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Determination of Seasonal Effects through Ratio to Trend Method for the Ground Water Levels in Anantapuramu District

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Abstract: ***Ground Water Levels is the most important or needed in Primary Sector, Industrial Sector and Service Sector also, especially Agricultural Sector its play a vital/crucial role. Present paper deals with the application of 'Time Series Analysis' to analyze and predict Ground Water Levels (GWLs) in Anantapuramu district based on the data collected from January 2001 to November 2017. Through with Ratio to Trend Method, for the purpose of analysis the district is divided into five Zones or Revenue Divisions (RD) namely, 1. Anantapuramu RD 2. Penukonda RD 3. Kadiri RD 4. Kalyandurg RD 5. Dharmavaram RD. We have calculated for the values of the Seasonal Indices (S.I) and compared among them by using the data. Further, validation of the fitted method identified the best suitable Zone. In the present paper we analyze the data collected and identified Seasonal effects for Ground Water Levels and conclusions are drawn based on the results obtained.***

Keywords: Ground Water Level, Time Series Analysis, Prediction, Ratio to Trend Method, Seasonal Indices

1. Introduction

Now a day's **Ground Water Levels (GWLs)** occupy a predominant role in many Sectors like., Agricultural, Industrial and Service Sector also its play a crucial role. **Water** is the main source and **vital need** for all living things for their existence. Even though the Water Storage system is introduced by British Government prior to Independence, more and more advancements and changes are introduced into the Water Storage system by onward Governments who came after the Independence.

For example General Sir Arthur Thomas Cotton was a British general and irrigation engineer. Cotton devoted his life to the construction of irrigation and navigation canals throughout British India. He helped many people by building the Dowleswaram Barrage (Rajamahendravaram), the Prakasam Barrage and the Kurnool Cuddappah Canal (K.C. Canal). His dream was only partially realized, but he is still honoured in parts of Andhra Pradesh (A.P) and Tamil Nadu for his efforts. The Sir Arthur Cotton Museum has been built in his honour in Rajamahendravaram, Andhra Pradesh. The museum holds approximately one hundred images and 15 machine tools that Cotton used when constructing the barrage in Andhra Pradesh from 1847 to 1852. This motivated us to do some work on Ground Water for future guidance and future plans for improving existing facilities. Motivated thus we have collected data from year **January 2001 to November 2017** in Anantapuramu District of A.P. In earlier papers we have determine trend values through linear and non-linear models like, Straight line, Parabola, Exponential and Power curve and identified '**Parabola**' trend model is the best model. Further papers our concentration is diverted towards the determination of Seasonal effects on the variables under consideration using Simple Averages Method.

In the present paper an improved method namely, **'Ratio to Trend Method'** is applied and determined the Seasonal Indices for the **Ground Water Levels** in Anantapurmau district. Now we proceed to explain some preliminaries of Ratio to Trend Method and some relevant definitions required to obtain the results of **Seasonal Indices** in the following section.

2. Methodology

Now we proceed to explain some preliminary definitions, terms used in calculating Seasonal Indices in Ratio to Trend Method.

This method is an improvement over the simple averages method and is based on the assumption that seasonal variation for any given month is constant factor of the trend. The measurement of seasonal variation by this method consists on the following steps [1, 2, 3, 4, 5, 6, 7, and 8]:

Step-I : Obtain the trend values by the least squares method by fitting a mathematical curve, straight line or second degree polynomial etc.

Step-II: Express the original data as the percentage of the trend values. Assuming the multiplicative model, these percentages will contain the seasonal, cyclic and irregular components.

Step-III: The cyclic and irregular components are then wiped out by averaging the percentages for different months (quarters) if the data are monthly (quarterly), thus leaving us with indices of seasonal variations. Either arithmetic mean or median can be used for averages, but median is preferred to arithmetic mean since the latter gives undue weightage to extreme values which are not primarily due to seasonal swings. If there are few abnormal values, modified mean (which consists of calculating arithmetic mean after

dropping out the extreme or abnormal values) may be used with advantage.

