USE OF GEOGRAPHIC INFORMATION SYSTEMS IN IRRIGATION MANAGEMENT: A REVIEW

Saroj Acharya¹, Ashish Pandey² and U.C. Chaube³

ABSTRACT

In this study review of the Geographic Information System (GIS) based system/tools for irrigation management has been carried out. A brief review of customization of ArcGIS as irrigation management tool is also presented. Need and potential of development of the GIS based irrigation management tools to visualize and analyze irrigation management data is discussed in detail. This technique can be employed to develop thematic maps of irrigation requirements to be used by decision-makers. The relevant review literature indicates that GIS is versatile tool that can be used to provide an appropriate framework for manipulating, analyzing and visualizing spatial data and produce results in the form of map, table and graph to support planning and decision making process in irrigation management. Review of various studies revealed that GIS can be customized effectively to develop a tool capable of simulating irrigation water requirements spatially, useful in decision making process in irrigation management.

Keywords: Irrigation Management; Geographic Information System (GIS); Water requirements; GIS Customization, Geospatial, Remote Sensing

INTRODUCTION

Prediction shows that there will be sharp increase in water withdrawals on a global scale along with increase in future water demand for the urban, industrial, agriculture and environmental sectors (Shiklomanov, 2000). The situation would be worse in semi arid regions of Asia, Middle-East and sub-Saharan Africa, where there is already high concentration of population. There is an urgent need for better management and utilization of water resource to meet ever increasing demand of water. Agriculture is the largest water consuming sector, accounting 69% of the freshwater withdrawal at world level while 85% to 95% for most developing countries (FAO, 2003). About 40% of total agricultural production is obtained from irrigated areas (Gundogdu et al., 2002).

Irrigation is one of the most important inputs for an efficient and sustainable agricultural production (Gundogdu et al., 2002). The irrigation water management has key role in increasing food grain production with less water as well as to meet the ever increasing demand of other water uses. Management of irrigation system reduces water demand, saving water for other uses and further helps in improving agriculture productivity. Irrigation management is one of the major challenges for the irrigation professionals and managers because it involves multi tasks, multi stakeholders with varying goals. An efficient water management allows optimization of available water, an effective control on the quality of agricultural products and further helps in reduction of the adverse environmental impacts of irrigation.

Most of the data related to irrigation management is complex, spatially distributed and temporal in nature. The integration of the irrigation data and use in irrigation planning and management has led to introduction of Geographic Information Systems (GIS) and other technologies (Su and Wen, 2001; Bioggio and Ding, 2001; Kjelds and Storm, 2001). GIS is an effective tool for exploring, storing, managing and displaying spatial data and can be employed for the decision making and management functions that lie at the heart of the planning and management of any irrigation scheme. The GIS not only allows user in analyzing and visualizing spatial and non spatial data and in the form of maps but also allows in customizing with it to develop a custom tool. Remote sensing and GIS are beneficial for spatial analyses and visualization for better irrigation management. GIS can be a very effective tool to provide information to the farmers and irrigation professionals in the form of maps using interpolation. These maps can be easily understood by farmers, planners and specialists for irrigation planning, management and research providing information most effectively and accurately. The customization capability of ArcGIS can be used to develop an essential tool for modeling of irrigation water requirements spatially.

With the rapid advances in computer technology, water agencies and researchers around the world are investing extensive effort to develop generalized computer models/tools for simulating irrigation management. Although, the development of software for improved management of irrigation systems has been moving very slowly as compared to other sectors, in past a number of simulation models, irrigation scheduling models and decision supporting system to support irrigation management were developed (Fortes et al., 2005; Todorovic and Studuto, 2003; Heinemann et al., 2002). Computer based systems and tools help the decision maker to manage irrigation system quickly and efficiently. Few computer-based tools/system have become popular among the irrigation experts and authority. These tools are effectively applied in the past for irrigation management.

