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WATER SHED MEASUREMENT USING RS AND GIS APPLICATIONS

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Abstract-

Traditionally watersheds were spatial extents that capture rainwater. Recently it has been identified that unless the watersheds are not managed in an integrated sustainable manner, then not only the water resources but also other resources such as vegetation, fertile soil, fauna and flora get depleted. Rational management of upper and lower parts of a watershed is equally important for the sustenance of the environment. Therefore it is extremely important to use an integrated spatial approach for managing watersheds and river basins. The remote sensing and GIS for watershed management constitutes theoretical aspects of Geographic Information Systems (GIS) & Remote Sensing and their application for watershed management.

The Maumee River watershed is the largest drainage basin that discharges into the Great Lakes. Although the watershed is largely a rural landscape, several major urban-industrial cities, including Fort Wayne and Toledo are located along the river. Many water quality concerns are present, especially nonpoint rural runoff that contributes significant amounts of sediment into the Maumee River. There is an important need to collect, organize and assess the available information on the watershed conditions and to better determine the status of the changes with land uses, crop rotation, and implementation of conservation tillage practices within this watershed.

1.INTRODUCTION

Water as natural resources play a crucial role not only for agriculture and industry but because daily availability of potable drinking water eludes many people in our country. The scope of optimal utilization of water resources has become bleak and warrants judicious utilization. The erratic and irregular distribution of monsoon rainfall usually results in flood or drought situations in different parts of the country. Therefore, information on the extent and nature of flood plains is important to protect life and property in flood-affected area. So the knowledge of potential locations of storage of water in surface and ground water aquifer is essential for making available sustainable supply of water for domestic, agriculture and industrial use in water scarcity area. Also information on surface water bodies and location of potential ground water areas are very important tasks having high priority in water scarcity areas. Remote sensing with synoptic view and repetitive coverage of extensive inaccessible areas has a great potential to provide a wide range of data for water resources development & management namely for their inventory, forecasting and design. At present, for studying different components of water resources, the use of remote sensing is at different stages of operationalization.

The main sources of river pollution are usually point sources originated from household and industrial discharges as well as diffuse pollution generated by agricultural and urban runoff. Characterizing pollutants requires extensive knowledge of the area's geography and non point sources; therefore the possible point and diffuse sources of pollution must be identified and located in order to be assessed.

2.Objectives

1.To estimate the evapotranspiration by Priestley Taylor method using MODIS data products.

2.Land development including moisture conservation like contour or graded bund covered by vegetation, etc. in hilly area. 3.Development of small water harvesting structure as check dam, recharge wells etc.

4.Nursery rising for timber, fule wood and horticultural species.

5.Afforestation and planting the trees also improved area.

6.Preference is given first for drinking water for human being and animal and secondary for agricultural

3. LITERATURE REVIEWS

David A. King, Dominique M. Bachelet (2015) They developed an algorithm for linking PET to extraterrestrial solar radiation (incoming top-of atmosphere solar radiation), as well as temperature and atmospheric water vapor pressure, and incorporated this algorithm into the dynamic global vegetation model MC1. We tested the new algorithm for the Northern Great Plains, USA, whose remaining grasslands are threatened by continuing woody encroachment. Both the new and the standard temperature-dependent MC1 algorithm adequately simulated current PET, as compared to the more rigorous PenPan model of Rotstayn et al. (2006). However, compared to the standard algorithm, the new algorithm projected a much more gradual increase in PET over the 21st century for three contrasting future climates. This difference led to lower simulated drought effects and hence greater woody encroachment with the new algorithm, illustrating the importance of more rigorous calculations of PET in ecological models dealing with climate change.

P D Semalty, K Dev (April 2011*)* In their study different approaches were applied for the estimation of ET; these include energy balance method, mass transfer method, pan evaporation method and estimation from the meteorological data. In the current approach for estimating evapotranspiration through daily-observed climatic parameters, they have used the Priestley-Taylor model.This model is the simplest among the various methods because it required minimum four parameter i.e., net radiation, air temperature, soil moisture and humidity giving reasonable estimation of evapotranspiration.

Kumar Raju (2010) He used an algorithm based on the surface energy balance method and Priestley-Taylor equation to estimate the regional evapotranspiration of Netravathi river basin. MODIS land surface temperature and surface reflectance were used for mapping the ET by both the methods.

Bella et al., (2004) From their study evapotranspiration was estimated using NOAA AVHRR imagery in the Pampa region of Argentina. They used multiple regression analysis to relate evapotranspiration (ET), computed from a water balance technique, to both thermal infrared and normalized difference vegetation index data obtained from the Advanced Very High Resolution Radiometer (AVHRR) sensor on board on the National Oceanic and Atmospheric Administration (NOAA) satellite. This approach, based on only remotely sensed data provided a reliable estimate of ET over the Pampas, the main agricultural region of Argentina.