Step-IV: Finally, these indices, obtained in **Step-III**, are adjusted to a total of 1200 for monthly data or 400 for quarterly data by multiplying them throughout by a constant 'k 'given by

$$k = \frac{1200}{Total\ of\ the\ indices}\ and\ k = \frac{400}{Total\ of\ the\ indices}$$

for monthly and quarterly data respectively.

Merits and Demerits:
This method is based on the basic assumption that the data do not contain any trend and cyclic components and consists in eliminating irregular components by averaging the monthly (or quarterly) values over years. Since most of the economic time series have trends, these assumptions are not in general true and as such this method, through simple, is not of much practically utility[2,4,5,6,7,8].

Since this method attempts at ignoring out the cyclical or irregular components by the process of averaging, the purpose will be accomplished only if the cyclical variations are known to be absent or they are not so pronounced even if present. On the other hand, if the series exhibits pronounced cyclical swings, the trend values obtained by the least square method can never follow the actual data as closely as 12-month moving average and as such the seasonal indices obtained by 'Ratio to Moving Average Method' discussed in next Research Paper.

The obvious advantage of this method over the moving average method lies in the fact that 'Ratio to Trend' can be obtained for each month for which the data are available and as such, unlike the 'Ratio to Moving Average' method, there is no loss of data [1,2 and 3].

Remark: In the above explained procedure, calculations are simplified to a great extent by first fitting a trend equation to the yearly totals (or averages) and then obtained the monthly (or quarterly) trend values by a suitable modification of the trend equation.

1) If instead of monthly averages, we use monthly totals for all the years, the result remains the same.
2) Total of seasonal indices is 12 × 100 = 1200 for monthly data and 4 × 100 = 400 for quarterly data.

Using above explained procedure now we proceed to calculate results for the Ground Water Levels data in Anantapuramu district.

3. Data and Calculations (Month-Wise) of Seasonal Indices

Table 3.1: Ratio to Trend Method for Ground Water Levels data for Zone–I

Years/ Months	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jan	8.15	5.16	12.16	13.42	13.7	8.87	12.27	8.08	9.17	11.24	11.27	12.78	13.25	15.36	14.94	13.11	16.42
Feb	8.35	6.11	13.97	14.44	14.08	9.52	12.18	8.34	10.45	12.4	11.78	14.47	14.16	15.19	15.9	14.15	16.99
Mar	8.55	7.09	12.85	15.36	14.64	10.12	12.82	9.88	11.09	12.92	12.1	15.73	14.9	15.57	15.85	15.7	18.02
Apr	8.94	7.16	12.56	16	15.34	9.94	13.4	10.23	11.78	14.3	12.51	15.58	16.66	16.59	16.02	16.73	18.9
May	9.63	8.5	13.4	15.08	15.97	11.02	13.91	10.12	12.32	15.49	12.52	16.75	17.19	15.66	16.37	16.99	19.63
Jun	10.33	7.54	13.76	14.58	16.08	11.32	12.48	10.44	12.67	14.54	12.85	18.09	17.47	17.24	16.44	16.52	18.86
Jul	10.77	8.03	14.08	13.36	16.2	11.6	10.68	10.67	14.23	13.4	12.88	16.84	18.04	17.63	16.72	14.96	19.54
Aug	11.08	8.71	14.31	13.92	14.81	12.79	11.09	11.65	14.92	13.4	13.11	16.89	18.62	15.57	15.86	15.69	20.24
Sep	9.92	9.69	15.36	13.8	12.18	12.1	7.58	10.09	13.65	12.61	13.05	14.48	16.92	15.82	14.34	15.6	16.96
Oct	4.77	9.36	12.92	13.89	9.31	11.86	6.67	10.28	12.35	11.85	12.52	13.49	14.12	16.45	12.28	15.64	11.4
Nov	4.83	9.16	13.76	13.81	9.31	11.32	7.21	10.19	12.04	10.55	13.43	12.84	14.71	15.19	11.77	15.97	9.94
Dec	4.89	9.52	13.7	13.42	8.86	12.04	6.97	9.65	11.44	10.22	14.29	12.28	15.5	15.87	12.14	15.82	