This paper encompasses review of irrigation management tool/systems developed in the past to answer irrigation water management questioning. This paper includes the importance of GIS and its integration with the irrigation management tools/system for improved irrigation management. Further, a brief review on customization of GIS along with needs and potential of development of GIS based tool for better irrigation management is discussed.

1. Trainee officer, Dept. of WRD&M, Indian Institute of Technology Roorkee-247667
2. Associate Prof., Dept. of WRD&M, IIT Roorkee-247 667
3. Emeritus Fellow, Dept. of WRD&M, IIT Roorkee-247 667
*Corresponding Author-E-mail: sarojacharya116@gmail.com
Manuscript No.: 1378
GEOGRAPHIC INFORMATION SYSTEM
GIS is a collection of computer hardware and software, data and skilled personnel for managing and analyzing geographic data (Maguire et al., 1991). In GIS data is represented in the form of points, lines, polygons or pixels. Rather than just a map, in which colours and symbols represent geographical features, the user can interact to varying levels with a GIS. At present, GIS technology is widely applied in several fields such as natural resource management, agriculture management, commercial, urban and regional management to address complex and multidisciplinary planning and management problems at regional and global scales. GIS has gained widespread acceptance as an important versatile tool because of its ability to carry out complex spatial operations and capability to link spatial and non spatial data.

GIS has the capability to manage many layers, integrate and analyze spatial data from different sources, with diverse formats, structures, projections and helps in spatial modeling (Goodchild, 1992). GIS is capable to import the most common data formats both for raster and vector maps. The basic functions of GIS are data collection and capturing; data storing, processing and analysis; store, quarry and analyze data; production of data; display data; produce output from the information in it. GIS is a collectively broad term that contains a number of technologies, processes, and methods. It is attached to many operations and has wider applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business.

CUSTOMIZATION OF ARCgis
ArcGIS is most commonly used, versatile and user friendly GIS application in irrigation and water resources management projects. The ArcGIS allows user in analyzing and visualizing spatial and non spatial data and in the form of maps and also allows in customizing with it to develop a custom tool and interface. ArcGIS can be customized with close interaction with python which is included and fully supported in ArcGIS. ESRI ArcObjects is the development platform for the ArcGIS family of applications, such as ArcMap to developers.

All the ArcGIS tools and commands called ESRI object library can be initiated and can be called through the codes inside the buttons and controls. ArcGIS contains library of software components known as ArcObjects (ArcGIS Help, 9.3). The ESRI object libraries are always available for the customization in the Integrated Development Environment.

With Python add-in and ArcObjects own menus, tools, workflows, applications, and custom feature classes can be created for use with ArcGIS. These ArcObjects can be accessed via menus and buttons that should have some program to provide additional functionality through the objects’ interfaces. ArcGIS can be customized and improve productivity using Python add-in and ArcObjects can contain scripts and can be hooks into the application framework so that can be responded to actions that happen on the buttons or commands created (ArcGIS Resources Center).

Many tasks associated with editing and quality checking (QCing) GIS datasets can be tedious, repetitive, and time consuming. Automation of some of these tasks, such as systematic planning around a map and semi-automated feature attribution, is sometimes desirable. Using the Integrated Development Environment, which is included, and fully supported in ArcGIS, applications can be developed to automate and speed up these tasks (ESRI Developing Network). Users can create custom user interface forms and tools visually using many of the same components available in larger, more robust programming environments such as VB .NET and Visual C++ (ESRI Developing Network).

The customization capability of ArcGIS can be used to develop an essential tool for modeling of irrigation water requirements spatially which can help the decision maker to manage irrigation system quickly and efficiently.

GIS IN IRRIGATION MANAGEMENT
GIS is a familiar and popular tool for management and decision making in water resources for agricultural and conservation purposes. A spatial approach such GIS is particularly appropriate for the handling the spatial data in irrigation management. GIS technology such as ARC/INFO software was efficiently and effectively used in many water resources planning and management worldwide. It can help to establish agricultural water rights, support the application for drilling permits for irrigation purposes, and track water rights information. It can also be used to evaluate the loss of water from soil drainage and unlined canals, as well as help determine the suitability, cost-effectiveness, and prioritization of canal projects in planning stages.

