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APPLICATIONS OF REMOTE SENSING AND GIS IN WATER RESOURCES MANAGEMENT

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LECTURE NOTE

REMOTE SENSING AND GIS APPLICATIONS IN IRRIGATION WATER MANAGEMENT

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REMOTE SENSING AND GIS IN IRRIGATION WATER MANAGEMENT

Irrigation development has been accepted as a major factor in increasing agricultural production. Development of irrigation is, therefore, the *sine-qua-non* for agricultural prosperity and general economic well being of the population in the country. Irrigation forms the datum line for sustained agriculture.

The massive development of a vast irrigation network in India has been recognised as a landmark in the history of agricultural development anywhere in the world. There is no other country which has attached so much importance to the development of irrigation as India has in recent years, with its ambitious plans to create a gross irrigation potential of 113 million hectares by next few decades.

In most of the Irrigation Command Areas in India, the present status indicates that there is considerable scope for improving efficiency in the realm of water management. All the irrigation command areas suffer from the problems of inadequate and unreliable water supply, wide gaps between created and utilized irrigation potentials, temporal imbalances of water demands and supplies, excessive seepage losses, and rise of groundwater table leading to problems of water logging and salinity. The poor state of affairs in irrigated agriculture is the consequence of lack of scientific approach to planning and management of irrigation water.

In the context of growing population, and ever increasing demand for more food grain production, constrained by the finite and limited available arable land and water resources, the emphasis is on raising productivity of the land, both by intensifying the land use and by increasing the crop yield per unit area. This calls for intensive agriculture based on optimal land and water use policies. The National Water Policy (1987) and the National Landuse Policy outline (1986) are the two recent developments emphasizing the integrated management of the precious land and water resources of India.

The foremost priority at this stage should be the scientific management of the resource created with so much investment and dedication. Since there are no ready made models available which we can emulate, much of the knowledge of scientific management of irrigation systems must be generated within India and must accrue from our own experiences from the past 40 years. To get the optimum benefit per unit of water used, it is essential that water must be used efficiently. Efficient water management includes judicious use of both surface water and groundwater along with the other inputs, and proper manipulation of agronomical practices for maximizing the crop production.

Another major concept which has not received attention in water management is that of water balance of the command area. In fact, the potential for groundwater development has increased because of recharge to aquifers from water conveyance and distribution systems of the irrigation canal networks. Ground water was the main source of irrigation in many areas prior to the introduction of canal irrigation. It continues to be so in several major irrigation project areas even though this fact was not explicitly considered in the design and operation. However, in recent years there has been more emphasis on groundwater development in irrigation projects and on the planned conjunctive use of canal water and groundwater to augment canal supplies and control water logging and salinity there by increasing the reliability of irrigation system operation. This fact is duly recognized in India and constitutes one of the strategies for sustainable development of irrigated agriculture (Ministry of Irrigation, 1984 and planning commission, Govt. of India, 1985).

The Remote Sensing technology makes significant difference to the quality of decision making for command area development by providing objective data that aid in resolving mismatch amongst the various data gathering organisations in the domain. Accurate and timely estimates of the major agricultural crops in each growing season become necessary to optimise the water supply through the canal system and bring more area under irrigation.

The usefulness of remote sensing techniques in inventory of irrigated lands, identification of crop types, their extent and condition and production estimation has been demonstrated in various investigation in India as well as in other countries. Periodic satellite monitoring of command areas has helped in evaluating increase in irrigation utilization and improvement in agricultural productivity through the years. Deviation from the recommended cropping pattern and unauthorized irrigation leading to ineffective water management have been detected. Problem soils viz. saline, alkaline and water logged soils resulting from injudicious water management have been mapped and monitored to aid reclamation activities. Remote sensing techniques are now increasingly applied in land use planning and in identifying areas suitable for sustained irrigated cropping through satellite derived irrigability maps. It has been amply demonstrated that improvements could be achieved in conventional irrigation scheduling techniques by judiciously combining satellite derived crop condition, soil moisture status with the soil and meteorological information for efficient use of irrigation water.

In India, the command areas of irrigation projects, besides reservoir water supply, are also fed by other sources of irrigation like tanks, ponds and groundwater wells. Inventory of irrigation tanks in regard to location, ayacut delineation, water spread, loss of storage through silting, etc. can be estimated using remote sensing which in turn would significantly help in efficient use of this important resource in particular and efficient use of total available water resources in general, in irrigation command areas.

