

# APPLICATION OF G.I.S. AND MODELING TECHNIQUE IN INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUND WATER IN IRRIGATION SECTOR

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**Abstract** -The work which is carried out is based on GIS and integrated modeling technique. Which integrates soil moisture and irrigation water requirement, rainfall-runoff, system loss and groundwater flow system? Developed model is employed to evaluate different water management scenarios such as change in rainfall sequence (wet, normal and dry season), change in canal water supply, impact of land use changes including their socio-economic implications. The application of model is illustrated with real application in Daulatpur distributaries a part of Indo-Gangetic plain of Uttar Pradesh in India. In this paper the different modes of irrigation are assessed and compares them with conjunctive use of surface and groundwater. The data used in this study was collected from different department e.g. Irrigation Department U.P., Sawara office and Ground water Department at Lucknow. The results highlighted the problem of increased use of tube well water which has led to the problem lowering of groundwater. Conjunctive water management in crop increased the farm income, compared to only using the canal and tube well water, respectively. The model optimization results showed that it is possible to increase the total gross margins while keeping the changes in depth to water table in the acceptable limits through conjunctive water management.

## Introduction

Conjunctive use of groundwater and surface water in an irrigation setting is the process of using water from two different sources to meet crop demand. Conjunctive use can refer to the practice at the farm level of sourcing water from both well and irrigation canal or it is an approach at irrigation command level where surface and ground water inputs are centrally managed as an input to irrigation system. Typically, water has been sourced either surface or ground water supplies with primary supply supplemented by alternative source over time. Increasing demand and decreasing water quality has put enormous pressure on the agriculture sector to use its available water resources more efficiently. These pressures are a result of the increasing demand for food and inter-sect oral competition for water, particularly from the municipal and industrial sector. Therefore, in future, irrigation's contribution to food security will largely depend on the use of low-quality water in agriculture in addition to renewing efforts to achieve water conservation. Without assured irrigation supplies, these arid and semiarid areas of India cannot support any agriculture, as the evaporation- transpiration demand is high and rainfall is either very less or unreliable. The operation of the Indo-Gangetic plain irrigation system is based on a continuous water supply and is not related to actual crop water requirements. Irrigation canals are usually not allocated more than their design capacity. Despite significant increase in storage capacities, it is essentially a supply-based system. Hence, it cannot adequately accommodate changing water demand during crop periods. At the resource level, groundwater pumping for irrigation used in conjunction with surface water provides benefits that increase the water supply or mitigate undesirable fluctuations in the supply (Tsur, 1990) and control shallow water table levels and consequent soil salinity.

This paper deals how the application of G.I.S. and modeling technique is useful in management of surface water and ground water and explores the reasons the poor approach to full integration in the management and use of both water sources.

In most climates around the world, precipitation, and consequently peak river discharge, occurs during a particular season of the year, whereas crop irrigation water requirements are at their greatest during periods of low rainfall when unregulated stream flows are significantly lower. For many irrigation systems, water supply is aligned with crop water requirements through the construction and management of dams which capture water during periods of high flow, enabling regulated releases to meet crop water requirements.

However, the construction, operation and distribution of water from dams are inherently costly undertakings. Furthermore, dams and the associated distribution systems are commonly subject to high system losses through evaporation and leakage, and they have social and ecological impacts upon communities and the environment in and on which they are built. Conversely, under natural recharge regimes, groundwater storage requires no infrastructure, the aquifer serving as the natural distribution system. The point of irrigation, in a groundwater-fed irrigation command, is mostly opportunistically located close to the groundwater extraction point, which in turn is integrated into on-farm irrigation infrastructure. Under a sustainable extraction regime, groundwater of a suitable quality can provide a reliable source of water either as a sole supply of water, or to supplement alternative sources. These benefits take the form of economic gains, increase in productivity, energy savings, and increased capacity to irrigate via larger areas, water resource efficiency and infrastructure optimization.

**Study Area** The Study area is Daulatpur distributaries of Tilloi block District Amethi (between latitudes 26°17' and 26°24' and longitudes 81°23' and 81°29'). The length of canal is 17.85 km. and it is taking off from km 27.14(R) of Jaunpur branch. The discharge is 39.00 cusec; G.C.A. and C.C.A. is 3709.16 Hectare meter and 3328.82 Hectare meter respectively.

