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Prototype for Estimation of Water Budget: Case Study: Vadeshwar village, India

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ABSTRACT: Water is the most essential and important resource. There are many regions in India where there is scarcity of water. Farmers are facing difficulties in cultivation of crops due to less water. And this is because of improper management and conservation of water. So, through our prototype we are calculating the water budget of a village by considering different parameters like rainfall, groundwater, precipitation, evapotranspiration etc. Water budget will be useful for management of water and also it will solve many problems faced by farmers for agriculture. Overall result will show the surplus and deficient water of that particular village.

KEYWORDS: Water Resources, Databases, Evapotranspiration, Precipitation, Water budget, Evaporation, Storage, Delta Storage, Temperature, Thornthwaite method.

I. Introduction

Water is said to be the basic need of every human being on this planet. Today, most of the villages are facing difficulties in acquiring the water resources. Due to scarcity of water the farmers are not getting proper yield. There are many challenges faced by villagers due to lack of water. So, for proper management of water, water budget is an important parameter which should be calculated. A water budget is the accounting of rates of water movement and the change in water storage in all or parts of the atmosphere, land surface, and subsurface. Although simple in concept, water budgets may be difficult to accurately determine. It is important for the public and decisionmakers to have an appreciation of the uncertainties that exist in water budgets and the relative importance of those uncertainties in evaluating how much water may be available for human and environmental needs.

II. LITERATURE SURVEY

•FIELD SURVEY

Farmers are facing various challenges in their day to day life. While our survey we found out these challenges.
The following are the challenges faced by them:

- Low Rainfall
- Shallow soil
- Low value coarse cereals
- Degraded soil
- Small holdings
- Poor financial and market access

From so many challenges we found that main resource needed is water. And if there is scarcity of water then all the other problems cannot be solved. We also visited a village named Vadeshwar in Maval region, Pune (India).Considering all these problems we thought that the water is most essential and so chose to solve this problem by proposing a system which will be feasible to the farmers.

[1] As testing the accuracy of the prediction methods under new conditions is time consuming and costly, yet crop water requirement data are frequently needed at short notice for project planning. In this paper, prediction methods are reviewed to evaluate water requirement of crops under different climatic and agronomic conditions present study reveals that the modified Penman method offers the best results with minimum possible error of plus or minus 10

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percent in summer, and -up to 20 percent under low evaporative condition followed by the Pan method with an error of 15 percent, depending on the location of the pan. This is the overall view of the paper.

Limitations: There are various methods used which have some limitations as stated below

•The Pan method used in this paper can be graded next with possible error of 15 percent, depending on the location of the pan.

•The modified Penman method would offer the best results with minimum possible error of plus or minus 10 percent in summer, and -up to 20 percent under low evaporative conditions.

•The Radiation method, in extreme conditions, involves a possible error of up to 20 percent in summer. •The Blaney-Criddle method should only be applied for periods of one month or longer; in humid, windy, mid-latitude winter condition- an over and under prediction of up to 25 percent has been noted.

In [2] the pan method of evaporimeters-lisimeters and energy balance method are most widely applied. A water balance method is often applied for small areas during a warm season when subsurface water is deep and surface runoff is not observed. It has been established that under the assessment of experimental methods for determining evaporation, quite reliable results for monthly intervals are provided by the standard version of the heat balance method based on the use of Bowen's equation. In the second group methods based on the solution of the equations of turbulent diffusion, heat balance or complex schemes are most suitable for computation of evaporation from land for particular months during the warm season. The use of a single model of water and heat regime formation within some territory with accounting its specific features is one of the basic ways to improve the accuracy of land evaporation computation.

The Experimental Methods for Determining Evaporation from Land :

$$E = P - (Wf - Wb)$$

In this scheme evaporation (E) is estimated from the water balance equation of the study area, say a field: where: P is precipitation during the design time interval; Wf and Wb are basic and final soil moisture storage, usually in the top soil layer 1m deep, estimated by any well known method (thermostatic, gravimetric, neutron, gamma-indication, tensiometric, osmic, etc.)

In [3] they have estimated the overall water budget by taking into consideration the basic parameters like precipitation, Evaporation and Evapotranspiration. Now, the precipitation is the input to the calculation of water budget. Rainfall is the most important parameter for the precipitation. It also includes groundwater like rivers, wells etc. So there will be the outflow of water. For calculating the water budget , in this paper they have considered evapotranspiration as a important parameter. The total water budget and even the surplus water is determined.