Table 3.2: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–I

Months	Total	**Avg($\bar{x}_i$) or (U_t)**	T_t
Jan	199.35	11.73	13.40
Feb	212.48	12.50	13.33
Mar	223.19	13.13	13.25
Apr	232.64	13.68	13.18
May	240.55	14.15	13.10
Jun	241.21	14.19	13.03
Jul	239.63	14.10	12.95
Aug	242.66	14.27	12.87
Sep	224.15	13.19	12.80
Oct	199.16	11.72	12.72
Nov	196.03	11.53	12.65
Dec	186.61	11.66	12.57

Table 3.3: Ratio to Trend Method for Ground Water Levels data for Zone–II

Years/ Months	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jan	13.78	10.39	12.67	20.7	25.02	16.26	22.16	21.9	15.89	15.4	12.08	18.51	23.09	19.98	27.62	19.99	36.12
Feb	13.98	10.85	13.39	21.77	25.66	17.39	23.77	21.84	17.15	16.33	13.36	19.73	21.49	20.26	28.79	21.95	36.92
Mar	14.55	11.8	20.76	23.01	27.24	18.18	24.75	22.95	17.5	15.91	13.93	19.35	22.89	20.7	28.27	24.27	40.02
Apr	14.53	12.56	21.09	23.36	27.96	19.55	25.7	22.69	18.07	16.29	14.67	19.61	24.9	24.28	29.11	26.37	41.63
May	15.14	13.23	21.73	22.25	28.26	19.52	25.89	23.49	18.75	16.36	15.45	20.84	26.85	20.73	29.09	26.18	42.01
Jun	15.27	13.47	22.57	22.26	29.47	20.49	24.62	23.51	18.55	15.67	15.54	21.4	28.4	23.13	28.39	25.14	41.68
Jul	16.82	14.09	23.35	22.56	29.59	19.98	24.77	23.73	19.56	15.88	16.45	21.8	28.01	24.48	29.48	27.34	43.23
Aug	17.41	14.61	23.28	22.67	26.28	20.7	23.97	22.97	20.25	15.44	16.54	22.37	24.71	25.73	30.06	25.15	44.76
Sep	16.68	15.99	23.81	22.07	21.24	21.63	22.17	18.12	18.23	15.64	15.48	21.44	19.9	25.97	26.83	27.86	43.23
Oct	11.42	16.48	23.85	22.53	17.3	21.24	18.33	16.22	15.35	14.8	15.74	20.15	18.71	25.19	24.11	31.83	34.83
Nov	10.29	16.67	20.05	23.04	17.3	21.35	17.28	15.82	15.38	11.44	16.03	19.82	18.53	24.83	20.87	33.65	26.54
Dec	10.36	18.14	20.11	24.6	15.58	19.73	17.61	15.46	15.66	11.66	16.72	20.98	19.6	25.78	18.88	33.65	

Table 3.4: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–II

Months	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
Jan	331.56	19.50	21.83
Feb	344.63	20.27	21.76
Mar	366.08	21.53	21.69
Apr	382.37	22.49	21.62
May	385.77	22.69	21.55
Jun	389.56	22.92	21.48
Jul	401.12	23.60	21.41
Aug	396.9	23.35	21.34
Sep	376.29	22.13	21.27
Oct	348.08	20.48	21.20
Nov	328.89	19.35	21.13
Dec	304.52	19.03	21.06

