

**SEASONAL AND ANNUAL WATER BALANCE ELEMENTS OF THE
TAMILNADU STATE, INDIA**

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ABSTRACT

The Tamilnadu state covering an area of about 1.3 lakhs sq.km has been studied with a view to study the water balance elements on seasonal and annual basis for about 48 stations basing on mean monthly rainfall and mean monthly temperature over a period of 40 years. The Thornthwaite and Mather (1955) book keeping procedure has been adopted to workout the potential evapotraspiration, actual evapotraspiration, water deficit, water surplus, moisture adequacy, Aridity Index and Moisture Index. From the analysis of water balance elements it is found that during northeast monsoon there is no water deficit. The water deficit is found high during southwest monsoon period. The Aridity Index is high during summer period. The study of average annual water balance elements reveal that in the Tamilnadu the average annual water deficit is 699 mm. The annual moisture adequacy is 59% and annual Aridity Index is 41%. Climatologically the state experience type of humid climate in Nilgiris and Kodaikanal hills and dry subhumid and semiarid in the plain regions. The water balance of the Tamilnadu state reveals that out of 127,957,160,000 m³ of water, 10% is stored in the surface ponds, tanks, lakes, and reservoirs, 12.42% is recharged to ground water, 20% is lost in the form of surface run-off and 57.58% is lost in the form of evaporation and evapotraspiration.

INTRODUCTION

Water balance, as the comparative study of rainfall and evapotranspiration plays an important role in many earth science fields, especially, agriculture and water resources development. It is now well established that the water supply to a region is primarily through precipitation and water loss is almost entirely due to evaporation and evapotranspiration. The wetness and dryness is, therefore determined by the relative magnitude of precipitation and potential evapotranspiration. The former one is measured widely through a good network of rain-gauge stations and the later, the potential evapotranspiration or the water loss is a very difficult parameter to measure experimentally. Thornthwaite and Mather (1955), Penman (1956), Van Bavel (1966), Hargreaves (1968) and Christianan (1970) have developed empirical formulae for estimation of potential evapotranspiration.

In India the formula devised by Thornthwaite and Mather (1955) has been extensively used by many eminent climatologists like Subrahmanyam (1956, 1957, 1958, 1963, 1982 and 1983), Subrahmanyam and subramaniam (1965), Subrahmanyam and Murthy (1969), subrahmanyam and Sastry (1969), Subrahmanyam et al, (1963 and 1970), subrahmanyam and Kamaraju (1983), Subramaniam and Uma Devi (1983), Subramaniam et al. (1982), SambasivaRao and Rajeswari (1984 and 1985), Rajaeswari (1984), Kalavathy (1985), Joic Swarooparani (1985), Padmini (1987), Kasturibai (1987), Gandhimathi (1988), Rajasekhararatna Kumar (1988), Vasthala (1989), Krishna Reddy (1990), Madhuramma (1990 and 1992), SureshBabu (1994), Purushotham Babu (1994), Rajeswari (1995) Hemamalini (1979) has studied the eco-climatology of the Andhra Pradesh State, and Samuel Raju (1996).

Ram Mohan (1978, 1980 and 1983) has studied the water balance and soil moisture variations of Tamilnadu using Thoranthwaite and Mather (1955) book keeping procedure and worked out imbalance in water budget caused by annual rainfall.

STUDY AREA:

The Tamilnadu state cover an area of about 1.3 lakh sq.km and lies 8.05' to 13.34 north latitude and 76.10 to 80.20' east longitude in south-eastern part of India. The total population of the State is 55,638,318 (1991 Census). The density of population is 371/km² persons. The state in the north is bordered by Andhra Pradesh, northwest by Karnataka, west and southwest by Kerala and east by Bay of Bengal. The State on an average receives rainfall of about 986 mm. per annum. There are thirty three districts, 151 taluks and 379 blocks in the state. The total number of revenue villages are 16,598, hamlets 58,457 and 434 urban centres. The total length of coastline is 1000 kms.