The National water policy (GOI, 1987) stipulates that the prime requisite for resource planning shall be a well developed information system consisting of scientifically designed data bases for improving both the quality of data and the data processing capabilities. The large size of areas commanded by the major irrigation projects, spatial and temporal variability of their climatic and crop conditions, system operational constraints and centralized management renders the problem of water management in these systems highly complex. Conventional methods of irrigation management are based primarily on unreliable databases, with considerable time lag in their generation, trial and error approaches and operator experience. Now methods which use computer based capabilities of data collection, management, analysis and decision support are, therefore, needed to increase the efficiency of irrigation system operation. To this end recent advances in the satellite Remote Sensing Technology and improved data handling system (GIS) offers a great scope for efficient water management in irrigation systems.

The objective of efficient water management is to ensure optimum linkage between availability and demand in all its dimensions. Efficient water use planning in agriculture is dealt by optimum utilisation of all the available water resources so as to match the crop water needs. Prior to such planning it is important to understand how an irrigation system actually performs in quantitative terms. This is best done by matching demand for water in terms of crop water requirements and available supplies in time and quantity. Irrigation command inventory, which includes the information on crop types and their extent, surface water body inventory, source wise irrigated area, etc. become indispensable in such studies.

India is a leading country in the world having a series of Remote Sensing satellites in the orbit. IRS 1C, IRS 1D, IRS P6 (resourcesat), Cartosat 1 and Catosat 2 are some of the satellite which can be be very useful for Spatial and temporal data collection in irrigation command.

DATA REQUIRED

For irrigation command management, we need certain data, which is as follows:

1. Crop acreage
2. Crop calendar
3. Soil map
4. Evapotranspiration
5. Crop coefficient
6. Canal network
7. Rainfall data

CREATION OF DATABASE USING RS & GIS

1. Crop Acreage

This is the basic input required for irrigation command area management. This information can be collected by digital or visual interpretation of multi date satellite images. The digital data can be classified by using supervised and unsupervised classification procedure. Visual interpretation techniques are also used to determine crop type and crop acerage.

2. Crop Calendar

This has to be obtained from the concern field authorities or from a nearby agricultural research station. This is useful to know the crop growth stages at the time of satellite data acquisition. Irrigation water requirement depends upon the growth stage of crop hence, this information is very much useful to calculate the irrigation water requirement. This data is stored in tabular form.

3. Soil Map

Soil map can be obtained either from concern field authorities or by remote sensing data with field truth. Soil map should be digitized and codified in polygon mode. This map is helpful in determining the percolation loss as well as to derive the hydrologic soil group map.

4. Evapotranspiration

Evapotranspiration denotes the quantity of water transpired by plants during their growth or retained in the plant tissue, plus the moisture evaporated from the surface of the soil and the vegetation. In other term, Evapotranspiration is the water consumed by crop for its growth. Hence, this is very essential to calculate crop water requirement. Various mathematical models are available to estimate Evapotranspiration. Remote sensing can also provide some of the important input parameters viz. NDVI, LAI, Albedo, surface temperature etc. Surface energy balance algorithm is used by many researchers to estimate Evapotranspiration.

5. Crop Coefficient

It is defined as the ratio of actual crop water requirement to potential Evapotranspiration. At various stages of crop growth the coefficient changes. Standard tables are available. These tables should be entered into GIS environment.

6. Canal Network

Canal network map and command area boundary map which are obtained from the concern field authorities are to be digitized. The command area boundary becomes the boundary of the study area. The canal network is a 'line' feature and the canal command area is a 'polygon' feature, and the canal outlets are point features. The aerial extent of each canal command area can be obtained by looking at the polygon information file. The length of the canals can be obtained by using the no. of pixels in raster GIS (ILWIS), of course do not forget to digitize the different canals with different feature codes. In case of vector GIS (ARC/INFO) the length of the canal is directly available in the attribute table (different canals are to be given different IDs)

By adding the lengths of different canals in a canal network, the total length of the canals from the various outlets can be obtained using distance functions. This is useful in computing the conveyance losses.

7. Rainfall data

This data can be obtained from meteorological station. Seasonal as well as annual rainfall data is required. In the command area point map is digitized and then Theisean polygon method is applied to get the spatial information of rainfall.

