ABSTRACT

Optimum utilization of water available for agriculture is a great concern, as it being the limited resource. The irrigated agriculture uses large chunk of water, thus a big responsibility lies with irrigation managers to efficiently use the water. Irrigation is supplied to compensate the moisture deficit in soil occurred due to evapotranspiration. To match the irrigation supply with demand, estimation of the evapotranspiration is required to be done with appropriate methods.

Evapotranspiration is the combined process, through which water is lost by evaporation from the soil surface and from the crop by transpiration. Evapotranspiration is generally estimated by using different methods, which requires measurements of climatological parameters. FAO-PM is considered to be the sole standard method to estimate reference evapotranspiration. The crop coefficient approach is widely used because of its simplicity in which, crop coefficient values are multiplied with reference evapotranspiration to obtain crop evapotranspiration.

Crop coefficient is further classified as single crop coefficient and dual crop coefficient. Dual crop coefficient gives precise estimates of crop water requirement especially during light & frequent wetting events. Dual crop coefficient could play a vital role in moisture deficit fields, due to climate change in tropical regions. WEAP model uses dual crop coefficient to precisely estimate crop water requirement. The daily variation in soil surface wetness, soil moisture profile due to frequent or light wetting, because of rainfall and irrigation can have a significant impact on crop evapotranspiration. Irrigation is one of the input parameters in soil moisture balance model, which is derived from adopted irrigation scheduling techniques. Soil water balance techniques can be applied over large areas such as Sardar Sarovar Project (SSP) to estimate evapotranspiration.

SSP is having gross command of 3.43 million hectare, while CCA of 2.12 million hectare in Gujarat state. The entire command has been divided into 13 different homogeneous agro-climatic regions. The climate of area is semi arid; the rainfall is erratic and non uniform. Type of surface soil prevalent is deep black and coastal alluvial. The study area lies between in SSP command area phase- I Gujarat state. The study area constitutes 16 blocks of Region I (CCA = 161900 ha) and four blocks

of Region II (CCA = 35731 ha) of Sardar Sarovar Project (SSP). Availability of water is limited spatially and temporally in Gujarat state.

Conventional approach is to apply irrigation water of fixed depth at fixed interval. Conventional irrigation practices result into over irrigation or moisture stress condition. Evaluating alternative irrigation strategies and selecting the irrigation schedule, which maximizes yields with given water supply in region I and II for Sardar Sarovar Project is required.

Research objective is to compute crop evapotranspiration for major crops grown in the study area. Crop evapotranspiration under pristine and water stress conditions are to be estimated (i) Developing crop water use model using dual crop coefficient approach (ii) Coupling crop water use model into soil moisture balance model (iii) Predicting water demand and yield under alternative irrigation strategies along with conjunctive use approach.

To achieve above objectives WEAP-MABIA model was used to compute actual evapotranspiration and soil moisture balance, as it uses Penman Monteith Method with dual crop coefficient approach. Effective precipitation was estimated by SCS method, which is taken as an input in soil moisture balance for calculating crop water requirements. Water use efficiency and irrigation water use efficiency was computed for evaluating the strategies. Statistical tools such as ANOVA and RBD were used to provide a help in decision making for usage of a particular strategy.

Strategies employed were as follows (i) Strategy S I: Irrigation at fixed interval with fixed amount of irrigation, (ii) Strategy S II: fixed amount of irrigation is applied at 100% of RAW, (iii) Strategy S III: No stress condition strategy, (iv) S IV: Protective irrigation of reduced fixed depth is applied, at 80 % of TAW, (v) S V: Regulated deficit irrigation is applied, and (vi) To achieve water saving and ease in implementation strategy S VI is devised with combination of one or two methods.

FAO-56 Penman Monteith model to estimate reference evapotranspiration coupled with dual crop coefficient approach is found useful, for precise estimation of crop water requirement. The dual crop coefficient approach helps in computing separately soil evaporation and transpiration, under normal and water stress condition.

Crops under S I strategy get over irrigated in Kharif season. In Strategy S II, if fixed depth irrigation is much greater than RAW depth, it results in greater losses due to percolation, leading to lower irrigation water use efficiency. The model determined no stress irrigation strategy S III, maximizes yield of crop and prevents losses, thus has been found useful. Strategy S IV ensured minimal yield and was useful for marginal farmers who don't own wells/tube wells, but buy water from other farmers. Mild water stress under strategy S V during different growth stage/ s, reduces the yield marginally for some crops with significant increase in irrigation water use efficiency. Strategy S VI overcomes some of the difficulties faced in other strategies with benefits of ease in implementation, reasonable good yield and reduced irrigation depths.

Strategies best suited for attaining significant yield and water savings simultaneously for Rice Tuver, Chana, Cabbage, Castor, Cotton, Kharif Groundnut, and Tobacco crops are S III, followed by S VI, S II, and SI. Strategies S II, S VI, and S I can be recommended for Wheat, Maize and Sugarcane crop to attain higher yields with significant water savings. Strategies best suited for Jowar and Bajra crop are S III, followed by S II and S IV, as optimum yield is attained, with little or no irrigation depending upon wet or dry scenarios.

Irrespective of dry or wet scenarios, peak water demand in study area under strategy S III is month of October, while for strategy S VI it is December. Fluctuations of canal water demand, under strategy S VI is noticed during month of November, afterwards the demand is same except year 2008. Large amount of water is lost due to deep percolation in the initial and development stages in most of the strategies, except model determined strategy S III, where flow to groundwater is nil. Reasonable water saving criteria requires to be taken into consideration, before recommending a particular strategy. Results of the statistical analysis show that strategy S III is best suited for all crops. Irrigation with strategy S III is feasible, if irrigation requirement is triggered according to soil moisture deficit with help of automated sensor installed, to assess the soil moisture status. This strategy is difficult to implement under canal irrigation. The second best strategy is S VI, S II, or S I, depending upon crop however; if water savings is also considered together, then S VI is better placed than other strategies.