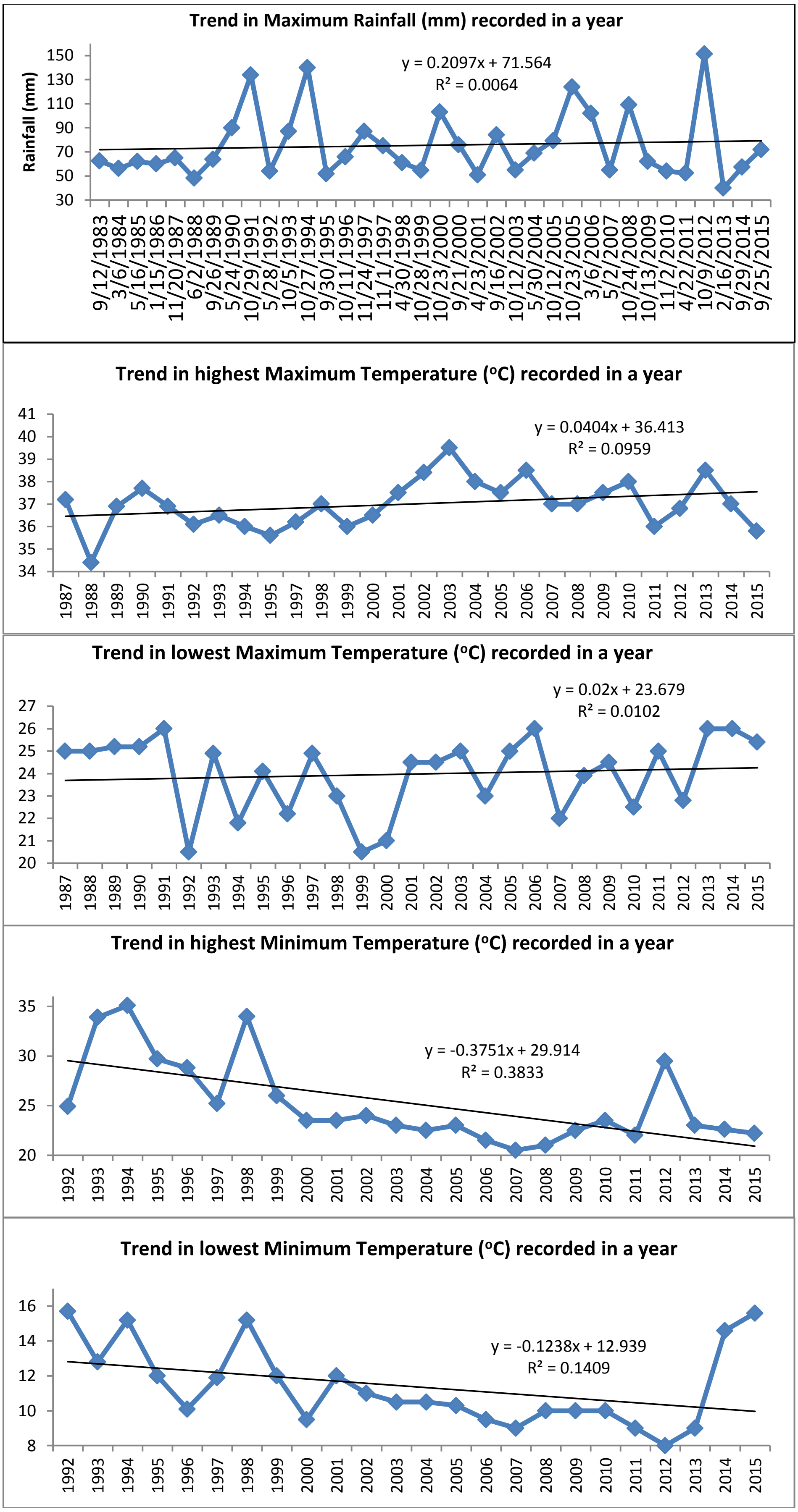

Fig-4.1: Trends in highest and lowest values of weather occurred every year

4.1.2. Seasonal rainfall

The season-wise rainfall distribution during the period is presented in Table 4.4. The mean, minimum and maximum rainfall during different seasons and their statistical inferences are given. Since, South-West monsoon season is the main crop growing season in this station, it is most necessary to highlight the distribution of rainfall during south-west monsoon. In this place, monsoon starts during first week of June and ends during early October. This station receives about 292.2 mm rain during South-West monsoon which is about 42.8 per cent of the annual rainfall. South -West monsoon shows above 300 per cent coefficient variation.

Immediately after the cessation of south-west monsoon, north-east monsoon sets in during 2nd week of October and brings rains during October and November. North- East monsoon is becoming more and causing floods sometimes due to the high winds. Hence contribution from North-East monsoon is also important for the completion of the cropping period. 213.5 mm of rain received during North-East monsoon adds up to about 29.5 per cent of the annual mean rainfall. It has above 179 per cent of coefficient of variation. Winter months (January and February) on an average receive about 12.9 mm rainfall which is about just 1.8 per cent of the mean annual rainfall with 47 per cent coefficient variation. During summer months (March to May) it receives an average of about 179.4 mm rainfall contributing to an extent of 25.9 per cent of the annual rainfall.

Graphs of seasonal rainfall and their trends are presented in Figure-4.2. South west monsoon has decreasing trend while north east monsoon has increasing trend. Contribution of each season to the annual rainfall is presented in Figure-4.3.

Frequency distribution of rainfall recorded per day over different seasons is categorized as 10 to 25, 25 to 50, 50 to 75, 75 to 100 and more than 100 mm are tabulated. Only seven days of the winter received rainfall above 20 mm. Graphs plotted (Figure-4.4) clearly shows that there is increasing number of winter days (Table-4.5) recording 10 to 50 mm while decreasing trend of days recording 50 to 75 mm of rainfall. It is very clear from the graph (Figure-4.5) and Table -4.6 that there is a decreasing number of days receiving above 25 mm of rainfall in the summer while number of days receiving 10 to 25 mm of rainfall is increasing. Number of days receiving rainfall above 10 mm in south west monsoon (Figure-4.6 and Table-4.7) is decreasing. Interestingly number of days receiving 25 to 50 mm and above 100 mm is increasing in North east monsoon (Figure-4.7 and Table-4.8).

Table-4.4: Annual and seasonal rainfall (mm) (1983-2015)

Year	WTR	SMR	SWM	NEM	Annual	per cent of Annual			
						WTR	SMR	SWM	NEM
1983	0	132.4	415.1	183.5	731	0.0	18.1	56.8	25.1
1984	8.8	206	355.3	56.1	626.2	1.4	32.9	56.7	9.0
1985	0	148	257.6	87.6	493.2	0.0	30.0	52.2	17.8
1986	91.8	132.3	238.3	239.1	701.5	13.1	18.9	34.0	34.1
1987	0	94.7	290.5	276.8	662	0.0	14.3	43.9	41.8
1988	0	98.7	410.8	36.9	546.4	0.0	18.1	75.2	6.8
1989	0	195.3	407.1	90	692.4	0.0	28.2	58.8	13.0
1990	3	221.7	84.5	153.5	462.7	0.6	47.9	18.3	33.2
1991	4	254.8	330	210.9	799.7	0.5	31.9	41.3	26.4
1992	0	153.6	514.1	85.4	753.1	0.0	20.4	68.3	11.3
1993	4	239.9	230	405.7	879.6	0.5	27.3	26.1	46.1
1994	112.7	190	248.3	317.9	868.9	13.0	21.9	28.6	36.6
1995	0	116.5	296.9	79.1	492.5	0.0	23.7	60.3	16.1
1996	0	217.6	480.2	164.8	862.6	0.0	25.2	55.7	19.1
1997	4.7	279.2	266.2	403.8	953.9	0.5	29.3	27.9	42.3
1998	0	183	324.7	156.4	664.1	0.0	27.6	48.9	23.6
1999	0	209.9	242.8	380.9	833.6	0.0	25.2	29.1	45.7
2000	61.4	225.2	405.6	379.4	1071.6	5.7	21.0	37.8	35.4
2001	3	194	233.7	225.8	656.5	0.5	29.6	35.6	34.4
2002	2.2	61.7	295.8	118.3	478	0.5	12.9	61.9	24.7
2003	47	84.7	178.6	304.6	614.9	7.6	13.8	29.0	49.5
2004	0	365.2	385.7	159	909.9	0.0	40.1	42.4	17.5
2005	13.7	180	371	521.2	1085.9	1.3	16.6	34.2	48.0
2006	0	278.7	242.2	102.7	623.6	0.0	44.7	38.8	16.5
2007	0	155.1	243.8	269.2	668.1	0.0	23.2	36.5	40.3
2008	4.1	179.1	231	189.4	603.6	0.7	29.7	38.3	31.4
2009	0	87.4	295.2	146.2	528.8	0.0	16.5	55.8	27.6
2010	0	231.1	267.4	336	834.5	0.0	27.7	32.0	40.3
2011	26.2	245.3	148.3	225.9	645.7	4.1	38.0	23.0	35.0
2012	0	114.4	168.9	281.1	564.4	0.0	20.3	29.9	49.8
2013	40	106.4	148.7	69.2	364.3	11.0	29.2	40.8	19.0
2014	0	169.6	332.1	176.8	678.5	0.0	25.0	48.9	26.1
2015	0	169	301.6	213.4	684.0	0.0	24.7	44.1	31.2
Average	12.9	179.4	292.2	213.5	698.1	1.8	25.9	42.8	29.5
Min	0.0	61.7	84.5	36.9	364.3	0.0	12.9	18.3	6.8
Max	112.7	365.2	514.1	521.2	1085.9	13.1	47.9	75.2	49.8
Std. Devn	27.5	67.0	97.0	119.0	171.8	3.8	8.4	13.9	12.4
CV	47.0	267.8	301.2	179.4	406.2	48.6	307.4	307.7	238.2
WTR=WINTER RAINY SEASON (JAN & FEB)				SWM=SOUTH WEST MONSOON(JUNTO SEP)					
SMR=SUMMER RAINY SEASON (MAR TO MAY)				NEM=NORTH EAST MONSOON(OCT TO DEC)					

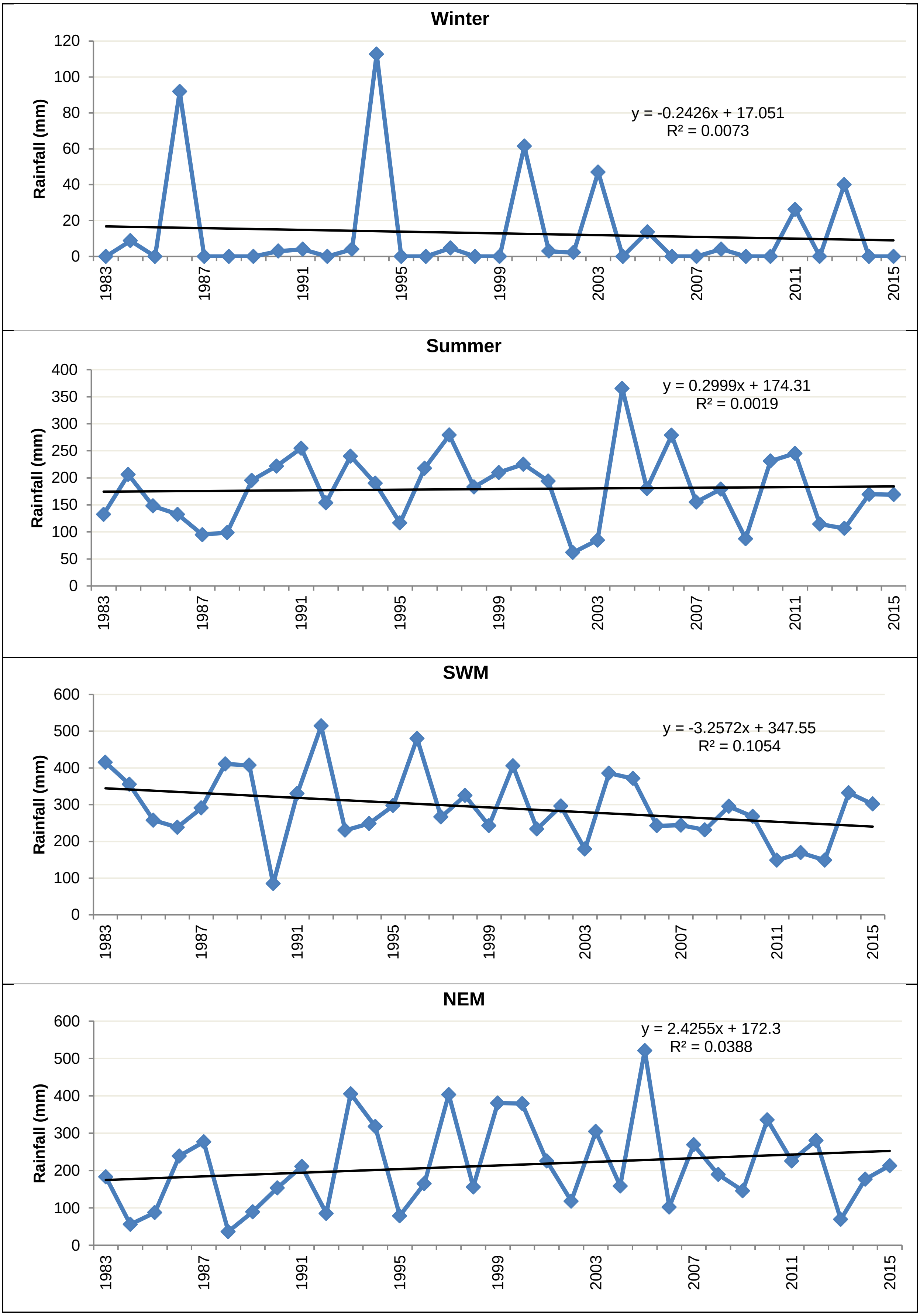

Fig-4.2: Trends in seasonal rainfall (mm) of Naganahally research station

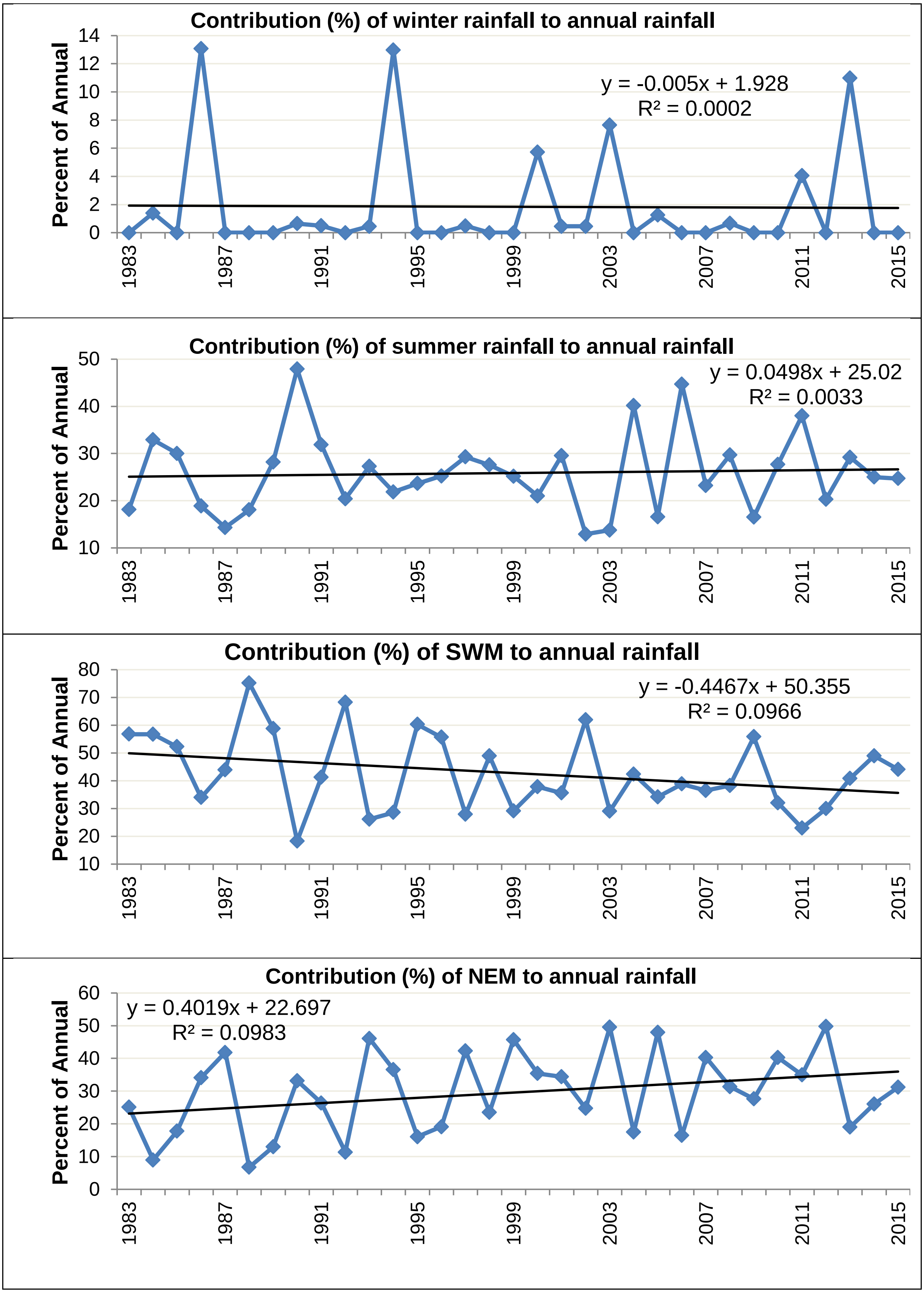

Fig-4.3: Contribution of seasonal rainfall (mm) to annual rainfall (mm)

Table-4.5: Frequency distribution of rainfall (mm) recorded per day in winter

Year	10 - 25		25 - 50		50 - 75		75 - 100		>= 100	
	Days	Total	Days	Total	Days	Total	Days	Total	Days	Total
1983	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	1	60	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0
1994	0	0	1	48.8	1	61.1	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	1	56.4	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0
2003	0	0	1	47	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0
2011	1	24.8	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0
2013	0	0	1	40	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0

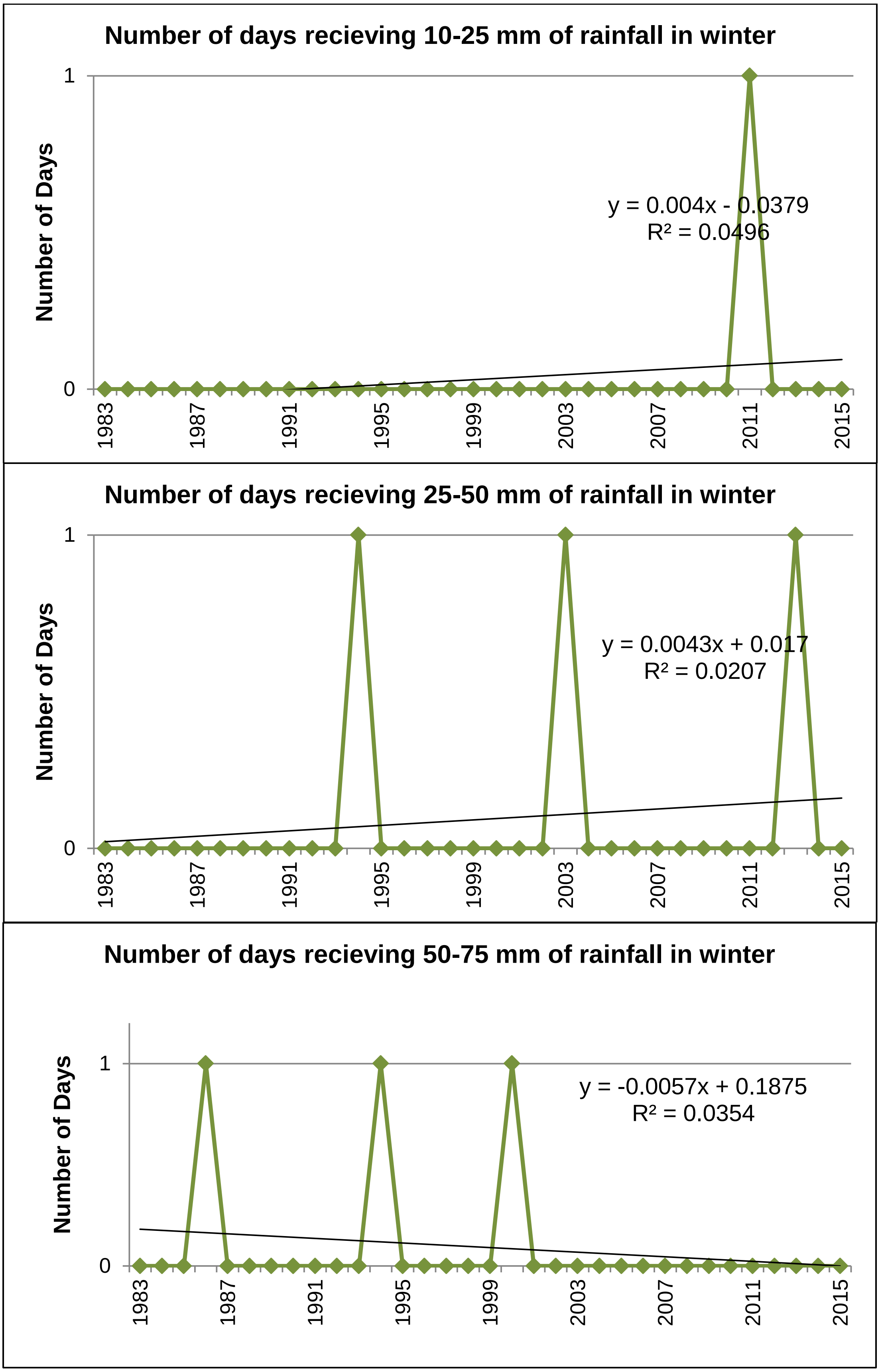

Fig-4.4: Frequency distribution of rainfall (mm) in winter

Table-4.6: Frequency distribution of rainfall (mm) recorded per day in summer

Year	10 - 25		25 - 50		50 - 75		75 - 100		>= 100	
	Days	Total	Days	Total	Days	Total	Days	Total	Days	Total
1983	2	38.3	3	79.1	0	0	0	0	0	0
1984	5	87.3	1	47.6	1	56.3	0	0	0	0
1985	2	27.2	1	28	1	62	0	0	0	0
1986	4	58.9	0	0	1	56	0	0	0	0
1987	4	65.3	0	0	0	0	0	0	0	0
1988	3	50.1	1	40.4	0	0	0	0	0	0
1989	2	25	3	94.2	1	54.7	0	0	0	0
1990	5	75.9	1	44.4	0	0	1	90	0	0
1991	2	35.7	5	168.5	0	0	0	0	0	0
1992	3	46.6	1	25	1	54	0	0	0	0
1993	1	10.7	4	111.2	1	67.4	0	0	0	0
1994	2	24	3	92.6	1	55.8	0	0	0	0
1995	5	83.1	0	0	0	0	0	0	0	0
1996	5	81	3	111.7	0	0	0	0	0	0
1997	5	74.2	1	45.2	2	116.8	0	0	0	0
1998	2	24	3	91	1	61	0	0	0	0
1999	6	89.6	2	71.4	0	0	0	0	0	0
2000	5	73.9	2	66.6	1	50.2	0	0	0	0
2001	4	54.4	2	80	1	51	0	0	0	0
2002	0	0	1	37.2	0	0	0	0	0	0
2003	3	51	0	0	0	0	0	0	0	0
2004	5	93.5	5	153.3	1	69	0	0	0	0
2005	5	92.8	2	55.5	0	0	0	0	0	0
2006	6	85.6	2	70.2	0	0	0	0	1	102
2007	2	25.1	2	65.3	1	55	0	0	0	0
2008	3	36.2	2	78.3	0	0	0	0	0	0
2009	4	50.4	0	0	0	0	0	0	0	0
2010	7	126.8	2	69.6	0	0	0	0	0	0
2011	3	56	2	82.6	1	52.4	0	0	0	0
2012	3	41.8	1	36.8	0	0	0	0	0	0
2013	2	39.2	1	35.8	0	0	0	0	0	0
2014	3	49.1	2	74.7	0	0	0	0	0	0
2015	3	53.2	0	0	1	57.3	0	0	0	0

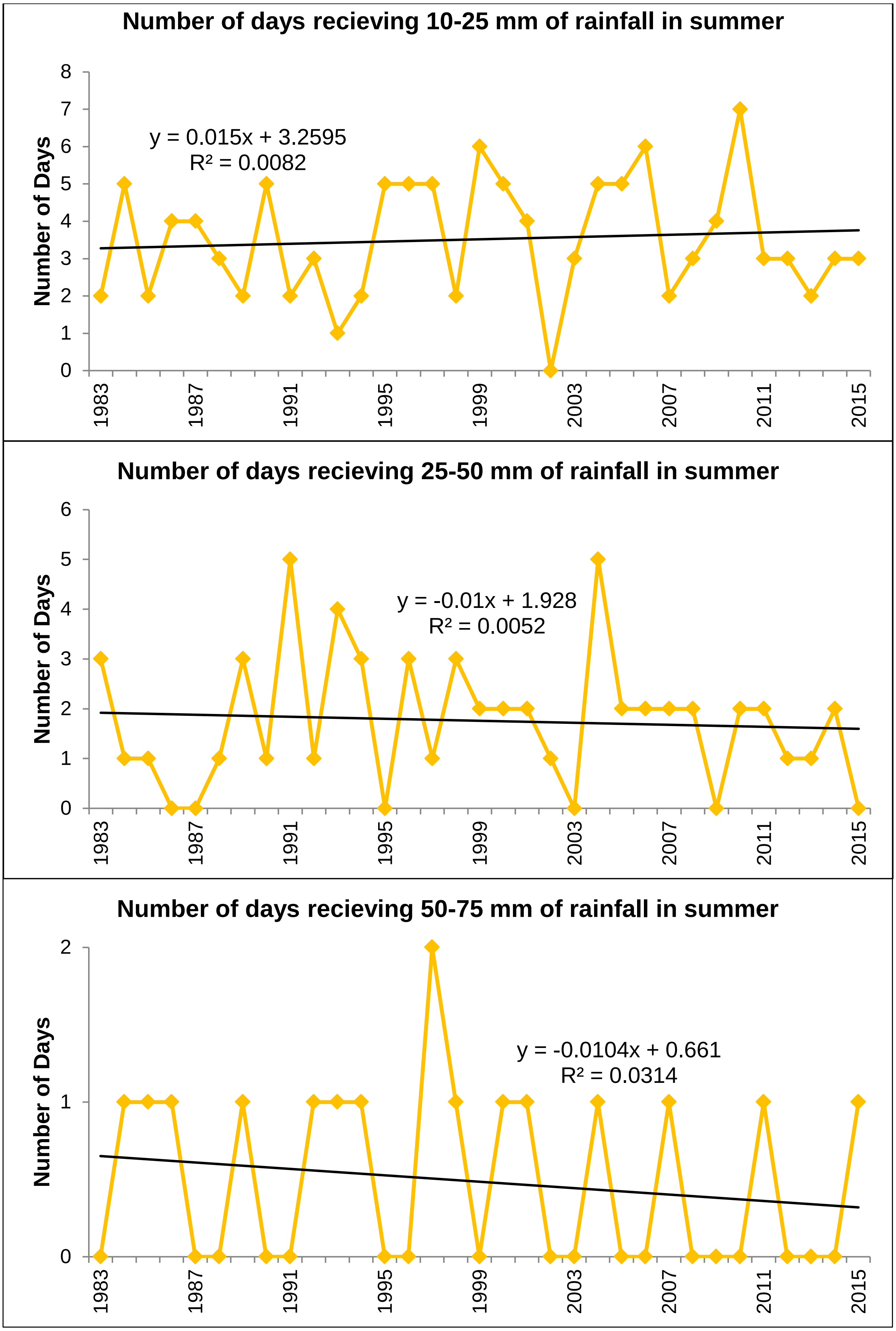

Fig-4.5: Frequency distribution of rainfall (mm) recorded per day in summer

Table-4.7: Frequency distribution of rainfall (mm) recorded per day in south - west monsoon

Year	10 - 25		25 - 50		50 - 75		75 - 100		>= 100	
	Days	Total	Days	Total	Days	Total	Days	Total	Days	Total
1983	8	101.7	4	138.4	1	62.5	0	0	0	0
1984	5	72.2	4	152.9	0	0	0	0	0	0
1985	7	103.8	2	78.2	0	0	0	0	0	0
1986	4	51.2	2	72	0	0	0	0	0	0
1987	7	106.8	3	97	0	0	0	0	0	0
1988	7	114.1	6	206.3	0	0	0	0	0	0
1989	7	89.3	3	97.8	2	119.5	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0
1991	6	90.2	1	25	3	170	0	0	0	0
1992	13	202.9	5	191.1	0	0	0	0	0	0
1993	4	61	0	0	2	116	0	0	0	0
1994	8	126.6	1	35	0	0	0	0	0	0
1995	9	132.4	1	25.3	1	51.8	0	0	0	0
1996	9	155.2	5	183.9	1	52.4	0	0	0	0
1997	5	87	4	110.9	0	0	0	0	0	0
1998	5	91	3	109.9	0	0	0	0	0	0
1999	4	60.2	3	88	0	0	0	0	0	0
2000	9	142.2	3	100.6	0	0	1	76	0	0
2001	1	10	4	113.1	0	0	0	0	0	0
2002	3	51.5	3	105	0	0	1	84.3	0	0
2003	3	60.2	1	26	0	0	0	0	0	0
2004	8	116.6	5	175.4	0	0	0	0	0	0
2005	8	152.2	3	96.4	0	0	0	0	0	0
2006	4	60.7	1	28.2	1	61.2	0	0	0	0
2007	8	99.8	0	0	0	0	0	0	0	0
2008	4	63.7	2	58	0	0	0	0	0	0
2009	3	49.3	4	150.4	0	0	0	0	0	0
2010	6	102.4	1	29	0	0	0	0	0	0
2011	2	31.5	0	0	0	0	0	0	0	0
2012	2	32.8	0	0	1	51	0	0	0	0
2013	5	83.5	0	0	0	0	0	0	0	0
2014	4	69.4	4	156.6	1	57.4	0	0	0	0
2015	6	116.1	1	34	1	72	0	0	0	0

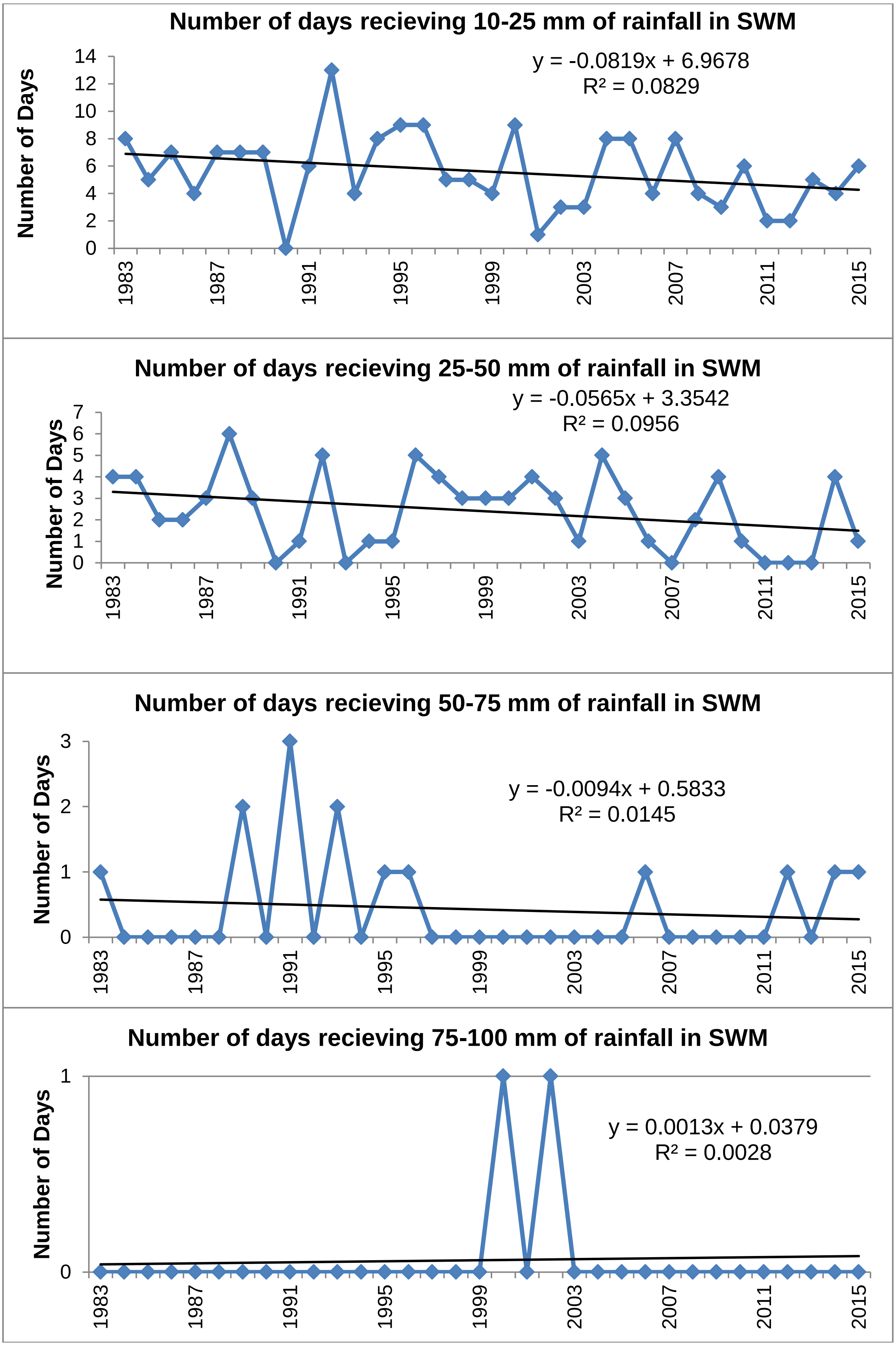

Fig-4.6: Frequency distribution of rainfall (mm) recorded per day in south-west monsoon (SWM)