OBJECTIVES:

The main objectives of the study are:

1. to study the water balance elements of the tamilnadu state on seasonal and annual basis,
2. to assess the water balance of the tamilnadu state and
3. to bringout relationship between water balance and water resources development of the tamilnadu state,

METHODOLOGY:

The magnitude of water balance elements namely precipitation, potential evapotranspiration, actual evapotranspiration, water deficit, water surplus, moisture adequacy, Aridity Index, Moisture Index have been worked out on monthly, seasonal and annual basis adopting Thornthwhite and Mather (1955) book keeping procedure and Penman (1956) formula for calculation of potential evapotranspiration. The water balance graphs for 50 strations have been constructed to identity the water deficit and water surplus months.

SEASONAL WATER BALANCE ELEMENTS OF TAMILNADU STATE:

WINTER PERIOD:

During the period the Potential evapotranspiration values from a minimum of 185 mm in Udagamangalam to a maximum of 297 mm in Tuticorin (Table 1). The average PE value of the state is 241 mm. The spatial distribution shows high values in eastern parts of the state. The Actual evapotranspiration values vary from a minimum of 62 mm in Pollachi to a maximum of 230 mm in Vedaranyam. The average of the state is 156 mm. The water deficit in the state varies from 11 mm in Kodaikanal to a maximum of 215 mm in Pollachi. The average of the state is 85mm. The moisture adequacy varies from 22% in Pollachi to a maximum of 94% in Kodaikanal. The average values of the state is 65%. The Aridity Index ranges from 6% in Kodaikanal to 78% in Pollachi. The average of the state is 35%. Climatologically the state experiences dry subhumid type of climate in winter period.

TABLE-1
WATER BALANCE ELEMENTS OF TAMILNADU
(WINTER)

Sl.No.	Station	In mm							In %	
		P IA	PE CC	AE	WD	WS	IMA			
1	2	3	4	5	6	7	8	9	10	
1.	Ponneri	17	246	100	146	0	41	59	D	
2.	Chennai	57	236	140	96	0	59	41	C1	
3.	Chengalpattu	54	235	134	101	0	57	43	C1	
4.	Thanjavur	85	252	194	58	0	77	23	C1	
5.	Puddukottai	55	241	166	75	0	69	31	C1	
6.	Ramanad	75	255	165	90	0	65	35	C1	
7.	Tuticorin	58	297	188	109	0	63	37	C1	
8.	Radhapuram	48	288	167	121	0	58	42	C1	
9.	Kanyakumari	46	255	176	79	0	69	31	C1	
10.	Udagamangalam	70	185	153	33	0	82	18	C1	
11.	Kodaikanal	107	191	180	11	0	94	6	C1	
12.	Beneford's Estate	102	195	181	14	0	93	7	C1	
13.	Hereford's Estate	51	188	145	43	0	77	23	C1	

14.	Vellore	39	230	99	131	0	57	43	C1
15.	Tiruttani	16	231	76	155	0	33	67	D
16.	Villipuram	57	240	167	73	0	70	30	C1
17.	Dharmapuri	31	215	131	64	0	70	30	C1
18.	Salem	25	225	155	70	0	69	31	C1
19.	Coimbatore	31	224	123	81	0	64	36	C1
20.	Bhavani sagar	22	231	141	90	0	61	39	C1
21.	Avanashi	10	215	121	94	0	56	44	C1
22.	pollachi	10	277	62	215	0	22	78	D
23.	Tiruchi	40	245	148	97	0	60	40	C1
24.	Erode	26	215	137	78	0	64	36	C1
25.	Dindigul	44	225	150	75	0	67	33	C1
26.	Palani	40	230	132	98	0	57	43	C1
27.	Vedasandur	38	225	156	69	0	69	31	C1
28.	Uttampalayam	39	228	156	72	0	68	32	C1
29.	Madurai	53	255	175	80	0	69	31	C1
30.	Sivaganga	53	255	168	87	0	66	34	C1
31.	Virdhunagar	59	228	149	79	0	65	35	C1
32.	Nilakkottai	44	252	198	54	0	79	21	C1
33.	Tirunelveli	130	265	212	53	0	80	2	C1
34.	Nanguneri	58	282	162	120	0	57	43	C1
35.	Tenkasi	89	252	198	54	0	79	21	C1
36.	Ambasamudram	114	247	217	30	0	74	26	C1
37.	Tondi	52	252	158	94	0	63	37	C1
38.	Vedaranyam	129	254	230	24	0	91	9	C1
39.	Nagapatnam	108	250	208	42	0	83	17	C1
40.	Cuddalore	89	248	189	59	0	76	24	C1
41.	Vulandarpet	60	244	165	79	0	68	32	C1
42.	Attur	38	222	129	93	0	58	42	C1
43.	Aruppukkottai	53	284	161	123	0	58	42	C1
44.	Kuilapatti	82	284	182	102	0	61	39	C1
45.	Tiruannamalai	69	244	179	65	0	73	27	C1
46.	Pamban	66	254	156	98	0	62	38	C1
47.	Karur	18	262	111	51	0	42	58	C1
48.	Palladam	30	254	140	114	0	55	45	C1

