# SESSION-6 :

# EVAPORATION STUDIES, SOIL MOISTURE STUDIES, CROPPING PATTERN

*14th National Symposium on Hydrology with focal theme on "Management of Water Resources under Drought Situation", 21-22 December, 2010, Organized by National Institute of Hydrology, Roorkee and Malaviya National Institute of Technology, Jaipur at Jaipur, Rajasthan*

# EVALUATION OF SOME SELECTED MODELS OF ESTIMATING EVAPORATION FOR A SEMI-ARID REGION IN INDIA

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## ABSTRACT

Accurate estimates of evaporation rates are essential for precise estimates of water availability in the water bodies. They are also needed for various other purposes such as water resources planning and management, heat balance studies, ecological modeling etc. Inspite of its significance, however, precise estimation of evaporation still remains one of the challenging tasks. At present there is no single reliable direct method for measuring evaporation from open water surfaces. Although models such as the energy balance and Penman model are considered as reasonably accurate for indirectly estimating evaporation, they have extensive data requirements which can not always be met. A number of other simpler, semi-empirical models have, hence, been developed to overcome the situation. However, reported studies on the relative performance of these models give different results for different climatic settings and there are hardly any studies for tropical climates. As such these models need to be evaluated for tropical climate. Moreover, for a developing country like India, where data availability is a limiting factor and even the data requirements of Penman model are not easily met at most locations, there is a need for simple models with less data requirements. So, the present investigations have been carried out to evaluate some commonly used simpler models of evaporation for recommending a suitable approach for the semi arid tropical climates in India. Four evaporation models which are commonly used in different parts of the world, have been tested in the study. These models include Jansen-Haise Model, Stephens-Stewart Model, Priestly-Taylor Model and Brutsaert Model. The study has been carried out for Udaipur in the sate of Rajasthan in India which climatically is a semi arid climatic region with three distinct seasons. Six years of daily data (2002-2007) of various meteorological parameters have been used in the study. Evaporation estimated using Penman Method is considered as actual evaporation for evaluating the performance of the other models.

Statistical analysis of the model outputs has been carried out to evaluate their performance. A number of statistical criteria have been used in the study for the purpose. Results indicate that all the four models vary in their performance in predicting the actual evaporation. Both Jansen-Haise model and Stephens are observed to underestimate evaporation. However, errors of Jansen-Haise model are relatively less than the Stephen-Stewart model. The Priestly-Taylor Model also underestimates for most of the months but the errors are much smaller

compared to the Jansen-Haise and Stephens-Stewart models, and are also well within the acceptable limits for the daily time scale. The performance of Brutsaert Model is relatively much poorer. Statistical parameters of the various models indicate that the Priestly-Taylor Model has the highest ME coefficient (0.74) as well as the high index of agreement (0.92) indicating its close agreement with the actual data as well as superior performance over the other models. The study concludes that the Priestly-Taylor Model can be considered as reasonably suitable for estimating evaporation from open water surfaces for the semi arid climatic regions in India.

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# PAN COEFFCIENTS FOR UDAIPUR REGION, RAJASTHAN

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## ABSTRACT

Precise estimates of evaporation rates are essential for estimating water availability in the water bodies. They are also needed for various other purposes such as water resources planning and management, heat balance studies, ecological modeling etc. Inspite of its significance, however, precise estimation of evaporation still remains one of the challenging tasks. At present there is no direct method for measuring evaporation from water bodies such as lakes and reservoirs. Although models such as the energy balance and Penman model are considered as reasonably accurate for indirectly estimating evaporation, they have extensive data requirements which can not always be met. A number of other simpler, semi-empirical models have hence been developed to overcome the situation. Pan method is another available method and is one of the most popular methods of estimating lake and reservoir evaporation especially by field engineers. Most of the state irrigation departments in India make use of this method. In India USWB class – A pans are being used for the measurement of pan evaporation. Since thermodynamics of a pan is different than a water body like lake or a reservoir, a coefficient called Pan Coefficient is applied to the pan data to convert it to the lake or reservoir evaporation. However, pan coefficients are known to vary temporally as well as spatially. As such application of the pan method needs local pan coefficients for different time scales which are generally not available and have to be derived from a standard method. Pan coefficients are not available for most regions in India.