Table-4.8: Frequency distribution of rainfall (mm) recorded per day in north-east monsoon

Year	10 - 25		25 - 50		50 - 75		75 - 100		>= 100	
	Days	Total	Days	Total	Days	Total	Days	Total	Days	Total
1983	6	112.3	1	37.4	0	0	0	0	0	0
1984	2	35.1	0	0	0	0	0	0	0	0
1985	3	53.9	0	0	0	0	0	0	0	0
1986	5	83.7	1	25	1	50.8	0	0	0	0
1987	6	93	0	0	2	125	0	0	0	0
1988	2	27.7	0	0	0	0	0	0	0	0
1989	3	37.5	1	26.1	0	0	0	0	0	0
1990	1	24	1	28	1	50	0	0	0	0
1991	3	51.6	0	0	0	0	0	0	1	134
1992	1	14.8	2	58	0	0	0	0	0	0
1993	5	79	4	146.1	1	54.1	1	87	0	0
1994	7	107.8	1	36.1	0	0	0	0	1	140
1995	3	40.6	0	0	0	0	0	0	0	0
1996	1	10	1	25.2	1	66	0	0	0	0
1997	5	76.8	4	121.8	0	0	2	162	0	0
1998	1	11.2	3	105.2	0	0	0	0	0	0
1999	11	196.8	2	59.2	1	54.8	0	0	0	0
2000	3	44.6	6	206.8	0	0	0	0	1	103.2
2001	2	30	5	170.3	0	0	0	0	0	0
2002	1	15	2	64.2	0	0	0	0	0	0
2003	6	104.2	3	104.4	1	55	0	0	0	0
2004	5	70.9	1	33.1	0	0	0	0	0	0
2005	2	30.4	5	188.3	1	51.4	1	79.3	1	124
2006	3	38.5	1	36	0	0	0	0	0	0
2007	4	58.5	4	172.1	0	0	0	0	0	0
2008	1	12.2	0	0	0	0	0	0	1	109.2
2009	1	13.6	1	38	1	62.2	0	0	0	0
2010	8	124.6	2	62	2	106	0	0	0	0
2011	6	92.3	3	97.6	0	0	0	0	0	0
2012	1	14.6	1	33.6	1	51.4	0	0	1	151.4
2013	4	57.9	0	0	0	0	0	0	0	0
2014	6	108.9	1	29.1	0	0	0	0	0	0
2015	2	40.2	4	118.6	0	0	0	0	0	0

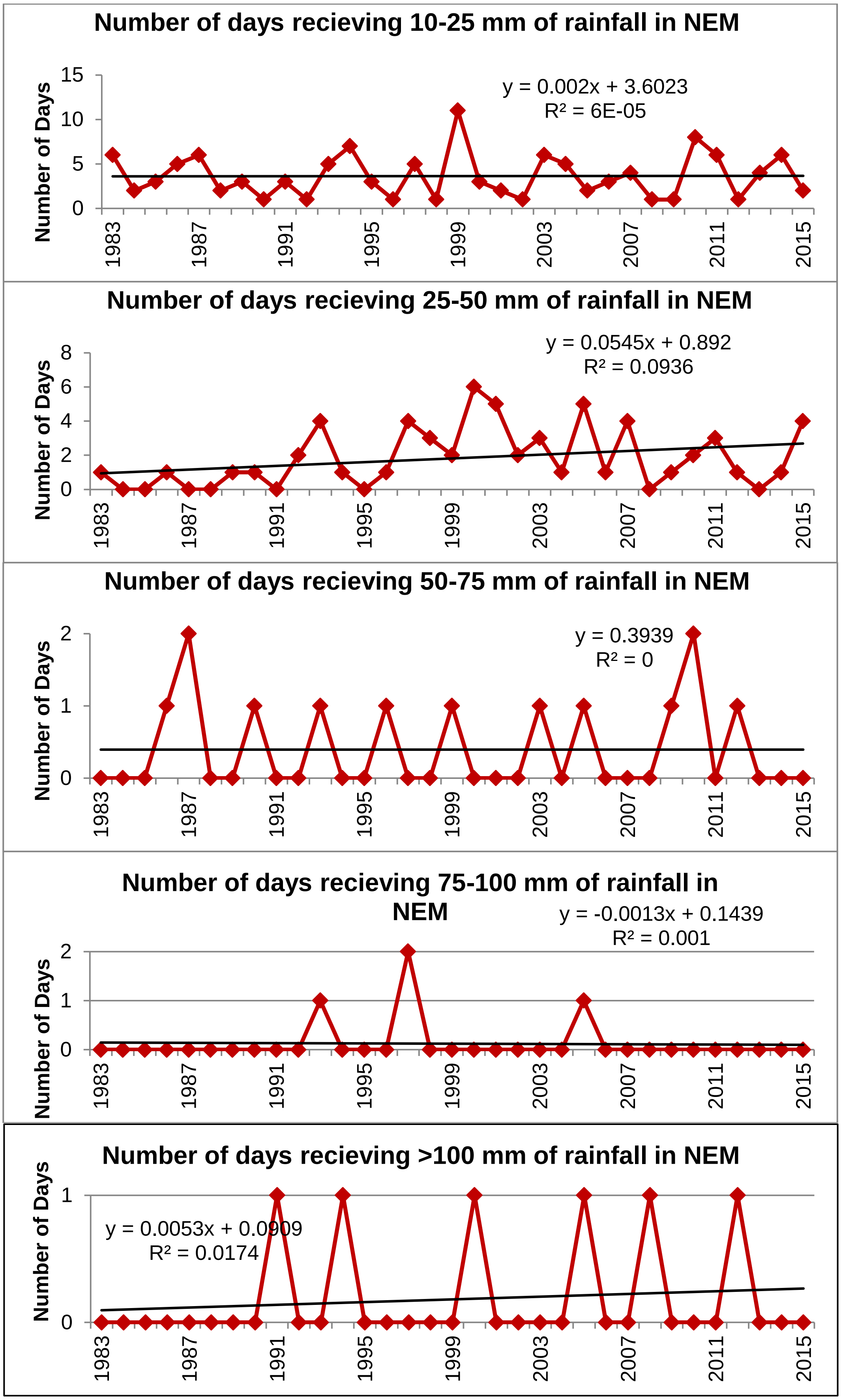

Fig-4.7: Frequency distribution of rainfall (mm) recorded per day in north-east monsoon (NEM)

4.1.3 Monthly rainfall

Monthly rainfall received during 1983 to 2015 has been presented in Table 4.9 while their contribution to the annual rainfall is presented in Table 4.10. The monthly mean distribution (Normal's) is also depicted in Fig. 4.8. It is clear from the Figures that the annual rainfall pattern in this region is a bi-model i.e., it has two distinguished peaks, one in the month of May and the other one is during October. The pre-monsoon rains (summer rains) which begins during March gradually increases and reaches a peak during May but falls in June. Subsequently the South -West monsoon sets in during the first week of June. Further, there is increasing trend from July to October month. Highest monthly rainfall is received during October (20.7 %) and followed by September (16.4 %).

Month wise rainfall along with their trend line are presented in Fig.4.9 while contribution of monthly rainfall to the annual rainfall is presented in Fig - 4.10. It is also observed that highest rainfall receiving months are having lowest coefficient of variation (C.V.) that is the two distinguished peaks (May and September) are having lowest C.V. This bi-model distribution helps to take up double cropping system.

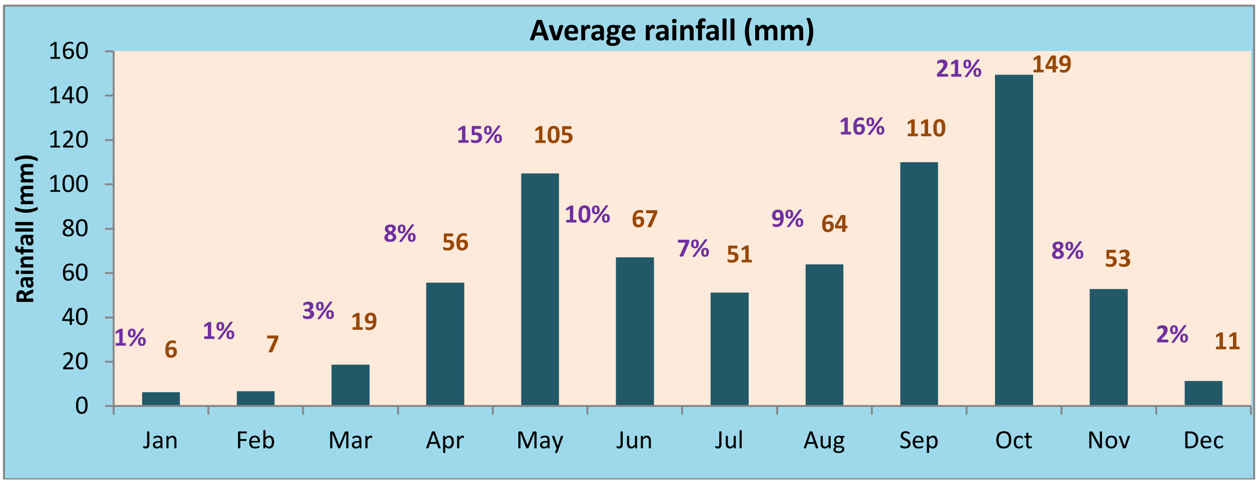

Fig-4.8: Monthly normal rainfall (mm) from 1983 to 2015

4.1.3 Nakshatra-wise rainfall

For the convenience of the farmers, the rainfall data was also analyzed as per ancient Nakshatra-wise; the name of the nakshatra, the duration of the nakshatra as per Christian's calendar and amount of mean rainfall is presented in Table 4.11.

It is observed that, a considerable amount of 10 mm rainfall and above rainfall is received from Revathi up to Anuradha (April to December). Hastha and Uttara bring mean highest rainfall of 64.6 mm and 63.3 mm respectively but maximum rainfall is recorded at Chitta nakshatra showers. Generally, this period coincides with the grand growth period of the crops sown during July wherein crops required maximum amount of water for transpiration. Nakshathra wise average rainfall during 1983 to 2015 is presented as graph in Figure 4.11.

Table-4.9: Monthly total rainfall (mm) data (1983-2015)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1983	0.0	0.0	0.0	0.0	132.4	117.3	74.8	74.1	148.9	95.1	0.0	88.4	731.0
1984	0.0	8.8	65.4	39.3	101.3	69.6	82.6	20.0	183.1	49.9	0.0	6.2	626.2
1985	0.0	0.0	0.0	57.4	90.6	33.4	44.7	12.8	166.7	64.6	10.2	12.8	493.2
1986	73.4	18.4	17.9	7.3	107.1	38.0	19.3	28.4	152.6	121.0	99.0	19.1	701.5
1987	0.0	0.0	5.4	29.3	60.0	28.3	23.9	102.2	136.1	151.8	93.5	31.5	662.0
1988	0.0	0.0	0.0	38.1	60.6	56.7	104.6	97.2	152.3	27.7	7.4	1.8	546.4
1989	0.0	0.0	10.0	57.3	128.0	134.6	102.0	25.7	144.8	83.6	6.4	0.0	692.4
1990	3.0	0.0	4.0	17.7	200.0	20.8	32.8	19.9	11.0	87.5	66.0	0.0	462.7
1991	4.0	0.0	0.0	104.2	150.6	104.7	30.1	62.2	133.0	191.9	19.0	0.0	799.7
1992	0.0	0.0	0.0	25.8	127.8	211.6	87.4	82.6	132.5	51.0	34.4	0.0	753.1
1993	0.0	4.0	28.5	43.0	168.4	111.0	21.8	12.4	84.8	331.6	33.0	41.1	879.6
1994	112.7	0.0	6.6	29.0	154.4	38.5	79.5	41.4	88.9	292.0	25.9	0.0	868.9
1995	0.0	0.0	4.0	60.1	52.4	59.3	55.3	107.5	74.8	67.9	11.2	0.0	492.5
1996	0.0	0.0	0.0	85.2	132.4	174.8	41.2	161.9	102.3	94.1	10.6	60.1	862.6
1997	4.7	0.0	80.6	66.2	132.4	79.1	62.2	39.0	85.9	155.8	238.5	9.5	953.9
1998	0.0	0.0	0.0	125.6	57.4	28.7	129.1	107.2	59.7	104.4	52.0	0.0	664.1
1999	0.0	0.0	3.2	71.8	134.9	18.6	32.8	108.6	82.8	304.3	65.0	11.6	833.6
2000	0.0	61.4	0.0	114.2	111.0	56.8	27.0	109.4	212.4	307.4	41.2	30.8	1071.6
2001	0.0	3.0	0.0	148.2	45.8	23.1	21.7	37.6	151.3	98.2	118.5	9.1	656.5
2002	0.0	2.2	0.0	12.3	49.4	113.8	23.4	36.9	121.7	111.4	5.6	1.3	478.0
2003	0.0	47.0	30.2	49.5	5.0	31.5	22.8	89.0	35.3	278.4	26.2	0.0	614.9
2004	0.0	0.0	7.0	103.0	255.2	57.5	132.6	30.1	165.5	119.3	39.7	0.0	909.9
2005	9.2	4.5	0.0	68.1	111.9	45.4	97.1	135.0	93.5	448.8	72.4	0.0	1085.9
2006	0.0	0.0	174.1	11.3	93.3	125.9	35.7	33.5	47.1	75.7	27.0	0.0	623.6
2007	0.0	0.0	0.0	0.0	155.1	61.0	27.6	68.5	86.7	244.2	8.6	16.4	668.1
2008	0.0	4.1	130.3	18.2	30.6	55.4	48.1	77.9	49.6	165.8	22.5	1.1	603.6
2009	0.0	0.0	1.0	34.5	51.9	5.4	38.0	88.9	162.9	64.6	77.8	3.8	528.8
2010	0.0	0.0	1.2	136.8	93.1	67.8	71.6	67.8	60.2	91.6	242.8	1.6	834.5
2011	0.0	26.2	11.4	137.3	96.6	30.6	32.8	45.5	39.4	118.7	107.2	0.0	645.7
2012	0.0	0.0	2.2	87.8	24.4	40.4	11.8	22.2	94.5	253.8	23.4	3.9	564.4
2013	0.0	40.0	0.0	29.0	77.4	37.6	18.9	8.0	84.2	44.1	25.1	0.0	364.3
2014	0.0	0.0	22.3	23.4	123.9	53.6	17.7	79.0	181.8	157.3	0.3	19.2	678.5
2015	0.0	0.0	13.6	5.6	149.8	83.2	36.5	77.5	104.4	78.4	133.0	2.0	684.0
Average	6.3	6.7	18.8	55.7	105.0	67.1	51.1	63.9	110.0	149.5	52.8	11.3	698.1
Minimum	0.0	0.0	0.0	0.0	5.0	5.4	11.8	8.0	11.0	27.7	0.0	0.0	364.3
Maximum	112.7	61.4	174.1	148.2	255.2	211.6	132.6	161.9	212.4	448.8	242.8	88.4	1085.9
Std.Devn	23.0	15.1	39.4	43.4	53.4	46.9	33.8	39.2	49.5	102.2	60.8	19.7	171.8
CV (%)	367	227	210	78	51	70	66	61	45	68	115	175	25

Table-4.10: Contribution (%) of monthly total rainfall to the annual rainfall (mm) (1983-2015)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	0.0	0.0	0.0	0.0	18.1	16.0	10.2	10.1	20.4	13.0	0.0	12.1
1984	0.0	1.4	10.4	6.3	16.2	11.1	13.2	3.2	29.2	8.0	0.0	1.0
1985	0.0	0.0	0.0	11.6	18.4	6.8	9.1	2.6	33.8	13.1	2.1	2.6
1986	10.5	2.6	2.6	1.0	15.3	5.4	2.8	4.0	21.8	17.2	14.1	2.7
1987	0.0	0.0	0.8	4.4	9.1	4.3	3.6	15.4	20.6	22.9	14.1	4.8
1988	0.0	0.0	0.0	7.0	11.1	10.4	19.1	17.8	27.9	5.1	1.4	0.3
1989	0.0	0.0	1.4	8.3	18.5	19.4	14.7	3.7	20.9	12.1	0.9	0.0
1990	0.6	0.0	0.9	3.8	43.2	4.5	7.1	4.3	2.4	18.9	14.3	0.0
1991	0.5	0.0	0.0	13.0	18.8	13.1	3.8	7.8	16.6	24.0	2.4	0.0
1992	0.0	0.0	0.0	3.4	17.0	28.1	11.6	11.0	17.6	6.8	4.6	0.0
1993	0.0	0.5	3.2	4.9	19.1	12.6	2.5	1.4	9.6	37.7	3.8	4.7
1994	13.0	0.0	0.8	3.3	17.8	4.4	9.1	4.8	10.2	33.6	3.0	0.0
1995	0.0	0.0	0.8	12.2	10.6	12.0	11.2	21.8	15.2	13.8	2.3	0.0
1996	0.0	0.0	0.0	9.9	15.3	20.3	4.8	18.8	11.9	10.9	1.2	7.0
1997	0.5	0.0	8.4	6.9	13.9	8.3	6.5	4.1	9.0	16.3	25.0	1.0
1998	0.0	0.0	0.0	18.9	8.6	4.3	19.4	16.1	9.0	15.7	7.8	0.0
1999	0.0	0.0	0.4	8.6	16.2	2.2	3.9	13.0	9.9	36.5	7.8	1.4
2000	0.0	5.7	0.0	10.7	10.4	5.3	2.5	10.2	19.8	28.7	3.8	2.9
2001	0.0	0.5	0.0	22.6	7.0	3.5	3.3	5.7	23.0	15.0	18.1	1.4
2002	0.0	0.5	0.0	2.6	10.3	23.8	4.9	7.7	25.5	23.3	1.2	0.3
2003	0.0	7.6	4.9	8.1	0.8	5.1	3.7	14.5	5.7	45.3	4.3	0.0
2004	0.0	0.0	0.8	11.3	28.0	6.3	14.6	3.3	18.2	13.1	4.4	0.0
2005	0.8	0.4	0.0	6.3	10.3	4.2	8.9	12.4	8.6	41.3	6.7	0.0
2006	0.0	0.0	27.9	1.8	15.0	20.2	5.7	5.4	7.6	12.1	4.3	0.0
2007	0.0	0.0	0.0	0.0	23.2	9.1	4.1	10.3	13.0	36.6	1.3	2.5
2008	0.0	0.7	21.6	3.0	5.1	9.2	8.0	12.9	8.2	27.5	3.7	0.2
2009	0.0	0.0	0.2	6.5	9.8	1.0	7.2	16.8	30.8	12.2	14.7	0.7
2010	0.0	0.0	0.1	16.4	11.2	8.1	8.6	8.1	7.2	11.0	29.1	0.2
2011	0.0	4.1	1.8	21.3	15.0	4.7	5.1	7.0	6.1	18.4	16.6	0.0
2012	0.0	0.0	0.4	15.6	4.3	7.2	2.1	3.9	16.7	45.0	4.1	0.7
2013	0.0	11.0	0.0	8.0	21.2	10.3	5.2	2.2	23.1	12.1	6.9	0.0
2014	0.0	0.0	3.3	3.4	18.3	7.9	2.6	11.6	26.8	23.2	0.0	2.8
2015	0.0	0.0	2.0	0.8	21.9	12.2	5.3	11.3	15.3	11.5	19.4	0.3
Average	0.8	1.1	2.8	7.9	15.1	9.7	7.4	9.2	16.4	20.7	7.4	1.5
Minimum	0.0	0.0	0.0	0.0	0.8	1.0	2.1	1.4	2.4	5.1	0.0	0.0
Maximum	13.0	11.0	27.9	22.6	43.2	28.1	19.4	21.8	33.8	45.3	29.1	12.1
Std.Devn	2.8	2.5	6.2	6.0	7.7	6.5	4.7	5.5	8.2	11.5	7.6	2.6
CV (%)	362	237	221	75	51	67	63	60	50	55	103	171

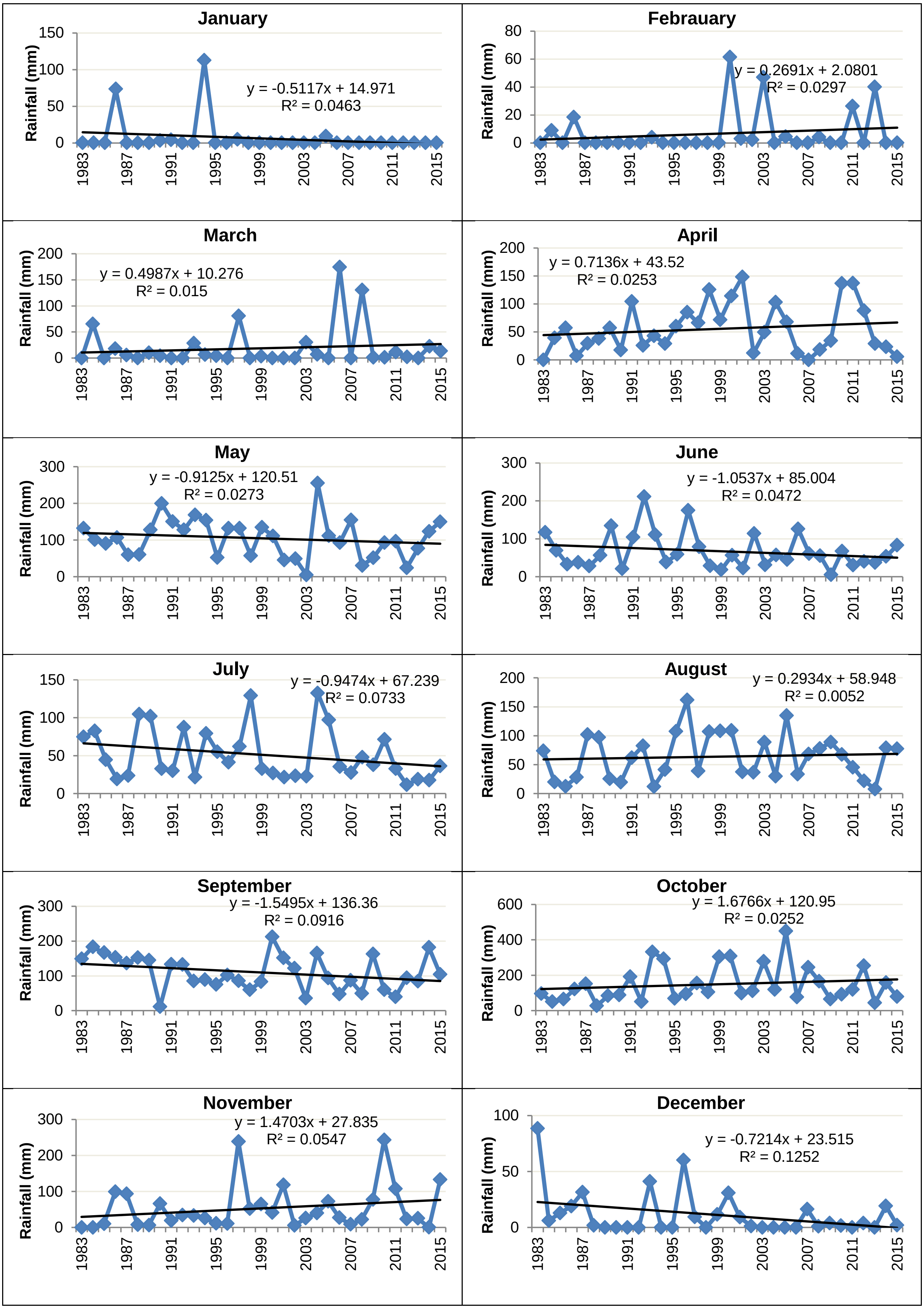

Fig-4.9: Monthly total rainfall (mm) recorded from 1983-2015

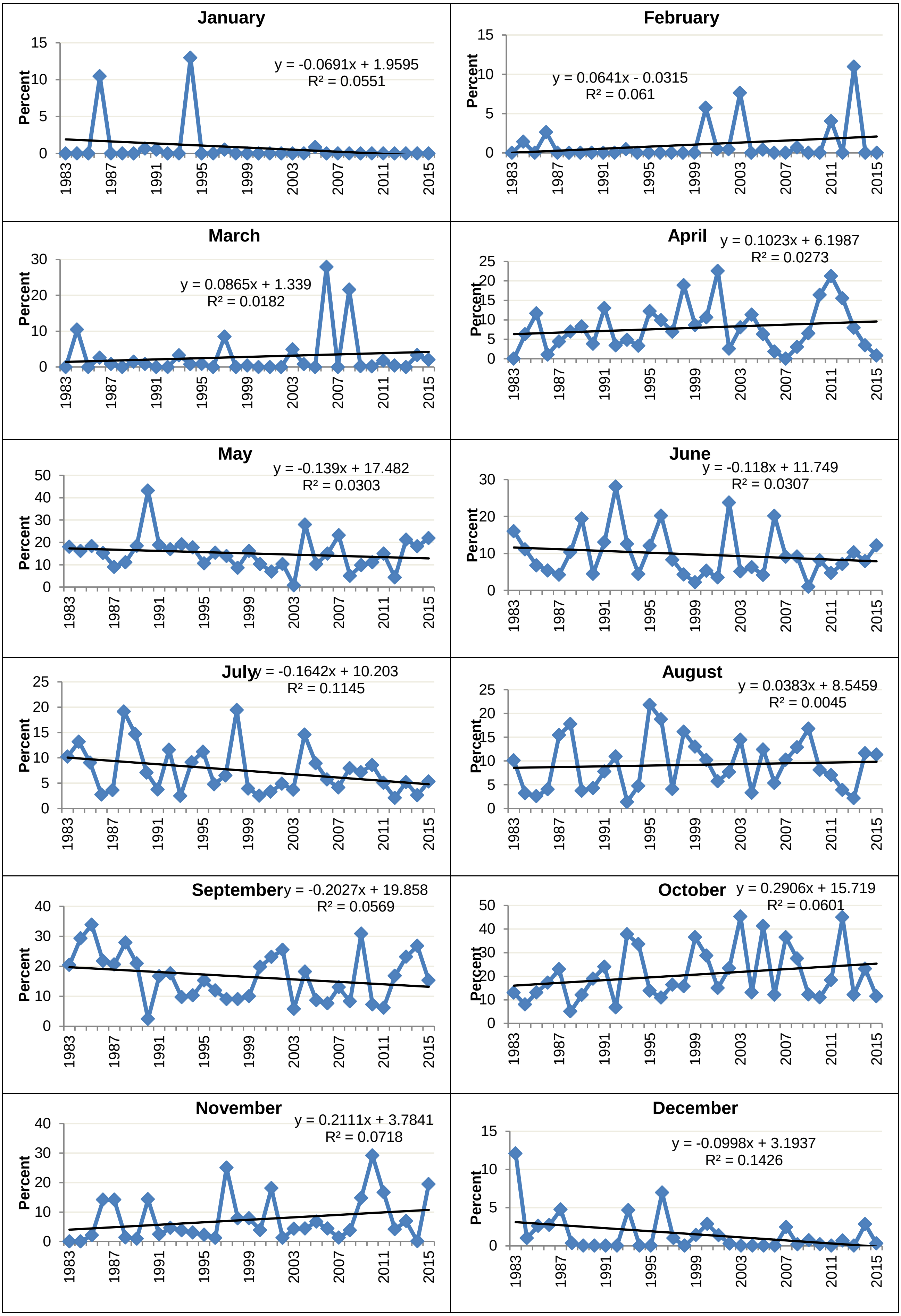

Fig-4.10: Contribution (%) of monthly rainfall to annual rainfall (mm) for period 1983-2015

Table-4.11: Nakshatra wise duration and mean rainfall (mm) (1983-2015)

NAKSHATHRA	MONTHS	DURATION	MEAN	MAX	MIN	STD	CV
ASHWINI	(Apr.13 - Apr.26)	14	29.9	144.8	0.0	34.4	115
BHARANI	(Apr.27 - May.10)	14	45.3	138.9	0.0	36.3	80
KRUTHIKA	(May.11 - May.24)	14	45.7	182.5	0.0	41.6	91
ROHINI	(May25 - Jun.7)	14	52.7	159.9	0.0	43.3	82
MRUGASHIRA	(Jun8 - Jun.21)	14	26.5	128.0	0.0	30.2	114
AARIDHRA	(Jun22 - Jul.5)	14	17.0	117.8	0.0	19.4	114
PUNARVASU	(Jul 6 - Jul.19)	14	24.9	90.4	0.0	23.3	94
PUSHYA	(Jul 20 - Aug.2)	14	24.3	101.0	0.8	21.7	89
AASHLESHA	(Aug. 3 - Aug.16)	14	21.6	71.3	0.0	18.2	84
MAKHA	(Aug 17 - Aug.30)	14	32.8	142.8	0.0	36.5	112
PUBBA	(Aug.31 - Sep.12)	13	33.9	142.8	0.0	37.5	111
UTTHARA	(Sep.13 -Sep.26)	14	63.3	188.5	0.0	47.9	76
HASTHA	(Sep.27 - Oct.10)	14	64.6	215.2	0.0	57.2	89
CHITTHA	(Oct.11 - Oct.23)	13	57.7	310.3	0.0	58.8	102
SWATHI	(Oct.24 - Nov.5)	13	48.1	212.7	0.0	52.0	108
VAISHAKA	(Nov.6 - Nov.19)	14	22.7	118.5	0.0	29.5	130
ANURADHA	(Nov.20 - Dec.2)	13	14.7	113.6	0.0	25.6	174
JHESTA	(Dec.3 - Dec.15)	13	7.3	99.0	0.0	18.6	254
MOOLA	(Dec.16 - Dec.28)	13	4.5	73.4	0.0	12.4	272
POORVASHADA -I	(Dec.29 - Dec.31)	3	0.4	15.0	0.0	2.3	536
POORVASHADA -II	(Jan.01 - Jan.10)	10	0.3	8.2	0.0	1.4	431
UTTHARASHADA	(Jan.11 - Jan.23)	13	4.0	112.7	0.0	19.2	483
SHRAVANA	(Jan.24 - Feb.5)	13	0.5	20.0	0.0	3.0	560
DHANISHTA	(Feb.6 - Feb.18)	13	2.1	40.0	0.0	6.6	319
SHATHABHISHA	(Feb.19 - Mar.3)	13	6.4	67.9	0.0	16.3	255
POORVAABHADRA	(Mar.4 - Mar.16)	13	6.8	174.1	0.0	26.9	394
UTTHARAABHADRA	(Mar.17 - Mar.30)	14	7.5	99.3	0.0	19.7	265
REVATHI	(Mar.31 - Apr.12)	13	12.2	94.4	0.0	18.2	149

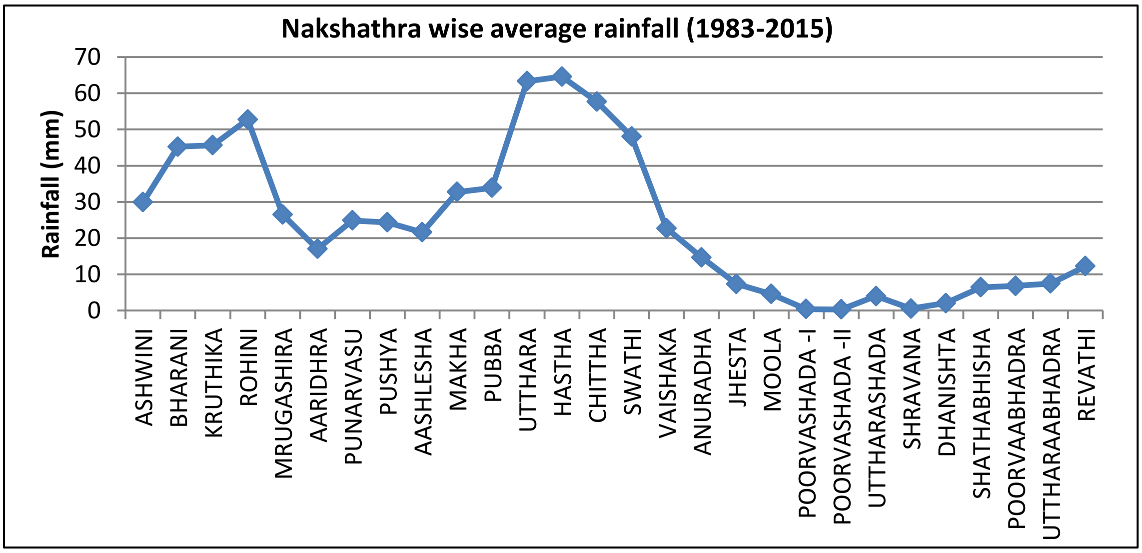

Fig-4.11: Nakshatra wise average rainfall (mm) during 1983 to 2015

4.1.4. Weekly rainfall

Weekly rainfall received for the period from 1983 to 2015 and their statistical analysis are given in Table 4.12. Standard Meteorological Weeks (SMW) receiving more than 10 mm of rainfall is considered as wet week. Since 10 mm of rainfall would be enough to meet the 1/3rd of Potential Evapotranspiration, it is observed that, Naganahally can take up double cropping system. 15th SMW onwards, the weekly rainfall is above 10 mm up to 45th SMW with a break of two weeks during 26th and 27th week. The highest mean rainfall of 37.9 mm is received during 41st SMW followed by 37.5 mm received during 43rd SMW and 35 mm received during 39th SMW.

