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Markov chain model probability of dry, wet weeks during moonson period over Andhra Pradesh

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सार — कृषि योजना के लिए शुष्क व आर्द्र अवधियों के अनुक्रम को जानना आवश्यक है। इस हेतु एक सप्ताह की अवधि को अनुकूलतम समय माना जा सकता है। फसलों की सफलता या असफलता, मुख्यतः वर्षा पर निर्भर अवस्था में, वर्षा के ढांचे पर आधारित होती है। इस अध्ययन में मार्कोव श्रृंखला निदर्शक पद्धति से आन्ध्र प्रदेश में मानसून अवधि में शुष्क व आर्द्र सप्ताह और 2 या 3 पास-पास के (अविच्छिन्न) सप्ताह शुष्क व आर्द्र होने की संभावना की जानकारी के लिए उपयोग किया गया।

ABSTRACT. For agricultural planning, it is important to know the sequence of dry, wet periods. For this purpose a week period may be taken as the optimum length of time. The success or failure of crops particularly under rainfed conditions is closely linked with the rainfall patterns. In this study the Markov chain model method has been applied to know the probability of having a dry or a wet week and consecutive dry or wet periods of 2 or 3 weeks during monsoon period over Andhra Pradesh.

Key words — Markov chain model, Dry and wet periods, Monsoon, Correlation probability

1. Introduction

The knowledge of climate and weather is being increasingly used in various agricultural activities. The success or failure of crops, particularly under rainfed conditions, is closely linked with the rainfall patterns. Simple criteria related to sequential phenomennon like dry and wet spells could be used for analysing rainfall data to obtain specific information needed for crop planning and for carrying out agricultural operations (Sastry 1976). For planning purposes it is important to know the sequence or persistence of dry, wet periods.

Markov chain probability model has been found suitable to describe the long term frequency behaviour of wet or dry weather spells (Gabriel and Neuman 1962, Victor and Sastry 1979). The Markov chain conditional probability model has been accepted as fully justified in the analysis of weekly rainfall data and a number of research workers have demonstrated its practical utility in agricultural planning, both for a long term and a short term period such as a week. When applied to periods like a week, this model enables the determination of probability of occurrence of dry or wet weather during a particular week depending on the weather conditions during the preceding week. Results based on the Markov chain analysis have been successfully applied in India in farm] management (Sarker 1988).

2. General features of Andhra Pradesh

Andhra Pradesh lies between latitudes 12° 37′ & 19° 54′ N and longitudes 74° 46′ & 84° 46′ E. The total geographical area is estimated to be about 275 lakh hectares of which forest occupies about 22.2%, net area sown is about 41.3% and 36.5% area covers barren, uncultivable land, permanent pastures etc. Of the total area, cultivable waste is about 3.5%. Nearly 80% of the States population depends directly on agriculture, which contributes over 50% to the States income.

Southwest monsoon is the main rainy season for the State except Nellore district and parts of Prakasam and Chittoor districts. Southwest monsoon strikes the State by about 7th of June and generally covers whole of the State by the end of third week. Monsoon withdraws from most of Andhra Pradesh by the end of first week of October. The characteristic feature of monsoon (June to September) is well known to be pulsatory. Occasionally there would be breaks in monsoon, which some times leads to disasterous consequences owing to crop failures over a large area.

The variability of annual rainfall during monsoon is 25% over Telangana and coastal belt of Andhra except Nellore district, while it increases to 40% in Rayalaseema and Nellore district. Monthly rainfall is highly variable particularly in Rayalaseema and adjoining areas. The probability of occurrence of drought (rainfall less than 75% of the normal) is 25% in Rayalaseema and 25% in south coastal Andhra Pradesh but decreases to 10% in north coastal Andhra Pradesh and it is 15% in Telangana. The probability occurrence of severe drought (rainfall less than 50% of the normal) is about 10% in Rayalaseema and coastal Andhra Pradesh but in Telengana it is rare.

