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Research paper

Monsoon Agriculture - Suggestieve Methods Using Dependable Inflow & Rainfall for a Command Area

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Abstract

In the recent trend of changing environment, the rainfall and the inflow to the reservoir are getting reduced year by year respectively in agricultural field and in river basins. In this paper the dependable inflow into the reservoir and the rainfall in the command area is estimated with the past 30 years data. The statistical methods and formulae (Variance, Mann- Kendall method) are used to determine the dependable inflow and rainfall for both the monsoons. It is found that the inflow is not dependable for South –West monsoon, to do the agriculture, for a normal crop, with medium water requirement.. For the North - East monsoon both the inflow and rainfall are dependable hence the agriculture can be carried out with a single crop (paddy) having more water requirement (or) possible multi-crops, according to the storage in the reservoir and prediction of rainfall in that season. The deductions for other requirements of the dam, losses for evaporation, conveyance etc has been taken into account. The case study is done with the data for 30 years (1982-2012)for a dam in Tamil Nadu, India.

Keywords: *Dependable inflow, Dependable rainfall, Variance, Reliability, Mann Kendalltest.*

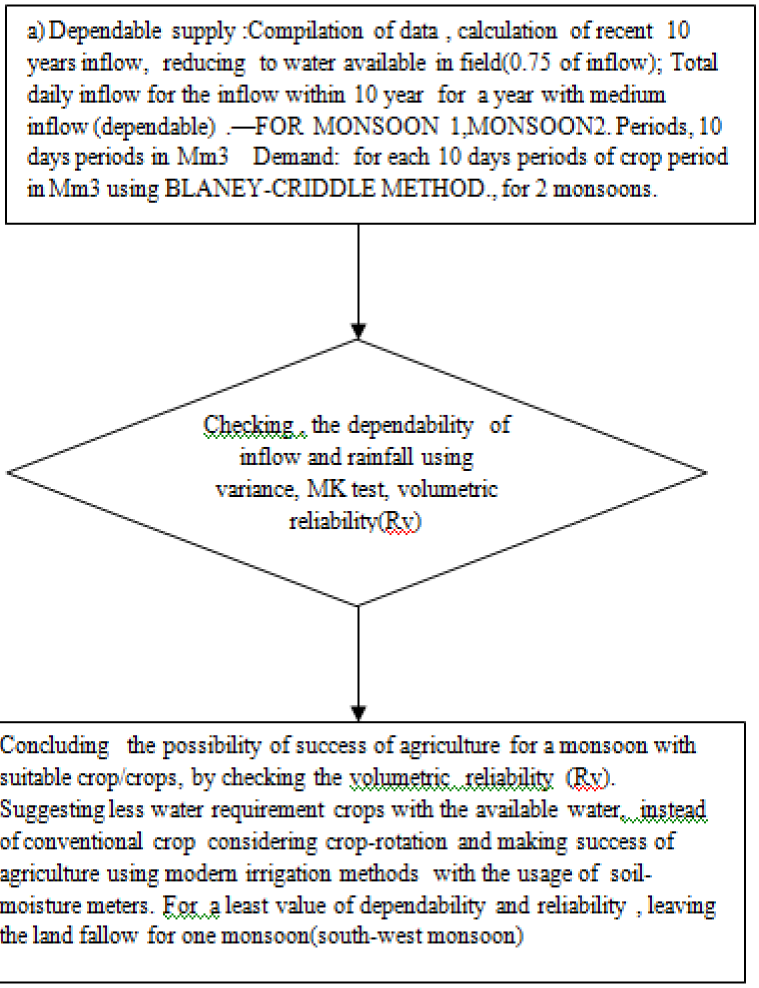
1. Introduction

Climatic change is a long term process, the statistical distribution of weather pattern over a period of time range from decades thousands of years[1]. The trend analysis is a method to determine the temporal changes and spatial variations for different parameters according to that climate. According to this, determination of the trend for rainfall and inflow is analysed to known whether the trend is increasing or decreasing for the monsoons [2]. By using the reliability concept plays a major role to analyse and design of water resources system [3] .The non – parametric test (Mann - Kendall) and statistical method (Coefficient of variation) are used to determine the rainfall and inflow trends for the monsoons, in this paper.