Table-4.12: Weekly rainfall (mm) during 1983 to 2015

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
1983	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	0.0	64.4	1.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	2.6	70.8	0.0	0.0	9.2	9.2	0.0	0.0	0.0	15.8	2.1	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
1990	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0
1991	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.5	0.0	0.0	0.0	0.0
1994	0.0	0.0	112.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	3.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	70.2	6.8
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.4	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	7.1
2003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.0	0.0	26.0	4.2	0.0
2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
2005	8.2	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	134.1	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	3.0	1.1	0.0	0.0	0.0	32.4	48.7	56.3
2009	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.2	0.0	0.0	0.0	1.8	9.6
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
2013	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	17.2	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	7.3	0.0	0.0	0.0
Average	0.4	0.3	5.6	0.0	0.2	0.5	1.9	0.8	5.8	6.9	2.6	3.9	3.8
Maximum	8.2	3.9	112.7	0.0	5.5	9.2	40.0	26.2	61.4	134.1	32.4	70.2	56.3
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Std. Devn	1.6	0.9	22.8	0.0	1.0	1.7	7.2	4.6	15.4	25.6	7.5	14.6	10.1
CV(%)	23.6	30.6	24.5	-	17.4	26.6	25.8	17.4	37.9	26.9	34.0	27.0	37.5

Week	14	15	16	17	18	19	20	21	22	23	24	25	26
1983	0.0	0.0	0.0	0.0	0.0	26.0	23.3	55.1	28.0	39.9	77.0	0.4	0.0
1984	0.0	4.7	10.6	24.0	20.1	0.0	47.6	33.6	15.0	0.0	20.0	25.0	10.6
1985	30.6	0.0	8.0	5.0	13.8	7.0	70.2	0.0	13.4	7.0	13.2	5.3	24.2
1986	0.0	0.0	0.0	7.3	7.4	21.8	10.8	56.0	15.4	0.0	6.3	17.6	9.8
1987	0.0	0.0	0.0	29.3	0.0	0.0	13.4	45.8	4.4	0.0	2.2	15.6	6.9
1988	0.0	0.0	18.2	19.9	16.0	4.2	0.0	40.4	56.7	0.0	0.0	0.0	0.0
1989	2.6	0.0	0.0	54.7	5.6	20.1	74.1	28.2	83.9	11.2	28.8	10.7	0.0
1990	0.0	4.4	13.3	0.0	77.2	0.0	0.0	119.8	3.0	10.0	6.0	1.4	3.4
1991	9.1	28.1	0.0	67.0	55.8	14.3	0.0	64.9	20.6	72.9	23.8	0.0	3.0
1992	0.0	0.0	4.0	21.8	6.0	25.0	42.8	0.0	77.0	84.2	39.6	45.8	19.0
1993	0.0	16.0	0.0	0.0	36.0	28.2	29.0	102.2	0.0	91.0	19.0	1.0	0.0
1994	0.0	28.0	1.0	0.0	1.1	0.0	33.9	63.6	55.8	17.8	9.7	0.0	11.0
1995	11.0	25.1	24.0	0.0	0.0	43.4	6.0	3.0	19.6	12.1	10.8	8.1	8.7
1996	0.0	60.8	19.6	4.8	36.2	0.0	13.2	63.0	41.1	13.3	105.9	27.5	7.0
1997	8.2	0.0	58.0	0.0	30.8	53.0	7.0	32.0	9.6	34.6	7.4	15.6	21.5
1998	0.0	0.0	14.8	49.8	63.2	0.0	0.0	55.2	6.2	0.0	1.2	11.0	12.5
1999	0.0	2.4	13.2	56.2	82.6	8.4	31.7	12.2	0.0	3.8	9.6	5.2	0.0
2000	4.0	19.2	47.4	43.6	80.9	18.5	0.0	0.0	42.8	5.2	16.2	4.2	0.0
2001	0.0	45.4	51.8	51.0	33.2	0.0	2.4	10.2	0.0	0.0	16.6	6.5	0.0
2002	5.2	0.0	0.0	0.0	0.0	37.2	5.1	1.0	6.1	80.0	25.2	3.6	5.0
2003	12.3	23.0	5.0	0.0	9.2	0.0	0.0	5.0	9.4	0.0	0.0	21.1	1.0
2004	39.0	0.0	25.0	34.0	54.0	58.0	16.0	34.7	123.5	2.4	22.1	0.0	2.0
2005	22.0	17.7	0.0	28.4	0.0	23.6	0.0	55.1	38.3	4.0	3.0	30.3	7.0
2006	0.0	0.0	11.3	0.0	5.5	28.1	45.4	1.0	26.7	3.2	9.5	92.7	8.1
2007	0.0	0.0	0.0	0.0	98.3	6.7	0.0	34.0	16.1	13.0	19.5	14.4	18.6
2008	1.0	0.0	0.0	3.0	7.1	11.2	0.0	4.3	51.1	7.0	0.0	2.6	9.8
2009	0.0	0.0	27.1	7.4	7.4	4.5	20.2	0.0	22.9	2.3	0.0	0.0	4.0
2010	0.0	48.6	34.4	45.2	15.4	25.6	24.7	7.4	49.0	23.9	12.9	2.0	0.0
2011	0.0	0.0	78.8	58.5	4.0	0.0	25.0	55.6	15.0	9.2	13.4	2.2	2.8
2012	11.2	0.0	13.2	63.4	21.0	2.6	0.8	0.0	0.0	0.0	5.0	13.8	21.6
2013	16.0	0.0	6.6	6.4	23.2	9.0	35.8	5.8	27.0	0.0	4.2	8.0	2.0
2014	0.0	19.2	4.2	0.0	35.0	36.0	3.0	0.0	103.0	0.0	0.0	0.3	0.2
2015	0.0	0.6	0.0	5.0	21.4	22.0	88.4	0.0	34.2	22.2	27.3	12.6	5.9
Average	5.2	10.4	14.8	20.8	26.3	16.2	20.3	30.0	30.8	17.3	16.8	12.3	6.8
Maximum	39.0	60.8	78.8	67.0	98.3	58.0	88.4	119.8	123.5	91.0	105.9	92.7	24.2
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Std. Devn	9.5	16.4	19.5	23.3	27.9	16.3	23.8	31.7	30.7	26.4	21.9	18.0	7.2
CV(%)	54.8	63.3	75.9	89.2	94.1	99.3	85.3	94.6	100.3	65.3	76.7	68.2	94.9

Week	27	28	29	30	31	32	33	34	35	36	37	38	39
1983	5.4	28.4	21.4	11.6	28.8	16.8	0.0	15.7	32.4	20.5	116.8	0.0	0.0
1984	0.0	6.8	60.0	6.0	10.3	10.7	0.0	0.0	7.8	0.0	0.0	79.2	103.9
1985	0.0	13.7	5.7	9.0	6.4	1.8	0.0	4.6	0.0	23.6	2.2	0.0	140.9
1986	12.0	4.3	3.0	0.0	7.0	20.4	1.0	0.0	37.0	10.6	35.0	33.4	36.6
1987	4.2	0.0	0.0	3.8	73.5	22.2	20.2	2.2	0.0	0.0	27.0	84.8	24.3
1988	43.9	3.0	43.0	14.7	12.2	3.9	18.8	5.3	57.0	38.1	107.6	0.0	6.6
1989	3.1	44.1	20.1	24.3	10.4	0.0	17.2	4.9	3.6	13.3	30.0	25.8	75.7
1990	3.0	9.8	20.0	0.0	0.0	9.0	8.5	2.4	0.0	3.0	8.0	0.0	0.0
1991	0.0	22.6	7.5	0.0	22.2	40.0	0.0	0.0	0.0	0.0	133.0	0.0	0.0
1992	48.5	20.0	7.0	11.9	8.8	48.8	9.1	5.0	10.9	15.4	0.0	56.9	60.2
1993	3.8	5.0	3.0	10.0	5.0	1.0	2.0	4.4	54.0	15.0	9.0	6.8	0.0
1994	11.4	42.4	11.1	6.1	9.5	17.8	0.0	19.0	3.6	7.8	0.0	10.0	71.1
1995	6.2	10.9	12.2	26.0	25.3	23.9	6.4	21.4	30.5	10.9	0.0	0.0	63.9
1996	3.2	32.8	4.7	0.5	0.0	10.4	8.1	114.5	28.9	76.9	5.2	13.2	7.0
1997	30.5	10.4	0.0	17.1	4.2	3.2	28.4	7.4	3.0	3.9	52.4	26.6	0.0
1998	13.2	4.4	93.1	10.0	11.4	1.6	52.6	47.8	0.0	12.8	14.4	4.6	27.9
1999	7.2	0.0	17.2	6.6	3.8	1.0	65.0	31.0	9.6	18.0	21.4	0.0	43.4
2000	17.0	10.0	0.0	0.0	69.8	2.0	23.6	8.2	5.8	32.4	56.0	104.2	19.8
2001	2.0	2.5	0.0	17.2	10.0	2.6	11.0	9.0	5.0	0.0	15.5	91.3	44.5
2002	1.0	2.3	16.3	2.6	6.0	5.8	23.6	2.7	0.0	0.0	84.3	8.1	29.3
2003	0.0	5.7	7.9	2.2	20.0	1.2	38.0	6.4	31.7	8.0	0.0	0.0	26.0
2004	6.2	83.7	10.7	10.7	36.3	8.7	5.3	1.1	0.0	39.4	79.7	22.2	24.2
2005	4.6	43.7	21.2	17.4	7.6	4.3	6.1	34.8	124.5	44.9	12.5	0.0	0.0
2006	6.5	21.1	5.1	2.0	0.0	9.3	22.2	2.0	1.2	11.0	4.0	1.5	29.4
2007	6.4	10.2	1.1	3.4	14.3	18.7	0.0	33.4	4.1	15.7	40.1	20.9	10.0
2008	2.3	1.2	12.2	29.2	10.8	3.4	24.1	7.5	64.3	15.6	1.0	4.0	0.0
2009	10.8	4.6	17.6	0.0	31.0	0.5	39.4	11.6	42.4	2.6	49.4	52.0	23.9
2010	8.1	36.4	13.9	10.4	6.9	0.0	12.0	41.7	10.0	8.2	27.8	21.6	2.6
2011	10.8	5.0	6.8	10.2	11.2	6.4	24.8	0.6	12.0	24.3	0.6	2.0	3.0
2012	0.0	3.0	6.4	2.4	3.2	9.8	1.0	7.4	2.0	9.2	22.3	7.0	54.8
2013	12.8	0.0	3.6	2.5	0.2	1.0	0.0	0.0	9.0	33.7	35.3	12.6	0.4
2014	11.1	2.7	0.5	3.4	1.6	9.3	57.4	9.9	0.8	1.0	3.9	43.7	133.2
2015	7.4	0.4	3.0	24.7	2.2	4.8	56.2	14.3	0.0	9.6	3.5	0.0	91.3
Average	9.2	14.9	13.8	9.0	14.2	9.7	17.6	14.4	17.9	15.9	30.2	22.2	35.0
Maximum	48.5	83.7	93.1	29.2	73.5	48.8	65.0	114.5	124.5	76.9	133.0	104.2	140.9
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Std. Devn	11.4	18.4	19.0	8.4	17.4	11.4	18.9	22.0	26.8	16.5	36.6	30.0	39.0
CV(%)	80.6	80.8	72.7	107.0	81.6	85.5	93.3	65.5	66.9	96.6	82.7	74.0	89.7

Week	40	41	42	43	44	45	46	47	48	49	50	51	52
1983	16.1	0.0	58.0	0.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	37.0	51.4
1984	35.1	0.0	0.0	14.8	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0
1985	38.3	23.1	3.2	0.0	0.0	10.2	0.0	0.0	0.0	12.8	0.0	0.0	0.0
1986	82.9	5.2	0.0	25.0	27.4	66.8	12.7	0.0	0.0	3.0	0.0	0.0	16.1
1987	48.8	33.0	68.0	0.0	2.0	7.8	5.2	80.5	0.0	3.0	24.3	1.0	3.2
1988	14.4	13.3	0.0	0.0	0.0	7.4	0.0	0.0	0.0	0.0	1.8	0.0	0.0
1989	46.4	0.0	21.0	0.0	16.2	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	52.0	0.0	14.0	24.5	50.0	4.0	2.0	7.0	0.0	0.0	0.0	0.0
1991	41.0	8.1	0.0	8.8	134.0	5.2	13.8	0.0	0.0	0.0	0.0	0.0	0.0
1992	22.8	0.0	28.2	0.0	0.0	29.8	0.0	4.6	0.0	0.0	0.0	0.0	0.0
1993	140.0	80.3	55.5	17.6	55.0	16.2	0.0	0.0	0.0	41.1	0.0	0.0	0.0
1994	42.7	21.7	40.8	186.8	25.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	55.6	4.2	4.1	4.0	0.0	10.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0
1996	4.4	70.2	19.5	0.0	0.0	0.0	4.2	6.4	0.0	11.0	39.1	6.0	4.0
1997	57.4	49.0	0.0	47.2	79.6	29.4	13.1	102.0	16.6	7.9	0.0	1.6	0.0
1998	4.0	85.2	0.0	15.2	39.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	46.0	25.4	84.7	122.4	25.8	17.0	0.0	43.4	4.6	0.0	0.0	11.6	0.0
2000	95.6	65.4	11.8	134.6	0.0	0.0	0.0	30.2	36.8	0.0	0.0	0.0	5.0
2001	5.0	15.0	33.2	45.0	0.0	90.4	28.1	0.0	0.0	0.0	0.0	9.1	0.0
2002	7.1	39.9	44.5	1.8	22.4	1.3	0.0	0.0	0.0	1.3	0.0	0.0	0.0
2003	84.2	79.0	89.2	26.0	1.0	19.2	0.0	0.0	6.0	0.0	0.0	0.0	0.0
2004	23.5	15.4	56.8	0.0	24.7	15.4	23.2	0.0	0.0	0.0	0.0	0.0	0.0
2005	21.8	149.8	43.1	231.1	59.5	15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	20.0	37.1	0.0	15.1	16.5	2.2	2.3	9.5	0.0	0.0	0.0	0.0	0.0
2007	17.4	0.0	94.1	98.7	35.3	7.3	0.0	0.0	0.0	0.0	0.0	16.4	0.0
2008	7.0	7.7	26.1	125.0	0.0	0.0	0.0	4.3	18.2	1.1	0.0	0.0	0.0
2009	2.4	62.2	0.0	0.0	5.6	63.6	5.2	3.4	0.0	3.2	0.0	0.0	0.6
2010	30.2	15.6	19.8	18.8	89.2	130.4	22.2	4.0	4.2	1.6	0.0	0.0	0.0
2011	53.3	20.0	20.6	18.8	53.6	4.2	0.0	0.0	55.4	0.0	0.0	0.0	0.0
2012	4.6	207.2	39.6	0.0	22.4	0.0	0.0	3.4	0.0	3.6	0.0	0.0	0.3
2013	0.0	2.0	23.0	19.0	0.0	10.1	10.8	4.2	0.0	0.0	0.0	0.0	0.0
2014	30.4	58.4	20.7	46.5	1.3	0.0	0.3	0.0	0.0	0.0	19.2	0.0	0.0
2015	36.4	6.5	0.0	0.0	87.0	53.8	8.0	19.3	0.4	2.0	0.0	0.0	0.0
Average	34.4	37.9	27.4	37.5	26.3	20.5	4.8	9.6	4.7	2.8	2.6	2.5	2.4
Maximum	140.0	207.2	94.1	231.1	134.0	130.4	28.1	102.0	55.4	41.1	39.1	37.0	51.4
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Std. Devn	31.5	45.6	28.4	58.8	32.8	30.1	7.7	23.2	11.8	7.6	8.4	7.3	9.3
CV(%)	109.0	83.1	96.6	63.7	80.2	68.0	62.9	41.6	39.9	36.7	30.3	34.5	26.3

4.1.5. Daily rainfall

Frequency distribution of every day rainfall recorded per day is categorized as 10 to 25, 25 to 50, 50 to 75, 75 to 100 and more than 100 mm is tabulated (table-4.13) and plotted (Fig-4.12). R^2 values in the graph (Fig-4.12) are lesser than 0.1. It clearly indicate that trend lines developed are not significant. There exists no significant change (Fig-4.13) in maximum monthly one day rainfall recorded over years. Contrastingly over the period 1992 to 2015 count of per day rainfall more than 10 mm (Fig-4.14), 20 mm (Fig-4.15) and 25 mm (Fig-4.16) has significantly (low p-value and high R^2) decreasing trend (negative slope values).

Table-4.13: Frequency distribution of rainfall (mm) recorded per day

	10 - 25		25 - 50		50 - 75		75 - 100		>= 100	
Year	**Days**	**Total**	**Days**	**Total**	**Days**	**Total**	**Days**	**Total**	**Days**	**Total**
1983	16	252.3	8	254.9	1	62.5	0	0	0	0
1984	12	194.6	5	200.5	1	56.3	0	0	0	0
1985	12	184.9	3	106.2	1	62	0	0	0	0
1986	13	193.8	3	97	3	166.8	0	0	0	0
1987	17	265.1	3	97	2	125	0	0	0	0
1988	12	191.9	7	246.7	0	0	0	0	0	0
1989	12	151.8	7	218.1	3	174.2	0	0	0	0
1990	6	99.9	2	72.4	1	50	1	90	0	0
1991	11	177.5	6	193.5	3	170	0	0	1	134
1992	17	264.3	8	274.1	1	54	0	0	0	0
1993	10	150.7	8	257.3	4	237.5	1	87	0	0
1994	17	258.4	6	212.5	2	116.9	0	0	1	140
1995	17	256.1	1	25.3	1	51.8	0	0	0	0
1996	15	246.2	9	320.8	2	118.4	0	0	0	0
1997	15	238	9	277.9	2	116.8	2	162	0	0
1998	8	126.2	9	306.1	1	61	0	0	0	0
1999	21	346.6	7	218.6	1	54.8	0	0	0	0
2000	17	260.7	11	374	2	106.6	1	76	1	103.2
2001	7	94.4	11	363.4	1	51	0	0	0	0
2002	4	66.5	6	206.4	0	0	1	84.3	0	0
2003	12	215.4	5	177.4	1	55	0	0	0	0
2004	18	281	11	361.8	1	69	0	0	0	0
2005	15	275.4	10	340.2	1	51.4	1	79.3	1	124
2006	13	184.8	4	134.4	1	61.2	0	0	1	102
2007	14	183.4	6	237.4	1	55	0	0	0	0
2008	8	112.1	4	136.3	0	0	0	0	1	109.2
2009	8	113.3	5	188.4	1	62.2	0	0	0	0
2010	21	353.8	5	160.6	2	106	0	0	0	0
2011	12	204.6	5	180.2	1	52.4	0	0	0	0
2012	6	89.2	2	70.4	2	102.4	0	0	1	151.4
2013	11	180.6	2	75.8	0	0	0	0	0	0
2014	13	227.4	7	260.4	1	57.4	0	0	0	0
2015	11	209.5	5	152.6	2	129.3	0	0	0	0

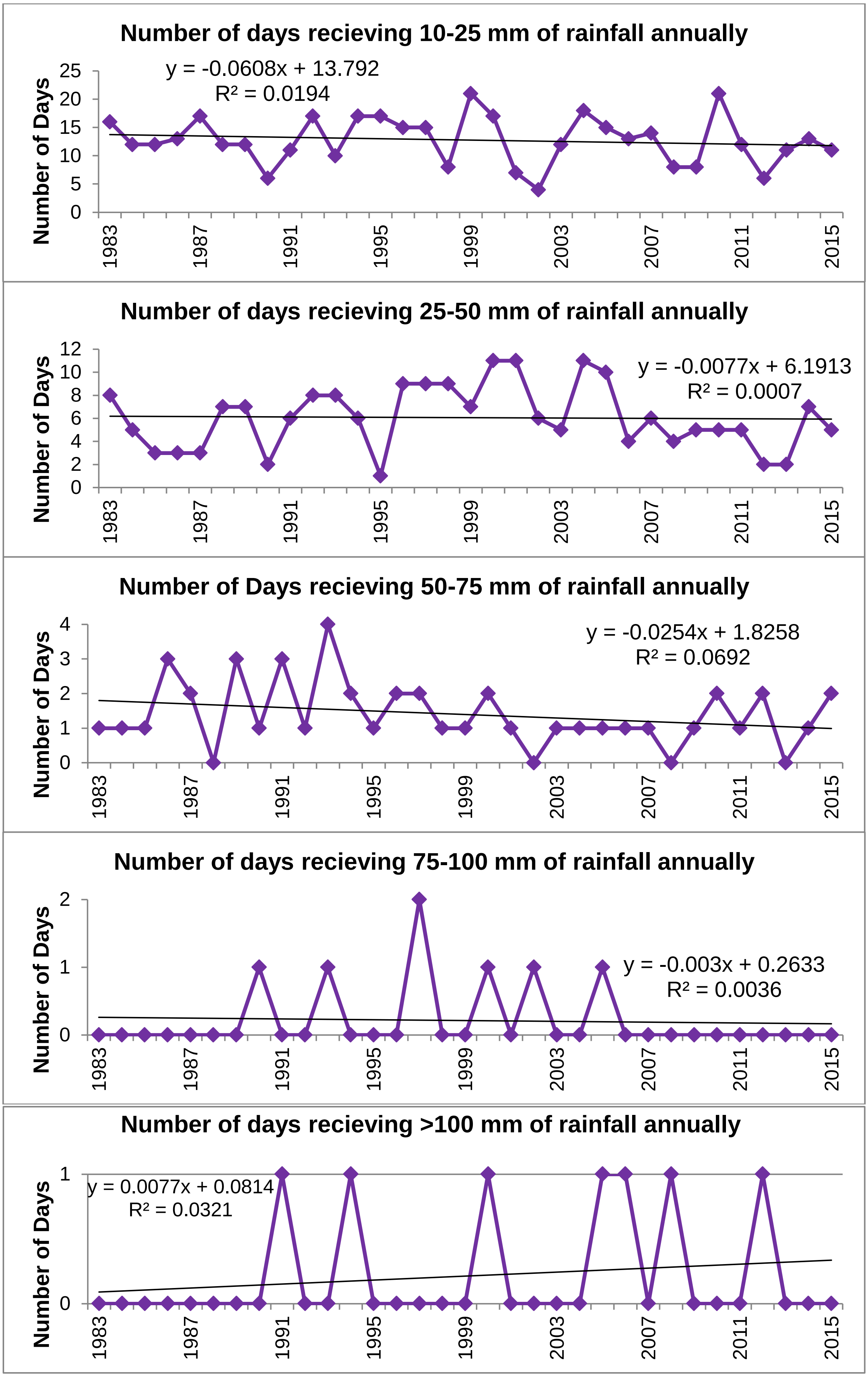

Fig-4.12: Frequency distribution of rainfall (mm) recorded per day annually

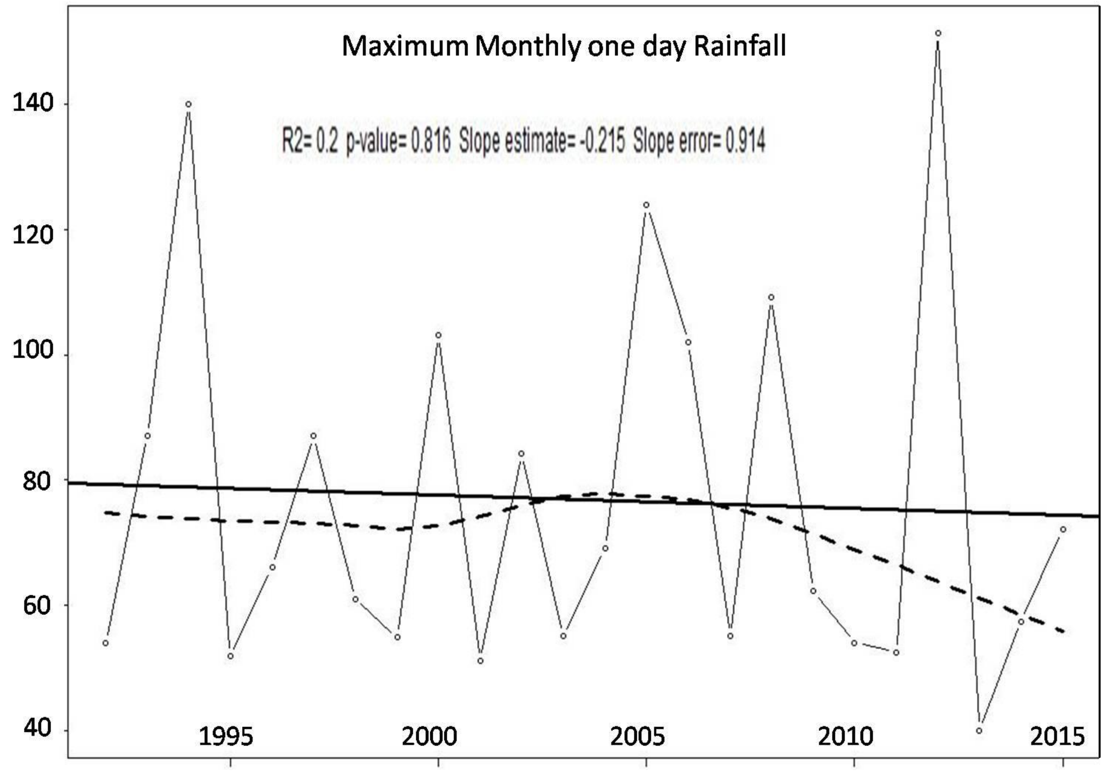

Fig-4.13: Maximum monthly one day rainfall (mm) recorded over years

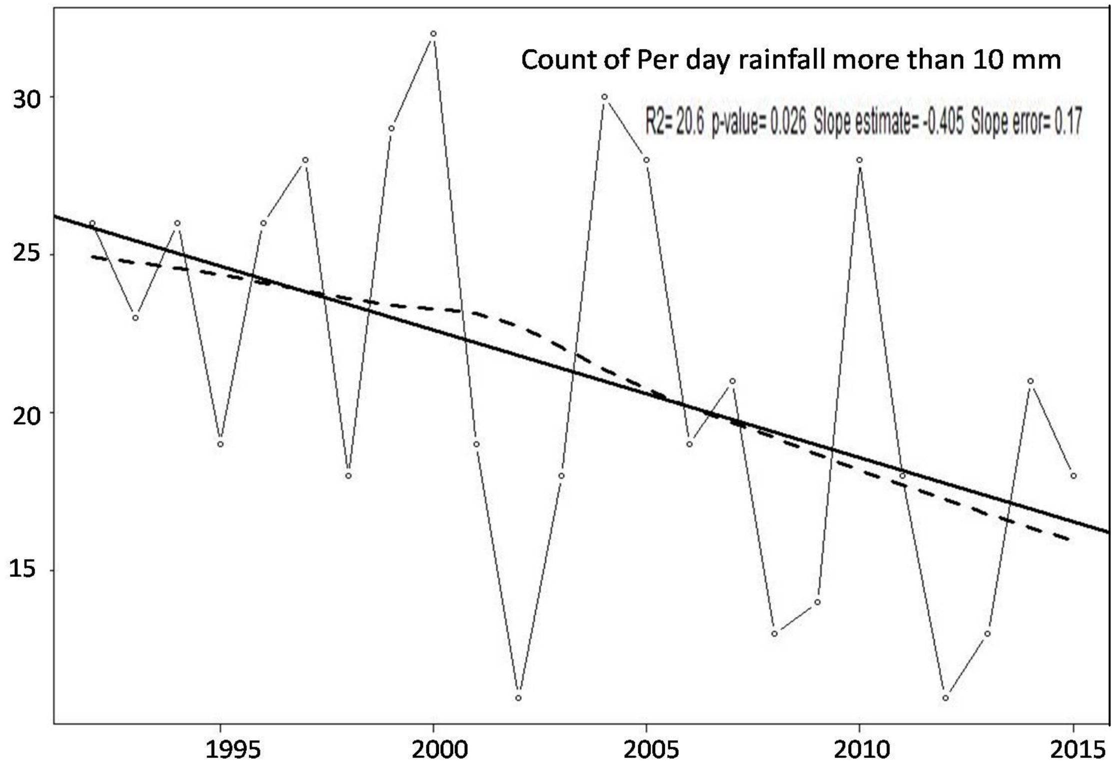

Fig-4.14: Count of per day rainfall (mm) more than 10 mm over years

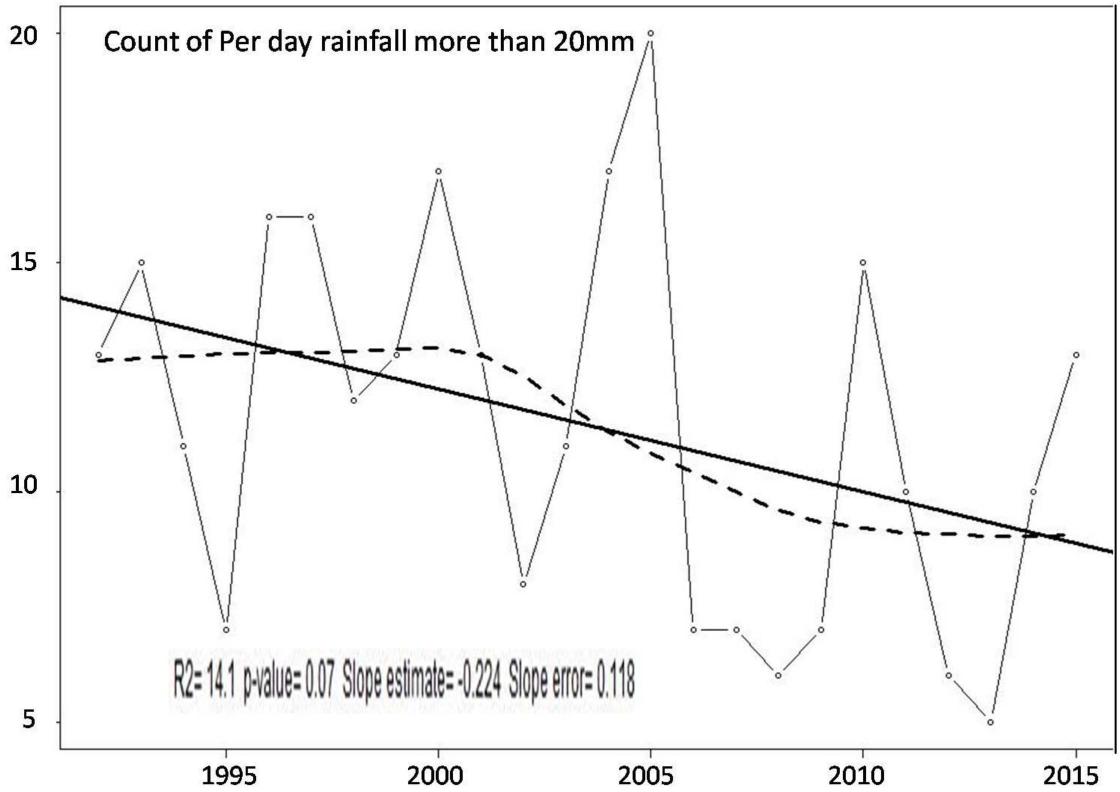

Fig-4.15: Count of per day rainfall (mm) more than 20 mm over years

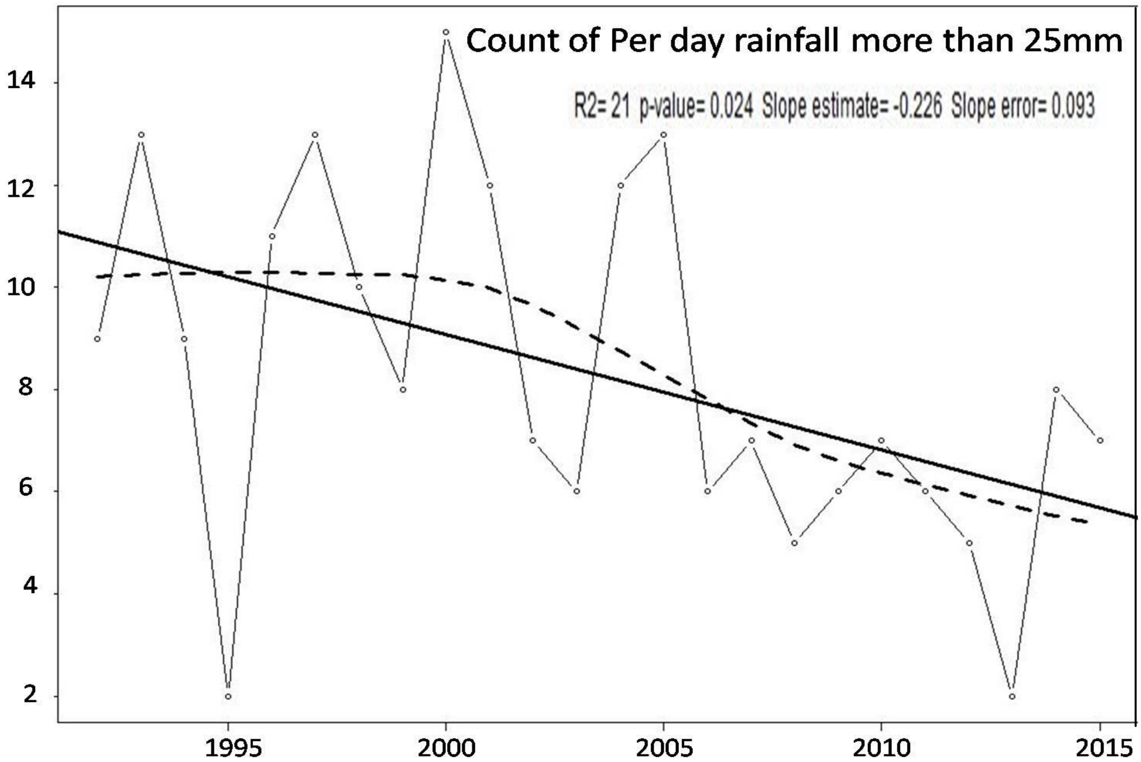

Fig-4.16: Count of per day rainfall (mm) more than 25 mm over years

4.1.5. Consecutive rainfall events

Spread of rainfall is always the necessity for better crop growth than the total amount of rainfall. In this context, consecutive rainfall events are measured as Consecutive dry days and Consecutive wet days as below:

1. CDD: Consecutive dry days: The largest number of consecutive days in a year where daily precipitation amount on day is less than 1 mm. Figure 4.17 indicates that there is decrease in number of consecutive dry days over the period. Figure depicts that variation in number of CDD has got reduced over time.As slope error is very high when compared to slope estimate decreasing trend need not be significant.