Note:- P:-Precipitation; PE:-Potential evapotranspiration; AE:- Actual evapotranspiration; WD:- Water deficit; WS:- Water surplus; Ima :- Moisture adequacy, Ia:-Aridity Index; CC:- Climatic Classification.

SUMMER PERIOD:

During summer period the Potential evapotranspiration values vary from 340 mm in Udagamangalam to a maximum of 543 mm in Vedsandur (Table 2). The average of the state is 479 mm. The spatial distribution shows lower values in western hilly terrain and higher values exceeding 500 mm in southeastern and northeastern parts of the state. The Actual evapotranspiration values range from a minimum of 100 mm in Chennai to a maximum of 350 mm in Kodaikanal. The average of the state is 206 mm. The water deficit values in the state vary from 31 mm in Beneford's estate to a maximum of 424 mm in Tiruttani. The average of the state is 273mm. The moisture adequacy values vary from 19% in Tiruttani to 91% in Beneford's estate. They are 100% in Kodaikanal and Hereford's estate. The average of the state is 33%. The Aridity Index values range from a minimum of 9% in Beneford's estate to a maximum of 85% in Tiruttani. The Aridity Index is nil in Kodaikanal and Beneford's estate. The state average is 67%. Climatologically the state enjoys wet subhumid, dry subhumid and semiarid types of climate during summer period.

TABLE-2
WATER BALANCE ELEMENTS OF TAMILNADU
(SUMMER)

Sl.No.	Station	In mm							In %
		P IA	PE CC	AE	WD	WS	IMA		
1	2	3	4	5	6	7	8	9	10
1.	Ponneri	68	526	124	402	0	24	76	D
2.	Chennai	58	466	100	366	0	21	79	D
3.	Chengalpattu	68	523	125	398	0	24	76	D
4.	Thanjavur	144	459	218	241	0	48	52	C1
5.	Puddukottai	125	468	190	278	0	41	59	D
6.	Ramanad	109	496	124	212	0	37	63	D
7.	Tuticorin	97	540	165	375	0	31	69	D
8.	Radhapuram	99	535	139	396	0	26	74	D
9.	Kanyakumari	312	494	412	82	0	83	17	C1