2. Study Area and Data Used

The area of case study is the Sathanur reservoir, constructed during 1985 in Thiruvannamalai district, Tamilnadu, India. It is across the river ponnaiar. It is having the catchment area of 10835 Km2. The length of the masonry Dam is 418 m and the length of the earth dam is 362 m. The height of the dam is 45 m above foundations. The capacity of an reservoir is 229 million m3 and the live storage capacity is 207 million m3 the spillway has 9 vents
of 12.2 m x 6.1 m the capacity of saddle spillway is 2234 m3/s.The length of the river is 7.2 km up to pick up weir. Period of wet season is September - January and the period of dry season is from December – march. Command area under wet period is 3164 hectare and the crop is paddy. The command area under dry period is 15200 hectare and the crop is groundnut it is having two main canals like LBC (left bank canal), RBC (right bank canal) by this canal the water is supplying for both the seasons. The various feature of the dam are (i) capacity of the reservoir – 340 million cu.m (ii) no of fillings – 20 out of 55 years (iii) annual storage – 6796 million cu.m (iv) water spread area -126.6 ha (v) catchment area – 87.023 sq.m (vi) area submerged – 102.935 ha .The dependable yield available at a site 10.26 cu.m. The new command area 740.57 ha and a old command area was 109.67 ha it contains no of spillway 2 no's. The area reaming after the construction of dam has been increased, additional area of irrigation was achieved I addition to the demand for riparianrights. The 30 years (1982-2012) of rainfall and inflow data are obtained from the damauthorities.

3. Methodology



In this article statistical non parametric estimators are applied i.e coefficient of variation and Mann – Kendall test to determine trends for monsoons according to the 30 years of data .generally Mann – Kendall method most preferable to found out the trend analysis . This formula was derived by both Mann and Kendall. Mann formulated a non- parametric test to deduct trend were Kendall gave the statistic distribution for non - linear trend and turning point.

3.1 MANN – Kendall Test

The Mann Kendall formula is given as

$$S=\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} sgn(x_j-x_i) \quad \ldots(1)$$

$$\operatorname{sgn}(x)=\begin{cases}+1, & x>0\\ 0, & x=0\\ -1, & x<0\end{cases} \quad (2)$$

$$E[S]=0 \quad (3)$$

$$\operatorname{Var}[S]=\frac{\left\{n(n-1)(2n+5)-\sum_{j=1}^{p} t_j(t_j-1)(2t_j+5)\right\}}{18} \quad (4)$$

$$Z=\begin{cases}\dfrac{S-1}{[\operatorname{Var}(S)]^{\frac{1}{2}}} & \text{if } S>0\\ & \text{if } S=0\\ \dfrac{S+1}{[\operatorname{Var}(S)]^{\frac{1}{2}}} & \text{if } S<0\end{cases} \quad (5)$$

Were 'n' represents the no of years.

From the above equations the value of S can calculated by using equation (1), were n is the no of years, sgn (x_i - x_j) it is a difference of each earlier year from each later year. Value follows a standard normal distribution. The positive and negative value of Z_{mk} indicates the increasing and decreasing trend. A 95 % confidence level with two tailed Z value of 1.96.If the Z_{mk} value is greater than z value then the trend is increasing or else it is a no trend.

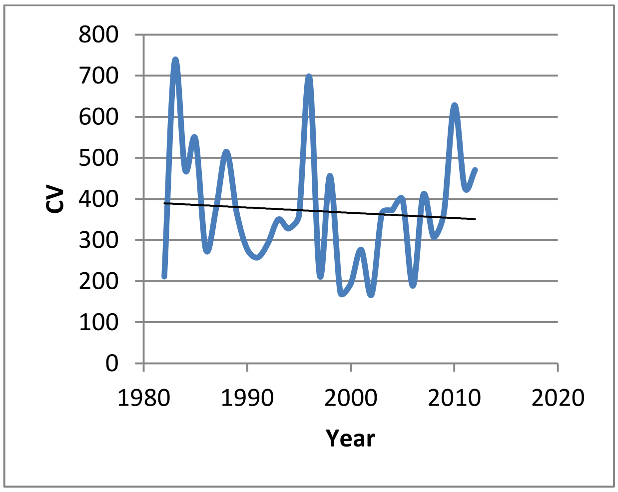


Fig. 3.1.1: Rainfall for monsoon1 recent 10 years)

