ESTIMATION OF IRRIGATION RETURN FLOW

Excess water application, over and above plant water requirement and soil-water detainment, either goes waste if the quantity is more or replenishes groundwater for subsequent uses. Use of optimal quantity of irrigation water satisfying crop water requirement will not only save water for irrigation of larger area but will also save money against withdrawal of water and restrict excess water from flowing to the aquifer (which may cause waterlogging in command areas).

TECHNOLOGY

Irrigation Return Flow (IRF) is part of artificially applied water that is not consumed by plants or evaporation, and that eventually "returns" to an aquifer or surface water body. This means that when water is applied over a crop field in the form of irrigation water, it will first infiltrate and percolate to the soil, a part of it will evaporate from the soil surface, another part of water will be consumed by crop through its roots and will transpire to atmosphere in the form of evapotranspiration, yet another part of water will be retained by the soil in the unsaturated zone, and the remaining part will flow to the surface water body or an aquifer which is termed as IRF. Figure-1 describes a schematic component of Irrigation Return Flow of artificially applied water.

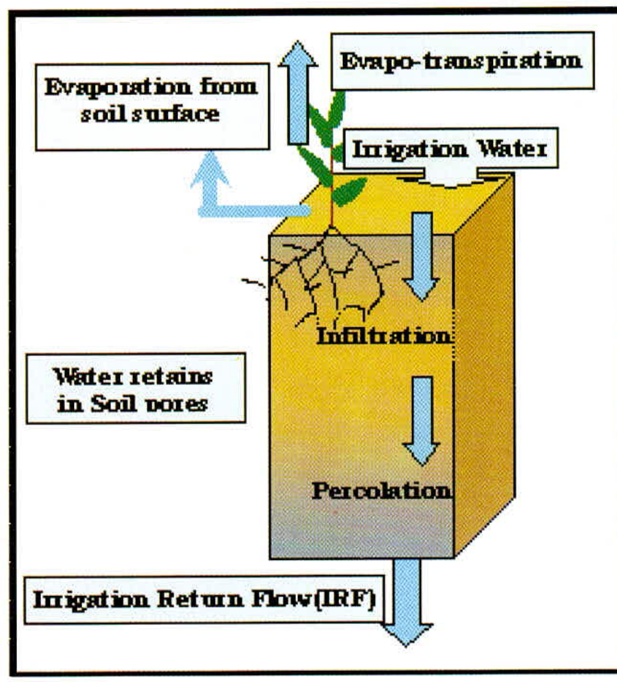

Figure – 1 Components of artificial irrigation water application

The question is: how to estimate the components of IRF? Neither the field measurements of all components nor the measurement of IRF component alone is an easy and straightforward task. If we can make an estimation of each shareholder of an irrigation water application separately, except the IRF component, and put those estimated components in the form of water balance equation for a given period of time, the unknown component, IRF, can then easily be computed. This method is known as Soil Moisture Modeling (SMM) Approach. In SMM approach, change of soil moisture in the unsaturated zone (the zone in which roots of crops and plants lie) for a given input and forcing outputs (such as crop's uptake, rejected outflow etc.) over a period of time is estimated. The rejected flow from the unsaturated zone is the IRF.

Adopting the concept of SMM, a process level model has been developed at the Institute that gives estimation of IRF from a crop field at a micro level and gives estimation of IRF from a command area for artificially applied water in an integrated form. Schematic representation of an irrigation command showing components of irrigation application is shown in Figure-2.

A numerical model based on one-dimensional Richard's equation formed the basis of development. The methodology is as follows:

i) Assess the land-use pattern and the crop types including their rotation and base period of a command area using remote sensing data and GIS information or from the statistical record.
ii) Delineate the soil types including their texture.
iii) Group them according to the crop types.
iv) Determine the soil properties; such as, saturated hydraulic conductivity (K_s), specific gravity of soil, particle size density, bulk density, saturated moisture content, wilting point, field capacity for each soil group.