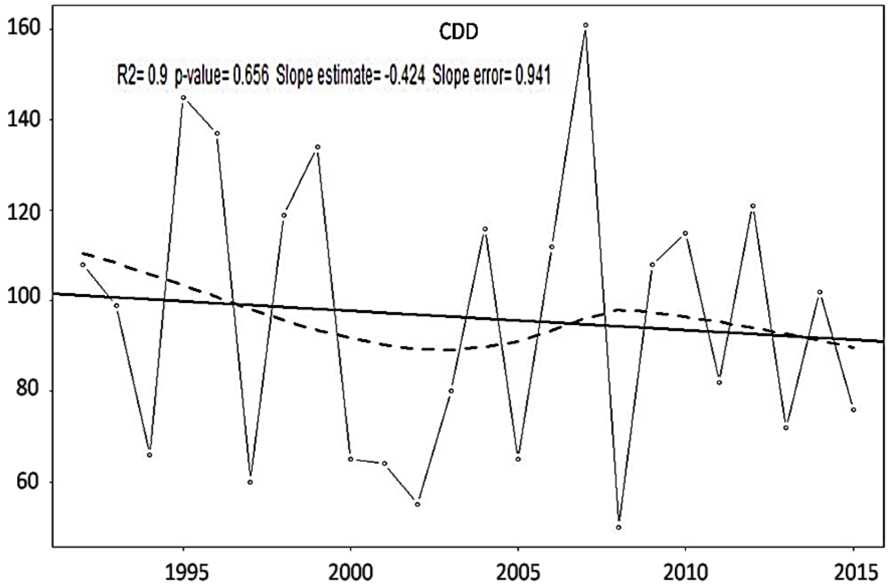

Fig-4.17: Consecutive dry days recorded over years

2. CWD: Consecutive wet days: The largest number of consecutive days in a year where daily precipitation amount on day is more than 1 mm. Figure 4.18 depicts that there exist almost no change in number of consecutive wet days over time.

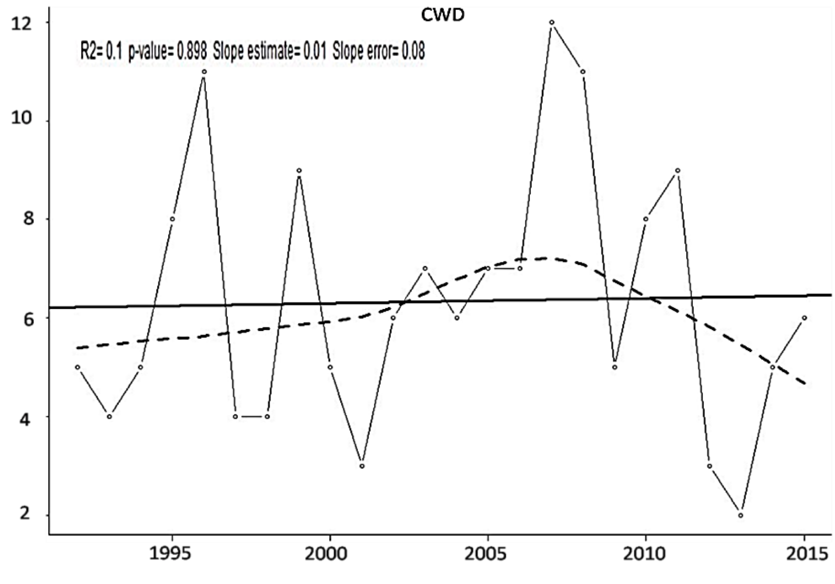

Fig-4.18: Consecutive wet days recorded over years

3. Maximum monthly consecutive 5 days rainfall: Figure 4.19 clearly indicates that the decreasing trend in quantity of rainfall recorded in consecutive five days over the period 1992 to 2015 is not significant.

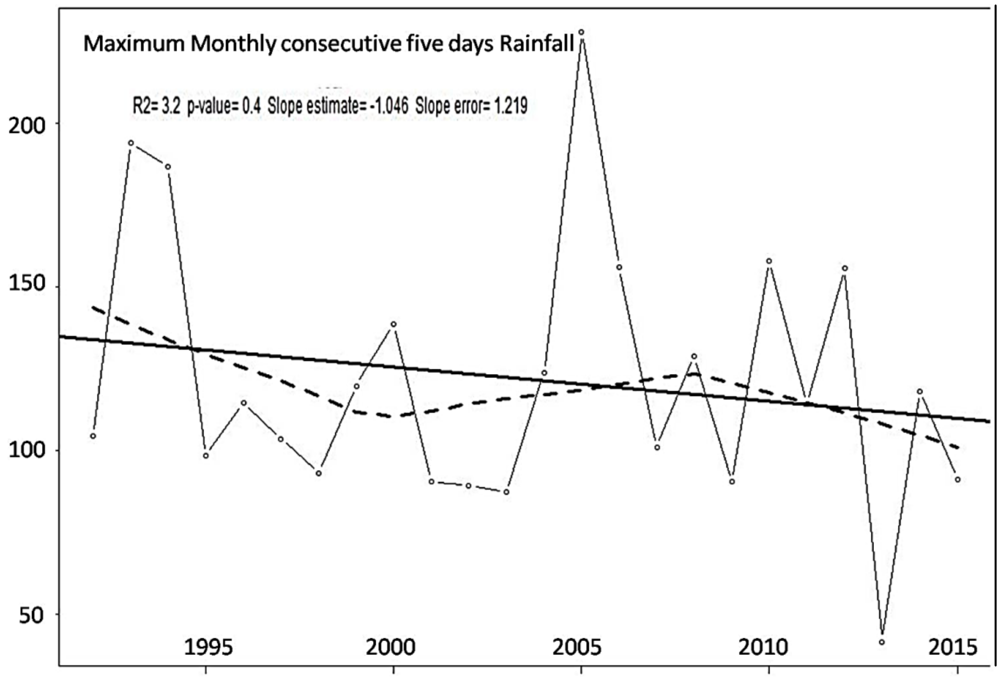

Fig-4.19: Maximum monthly consecutive 5 days rainfall (mm)

4.1.6 Drought events

According to National Commission on Agriculture (1976), definition of *Kharif* and *rabi* drought is as below:

4.1.6.1 *Kharif* Drought: When at least four consecutive weeks of south west monsoon receives less than half of the normal rainfall (> 5 mm), then *Kharif* of that year is declared as drought. Details of *kharif* drought over the years are presented in Table 4.14.

4.1.6.2 *Rabi* Drought: When at least six consecutive weeks of North east monsoon receives less than half of the normal rainfall (> 5 mm), then Rabi of that year is declared as drought. Standard weeks from 41 to 47 of 1984 and 1995 is categorized as *rabi* drought while 42nd to 47th week of 1985 and 40th to 47th week of 1988 are grouped as *Rabi* drought.

4.1.7. Rainfall probability

In rainfall series, usually characterized by a large variability, there is a need for finding suitable models that correctly capture the data behavior. The rainfall amounts are usually estimated based on the assumption that they follow a certain theoretical probability distribution. Several such distributions have been used in weather generators, such as the one-parameter exponential distribution, two parameter gamma, Weibull distributions and three-parameter skewed normal and mixed exponential distributions. Some studies have assessed their performances over different regions. Most works dealing with such a problem have considered the modeling of annual or monthly totals, where the normal distribution in the first case, and several asymmetrical distributions such as the lognormal, or incomplete gamma distributions in the second case, have been suggested.

The Gamma distribution with shape parameter α and scale parameter β is often assumed to be suitable for distributions of rainfall events. This distribution has been proven to be effective for the analysis of rainfall. Gamma distribution efficiency for analyzing the amount of rainfall has been demonstrated for the model and observational data by many authors. Wilks and Wilby suggest that the reason for this is due to the flexible representation involving only two parameters. Gamma distribution can be applied to the series, in which there is at least 4 non-zero value. The amount of rainfall at different probability levels (10-90%) called assured rainfall have been computed for each standard week by fitting Incomplete Gamma Distribution model. Quantity of rainfall at different probabilities and the average rainfall as per Incomplete gamma distribution is presented in Table-4.15.

Table-4.14: Drought events in *Kharif* of Naganahally station

Year	No. of events	Week	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1983	1	38 - 41																						
1984	1	33 - 37																						
1985	1	31 - 35																						
1986	1	28 - 31																						
1987	1	27 - 30																						
1988	2	23 - 26 38 - 42																						
1990	2	24 - 27 33 - 40																						
1991	1	33 - 36																						
1993	2	25 - 29 31 - 34																						
1994	1	35 - 38																						
2001	1	26 - 29																						
2008	1	37 - 41																						
2012	1	27 - 31																						
2013	1	28 - 34																						
2014	2	23 - 26 28 - 31																						
			22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43

Table-4.15: Rainfall (mm) at different probabilities of incomplete gamma distribution

Week	90%	75%	50%	25%	10%	Mean(mm)
1	0.5	0.8	1.2	1.8	2.5	0.4
2	0.6	0.8	1.2	1.6	2.1	0.3
3	0.1	0.5	2.6	8.5	18.3	5.6
4	0.5	0.7	0.9	1.3	1.6	0
5	0.6	0.8	1.1	1.5	1.8	0.2
6	0	0.1	0.5	2.8	4	0.5
7	0	0	1.9	7.8	12.2	1.9
8	0	0	0.8	4.9	7.8	0.8
9	0.1	0.7	3.1	9	18.5	5.8
10	0.1	0.6	3.1	10.2	21.9	6.9
11	0.2	0.7	2.1	4.9	8.8	2.6
12	0.1	0.6	2.4	6.6	13.1	3.9
13	0.2	0.9	2.8	6.6	12	3.8
14	0.3	1.1	3.6	8.5	15.7	5.2
15	0.3	1.4	5.7	15.3	30.1	10.4
16	0.7	2.9	9.1	21.7	39.9	14.8
17	0.8	3.5	11.9	29.7	56	20.8
18	2	6.4	17.4	37.8	65.7	26.3
19	1.2	4	10.9	23.8	41.5	16.2
20	1	3.8	12.2	29.2	53.7	20.3
21	1.3	5.4	17.5	42.4	78.6	30
22	3.1	8.7	21.6	44	73.9	30.8
23	0.6	2.8	9.9	24.9	47.1	17.3
24	1.6	4.8	12	24.7	41.8	16.8
25	1	3.2	8.6	18.4	31.8	12.3
26	1	2.5	5.7	10.8	17.5	6.8
27	1.4	3.4	7.4	14.1	22.6	9.2
28	1.5	4.3	10.8	22	37.1	14.9
29	1.5	4.1	10.1	20.5	34.3	13.8
30	1.5	3.5	7.5	13.8	21.7	9
31	1.8	4.7	10.9	21.1	34.5	14.2
32	1.4	3.5	7.8	14.8	23.8	9.7
33	1.3	4.2	11.8	25.8	45.1	17.6
34	1.2	3.7	10	21.4	36.9	14.4
35	0.7	3.1	10.5	25.8	48.4	17.9
36	2	5.1	12	23.4	38.5	15.9
37	1.4	5.7	18	42.9	78.7	30.2
38	0.7	3.4	12.2	31.5	60.3	22.2
39	1.4	6.1	20.2	49.2	91.5	35
40	4.5	11.3	25.5	49	79.4	34.4
41	2.2	7.9	23.5	53.7	96.4	37.9
42	1.2	4.8	16	38.9	72.3	27.4
43	0.6	3.8	17.3	50.8	104.3	37.5
44	0.8	3.9	14.3	37	71.2	26.3
45	0.8	3.5	11.8	29.3	55.1	20.5
46	0.4	1.3	3.6	8.1	14.3	4.8
47	0.2	1.1	4.9	14.1	28.7	9.6
48	0.2	0.9	3	7.8	14.8	4.7
49	0.3	0.9	2.4	5.2	9.1	2.8
50	0.1	0.6	2	4.9	9	2.6
51	0.2	0.7	2.1	4.8	8.6	2.5
52	0.2	0.7	2	4.7	8.6	2.4
Annual	492.8	578.7	685.4	804.6	922.8	698

4.1.8 Rainfall probability of wet and dry week

The probability of week being wet [$P_{(W)}$] or dry [$P_{(D)}$] is worked out for all standard meteorological weeks. A week that gets rainfall of 10 mm or more is considered as wet week. Using the above initial probabilities, the conditional probabilities of wet week followed by wet week $P_{(W/W)}$, the wet week followed by dry week $P_{(W/D)}$, dry week followed by wet week $P_{(D/W)}$ and the dry week followed by dry week $P_{(D/D)}$ are worked out and is tabulated in table 4.16 and plotted in Figure 4.20 and 4.21.

Weeks from 1 to 22 (January to May) covers Pre monsoon season. Of this 4th SMW is the only dry week. Conditional probability of wet week followed by wet week follows the similar trend of that initial probability of wet weeks. Probability of wet week followed by wet week (more than 0.5) during 10th to 21st week (except 11th, 14th and 15th) of the pre monsoon season indicates that there exists higher chances supply of necessary amount of moisture to the crop growth during this period in most of the years. This indicates that a short duration crop can be grown. Continuous higher probability of wet week followed by wet week during South west monsoon, indicates that main crop of the year can be grown so that there exists adequate supply of moisture to the crop growth during this period in most of the years. The drop in conditional probability of P (W/W) is noted during north east monsoon i.e. from 40th week to 47th week.

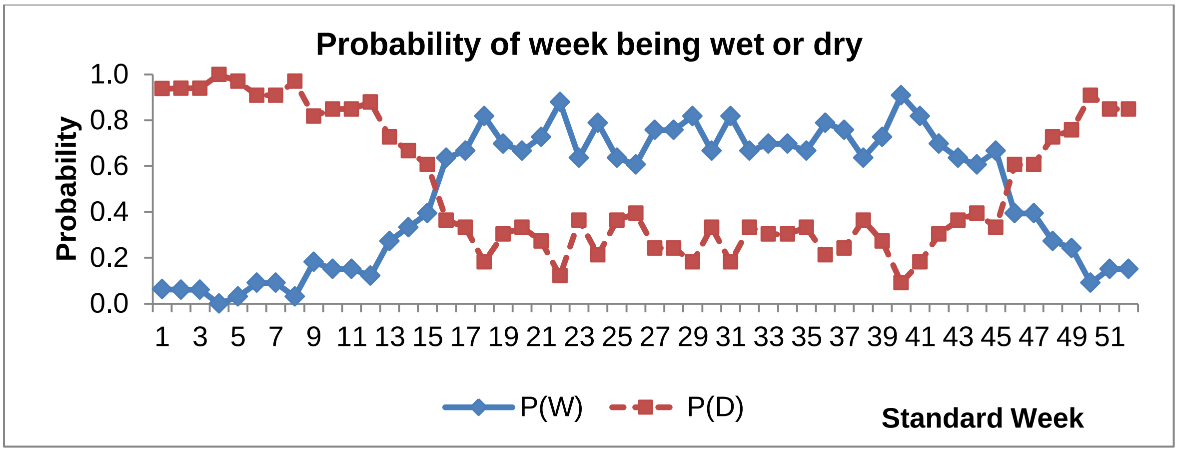

Fig-4.20: Probability of standard week being wet or dry

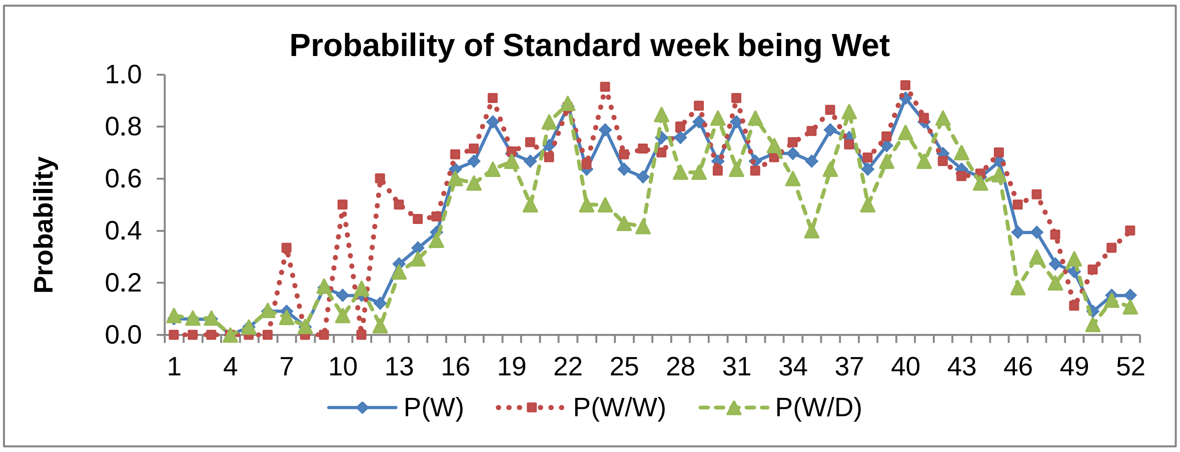

Fig-4.21: Probability of standard week being wet

Table-4.16: Weekly initial and conditional probabilities of rainfall

WEEK	INITIAL PROBABILITIES		CONDITIONAL PROBABILITIES			
	P(W)	P(D)	P(W/W)	P(D/W)	P(D/D)	P(W/D)
1	0.06	0.94	0.00	1.00	0.93	0.07
2	0.06	0.94	0.00	1.00	0.94	0.06
3	0.06	0.94	0.00	1.00	0.94	0.06
4	0.00	1.00	0.00	1.00	1.00	0.00
5	0.03	0.97	0.00	0.00	0.97	0.03
6	0.09	0.91	0.00	1.00	0.91	0.09
7	0.09	0.91	0.33	0.67	0.93	0.07
8	0.03	0.97	0.00	1.00	0.97	0.03
9	0.18	0.82	0.00	1.00	0.81	0.19
10	0.15	0.85	0.50	0.50	0.93	0.07
11	0.15	0.85	0.00	1.00	0.82	0.18
12	0.12	0.88	0.60	0.40	0.96	0.04
13	0.27	0.73	0.50	0.50	0.76	0.24
14	0.33	0.67	0.44	0.56	0.71	0.29
15	0.39	0.61	0.45	0.55	0.64	0.36
16	0.64	0.36	0.69	0.31	0.40	0.60
17	0.67	0.33	0.71	0.29	0.42	0.58
18	0.82	0.18	0.91	0.09	0.36	0.64
19	0.70	0.30	0.70	0.30	0.33	0.67
20	0.67	0.33	0.74	0.26	0.50	0.50
21	0.73	0.27	0.68	0.32	0.18	0.82
22	0.88	0.12	0.88	0.13	0.11	0.89
23	0.64	0.36	0.66	0.34	0.50	0.50
24	0.79	0.21	0.95	0.05	0.50	0.50
25	0.64	0.36	0.69	0.31	0.57	0.43
26	0.61	0.39	0.71	0.29	0.58	0.42
27	0.76	0.24	0.70	0.30	0.15	0.85
28	0.76	0.24	0.80	0.20	0.38	0.63
29	0.82	0.18	0.88	0.12	0.38	0.63
30	0.67	0.33	0.63	0.37	0.17	0.83
31	0.82	0.18	0.91	0.09	0.36	0.64
32	0.67	0.33	0.63	0.37	0.17	0.83
33	0.70	0.30	0.68	0.32	0.27	0.73
34	0.70	0.30	0.74	0.26	0.40	0.60
35	0.67	0.33	0.78	0.22	0.60	0.40
36	0.79	0.21	0.86	0.14	0.36	0.64
37	0.76	0.24	0.73	0.27	0.14	0.86
38	0.64	0.36	0.68	0.32	0.50	0.50
39	0.73	0.27	0.76	0.24	0.33	0.67
40	0.91	0.09	0.96	0.04	0.22	0.78
41	0.82	0.18	0.83	0.17	0.33	0.67
42	0.70	0.30	0.67	0.33	0.17	0.83
43	0.64	0.36	0.61	0.39	0.30	0.70
44	0.61	0.39	0.62	0.38	0.42	0.58
45	0.67	0.33	0.70	0.30	0.38	0.62
46	0.39	0.61	0.50	0.50	0.82	0.18
47	0.39	0.61	0.54	0.46	0.70	0.30
48	0.27	0.73	0.38	0.62	0.80	0.20
49	0.24	0.76	0.11	0.89	0.71	0.29
50	0.09	0.91	0.25	0.75	0.96	0.04
51	0.15	0.85	0.33	0.67	0.87	0.13
52	0.15	0.85	0.40	0.60	0.89	0.11

4.1.9 Rainy days and rainfall

Seasonal and annual rainfall along with rainy days, its mean standard deviation, C.V along with correlation coefficients are presented in Table 4.17. Interestingly ratio of rainfall recorded to the rainy days mentioned in the table shows that per day rainfall is more in north east monsoon (16.5) and summer (16.3) months when compared to south west monsoon (12.2). Rainy days and rainfall of summer is better associated with North east monsoon when compared to association between NEM and Winter rains. South west monsoon has no much notable relation with rains of other seasons. Within season correlation coefficient recorded at all seasons are above 0.6. So, we can conclude that within season Rainy days and rainfall are highly associated. Same results are reflected with respect to trends. Trends in both annual (Figure 4.22), seasonal rainfall (Fig-4.2) and rainy days (4.23) presented shows that both rainfall and rainy days have similar behaviour. Winter and South west monsoon has decreasing trend while summer and North east monsoon has increasing trend. Except for February and May months, trends in rainfall and rainy days are almost same (Fig-4.9 and 4.24) with respect to monthly totals.

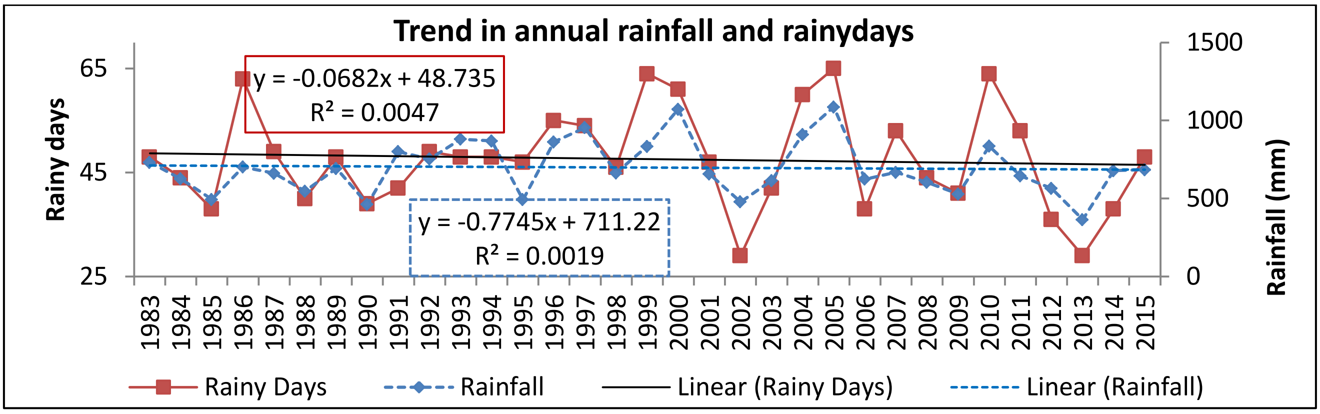

Fig4.22:- Trends in annual rainfall (mm) and rainy days

4.1.10 Rainy days

The number of mean rainy days in each month during 1983 to 2015 is given in Table 4.18. The highest and the lowest number of rainy days in each month for the period of 1983-2015 are also tabulated in same table. Monthly total number of rainy days recorded from 1983-2015 and its trend line is presented in Fig.4.24. A day is considered as the rainy day when the rainfall recorded is more than or equal to 2.5 mm. This amount is fixed to this area assuming the mean Potential Evapotranspiration (PET) is equal to 7.5 mm i.e., amount of rainwater to meet the minimum of one-third of the PET requirement of the day. Annually this station receives this requirement in 48 days on an average. May to October month records maximum number of rainy days ranging from 6 to 8 days with October month recording the maximum. Lowest rainy days are observed from November to April. The highest number of 65 rainy days was observed during 2005 and the lowest of 29 rainy days observed during 2002. It is noted in the previous section that rainfall and rainy days are associated. But behaviour of Co efficient of Variation (CV) of rainy days is quite opposite to rainfall. CV of monthly total rainy days is very high in rainy months when compared to dry months. This implies that variability of rainfall is high in rainy months while variation in rainy days is more in non rainy months. The per cent contribution of Monthly total Rainy days to mean total Rainy days for the period 1983-2015 is presented in Table-4.19 and Figure 4.25.

Table-4.17: Seasonal rainfall (mm), rainy days and its correlation

Year	Winter		Summer		South West		North East	
	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
1983	0	0	7	132	30	415	11	184
1984	1	9	9	206	29	355	5	56
1985	0	0	9	148	20	258	9	88
1986	6	92	9	132	29	238	19	239
1987	0	0	8	95	24	291	17	277
1988	0	0	6	99	31	411	3	37
1989	0	0	10	195	30	407	8	90
1990	1	3	10	222	17	85	11	154
1991	1	4	15	255	18	330	8	211
1992	0	0	10	154	34	514	5	85
1993	1	4	13	240	15	230	19	406
1994	3	113	9	190	22	248	14	318
1995	0	0	11	117	25	297	11	79
1996	0	0	12	218	29	480	14	165
1997	1	5	14	279	22	266	17	404
1998	0	0	7	183	28	325	11	156
1999	0	0	16	210	22	243	26	381
2000	2	61	15	225	29	406	15	379
2001	1	3	9	194	26	234	11	226
2002	0	2	5	62	15	296	9	118
2003	1	47	8	85	17	179	16	305
2004	0	0	19	365	26	386	15	159
2005	2	14	12	180	32	371	19	521
2006	0	0	13	279	17	242	8	103
2007	0	0	7	155	32	244	14	269
2008	0	4	13	179	20	231	11	189
2009	0	0	10	87	22	295	9	146
2010	0	0	16	231	28	267	20	336
2011	1	26	14	245	22	148	16	226
2012	0	0	9	114	17	169	10	281
2013	1	40	8	106	14	149	6	69
2014	0	0	12	170	15	332	11	177
2015	0	0	14	169	19	302	15	213
Mean	1	13	11	179	24	292	13	214
SD	1	28	3	67	6	97	5	119
CV	182	213	30	37	25	33	40	56
Ratio (Rainfall to rainy days)	13.0		16.3		12.2		16.5	

Correlation Matrix		Winter		Summer		South West		North East	
		Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
Winter	**Rainfall**	0.837	1.000						
Summer	**Rainy Days**	-0.034	-0.094	1.000					
	Rainfall	0.022	-0.082	0.785	1.000				
South West	**Rainy Days**	0.106	0.001	-0.079	0.049	1.000			
	Rainfall	-0.193	-0.204	0.054	0.069	0.653	1.000		
North East	**Rainy Days**	0.293	0.211	0.479	0.269	0.009	-0.231	1.000	
	Rainfall	0.334	0.260	0.371	0.229	0.009	-0.181	0.814	1.000

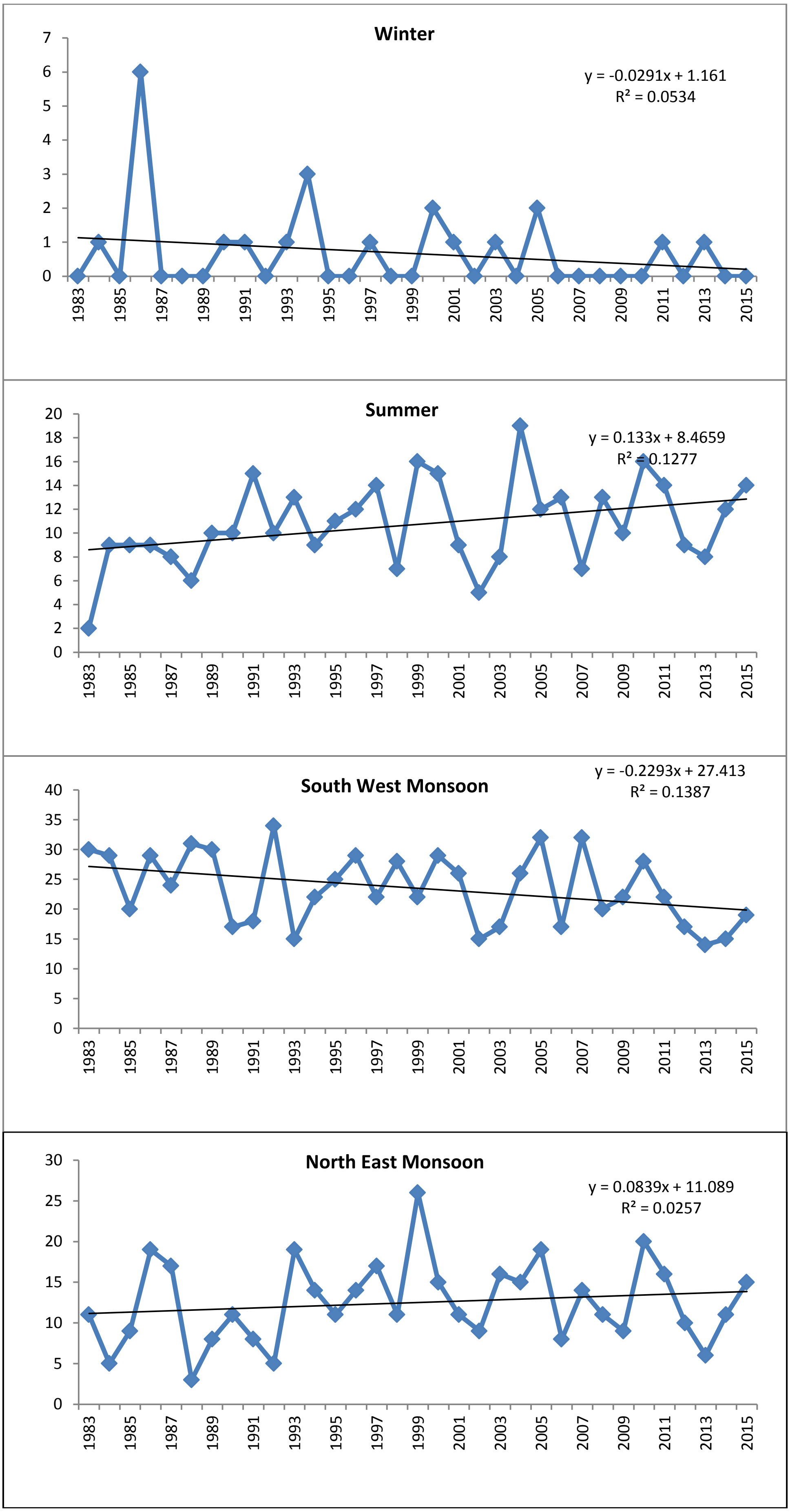

Fig-4.23: Seasonal mean rainy days

Table-4.18: Monthly total rainy days during 1983 to 2015

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1983	0	0	0	0	7	7	9	6	8	4	0	7	48
1984	0	1	2	3	4	11	7	2	9	4	0	1	44
1985	0	0	0	5	4	5	5	2	8	6	2	1	38
1986	3	3	1	2	6	10	3	5	11	10	7	2	63
1987	0	0	1	2	5	5	4	6	9	9	4	4	49
1988	0	0	0	2	4	2	11	9	9	2	1	0	40
1989	0	0	1	2	7	9	9	4	8	7	1	0	48
1990	1	0	1	2	7	4	6	4	3	7	4	0	39
1991	1	0	0	5	10	9	3	3	3	5	3	0	42
1992	0	0	0	4	6	12	4	10	8	3	2	0	49
1993	0	1	3	3	7	4	4	2	5	12	4	3	48
1994	3	0	1	3	5	5	6	5	6	12	2	0	48
1995	0	0	1	4	6	7	5	9	4	9	2	0	47
1996	0	0	0	5	7	13	2	8	6	6	2	6	55
1997	1	0	4	2	8	6	6	4	6	7	9	1	54
1998	0	0	0	5	2	4	9	6	9	6	5	0	46
1999	0	0	1	5	10	4	4	6	8	19	5	2	64
2000	0	2	0	9	6	5	6	9	9	11	2	2	61
2001	0	1	0	6	3	4	3	9	10	6	4	1	47
2002	0	0	0	2	3	5	2	3	5	8	1	0	29
2003	0	1	3	4	1	5	3	7	2	14	2	0	42
2004	0	0	1	6	12	5	10	4	7	11	4	0	60
2005	1	1	0	4	8	6	12	8	6	13	6	0	65
2006	0	0	4	1	8	6	4	3	4	6	2	0	38
2007	0	0	0	0	7	8	4	10	10	11	1	2	53
2008	0	0	7	2	4	4	6	5	5	9	2	0	44
2009	0	0	0	4	6	0	4	9	9	1	7	1	41
2010	0	0	0	8	8	7	8	6	7	9	11	0	64
2011	0	1	1	7	6	5	7	5	5	9	7	0	53
2012	0	0	0	7	2	4	2	3	8	6	3	1	36
2013	0	1	0	3	5	4	3	1	6	3	3	0	29
2014	0	0	2	2	8	2	2	5	6	10	0	1	38
2015	0	0	3	1	10	5	5	5	4	6	9	0	48
Average	0	0	1	4	6	6	5	6	7	8	4	1	48
Minimum	0	0	0	0	1	0	2	1	2	1	0	0	29
Maximum	3	3	7	9	12	13	12	10	11	19	11	4	65
Std. Devn	0.77	0.70	1.62	2.22	2.52	2.84	2.73	2.56	2.29	3.79	2.78	1.73	9.59
CV (%)	39	52	69	164	243	205	198	216	295	208	127	61	496