Table 3.5: Ratio to Trend Method for Ground Water Levels data for Zone–III

Years/ Months	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jan	10.41	6.17	14.61	13.63	17.75	7.95	13.84	8.8	8.67	11.05	7.49	13.07	18.14	12.49	27.85	9.73	22.7
Feb	10.61	6.74	15.73	14.66	18.29	8.75	14.56	9.53	9.95	11.58	9.2	14.36	20.05	13.8	28.67	11.8	26.68
Mar	10.9	7.99	13.39	15.67	18.76	9.42	15.5	9.51	10.82	13.46	10.71	15.69	18.52	14.84	31.74	12.59	26.33
Apr	11.2	8.21	13.85	15.96	19.53	10.23	16.48	9.81	11.65	14.25	11.76	15.95	23.5	14.63	32.17	13.54	28.86
May	12.28	9.04	14.4	14.72	20.78	10.85	16.6	10.53	12.21	14.58	12.43	15.95	24.81	18.51	33.5	13.94	29.15
Jun	11.71	8.88	15.19	15.58	21.09	10.89	15.82	10.35	10.24	14.46	13.12	16.82	24.75	17.93	27.56	13.89	31.2
Jul	13.17	9.56	15.91	15.76	21.32	11.4	15.51	11.63	12.15	13.34	14.11	17.46	25.22	20.93	27.8	14.43	31.2
Aug	12.71	10.25	15.89	16.37	18.66	12.16	14.72	11.49	13.29	13.34	12.57	17.02	22.56	23.71	30.97	13.89	32.7
Sep	12.67	11.08	16.85	16.6	15.05	12.72	13.18	8.3	12.3	12.94	11.58	17.65	17.28	24.96	27.81	15.41	22.58
Oct	5.75	10.35	13.15	15.14	8.22	12.87	12.05	7.19	10.78	12.68	12.43	17.08	12.14	25.44	25.07	19.94	17.26
Nov	5.1	10.37	12.46	16.13	8.22	12.91	10.91	7.36	10.8	6.34	11.53	16.26	10.97	24.28	14.27	23.78	15.66
Dec	5.8	10.8	12.57	17.24	7.46	10.87	11.61	6.9	10.15	6.34	10.74	16.26	11.16	25.63	9.24	21.25	

Table 3.6: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–III

Months	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
Jan	224.35	13.20	15.70
Feb	244.96	14.41	15.58
Mar	255.84	15.05	15.47
Apr	271.58	15.98	15.35
May	284.28	16.72	15.24
Jun	279.48	16.44	15.12
Jul	290.9	17.11	15.01
Aug	292.3	17.19	14.90
Sep	268.96	15.82	14.78
Oct	237.54	13.97	14.67
Nov	217.35	12.79	14.55
Dec	194.02	12.13	14.44

Table 3.7: Ratio to Trend Method for Ground Water Levels data for Zone–IV

Years/ Months	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jan	9.63	8.12	11.94	16.27	19.87	12.51	14.72	11.72	8.93	8.24	6.74	11.69	14.68	16.46	19.37	15.93	23.16
Feb	9.83	8.8	12.53	16.85	19.89	13.2	15.13	11.85	9.68	8.22	7.09	12.85	15.64	18.74	19.76	16.88	23.51
Mar	10.04	9.7	13.19	17.68	20.54	13.26	16.43	12.24	10.17	9.09	7.83	13.98	16.72	18.53	20.65	18.19	23.78
Apr	11.66	10.35	13.84	18.02	21.06	14.6	16.8	12.26	10.85	9.7	8.32	13.67	17.57	19.28	21.15	18.87	25.27
May	12.42	10.44	14.69	17.17	21.47	14.08	17.46	12.67	11.03	10.42	8.47	13.68	17.98	19.55	21.04	19.09	26.33
Jun	12.11	10.45	14.99	16.81	21.33	14.75	16.1	11.89	10.78	9.76	8.67	14.91	18.51	20.38	20.75	18.16	26.45
Jul	12.92	10.78	15.85	17.21	20.56	15.28	15.89	12.3	11.29	9.61	9.28	15.03	18.44	19.71	20.77	19.95	27.02
Aug	13.08	10.83	15.96	17.41	18.16	15.92	16.43	12.25	11.49	9.01	9.67	14.49	18.89	19.18	21.65	20.37	27.63
Sep	12.97	11.24	16.17	17.51	15.15	15.94	14.5	8.41	10.11	8.47	10.07	14.56	16.9	19.1	20.07	20.47	27.25
Oct	7.41	10.9	16.35	17.97	11.86	15.82	13.08	8.08	7.19	7.71	10.15	13.46	15.7	18.82	16.08	21.23	23.28
Nov	11.31	11.11	15.86	17.65	11.86	15.14	11.44	8.36	6.56	6.09	9.92	13.14	15.82	18.43	14.83	22.05	19.03
Dec	7.87	11.45	15.72	19.3	11.65	13.9	12.03	8.5	6.82	6.6	11.15	13.7	16.78	18.73	14.76	22.73	