III. PROPOSED SYSTEM

- PARAMETERS CONSIDERED

For estimating the proper water budget of a village we need different parameters and also the Fig 1. shows the use of these parameters.

Following are the parameters needed :-

- Precipitation
- Dams, Rivers, Lakes
- Evapotranspiration
- Ground water
- Village population
- Delta Storage
- Storage
- Surplus
- Deficiency

- **Precipitation:** Precipitation is nothing but inflow (income) of water from various sources. Precipitation can be written as the sum of rain, groundwater, river, dams, lakes etc.
  P = Total gain- ET, where ET= Evapotranspiration

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Total gain= Rain water +River-inflow + Groundwater + dam/lakes inflow.
Units: mm or cm (millimeters or centimeters)

- **Evapotranspiration:** [4]Evapotranspiration (ET) is the sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and waterbodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. Evapotranspiration is an important part of the water cycle.
- **Population:** Every 10 years a census is taken to calculate the overall population in India. Population is also calculated dynamically based on death rate and birth rate. Geographically area of already calculated based on the dimensions of the land.
- **Groundwater:**It is one of the parameter which is going to help in calculating the water budget of the village. The Pre-monsoon, Monsoon, Post-monsoon-Rabi and Post-monsoon-Kharif are the parameters which are considered in analyzing the ground water level.
- **Delta Storage:** It is the change in water storage. Initially Storage is considered as 100 units and eventually it changes according to calculations.
- **Storage:** It is the water content in the soil where soil is considered as the natural container of the water. Initially Storage value is 100 and depends on delta storage.
- **Surplus:** It is the excess of water and given in mm/day or mm/month.
- **Deficiency:** It is the lack of water. It is measured in mm/day or mm/month.

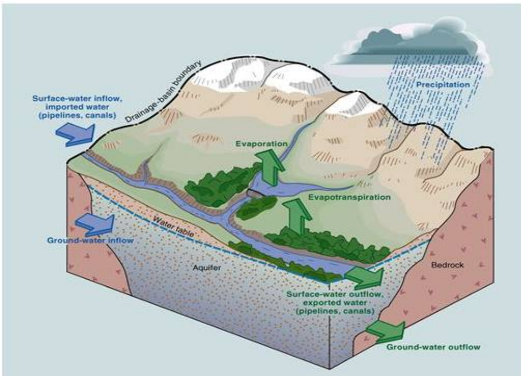

Fig 1. Main Components of Water Budget in Hydrolic-cycle.

By observing the challenges faced by the villagers and even farmers for agriculture, we are making a prototype for solving this issue by estimating the water budget. As the parameters mentioned above we have used those in different formulas for calculation.

Evapotranspiration formulas:

1. $I_i = (T_i/5)^{1.514}$
2. J= $\sum_{i=1}^{12}(I_i)$
3. c=$(6.75 \times 10^{-7})\, I^3 - (7.71 \times 10^{-5})\, I^2 + (1.792 \times 10^{-2}) I + 0.49239$
4. $PEt_i(0^\circ) = 1.6(10T_i/J)^c$
5. $PEt_i(L^\circ) = K \times PEt_i(0^\circ)$

Where, T = Mean average temperature of month, J= Heat index which depends on 12 months mean temperature T, c= Constant, L= Latitude (It can only be north and south and for rest values it will be 0), PEt = Potential Evapotranspiration. PEt when latitude = 0° , the day length will be 0 or 24 hrs. Use $PEt_i(L^\circ)$ this formula with K as an error correction. This prototype also considers the hemisphere of the area to be calculated.

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Overall Budget Calculation:

1. P= Rain water +River inflow + Groundwater + dam/lakes inflow
2. $\text{PEt}_i(L^{\circ}) = \text{K} \times \text{PEt}_i(0^{\circ})$
3. Overall gain =P- PEt_i
4. St(Storage) = If storage is 100% than no extra intake can be taken. Else if Storage is greater than 0 and less than 100 addition or subtraction of water can be done.
   Where, 0< St <100.
5. Ea (Actual Evapotranspiration) = P + previous St
   Where, St=0. Else Ea= Pet
6. D (Deficit)= When there is no enough storage to make the needs of Ep. D can be given as, when St=0.
7. D= PEt – Ea
8. Surplus S = We have surplus only when St = 100.
   S= P – (PEt + Change in storage).
9. Change in storage = P – PEt or 0, when St=100.