Use of GIS especially for analysing spatial water and irrigation requirements with their large volumes of spatially and temporally distributed data is widely adopted. The GIS capability to integrate spatial data, integrating remote sensing data and handling large volume of data has been popular among the irrigation experts. The integration and use of georeferenced data in irrigation management certainly requires the use of GIS technologies. GIS offer a spatial representation of irrigation systems.

GIS has capabilities to integrate database, statistics, remote sensing, maps with advance graphics for visualization and analysis. Spatial database of soil, rainfall, geology, land use, transportation, topography, demography and socioeconomic can be implemented for better decisions in irrigation planning and management. With its powerful capacity for management and analysis of spatial data, GIS has becomes an important tool in irrigation management (Lin et al., 2004). Over the last decade, rapid advance in computer hardware and software, combined with the development with extensive digital database, have encouraged the application of GIS in irrigation management.

A GIS technique allows modeling of water demand with different scenario for soil, crop, weather and irrigation data. A GIS-based decision support system for real-time estimation of water demands in delivery systems was developed by Rao et al. (2004) and applied in Some Irrigation Project, Bihar, India. Ray and Dadhwal (2001) used remote sensing and GIS for estimation of the crop evapotranspiration of command area of Mahi Right Bank Canal (MRBC) command in Gujarat, India. Spatial estimation of regional crop evapotranspiration was described by Hashimi et al. (1995) for the study area of Poudre Basin in Colorado. A GIS application to improve irrigation
planning in Yemen was illustrated by Muthanna and Amin (2003). Martin (1996) used GIS for scheduling in irrigation districts to help in decision process on irrigation scheduling with an interactive, graphic interface. Most GIS-applications are separated from main management systems and usually require manual data export to produce map reports.

In past, many research studies have been carried out for estimation of irrigation water requirement, mostly focused on finding water requirements for different climate, soil and crop scenario. For the irrigation scheduling and modeling as farm level, large number of tools, models and decision support systems are available. Although these tools help in improvement in irrigation management in specific aspects, large number of models raise doubt about their general validity (Lozano and Mateos, 2008). Most of these available tools are limited to computation of crop water requirements, simulate soil water balance, estimate the irrigation schedule and evaluate the existing irrigation scheduling on field level. These type of Irrigation scheduling tools and models are particularly useful at farm level to support farmers and irrigation advisory services (Ortega et al., 2005). Main focus of these models was to simulate irrigation scheduling with alternate irrigation schedule at different crop stage and to simulate with different water availability. Few tools have been integrated with GIS for estimation of irrigation requirement to extend the work from farm scale to region level along with better irrigation management capabilities. Some of the models are integrated with GIS which expand its analysis from farm scale to region scale, enabling water resource planning and environmental studies. Some of the tools/system developed in recent years indicating aims and features are summarized and presented in Table 1.

Naidu and Giridhar (2011). Employed GIS for Geo-Spatial Database Creation for Wazirabad Canal Command Area. GIS based system helps to analyze the spatial information about its engineers and farmers to improve planning, management and supply of water resources to its corresponding blocks in command area. In order to manage water efficiently in the command area, it is needless to say that calculation and evaluation of water demands in detail at block and minor level is to be given overriding priority. In their study, blocks and chak boundaries were delineated from the Digital Elevation Model using GIS techniques. These boundaries are helpful to plan and allocate the water resources to improve the water allocation strategies and in turn water use efficiency and can make inter-canal comparisons. The delineated block boundaries are refined exactly using the drainage, topography and existing canal network in GIS platform.

The irrigation scheduling simulation model ISAREG tool is soil water balance model to simulate irrigation schedule for a

Table 1: Details of tools/systems with their features and Locations.