Table 3.8: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–IV

Months	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
Jan	229.98	13.53	15.09
Feb	240.45	14.14	15.03
Mar	252.02	14.82	14.97
Apr	263.27	15.49	14.91
May	267.99	15.76	14.85
Jun	266.8	15.69	14.79
Jul	271.89	15.99	14.74
Aug	272.42	16.02	14.68
Sep	258.89	15.23	14.62
Oct	235.09	13.83	14.56
Nov	228.6	13.45	14.50
Dec	211.69	13.23	14.44

Table 3.9: Ratio to Trend Method for Ground Water Levels data for Zone–V

Years/ Months	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jan	11.32	6.43	14.29	15.34	18.44	13.74	17.11	8.41	8.02	11.04	10.52	10.74	15.27	12.53	19.15	13.83	18.39
Feb	11.52	7.11	15.64	16	19.12	14.77	17.82	8.67	8.08	11.64	11.52	12.03	15.21	11.57	19.44	14.39	19.84
Mar	11.96	8.6	13.2	16.67	20.24	15.63	18.97	9.39	8.25	12.73	12.22	12.65	16.73	13.04	18.98	16.84	19.53
Apr	12.29	9.26	13.89	17.26	20.83	15.2	20.11	10.32	8.88	13.69	12.91	13.4	15.46	12.71	20.15	17.35	21.2
May	13.05	8.17	14.54	16.75	22.51	15.52	20.99	11.11	9.48	13.34	12.87	13.37	16.56	15.7	19.84	17.9	20.8
Jun	13.67	7.92	15.4	16.99	21.94	16.98	19.37	10.88	9.42	12.1	13.33	13.12	16.48	14.07	16.24	15.09	20.48
Jul	14.71	9.36	16.29	16.3	22.11	15.79	18.53	11.41	10.65	11.83	13.84	13.72	16.84	14.67	19.04	14.36	21.08
Aug	15.53	9.54	16.17	16.45	19.55	16.29	18.48	11.19	12.58	11.76	13.18	13.8	14.31	17.48	17.53	14.59	23.11
Sep	14.49	10.43	16.19	17.37	14.8	16.67	15.6	7.36	12.32	11.7	13.58	14.7	10.85	18.58	17.44	15.47	20.32
Oct	5.12	9.98	15.78	16.92	12.67	17.49	13.29	6.47	11.79	12.14	13.33	13.62	10.63	18.44	16.42	16.35	12.65
Nov	4.81	10.35	14.23	17.39	12.67	18.17	11.88	7.26	11.93	9.36	12.74	13.75	10.91	16.99	14.25	18.75	8.72
Dec	6.18	10.87	14.4	18.33	12.49	21.32	12.17	6.57	11.54	10.16	13.72	13.45	11.52	18.71	13.61	18.71	

Table 3.10: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–V

Months	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
Jan	224.57	13.21	14.65
Feb	234.37	13.79	14.58
Mar	245.63	14.45	14.51
Apr	254.91	14.99	14.44
May	262.5	15.44	14.37
Jun	253.48	14.91	14.30
Jul	260.53	15.33	14.23
Aug	261.54	15.38	14.16
Sep	247.87	14.58	14.09
Oct	223.09	13.12	14.02
Nov	214.16	12.60	13.95
Dec	213.75	13.36	13.88