Table-4.19: Contribution of monthly total rainy days to the annual rainy days (1983-2015)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	0.0	0.0	0.0	0.0	14.6	14.6	18.8	12.5	16.7	8.3	0.0	14.6
1984	0.0	2.3	4.5	6.8	9.1	25.0	15.9	4.5	20.5	9.1	0.0	2.3
1985	0.0	0.0	0.0	13.2	10.5	13.2	13.2	5.3	21.1	15.8	5.3	2.6
1986	4.8	4.8	1.6	3.2	9.5	15.9	4.8	7.9	17.5	15.9	11.1	3.2
1987	0.0	0.0	2.0	4.1	10.2	10.2	8.2	12.2	18.4	18.4	8.2	8.2
1988	0.0	0.0	0.0	5.0	10.0	5.0	27.5	22.5	22.5	5.0	2.5	0.0
1989	0.0	0.0	2.1	4.2	14.6	18.8	18.8	8.3	16.7	14.6	2.1	0.0
1990	2.6	0.0	2.6	5.1	17.9	10.3	15.4	10.3	7.7	17.9	10.3	0.0
1991	2.4	0.0	0.0	11.9	23.8	21.4	7.1	7.1	7.1	11.9	7.1	0.0
1992	0.0	0.0	0.0	8.2	12.2	24.5	8.2	20.4	16.3	6.1	4.1	0.0
1993	0.0	2.1	6.3	6.3	14.6	8.3	8.3	4.2	10.4	25.0	8.3	6.3
1994	6.3	0.0	2.1	6.3	10.4	10.4	12.5	10.4	12.5	25.0	4.2	0.0
1995	0.0	0.0	2.1	8.5	12.8	14.9	10.6	19.1	8.5	19.1	4.3	0.0
1996	0.0	0.0	0.0	9.1	12.7	23.6	3.6	14.5	10.9	10.9	3.6	10.9
1997	1.9	0.0	7.4	3.7	14.8	11.1	11.1	7.4	11.1	13.0	16.7	1.9
1998	0.0	0.0	0.0	10.9	4.3	8.7	19.6	13.0	19.6	13.0	10.9	0.0
1999	0.0	0.0	1.6	7.8	15.6	6.3	6.3	9.4	12.5	29.7	7.8	3.1
2000	0.0	3.3	0.0	14.8	9.8	8.2	9.8	14.8	14.8	18.0	3.3	3.3
2001	0.0	2.1	0.0	12.8	6.4	8.5	6.4	19.1	21.3	12.8	8.5	2.1
2002	0.0	0.0	0.0	6.9	10.3	17.2	6.9	10.3	17.2	27.6	3.4	0.0
2003	0.0	2.4	7.1	9.5	2.4	11.9	7.1	16.7	4.8	33.3	4.8	0.0
2004	0.0	0.0	1.7	10.0	20.0	8.3	16.7	6.7	11.7	18.3	6.7	0.0
2005	1.5	1.5	0.0	6.2	12.3	9.2	18.5	12.3	9.2	20.0	9.2	0.0
2006	0.0	0.0	10.5	2.6	21.1	15.8	10.5	7.9	10.5	15.8	5.3	0.0
2007	0.0	0.0	0.0	0.0	13.2	15.1	7.5	18.9	18.9	20.8	1.9	3.8
2008	0.0	0.0	15.9	4.5	9.1	9.1	13.6	11.4	11.4	20.5	4.5	0.0
2009	0.0	0.0	0.0	9.8	14.6	0.0	9.8	22.0	22.0	2.4	17.1	2.4
2010	0.0	0.0	0.0	12.5	12.5	10.9	12.5	9.4	10.9	14.1	17.2	0.0
2011	0.0	1.9	1.9	13.2	11.3	9.4	13.2	9.4	9.4	17.0	13.2	0.0
2012	0.0	0.0	0.0	19.4	5.6	11.1	5.6	8.3	22.2	16.7	8.3	2.8
2013	0.0	3.4	0.0	10.3	17.2	13.8	10.3	3.4	20.7	10.3	10.3	0.0
2014	0.0	0.0	5.3	5.3	21.1	5.3	5.3	13.2	15.8	26.3	0.0	2.6
2015	0.0	0.0	6.3	2.1	20.8	10.4	10.4	10.4	8.3	12.5	18.8	0.0
MEAN	0.6	0.7	2.5	7.7	12.9	12.3	11.3	11.6	14.5	16.5	7.2	2.1
MAX	6.3	4.8	15.9	19.4	23.8	25.0	27.5	22.5	22.5	33.3	18.8	14.6
MIN	0.0	0.0	0.0	0.0	2.4	0.0	3.6	3.4	4.8	2.4	0.0	0.0
STD	1.5	1.3	3.7	4.4	5.0	5.7	5.3	5.2	5.2	7.1	5.1	3.4
CV(%)	249.4	180.0	150.1	57.3	38.8	46.5	46.8	44.7	35.5	42.8	70.6	161.3

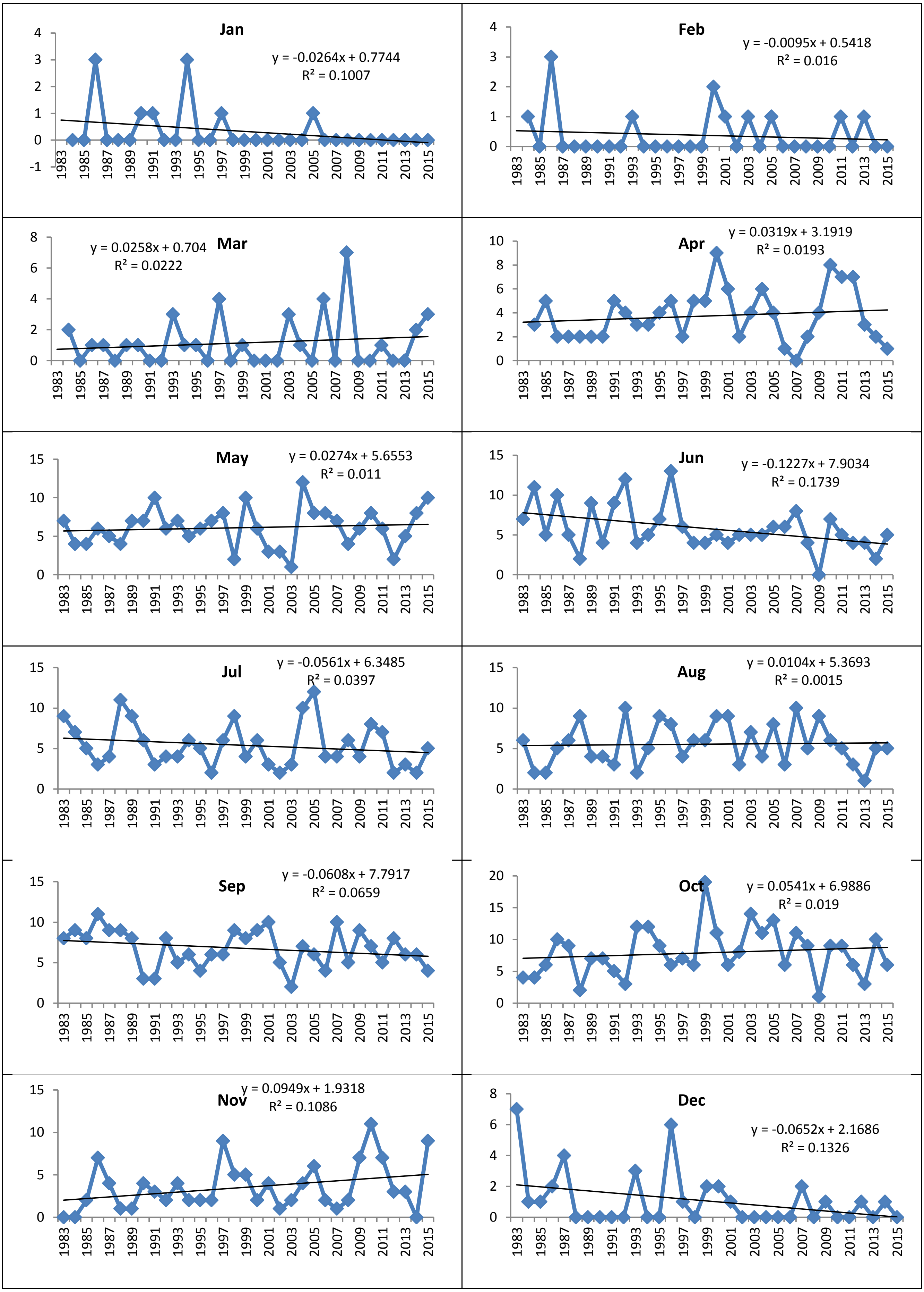

Fig-4.24: Trends in monthly total rainy days

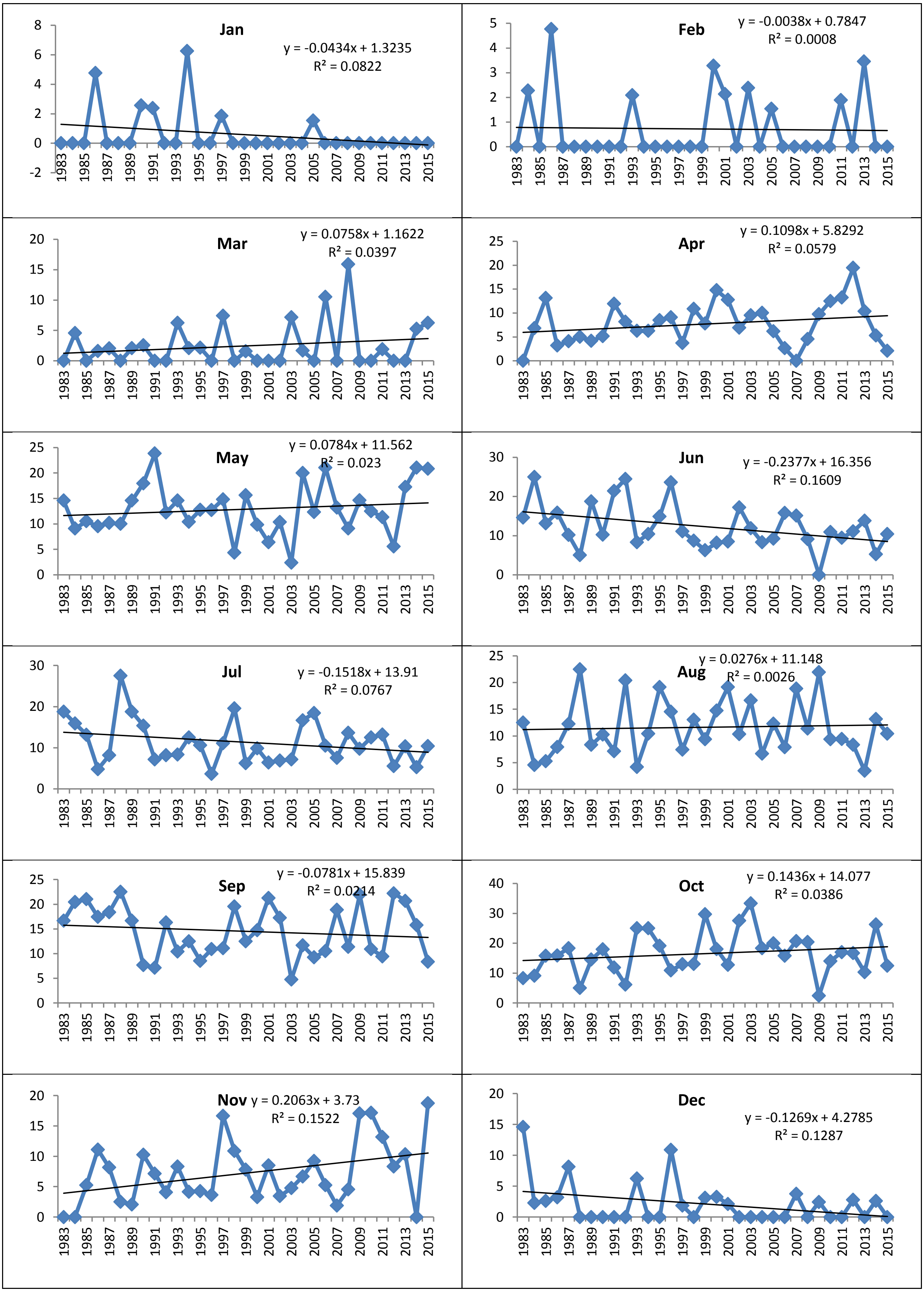

Fig-4.25: Contribution (%) of monthly total rainy days to total annual rainy days for period 1983-2015

4.2 Temperature

The mean air temperature is the derived parameter using maximum and minimum temperatures observed during 24 hours. Temperature is one of the other important weather parameter that regulates the growth of the crop in any given region. For each species of plants there are upper (maximum) and lower (minimum) limits of temperature at which growth is nil or negligible and optimum temperature at which growth is maximum. Most of the crop plants grow best at 15 to 30 °C. Many crop plants die at temperature of 45 to 55 °C. There are also optimal temperatures for different growth stages. The data on maximum temperature and minimum temperature features are presented below.

- **Cool season crops:** The crops which grow best in cool weather period are called cool season crops and are generally grown in winter season (November to February). Most of the cool season crops cease to grow at an average temperature of 30 to 38 °C. The important cool season crops are wheat, barley, potato, oats, etc. These crops are also called temperate crops. The cardinal temperature ranges for cool season crops are maximum Temperature 30-38 °C. Minimum temperature 0-5 °C and optimum temperature 25-30 °C.

- **Warm season crops:** The important warm season crops are rice, sorghum, maize, sugarcane, pearl millet, groundnut, pigeon pea, cowpea, etc. These crops are also called tropical crops. These crops are generally grown in monsoon and some also in summer season. The cardinal temperature ranges for warm season crops are maximum temperature 45-50 °C, minimum temperature 15-20 °C and optimum temperature 30-38 °C.

4.2.1 Maximum temperature

The monthly mean maximum temperature (°C) for the period 1987-2015 is presented in Table-4.20. The highest, monthly mean maximum temperature of 34.8 °C observed during April followed by March of 34.0°C and May of 33.9°C. The lowest monthly mean maximum temperature of 27.9°C recorded in December followed by November (28.3°C) and august (29.0°C). Though not significant, still mean maximum temperature in this Centre exhibits unimodal behaviour with maximum peak at April. We notice that temperature gradually increases from January end, attains its peak at April gradually decrease up to the month of august, again slightly increase in September stabilizes till October and finally reaches its minimum value in December. Thus, we notice cooler days from November to January and hotter in March and April and warmer during other months. C.V per cent ranges from 2.5 (Feb) to 7.4 (Nov) which indicates that there are notable extent of variations in the mean values that could be realized.

Monthly mean maximum temperature and its trend for the period from 1983 to 2015 are presented in Figure-4.26. Except for October, Monthly mean maximum temperatures over years have indicated the increasing trend. Moderate R^2 values of January trend (0.429) and December (0.399) months indicate notable increase in maximum temperature in cooler months. Not just the mean maximum temperature even the highest maximum temperature is recorded mostly in April (Table-4.3 and Fig-4.1) month. Least maximum temperature is recorded in November month of most of the years (Table-4.3 and Fig-4.1).

4.2.2. Minimum temperature

Monthly mean minimum temperature (°C) during 1992 to 2015 is given in Table 4.21. The lowest monthly mean minimum temperature of 15.5°C was observed during January followed by December (15.6°C). The highest monthly mean minimum temperature of 21.5°C was observed during April month. We notice that temperature gradually increases from January end, attains its peak during April and then continues till first fortnight of May. Afterwards it gradually decreases till the month of September. Not just the mean maximum temperature even the highest minimum temperature is recorded mostly in April (Table-4.3 and Fig-4.1) month. Least minimum temperature is recorded in January month of most of the years (Table-4.3 and Fig-4.1). Sudden fall in minimum temperature is noted during the end of October month and finally reaches its minimum value in December. Thus, we notice cooler nights from November to February and hotter in April to June and warmer during other months. C.V per cent ranges from 8.7 (Jul) to 18.5 (Dec) which indicates that there are notable extent of variations in the mean values that could be realized.

Monthly mean minimum temperature (°C) and its trend from 1992 to 2015 is presented in Figure 4.27. During 1992 to 2015, decreasing trend is observed in all months. Variations in minimum temperature in almost all the months has got reduced over time. Minimum value of R^2 of minimum temperature of May (0.191), November (0.170) and December (0.085) months imply that though there exist decreasing trend the minimum temperature of these months have almost remained same over time. Higher R^2 values of January (0.438), February (0.441) and March (0.442) shows that there exist significant decrease in minimum temperature recorded in these months.

Table4.20: Monthly mean maximum temperature (^{o}C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1987	28.3	32.4	33.1	35.1	33.9	31.5	31.1	29.7	31.5	30.1	28.8	26.7	31.0
1988	28.2	31.8	34.6	34.7	34.8	29.7	28.8	29.4	29.2	30.4	28.0	28.0	30.6
1989	28.3	31.7	33.3	34.5	34.1	29.5	28.9	28.6	30.0	30.7	29.5	27.6	30.6
1990	29.2	32.4	34.2	36.3	33.9	31.1	29.1	29.5	31.2	31.0	27.7	27.4	31.1
1991	28.4	31.8	35.2	35.6	34.6	28.9	27.7	27.4	27.9	27.9	22.3	26.0	29.5
1992	26.6	30.7	33.3	34.5	33.0	29.0	27.3	27.0	27.9	29.3	27.8	25.1	29.3
1993	27.4	30.9	32.4	34.5	33.4	29.2	28.0	28.6	28.6	28.5	26.7	26.2	29.5
1994	27.2	30.7	34.0	33.9	33.7	27.5	27.6	28.8	27.5	30.9	28.9	26.4	29.8
1995	29.5	30.9	34.1	35.0	33.5	33.1	31.5	30.4	30.7	30.1	30.6	28.1	31.4
1996	29.0	31.6	34.5	34.0	35.6	31.6	29.0	28.6	28.4	28.4	29.7	26.6	30.6
1997	27.9	31.0	33.0	33.6	33.2	31.9	28.8	27.3	30.1	29.7	28.6	28.5	30.3
1998	30.0	32.0	34.7	35.1	33.5	32.7	28.8	29.0	29.0	28.6	28.6	28.2	30.8
1999	29.2	31.3	34.0	34.2	31.2	29.8	28.7	29.0	29.9	29.4	28.7	27.6	30.3
2000	29.6	30.9	33.6	34.2	33.7	30.1	29.4	28.6	29.5	29.8	29.2	26.8	30.5
2001	29.2	33.0	34.6	33.5	33.5	31.0	29.9	28.8	31.2	30.0	29.3	28.1	31.0
2002	30.2	31.6	35.0	35.8	34.9	31.5	31.0	29.3	31.3	29.8	29.5	29.6	31.6
2003	30.0	33.1	34.3	35.4	36.3	32.4	30.5	29.8	30.3	29.8	28.4	28.5	31.6
2004	30.0	32.6	35.9	34.8	30.5	29.8	29.2	28.8	29.7	29.3	28.1	28.7	30.6
2005	29.9	32.2	34.4	34.0	34.5	30.7	29.1	28.6	29.2	28.8	20.3	29.5	30.1
2006	29.3	31.2	32.7	35.5	34.2	30.4	29.3	29.4	29.8	30.1	29.4	28.8	30.8
2007	30.0	31.1	34.8	35.7	34.3	30.8	29.1	28.5	29.3	29.7	29.3	28.1	30.9
2008	29.9	31.0	31.4	33.8	34.3	30.5	30.0	29.2	29.9	30.8	29.6	29.1	30.8
2009	29.4	32.9	34.3	35.6	34.1	31.9	28.7	29.5	29.6	30.1	28.9	28.6	31.1
2010	29.7	32.8	35.5	34.9	34.1	31.0	29.2	29.5	29.8	29.9	27.9	28.1	31.1
2011	29.7	30.7	33.2	33.6	33.7	29.9	30.3	29.2	29.9	31.2	28.4	28.5	30.7
2012	29.8	32.3	35.2	35.3	34.2	31.6	30.9	30.2	30.9	30.1	29.6	29.7	31.7
2013	31.1	32.6	35.3	37.0	35.8	30.3	29.0	30.8	30.2	29.3	29.1	27.9	31.5
2014	29.4	30.8	32.9	36.1	35.1	34.9	34.7	29.1	28.5	28.8	28.5	28.5	31.4
2015	29.1	30.9	33.4	33.5	31.5	27.7	28.5	28.4	29.1	29.3	28.1	28.3	29.8
MEAN	29.2	31.7	34.0	34.8	33.9	30.7	29.5	29.0	29.7	29.7	28.3	27.9	30.7
MAX	31.1	33.1	35.9	37.0	36.3	34.9	34.7	30.8	31.5	31.2	30.6	29.7	31.7
MIN	26.6	30.7	31.4	33.5	30.5	27.5	27.3	27.0	27.5	27.9	20.3	25.1	29.3
STD	1.0	0.8	1.0	0.9	1.2	1.6	1.5	0.8	1.1	0.8	2.1	1.1	0.7
CV(%)	3.4	2.5	3.1	2.6	3.7	5.1	4.9	2.9	3.6	2.7	7.4	4.0	2.2

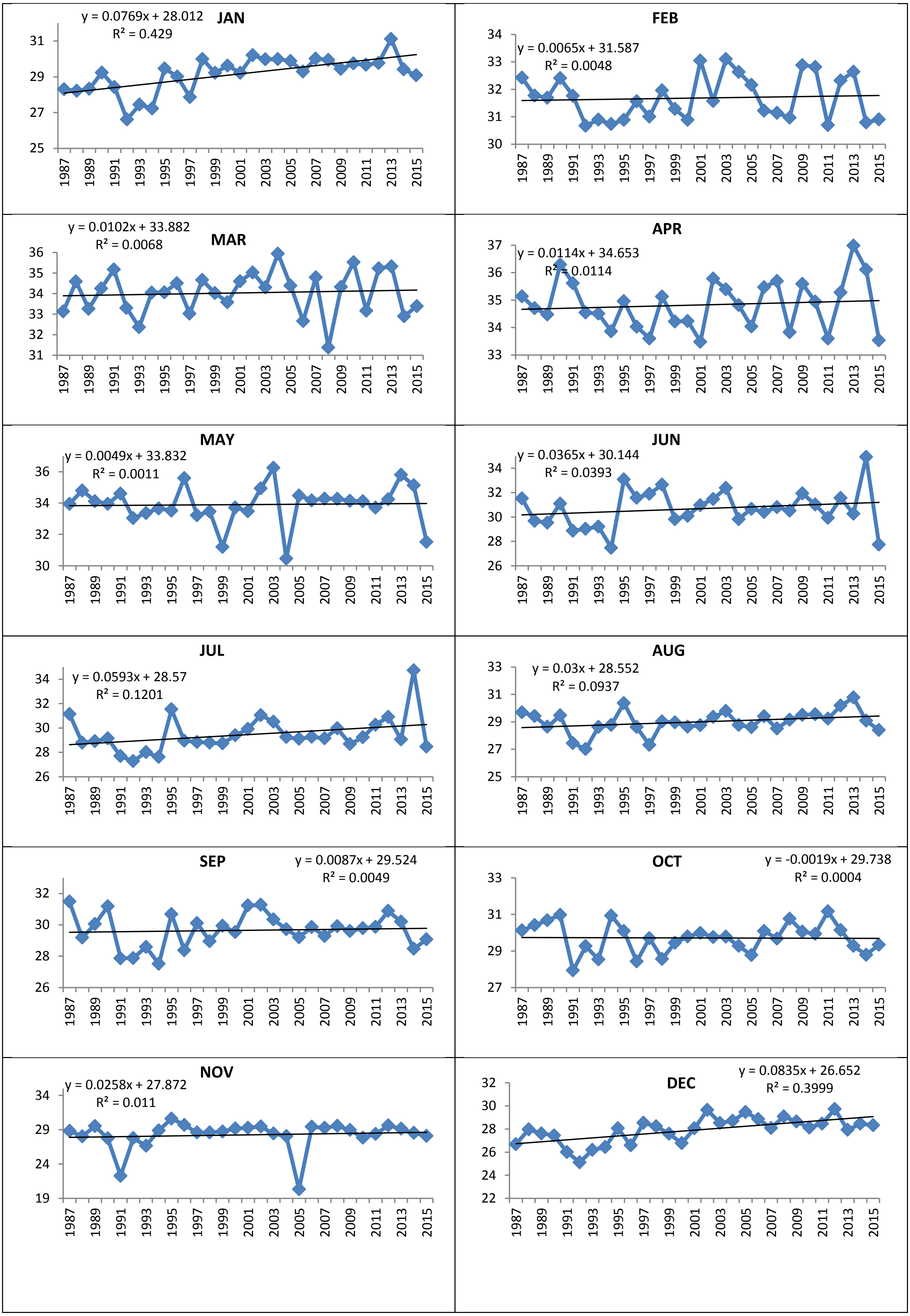

Fig-4.26: Trends in monthly mean maximum temperature (^oC)

Table 4.21: Monthly mean minimum temperature (^oC)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	21.2	21.9	22.8	22.8	22.2	20.8	21.1	20.4	20.5	22.4	19.5	17.9	21.1
1993	18.2	20.9	24.5	32.1	31.8	24.5	24.7	23.6	24.1	21.5	18.5	18.6	23.6
1994	19.9	26.9	27.5	25.1	22.9	21.0	22.0	22.2	24.9	22.0	23.6	18.8	23.1
1995	19.7	18.1	22.3	22.9	21.5	21.8	19.2	21.6	24.7	20.1	17.6	18.1	20.6
1996	16.8	18.9	20.6	22.0	20.9	18.7	20.6	17.7	17.3	17.6	17.8	13.8	18.6
1997	15.7	16.9	16.6	18.4	21.4	22.5	20.7	19.4	21.4	21.8	21.5	21.1	19.8
1998	18.5	18.7	22.4	24.4	15.6	26.5	23.0	23.1	20.5	21.6	21.0	19.7	21.2
1999	15.2	17.8	20.4	20.4	20.7	21.3	20.1	20.5	20.7	20.4	17.3	15.4	19.2
2000	15.9	17.7	19.6	21.7	21.4	21.0	20.5	19.9	20.2	19.9	17.3	14.8	19.2
2001	15.2	17.8	20.2	21.7	21.2	20.6	20.8	19.9	20.2	19.9	19.6	15.8	19.4
2002	15.6	17.1	18.3	22.7	21.5	20.7	20.1	20.0	19.4	19.7	17.4	13.9	18.9
2003	14.5	17.7	18.6	21.1	21.3	20.7	20.0	19.6	18.3	18.6	16.5	12.9	18.3
2004	14.1	14.8	17.8	20.0	19.3	18.9	19.1	19.2	19.5	18.7	16.6	12.6	17.6
2005	15.4	17.3	19.9	21.1	20.9	20.4	19.4	18.9	18.8	18.4	11.5	10.0	17.7
2006	13.0	12.2	17.6	19.9	19.4	18.7	18.2	17.9	17.9	18.1	16.8	12.7	16.9
2007	11.8	13.8	17.2	18.3	18.1	17.3	16.7	15.8	16.0	15.0	13.4	12.2	15.5
2008	12.8	17.2	16.8	19.4	19.1	18.6	18.3	18.2	17.3	16.9	14.6	13.2	16.9
2009	12.6	15.0	18.9	20.3	19.7	20.0	19.6	19.4	19.2	17.9	17.7	16.0	18.0
2010	14.2	16.5	19.2	20.4	20.7	19.7	19.0	19.9	19.3	18.9	18.0	14.9	18.4
2011	12.9	15.7	16.9	20.3	19.9	19.6	19.1	18.8	18.3	18.4	15.3	13.3	17.4
2012	12.4	13.8	18.4	19.8	20.0	18.6	18.5	18.4	18.2	17.5	14.4	13.8	17.0
2013	12.5	14.7	17.4	19.2	18.4	17.3	17.3	17.5	18.4	20.1	19.4	18.4	17.5
2014	17.8	17.0	19.5	20.9	21.4	21.5	20.6	20.0	19.8	19.0	17.9	17.8	19.4
2015	17.2	17.4	18.9	20.0	20.6	20.3	19.9	19.9	20.1	19.4	19.3	18.8	19.3
MEAN	15.5	17.3	19.7	21.5	20.8	20.5	19.9	19.6	19.8	19.3	17.6	15.6	18.9
MAX	21.2	26.9	27.5	32.1	31.8	26.5	24.7	23.6	24.9	22.4	23.6	21.1	23.6
MIN	11.8	12.2	16.6	18.3	15.6	17.3	16.7	15.8	16.0	15.0	11.5	10.0	15.5
STD	2.7	3.0	2.6	2.8	2.8	2.1	1.7	1.8	2.2	1.8	2.6	2.9	1.9
CV(%)	17.1	17.2	13.4	13.2	13.4	10.1	8.7	8.9	11.3	9.2	14.9	18.5	10.3

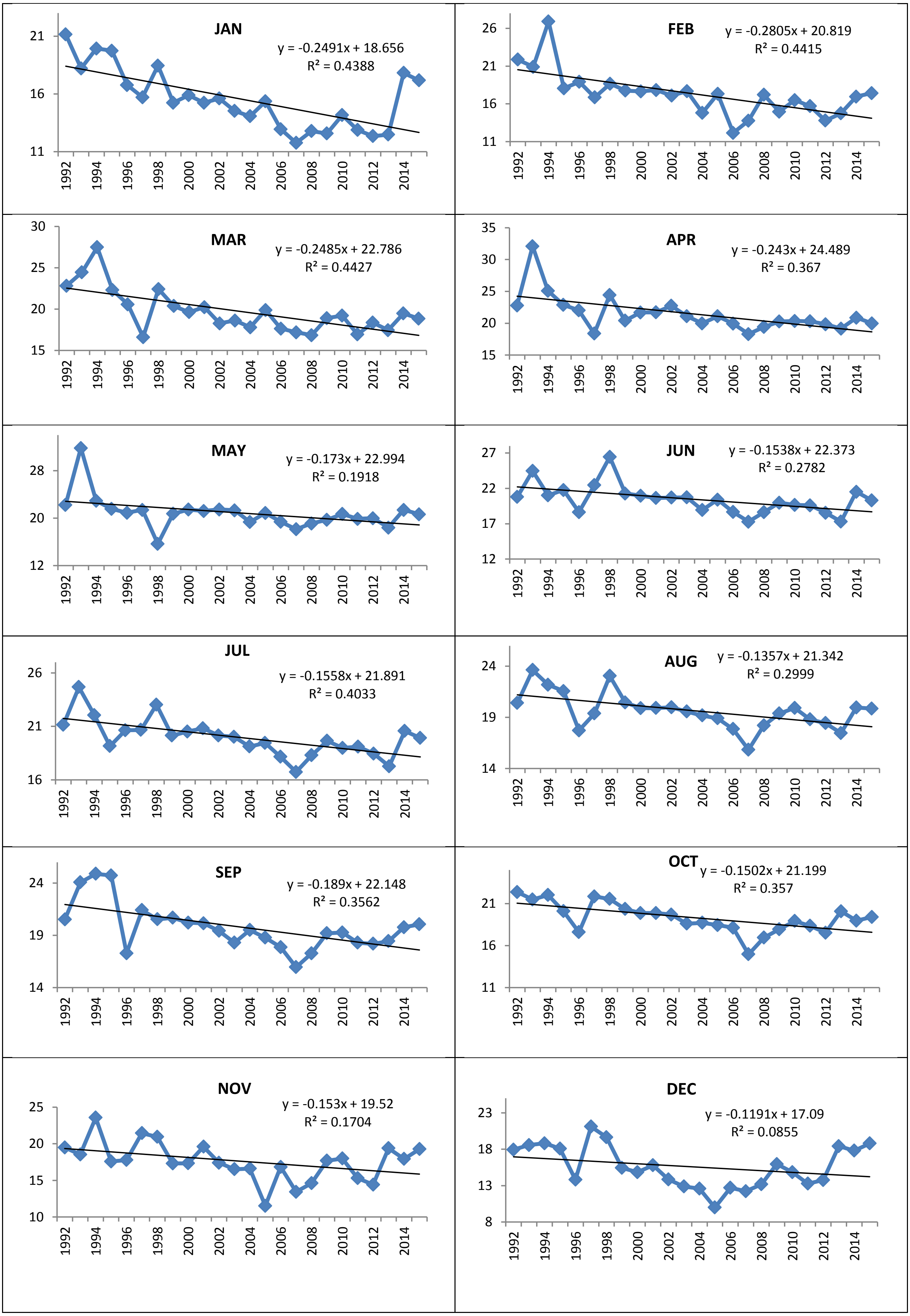

Fig-4.27: Trends in monthly mean minimum temperature (^{O}C)

4.2.3 Cold spell duration indicator

Annual count of days with at least 6 consecutive days when minimum temperature is less than 10th percentile is used to understand the cold spell duration (Fig-4.28) over the period 1992 to 2015. Though R^2 (0.6) is high, the error being larger than slope estimate explains that the increasing trend in cold spell duration is not significant.