3. Data and method of analysis

In order to cover three sunspot cycles and also to fulfill the climatological data requirement, 34 years of continuous data (1947-1980) have been used in respect of Hyderabad, Nizamabad, Cuddapah, Kurnool, Nellore, Machilipatnam, Kakinada, Visakhapatnam and for Khammam (1901-1934). However, in respect of Kalingapatnam (1941-1975) and Rentachintala (1901-1945) 35 years, Ramagundam (1901-1930) 30 years Mahabubnagar (1901-1929) 29 years and Anantapur (1947-1971) 25 years available continuous data have been used. The monsoon weeks are counted from the calendar month of 1 June to 30 September. With a view to cover entire monsoon season the 17th week is taken as 10 days (21-30 September).

The Markov chain probability method makes use of the fact that the atmosphere is persistent in its behaviour, that is, the events of the atmosphere are not independent of those which closely precede them. The analysis is carried out as given by Roberson (W.M.O. 1982), who used daily rainfall data to establish drought frequencies during 10-day periods. He defined dry decade (if the decade rainfall is less than 30 mm) and wet decade (if the decade rainfall is 30 mm or more). In the present study, a threshold of 20 mm per week is considered to demarcate dry weeks. Based on experimental evidence, in a given week when the raintall is less than 20 mm, that week has been classified as dry week and a week with 20 mm or more as wet week. With the following notations the various formulae used in the calculations are given below :

$$P_D = F_D/n,\ P_{DD} = F_{DD}/F_D,$$

$$2D = P_{Dw1}.\ P_{DDw2};\ 3D = P_{Dw1}.\ P_{DDw2}.\ P_{DDw3}$$

$$P_W = F_W/n\ ;\ P_{WW} = F_{WW}/F_W$$

$$2W = P_{Ww1}.\ P_{WWw2}\ ;\ 3W = P_{Ww1}.\ P_{WWw2}.\ P_{WWw3}$$

where,

P_D — Probability of the week being dry,

P_{DD} — Probability (conditional) of a dry week preceded by a dry week,

$2D, 3D$ — Probability of 2 and 3 consecutive dry weeks respectively starting with the week,

P_W — Probability of the week being wet,

P_{WW} — Probability of the wet week preceded by a wet week,

$2W, 3W$ — Probability of 2 and 3 consecutive wet weeks respectively starting with the week,

n — Number of years of data,

w_1, w_2, w_3 — Indicate three consecutive weeks,

F_D — Number of dry weeks,

F_{DD} — Number of dry weeks preceded by another dry week,

F_W — Number of wet weeks,

F_{WW} — Number of wet weeks preceded by another wet week,

P_{Dw1} — Probability of the week being dry (first week),

P_{DDw2} — Probability of second consecutive week being dry given the preceding week dry,

P_{DDw3} — Probability of third week being dry, given the preceding week dry,

P_{Ww1} — Probability of the week being wet (first week),

P_{WWw2} — Probability of second week being wet, given the preceding week wet,

P_{WWw3} — Probability of third week being wet, given the preceding week wet.

Using the above formulae, probabilities of dry, wet weeks conditional probabilities of dry week preceded by a dry week, wet week preceded by a wet week, consecutive 2 or 3 dry/wet weeks starting with the week have been computed. The salient features of probabilities regionwise is given below :

3.1. *Telangana* (*Tables* 1*a, b, c*)

The probability occurrence of a dry week is high (40 to 76%) in the first three weeks, but it rapidly falls in subsequent weeks. The conditional probability of dry week preceded by a dry week is also high, but the probability occurrence of two or three consecutive dry weeks is small except in the first and second weeks of June. The conditional probability of a wet week preceded by a wet week is also high, except in the first three weeks of June. The probability occurrence of two or three consecutive wet weeks is moderate to high (varies 20 to 70%). It may be noted here that the assured weekly rainfall at 50% probability level varies by 20 to 48 mm in south Telangana, while it varies between 30 to 60 mm in north Telangana, barring in the first three weeks (Mondal *et al.* 1983).

