International Journal of Research in Advent Technology, Vol.3, No.9, September 2015
E-ISSN: 2321-9637
Available online at www.ijrat.org

An Empirical Approach to Estimate Runoff of an Ungauged Catchment- Strange Table Method

M.Latha[1] and M.Rajendran[2]
Department of Civil Engineering[1, 2], Annamalai University[1, 2]
Email:kmlatha@gmail.com [1] ,raje69paru@gmail.com [2]

Abstract - Water is the elixir of life and a precious gift of nature to the mankind. It is fast becoming a scarce commodity in most parts of the world. The source of all water on the globe is precipitation. Runoff is one of the most important hydrologic variables used in most of the water resources applications. Reliable prediction of quantity and rate of runoff from land surface into streams and lakes is difficult and time consuming to obtain for ungauged watersheds. In this study strange table approach is used to estimate runoff of Veeranam catchment, Tamil Nadu, India. The runoff estimated using Strange table method is compared with Indirectly estimated flow for the period 1995-2011.R^2 values between Indirectly estimated flow Vs simulated flow shows a value of 0.87 insisting that this model can predict fairly the future runoff.

Index terms- Indirectly estimated flow, Runoff, Simulated flow, Ungauged Catchment.

1. INTRODUCTION

Air, water and soil of earth globe are playing an important role to support survival of various living organism in the bio-sphere. If the water is concerned its spatial and temporal distribution over a region are not homogenous. Its distribution to be properly planned and managed for effective utilization. Primary usage of drinking and Irrigation for agriculture. [9] Global water budget is concerned only 2.8% of freshwater availability both in surface and sub surface .Irrigation committee of India (1972) estimated seasonal and annual surface and subsurface water budget with respect to time and space is 1800 km^3 over the area $3.8km^2$ comes from Himalayan snow melt tropical dominant southwest monsoon and moderate North east Monsoon rainfall. The frequency and intensity of water related disasters rise significantly with increasing greenhouse gas emissions. Exploitation of new data sources better model and more powerful data analysis methods, as well as the design of adaptive management strategies help respond effectively to changing and uncertain conditions. [8] In this present scenario water management practice followed in the earlier millennium through the gauged and ungauged irrigation structures becoming difficult.

In this research paper it is aimed to investigate the performance of one of the empirical approach particularly developed for deccan plateau named Strange method to estimate the runoff for respective rainfall under the present condition for Veeranam catchment. **[4]** The strange table method can be used with a reasonable degree of accuracy for the prediction of runoff from catchments of irrigation tanks and small reservoirs. The observed runoff and computed runoff values for isolated rainfalls compared very well. There is close agreement between observed and computed values while considering short periods of data. **[5]** In the absence of flow measurement from its own catchment, the runoff depth estimated by the strange table method is compared and correlated with the results of another method curve number technique for the same period. Strange table estimation is well correlated of 98% with results of curve number technique. **[3]** One of the major problems confronted by the hydrologists for many years is the prediction of runoff from a given basin for a known rainfall. This problem is so complex that its complete solution is practically impossible, as there are numerous factors which affect the runoff process. In this study rainfall-runoff modeIling by using various empirical formulae is considered over the Nira Deoghar Catchment located in Pune District of Maharashtra. Models were evaluated using available rainfall-runoff relationships of the adjacent Dhom dam and downstream Veer dam. It is inferred that there is significant deviations between the measured and calculated yields for the catchment. The result of Stranges Table method was slightly higher than the measured values. **[1]** attempted to estimate runoff by one of the well-known methods i.e. soil conservation services method of America. It is compared with empirical methods. Satellite data for geographic information is used for computing runoff in soil conservation service method with GIS software's. The micro watershed is located in Sangli region, Maharashtra. Area covered in this study is 51.91 sq.km. For given study area that is Sangli micro watershed's CN number is calculated. This is used for daily runoff calculations. From the runoff calculations, it is found that SCN Curve number method results are closure to strange table method, khoslas method and Englis desouza method this study is useful for the watershed development and planning of water resources effectively.