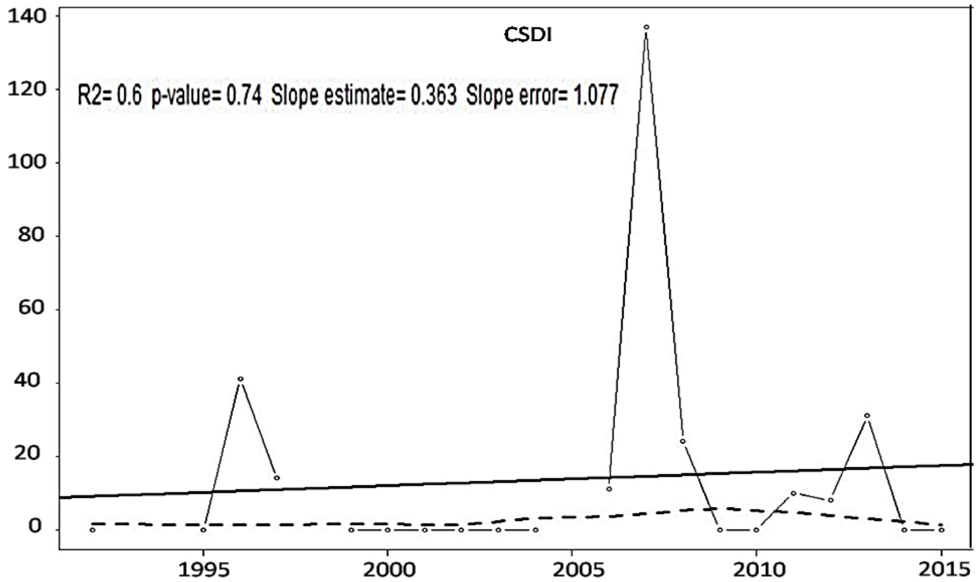

Fig-4.28: Cold spell duration

4.2.4 Temperature extremities

Days with Maximum (Fig-4.29 and Fig-4.30) and Minimum (Fig-4.31 and Fig-4.32) temperature above 90 percentile and below 10th percentile are considered to be extreme. Decrease in 10th percentile values and increase in 90th percentile of maximum temperature values shows that Days are becoming more hotter over time. Over time decrease in 90th percentile and increase in 10th percentile minimum temperature values shows that nights are falling to normal range and extremities are getting reduced.

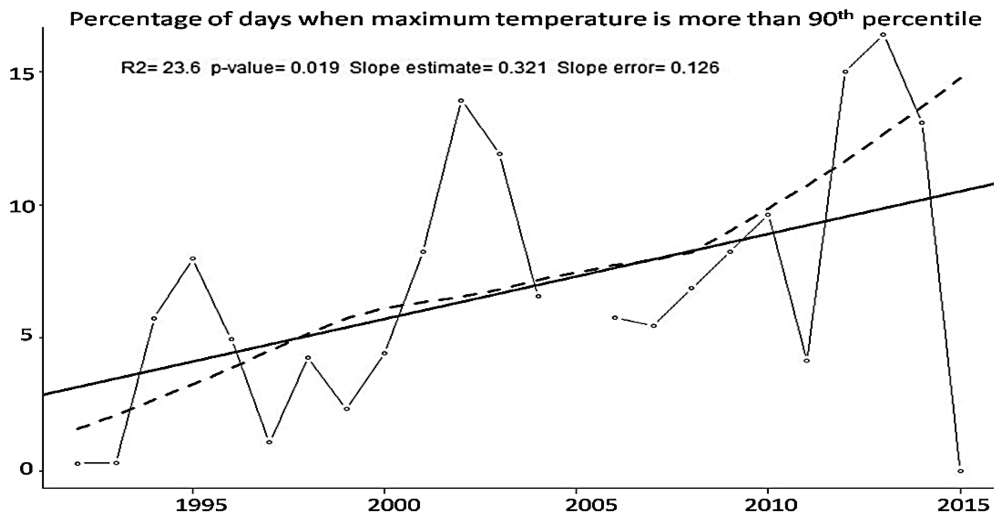

Fig-4.29: Percentage of days with maximum temperature (^{O}C) above 90thpercentile

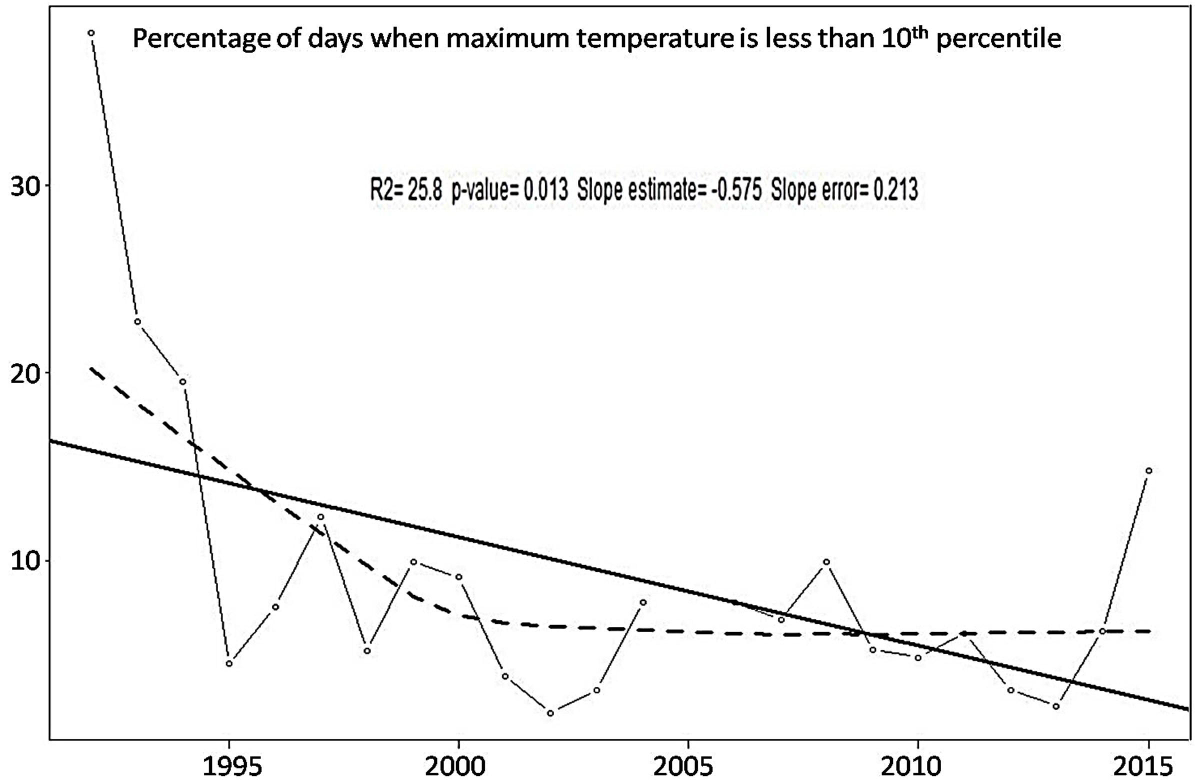

Fig-4.30: Percentage of days with maximum temperature (°C) below 10th percentile

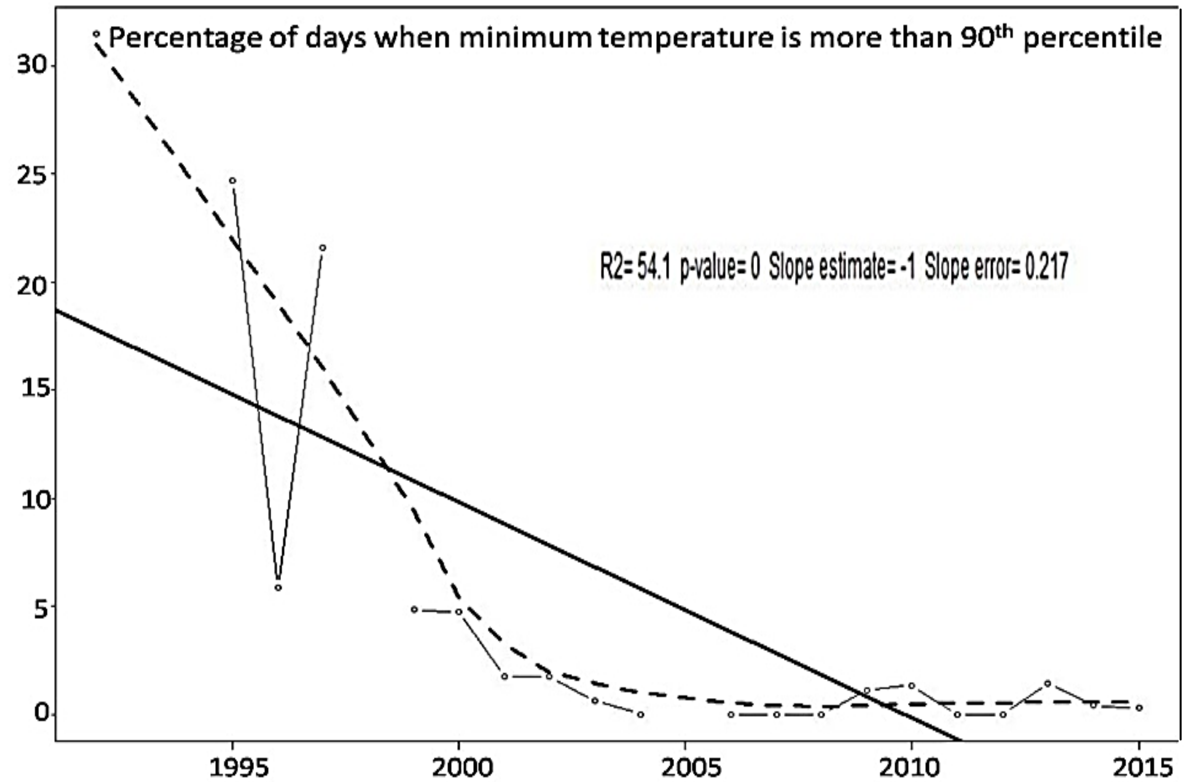

Fig-4.31: Percentage of days with minimum temperature (°C) above 90th percentile

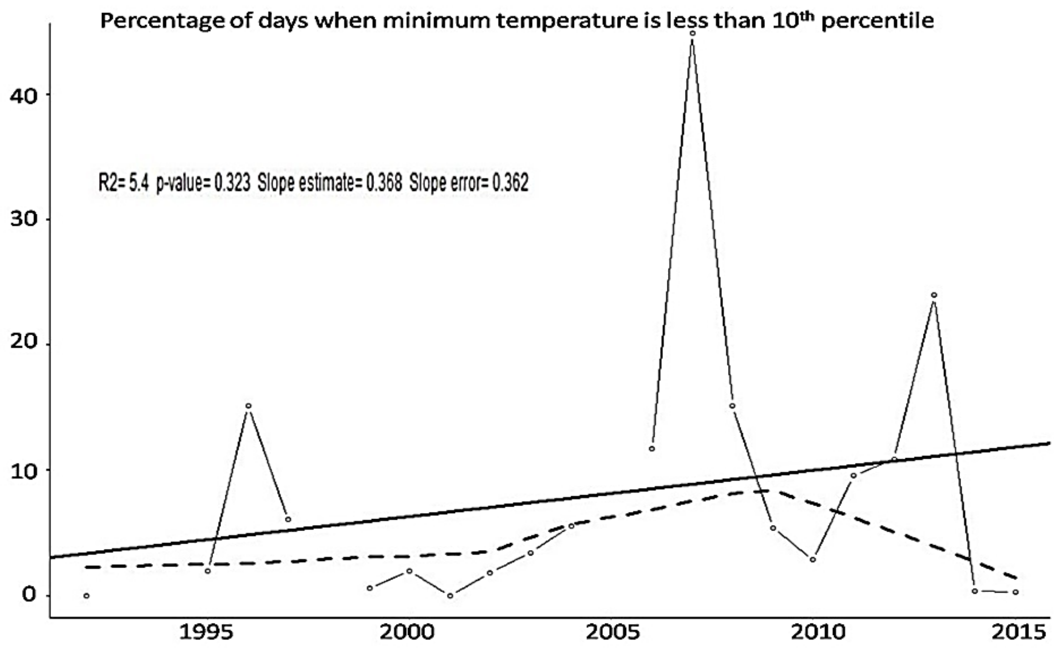

Fig-4.32: Percentage of days with minimum temperature (^{O}C) below 10^{th} percentile

4.2.5 Diurnal temperature range

The diurnal temperature range (DTR) is the difference between the daily maximum and minimum temperature. Changes in DTR have multiple possible causes (cloud cover, urban heat, land use change, aerosols, water vapor and greenhouse gases). Temperature lag is an important factor in diurnal temperature variation: peak daily temperature generally occurs *after* noon, as air keeps net absorbing heat even after noon, and similarly minimum daily temperature generally occurs substantially after midnight, indeed occurring during early morning in the hour around dawn, since heat is lost all night long. The analogous annual phenomenon is seasonal lag. DTR for the period 1992 to 2015 is plotted in Figure-4.33. High R^2 and low slope error indicates significantly increasing trend in DTR. It implies that the gap between maximum and minimum temperature is getting reduced and range is increasing over time.

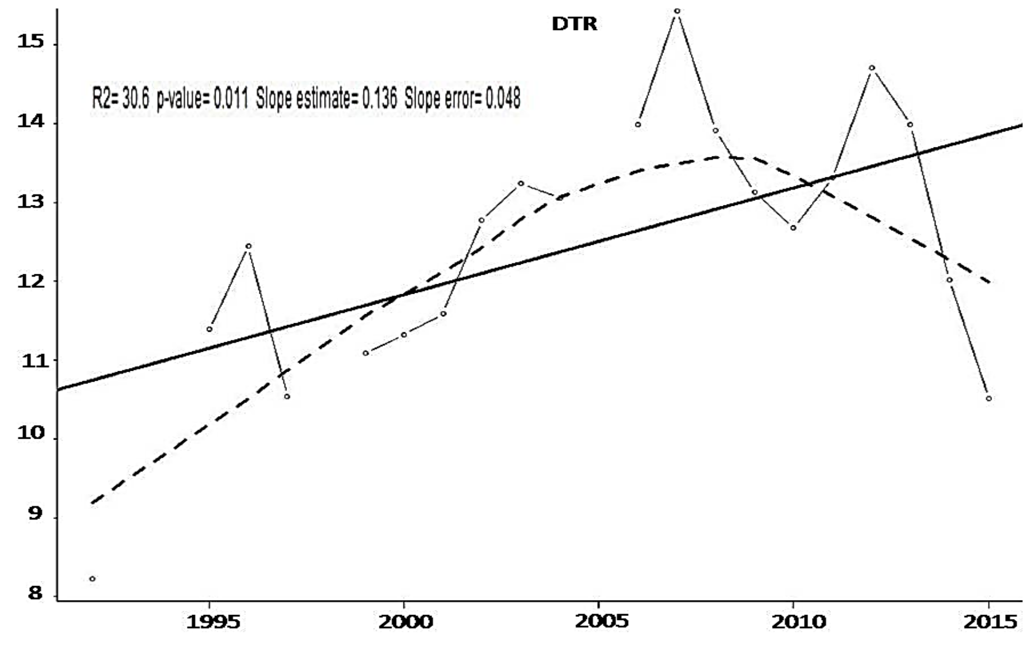

Fig-4.33: Diurnal temperature range

4.3 Relative humidity (RH)

Relative humidity is the ratio of actual water vapour content to the saturated water vapour content at a given temperature and pressure expressed in percentage (%). Key points with respect to **Diurnal variation in relative humidity are:** Mean maximum relative humidity occurs in the early morning; Mean minimum, relative humidity occurs in the early afternoon and Low RH in the afternoon is due to expansion of air and thus increases the total water vapour capacity. In General, Distribution of RH is as follows

- Maximum RH is in the equatorial region due to high evaporation.
- Decreases towards poles up to 30° N and S due to subsiding air mass.
- RH increases in poles due to low temperature.

4.3.1 Effect of relative humidity on crop production

Humidity which indicates the moisture content in the atmosphere is also a very important weather parameter which influences the development of crop in different phenological stages. RH directly influences the water relations of plant and indirectly affects leaf growth, photosynthesis, pollination, occurrence of diseases and finally economic yield. The dryness of the atmosphere as represented by saturation deficit (100-RH) reduces dry matter production through stomatal control and leaf water potential.

Leaf Growth

1. Leaf growth not only depends on synthetic activities resulting from biochemical process but also upon the physical process of cell enlargement.
2. Cell enlargement occurs as a result of turgor pressure developed within the cells.
3. Turgor pressure is high under RH due to less transpiration. Thus leaf enlargement is high in humid areas

Photosynthesis

1. Photosynthesis is indirectly affected by RH. When RH is low, transpiration increases causing water deficits in the plant.
2. Water deficits cause partial or full closure of stomata and increase mesophyll resistance blocking entry of carbon dioxide.

Pollination: Moderately low air humidity is favorable for seed set in many crops, provided soil moisture supply is adequate. At high RH pollen may not be dispersed from the anthers

For example, seed set in wheat was high at 60 per cent RH compared to 80 per cent when water availability in the soil was not limiting.

Pests

1. The incidence of insect pests and diseases is high under high humidity conditions.
2. High RH favours easy germination of fungal spores on plant leaves.

For example: The blight diseases of potato and tea spread more rapidly under humid conditions. Several insects such as aphids and jassids thrive better under moist conditions.

Grain Yield

Very high or very low RH is not conducive for high grain yield. Under high humidity, RH is negatively correlated with grain yield of maize. The yield reduction was 144 kg/ha with an increase in one per cent of mean monthly RH. Similarly, wheat grain yield is reduced in high RH. It can be attributed to adverse effect of RH on pollination and high incidence of pests. On the contrary, increase in RH during panicle initiation to maturity increased grain yield of sorghum under low humidity conditions due to favorable influence of RH on water relations of plants and photosynthesis. With similar amount of solar radiation, crops that are grown with irrigation gives less yield compared to those grown with equal amount of 'water as rainfall. This is because the dry atmosphere, which is little affected by irrigation, independently suppresses the growth of crops.

Very high relative humidity:

- Reduces evapotranspiration
- Increases heat load of plants
- Stomatal closure
- Reduced CO2 uptake
- Reduced transpiration influences translocation of food materials and nutrients
- Moderately high RH of 60-70% is beneficial.
- Low RH increases the evapotranspiration

Relative Humidity which is indirectly calculated using the dry bulb and wet bulb thermometer readings recorded at 7.00 A.M. IST and 2.00 P.M. IST. The relative humidity observed at these two different hours indicates the maximum and minimum relative humidity during 1st and 2no observations respectively.

4.3.2 Relative humidity at 7.00 A.M. IST

The monthly mean relative humidity observed at 7.00 A.M. IST (morning hours) for the period from 1983 to 2015 is being presented in Table-4.22 and Figure-4.34. Highest mean monthly relative humidity of 88.7 per cent at 7.00 A.M. IST was observed during October month followed by September month (87.3%). The lowest relative mean humidity of 83.1 per cent during morning hours was observed during March. Lower R^2 of November (0.09) and December (0.18) shows that the increasing trend in morning relative humidity may not be significant. While moderate R^2 (0.22 to 0.45) exhibits significant increase in early morning relative humidity for rest of the months.

4.3.3 Relative humidity at 2.00 P. M. IST

The monthly mean relative humidity observed at 7.00 A.M. IST (morning hours) for the period from 1983 to 2015 is being presented in Table-4.23 and Figure-4.35. Generally the relative humidity during afternoon hours would be lower than during morning hours because of diurnal solar radiation. Highest mean monthly relative humidity at 2.00 P.M. IST was observed during July (66.4%) and August (66.3%) month followed by October (65.9%) and September month (65.8%). The lowest relative mean humidity of 43.4 per cent was observed during noon hours of March. Lower R^2 at almost all months shows that there exists no significant change in noon relative humidity.

Table-4.22: Monthly mean relative humidity recorded at 7.00 a. m

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1983	74	76	70	65	75	81	84	85	86	81	84	88	79
1984	84	83	82	83	80	82	84	81	85	85	84	75	82
1985	81	82	79	81	82	81	83	85	84	83	84	85	83
1986	82	79	78	82	80	80	82	84	85	82	84	82	82
1987	84	72	70	79	82	79	78	81	82	84	83	83	80
1988	81	79	79	79	83	78	81	82	83	81	81	79	80
1989	75	72	73	67	79	77	78	81	78	83	74	74	76
1990	68	74	80	80	76	85	81	84	84	87	86	89	81
1991	85	87	85	83	87	78	88	89	90	90	88	88	87
1992	86	82	87	87	87	87	86	85	89	90	88	82	86
1993	82	71	88	78	84	88	86	88	86	85	83	85	84
1994	85	89	84	80	84	86	82	80	83	85	81	80	83
1995	80	78	87	85	85	86	84	81	82	83	76	77	82
1996	83	78	67	80	77	77	72	68	80	80	72	72	75
1997	80	70	66	68	69	74	72	72	77	85	83	85	75
1998	86	79	69	79	85	83	87	86	83	85	83	84	82
1999	92	82	89	94	87	91	89	90	86	91	83	90	89
2000	92	90	88	90	88	91	92	92	93	92	91	90	91
2001	92	92	90	89	89	91	89	88	89	90	91	89	90
2002	93	91	89	86	87	90	92	93	88	92	92	92	92
2003	93	94	92	91	91	92	92	91	91	94	92	89	92
2004	91	85	83	89	92	91	92	91	92	93	93	92	90
2005	92	91	87	86	91	89	91	89	94	93	66	90	81
2006	92	88	89	88	92	91	91	90	92	92	91	92	91
2007	92	91	89	87	90	91	92	91	91	93	85	92	90
2008	92	90	87	87	84	90	87	87	90	92	87	90	89
2009	91	89	84	82	84	80	83	89	91	87	91	90	87
2010	87	86	85	85	87	89	88	90	90	92	96	93	89
2011	92	92	85	89	87	87	90	91	88	96	91	93	90
2012	93	86	86	90	93	90	91	92	94	93	94	94	91
2013	92	90	85	87	85	87	87	83	87	84	78	74	85
2014	79	85	83	84	91	93	94	94	95	96	87	83	89
2015	91	78	85	87	90	92	88	87	86	82	86	86	87
MEAN	87.0	83.8	83.1	84.1	85.7	86.3	86.3	86.5	87.3	88.7	85.1	86.0	85.6
MAX	93.1	93.9	91.6	93.6	92.7	92.5	94.0	94.0	95.1	95.8	95.6	93.7	91.9
MIN	68.1	69.5	65.6	65.1	68.6	74.3	71.8	68.4	76.5	79.8	65.5	71.9	75.0
STD	6.4	7.0	7.2	6.7	5.5	5.4	5.6	5.7	4.7	4.8	6.6	6.2	5.0
CV(%)	7.4	8.3	8.7	7.9	6.4	6.3	6.5	6.6	5.3	5.4	7.8	7.2	5.8

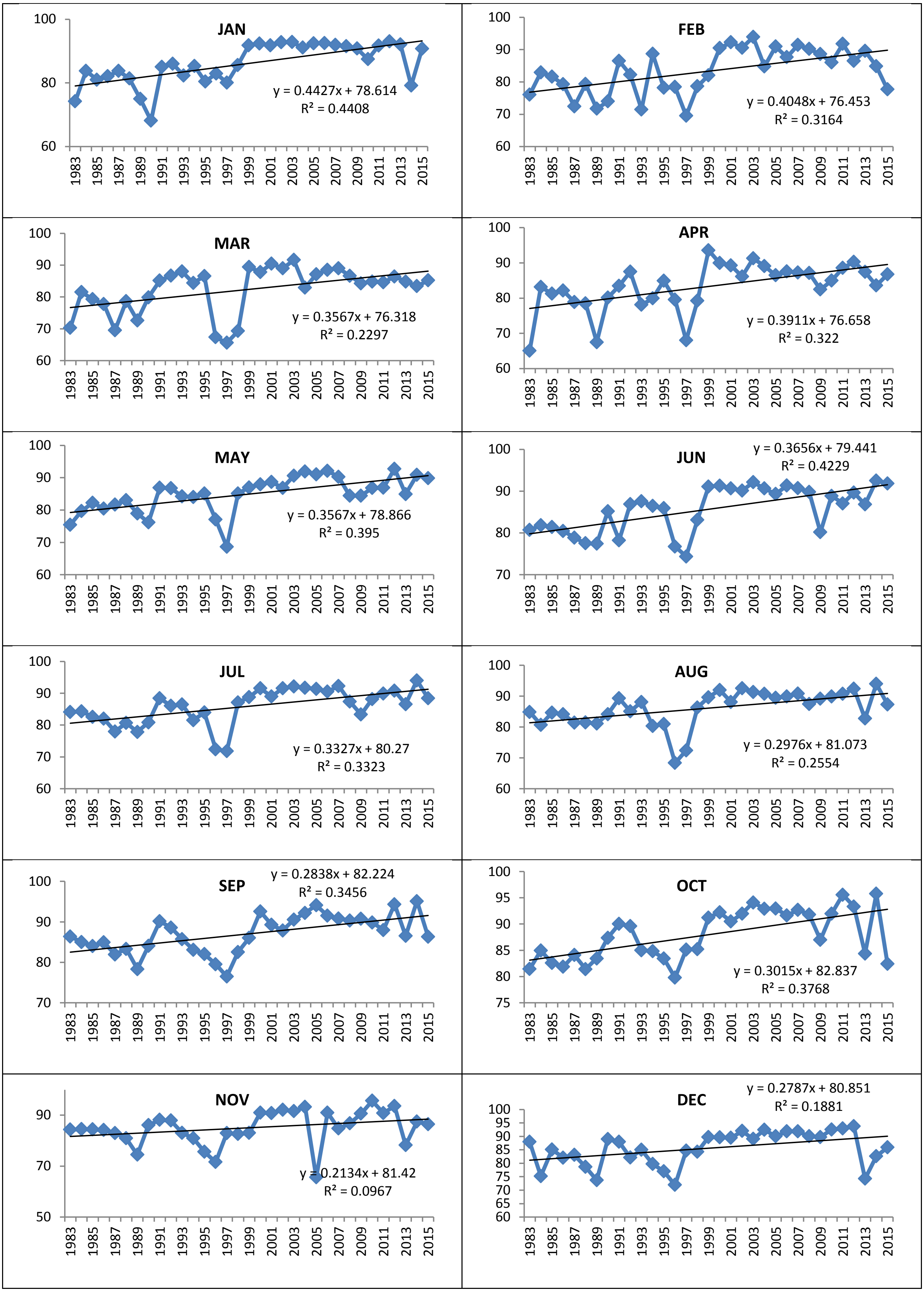

Fig-4.34: Trends in monthly mean relative humidity recorded at 7.00 a. m

Table- 4.23: Monthly mean relative humidity recorded at 2.00 p. m

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1983	43	33	36	53	47	59	69	78	83	77	78	83	62
1984	68	64	48	54	50	77	73	66	70	72	64	49	63
1985	46	41	38	46	46	64	63	64	62	60	53	42	52
1986	44	40	43	48	43	58	56	66	48	54	56	46	50
1987	42	48	36	44	41	55	51	60	51	55	55	61	50
1988	59	41	38	40	54	56	61	75	69	59	75	52	57
1989	51	28	42	41	52	59	66	68	65	68	47	44	52
1990	55	68	43	39	49	51	60	66	52	54	66	72	56
1991	84	76	59	59	70	73	73	66	66	63	62	43	66
1992	51	37	30	42	46	63	71	69	58	75	59	68	56
1993	49	71	56	40	56	69	74	69	68	66	60	69	62
1994	68	47	36	48	57	70	69	70	77	60	54	78	61
1995	75	60	45	49	63	71	78	59	67	72	56	55	63
1996	54	40	38	41	51	52	43	57	62	66	49	53	51
1997	36	35	32	46	47	68	64	57	66	63	75	72	55
1998	71	50	51	81	66	82	72	67	69	73	63	52	66
1999	61	86	90	92	81	80	81	75	74	76	67	67	77
2000	62	64	61	65	69	74	69	78	71	68	63	64	67
2001	61	51	57	59	64	70	73	76	70	73	73	65	66
2002	63	59	52	54	62	70	67	74	69	72	73	95	68
2003	59	56	57	59	59	74	72	68	63	70	65	52	63
2004	50	39	39	57	76	68	73	71	71	70	70	58	62
2005	60	51	51	54	57	61	65	70	78	78	49	50	56
2006	40	32	41	46	57	66	63	58	59	61	62	49	53
2007	50	54	38	37	47	63	67	68	68	66	58	55	56
2008	36	39	42	42	45	56	63	62	59	60	53	50	50
2009	35	30	31	34	47	51	65	61	66	51	61	57	49
2010	45	36	31	43	53	62	66	59	60	63	73	67	55
2011	41	53	27	45	50	73	73	68	76	77	72	53	59
2012	40	34	28	38	43	49	50	55	55	58	51	47	46
2013	66	73	31	36	41	56	60	58	69	66	59	56	56
2014	59	51	36	31	50	57	68	69	64	69	57	56	56
2015	46	36	44	42	54	69	68	67	66	62	70	60	57
MEAN	54.1	49.9	43.4	48.4	55.4	64.5	66.4	66.3	65.8	65.9	62.0	59.4	58.3
MAX	83.7	86.1	89.6	92.1	80.8	82.5	81.5	78.2	83.4	77.8	78.1	95.2	77.5
MIN	34.9	28.3	27.2	30.8	40.5	49.2	42.7	54.9	47.9	51.2	46.7	41.6	45.6
STD	12.1	14.8	12.6	12.8	10.0	8.8	8.1	6.4	7.9	7.3	8.6	12.1	6.8
CV(%)	22.4	29.7	29.0	26.3	18.0	13.7	12.1	9.6	11.9	11.1	13.9	20.3	11.7

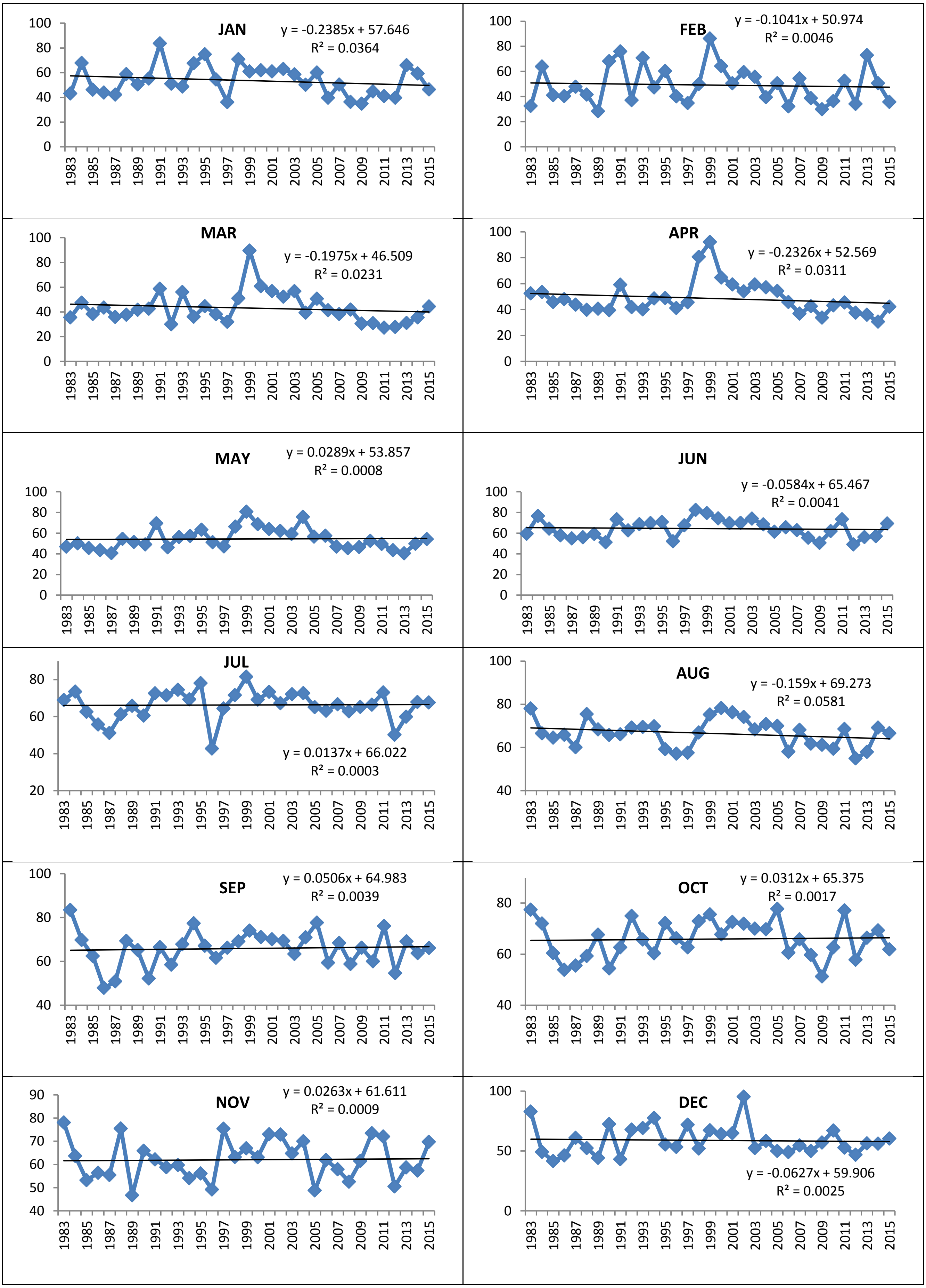

Fig-4.35: Trends in monthly mean relative humidity recorded at 2.00 p. m

4.4 Wind speed

Wind direction and velocity have significant influence on crop growth. Wind influences crop production both physiologically and mechanically. Some of the major beneficialimpact of wind is as follows:

1. Wind increases the turbulence in atmosphere, thus increasing the supply of carbon dioxide to the plants resulting in greater photosynthesis rates.
2. Wind alters the balance of hormones.
3. Wind increases the ethylene production in barley and rice.
4. Wind decreases gibberellic acid content of roots and shoots in rice.
5. Nitrogen concentration in both barley and rice increase with increase in wind speed

4.4.1 Physiological impact:

- Increases transpiration especially cuticular transpiration than stomatal transpiration.
- Hot wind accelerates the drying of the plants by replacing humid air by dry air in inter cellular spaces. For example, rice crop during June-July months shows tip drying.
- Wind increases turbulence in the atmosphere and availability of CO2 and thereby increased photosynthesis.
- Beyond a certain wind speed the rate of photosynthesis becomes constant.