IV. RESULTS

VADESHWAR WATER BUDGET 2018

DISTRICT : PUNE

TALUKA : MAWAL

MONTHS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBE
MEAN TEMPERATURE (Celsius)	19.3	20.6	23.5	25.7	26.1	23.6	21.6	21.3	21.6
PRECIPITATION (mm)	1.0	0.0	2.0	12.0	35.0	382.0	1236.0	796.0	350.0
EVAPOTRANSPIRATION (mm/month)	55.33	68.25	99.66	131.63	142.17	111.83	88.31	82.87	81.88
(P - Ep)	54.33	68.25	97.66	119.63	107.17	270.17	1147.69	713.13	268.12
DELTA STORAGE	-54.33	-45.67	0.00	0.00	0.00	100.00	0.00	0.00	0.00
STORAGE	45.67	0.00	0.00	0.00	0.00	100.00	100.00	100.00	100.00
ACTUAL EVAPOTRANSPIRATION (Ea)	55.33	45.67	2.00	12.00	35.00	111.83	88.31	82.87	81.88
DEFICIENCY (D)	0.00	22.58	97.66	119.63	107.17	0.00	0.00	0.00	0.00
SURPLUS (S)	0.00	-1.00	-1.00	-1.00	-1.00	270.17	1147.69	713.13	268.12
RESULTS	Sufficient	InSufficient	InSufficient	InSufficient	InSufficient	extra	extra	extra	extra

FIG 3. SAMPLE WATER BUDGET

The Fig 3. Shows calculations of water budget considering the precipitation and temperature(degree Celsius) as input parameters and depending on these input parameters further calculations are done.

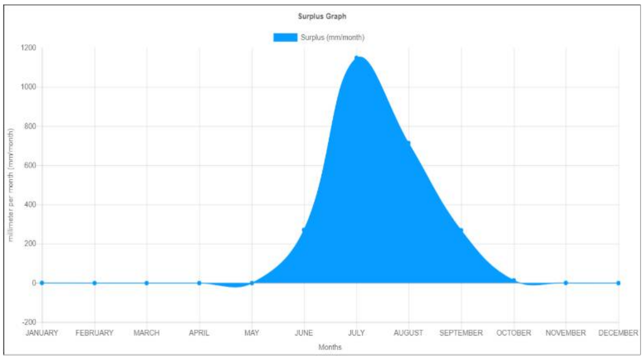

Fig 4. Surplus Graph

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The Fig 4 shows excess of water. It also helps in analyzing in which month there was excess water.

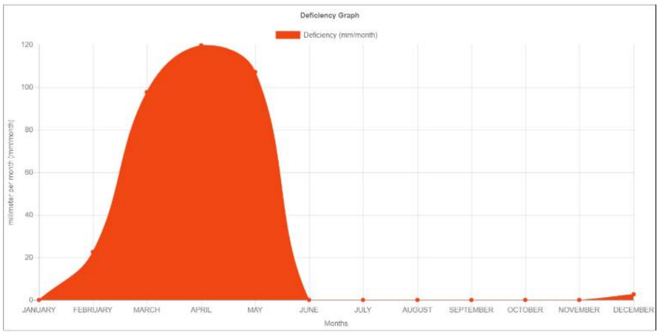

Fig 5. Deficiency Graph

The Fig 4 shows excess of water. It also helps in analyzing in which month there was excess water.

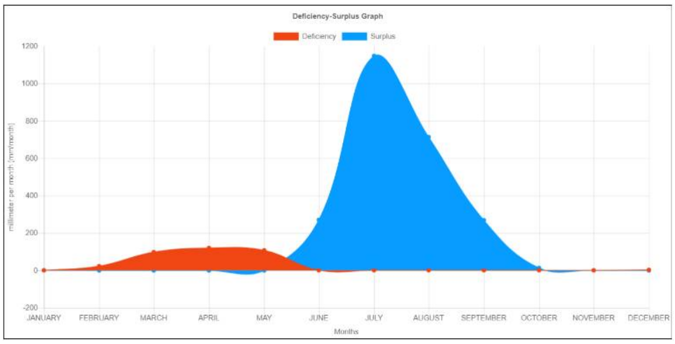

Fig 5. Deficiency and Surplus

The above graphs shows the surplus and deficient water in the Vadeshwar village. Through this representations people will come to know the water availability and the requirement to their village.

IV. CONLUSION

The water budget prototype will be very much useful for people to analyze the water availability and requirement for their village. It will also help to take precaution for the further water management. So, as water is the most important resource it should be used carefully.

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