3.2. *Coastal Andhra Pradesh except Nellore district* (*Tables* 1*f, g*)

Leaving the first two weeks, the probability occurrence of a dry week is moderate to high (30 to 60%) in north coastal Andhra Pradesh and it is 20 to 50% in south coastal Andhra Pradesh. The conditional probability occurrence of a dry week given the preceding week dry is also high, but the occurrence of two or three consecutive dry weeks is small. The probability occurrence of a wet week is moderate to high. The conditional probability occurrence of a wet week preceded by a wet week is moderate to high. However, the probability occurrence of two or three consecutive wet weeks is moderate in south coastal Andhra Pradesh but it is low in north coastal Andhra Pradesh.

3.3. *Rayalaseema and Nellore district* (*Tables* 1*d, e*)

The probability occurrence of a dry week and the conditional probability occurrence of a dry week preceded by a dry week are high in all the monsoon weeks. It is observed that the probability occurrence of two or three consecutive dry weeks is moderate to high (20 to 60%) while the occurrence of two or three consecutive wet weeks is very low. Further it is also noticed that the assured weekly rainfall at 50% probability level varies from 2 to 20 mm in the first 15 weeks of the monsoon period, but in the last two weeks (16th, 17th weeks) it exceeds 20 mm.

4. Correlation of successive weeks rainfall

To understand the behaviour of weekly rainfall correlations of successive weeks rainfall ($\gamma_{i,\ i+1}$ where,

TABLE 1

Markov chain probabilities (%) of dry, wet weeks

W. No.	P_D	P_{DD}	$2D$	$3D$	P_W	P_{WW}	$2W$	$3W$	P_D	P_{DD}	$2D$	$3D$	P_W	P_{WW}	$2W$	$3W$
				(a) Hyderabad								(a) Khammam				
1	76	—	69	43	23	—	11	36	62	—	47	31	38	—	23	10
2	62	90	39	18	38	46	13	05	62	76	41	26	38	61	17	09
3	56	63	25	11	44	33	17	13	53	67	34	13	47	44	24	17
4	32	45	14	07	68	39	50	37	32	64	12	01	68	52	47	37
5	41	43	22	13	59	75	43	20	23	37	03	01	76	69	61	36
6	56	53	33	27	44	73	21	12	41	12	17	17	59	80	35	25
7	50	59	42	18	50	47	29	26	35	42	35	06	65	59	46	44
8	18	83	08	01	82	57	76	52	09	100	02	01	91	71	87	64
9	26	44	04	02	73	92	51	39	32	18	15	05	68	96	50	35
10	35	17	16	11	65	68	49	30	32	45	12	06	68	74	47	38
11	53	44	36	24	47	75	29	20	32	36	17	09	68	70	55	36
12	47	69	31	16	53	61	36	22	38	54	19	06	62	81	41	30
13	44	67	22	10	56	68	33	21	29	50	10	05	71	67	51	38
14	41	50	18	11	59	60	37	18	35	33	17	08	65	73	48	29
15	53	44	31	17	47	62	23	17	44	47	22	13	56	74	33	22
16	35	58	20	—	65	50	47	—	41	50	25	—	59	60	39	—
17	26	55	—	—	73	72	—	—	29	60	—	—	71	67	—	—
				(b) Nizamabad								(b) Mahabubnagar				
1	76	—	60	49	23	—	06	03	62	—	40	26	38	—	17	04
2	68	78	55	27	32	27	14	08	69	65	44	13	31	44	08	03
3	47	81	23	05	53	44	29	17	48	64	14	07	52	27	22	16
4	35	50	07	04	65	54	38	29	34	30	17	04	65	42	48	27
5	29	20	17	06	71	58	55	48	34	50	08	03	65	74	37	19
6	21	57	07	03	79	78	69	49	45	23	18	14	55	56	29	22
7	32	36	14	03	68	87	48	38	34	40	28	10	65	53	49	44
8	21	43	05	02	79	70	63	61	15	80	05	02	83	75	75	57
9	12	25	04	02	88	80	85	67	23	37	08	04	72	90	55	41
10	26	33	11	06	73	96	58	50	35	33	19	16	59	76	44	22
11	29	40	16	09	71	79	61	42	59	53	50	23	35	75	18	16
12	38	54	21	08	62	86	43	28	24	86	11	05	76	50	67	49
13	32	54	12	04	68	70	44	32	38	45	19	10	62	89	45	26
14	32	36	12	05	68	65	49	26	48	50	26	17	52	73	29	18
15	47	37	20	12	53	72	28	10	52	53	33	24	48	57	29	17
16	62	43	35	—	38	54	13	—	48	64	34	—	52	60	31	—
17	41	57	—	—	59	35	—	—	24	71	—	—	76	59	—	—