4.4.2 Mechanical impact on plants:

- Strong wind damages the shoots
- Lodging (Paddy, Sugarcane, Banana etc.,)
- Flower and fruit shedding
- Crops and trees with shallow roots are uprooted.
- Cold wind causes chilling injuries
- Causes soil erosion
- Soil deposition causes poor aeration in root zone

4.4.3 Measuring Wind speed

The daily wind speed at a height of 10 feet above the ground level recorded during the years 1993 to 2015 has been used to compute the monthly mean wind speed and tabulated in the table 4.24. On the average, highest wind speed of 7.9 km/hr was in June month followed by July month with 7.6 km/hr and August month with 6.9 km/hr. Lowest mean monthly wind speed of 2.5 km/hr was recorded during November and 2.7 Km/hr in December. Later, the wind speed remains moderate about 3.0 to 3.8 km/hr from January to April. It normally increases from the month of May and reaches maximum during June and July. Generally, the high wind speed is observed during South-West monsoon. Higher C.V per cent clearly says that there exist notable variations from mean monthly values. Mean Wind speed recorded along with its trend is presented in Figure-4.36. R^2 values are less than 0.2 indicating no much change over the period 1993 to 2015.

Table 4.24: Monthly mean wind speed (Km/hr)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1993	3.3	3.1	2.8	4.3	4.7	6.0	5.7	5.3	4.0	3.5	1.6	1.5	3.8
1994	3.8	1.5	3.1	2.5	4.1	5.0	7.3	9.7	5.7	2.9	2.4	1.4	4.1
1995	2.7	1.5	2.9	1.2	2.8	5.5	5.2	1.6	2.3	1.3	2.7	2.9	2.7
1996	3.0	1.3	1.6	2.9	2.2	2.2	1.9	2.9	1.2	2.7	3.0	2.9	2.3
1997	1.2	2.8	2.8	2.6	2.6	2.7	2.1	2.3	1.5	2.8	2.0	2.7	2.3
1999	2.8	4.0	4.3	4.7	7.1	8.6	8.8	9.6	6.4	3.3	2.3	2.5	5.4
2000	2.5	2.2	2.0	2.9	4.4	9.2	9.3	7.6	2.4	1.3	1.6	2.7	4.0
2002	3.2	4.0	4.3	4.7	7.1	8.6	8.8	9.6	6.4	3.3	2.3	2.5	5.4
2003	3.1	3.5	3.8	4.5	7.6	12.6	10.0	8.9	6.8	2.6	2.8	2.8	5.7
2004	3.2	3.6	4.9	4.9	6.5	9.9	8.0	8.9	3.9	3.2	3.3	3.4	5.3
2005	2.8	3.6	4.2	4.2	5.5	9.3	9.7	8.8	6.8	3.0	1.8	2.0	5.1
2006	3.6	3.7	3.5	5.1	6.9	7.7	12.4	9.3	6.6	3.4	2.6	3.5	5.7
2007	3.6	3.9	3.8	4.7	6.8	8.9	9.2	7.9	5.6	2.8	2.2	3.6	5.3
2008	3.3	3.2	3.9	3.8	6.2	9.2	7.7	7.1	4.9	2.2	2.4	3.2	4.8
2009	3.5	3.7	3.8	4.7	6.2	8.8	12.8	7.2	5.9	4.5	3.3	3.3	5.6
2010	3.0	3.2	4.2	3.8	5.3	6.8	2.3	2.0	2.0	2.0	2.0	2.0	3.2
2011	2.8	3.3	3.4	3.7	4.5	8.1	8.1	7.4	7.5	2.6	2.6	2.6	4.7
2012	2.3	3.2	3.5	3.5	4.7	6.6	8.2	8.2	5.4	3.0	2.5	2.6	4.5
2013	2.4	3.3	3.7	4.5	5.3	7.8	7.1	7.6	6.6	4.8	3.2	2.9	4.9
2014	3.0	3.1	3.5	3.6	5.2	7.4	8.2	7.6	7.2	3.7	3.0	3.2	4.9
2015	3.0	2.9	3.7	4.0	4.5	9.1	12.2	5.9	5.4	3.7	3.1	2.4	5.0
MEAN	3.0	3.1	3.5	3.8	5.2	7.6	7.9	6.9	5.0	3.0	2.5	2.7	4.5
MAX	3.8	4.0	4.9	5.1	7.6	12.6	12.8	9.7	7.5	4.8	3.3	3.6	5.7
MIN	1.2	1.3	1.6	1.2	2.2	2.2	1.9	1.6	1.2	1.3	1.6	1.4	2.3
STD	0.6	0.8	0.8	1.0	1.5	2.4	3.1	2.6	2.0	0.8	0.5	0.6	1.1
CV(%)	18.8	26.0	22.1	25.6	29.3	31.2	39.3	37.9	40.4	28.6	20.8	22.6	23.9

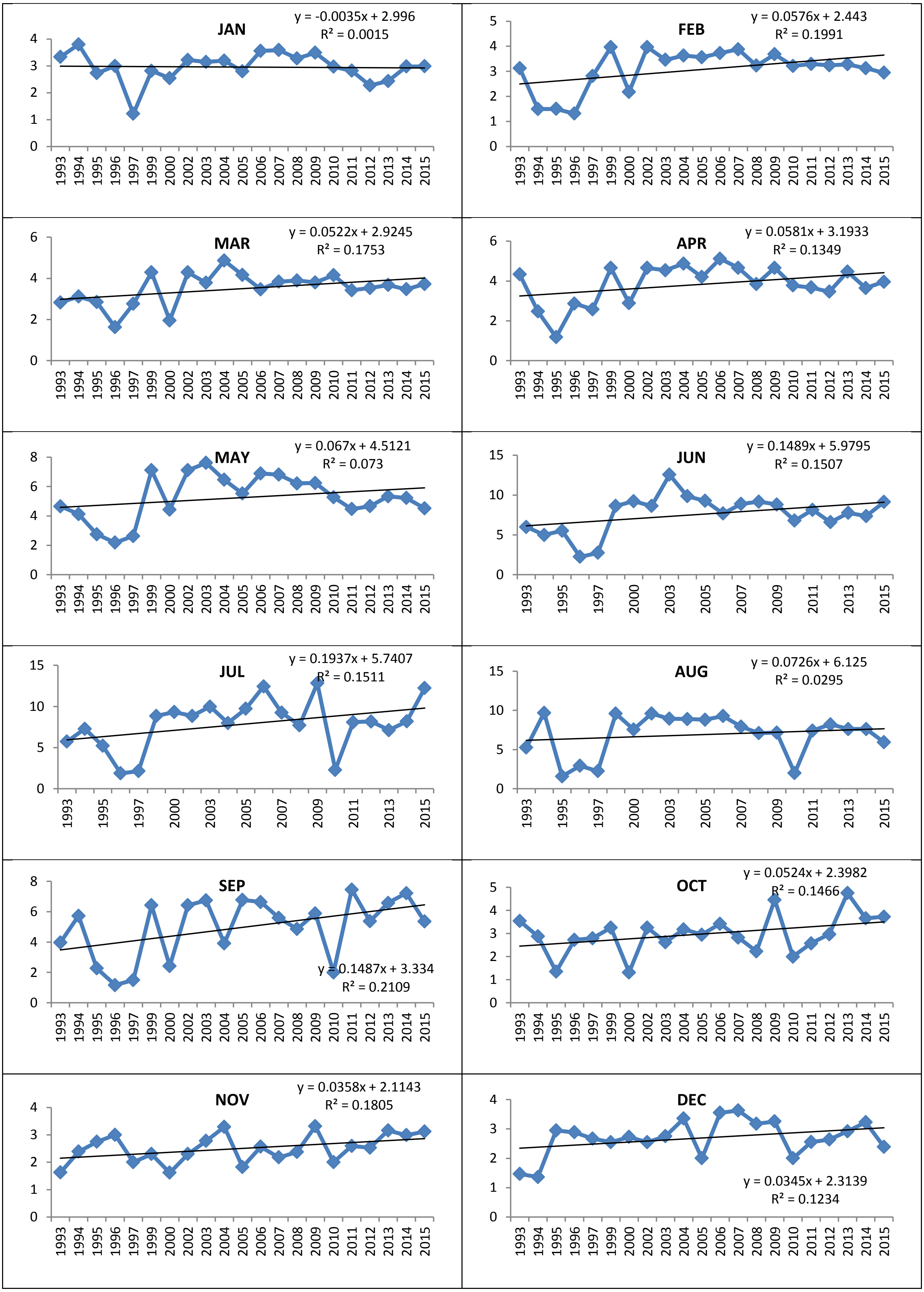

Fig-4.36: Trends in monthly mean wind speed (Km/hr)

4.5 Evaporation

The daily evaporation data has been used to compute the monthly mean evaporation for the period 1983 to 2015 and the same is tabulated in table 4.25 and Figure 4.37. It is observed that March month is having highest mean evaporation of 5.2 mm followed by April month with 5.1 mm. November and December months are having the lowest of 3.5 mm evaporation. Highest evaporation is noticed in summer months followed by south-west monsoon months and lower during North-East monsoon. R^2 values are less than 0.2 indicating no much change over the period 1993 to 2015.

Table-4.25: Monthly mean evaporation(mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1983	3.8	4.8	6.7	7.9	5.7	5.5	4.4	3.1	2.9	3.9	3.9	3.7	4.7
1984	3.7	4.6	5.5	5.6	5.8	3.9	4.5	5.1	4.6	4.4	3.7	3.8	4.6
1985	3.9	4.4	5.2	3.8	4.8	4.2	3.6	4.1	4.4	4.8	3.8	4.3	4.3
1986	3.8	4.2	4.8	5.4	4.5	4.3	3.3	3.9	4.2	3.6	3.5	3.7	4.1
1987	3.3	4.1	4.5	4.7	4.3	3.9	4.3	4.3	4.6	3.6	3.9	3.1	4.0
1988	3.9	4.8	4.6	4.8	3.7	3.3	2.5	2.4	2.4	3.1	3.4	3.8	3.6
1989	4.2	5.0	5.6	5.0	4.0	3.9	4.1	4.1	4.2	4.4	4.7	4.0	4.4
1990	4.0	5.0	5.0	4.8	3.4	4.1	3.3	3.9	4.5	4.0	3.8	4.0	4.1
1991	3.9	4.8	5.0	4.5	4.5	2.8	3.7	3.2	3.2	2.7	3.1	2.8	3.7
1992	2.1	3.3	3.7	4.4	3.8	2.4	1.9	2.6	2.9	3.4	3.4	3.4	3.1
1993	3.8	4.2	4.1	4.7	3.9	4.0	4.3	4.8	4.2	3.1	3.5	3.2	4.0
1994	3.6	4.1	4.2	4.6	4.0	4.0	3.7	4.2	4.1	3.6	4.2	4.4	4.1
1995	4.4	4.7	5.2	4.7	4.4	4.0	3.6	3.3	4.3	3.7	4.0	4.1	4.2
1996	4.4	4.9	5.4	4.7	4.9	3.5	4.4	4.2	4.1	4.2	4.3	3.7	4.4
1997	4.4	5.1	4.9	4.9	4.0	3.9	3.7	4.4	4.3	4.0	3.1	3.9	4.2
1999	4.8	4.6	6.4	5.3	4.1	4.1	4.7	4.8	4.6	3.5	3.4	3.4	4.5
2000	3.8	4.5	5.4	5.2	5.3	4.8	5.3	4.0	5.4	4.9	4.3	4.2	4.8
2001	4.8	5.8	6.2	5.6	5.7	4.2	5.4	5.5	6.0	5.7	5.5	5.0	5.4
2002	3.3	3.1	5.6	6.7	6.5	4.6	4.6	3.8	5.7	3.9	3.0	3.2	4.5
2003	4.2	4.7	5.4	6.5	6.0	5.4	4.5	3.9	4.6	4.6	4.0	3.8	4.8
2004	4.2	4.5	6.2	5.2	3.9	4.3	3.9	4.1	3.5	4.2	3.0	3.6	4.2
2005	3.9	5.2	5.7	4.7	4.8	4.5	4.2	4.2	4.0	3.8	2.5	2.0	4.0
2006	4.0	4.4	4.5	5.4	5.4	3.9	3.1	3.7	4.0	3.5	2.8	2.9	4.0
2007	3.3	4.3	6.2	6.2	5.1	3.8	3.1	3.2	3.0	3.7	3.5	3.3	4.1
2008	3.6	3.7	4.4	4.9	6.0	3.4	3.3	3.2	4.0	3.5	3.6	3.1	3.9
2010	3.8	5.4	6.7	5.7	5.2	3.9	2.8	3.3	3.5	3.3	1.8	3.0	4.0
2011	3.8	5.2	6.1	5.5	6.3	3.5	4.2	3.8	3.6	4.1	3.5	3.2	4.4
2012	3.6	5.0	5.5	5.7	5.1	4.9	5.0	5.1	5.6	3.7	4.3	4.5	4.8
2013	4.2	5.1	6.2	6.5	6.0	4.1	4.4	4.8	4.1	3.8	3.3	3.2	4.6
2014	2.9	2.8	3.9	4.7	4.6	4.1	3.0	2.4	3.0	2.8	3.2	3.0	3.4
2015	2.8	3.1	3.4	3.5	3.5	3.4	3.8	3.9	4.1	3.9	2.3	2.9	3.4
MEAN	3.8	4.5	5.2	5.1	4.8	4.0	3.9	3.9	4.1	3.8	3.5	3.5	4.2
MAX	4.8	5.8	6.7	7.9	6.5	5.5	5.4	5.5	6.0	5.7	5.5	5.0	5.4
MIN	2.1	2.8	3.4	3.5	3.4	2.4	1.9	2.4	2.4	2.7	1.8	2.0	3.1
STD	0.6	0.7	0.9	0.9	0.9	0.6	0.8	0.8	0.9	0.6	0.7	0.6	0.5
CV(%)	14.7	15.7	16.9	17.2	18.6	16.3	20.4	19.6	20.7	16.3	20.6	17.4	11.6

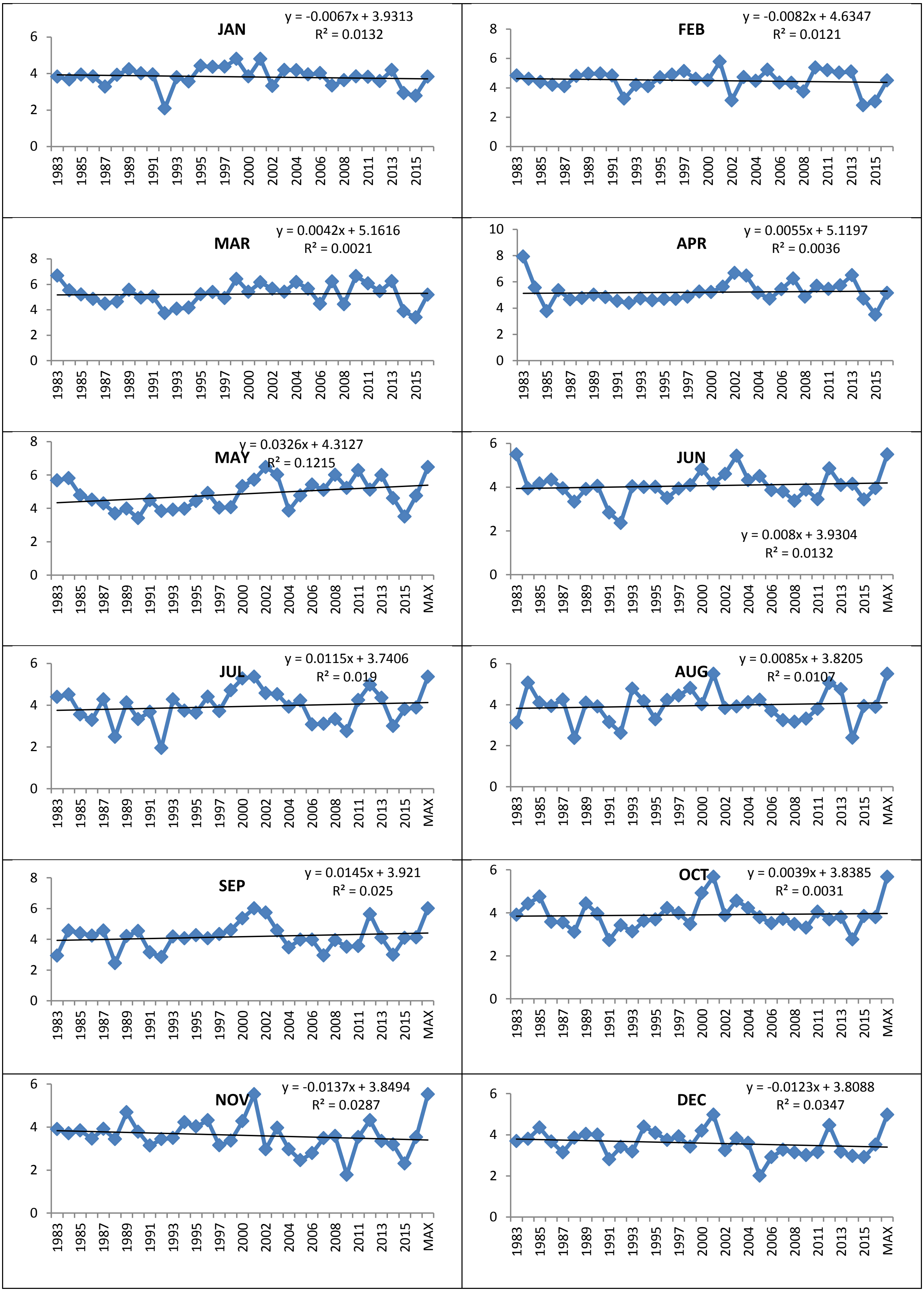

Fig-4.37: Trends in monthly mean evaporation (mm)

4.6 Cloud cover

Understanding how clouds respond to anthropogenic-induced perturbations of our planet's atmosphere is of paramount importance in determining the impact of the ongoing rise in the air's CO2 content on global climate; for as Charlson *et al.* (2001) have noted, "man-made aerosols have a strong influence on cloud albedo, with a global mean forcing estimated to be of the same order (but opposite in sign) as that of greenhouse gases." And because of the great importance of this complex subject, this summary presents a brief review of a number of scientific papers that address various aspects of this crucial issue. Some of the basic points which are relevant, and which are explained later in this paper, include:

- The range of light intensity which we experience can range from more than 2,000 micro-mols per square meter per second (hereafter referred to as a unit) on a sunny day with some clouds in mid-summer to less than a thousandth of a unit under a moonlit sky with a half moon. That is a variation of more than two million times.
- Somewhat similarly, the response of plant growth tends to be related to the logarithm of the light intensity (Blackman and Wilson 1951, Helliwell and Harrison 1979); so, although light which comes directly from the sun may be several times as strong as diffuse light from the rest of the sky, a beam of direct sunlight shining through a gap in a woodland canopy for half an hour might result in an increase in plant growth by a factor of about 2 for that half hour (Helliwell 2012). Taking the day as a whole, this will not result in a very great increase in growth, even though the total measurable amount of light for the day at that point may have been doubled.
- On days with a relatively thin or patchy cloud cover there will be more diffuse of light than from a clear blue sky, as the moisture droplets in clouds reflect more sunlight than air. Consequently, the amount of plant growth in partially shaded locations (where there is direct sunlight for only a small proportion of the time, even on sunny days) is likely to be greater on such days than on a day with a clear blue sky.
- However, if there is a very thick cover of cloud, a greater proportion of the light will be reflected back into space or lost within the cloud, and the amount that reaches the ground will be relatively small; and plants in shaded locations might not receive enough light to grow at all while such conditions persist.
- Diffuse light from a uniformly overcast sky will normally be between 2 and 3 times as strong if it comes from directly above, rather than from close to the horizon. However, the amount of light will be similar from all points of the compass; north, south, east, or west.
- The effect of any beam of light is proportional to the cosine of the angle at which it strikes a flat surface (such as a leaf, a lawn, or a dense group of tree seedlings). This means that the sun on midsummer day in London (when the sun reaches a maximum angle of 62.5º above the horizon) can provide almost as much energy as the sun at the equator on that day (when the sun reaches a maximum angle of 66.5°, or at least 70% as much as in locations close to the tropic of Cancer. In addition, the day length is longer in England than in the tropics, so the total amount of radiation in June will be greater in southern England than at the

equator (given similar cloud conditions). The temperature might be greater at the equator, but there is no more need to wear a pith helmet in the tropics than in London, in order to protect against solar radiation [which is probably why there is little demand for them these days].

• Chlorophyll absorbs more blue and red than green light; which is why most plants look green. As a result of the reflection of light from (and some transmission through) leaves, the spectral composition of light in woodlands becomes altered, and this change can be detected by plants, many of which react by growing taller and thinner (Helliwell, 2011 for a brief review).

• The total increase in biomass of a plant is likely to be related logarithmically to the intensity of light, and arithmetically to the time over which the light is available, assuming that other factors such as temperature and the availability of moisture are favorable.

• The increase in total biomass of the plant is unlikely to be affected by a change in the proportions of red and far-red light, but the shape of the plant may be.

• Plants require energy in order to function, at a basic level, and stay alive, even if they are not putting on any new growth, and a certain amount of daylight is needed to support this. Some types of algae can grow under very low levels of illumination, but most higher plants require at least 3% of full daylight, and some considerably more, in order to survive. This level of illumination is referred to as the "compensation point", when the amount of energy gained by a plant from photosynthesis equals the losses due to respiration, and the logarithmic relationship between the amount of daylight and growth will only apply to amounts greater than this.

• Leaves can transmit a small amount of light; and they will also reflect some light. The amount that is reflected by leaves is not very large, as compared to the amount reflected by snow or a white painted wall, but particularly on a sunny day it can be enough to have some effect on the amount of light received in a woodland glade or in windows on the side of a building which faces away from the sun. The amount of light that is reflected by a tree will be related to the colour and texture of the foliage and to the density of foliage at the edge of the crown. A vigorous young tree, or a neatly trimmed hedge, will reflect more light than a freely grown mature tree with a relatively open branch system, where much of the light will pass between the branches into the crown of the tree and be effectively lost. And foliage of a pale color will reflect more light than darker foliage.

Cloud amount

Cloud amount, is the amount of water vapour present in the atmosphere. It indicates about the chances of raining in that area. The cloud amount is recorded at 7.00 A.M. IST and 2.00 P.M. IST.

4.6.1 Cloud amount at 7.00 A.M. IST

The monthly mean cloud amount observed at 7.00 A.M. IST (morning hours) for the years from 1984 to 2015 is presented in Table-4.26. Highest mean monthly cloud amount of 4 (4.2) Oktas at 7.00 A.M. IST was observed during July and August months followed by June with 4 (4.1) Oktas. The lowest monthly cloud amount of 1 Oktas during morning hours is observed from January to February months.Cloud

Amount recorded at 7.00 A.M. averaged over the period 1984 to 2015 is presented in Figure - 4.38. When observed from the period 1984 to 2015, there exists almost no change in the cloud cover over almost all the months. Though there exists no change, notable continuous fluctuations are observed over the period.

Table 4.26: Monthly mean cloud amount recorded at 7.00 a. m

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1984	2	3	1	2	1	6	5	3	4	3	3	2	3
1985	2	3	1	3	1	4	3	3	4	4	5	3	3
1986	3	0	1	1	3	4	3	4	3	4	3	1	2
1987	1	0	1	0	2	4	3	4	3	4	4	3	3
1988	1	0	1	2	3	5	6	6	5	4	3	2	3
1989	3	3	1	3	4	5	5	5	4	4	3	4	3
1990	2	0	1	1	4	5	6	6	3	5	4	3	3
1991	3	0	0	2	3	6	7	5	4	4	3	5	3
1992	1	3	1	0	2	6	6	6	4	4	4	1	3
1993	1	0	1	1	0	3	4	4	3	4	5	2	2
1994	1	1	0	1	2	5	6	5	5	4	5	1	3
1995	1	0	0	0	3	5	6	5	3	4	4	0	3
1996	1	1	0	3	1	4	5	6	6	5	5	4	3
1997	2	0	1	0	4	5	5	5	4	5	6	6	4
1998	0	1	0	0	2	1	0	0	1	5	4	3	1
1999	1	2	0	1	3	3	4	2	1	2	1	1	2
2000	0	1	0	1	1	3	4	3	2	2	1	2	2
2001	1	2	0	1	2	5	4	4	3	3	3	1	3
2002	1	1	1	1	2	3	2	2	1	2	1	1	2
2003	0	0	1	1	3	3	3	3	2	2	2	0	2
2004	2	0	1	2	4	3	3	3	3	2	2	1	2
2005	2	2	1	2	2	3	3	3	2	3	2	0	2
2006	0	1	1	1	2	3	2	2	3	3	3	1	2
2007	1	1	0	0	2	3	4	4	4	3	2	2	2
2008	1	2	3	2	2	4	4	4	3	2	2	1	2
2009	0	0	2	3	3	4	6	6	6	3	4	4	3
2010	2	1	1	2	3	6	6	6	6	5	6	5	4
2011	1	1	0	3	3	5	4	5	4	4	3	0	3
2012	0	1	0	2	3	4	3	4	3	4	2	1	2
2013	0	1	0	1	2	4	3	3	3	3	2	1	2
2014	0	2	2	2	3	4	4	5	4	5	3	4	3
2015	3	1	2	3	3	4	4	4	5	3	5	3	3
MEAN	1.1	1.0	0.8	1.4	2.4	4.1	4.2	4.2	3.3	3.6	3.2	2.1	2.6
MAX	3.2	2.9	2.8	3.4	4.0	6.3	6.6	6.3	6.3	5.3	6.3	5.7	4.1
MIN	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.6	1.9	1.2	0.0	1.4
STD	0.9	0.9	0.6	1.0	0.9	1.1	1.5	1.5	1.4	0.9	1.4	1.5	0.7
CV(%)	83.7	91.6	83.3	67.6	39.0	28.0	34.5	34.7	41.5	26.0	45.7	72.6	27.1

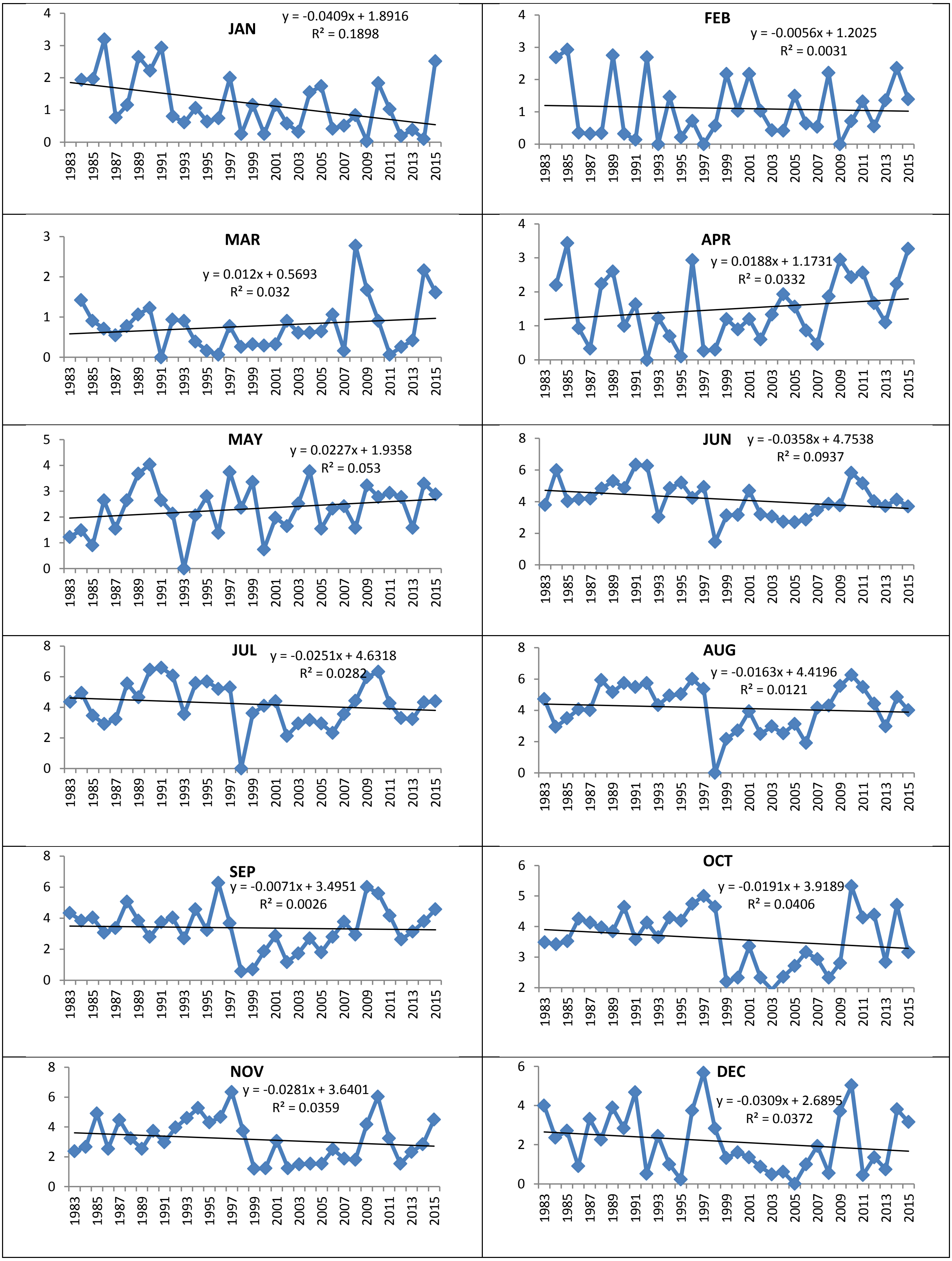

Fig-4.38: Trends in monthly mean cloud amount recorded at 7.00 a. m

4.6.2 Cloud amount at 2.00 P.M. IST

The monthly mean Cloud amount observed at 2.00 P.M. IST (afternoon hours) for the year 1984 to 2015 is presented in Table-4.27. The Cloud amount during afternoon hours is marginally lower than during morning hours because of diurnal solar radiation. The lowest mean monthly Cloud amount of 1 Oktas at 2.00 P.M. IST has been observed during January, February and March months and then it gradually increases from April month reaching the maximum during July and August and then gradually decreases up to March. Mean Cloud Amount recorded at 2.00 P.M. IST for the period 1984 to 2015 is being presented in Figure - 4.39. Cloud Amount at 2.00 P.M exhibit similar behavior as of cloud coverage recorded at 7.00 A.M. When observed from the period 1984 to 2015, there exists almost no change in the cloud cover over almost all the months. Though there exists no change, notable continuous fluctuations are observed over the period.