Present study area is part of Ghaghara Gomti - basin. This work developed integrated framework and demonstrated its application in canal network of Daulatpur distributaries system.

- The main problem of this area is water logging and salinity.
- The recharge of the aquifer due to seepage from the (canals) of the irrigation system is considered as the main cause of drainage problem.
- Ground water management has been accorded a low priority.
- The farmers of tail portion of canal are not getting required quantity of water as per demand of different crops.



Site Photograph of Daulatpur Distributaries

Below is the picture showing water logged area of Daulatpur Distributaries



### GIS based modeling

G.I.S. plays an important role for land and water management. These techniques have changed the concept and idea regarding management of natural water resources. In groundwater hydrology the main areas where G.I.S. is applicable are.

- i) In exploring and assessing the ground water resources.
- ii) Artificial recharge sites can be selected by use of this technique.
- iii) In sub surface flow modeling this technique can be used.
- iv) In estimating the natural recharge distribution G.I.S. technique can be used.

There are many advantages if we use ground water model with geographic information system (G.I.S.) over traditional models. The main benefit of using G.I.S. is that here everything is defined within a spatial context and also all the thing such as distribution of precipitation, ground water recharge as well as pumping can be observed in a single map.

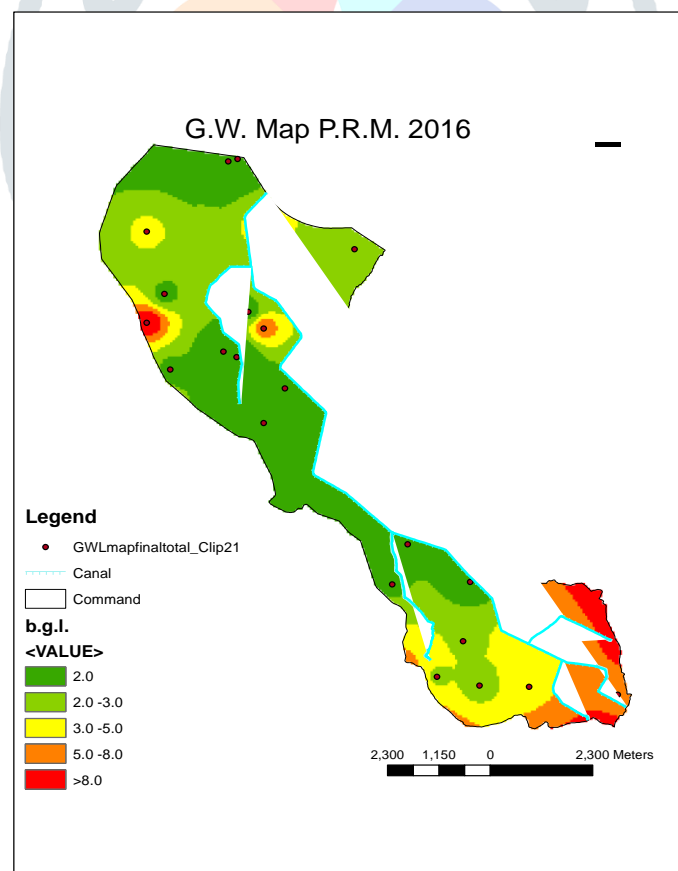
Since G.I.S. is essentially a database hence this information can be grouped in number of ways and the relationship between different components can be easily determined. The main advantage of G.I.S. technique is that a single model can perform all analysis in many ways in different situation if knowledge pertaining its physical parameters and map of region is available.

With the help of G.I.S .civil engineers use to manage and share data and ultimately changed into easily understood reports, which can be analyzed and communicated to others. Based on Arc G.I.S. software a centralized information system which provides civil engineers for maintaining and deploying critical data and application across every aspect of civil engineering project life cycle including planning and design, construction and operation management. Latest technologies e.g .G.I.S. and remote sensing is very useful for studying Geological and geomorphologic conditions. These two technologies have proved to be very efficient tool in groundwater studies.