TABLE 1 (*Contd.*)

W. No.	P_D	P_{DD}	$2D$	$3D$	P_W	P_{WW}	$2W$	$3W$	P_D	P_{DD}	$2D$	$3D$	P_W	P_{WW}	$2W$	$3W$
			(c) Ramagundam								**(c) Rentachintala**					
1	73	—	57	38	27	—	10	02	74	—	54	44	26	—	06	02
2	73	77	49	28	27	37	06	04	74	73	60	42	26	22	11	02
3	40	67	23	06	60	22	39	30	74	81	52	31	26	44	06	04
4	23	57	06	05	77	65	59	50	49	71	29	16	51	22	36	07
5	27	25	21	03	73	77	61	51	63	59	35	22	37	69	07	01
6	17	80	02	01	83	84	69	57	71	56	45	29	29	20	05	03
7	23	14	12	04	77	83	64	52	54	63	35	16	46	19	24	16
8	20	50	07	02	80	83	65	60	40	64	19	07	60	52	40	11
9	10	33	02	01	90	81	83	73	49	47	18	13	51	67	14	05
10	13	25	02	01	87	92	76	49	69	37	48	29	31	27	10	05
11	43	15	27	10	57	88	36	29	57	70	35	21	43	33	20	12
12	27	63	09	04	73	64	59	31	51	61	31	17	49	47	29	15
13	47	36	19	03	53	81	28	22	51	61	28	18	49	59	26	16
14	17	40	02	01	83	52	68	45	51	55	32	19	49	53	31	13
15	47	14	28	12	53	81	35	17	60	62	37	26	40	64	16	09
16	50	60	22	—	50	67	24	—	51	61	36	—	49	41	27	—
17	30	44	—	—	70	48	—	—	29	70	—	—	71	56	—	—
			(d) Anantapur								**(d) Kurnool**					
1	68	—	47	30	32	—	11	04	56	—	30	20	44	—	16	03
2	64	69	42	33	36	33	14	03	76	54	52	33	23	37	04	01
3	80	65	64	53	20	40	04	04	65	68	41	24	35	17	12	03
4	80	80	67	61	20	20	20	00	65	64	38	29	35	33	09	04
5	96	83	92	77	04	100	00	00	65	59	49	25	35	25	17	08
6	89	95	74	55	12	00	00	00	50	76	25	15	50	47	25	10
7	76	84	56	41	24	00	04	01	59	50	34	14	41	50	17	11
8	76	74	56	45	24	17	04	02	35	58	14	05	65	41	43	34
9	76	74	61	48	24	17	10	02	29	40	10	07	71	67	55	32
10	80	80	63	50	20	40	03	01	59	35	40	29	41	79	24	10
11	76	79	61	40	24	17	07	05	65	68	47	25	35	58	15	08
12	60	80	40	32	40	30	30	00	53	72	29	18	47	44	25	10
13	84	67	68	60	16	75	00	00	62	54	39	28	38	54	15	05
14	84	81	74	59	16	00	04	02	71	62	52	30	29	40	10	05
15	68	88	54	27	32	25	13	08	56	74	32	23	44	33	21	09
16	40	80	20	—	60	40	40	—	56	58	40	—	44	47	20	—
17	40	50	—	—	60	67	—	—	21	71	—	—	79	44	—	—

TABLE 1 (*Contd.*)