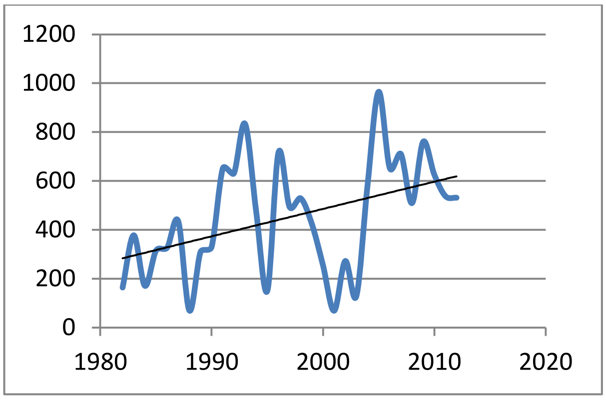


Fig. 3.1.2: Rainfall for monsoon2 --- (recent (1982-2012 rece 10years)

The obtained z value from Mann Kendall test for monsoon 1 and monsoon 2 was 1.04, 2.31. According to the above rainfall graph it is clearly mentioned that monsoon 1 has no trend and monsoon 2 is an increasing trend. It satisfies the Mann Kendall test.

3.2 Cofficient of Variation

The coefficient of variation (cv) is a measure of relative variability. It is the ratio of standard deviation to the mean (average). Then the statistical parameters like mean, standard deviation and cv is calculated for 30 years of rainfall data.

Table showing the results of statistical calculations for the data

Year	Mean	Std.Deviation	C.v	Mean	Std.Deviation	C.v
1982	52.75	50.76	96.23	9790	57.12	139.33
1983	183.75	157.02	85.45	40169	115.71	122.44
1984	135.75	114.26	84.17	2664.75	29.08	69.71
1985	136.5	38.75	28.38	6390.75	46.15	58.60
1986	69.5	63.47	91.65	5304.75	42.05	51.438
1987	94.25	83.77	88.89	22974.75	87.51	80.47
1988	128.75	113.15	87.89	1257	20.46	116.96
1989	91.25	75.99	183.28	16640.69	74.47	96.25
1990	69.5	95.5	137.41	7264.75	49.20	59.46
1991	64.32	41.94	65.21	104173.2	186.34	114.40
1992	73	60.51	82.83	147116.9	221.44	140.33
1993	87.5	45.65	52.17	96675.03	171.51	86.10
1994	81.95	80.95	98.78	54596.88	134.90	113.55
1995	90	22.73	25.25	5277	41.94	111.84
1996	111.75	84.04	75.21	82042	165.37	92.38
1997	53.5	36.02	67.33	30931	101.53	82.21
1998	114	76.17	66.82	33836.75	106.20	80.34
1999	43	42.94	99.88	35761.72	109.18	102.90
2000	48.37	59.81	123.65	9592.14	56.54	88.49
2001	69.15	61.82	89.40	3570.75	34.5	200
2002	41.62	45.02	108.16	24806.19	90.93	133.47
2003	91.15	109.23	119.83	5244.75	41.81	129.64
2004	93.12	131.49	141.19	103567.9	185.80	127.89
2005	99.6	61.97	62.22	165322.4	234.74	97.30
2006	47.1	41.23	87.54	96621.98	179.46	109.91
2007	102.6	50.23	48.96	57697.69	138.68	78.09
2008	76.87	33.73	43.87	41609.87	117.77	92.47
2009	91.75	129.38	141.01	71603.19	154.49	81.24
2010	156.95	78.55	50.04	86623.44	169.92	108.50
2011	106.95	41.35	38.66	24265.63	89.93	66.84
2012	117.62	75.27	63.99	43310.11	120.15	90.44

Mean: $(X_{avg}) = \sum X_i/n$ Were X_i is the rainfall, n is the no of years.

Standard deviation: $\sigma = [\sum(X_i - X_{avg})^2 / n\text{-}1]^{1/2}$ Were X_{avg} is the mean value.

