REMOTE SENSING APPLICATION IN IRRIGATION WATER MANAGEMENT

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1.0 Introduction

Irrigation development has been accepted as a major factor in increasing agricultural production. Development of irrigation is, therefore, the sine-qua-non for agricultural for agricultural prosperity and general economic well being of the population in the country. Irrigation forms the datum line for sustained successful 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 the gross irrigation potential of 113 million hectares by the end of the century.

Notwithstanding the impressive progress made in creating the irrigation potential since 1950, the productivity of irrigated areas has remained low, between 20 to 30 per cent. Now, questions are being increasingly asked, whether the country is taking full advantage of this heavy investment and this unique network of our irrigation systems. These questions flow naturally from the achievements and experiences from the past. In no way they should constructed as criticism of what has been achieved. The question of economic efficiency in water use has not been taken up seriously in this period. Therefore, the agricultural practices are attuned to this scarcity and unreliable water supplies quite understandable that our efforts have mostly concentrated on the creation of the vast irrigation systems, this is most logical thing to do in the context of serious food shortages in the 1960s. The important thing therefore is not to belittle the achievements of the past but to ask relevant questions with regard to the future.

The most important issue, which should now receive the highest attention, is review and reorganisation of the management of irrigation systems so that overall efficiency of the irrigation command areas is appreciably increased. The optimum allocation and economic use of a crucial and scarce input like irrigation water, which is the lifeblood of agriculture, is a basic problem, which needs immediate attention. This is considered to be feasible objective if we can only clarify the issues at this stage and take important policy decisions with regard to the future directions of irrigation development and management in this country.

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 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 groundwater populations, 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 Land Use Policy outline (1986) are the two recent development emphasing 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 can be 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 maximising the crop production. The technology is location specific and governed by the nature and extent of water availability, soils, climatic conditions, crop species, cropping pattern, geohydrology etc. of the area.

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 aquifer 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 the canal water and groundwater to augment canal supplies and control operation. This fact is duly recognised 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).

Judicious management of the water resources of a groundwater basin needs a comprehensive understanding of the total system and its response to recharge and various pumpages contemplated. Conjunctive use of groundwater and surface water calls for information on potential groundwater and surface water resources. It calls for information on potential groundwater areas, possible recharge areas and extent of present level of utilisation etc. An adequate estimate of the availability of groundwater storage in a basin requires determination of the groundwater basin boundaries, aquifer dimensions, aquifer characteristics and water budgeting. Water budgeting helps to evaluate the net available water resources both surface and subsurface and to assess the impact of existing water utilisation pattern and practices. The need for accurate and reliable information on crop inventory, land use pattern, land cover, soils, source wise distribution of irrigated areas, irrigation tank inventory etc. Have often precluded quantitative description and analysis of various processes that describe the water resource regime in any irrigation command. The emergence of remote sensing as a tool for providing the above mentioned base line information not only in spatial dimension but also monitor them through time is cost and time effective. This information together, with the conventional meteorological, canal flows, well inventory data can be used as inputs to the various existing empirical, semi-empirical and conceptual models to understand and estimate various components of the water budgeting for development of guidelines for planning sustainable use of groundwater resource in conjunction with surface water resources in irrigation command areas.

2.0 Remote Sensing and GIS Application

Agriculture, with its fundamental economic importance and its attendant uncertainties has been an obvious focus for remote sensing. Agricultural applications were envisaged in the original specifications of Landsat and the advent of relatively high spatial resolution led to important applications in identification of crop types, information on crop conditions and crop productivity, land evaluation and mapping in irrigation command areas. Remote sensing through synoptic and repetitive coverage would help to build historical and long-term records of command areas and hence useful in development of information base. This would give a picture of irrigation development in command areas through various stages. It would also be useful in detection and monitoring of land use changes including cropping pattern in the command areas over a period of time.

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 optimum 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 investigations in India as well as in other countries. Periodic satellite monitoring of command areas has helped in evaluating increase in irrigation utilisation and improvement in agricultural productivity through the years. Deviation from the recommended cropping pattern and unauthorised irrigation leading to ineffective water management has been detected. Problem soil viz. Saline, alkaline and water logged soils resulting from judicious water management have been mapped and monitored to aid reclaimation 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 improvement 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 effective use of irrigation water.