The present study has been taken up to develop pan coefficients for a semi arid tropical region, Udaipur in India. Lake evaporation obtained form modified Penman method has been considered as actual evaporation and the pan coefficients have been derived for daily, monthly and seasonal time scales using least square optimization technique. Since most of the pans being used in India are mesh covered, pan coefficients have been derived for mesh covered pans. The single daily value obtained is 0.975 which is much different than the generally assumed value of 0.7. The variation in the monthly pan coefficient is from 0.823 in May to 1.405 in January. Thus, although the summer values are closer to the generally assumed value of 0.7, the values for winter months deviate considerably from 0.7 by almost 100%. The seasonal values obtained for the study area for winter, summer and monsoon seasons are 1.314, 0.889 and 1.104 respectively. Average absolute errors for different months caused by the

use of the various daily, monthly and seasonal pan coefficients have also been estimated and reported.

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# DEVELOPMENT OF INSOLATION ASSESSMENT EQUATION FOR ESTIMATION OF EVAPORATION

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## ABSTRACT

The aspect of evaporation constitutes as important loss of water from open surfaces like channels, reservoirs, lakes, etc. An attempt has been made in this paper to develop a prediction equation correlating incident solar radiation ($Q_s$) with air temperature (T) from the records obtained from Sunshine Recorder installed at the Digha Meteorological Station of R.R.I. Another equation has been developed correlating mean monthly air temperature (T) with the ratio of monthly total evaporation (E) to monthly mean of daily solar radiation ($Q_s$). By observing only air temperature, the very common and easily measurable parameter, direct estimation of evaporation loss can be done with the help of the above two equations.

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# SIMULATION OF SOIL MOISTURE MOVEMENT IN GHATAPRABHA REPRESENTATIVE BASIN

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## ABSTRACT

In the recent past lot of efforts have been done on field measurement of soil physical properties and on the development of mathematical models to predict soil moisture movement and contaminant transport. The principle feature of field soils is their variability over many length and time scales. These kinds of variability in physical properties results in errors while modeling solute transport processes. A very large fraction of rainfall and irrigation water moves through unsaturated soil during the processes of infiltration, drainage, evaporation and the absorption of soil water by plant roots. Quantification of groundwater recharge is a complex function of hydrometeorology, soil, vegetation, physiographic characteristics and properties of geologic material within the paths of flow. A number of simulation models are available for investigating the soil water balance. SWIM is a physically based, isothermal, one dimensional model of water flow through the soil coupled with a simple crop water extraction model of the canopy and of the root system as an predetermined input. SWIM is driven by rainfall and potential evaporation and so appears to be more appropriate than similar models if limited meteorological data is available. Theerfore, the present study undertakes field and laboratory investigations in the Ghataprabha representative basin to determine the saturated hydraulic conductivity at 10 locations using Guelph Permeameter and soil moisture retention characteristics using the Pressure Plate Apparatus. The field and laboratory data were used to simulate the soil moisture movement in Ghataprabha representative basin using SWIM model. The model results showed good match between the observed and predicted soil moisture variations along the soil profile.

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# OPTIMAL CROPPING PATTERN FOR UKAI IRRIGATION PROJECT COMMAND AREA, GUJARAT

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## ABSTRACT

The linear programming (LP) model has been formulated for maximization of net benefits of Ukai command area. Available land and water for irrigation purpose are the constraints considered in the present study. The main objective of the paper is to carry out the sensitivity analysis with respect to the reduction in available water being supplied to the command area and its effect on the net benefits, using LINGO (Language for INteractive General Optimization) software. The net benefits have been calculated by reducing 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of available water for irrigation. It is observed that the net benefits remains sufficient even after reducing the existing water supply up to 30%.

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# SOIL LOSS ESTIMATION USING RUSLE MODEL FOR BENISAGAR DAM CATCHMENT IN BUNDELKHAND REGION OF M.P.

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## ABSTRACT

Sedimentation of the reservoir is a function of soil erosion rate of the river catchment area which reduces the water storage capacity of reservoir and availability of water for its designated use. Erosion of topsoil from the catchment also reduces fertility and the vegetation growth as well. Negative effects of sedimentation tend to become more and more relevant on a global scale due to population growth, reduction of dense forests, severe climatic conditions etc. which facilitate more and more soil erosion. The RUSLE model is the most commonly used model for estimation of spatial distribution of soil losses, soil erosion risk and planning development and conservation plan under different land cover conditions including croplands, rangelands, open and dense forests etc.