W. No.	P_D	P_{DD}	$2D$	$3D$	P_W	P_{WW}	$2W$	$3W$	P_D	P_{DD}	$2D$	$3D$	P_W	P_{WW}	$2W$	$3W$
	(e) Cuddapah								(e) Nellore							
1	65	—	43	29	35	—	14	03	85	—	74	64	15	—	04	00
2	71	67	48	30	29	40	07	02	88	87	76	64	12	25	00	00
3	65	68	40	30	35	25	11	04	88	87	75	59	12	00	00	00
4	71	62	52	34	29	30	11	03	76	85	60	49	23	00	08	01
5	68	74	44	30	32	36	09	03	82	78	67	50	18	33	02	00
6	68	65	46	26	32	27	11	05	79	81	59	42	20	14	02	004
7	56	68	32	16	44	33	20	14	71	75	49	29	29	10	06	02
8	41	57	21	11	59	45	40	20	59	70	34	24	41	21	16	04
9	53	50	29	20	47	69	23	12	70	58	49	42	29	40	08	05
10	59	55	41	27	41	50	22	16	68	69	57	39	32	27	18	10
11	50	71	32	22	50	53	36	19	59	85	40	21	41	57	22	08
12	59	65	40	20	41	71	22	07	56	68	29	20	44	53	16	06
13	56	68	28	21	44	53	13	05	68	52	47	33	32	36	12	04
14	71	50	52	36	29	30	11	04	68	69	47	25	32	36	12	02
15	68	74	46	25	32	36	11	06	68	69	36	25	32	36	04	02
16	47	69	25	—	53	33	31	—	56	53	39	—	44	13	03	—
17	44	53	—	—	56	58	—	—	50	70	—	—	50	59	—	—
	(f) Machilipatnam								(f) Kakinada							
1	65	—	48	33	35	—	19	06	56	—	33	29	44	—	33	04
2	68	74	46	29	32	54	11	04	88	60	77	36	32	75	04	02
3	65	68	40	20	35	33	12	06	47	87	22	09	53	11	28	15
4	47	62	23	05	53	33	29	18	44	47	18	06	56	53	30	22
5	29	50	07	04	71	54	46	27	29	40	11	04	71	54	52	35
6	50	23	32	16	50	65	30	18	32	36	11	03	68	74	46	33
7	41	64	21	07	59	60	36	22	26	33	07	02	73	68	53	34
8	23	50	08	02	76	61	46	34	35	25	12	03	65	73	41	30
9	26	33	07	03	73	60	54	35	26	33	07	04	73	64	54	35
10	44	27	22	17	56	74	36	19	44	27	25	11	56	74	36	23
11	59	50	45	23	41	64	21	14	41	57	18	15	59	65	38	21
12	38	77	19	08	62	52	41	32	59	45	49	20	41	64	22	16
13	29	50	12	06	71	67	55	44	35	83	14	08	65	54	46	26
14	35	42	17	10	65	77	52	24	50	41	28	17	50	71	28	16
15	56	47	33	13	44	80	21	11	53	55	33	28	47	56	26	16
16	44	60	16	—	56	47	30	—	47	62	40	—	53	55	33	—
17	23	37	—	—	76	54	—	—	21	86	—	—	79	63	—	—

TABLE 1 (*Contd.*)

W. No.	P_D	P_{DD}	2D	3D	P_W	P_{WW}	2W	3W	P_D	P_{DD}	2D	3D	P_W	P_{WW}	2W	3W
	(g) Visakhapatnam								(g) Kalingapatnam							
1	62	—	40	38	38	—	23	06	71	—	49	33	29	—	06	01
2	85	65	80	45	14	60	04	02	74	69	49	23	26	22	04	02
3	53	94	30	15	47	25	23	13	51	67	24	11	49	18	22	13
4	47	56	23	14	53	50	30	13	43	47	19	12	57	45	34	19
5	59	50	36	11	41	57	18	09	51	44	32	09	49	59	28	11
6	38	61	11	07	62	43	33	19	46	62	13	07	54	58	21	12
7	50	29	31	11	50	53	29	17	49	29	26	11	51	39	28	13
8	38	61	14	08	62	57	37	16	49	53	21	09	51	55	24	13
9	56	37	31	15	44	60	19	07	46	44	20	09	54	47	28	19
10	53	55	25	12	47	44	18	03	40	43	18	09	60	52	40	15
11	62	48	29	11	38	38	09	04	57	45	28	12	43	67	16	08
12	50	47	19	12	50	23	21	19	46	50	20	07	54	37	28	17
13	38	38	25	11	62	43	54	26	40	43	14	09	60	52	36	18
14	50	65	23	16	50	88	24	15	57	35	38	19	43	60	21	13
15	44	47	29	12	56	47	36	27	43	67	21	06	57	50	36	17
16	26	67	11	—	73	64	56	—	46	50	14	—	54	63	26	—
17	15	40	—	—	85	76	—	—	29	30	—	—	71	48	—	—