2. STUDY AREA

The Veeranam tank is 24 km in the West of Chidambaram town of Cuddalore district,Tamil Nadu ,India. The Veeranam catchment is geographically extended between 11°10' N and 11°25' N latitudes and 79°10' E and 79°25' E longitudes. It covers a total water spread area of 542.94 km^2 including the Veeranam tank. Veeranam tank system is an irrigation tank of Tamil Nadu and forms part of the Cauvery basin. The sub-basin to which it belongs is referred as Udayarpalayam minor basin of lower Coleroon basin. The total capacity of the Veeranam tank as per silt survey during New Veeranam project at Full Tank Level was 1,465 Mcft with the codification 4B1A5f and 4B1A5e. Veeranam receives water through Vadavar in addition to its own catchment. Figure 1 shows the Veeranam tank system and catchment

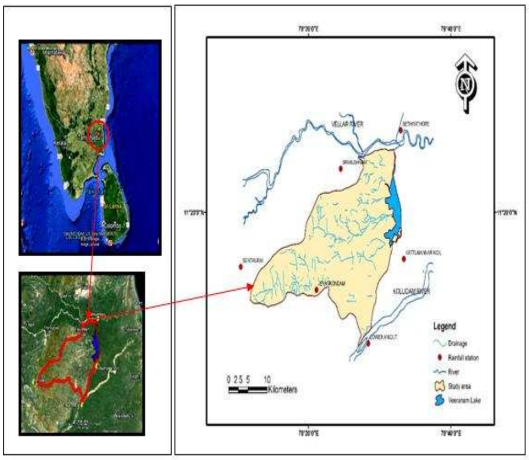

Figure 1 Veeranam tank system and catchment

3. DATA BASE AND METHODOLOGY

- Daily rainfall data (1995-2011) for the six raingauge stations in the study area have been used (Source: Department of Economics and Statistics, Chennai).
- Stage and outflow data (1995-2011)(Source : PWD, Chidambaram division, Tamil Nadu , India).
- Before the Independence of Indian nation and the colonial rule, British defence engineers were resources related research to construct irrigation structures in India. They developed empirical rainfall runoff model based on their experience in different region. Binnie's percentage table for Madyapradesh, Barlow's tables for Uttar Pradesh, Strange curves for Bombay-Deccan catchment are few of empirical approach found in the earlier literature **[6].**

One of the widely used empirical methods for computation of runoff is developed by Strange (1928). Strange conducted experiments in Bombay Presidency and developed the rainfall runoff profile and constructed a table when the catchment is dry, damp and wet condition. He believed and determined that the runoff depth which depends on the magnitude of rainfall occurred in the previous consecutive days in a_storm based on the soil moisture content due to successive rainfall days causes infiltration and saturated soil moisture yields the runoff depth for respective rainfall intensity. This method also referred now a days as Dry-Damp-Wet method and experimented in the Tamil Nadu State by the Public Works Department for mini to moderate catchment particularly for irrigation ponds to large tanks and modified the Strange table to predict runoff depth from rainfall data and similarly assessing the surface runoff potential for successful management practice. **[2]**. According to the yield, he classified the catchments as good,bad and average. Hence, a good catchment is the one which gives more runoff for the same rainfall, compared to average and bad type of catchments[7].

To assess the conditions of the catchment, he followed the following:

a) To assess the initial conditions of the catchment:

In order to find out whether the catchment is dry, the following four conditions should be satisfied. The rainfall should be less than anyone of the following:

i) ¼ inch in the previous day;
ii) ½ inch in the previous 3days;
iii) 1 inch in the previous 7days; and
iv) 1$^{1/2}$inch in the previous 10days.

For convenience, the computation of runoff can be started from the dry condition of the catchment.

b) Conditions required for transition from dry to damp:

The conditions required for transition from dry to damp is obtained when the rainfall is more than anyone of the following:

i) ¼ inch in the previous day;
ii) ½ inch in the previous 3days;
iii) 1inch in the previous 7days; and
iv) 1 ½ inch in the previous 10 days.

c) Conditions required for transition from damp to wet:

If the rainfall is more than anyone of the following, then the condition of the catchment is considered to be transitional from damp to wet.

i) 1/3inch in the previous day;
ii) ½ inch in the previous 2days;
iii) 1inch in the previous 3days; and
iv) 1 ½ inch in the previous 5 days.

d) Transition from dry to wet is made whenever $2^{1/2}$inches have fallen on theprevious day or on the same day. For example, for$4^{1/2}$inches rainfall in one day on a dry catchment, the runoff would be: for 2 ½ inches rain on a dry catchment, runoff = 0.38 inch; (4 ½ inches – 2 ½ inches); that is, 2 inches rain on a wet catchment’s runoff = 0.67 inch; and Total runoff = 1.05 inches.

e) Transition from wet to damp:

If the rainfall is less than anyone of the following (half the rainfall in(b)above) then the condition is said to be transitional from wet to damp.

i) $^{1/6}$inch in previous day;
ii) ¼ inch in previous 2days; and
ii) ½ inch in previous 3days.
iv) 3/4 inch in previous 5days.

f) Transition from damp to dry is obtained if the rainfall is less than anyone of the following:

i) 1/8inch in the previous day;
ii) 1/4 inch in the previous 3days;
iii) ½ inch in the previous 7days; and
iv) ¾ inch in the previous 10days.