Coefficient of variation: $Cv = (\sigma/X_{avg}) \times 100$

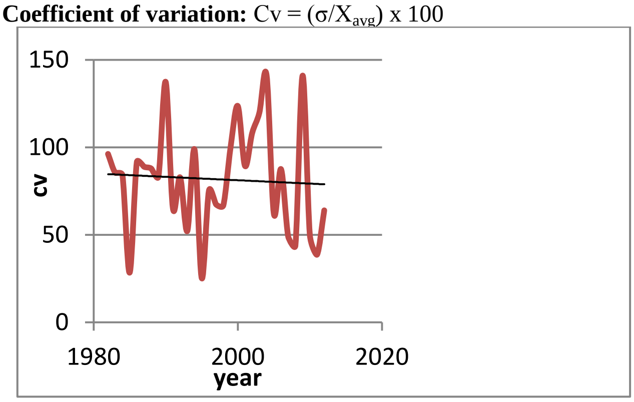


Fig. 3.2.1: c.v for monsoon1(1982-2012-- recent 10 years)

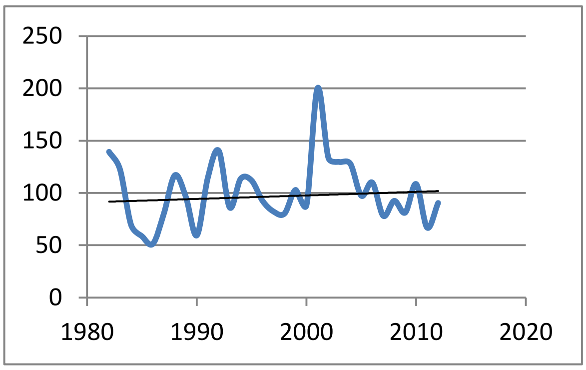


Fig. 3.2.2: c.v for monsoon2 (1982-2012- recent 10 years)

MONTH	DAYS	ET	K_C	ET CROP (mm)	ET CROP(m)	AREA	M3	Mm3
AUGUST	30	7.5	1.1	247.5	0.2475	31640000	7830900	7.83
SEPTEMBER	15	5.6	1.1	92.4	0.0924	31640000	2923536	2.92
SEPTEMBER	15	5.6	1.05	88.2	0.0882	31640000	2790648	2.79
OCTOBER	30	3.8	1.05	119.7	0.1197	31640000	3787308	3.78
NOVEMBER	20	3.8	1.05	79.8	0.0798	31640000	2524872	2.54
NOVEMBER	10	3.3	0.95	31.35	0.03135	31640000	991914	0.99
DECEMBER	15	2.9	0.95	41.32	0.04132	31640000	1307364	1.30

From the above graphs the trend of cv for monsoon 1 has no trend and the monsoon 2 has gradually increasing trend and hence the monsoon 2 is more reliable.

3.3 Reliability

Reliability is defined as a measure of how demand is met with supply for a given in a particular period of crop . In this arcticle volumetric releability concept is used to calculate the ratio between supply and demand for various periods of crop-periods in a particular monsoon season of year. The deamand for the food crop (paddy samba) is determined using the standard values of ETo , ETc from the manual preapred by IMTI (Irrigation Management Training Institute) Trichy,INDIA .The supply is calculated using 75 % of inflow data including the losses for evaporation and conveyance in the same monsoon period of normal inflow within the last 10 years (2002-2012)

3.4 Demand

The demand is calculated by using Blaney- criddle formula for Paddy using exact metrological details for the auycat area. In this area the paddy is irrigating from the month august to december for an irrigation area of 3164 hectare (The area of agricuture during

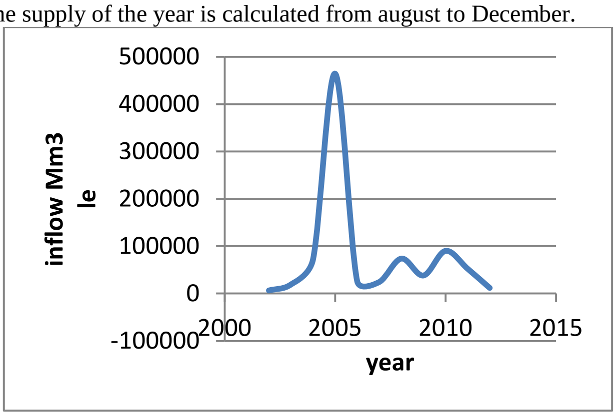
MONTH	INFLOW IN Mm3 (for a medium year)
August (30days)	1.155
September (15days)	2.016
September (15days)	2.016
October (30days)	3.024
November (20days)	69.006
November (10 days)	42.0045
December (15 days)	42.1754

wet period commaned by Sathanur dam)