PERFORMANCE EVALUATION OF IRRIGATION COMMAND

Case Study

A study is carried out to evaluate the performance of Kashorai Patan irrigation command, which is a part of Chambal Command.

Objectives:

The objectives of the study are as follows:

1. To identify crops and updating crop inventory
2. To estimate crop acreage.
3. To estimate reference evapotranspiration by using CROPWAT Model.(FAO,1992)
4. To estimate crop water requirement & irrigated water requirement
5. To compare the actual crop water requirement & actual irrigation water supply.

Study area:

The study area lies in between 25 ^{0} 15' – 25 ^{0} 40' North latitudes and between 75 ^{0} 45' – 76 ^{0} 20' east latitudes. The area is in the southeastern part of Rajasthan. Command is situated in the districts of Kota and Bundi, lying between the Parvati River on the eastern side and Bundi hills on the western boundary.

Material used:

Satellite data

1. IRS 1C LISS III 04-10-98
2. IRS 1C LISS III 08-01-99
3. IRS 1C PAN 30-11-99

Topographic data

1. SOI Topo Sheet no. 45(O/14, O/15) , 53(C/6, C/3, C/2)

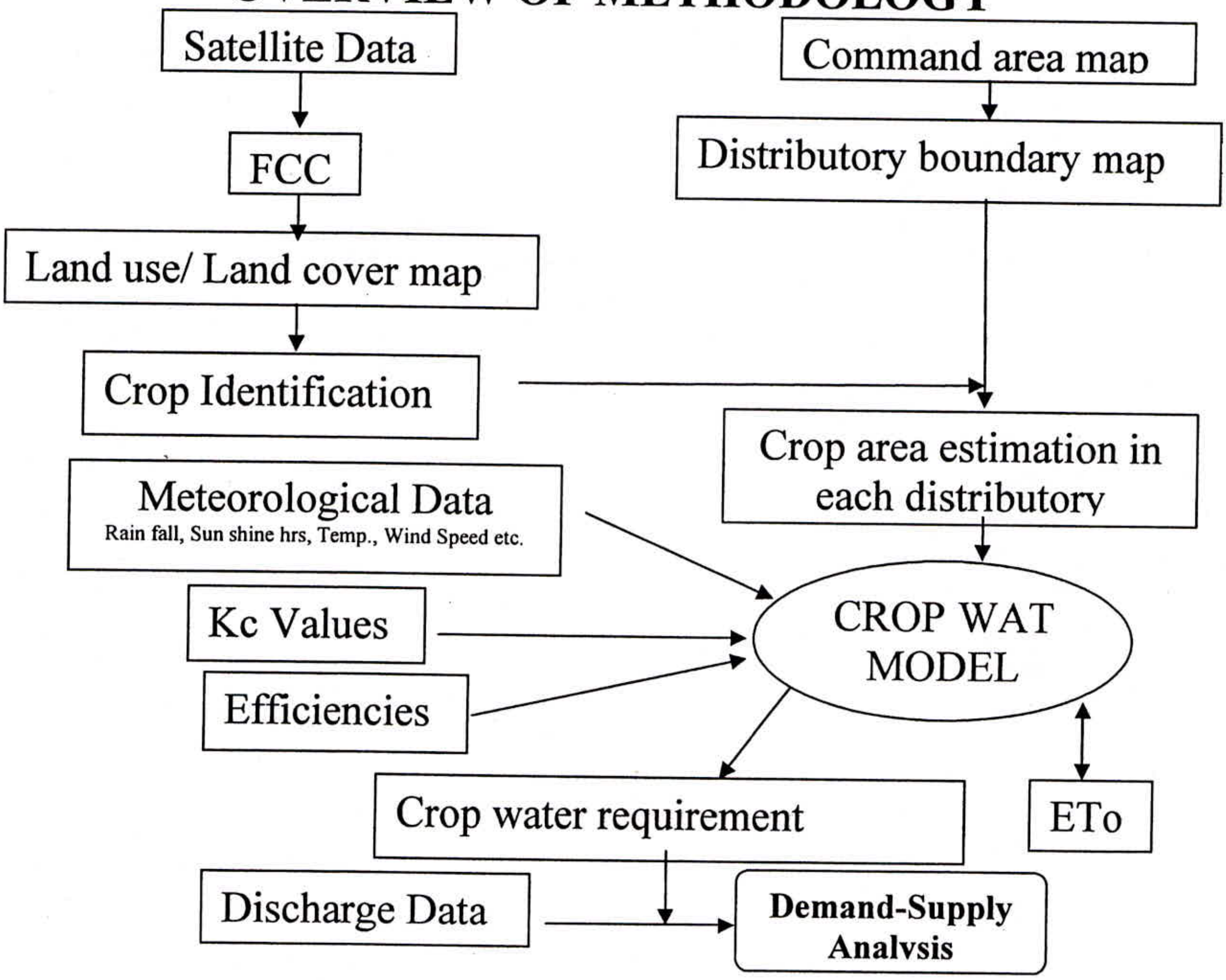
Other Data

1. Irrigation supply data
2. Meteorological Data

Methodology:

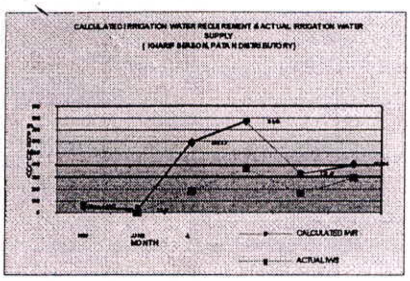
Following flow chart indicates the steps involved in achieving above said objectives:

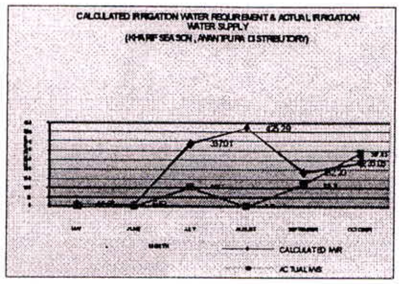