The catchment is delineated using the toposheets 58M/7,58M/8,58M/10,58M/11. There are six raingauge stations in and around the catchment, namely, Senthurai, Srimushnam, Sethiathope, Lower Anicut, Jayankondam, and Kattumannarkoil. Thiessen polygon were drawn for the raingauge stations and overlaid with the delineated catchment. Runoff is being estimated for NorthEast monsoon for the storm 2 days and above with vadavar inflow nill. Figure 2 Shows the Thiessen polygon with subwatersheds.

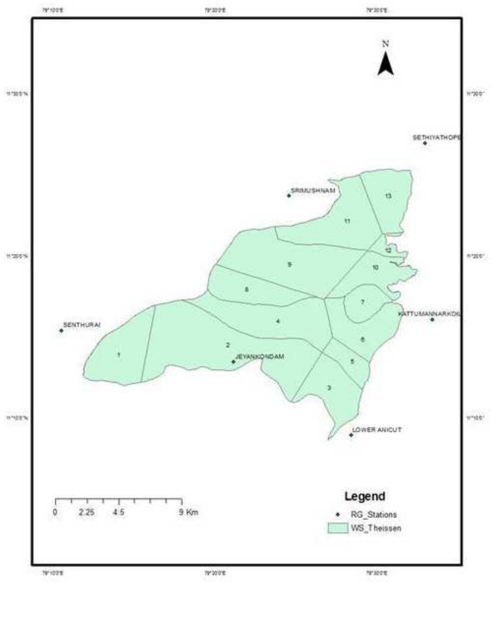

Figure 2 Thiessen polygon with subwatersheds

(1,2,3-SW1-Karruvattu odai, 4, 5, 6-sw2-Vannanguli odai,7-sw3-papagudi drain, 8, 9, 10- sw4- Sengal odai, 11,12,13-sw5-palayamkottai drain)

Since vadavar is the main feeder canal to Veeranam, Continuous storms two days and above were identified with vadavar inflow nill. Runoff for five subwatersheds have been estimated using Strange table and consolidated to obtain total runoff of the catchment.

3.1 Computation of Indirectly Estimated Flow

The basic water balance equation used to calculate the Indirectly estimated flow is:

$$I - O = \Delta S / \Delta t$$

Where I is the inflow in cusecs; O is the outflow in cusecs and ΔS / Δt is the change in storage in cusecs.

There is a chart known as the Stage-Capacity Chart, which shows the capacity of a tank in Mcft, for various stages of the tank (It is also a chart used by the PWD of the Government of Tamil Nadu to keep track of the stage capacities of tanks). It is often used in determining the change in storage of a tank between two consecutive days, when the stage increases or decreases in comparison with the previous day. The calculation is as follows:

Indirectly estimated flow= Change in storage + Outflow + losses when stage decreases in comparison with the previous day, Indirectly estimated flow =Outflow – Change in storage + losses

4. RESULTS AND DISCUSSIONS

Minimum runoff depth occurs in the year 2009 and maximum runoff depth occurs in the year 1996 Table1.Trend line analysis shows that there is a relation between rainfall Vs runoff and indirectly estimated flow Vs simulated runoff .Figure3 and Figure 4. It reveals that this Strange Table method can be used to simulate future runoff depth of ungauged catchments.