10.	Udagamangalam	276	340	294	46	0	86	14	C1
11.	Kodaikanal	342	350	350	0	0	100	0	C2
12.	Beneford's Estate	320	361	330	31	0	91	9	C1
13.	Hereford's Estate	379	347	347	0	32	100	0	C2
14.	Vellore	106	482	184	298	0	38	62	D
15.	Tiruttani	65	525	101	424	0	19	81	D
16.	Villipuram	97	482	157	325	0	33	67	D
17.	Dharmapuri	152	429	252	177	0	59	41	C1
18.	Salem	159	459	279	180	0	61	39	C1
19.	Coimbatore	152	479	213	266	0	45	55	C1
20.	Bhavani sagar	172	502	237	265	0	47	53	C1
21.	Avanashi	176	483	233	250	0	48	52	C1
22.	pollachi	153	538	172	366	0	32	68	D
23.	Tiruchi	134	457	206	215	0	45	55	C1
24.	Erode	162	483	219	264	0	45	55	C1
25.	Dindigul	154	532	231	301	0	43	57	D
26.	Palani	147	521	196	325	0	38	62	D
27.	Vedasandur	131	563	178	365	0	33	67	D
28.	Uttampalayam	152	466	178	288	0	38	62	D
29.	Madurai	171	472	249	223	0	53	47	C1
30.	Sivaganga	140	472	201	271	0	43	57	D
31.	Virdhunagar	164	466	209	257	0	45	55	C1
32.	Nilakkottai	182	468	247	221	0	53	47	C1
33.	Tirunelveli	139	513	205	308	0	40	60	D
34.	Nanguneri	126	535	170	365	0	32	68	D
35.	Tenkasi	207	489	287	202	0	59	41	C1
36.	Ambasamudram	157	500	278	222	0	56	44	C1
37.	Tondi	133	459	162	297	0	35	65	D
38.	Vedaranyam	132	458	232	226	0	51	49	C1
39.	Nagapatnam	106	454	286	168	0	63	37	C1
40.	Cuddalore	92	490	142	348	0	29	71	D
41.	Vulandarpet	108	474	178	296	0	38	62	D
42.	Attur	157	473	214	259	0	45	55	C1
43.	Aruppukkottai	162	516	202	314	0	40	60	D
44.	Kuilapatti	170	516	216	300	0	43	57	D
45.	Tiruannamalai	100	484	160	324	0	67	33	C1
46.	Pamban	133	492	200	292	0	41	59	D
47.	Karur	130	516	195	320	0	38	62	D
48.	Palladam	140	456	197	259	0	43	57	D

Note:- P:-Precipitation; PE:-Potential evapotranspiration; AE:- Actual evapotranspiration; WD:- Water deficit; WS:- Water surplus; Ima :- Moisture adequacy, Ia:-Aridity Index; CC:- Climatic Classification.

SOUTHWEST MONSOON PERIOD:

In southwest monsoon period the Potential evapotranspiration values in the state vary from a minimum of 350 mm in Udagamangalam to a maximum of 841 mm in Tuticorin station (Table 3). The average of the state is 618 mm. Spatially the PE values are high in southeastern parts of the state. The Actual evapotranspiration values range from 31 mm in Radhpuram to a maximum of 616 mm in Kanyakumari. The average of the state is 282 mm. The water deficit values range from 20 mm in Kanyakuamri to a maximum of 791 mm in Radhapuram. The average of the state is 336 mm. The water surplus is found in hilly terrain and varies from 187 mm to 711mm. The moisture adequacy is 100% in hilly terrain and Aridity Index is nil. The moisture adequacy values vary from 4% in Radhpuram to a maximum of 97% in Kanyakumari. The average of the state is 46%. The Aridity Index values range from 3% in Kanyakumari to 96% in Radhapuram. The average of the state is 54%. The state experiences perhumid and humid in hilly terrain, dry subhumid and semiarid in plain regions of the state during southwest monsoon period.

TABLE-3
WATER BALANCE ELEMENTS OF TAMILNADU
(SOUTHWEST MONSOON)

Sl.No.	Station	In mm					In %		
		P CC	PE	AE	WD	WS	IMA	IA	
1	2	3	4	5	6	7	8	9	10
1.	Ponneri	385	705	396	309	0	56	44	C1
2.	Chennai	364	620	370	250	0	60	40	C1
3.	Chengalpattu	397	691	402	235	0	58	42	C1
4.	Thanjavur	288	627	325	302	0	52	48	C1
5.	Puddukottai	346	591	363	228	0	61	39	C1