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Researcher/ Organization</th>
<th>Location</th>
<th>Goal (Aims)</th>
<th>GIS integration</th>
<th>Key Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISAREG</td>
<td>Teixeira and Pereira, 1992</td>
<td>Different part of the world</td>
<td>Simulate irrigation schedule for soil-climate-crop combination, evaluation of selected irrigation schedule</td>
<td>No</td>
<td>Decision support in selection of suitable irrigation schedule, applies to field scale and not suitable for large area</td>
</tr>
<tr>
<td>2</td>
<td>GISAREG</td>
<td>Fortes et al., 2005</td>
<td>Syr Darya basin, Uzbekistan</td>
<td>Simulate irrigation schedule for region/project, help in project management</td>
<td>Yes</td>
<td>Simulate irrigation schedule in different water management scenarios for region/project scale, can be visualize spatial distribution of water demand</td>
</tr>
<tr>
<td>3</td>
<td>Scheme irrigation management information system (SIMIS)</td>
<td>Mateos et al., 2002</td>
<td>Different part of the world</td>
<td>Facilitate water and day to day management, manage irrigation water delivery schedule, help in integrated management of irrigation project.</td>
<td>Yes</td>
<td>Simulate different crop and irrigation scenario for water delivery schedule, compare existing situation for improvement irrigation, can be visualized input/output.</td>
</tr>
<tr>
<td>4</td>
<td>A Web based GIS</td>
<td>Dhakal, 2010</td>
<td>Alentejo region, Portugal</td>
<td>Share weather and evapotranspiration information to farmers through internet to support irrigation management.</td>
<td>Yes</td>
<td>Publishes weather and evapotranspiration map from interpolation of automatic weather data through web.</td>
</tr>
<tr>
<td>5</td>
<td>A GIS based interactive tool for irrigation management</td>
<td>Pervez and Hoque; 2008</td>
<td>Bangladesh</td>
<td>Help managers in irrigation planning and management at project level, facilitate the operation and management processes of command area.</td>
<td>Yes</td>
<td>User friendly graphical user interface, decision support in design stage, real time analysis of irrigation components.</td>
</tr>
<tr>
<td></td>
<td>GIS based irrigation management system</td>
<td>Todorovic and Steduto, 2003</td>
<td>Apulia region, Italy</td>
<td>To support irrigation authority in evaluation of irrigation scenarios under different soil, climatic and management conditions,</td>
<td>Yes</td>
<td>identifying the areas with water deficit, applied on farm to region level, spatial irrigation requirement computation, ArcGIS data can be used in input/output.</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------</td>
<td>-----------------------------</td>
<td>-------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-----</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>GIS-based Decision Support System</td>
<td>Raut et al., 2008</td>
<td>India</td>
<td>conjunctive irrigation management for basin planning</td>
<td>Yes</td>
<td>Handy tool for basin planning, decision support in real time operation of canal system.</td>
</tr>
<tr>
<td>8</td>
<td>A GIS-based decision support system for real time water demand estimation in canal irrigation systems</td>
<td>Rao et al., 2004</td>
<td>India</td>
<td>Decision support for real time water demand computation and canal operation in canal irrigation system.</td>
<td>Yes</td>
<td>Computes the field irrigation requirement and water requirement on distributaries on real time, helps in decision making in operation of canal.</td>
</tr>
</tbody>
</table>

given soil, crop and climate (Teixeira and Pereira, 1992). ISAREG uses weather, soil and crop data as input and computes crop water requirements or evaluates the existing irrigation system using soil water balance (Teixeira and Pereira, 1992; Liu et al., 1998). ISAREG tool is useful for computing crop irrigation requirement and selecting the irrigation scheduling to support field irrigation. ISAREG tool was used to simulate irrigation schedule for a long time successfully with many irrigation scheme in several parts of the world. This type of simulation model is appropriate only for computations at field scale for specific soil, crop, and climate conditions (Fortes et al., 2005).