In India, the command areas of irrigation projects besides reservoir water supply, area 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 resources in particular and efficient use of total available water resources in general, in irrigation command areas.

Conjunctive use of groundwater and surface water calls for information on potential groundwater and surface water. Groundwater balance and groundwater recharge studies help evaluate the additional for groundwater development. Besides command area inventory, remote sensing helps in providing information on potential groundwater areas, possible recharge areas and extent of present level of utilisation etc.

From the above, it is clear that Remote Sensing can be looked upon as an aid in planning and decision making arrive at optimal land and water use strategies in irrigation command areas. Much efforts have been undertaken in all parts of the world, and for a wide spectrum of different purposes and problems in Irrigation Command Area, to apply remote sensing techniques, to develop appropriate methods to advance these techniques to an operational level.

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 centralised 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 method which use computer based capabilities of data collection, management, analysis and decision support is, 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.

Objectives

In view of the great potential for remote sensing technology in irrigation command areas for efficient water management, the objective of this 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 the 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.

Significant research has been done to evaluate the usefulness of satellite remote sensing techniques for irrigated command inventory. The information on crop types, acreages, their condition, land utilization pattern, problem agricultural lands, surface water bodies derived from satellite Remote Sensing data has been advantageously used in evaluating irrigation systems operating in the command area.

With the advent of satellite remote sensing technology, mapping of irrigation command areas for various crops during different season has become very easy. It is a very cost-and -time effective promising techniques. GIS is an analytical tool, which can be used to evaluate the performance of irrigation command and its management.

3.0 Data Required

For irrigation water management in the command area, we need certain data, which is as follows:

- Crop acreage
- Crop calendar
- Soil map
- Evapotranspiration
- Crop coefficient
- Canal network
- Rainfall data

Creation of Database in GIS

Crop Acreage

This is the basic input required for irrigation command area management. This information can be collected by visual interpretation of satellite image. This information is then digitised in polygon mode. Real world coordinate should be used to georeferencing the map. This map can directly be taken from satellite digital data. The digital data can be classified by using supervised and unsupervised classification procedure. This image should be georeferenced with real world coordinate.

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 states at the time of satellite data acquisition. Irrigation water requirement depends upon the growth stage of crop hence; this information is very useful to calculate the irrigation water requirement. This data is stored in tabular form.

Soil Map

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

Evapotranspiration

Evapotranspiration denotes the quantity of water transpired by plants during their growth of retained in the plant tissue, and the moisture evaporated from the surface of the soil and the vegetation. In other term, Evappotarnspiration is the water consumed by crop for its growth. Hence, this is very essential to calculate crop water requirement. This data can be obtained from meteorological station. This data will be stored in tabular form.

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.

Canal Network

Canal network map and command area boundary maps, which are obtained from the concern field authorities, are to be digitised using a coordinate system. The command area boundary becomes the boundary of the study area. The canal network is a 'line' feature, the canal command area is a 'polygon' feature, and the canal outlets are point feature. During the digitisation, if these features are not digitised separately, they should be separated after digitisation.

The real 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 digitise the canal 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 length 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.

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 digitised and then Theisean polygon method is applied to get the spatial information of rainfall.

4.0 Irrigation Water Requirement

To calculate the irrigation water requirement for a command area with various crops, soils and conveyance losses. The following GIS/Database procedures have to be used to calculate the irrigation water requirement:

- Crossing of Maps: If two maps are crossed, data can be obtained of the area occupied by each unique combination of mapA values and mapB values. Inputs are two maps and the outlet is cross table with the area of each unique combination and cross map with unique values for each combination.