In the present study, an attempt has been made to estimate soil loss from the catchment of Benisagar dam catchment using RUSLE model. The Benisagar dam is a medium project in drought prone Rajnagar block Chhatarpur district of Bundelkhand region of M.P The dam has been constructed for irrigation and supply water to historical Khajurah city. The ILWIS 3.6, a GIS software has been used for preperation of thematic maps for the model. The detailed soil testing including soil texture, nutrient analysis, infiltration rate and hydraulic conductivity have been carried out to determine the K-factor map. The flow lengths for computation of SL-factor has been determined using DEM hydro processing module of ILWIS. The Normal Deviation Vegetation Index (NDVI) has been used to estimate C-factor map and land use map obtained from digital image analysis of LISS III data of IRS P6 has been used for extraction of P-factor map. The results of analysis indicated that the average annual soil loss from the Benisagar dam catchmewnt under present condition may be 8.23 t/ha/yr. The spatial distribution of soil loss obtained from RUSLE model has been divided in to different classes of soil loss and it has been observed that more than 50% of the study area falls in the range of 0.0 t/ha/yr to 5.0 t/ha/yr. The spatial distribution obtained from the analysis may be useful for prioritization of sub watersheds and planning of soil conservation measures and it may be concluded that 5.01 sq. km area having soil loss more than 10 t/ha/yr should be treated on priority basis.

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# STUDIES ON CONJUNCTIVE USE PLANNING OF SELUD DISTRIBUTARY COMMAND IN DURG DISTRICT OF CHHATTISGARH

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## ABSTRACT

Present study deals with the conjunctive use planning of Selud distributary command of Tandula canal in Durg district. The conjunctive use planning was done for efficient use of surface as well as ground water for sustainable crop production. Scientific assessment of existing land and water resources availability has been done. The potential of surface and ground water use in the command area has also been quantified. Various data have been collected from relevant departments and used in this study. Field visits and personal interaction with field workers, water user association members and farmers were also carried out to gather the relevant information.

On the basis of primary and secondary data, discussions with farmers, members of water user association including departmental officials, use of simple formulae, norms and systematic analysis, the availability of land, surface and ground water, potential of surface and ground water use and their present use could be assessed. The total geographical area, cultivable land, net sown area, uncultivable (non-agriculture) and fallow land were assessed as 26,939.22, 22,217.43, 19,574.10, 4721.79 and 2643.33 ha, respectively. The total quantity of available water from all sources in kharif season was assessed as 164.01 $Mm^3$, out of which the available water from surface and ground water were found to be 117.30 and 46.71 $Mm^3$, respectively. The potential of water use from surface water and ground water resources in kharif season has been quantified as 105.57 and 29.85 $Mm^3$, respectively.

The share of surface and ground water use at present were 58.37 % and 41.63 %, respectively. Maximum surface runoff should be harvested with suitable water harvesting structures which goes out of the command as waste. This surface water can irrigate more areas and economical and will also recharge the ground water. The surface water (80.12%) and ground water (19.88 %) has been suggested to use which will keep the stage of development as 65% (safe category) and at the same time irrigate the entire net sown area without undesirable effects. The sites of the water harvesting and artificial recharge structures should be identified to harvest the maximum local runoff and artificial recharge of ground water besides treatment of the command area with suitable soil and water conservation measures.

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# WATERSHED MANAGEMENT OF THE KANGSABATI RIVER UNDER THE THREAT OF GLOBAL WARMING

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## ABSTRACT

The effects of global warming on India vary from the submergence of low-lying islands and coastal lands to the melting of glaciers in the Indian Himalayas, threatening the volumetric flow rate of many of the most important rivers of India and South Asia. In India, such effects are projected to impact millions of lives. As a result of ongoing climate change, the climate of India has become increasingly volatile over the past several decades; this trend is expected to continue.

Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. Addressing climate change requires a good scientific understanding as well as coordinated action at national and global level. The climate change issue is part of the larger challenge of sustainable development. As a result, climate policies can be more effective when consistently embedded within broader strategies designed to make national and regional development paths more sustainable. The impact of climate variability and change, climate policy responses, and associated socio-economic development will affect the ability of countries to achieve sustainable development goals.

A very well calibrated Soil and Water Assessment Tool (R2 = 0.9968, NSE = 0.91) was exercised over the Khatra sub basin of the Kangsabati River watershed in Bankura district of West Bengal, India, in order to evaluate projected parameters for agricultural activities. Evapotranspiration, Transmission Losses, Potential Evapotranspiration and Lateral Flow to reach are evaluated from the years 2041-2050 in order to generate a picture for sustainable development of the river basin and its inhabitants.

India has a significant stake in scientific advancement as well as an international understanding to promote mitigation and adaptation. This requires improved scientific understanding, capacity building, networking and broad consultation processes. This paper is a commitment towards the planning, management and development of the water resources of the Kangsabati River by presenting detailed future scenarios of the Kangsabati river basin, Khatra sub basin, over the mentioned time period.