G.I.S. is powerful tool in analyzing and quantifying of groundwater occurrence. With the help of G.I.S. techniques huge volume of data can be integrated and analyzed and the result can be validates with the help of field studies. This approach offers a better understanding of all parameter which control the ground water presence in rock aquifers. Now a day's digital technique is used for integrating various data to solve other problem pertaining to groundwater along with to indentify groundwater potential zones.

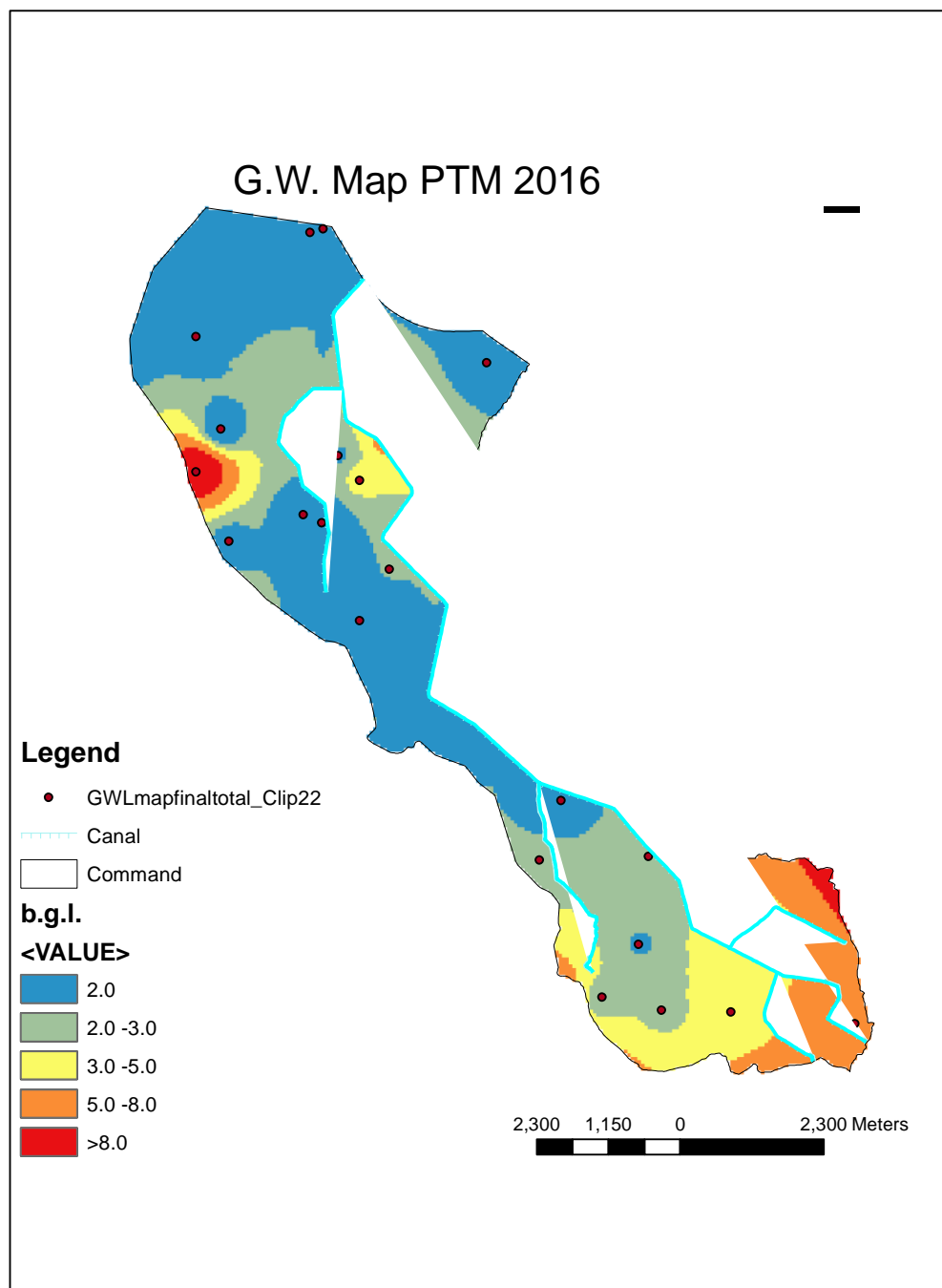
### Ground water Map using G.I.S.