6.	Ramanad	136	727	158	477	0	24	76	D
7.	Tuticorin	31	841	50	791	0	6	94	D
8.	Radhapuram	13	735	31	704	0	4	96	D
9.	Kanyakumari	546	636	626	20	0	97	3	C1
10.	Udagamangalam	1061	350	350	0	711	100	0	A
11.	Kodaikanal	546	359	359	0	187	100	0	B1
12.	Beneford's Estate	566	374	374	0	202	100	0	B2
13.	Hereford's Estate	1023	359	359	0	664	100	0	A
14.	Vellore	440	658	455	203	0	69	31	C1
15.	Tiruttani	468	693	472	221	0	68	32	C1
16.	Villipuram	431	652	447	205	0	69	31	C1
17.	Dharmapuri	178	553	215	338	0	39	61	D
18.	Salem	355	593	388	205	0	65	35	C1
19.	Coimbatore	178	553	193	360	0	35	65	D
20.	Bhavani sagar	156	641	176	465	0	27	73	D
21.	Avanashi	555	629	245	384	0	39	61	D
22.	pollachi	402	624	511	113	0	82	18	C1
23.	Tiruchi	373	623	300	323	0	48	52	C1
24.	Erode	213	629	237	397	0	37	63	D
25.	Dindigul	221	665	238	423	0	36	64	D
26.	Palani	149	657	156	501	0	24	76	D
27.	Vedasandur	170	676	178	498	0	26	74	D
28.	Uttampalayam	170	676	178	498	0	26	74	D
29.	Madurai	242	614	267	347	0	43	57	D
30.	Sivaganga	330	620	347	273	0	56	43	C1
31.	Virdhunagar	161	607	173	434	0	139	71	D
32.	Nilakkottai	208	613	222	391	0	36	64	D
33.	Tirunelveli	109	660	126	554	0	19	81	D
34.	Nanguneri	118	738	124	614	0	17	83	D
35.	Tenkasi	176	633	208	425	0	33	67	D
36.	Ambasamudram	117	638	138	500	0	22	78	D
37.	Tondi	394	614	398	219	0	625	34	C1
38.	Vedaranyam	245	626	275	351	0	44	56	D
39.	Nagapatnam	219	622	249	373	0	440	60	D
40.	Cuddalore	340	673	356	317	0	53	47	C1
41.	Vulandarpet	383	643	401	242	0	62	38	C1
42.	Attur	393	609	412	197	0	68	32	C1
43.	Aruppukkottai	102	713	110	603	0	82	68	D
44.	Kuilapatti	100	713	104	609	0	30	70	D
45.	Tiruannamalai	392	653	408	245	0	63	37	C1
46.	Pamban	185	619	201	418	0	32	68	D
47.	Karur	197	703	281	422	0	40	60	D

48.	Palladam	247	621	264	357	0	42	58	C1
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Note:- P:-Precipitation; PE:-Potential evapotranspiration; AE:- Actual evapotranspiration; WD:- Water deficit; WS:- Water surplus; Ima :- Moisture adequacy, Ia:-Aridity Index; CC:- Climatic Classification.

NORTHEAST MONSOON PERIOD:

In the northeast monsoon period the Potential evapotranspiration values vary from a minimum of 217 mm in Udagamangalam to a maximum of 420 mm in koilpatti and Arruppukkottai station (Table 4). The average PE value of the state is 368 mm. Spatially the PE values exceed 400 mm in and around Arruppukkottai region. The Actual evapotranspiration values range from a minimum of 217 mm in Udagamangalam to a maximum of 420 mm in Koilpatti and Arruppukkottai. The average AE value of the state is 368 mm. The AE values exceed 400 mm in southeastern part of the state. The water deficit is nil in the state. The water surplus varies from 1 mm in Tuticorin to 660 mm in Vedaranyam. The moisture adequacy values are 100% in all the stations and Aridity Index values are nil. Perhumid, humid and wet subhumid types of climate prevails in the state during northeast monsoon period.

From the study of seasonal water balance elements it is found that northeast monsoon period is highly favourable for crop cultivation followed by winter period. However the summer and southwest monsoon periods show unfavourable conditions on plain regions for crop cultivation. Crops could be cultivated by supplementing with irrigation water.

TABLE-4
WATER BALANCE ELEMENTS OF TAMILNADU
(NORTHEAST MONSOON)