Table-4.27: Monthly mean cloud amount recorded at 2.00 p. m

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1983					2	4	5	4	5	4	2	4	4
1984	2	2	1	3	2	6	4	3	4	3	3	2	3
1985	2	2	0	4	1	4	4	3	4	4	3	2	3
1986	2	0	0	1	2	4	3	4	3	4	3	1	2
1987	1	0	1	0	2	4	3	4	3	4	4	4	3
1988	1	0	1	2	3	5	5	6	4	4	2	2	3
1989	1	1	1	3	2	5	4	5	4	3	3	3	3
1990	2	0	1	1	4	6	6	5	3	4	3	3	3
1991	3	0	0	2	3	6	7	5	3	4	3	4	3
1992	1	1	0	0	2	5	6	6	4	4	4	0	3
1993	0	0	1	1	0	3	3	4	3	4	4	3	2
1994	1	1	0	1	2	5	5	5	5	4	5	1	3
1995	1	0	0	0	2	5	5	4	3	4	4	0	2
1996	1	0	0	3	1	4	4	6	6	5	4	4	3
1997	2	0	0	0	3	4	5	5	5	4	6	5	3
1998	0	0	0	0	2	3	0	0	0	4	3	3	1
1999	1	1	0	2	3	3	4	2	1	2	1	1	2
2000	0	1	0	1	0	3	4	4	2	3	1	1	2
2001	1	1	0	2	2	6	5	5	2	3	2	1	2
2002	0	0	0	0	2	3	3	3	2	3	1	0	2
2003	0	0	0	1	2	3	4	3	2	1	1	1	2
2004	0	0	1	1	4	3	4	3	3	2	1	0	2
2005	1	1	0	2	1	3	3	3	2	4	1	0	2
2006	0	0	1	1	2	3	4	3	3	3	2	1	2
2007	0	0	0	1	2	4	4	5	5	3	1	2	2
2008	1	1	2	1	1	4	4	4	2	3	2	1	2
2009	0	0	1	1	2	4	6	6	5	2	3	3	3
2010	1	1	1	1	2	5	7	6	5	5	6	4	4
2011	1	1	0	2	2	5	5	5	4	3	3	1	3
2012	0	1	1	1	2	3	2	4	2	3	1	1	2
2013	0	1	1	1	1	4	3	3	4	3	2	0	2
2014	0	2	2	2	4	4	5	5	4	5	3	4	3
2015	3	1	2	4	5	6	6	6	6	4	6	5	5
MEAN	1	1	1	1	2	4	5	4	3	3	3	2	3
MAX	3	2	2	4	5	6	7	6	6	5	6	5	4
MIN	0	0	0	0	0	3	0	0	0	2	1	0	1
STD	0.8	0.6	0.6	1.1	1.0	1.0	1.4	1.3	1.4	0.8	1.4	1.5	0.7
CV(%)	100.0	103.4	106.0	83.4	46.0	23.6	31.5	31.3	40.9	24.4	48.9	79.2	28.0

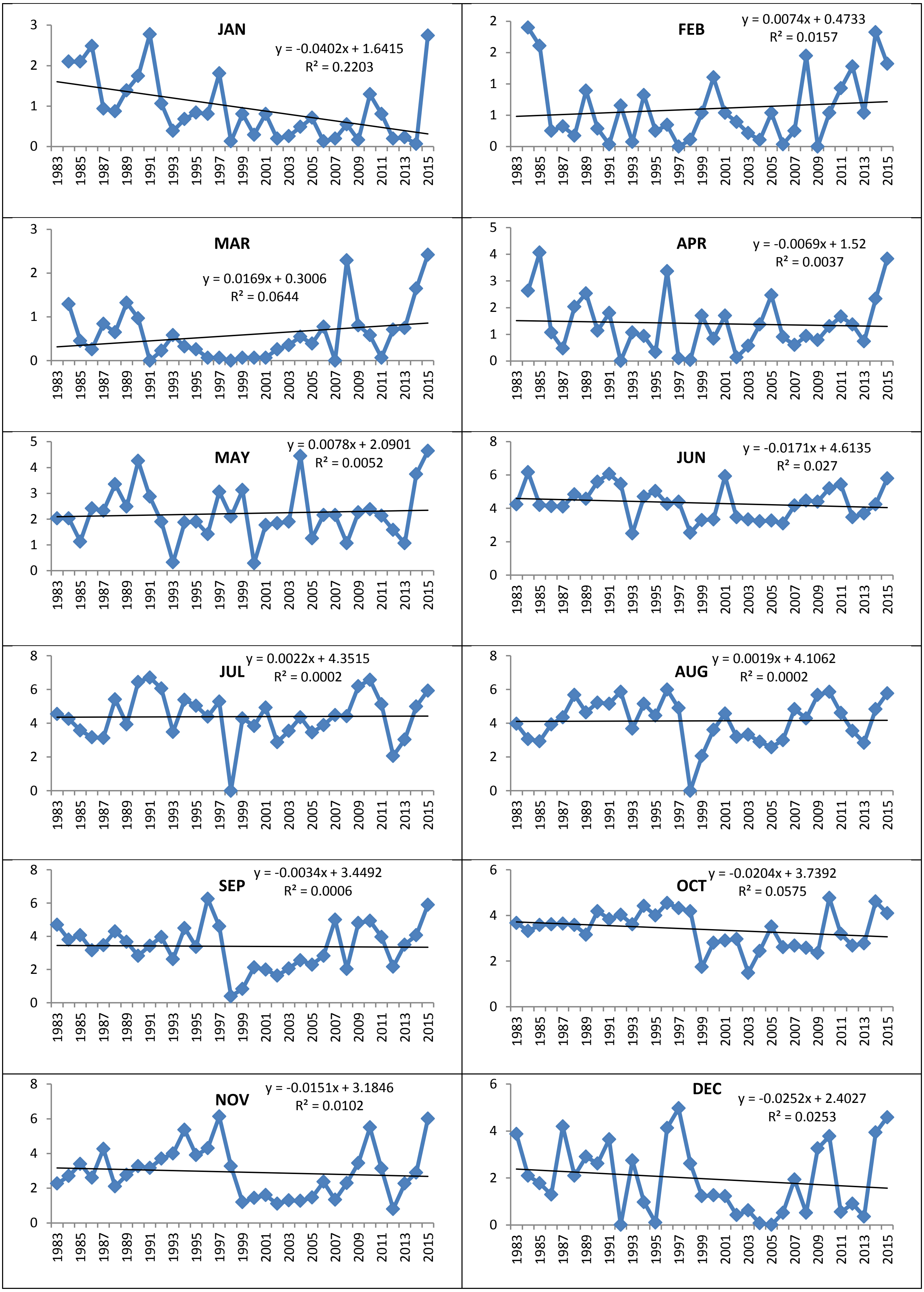

Fig-4.39: Trends in monthly mean cloud amount recorded at 2.00 p.m

4.7 Potential Evapotranspiration (PET)

Potential Evapotranspiration is the maximum amount of soil moisture that a crop canopy and the soil jointly transpire and evaporate under no limiting availability of soil moisture. This is depending on the prevailing weather parameters. The measurement of PET from a grass surface maintained as per specifications is very difficult and time consuming process. However, different approaches to measure the same can be listed as:

1. Water budgeting technique.
2. Direct soil water measurement (Gravimetric, neutron probe, TDR etc).
3. Hydrologic budget (mass balance) method.
4. Lysimetric measurement (Weighing, non-weighing, drainage lysimeters)
5. Indirect meteorological (Bowen ratio and eddy correlation) methods.
6. Chamber techniques.
7. Biological (Sap flow technique, porometer, photometer) methods.
8. Passive (Pan Evaporation) methods.

A major drawback to application of the most popular Penman-Monteith (PM) method in estimating PET, however, is the relatively high data demand, where the method requires air temperature, wind speed, relative humidity and solar radiation data. The limitation of reliable data motivated Hargreaves et al. (1985) to develop an alternative approach where only mean maximum and mean minimum air temperature and extraterrestrial radiation are required. The Hargreaves (HG) method has been tested using some high quality lysimeter data representing a broad range in climatological conditions (Hargreaves 1994). The results have indicated that this equation was nearly as accurate as PM in estimating ET0 on a weekly or longer time step, and was therefore recommended in cases where reliable data were lacking. Allen et al. (1998) and Temesgen et al. (1999) have indicated that except for extreme situations HG method estimates PET with higher accuracy which is on par with PM method. High humidity conditions may result in an overestimation by HG of ET0 and that conditions with high wind speed may result in an underestimation of ET0. Using the daily temperature, daily Potential Evapotranspiration (PET) values have been computed using Hargreaves method (Hargreaves et. al., 1985)for the period from 1992 to 2015, later monthly mean values are tabulated in table 4.28. The value of R_A on any given day was deduced from the Table 2 of Doorenbos and Pruitt (1977).

$$\mathbf{PET = 0.0023 R_A\, T_D^{0.5}\, (T_m+17.8)}$$

Where, R_A = extra-terrestrial radiation (mm day^{-1}); T_D = difference between maximum and minimum temperature (°C); T_m = mean temperature (°C)

It was observed that PET was high during February to May months which exceed 5 mm a day and lowest during monsoon months, i.e. during June to August months. Mean annual PET was about 4.8 mm. At this rate the annual PET was about 1771 mm. Monthly mean PET recorded over the years is presented in Fig-4.40. Moderate R^2 values explain that the increasing trend of monthly PET could be significantly notable in near future.

Table-4.28: Monthly mean PET (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	3.1	4.1	5.1	5.8	5.4	4.4	3.7	3.8	4.0	3.7	3.6	3.0	4.1
1993	3.3	4.4	4.8	3.2	3.0	3.4	3.7	3.7	3.1	3.7	3.5	3.1	3.4
1994	3.3	3.5	4.7	5.0	5.4	3.8	3.5	4.2	2.3	4.4	2.9	3.1	3.5
1995	3.9	4.8	5.5	5.9	5.7	5.4	5.4	4.6	4.2	4.5	4.6	4.0	4.7
1996	4.2	4.9	5.9	5.7	6.4	5.5	4.3	4.8	4.7	4.7	4.4	3.9	4.7
1997	4.0	5.0	6.0	6.2	5.6	4.9	4.3	4.2	4.5	4.0	3.5	3.3	4.6
1998	4.2	5.0	5.6	5.7	4.9	4.2	3.7	3.7	4.0	3.7	3.6	3.5	4.0
1999	4.4	4.9	5.7	6.0	5.1	4.5	4.4	4.4	4.6	4.2	4.2	3.9	4.7
2000	4.4	4.9	5.7	5.8	5.7	4.6	4.5	4.4	4.5	4.4	4.3	3.8	4.7
2001	4.4	5.4	5.9	5.6	5.7	5.0	4.6	4.5	5.1	4.5	4.0	4.0	4.9
2002	4.6	5.1	6.3	6.1	6.1	5.1	5.1	4.7	5.2	4.4	4.3	4.5	5.1
2003	4.6	5.4	6.1	6.3	6.5	5.4	5.0	4.9	5.1	4.6	4.2	4.3	5.1
2004	4.6	5.6	6.6	6.3	5.1	5.0	4.7	4.6	4.7	4.5	4.1	4.4	4.9
2005	4.5	5.2	5.9	5.9	6.1	5.0	4.7	4.6	4.7	4.4	4.1		4.3
2006	4.6	5.5	5.8	6.5	6.2	5.2	4.9	5.0	5.0	4.8	4.4	4.4	4.9
2007	4.7	5.3	6.4	6.7	6.4	5.5	5.1	5.1	5.2	5.1	4.7	4.2	4.7
2008	4.7	4.9	5.4	6.1	6.3	5.2	5.1	4.9	5.1	5.1	4.7	4.4	5.0
2009	4.7	5.6	6.0	6.5	6.1	5.4	4.5	4.8	4.7	4.8	4.2	4.1	5.1
2010	4.6	5.5	6.3	6.3	6.0	5.2	4.8	4.7	4.8	4.6	3.9	4.0	4.9
2011	4.6	5.0	6.0	5.9	6.0	4.9	5.1	4.8	5.0	5.0	4.3	4.2	4.4
2012	4.7	5.6	6.3	6.4	6.1	5.5	5.3	5.2	5.3	4.9	4.6	4.5	4.8
2013	5.0	5.5	6.5	7.0	6.8	5.3	5.0	5.5	4.9	4.2	4.0	3.6	5.0
2014	4.1	4.9	5.6	6.5	6.2	6.0	6.1	4.6	4.3	4.3	4.1	3.8	5.0
2015	4.1	4.9	5.8	5.9	5.2	4.1	4.4	4.4	4.4	4.4	3.7	3.6	4.6
Mean	4.3	5.0	5.8	6.0	5.7	4.9	4.7	4.6	4.6	4.5	4.1	3.9	4.8
Max	5.0	5.6	6.6	7.0	6.8	6.0	6.1	5.5	5.3	5.1	4.7	4.5	5.1
Min	3.1	3.5	4.7	3.2	3.0	3.4	3.5	3.7	2.3	3.7	2.9	3.0	3.4
STD	0.5	0.5	0.5	0.7	0.8	0.6	0.6	0.4	0.7	0.4	0.4	0.5	0.5
CV(%)	11.4	9.9	8.2	12.2	13.1	12.5	13.2	9.7	15.2	8.8	10.6	11.7	9.6

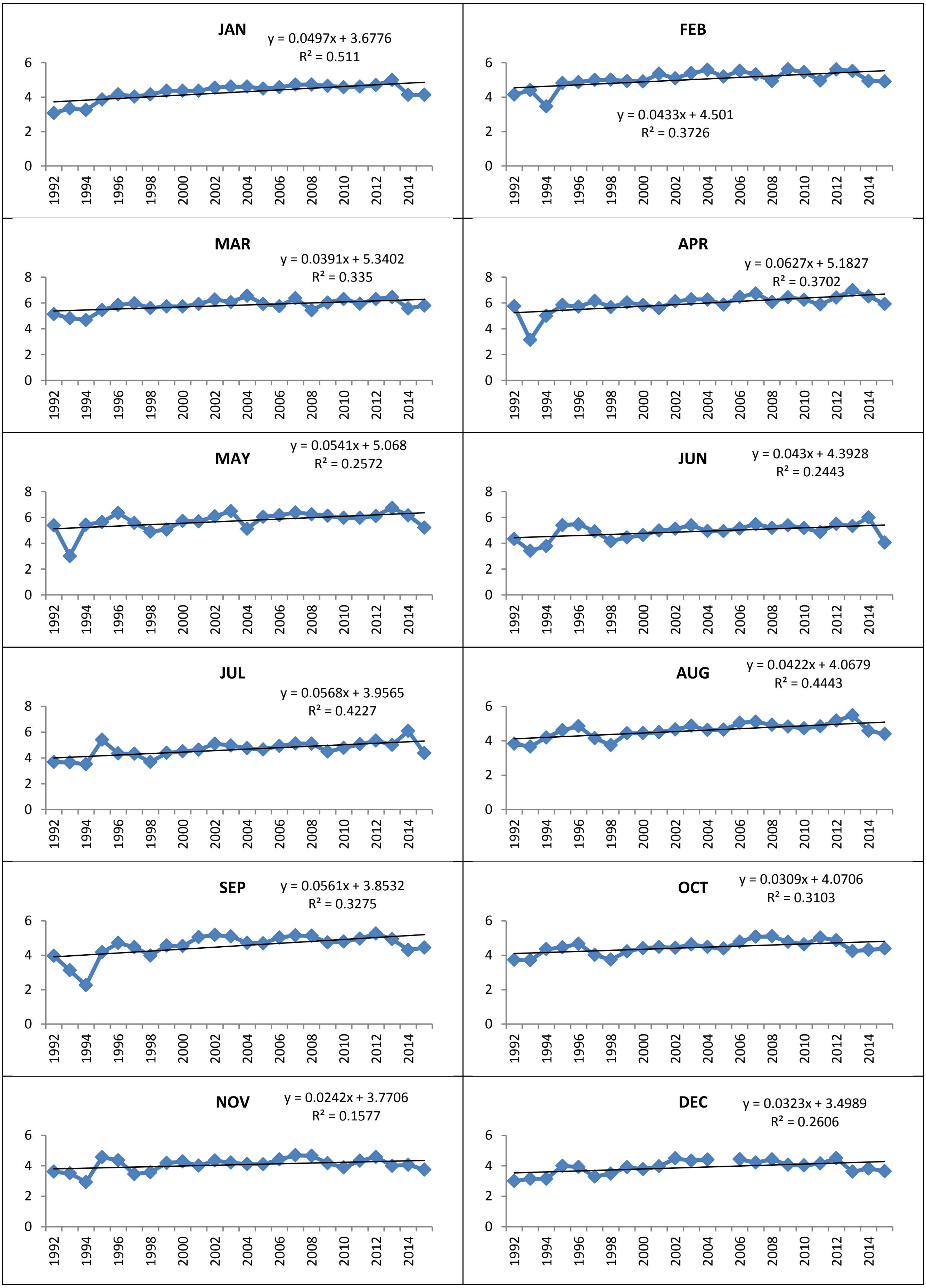

Fig-4.40: Monthly mean PET (mm)

4.8 Normal monthly weather parameters

Statistics calculated over standard periods (commonly a 30 year interval) are often called climate normals, and are generally used as reference values for comparative purposes. The period is long enough to include the majority of typical year to year variations in the climate, but not so long that it is significantly influenced by longer-term changes in climate. The current reference climate normal is generated over the period as mentioned in the table 4.29.

Climate normals can be used to assess how typical of the current climate a particular event was. For example, the difference between the average temperature for a calendar year at a site and the climate normal average temperature - the anomaly - can be used to indicate whether that year was relatively 'hot' or 'cool'. Normals are not just useful in comparing changes in climate over a long period, but also categorizing, defining and classifying climates into similar regimes.

Table-4.29: Normal weather parameters of Naganahally research station

Months/ Parameter	Rainfall (mm) (1983-15)	Rainy day (1983-15)	Max Temp °C (1987-15)	Min Temp °C (1992-15)	Wind Speed (Km/hr) (1993-15)	Evaporation (mm) (1983-15)	Rel Hum (%) I hr (1983-15)	Rel Hum (%) II hr (1983-15)	Cloud amount I hr (1984-15)	Cloud amount II hr (1984-15)
Jan	6.3	0	29.2	15.5	3.0	3.8	87.0	54.1	1.1	0.8
Feb	6.7	0	31.7	17.3	3.1	4.5	83.8	49.9	1.0	0.5
Mar	18.8	1	34.0	19.7	3.5	5.2	83.1	43.4	0.8	0.6
Apr	55.7	4	34.8	21.5	3.8	5.1	84.1	48.4	1.4	1.3
May	105	6	33.9	20.8	5.2	4.8	85.7	55.4	2.4	2.3
June	67.1	6	30.7	20.5	7.6	4.0	86.3	64.5	4.1	4.3
July	51.1	5	29.5	19.9	7.9	3.9	86.3	66.4	4.2	4.5
Aug	63.9	6	29.0	19.6	6.9	3.9	86.5	66.3	4.2	4.2
Sep	110	7	29.7	19.8	5.0	4.1	87.3	65.8	3.3	3.3
Oct	149.5	8	29.7	19.3	3.0	3.8	88.7	65.9	3.6	3.4
Nov	52.8	4	28.3	17.6	2.5	3.5	85.1	62.0	3.2	3.0
Dec	11.3	1	27.9	15.6	2.7	3.5	86.0	59.4	2.1	1.9
Annual	698.1	48	30.7	18.9	4.5	4.2	85.6	58.3	2.6	2.5

4.9 Soil water balance

Mean weekly climatic water balance for the period 1992 to 2015 has been computed, using Thornthwaite and Mather's method (1955, 1957). The water balance has been worked out taking the soil available water capacity (AWC) of 90 mm from 60 cm soil depth. Table 4.30 gives the weekly water rainfall (mm), PET (mm), water storage (mm), change in water storage (mm), AET (mm) and runoff (mm). The change in water storage takes place whenever there is depletion in soil moisture due to Evapotranspiration or addition of soil moisture due to rainfall.

The Actual Evapotranspiration (AET) is the actual quantum of the soil water evaporated from the soil beneath the crop canopy and the moisture that transpired from the plant canopy or crop canopy under the field condition.

The runoff is the excess rainwater that flows after the soil is fully recharged to the saturation level. Some time, if the intensity of rainfall is high and the field has high slope there will be a runoff even before the soil saturates fully.In order to track changes in soil moisture, several intermediary values are calculated, including precipitation minus potential evapotranspiration (P-PE), accumulated potential water loss (APWL), actual evapotranspiration, soil-moisture surplus, and soil-moisture deficit. These terms are described below.

➢ P minus PE (P – PE) — The first step in calculating a new soil moisture value for any given grid cell is to subtract potential evapotranspiration from the daily precipitation (P – PE). Negative values of P – PE represent a potential deficiency of water, whereas positive P – PE values represent a potential surplus of water.

➢ Accumulated Potential Water Loss (APWL) — The accumulated potential water loss is calculated as a running sum of the daily P – PE values during periods when P – PE is negative. This running sum represents the total amount of unsatisfied potential evapotranspiration to which the soil has been subjected. Soils typically yield water more easily during the first days in which P – PE is negative. On subsequent days, as the APWL grows, soil moisture is less readily given up. Note that the accumulated potential water loss can grow without bound; it represents the cumulative daily potential water loss given the potential evapotranspiration and observed precipitation.

➢ Δ soil moisture —The soil-moisture term represents the amount of water held in soil storage for a given grid cell. Soil moisture has an upper bound that corresponds to the soils' maximum water-holding capacity (roughly equivalent to the field capacity); soil moisture has a lower bound that corresponds to the soils' wilting capacity. When P – PE is positive, the new soil-moisture value is found by adding this P – PE term directly to the preceding soil-moisture value. If the new soil-moisture value is still below the maximum water-holding capacity, the Thornthwaite-Mather soil-moisture tables are consulted to back-calculate a new, reduced accumulated potential water-loss value. If the new soil-moisture value exceeds the maximum water holding capacity, the soil-moisture value is capped at the value of the maximum water-holding capacity, the excess moisture is converted to recharge, and the accumulated potential water loss term is reset to zero. When P – PE is negative, the new soil-moisture term is found by looking up the soil-moisture value associated with the current accumulated potential water-loss value in the Thornthwaite-Mather tables.

➢ Actual ET — When P – PE is positive, the actual evapotranspiration equals the potential evapotranspiration. When P – PE is negative, the actual evapotranspiration is equal only to the amount of water that can be extracted from the soil (Δ soil moisture).

➢ Soil moisture SURPLUS — If the soil moisture reaches the maximum soil-moisture capacity, any excess precipitation is added to the daily soil-moisture surplus value. Under most conditions, the soil-moisture surplus value is equivalent to the daily groundwater recharge value.

The runoff depends on the intensity of the rainfall, duration, condition of the soil, drainage capacity of the soil, slope of the land and the cropping pattern. Fig. 4.41 indicates the mean weekly values of the all the parameters. Sowing date should be selected such that this saturation period coincides with the grand growth period or maximum water requirement period. PET was met in the weeks between 35^{th} and 48^{th} SMW. It is observed that out of the mean total AET of 698.1 mm (mean of 1983-2015), 698.1 mm is met by rainfall with no run off.

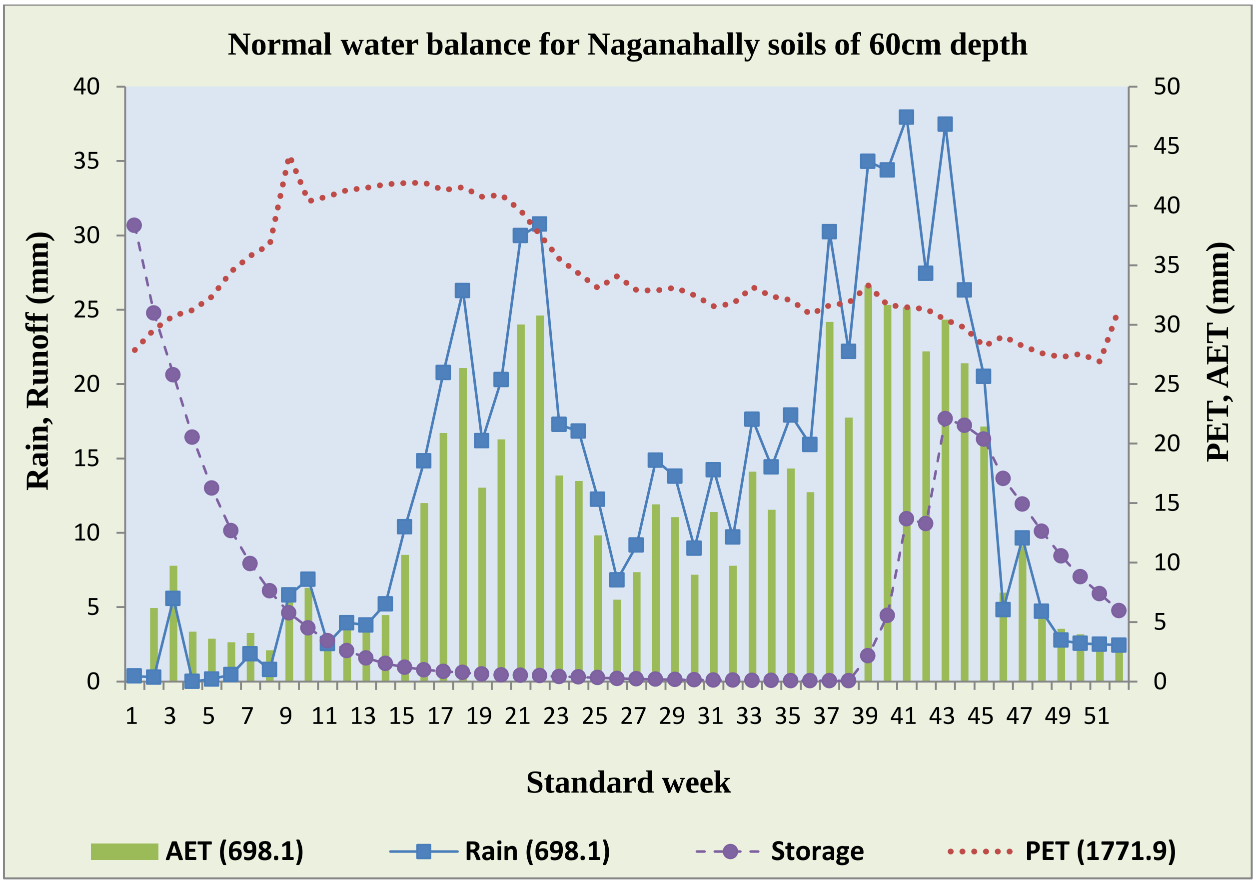

Fig-4.41: Normal water balance for Naganahally soils at 60cm depth

Table-4.30: Weekly climatic water balance with AWC=137.2 mm for 60 cm soil depth.

Week	Net Rain	PET	P- PET	Acc.Pwl	Storage	Ds	AET	Runoff
			(Pwl)	-178	4.8			
1	0.4	27.9	-27.5	-205.5	30.7	0	0	0.0
2	0.3	29.6	-29.3	-234.8	24.8	5.9	6.2	0.0
3	5.6	30.7	-25.2	-260.0	20.6	4.2	9.7	0.0
4	0.0	31.2	-31.2	-291.2	16.4	4.2	4.2	0.0
5	0.2	32.4	-32.2	-323.4	13.0	3.4	3.6	0.0
6	0.5	34.5	-34.0	-357.4	10.1	2.9	3.3	0.0
7	1.9	35.8	-34.0	-391.3	7.9	2.2	4.1	0.0
8	0.8	36.7	-36.0	-427.3	6.1	1.8	2.6	0.0
9	5.8	44.3	-38.4	-465.7	4.6	1.5	7.3	0.0
10	6.9	40.4	-33.5	-499.2	3.6	1.0	7.9	0.0
11	2.6	40.8	-38.2	-537.4	2.7	0.9	3.4	0.0
12	3.9	41.3	-37.4	-574.8	2.1	0.7	4.6	0.0
13	3.8	41.5	-37.7	-612.5	1.6	0.5	4.3	0.0
14	5.2	41.8	-36.6	-649.1	1.2	0.4	5.6	0.0
15	10.4	41.9	-31.5	-680.6	1.0	0.2	10.6	0.0
16	14.8	41.9	-27.1	-707.7	0.8	0.2	15.0	0.0
17	20.8	41.3	-20.5	-728.2	0.7	0.1	20.9	0.0
18	26.3	41.6	-15.3	-743.5	0.6	0.1	26.4	0.0
19	16.2	40.7	-24.5	-768.0	0.5	0.1	16.3	0.0
20	20.3	40.9	-20.6	-788.6	0.4	0.1	20.4	0.0
21	30.0	39.6	-9.6	-798.2	0.4	0.0	30.0	0.0
22	30.8	37.6	-6.8	-805.0	0.4	0.0	30.8	0.0
23	17.3	35.5	-18.2	-823.3	0.3	0.0	17.3	0.0
24	16.8	34.3	-17.5	-840.7	0.3	0.0	16.9	0.0
25	12.3	33.1	-20.8	-861.5	0.3	0.0	12.3	0.0
26	6.8	34.1	-27.2	-888.8	0.2	0.0	6.9	0.0
27	9.2	32.9	-23.7	-912.5	0.2	0.0	9.2	0.0
28	14.9	32.9	-18.0	-930.5	0.2	0.0	14.9	0.0
29	13.8	33.1	-19.3	-949.8	0.1	0.0	13.8	0.0
30	9.0	32.5	-23.5	-973.3	0.1	0.0	9.0	0.0
31	14.2	31.6	-17.3	-990.6	0.1	0.0	14.3	0.0
32	9.7	31.8	-22.1	-1012.7	0.1	0.0	9.7	0.0
33	17.6	33.2	-15.5	-1028.2	0.1	0.0	17.6	0.0
34	14.4	32.4	-18.0	-1046.2	0.1	0.0	14.4	0.0
35	17.9	32.1	-14.2	-1060.3	0.1	0.0	17.9	0.0
36	15.9	30.9	-15.0	-1075.3	0.1	0.0	15.9	0.0
37	30.2	31.6	-1.4	-1076.7	0.1	0.0	30.2	0.0
38	22.2	31.8	-9.7	-1086.3	0.0	0.0	22.2	0.0
39	35.0	33.3	1.7	-600.2	1.7	-1.7	33.3	0.0
40	34.4	31.7	2.7	-470.4	4.4	-2.7	31.7	0.0
41	37.9	31.5	6.5	-347.1	10.9	-6.5	31.5	0.0
42	27.4	31.3	-3.9	-351.0	10.6	0.3	27.7	0.0
43	37.5	30.4	7.0	-281.2	17.7	-7.0	30.4	0.0
44	26.3	29.8	-3.4	-284.6	17.2	0.4	26.8	0.0
45	20.5	28.2	-7.7	-292.3	16.3	0.9	21.4	0.0
46	4.8	29.0	-24.2	-316.5	13.7	2.6	7.5	0.0
47	9.6	28.2	-18.6	-335.1	11.9	1.7	11.4	0.0
48	4.7	27.6	-22.9	-358.0	10.1	1.8	6.5	0.0
49	2.8	27.3	-24.5	-382.5	8.4	1.7	4.4	0.0
50	2.6	27.5	-25.0	-407.5	7.0	1.4	4.0	0.0
51	2.5	26.9	-24.4	-431.8	5.9	1.1	3.7	0.0
52	2.4	31.4	-28.9	-460.8	4.8	1.1	3.6	0.0
	698.1	1771.9					698.1	0.0

CHAPTER - V

SUMMARY

An "Agro-climatic zone" is a land unit in terms of major climates, suitable for a certain range of crops and cultivars. Agro-climatic conditions mainly refer to soil types, rainfall, temperature and water availability which influences the type of vegetations. The book has been drafted to characterize the Agroclimate of Southern Dry Zone, which is useful for research, planning and extension purpose.

5.1 Zone re-delineation

In view of the climate change, the NARP zones delineated long back need to be modified. Hence, re-delineation of agro climatic zones of Southern Karnataka have been attempted, where in the taluks which do not match with the existing zone have been detached and added to the zones matching the rainfall, topography, crops and cropping systems.

Considering taluk borders and other soil characteristics, results from k-mean cluster analysis and field data on cropping systems Koratagere has been detached from Central Dry Zone and attached to Eastern Dry Zone. While, Tiptur and Arasikere have been detached from Central Dry Zone and attached to Southern Dry Zone.

5.2 Sub zone delineation based on Length of Growing Period (LGP)

LGP is an important criteria particularly needed for subdivision of zones keeping in view of the aridity and cropping system. Within a zone, wherever the LGP is less, monocropping or intercropping has been suggested. Whereas, the taluks which have more LGP have been regrouped and suggested with the double cropping systems.

5.3 Crop weather calendars (CWC)

Crop weather calendars for the dominant crops of the zone have been worked out for Mandya, Mysore, Tumkur, Hassan and Chamarajanagar districts and have been depicted pictorially involving the weather information and different stages of crops coinciding different standard weeks. Besides these, a detailed crop weather calendar has been worked out for two sowing windows of finger millet depicting the information on normal weather, favorable weather for different phenophases and congenial weather for pest and disease incidences and build up.

5.4 Climatic features and trend analysis of agromet field unit (AMFU) Naganahally

AMFU Naganahally is also an organic farming research station for Southern Karnataka. The historical weather data of the station is grouped and analyzed in-depth, for all the weather components of Southern dry zone in general and AMFU Naganahally in particular. Trend analysis of weather parameters have also been made and inferred accordingly.

REFERENCES

BLACKMAN, G.E. AND WILSON, G.L.,1951, Physiological and ecological studies in the analysis of plant environment. *Annals of Botany, New Series*, **15** (57): 63-94.

CHARLSON, R.J., SEINFELD, J.H., NENES, A., KULMALA, M., LAAKSONEN, A. AND FACCHINI, M.C., 2001, Reshaping the theory of cloud formation.*Science*, **292**: 2025-2026.

DOORENBOSS, J. AND W.O., PRUITT,1977,FAO Guidelines for predicting crop water requirements. Irrigation and drainage. **24** (2): 156-157.

HARGREAVES, G.L., HARGREAVES, G.H. AND RILEY, J.P., 1985, Agricultural benefits for Senegal river basin. *J. Irrig. and Drain. Engr*., ASCE **111**(2): 113-124.

HARGREAVES, G.H., 1994, Defining and using reference evapotranspiration. *J. Irrig. and Drain. Engrg*., ASCE **120**(6): 1132-1139.

HELLIWELL, D.R. AND HARRISON, A.F.,1979, Effects of light and weed competition on the growth of seedlings of four tree species on a range of soils.*Quarterly J. Forestry*,**73**:160-171.

HELLIWELL, R.,2011, Quality of light in woodlands. *Continuous Cover Forestry Group Newsletter.*,**31:** 8-9.

HELLIWELL, R., 2012, Plantgrowth and daylight in woodland.*Quarterly J. Forestry*,106, 37-42.

HIGGINS, G.M. & Kassam, A.K., 1981, FAO-agro ecological zone approach to determining of land potential. *Pedologie*,**31**(2): 147-168.

PETER DROOGERS.ANDRICHARD, G.,2002,Allen Irrigation and Drainage Systems- Estimating reference evapotranspiration under inaccurate data conditions.,Kluwer Academic Publishers. Netherlands., **16**: 33-45.

TEMESGEN, B., ALLEN, R.G. AND JENSEN, D.T., 1999, Adjusting temperature parameters to reflect well-water conditions. *J. Irrig. and Drain. Engg.*, ASCE **125**(1): 26-33.

THORNTHWAITE, C.W. AND MATHER, J.R., 1955, The water balance: Centerton, N.J., Laboratory of Climatology.*Climatology*.,**8**(1):1-104.

THORNTHWAITE, C.W. AND MATHER, J.R., 1957, Instructions and tables for computing potential evapotranspiration and the water balance: Centerton, N.J., Laboratory of Climatology.*Climatology*., **10**(3):185-311.

RAO, V.U.M., SUBBA RAO,A.V. M., SARATH CHANDRAN, M. A., PRABJYOTH KAUR, P., VIJAY KUMAR, B. BAPUJI RAO, I.R., KHANGONDA, C. H., SRINIVAS RAO AND SHIVARAMU, H.S., 2015, District level crop weather calendars of major crops in India,Directorate of CRIDA, Hyderabad, India