G.I.S. is very useful in preparing groundwater map of study area. Using Arc G.I.S. 2016 Pre and Post monsoon ground water map of study area i.e. Daulatpur Distributaries is prepared.



GROUND WATER MAP PRE MONSOON 2016





### GROUND WATER MAP POST MONSOON 2016

A GIS based generic decision support system is employed for management of water resources in canal commands of Ghagra-Gomti-Basin; the recharge obtained was used to simulate observed ground water levels by Visual MODFLOW. The model uses four levels of geo-spatial units: homogeneous unit (HU), sub-irrigation unit (SIU), micro sub-basin (MSB) and sub-basin (SB). The Sub-basin is the largest spatial unit within the model. This may be the gross command area of a branch or a main canal. MSB is the gross command area of a canal, which may be either a distributaries or a branch canal. A sub-basin may consist of several MSBs. Micro sub basin (MSB) and HU are the largest and smallest calculation units, respectively, in the model. Sub-irrigation unit consists of one or more HUs. All HU in a SIU has the similar potential to be waterlogged, soil characteristics, access to irrigation and depth to groundwater levels. They differ from each other in land use or crop grown. As the command area of a MSB is usually a large area having different water management practice at the canal head, middle and tail, each MSB is further divided into different SIUs or Sub-Irrigation Units. SIUs can also be classified based on command and non-command area, distance from canals, susceptibility to be waterlogged and soil drainage. The classification is based mainly on land use.

The irrigation demands are computed differently for ponded crops (i.e., rice) and non-ponded crops (all other crops eg. wheat, sugarcane etc). For all crops other than rice, crop water demand is computed using the reference evapo transpiration for a reference crop (ET<sub>o</sub>) and crop factors as per FAO 56 guidelines (Allen et al., 1998)

### Calculation of Recharge

Recharge is calculated as per ground water resource estimation committee norms (G.E.C.) .

#### Recharge from rainfall

(As per Ground water resources estimation committee norms (G.E.C.)

$$R_r = 2.0 (P - 15)^{0.4}$$

$$R_r = 1.35 (P - 14)^{0.5}$$

Where,  $R_r$  = net recharge due to precipitation during the year, in inches;