OVERVIEW OF METHODOLOGY

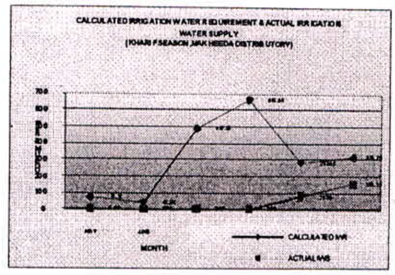


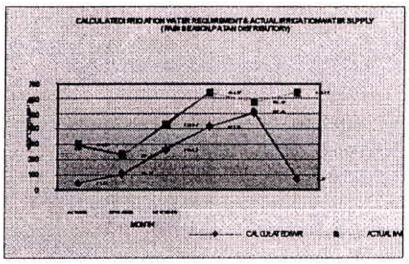
Results

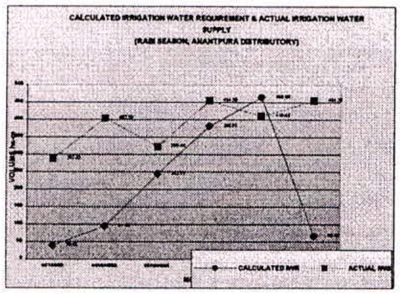
HEAD REACH | *MIDDLE REACH* | TAIL END

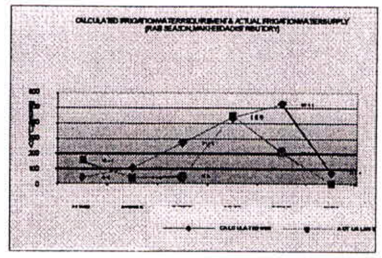












- In Kharif season Irrigation water supply is always less than Irrigation water requirement.
- In Rabi season Irrigation water supply is always more except in Makheeda distributory, which is the tail end of K.Patan command. It indicates generally at the head reach water is delivered more while at tail end less water is supplied This may be because of various conveyance losses as well as because of poor management of canal water supply .
- It is found that in Makheeda distributory hardly irrigation water supply meets the actual crop water requirement. This statement is further validated by using NDVI maps.
- Patan distributory which is at the head reach of Patan command ,NDVI is more (Vegetation Status is more) while at Mahkeeda distributory NDVI is less (Vegetation status is poor).
- In a nutshell, Supply of water from canal is always less than demand in Kharif season while Supply of water in rabi season is always more than required which may result into water logging. This misuse of water should be immediately stopped.

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