Week No. 1 : 1-7 Jun, 2 : 8-14 Jun, 3 : 15-21 Jun, 4 : 22-28 Jun, 5 : 29 Jun-5 Jul, 6 : 6-12 Jul, 7 : 13-19 Jul, 8 : 20-26 Jul 9 : 27 Jul-2 Aug, 10 : 3-9 Aug, 11 : 10-16 Aug, 12 : 17-23 Aug, 13 : 24-30 Aug, 14 : 31 Aug-6 Sep, 15 : 7-13 Sep, 16 : 14-20 Sep, 17 : 21-27 Sep, 18 : 28 Sep-4 Oct.

TABLE 2

Coefficient of variation of weekly rainfall during monsoon over Andhra Pradesh

Station	Week number																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	1-7 Jun	8-14 Jun	15-21 Jun	22-28 Jun	29 Jun - 5 Jul	6-12 Jul	13-19 Jul	20-26 Jul	27 Jul -2 Aug	3-9 Aug	10-16 Aug	17-23 Aug	24-30 Aug	31 Aug -6 Sep	7-13 Sep	14-20 Sep	21-30 Sep
	(in per cent)																
(1) Nizamabad	154	134	118	99	83	78	90	77	76	83	88	93	100	87	112	121	122
(2) Khammam	120	136	142	79	86	127	107	81	93	86	100	106	81	97	128	99	95
(3) Mahabubnagar	129	99	96	81	89	84	79	85	82	106	131	82	99	112	109	109	88
(4) Kurnool	128	125	116	123	101	96	111	86	89	107	153	147	116	132	137	106	92
(5) Anantapur	151	150	158	172	171	191	181	147	185	227	176	164	177	161	162	110	112
(6) Cuddapah	208	156	112	156	133	149	152	104	124	128	123	147	129	139	128	115	90
(7) Nellore	191	196	161	166	137	140	136	84	114	120	135	145	152	209	149	130	104
(8) Kakinada	239	142	152	106	99	87	87	83	79	96	102	107	82	118	100	96	91
(9) Machilipatnam	165	117	114	119	95	111	85	86	88	87	131	95	92	99	112	102	81
10) Rentachintala	154	126	121	109	113	111	118	103	109	138	123	123	96	115	131	104	101

TABLE 3

Correlation coefficients (percentage) of successive weeks rainfall ($\gamma i, i+1$)

Station	Between monsoon weeks															
	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
(1) Hyderabad	14	03	—16	—11	06	—05	19	06	—05	11	29	08	—14	15	11	13
(2) Khammam	08	08	—13	—01	—04	—21	47	06	15	24	39	11	—21	—12	—23	14
(3) Nizamabad	07	14	—10	—15	09	05	33	01	24	13	01	19	24	—07	04	06
(4) Mahabubnagar	18	—04	—05	—14	—06	—10	21	32	05	01	36	15	03	—03	09	02
(5) Ramagundam	32	—18	06	03	41	—01	40	09	00	43	—02	04	10	—13	08	—17
(6) Rentachintala	—14	04	—17	17	18	—03	—19	19	—21	10	16	20	—06	—02	01	32
(7) Anantapur	—14	01	03	00	04	17	17	14	15	08	06	55	—05	08	—06	01
(8) Kurnool	03	—03	—13	00	16	02	08	28	18	26	18	27	04	02	32	—05
(9) Cuddapah	00	03	04	07	12	06	10	37	10	07	05	29	36	03	17	08
(10) Nellore	18	—09	04	—03	05	—08	01	06	08	27	19	—08	—07	03	04	13
(11) Machilipatnam	15	13	—09	—01	21	01	04	—08	—10	06	16	09	14	15	06	24
(12) Kakinada	16	27	—14	09	06	14	05	—11	03	—03	15	06	10	07	—09	13
(13) Visakhapatnam	17	05	—04	03	—05	—01	00	11	16	—10	—06	03	03	—03	10	—06
(14) Kalingapatnam	04	—08	—16	—03	03	—01	—01	08	42	17	08	17	13	—11	—05	—14