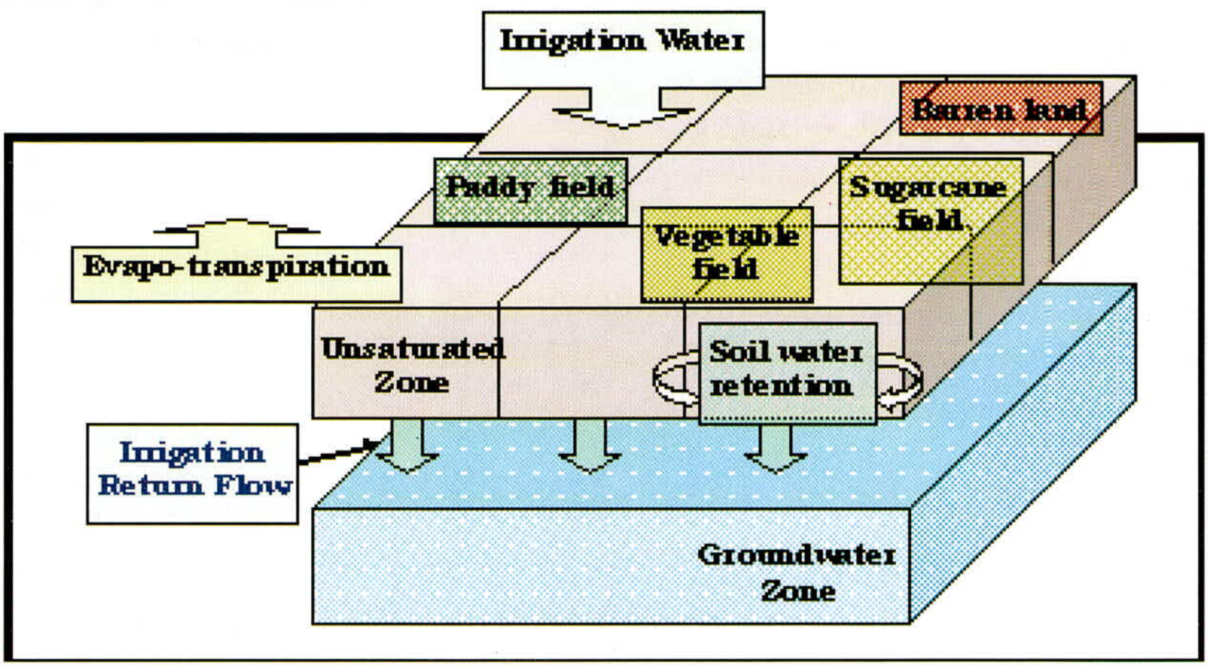

Figure – 2 Schematic representation of a command showing components of irrigation application

v) Calculate evapotranspiration from Pan evaporation data, or empirical formula for estimation of evapotranspiration using meteorological data.

vi) Obtain the field data, such as, irrigation water application (from Inflow/Outflow measurement of a field).

vii) Discretize the depth below the ground surface up to the groundwater tables into different vertical grids.

viii) Use Richard's equation with sink term for developing the source code in any computer language. The source code coupled with algebraic equations forms the mathematical model.

ix) Calibrate the model with one set of soil moisture data and then validate with two or more sets of data. Emphasis should be given for matching the moving front as well as the recession front. If matching is not obtained, adjust the soil properties in order to obtain a reasonable match.

x) Run the validated model for the complete base period (sowing to harvesting) of the crops.

xi) The volume of flow computed at the end of each time step, as vertical rejection of flow from the soil column to actual water infiltrated or applied, is the return flow of the given application of water.

xii) Integrate the processes of single column according to the soil groups, crop types and depth of water table to obtain the return flow from the whole command. Volume of water computed as return flow to the volume of water actually applied over irrigation command in terms of percent would give the percent irrigation return flow from that command.

xiii) Perform the water balance check either on a single column basis or the command area as a whole.

This technique has been developed, used and validated at the National Institute of Hydrology, Roorkee.

ENVIRONMENTAL IMPACT

Application of the proposed methodology does not effect any change in the natural processes. Hence, there is no threat to the environmental issues.

ECONOMICS

Irrigation return flow is one of the major components based on which most of the groundwater related schemes and agricultural schemes are developed and decided. Correct application of irrigation water and a pre-decided allocation in the form of IRF would save lots of water to go unutilized and would increase irrigation efficiency as well besides indirect benefit on monitory side.

BENEFICIARIES

Planners and decision-makers in the area of surface water, groundwater, and agriculture sectors are direct beneficiaries while the agricultural farmers are indirectly benefited.

INTELLECTUAL PROPERTY RIGHTS

Being the developer of methodology, the National Institute of Hydrology, Roorkee owns the Intellectual Property Rights.