Table 1 Computation of Runoff using Strange Table

Year	Thiessen rainfall in (mm)	Indirectly estimated runoff depth (mm)	Strange Table runoff depth (mm)
1995	90.13	6.00	10.30
1996	721.08	372.65	290.30
1997	644.61	141.48	153.34
1998	510.81	151.08	121.12
1999	145.40	30.46	96.08
2000	283.15	73.20	55.13
2004	368.66	114.62	162.55
2005	754.35	345.44	275.91
2006	181.07	37.00	26.26
2008	612.66	255.99	188.38
2009	60.28	46.00	8.15
2010	535.29	164.65	222.09
2011	463.78	75.20	98.18

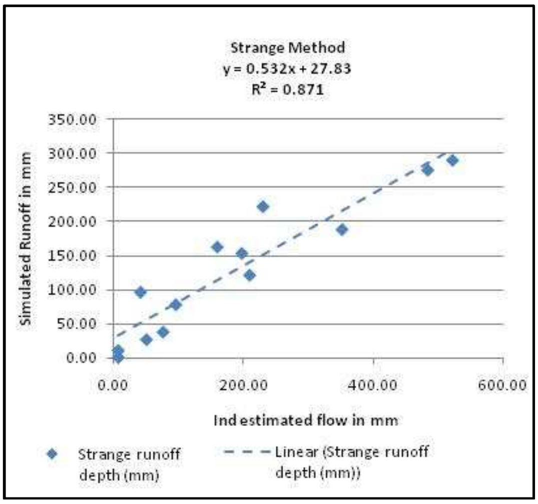

Figure 3 Trend line for Indirectly estimated flow Vs simulated flow (mm)

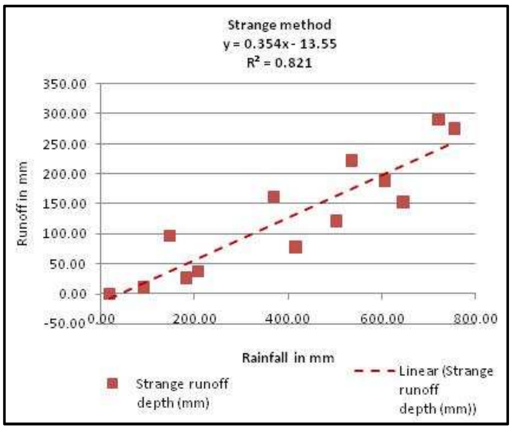

Figure 4 Trend line for Rainfall Vs Runoff mm

5. CONCLUSION

Strange Table is very widely used for South Indian watersheds or catchments. The PWD of Madras has adopted Strange Table for most of the catchments of the rivers of Tamil Nadu. The same method has been adopted in this study. For sixteen years of data rainfall-runoff relationships have been computed and Trend line has been plotted between rainfall VS runoff shows R^2 value of 0.82 and Indirectly estimated flow Vs simulated flow shows R^2 value of 0.87 indicating that there is a good simulation results obtained for runoff forecasting. Physical characteristics of the catchment vary over a wide range. Veeranam tank has an ungauged catchment. It means that discharge data is not available. Hence during North east monsoon period which influences the study area most of the runoff from the catchment that could not be stored is let to the sea as waste. This is the reason which paves way to the development of rainfall-runoff model. In this study Strange Table method is used to estimate the catchment runoff and compared with indirectly estimated flow for validation. It is inferred that this method fairly good in estimation of runoff from the catchment. The only drawback in Strange's method is that the estimation of yield due to monsoonic rainfall does not consider the variations either in the catchment characteristics or rainfall characteristics.

REFERENCES

[1] Anand B. Kudoli, R, Oak.A (2015) "Runoff Estimation by Using GIS Based Technique and Its Comparison with Different Methods- A Case Study on Sangli Micro Watershed" International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 Volume-4, Issue-5,PP131-137

[2] Ellis .W.M (1963) "College of Engineering Manual Irrigation".

[3] Kopade.D.K (2014) "Estimated Runoff yield for Nira deoghar catchment by using different empirical relations", International Journal Of Engineering And Science (IJES) Volume - 3 , Issue - 6 pp 75-81 ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805.

[4] Krishnan P.S. (1987), "Yield estimation for Pandiyanallur tank", M.E., thesis Anna university

[5] Rajendran. M and Nagarajan. N(2002) "Quantitative Assessment of Surface Runoff Potential in Veeranam Catchment" ,Proceedings of the National Seminar on Water Resources Systems Planning and Management, Mar 7-8, Annamalai University, pp. 16-26.

[6] Rao.K.L(1975) India's Water Wealth –Its Assessment ,uses and projections,Orient Longman press.

[7] Satya Narayanamurthy (2002) Water Resources Engineering Principles and Practice.

[8] The United Nations World Water Development Report (2015)"Water for a sustainable World".

[9] Ragunath.H.M (2006) "Hydrology Principles, Analysis Design" New Age International (P) Limited.