4. Data and Calculations (Quarter-Wise) of Seasonal Indices

Table 4.1: Ratio to Trend Method for Ground Water Levels data for Zone–I

Years/ Quarters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Q_1	25.05	18.36	38.98	43.22	42.42	28.51	37.27	26.3	30.71	36.56	35.15	42.98	42.31	46.12	46.69	42.96	51.43
Q_2	28.9	23.2	39.72	45.66	47.39	32.28	39.79	30.79	36.77	44.33	37.88	50.42	51.32	49.49	48.83	50.24	57.39
Q_3	31.77	26.43	43.75	41.08	43.19	36.49	29.35	32.41	42.8	39.41	39.04	48.21	53.58	49.02	46.92	46.25	56.74
Q_4	14.49	28.04	40.38	41.12	27.48	35.22	20.85	30.12	35.83	32.62	40.24	38.61	44.33	47.51	36.19	47.43	21.34

Table 4.2: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–I

Quarters	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
Q_1	635.02	37.35	40.27
Q_2	714.4	42.02	39.28
Q_3	706.44	41.56	38.30
Q_4	581.8	34.22	37.31

Table 4.3: Ratio to Trend Method for Ground Water Levels data for Zone–II

Years/ Quarters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
$\boldsymbol{Q_1}$	42.31	33.04	46.82	65.48	77.92	51.83	70.68	66.69	50.54	47.64	39.37	57.59	67.47	60.94	84.68	66.21	113.06
$\boldsymbol{Q_2}$	44.94	39.26	65.39	67.87	85.69	59.56	76.21	69.69	55.37	48.32	45.66	61.85	80.15	68.14	86.59	77.69	125.32
$\boldsymbol{Q_3}$	50.91	44.69	70.44	67.3	77.11	62.31	70.91	64.82	58.04	46.96	48.47	65.61	72.62	76.18	86.37	80.35	131.22
$\boldsymbol{Q_4}$	32.07	51.29	64.01	70.17	50.18	62.32	53.22	47.5	46.39	37.9	48.49	60.95	56.84	75.8	63.86	99.13	61.37

Table 4.4: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–II

Quarters	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
Q_1	1042.27	61.31	65.52
Q_2	1157.7	68.10	64.54
Q_3	1174.31	69.08	63.57
Q_4	981.49	57.73	62.59

Table 4.5: Ratio to Trend Method for Ground Water Levels data for Zone–III

Years/ Quarters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Q_1	31.92	20.9	43.73	43.96	54.8	26.12	43.9	27.84	29.44	36.09	27.4	43.12	56.71	41.13	88.26	34.12	75.71
Q_2	35.19	26.13	43.44	46.26	61.4	31.97	48.9	30.69	34.1	43.29	37.31	48.72	73.06	51.07	93.23	41.37	89.21
Q_3	38.55	30.89	48.65	48.73	55.03	36.28	43.41	31.42	37.74	39.62	38.26	52.13	65.06	69.6	86.58	43.73	86.48
Q_4	16.65	31.52	38.18	48.51	23.9	36.65	34.57	21.45	31.73	25.36	34.7	49.6	34.27	75.35	48.58	64.97	32.92

Table 4.6: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–III

Quarters	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
$\boldsymbol{Q_1}$	725.15	42.66	46.90
$\boldsymbol{Q_2}$	835.34	49.14	45.65
$\boldsymbol{Q_3}$	852.16	50.13	44.40
$\boldsymbol{Q_4}$	648.91	38.17	43.15

Table 4.7: Ratio to Trend Method for Ground Water Levels data for Zone–IV

Years/ Quarters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
$\boldsymbol{Q_1}$	29.5	26.62	37.66	50.8	60.3	38.97	46.28	35.81	28.78	25.55	21.66	38.52	47.04	53.73	59.78	51	70.45
$\boldsymbol{Q_2}$	36.19	31.24	43.52	52	63.86	43.43	50.36	36.82	32.66	29.88	25.46	42.26	54.06	59.21	62.94	56.12	78.05
$\boldsymbol{Q_3}$	38.97	32.85	47.98	52.13	53.87	47.14	46.82	32.96	32.89	27.09	29.02	44.08	54.23	57.99	62.49	60.79	81.9
$\boldsymbol{Q_4}$	26.59	33.46	47.93	54.92	35.37	44.86	36.55	24.94	20.57	20.4	31.22	40.3	48.3	55.98	45.67	66.01	42.31