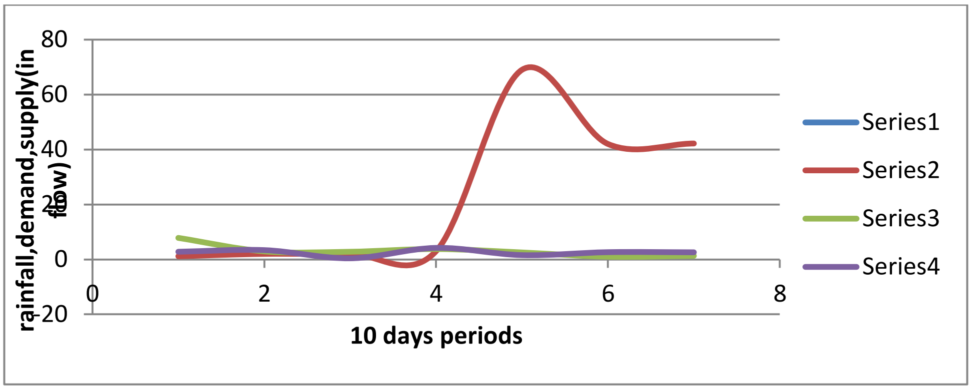
From this calculation the ET having a depth of 0.70027 m and a total demand for paddy is of 22.15654 Mm3.

3.5 Supply

From the normal year of inflow for the past 10 years (2002-2012) the supply of the year is calculated from august to December.



The supply for the particular season of the year is 217.9434Mm3. Hence the supply is low only at the beginning of the period when compare to the demand. It can manage by using the rainfall and by using the groundwater. And then the next period of agriculture can be done by using the inflow itself .Therefore for the wet period th e paddy agriculture is reliable.



Series 1---Demand, Series 2–supply, Serious3--Rainfall

Fig. 3.5.1: It shows for rainfall, supply and demand for a particular season (aug-dec)

3.6 Scheduling

The scheduling of agriculture is done for four phases of crop growth (paddy) is analysed and the volumetric reliability is also calculated for that season.

Volumetric reliability, = V_s/V_d
Were $V_s$is the volume of the water supplied.
V_d is the volume of the water demand during the period of the time.

Month	Supply Mm3	Demand Mm3	Volumetric reliability(Rv)
August (30)	1.155	7.83	0.1474
September(!5)	2.016	2.925	0.7054
September(15)	2.016	2.790	0.72413
October(30)	3.024	3.787	0.7984
November (20)	69.006	2.524	27.33049
November(10)	42.0045	0.9919	42.34692
December(15)	42.1754	1.307	32.25985

In this table the supply is multiplied by a factor of 0.75, for all losses including conveyance, evaporation etc. It is found that due to continuous irrigation during crop-period a supply-demand factor of 0.75 will suffice to maintain soil-moisture such that it doesn't go beyond critical level of wilting –point, and will resolve the problem of failure of crop until its full growth. But the Rv is very below 0.75 for the first month which can be tackled by the storage in the pre existing tanks by standard allocations, as per the riparian-rights of the Dam. Also with the high value of Rv for the remaining periods the farmer can suggest to do multi –cropping (or)mixed –cropping with the prediction for a particular year. Hence the volumetric reliability is satisfies for this period of time and the agriculture can be done safe at this period.

4. Results and Discussion

From the study of analysis of monsoons, it is found that the agriculture for the monsoon 2 can be carried out successfully for a normal year because the trend f\obtained from both the Mann Kendall and co efficient of variation is in increasing trend, for bath inflow and rainfall. For the monsoon 1 there is no trend is obtained from both Mann Kendall and co efficient of variation even for a normal year. Hence the agriculture is not suggestible with for monsoon 1. But that can be managed from the excess inflow water if available in the dam for each particular year after wet season, prediction of rainfall and by using water effective method for agriculture like drip irrigation & augmentation of water using ground water if available and percolation ponds. If crops other than paddy is taken which can be a used crop-rotation for monsoon 1 will be helpful to get back the nutrients for the soil.

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