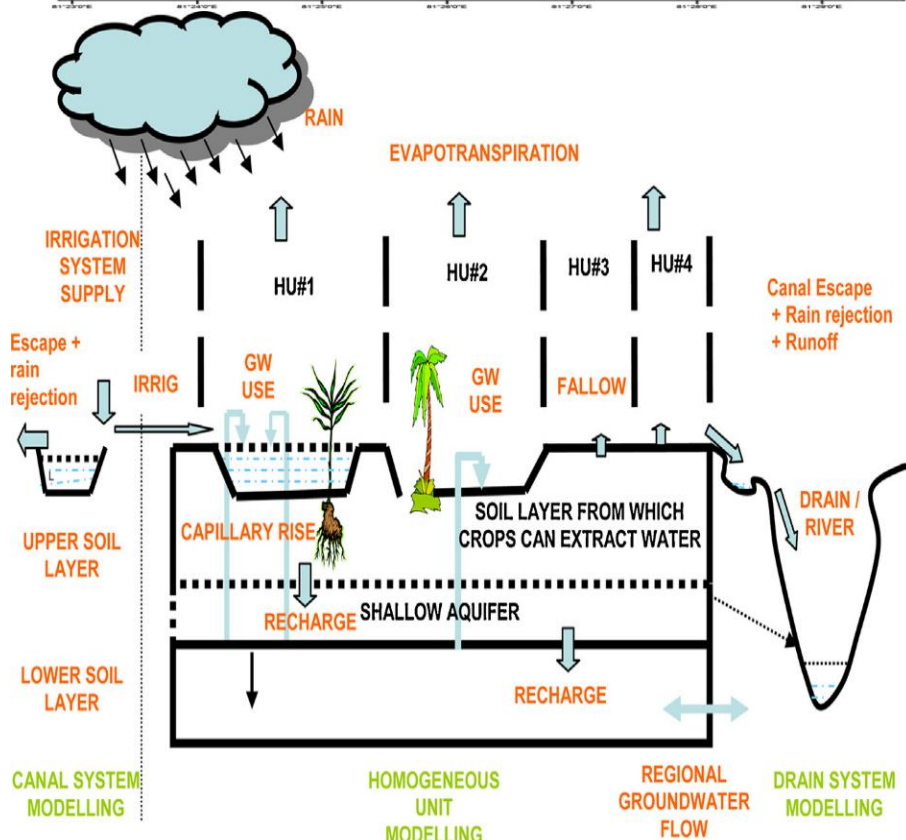
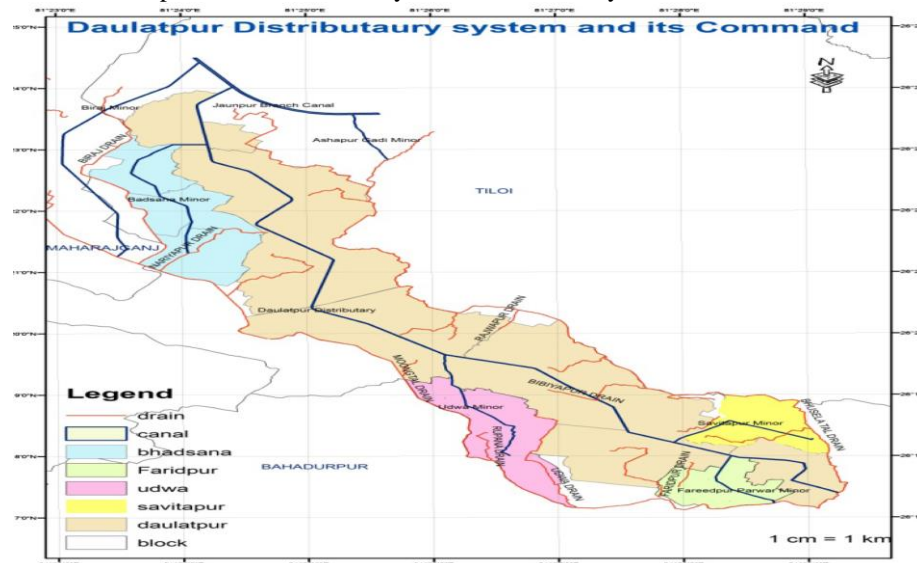
$P$  = annual precipitation, in inches

#### Recharge from Canal Seepage

$$R_{cmax} = K (B + 2D) \quad (\text{in case of deeper water table})$$

$$R_{cmin} = K (B - 2D) \quad (\text{in case of shallow water table})$$

Where  $B$  is width of canal,  $D$  is depth of flow and  $K$  is hydraulic conductivity of the bed material.



**Ground water modeling concept under each M.S.B**

### **Conclusion**

The work presented a framework for agricultural canal system simulation and management in Indo-Gangetic plains of Uttar Pradesh in India. Model results demonstrate potential applicability of the methodology in large canal systems. It is clear from the Ground water Map Pre and Post (2016) that there is water logging in upper and middle portion of study area where the depth of ground water is within 3m from b.g.l. and it is about 5m or more in tail portion of study area. This condition in upper reach is due to seepage from canal, rainfall and field irrigation and the condition in tail portion is mainly due to over extraction of ground water as less amount of surface water is available. Following conclusion can also be drawn.

The canal water use efficiency may increase with decrease in rainfall or canal water supply resulting in increased ground water use or depletion in ground water reservoir for the same cropping pattern and intensity. At the same time with the increase in rainfall or canal water supply, the canal water use efficiency may decrease but the ground water depletion is reduced. By opting conjunctive use of surface and groundwater in Daulatpur distributaries command, the water use efficiency of canal water may increase up to 58%. For the normal rainfall sequence of 847.3 mm per year and canal supply of 314.4 mm per year in Daulatpur distributaries system, canal water use efficiency increases to 40.7% against 37.3%, while the depletion in ground level is increased to 19c.m. in place of 18c.m. per year in case of present cropping intensity of 130% (of command area). It clearly indicates that depletion in ground water levels is directly related to proposed cropping pattern/cropping intensity and it reduces with increase in rainfall or increase in canal water supply or with the proposal of less water requiring crops. However this depletion in ground water level can be maintained more effectively at constant level with implementation of conjunctive use at Kulawa command level to bring more area under cultivation and saving energy cost in tail commands.

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