Table 4.8: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–IV

Quarters	Total	Avg$(\bar{x}_i)$ or (U_t)	T_t
Q_1	722.45	42.50	45.31
Q_2	798.06	46.94	44.51
Q_3	803.2	47.25	43.71
Q_4	675.38	39.73	42.91

Table 4.9: Ratio to Trend Method for Ground Water Levels data for Zone–V

Years/ Quarters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Q_1	34.8	22.14	43.13	48.01	57.8	44.14	53.9	26.47	24.35	35.41	34.26	35.42	47.21	37.14	57.57	45.06	57.76
Q_2	39.01	25.35	43.83	51	65.28	47.7	60.47	32.31	27.78	39.13	39.11	39.89	48.5	42.48	56.23	50.34	62.48
Q_3	44.73	29.33	48.65	50.12	56.46	48.75	52.61	29.96	35.55	35.29	40.6	42.22	42	50.73	54.01	44.42	64.51
Q_4	16.11	31.2	44.41	52.64	37.83	56.98	37.34	20.3	35.26	31.66	39.79	40.82	33.06	54.14	44.28	53.81	21.37

Table 4.10: Ratio to Trend Method Calculations of Trend Values (T_t) for Ground Water Levels for Zone–V

Quarters	Total	Avg($\bar{x}_i$) or (U_t)	T_t
Q_1	704.57	41.45	44.03
Q_2	770.89	45.35	43.07
Q_3	769.94	45.29	42.12
Q_4	651	38.29	41.16

Table 4.11: Calculation of S.I's Month-wise (Ratio to Trend Percentages $\frac{U_t}{T_t} \times 100$)

Months\Zones	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Zone-I	87.54	93.77	99.09	103.79	108.02	108.90	108.88	110.88	103.05	92.14	91.15	92.76
Zone-II	89.33	93.15	99.26	104.02	105.29	106.70	110.23	109.42	104.04	96.60	91.58	90.36
Zone-III	84.08	92.49	97.29	104.10	109.71	108.73	113.99	115.37	107.04	95.23	87.90	84.00
Zone-IV	89.66	94.08	99.00	103.89	106.13	106.09	108.48	109.13	104.17	94.99	92.76	91.62
Zone-V	90.17	94.58	99.59	103.81	107.45	104.27	107.73	108.62	103.48	93.58	90.32	96.25
Total	**440.78**	**468.07**	**494.23**	**519.61**	**536.60**	**534.69**	**549.31**	**553.42**	**521.78**	**472.54**	**453.71**	**454.99**
Average(P.S.I's)	**88.16**	**93.61**	**98.85**	**103.92**	**107.32**	**106.94**	**109.86**	**110.68**	**104.36**	**94.51**	**90.74**	**91.00**
S.I	**88.16**	**93.62**	**98.85**	**103.93**	**107.33**	**106.94**	**109.87**	**110.69**	**104.36**	**94.51**	**90.75**	**91.00**

Table 4.12: Calculation of S.I's Quarter-wise (Ratio to Trend Percentages $\frac{U_t}{T_t} \times 100$)

Quarters\Zones	Q_1	Q_2	Q_3	Q_4
Zone-I	92.75	106.98	108.51	91.72
Zone-II	93.57	105.52	108.67	92.24
Zone-III	90.96	107.65	112.91	88.46
Zone-IV	93.80	105.46	108.10	92.59
Zone-V	94.14	105.29	107.53	93.03
Total	**465.22**	**530.9**	**545.72**	**458.04**
Average(P.S.I's)	**93.04**	**106.18**	**109.14**	**91.61**
S.I	**93.05**	**106.19**	**109.15**	**91.61**