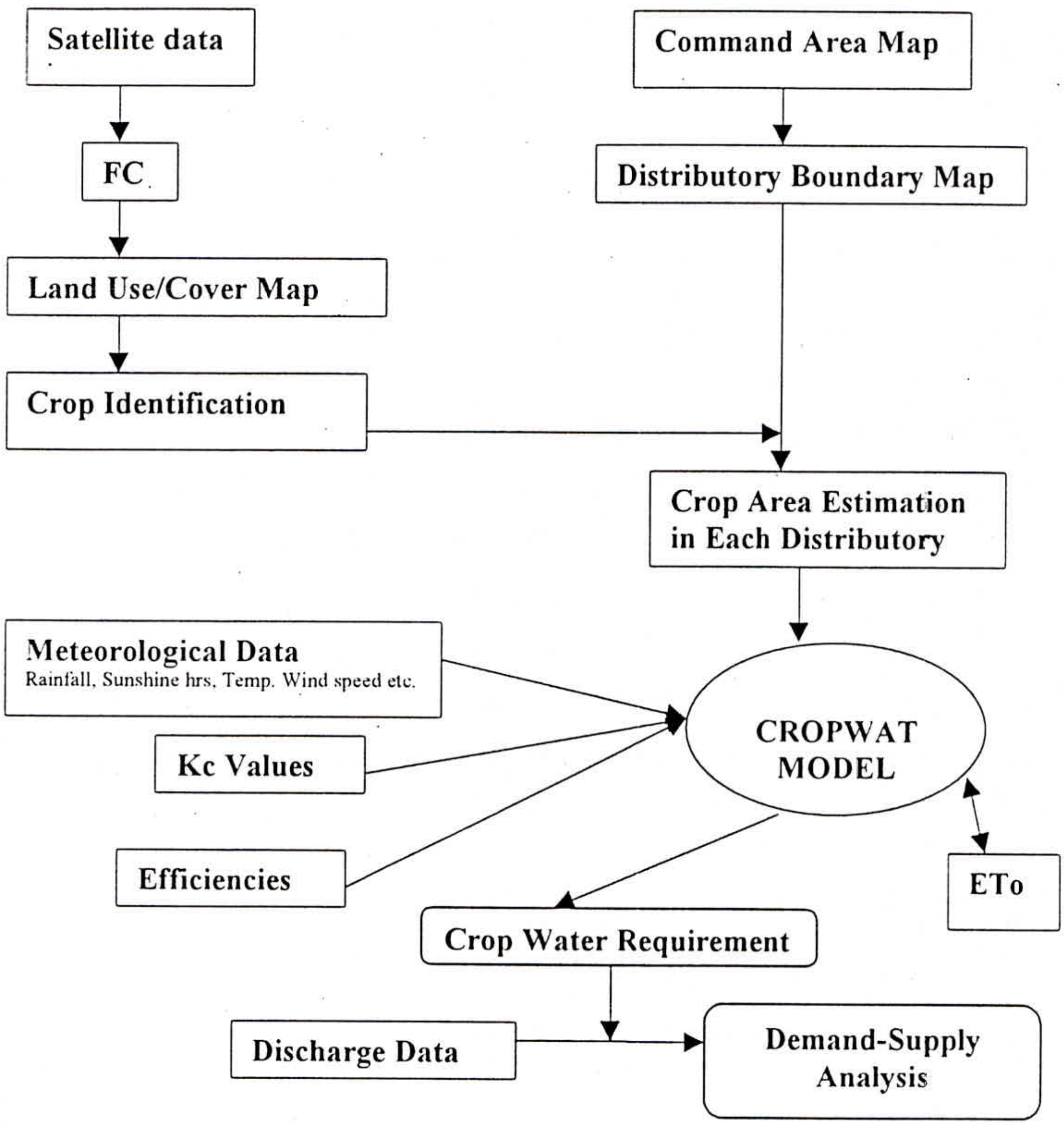
- Linking of Table with Map: A map can be created using the attribute data present in a table. Linking can only be done if the domain of the map is the same as the domain of the table.

- Linking of Tables: attribute data of one table can be transferred to another table using common key columns (the relational database concept). In such a way, tabular data can be transferred to histogram tables created from maps.

- Table Calculations: calculation can be performed on individual columns or a combination of columns.

- Aggregation: for each unit (e. g. Block number), another column can be aggregated. Function such as summation, average, minimum, maximum can be calculated per block.

Following flow chart indicates the steps involved in achieving the performance evaluation of irrigation command.



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