Sl.No.	Station	In mm					In %
		P	PE	AE	WD	WS	IMA
		IA	CC				

1	2	3	4	5	6	7	8	9	10
1.	Ponneri	556	407	407	0	149	100	0	C2
2.	Chennai	795	393	393	0	402	100	0	A
3.	Chengalpattu	691	373	373	0	318	100	0	B4
4.	Thanjavur	680	366	366	0	314	100	0	B4
5.	Puddukottai	393	344	344	0	49	100	0	C2
6.	Ramanad	498	375	375	0	123	100	0	B1
7.	Tuticorin	419	418	418	0	1	100	0	C2
8.	Radhapuram	444	417	417	0	27	100	0	C2
9.	Kanyakumari	398	398	398	0	0	100	0	C2
10.	Udagamangalam	513	217	217	0	296	100	0	A
11.	Kodaikanal	645	234	234	0	411	100	0	A
12.	Beneford's Estate	611	240	240	0	371	100	0	A
13.	Hereford's Estate	364	242	242	0	122	100	0	B2
14.	Vellore	395	395	395	0	0	100	0	C2
15.	Tiruttani	958	374	374	0	0	100	0	C2
16.	Villipuram	571	378	378	0	193	100	0	B2
17.	Dharmapuri	349	355	355	0	0	100	0	C2
18.	Salem	303	378	378	0	0	100	0	C2
19.	Coimbatore	349	356	356	0	0	100	0	C2
20.	Bhavani sagar	378	345	345	0	33	100	0	C2
21.	Avanashi	327	347	347	0	0	100	0	C2
22.	pollachi	314	378	378	0	0	100	0	C2
23.	Tiruchi	395	368	368	0	27	100	0	C2
24.	Erode	316	347	347	0	0	100	0	C2
25.	Dindigul	418	398	398	0	20	100	0	C2
26.	Palani	393	393	393	0	0	100	0	C2
27.	Vedasandur	383	403	403	0	0	100	0	C2
28.	Uttampalayam	383	403	403	0	0	100	00	C2
29.	Madurai	410	354	354	0	0	100	0	C2
30.	Sivaganga	495	344	344	0	151	100	0	B2
31.	Virdhunagar	432	376	376	0	56	100	0	C2
32.	Nilakkottai	349	359	359	0	0	100	00	C2
33.	Tirunelveli	486	390	390	0	96	100	0	B1
34.	Nanguneri	422	417	417	0	5	100	0	C2
35.	Tenkasi	509	383	383	0	126	100	0	B1
36.	Ambasamudram	539	403	403	0	136	100	0	B1
37.	Tondi	401	365	365	0	41	100	0	C2
38.	Vedaranyam	1028	368	368	0	660	100	0	A
39.	Nagapatnam	934	360	360	0	574	100	0	A
40.	Cuddalore	829	389	389	0	440	100	0	A
41.	Vulandarpet	492	370	370	0	122	100	0	B1

42.	Attur	387	360	360	0	27	100	0	C2
43.	Aruppukkottai	453	420	420	0	33	100	00	C2
44.	Kuilapatti	456	420	420	0	36	100	0	C2
45.	Tiruannamalai	624	379	379	0	245	100	0	B3
46.	Pamban	456	368	368	0	88	100	0	B1
47.	Karur	303	368	368	0	0	100	0	C2
48.	Palladam	304	359	359	0	0	100	0	C2

Note:- P:-Precipitation; PE:-Potential evapotranspiration; AE:- Actual evapotranspiration; WD:- Water deficit; WS:- Water surplus; Ima :- Moisture adequacy, Ia:-Aridity Index; CC:- Climatic Classification.

ANNUAL WATER BALANCE ELEMENTS OF TAMILNADU STATE:

The annual Potential evapotranspiration values in the state varies from 1092 mm in Udagamangalam to a maximum of 2096 mm in Tuticorin station (Table 5). The average value of the state is 1706 mm. spatially the PE values exceed 1800 mm in southeastern parts of the state and less than 1200 mm in hilly terrain. The annual Actual evapotranspiration values vary from 754 mm in Radhapuram to a maximum of 1602 mm in Kanyakumari. The average of the state is 1007 mm. The water deficit in the state varies from 181 mm in Kanyakumari to a maximum of 1275 mm in Tuticorin. The average of the state is 699 mm. The water surplus is found in hilly terrain and varies from 429 mm to 828 mm. The moisture adequacy in the hilly terrain is 100% and Aridity Index is nil. The moisture adequacy in plain regions vary from 38% to 90%. The average Ima of the state is 59%. The Aridity Index varies from !0% to 62% and the average of the state is 41%. Climatologically the state enjoys humid climate in hilly region and dry subhumid and semi-arid in the plain regions.