4.METHODOLOGY

Priestley-Taylor Method

The Priestley-Taylor equation (Priestley and Taylor, 1972) is a modification of Penman's theoretical equation. An empirical approximation of the Penman combination equation is made by the Priestley-Taylor to eliminate the need for input data other than radiation. Initially the Priestly-Taylor parameter set to 1.26. However, it is only applicable for water bodies and wet vegetation surfaces. Jiang and Islam (2001) modified the Priestly-Taylor parameter ranging from 0 to 1.26.

$$\lambda E = \varphi\ [(R_n - G)\Delta/(\Delta+\gamma)]$$

λE = Latent heat flux in W/m^2, φ = Modified Priestley-Taylor parameter, R_n = Net radiation in W/m2, G = Soil heat flux in W/m^2, Δ = Slope of saturation vapor pressure curve, γ = Psychometric constant.

Modified Priestley Taylor Parameter (φ)

The Modified Priestley-Taylor parameter (φ) ranges from 0 to 1.26. It is applicable for large heterogeneous areas (Jing and Islam, 2001). Land surface temperature derived from remote sensing data.

Net Radiation (R_n)

The main components are long and short wave radiation components and latent heat flux, where

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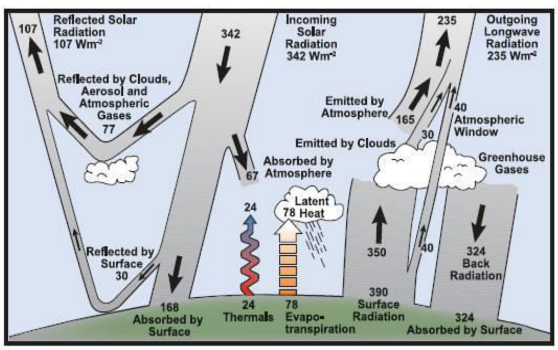
incoming components as shown in the figure 3.1 are positive and outgoing is counted as negative. The net radiation is the sum of the incoming and outgoing short and long wave components.

$$R_n = R_s(1 - \alpha) + R_i \downarrow - R_i \uparrow$$

α= Surface albedo, R_s = Incoming shortwave solar radiation (W/m^2),$R_i\downarrow$+$R_i\uparrow$=Longwave downward & upward radiation (W/m^2).



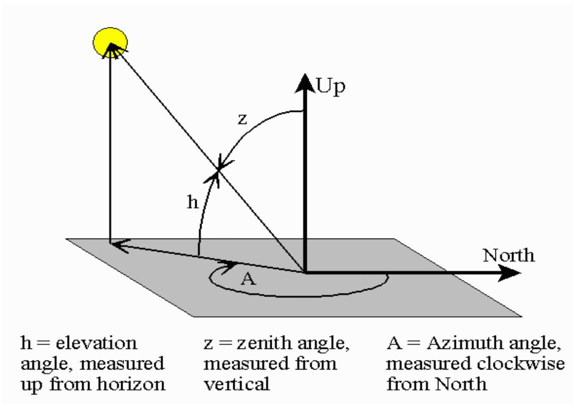
Surface Albedo (α)

Surface albedo is defined as the ratio of radiation reflected to the radiation incident on a surface. The proportion reflected is not only determined by properties of the surface itself, but also by the spectral and angular distribution of solar radiation reaching the Earth's surface. These factors vary with atmospheric composition, geographic location and time. While bi-hemispherical reflectance is calculated for a single angle of incidence, albedo is the directional integration of reflectance over all solar angles in a given period. The temporal resolution may range from seconds to daily, seasonal or annual averages. The surface albedo α is calculated from linear combination bands following the Liang's model.

$$\alpha = 0.160R_1 + 0.291R_2 + 0.243R_3 + 0.116R_4 + 0.112R_5 + 0.081R_7 - 0.0015$$

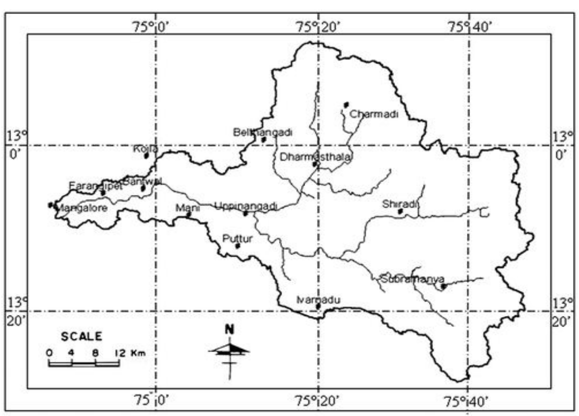
Where R_1 to R_7 = Land Surface Reflectance data(from the MODIS data)

Solar Zenith Angle (θ) The solar zenith angle is the angle between the zenith and the centre of the Sun's disc. The solar elevation angle is the altitude of the Sun, the angle between the horizon and the centre of the Sun's disc. Since these two angles are complementary, the cosine of either one of them equals the sine of the other. They can both be calculated with the same formula, using results from spherical trigonometry The maximum instantaneous solar radiation outside the atmosphere, measured at an average Sun-Earth distance and perpendicular to the solar rays is equal to 1367 watt/m2. The amount of energy at the top of the atmosphere is a function of the solar zenith angle at certain latitude and time and the distance between Sun and Earth. The solar zenith angle data can be obtained within the surface reflectance data of MODIS.