TABLE 4

Coefficients of correlation (%) of successive weeks cumulative rainfall ($\gamma c\, i, i+1$)

Station	Between monsoon weeks															
	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-1
(1) Hyderabad	14	—05	—13	09	11	—01	12	04	—07	05	04	20	—14	08	02	06
(2) Khammam	08	03	—02	—08	—05	—32	—04	32	15	32	35	13	—11	—28	04	00
(3) Nizamabad	07	14	—09	—16	11	—12	12	04	10	19	01	—05	18	—08	—05	—01
(4) Mahabubnagar	18	02	—08	—02	—09	—08	20	17	00	—04	17	03	14	—12	00	—06
(5) Ramagundam	32	—23	01	07	14	—02	—31	—14	—22	37	—05	09	—17	—02	—08	—03
(6) Rentachintala	—14	13	—07	—08	20	14	—17	17	—03	37	18	14	—32	—22	18	—12
(7) Anantapur	—14	—05	—12	—05	16	01	08	—04	—03	—11	18	26	—06	11	—17	—13
(8) Kurnool	03	—09	02	—13	06	13	12	12	—08	04	15	14	—01	—07	16	03
(9) Cuddapah	00	—03	—05	—15	18	—02	03	04	—11	06	03	32	25	—03	—05	—09
(10) Nellore	18	—11	00	—11	—15	—16	01	—07	13	19	13	12	07	15	—06	08
(11) Machilipatnam	15	—03	—09	—07	19	05	—01	19	18	10	10	12	07	14	05	13
(12) Kakinada	16	01	—04	02	—13	—02	—11	—10	13	07	00	—07	—10	01	01	—08
(13) Visakhapatnam	17	—03	—03	00	—08	02	—11	09	30	—03	12	11	—09	—09	04	08
(14) Kalingapatnam	04	—13	—21	—07	—06	02	—01	14	18	32	—04	10	01	—17	07	08

$i = 1, 2, 3, \ldots, 16$) and the correlations of the cumulative rainfall of successive weeks ($\gamma_{c\,i,\,i+1}$ where $i = 1, 2, 3, \ldots\ldots, 16$) have been computed and presented in Tables 3 & 4 respectively. It is seen that there is no set pattern of correlation of weekly rainfall but suggests that there is interdependence of weekly rainfall. The coefficients of variation of weekly rainfall have been given in Table 2. It is obvious that the weekly rainfall is highly variable. The important features of correlations of weekly rainfall in different regions are given below.

5.1. *Telangana*

The correlation of successive weeks rainfall in Telangana (Table 3) indicate that the coefficients swing both in positive and negative sides. In general, the positive correlations (up to 30%) are significant between 5th and 13th week and negative correlations (up to —20%) are significant between 1st and 5th and 13th and 17th week. This analysis indicate that at the onset and withdrawal times of the monsoon season the successive weeks rainfall is highly erratic. The week by week cumulative rainfall correlations also indicate more or less the same features as the correlations of weekly rainfall but with smaller coefficients.

5.2. *Coastal Andhra Pradesh*

The correlations of successive weeks rainfall in the extreme parts of coastal Andhra Pradesh (Table 3) have only one positive peak (about 30%), while in the central parts there are no such peaks. Generally negative correlations are small and they are spread over the entire period of monsoon.

5.3. *Rayalaseema*

The correlations of successive weeks rainfall in Rayalaseema (Table 4) are mostly on the positive side except during the onset phase of monsoon weeks, where we find negative correlations.

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