TABLE-5
WATER BALANCE ELEMENTS OF TAMILNADU
(ANNUAL)

Sl.No.	Station	In mm					In %		
		P CC	PE	AE	WD	WS	IMA	IA	
1	2	3	4	5	6	7	8	9	10
1.	Ponneri	1026	1884	1027	857	0	55	45	C1
2.	Chennai	1274	1715	1003	712	0	58	42	C1
3.	Chengalpattu	1210	1822	1034	788	0	57	43	C1
4.	Thanjavur	1167	1704	1103	601	0	65	35	C1
5.	Puddukottai	919	1644	1063	581	0	65	35	C1
6.	Ramanad	818	1753	874	879	0	50	50	C1
7.	Tuticorin	605	2096	821	1275	0	39	61	D
8.	Radhapuram	728	1975	754	1221	0	38	62	D
9.	Kanyakumari	1302	1783	1602	181	0	90	10	C1
10.	Udagamangalam	1920	1092	1092	0	828	100	0	B3
11.	Kodaikanal	1640	1134	1134	0	506	100	0	B2
12.	Beneford's Estate	1599	1170	1170	0	429	100	0	B1
13.	Hereford's Estate	1817	1136	1136	0	681	100	0	B2
14.	Vellore	980	1765	1133	632	0	64	36	C1
15.	Tiruttani	1007	1823	1008	815	0	52	48	C1
16.	Villipuram	1156	1752	1149	603	0	66	34	C1
17.	Dharmapuri	710	1552	967	585	0	62	38	C1
18.	Salem	842	1652	1180	472	0	71	29	C1
19.	Coimbatore	710	1612	900	712	0	56	44	C1
20.	Bhavani sagar	728	1719	899	820	0	52	48	C1
21.	Avanashi	738	1674	940	734	0	56	44	C1
22.	pollachi	879	1867	1109	758	0	59	41	C1
23.	Tiruchi	842	1693	1012	681	0	60	40	C1
24.	Erode	717	1674	916	758	0	55	45	C1
25.	Dindigul	837	1820	1009	811	0	55	45	C1
26.	Palani	729	1801	877	924	0	49	51	C1
27.	Vedasandur	722	1847	899	948	0	49	51	C1
28.	Uttampalayam	744	1773	899	874	0	51	49	C1
29.	Madurai	876	1695	1046	649	0	62	38	C1
30.	Sivaganga	1018	1691	1060	631	0	63	37	C1
31.	Virdhunagar	816	1677	907	770	0	54	46	C1
32.	Nilakkottai	783	1692	1016	676	0	60	40	C1

33.	Tirunelveli	864	1828	933	895	0	51	49	C1
34.	Nanguneri	724	1972	873	1099	0	44	56	C1
35.	Tenkasi	981	1757	1076	681	0	61	39	C1
36.	Ambasamudram	927	1738	1036	752	0	58	42	C1
37.	Tondi	985	1693	1083	610	0	64	36	C1
38.	Vedaranyam	1534	1706	1388	318	0	81	19	C1
39.	Nagapatnam	1367	1686	1103	583	0	65	35	C1
40.	Cuddalore	1350	1800	1076	724	0	60	40	C1
41.	Vulandarpur	1043	1731	1114	617	0	64	36	C1
42.	Attur	975	1664	1115	549	0	67	33	C1
43.	Aruppukkottai	770	1933	893	1040	0	46	54	C1
44.	Kuilapatti	872	1933	922	1011	0	48	52	C1
45.	Tiruannamalai	1185	1760	1126	634	0	64	36	C1
46.	Pamban	840	1733	925	808	0	53	47	C1
47.	Karur	648	1868	940	928	0	50	50	C1
48.	Palladam	731	1690	960	730	0	57	43	C1

Note:- P:-Precipitation; PE:-Potential evapotranspiration; AE:- Actual evapotranspiration; WD:- Water deficit; WS:- Water surplus; Ima :- Moisture adequacy, Ia:-Aridity Index; CC:- Climatic Classification.