The Netravathi Catchment

The Netravathi basin extends over 3314.43 km2 area. The river originates at Bellarayadurga in the Dakshina Kannada district at an altitude of 1 km and flows west up to its confluence with the Arabian Sea. The river basin consists of many sub basins namely Kumaradhara, Kallaji hole, Gowri hole, Belthangadi hole, Netravathi Hole, Neriya hole, and Shislahole.



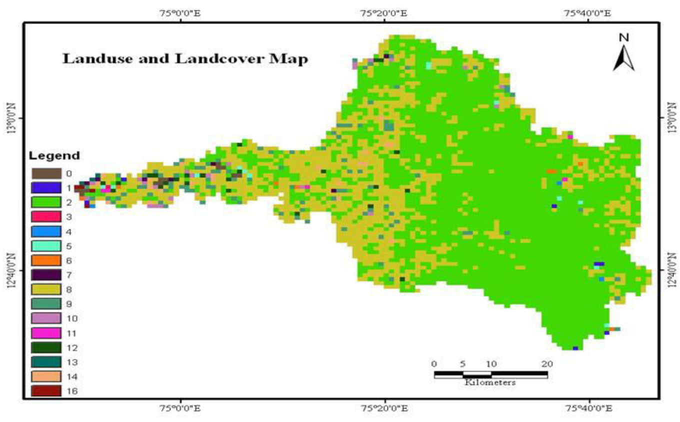
Netravathi river basin

Land Cover Map

The MODIS land use land cover data (MOD12Q1) are yearly products having 1 kms patial resolution. The primary land cover scheme identifies 17 land cover classes defined by the International Geosphere Biosphere Programme (IGBP), which includes 11 natural vegetation classes, 3 developed and mosaiced land classes, and 3 non-vegetated land classes. Area and number of pixels per each class are shown in Table 4.2 for the landuse/landcover classification.

Landuse landcover table of Netravathi basin

Pixel Value	No of Pixels	Classification	Area (sq.km)	Area (%)
0	12	Water	10.31	0.31
1	8	Evergreen Needle Leaf Forest	6.87	0.21
2	2478	Evergreen BroadLeaf Forest	2129.42	64.3
3	1	Decidious Needle Leaf Forest	0.86	0.03
4	1	Decidious BroadLeaf Forest	0.86	0.03
5	13	Mixed Forest	11.17	0.34
6	8	Closed Scrublands	6.87	0.21
7	7	Open Scrublands	6.02	0.18
8	1151	Woody Savannas	989.09	29.87
9	99	Savannas	85.07	2.57
10	21	Grasslands	18.05	0.54
11	5	Permanent Water Bodies	4.3	0.13
12	24	Croplands	20.62	0.62
13	6	Urban and Built-up	5.16	0.16
14	20	Cropland or Natural Vegetation Mosaic	17.19	0.52
15	3	Barren or Sparsely Vegetated	2.58	0.08
		Total	3314.43	100



Landuse and landcover map

Software Used

The main software used for manipulation and analyzing the data is MATLAB. MATLAB is a high-level scientific and engineering programming environment. which provides many useful capabilities for plotting and visualizing data and has an extensive library of built-in functions for data manipulation. In MATLAB it is easy to manipulate datapixel by pixel. The present study has been carried out using ARC-GIS and MATLAB.

CONCLUSION

The present project work was undertaken to estimate and map the spatially distributed evapotranspiration over Netravathi river basin for different days of three seasons. The dataset used was satellite products of MODIS and the auxiliary data i.e, air temperature (Ta), wind speed and sunshine hours, which were taken from meteorological station

1.From the MODIS landuse/landcover data (1 km spatial resolution), it was found that the two most predominant classes in the Netravathi basin are i) Evergreen broadleaf forest (64%) and ii) Woody savannas (30%).

2.Land surface temperature and surface reflectance data obtained from MODIS exhibit significant variations for the Netravathi basin both respect to time and space. That is, the spatial distribution of these variables is different on different dates and also on any given date variations within the basin were clearly evident. This implies that the MODIS sensors are capable of capturing temporal and spatial variations in surface conditions for the Netravathi basin and can, therefore, prove useful in studies related to energy balance.2.

3.From the method implemented for estimation of regional actual ET, rate of evapotranspiration is more during summer season from water bodies and permanent wet lands due to increase in solar radiation.

4.Output results indicated significant variations in actual ET both with respect to time and space.

Scope for Future Investigation

On the basis of the current investigation following suggestions are made for future research.

• Different satellite datasets like AVHRR and Land sat can be used and compared with MODIS.

• Detailed analysis on the relationship between evapotranspiration from different vegetation classes and hydrologic conditions can be carried out using GIS.

• The proposed methodology can be tested in other basins and validated using measurements.

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