The Seasonal indices calculated

1. For month-wise
2. For Quarter-wise are represented in the following figures.

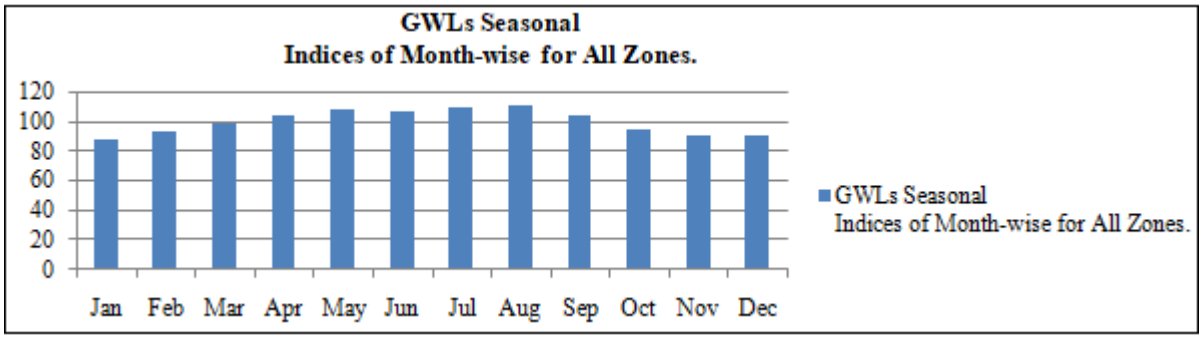

Figure 1: Seasonal Indices of Month-wise Graph for Ground Water Levels in Anantapuramu district

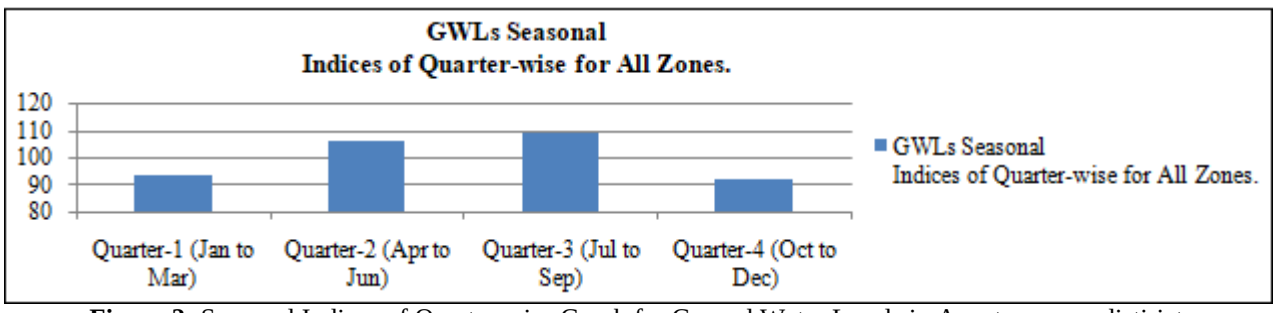

Figure 2: Seasonal Indices of Quarter-wise Graph for Ground Water Levels in Anantapuramu distirict

5. Results and Discussion

By comparing critically Monthly Seasonal Indices for Ground Water Levels data in all Zones that is April, May, June, July, August, September months Ground Water Levels is high. Similarly by comparing Quarterly Seasonal Indices for Ground Water Levels data in all Zones Quarter-2 and Quarter-3 Ground Water Levels is high. This is because of the fact that in every year especially hot weather season (summer) the Ground Water Levels is very high. Here high means the water level is going deeper and deeper. In general we can observe that as the Rainfall is increasing the depth of the Ground Water Level will be decreasing. It can observe through these graphs, in all the Zones under consideration the Ground Water Levels from 2001 January to 2017 November which is resulted in increasing the depth of the Ground Water Levels. Hence Ground Water Levels are showing increasing trend that is increasing in depth this is our conclusion.

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