WATER BALANCE GRAPHS OF TAMILNADU STATE:

The water balance graphs for all the 50 stations of the state reveal that over the hilly terrain water deficit is noticed in January, February and March months. From April to December in all the stations of hilly terrain water surplus is found. The annual water surplus varies from 429 mm to 828 mm. In the plain regions the water deficit is found from January to September months. The water deficit ranges from 181 mm to 1275 mm. In October, November and December months in the plain regions there is water surplus. However during December the water surplus is very low. From the study of water balance graphs it may be concluded that the state experiences high water deficit in plain regions for a period of nine months and water surplus in plain regions for a period of three months and water surplus for a period of nine months in the hilly terrain and water deficit in hilly terrain for three months.

WATER BALANCE OF THE TAMILNADU STATE:

1. Total surface water resources :127,957,160,000 m³
(Geographical area of the state x
Average Annual rainfall of the state)
2. Total surfacewater resources stored
in the ponds, lakes, tanks and resources :12,795,716,000 m³ (10%)
(10% of the total surface water
resources)
3. Total water resources : 15,901,208,000 m³ (12.42%)
recharged to ground water
4. Total water resources lost :25,591,439,000 m³ (20%)
in the form of surface run-off
5. Total water resources lost in the :73,668,704,000 m³ (57.58%)
form of evaporation and
evapotraspiration

WATER BALANCE AND WATER RESOURCES CONSERVATION:

The total surface water resources of the state are 127,957,160,000 m³. Out of this 12,795,716,000 m³ (10%) is stored in ponds, lakes, tanks and reservoirs of the state. About 15,901,208,000 m³ (12.42%) is recharged to ground water and 99,260,136,000 m³ (77.58%) of water is lost in the from of evaporation and evapotranspiration and surface run-off From the study of water balance of the Tamilnadu State it is found that majority of water resources are lost in the form of evaporation and evapotraspiration.

From the study of annual ground water level variations it is found that on the plain regions it varies from 1.92 metres to 8.29 metres. The ground water level increase from east to west. The annual fluctuations in ground water level ranges from 2.10 metres to 3.60 metres. The spatial distribution shows that the fluctuation varies from 2.0 to 2.5 metres in coastal plains and 2.5 to 3.0 metres in western uplands. The annual ground water recharge varies from 67.3 mm to 242.5 mm. Over the hilly terrain the annual recharge varies from 200 mm to 242.5 mm and on the plains it ranges from 67.3 mm 191.7 mm. The recharge on coastal plains of Tamilnadu State exceeds 100 mm.

Due to high potential evapotraspiration and low precipitation on the plain regions the water deficit is high. Geologically the Tamilnadu state comprises 95,500

km² of Archean rocks and accounts for 73.5% of the total geographical area of the state. The other rocks are Gondawanas (2,500 Km²), Cretaceous formations (1,500 km²), Tertiary formations (8,500 km²) and Quaternary formations (22,000 km²). Since major parts of the state is covered with Archean rocks the ground water is restricted to weathered, faulted, fractured and fissured zones. The specific yield is low and ground water yield is very low, except in faulted and fractured zones. Therefore, the ground water prospects in hard rock terrain is very limited and is restricted to faulted, fractured, and fissured zones. In Quaternary formations the ground water recharge is high. The Quaternary formations are good zones for excavation of ground water resources. A detailed survey of ground water resources has to be carried out on a large scale using modern remote sensing and geo-resistivity techniques for further excavation studies. Implementation of watershed development programmes will help to store more water resources surficially in check dams, percolation ponds, tanks and reservoirs, which would also lead to recharge of the ground water.

CONCLUSIONS:

The seasonal water balance elements depict that during northeast monsoon there is no water deficit. The water deficit is high during southwest monsoon followed by summer and winter periods. The water surplus is found in the Nilagiris and kodaikanal hills of the Tamilnadu state. The moisture adequacy is 100% in all the stations during northeast monsoon periods. The Aridity Index is high in summer followed by southwest monsoon period. The annual PE and AE values show that there is water deficit in the state. The average water deficit is 699 mm. Climatologically the state enjoys perhumid, humid, wet submid during northeast monsoon period. In other seasons the Tamilandu State experience dry subhumid climate on the plain regions. The annual Moisture Index values depict that there is humid climate in hilly terrain and dry subhumid and semi-arid climate in plain regions.

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