When ISAREG tool was applied for large scale it cannot perform due to significant number of combinations of field and crop characteristics requirement (Liang and Wu, 2012). The main limitation of this type of models is that they cannot handle the spatial data which is key input for handling in region scale. These tools become useful and attractive for wide range of scale particularly for regions if these tools can be integrated with GIS to handle spatially distributed data for input and output. With the advance in remote sensing and the availability of remotely sensed data the interest of this type of integration has increased (Fortes et al., 2005).

To overcome the limitation of ISAREG for its use at region scale, ISAREG was integrated with GIS to develop more useful model, GISAREG, capable to handle large around of spatially distributed irrigation data. GISAREG can handle spatial as well as non spatial data allowing visualization of the spatial distribution of the water demand for large area. GISAREG was aimed for the simulation of irrigation scheduling over region or project for improved irrigation management (Fortes et al., 2005). It can compute crop water requirement and irrigation scheduling with spatial climate data of cropped fields and user selected crop scenario. This model requires spatial data, the model can be used for different water management scenarios, it can produce crop irrigation maps and can simulate irrigation schedule from farm scale to region scale. The results of water management scenario are spatially distributed and helpful to support irrigation scheduling and environmental control (Fortes et al., 2005). Further improvement on GISREG would be inclusion of groundwater components allowing its impact on water requirements (Liang and Wu, 2012). Further GISAREG can be updated with newer versions of ArcGIS as it uses Arcview3.2, which is old version of ArcGIS.

Scheme Irrigation Management Information System (SIMIS), developed by FAO, is a decision support system for managing irrigation schemes at farm and canal level, based on simple water balance model (Mateos et al., 2002; Luciano et al., 2002). SIMIS is aimed to facilitate day to day managements along with water management on irrigation scheme and valid for most of the planning, scheduling, maintenance, administration and performance activities on any irrigation scheme. SIMIS Stores climate, soil, crop and irrigation data and computes water requirements, irrigation needs and further water delivery schedule in irrigation scheme. SIMIS can simulate different crop and irrigation scenario and compare to the existing situation for further improvement in irrigation scheme. The user can simulate delivery schedule, see the result and test new alternative until the satisfactory condition. Thus, SIMIS can be used in computing irrigation requirement, water management, developing irrigation layouts, scheduling water deliveries, and keeping records of water consumption. In wider sense SIMIS can help in integrated management of irrigation project. Many geo-referenced inputs and outputs can be visualized through the GIS contained within SIMIS and can be printed in reports. The SIMIS is very helpful for the scheme manager for deciding irrigation schedule in different water demand condition. The SIMIS is no longer supported by FAO but it established a framework for developing customized tool to adopt particular feature of irrigation project (Lozano and Mateos, 2008).

The integration of GIS within internet for irrigation management could be powerful decision support for irrigation managers and farmers as internet is becoming an easiest way of sharing information. The integration of irrigation data within internet for processing and displaying maps in internet allows better and quick information sharing of important parameters of irrigation requirements for better irrigation management. A Web based GIS was developed by animating weather and evapotranspiration map to support irrigation management for Alentejo region, Portugal (Dhakal, 2010). The
tool uses data from automatic weather station and produces weather and evapotranspiration maps using Geo-statistical interpolation techniques and publishes these maps in web. The system works automatically and no need of manual update as automatic weather station provides weather data automatically and web processes interpolation and publish maps automatically. The tool can create animated weather maps from the weather data which are useful for visualizing changing pattern of weather parameters and water requirement, which is key parameter for irrigation management, for over time. Forecasting with maps of weather and irrigation requirement parameters is also possible with this tool.

A GIS based interactive tool for irrigation management developed in relation with the Meghna-Dhonagoda Irrigation Project (MDIP), Bangladesh. This is an Arcview based GIS user friendly graphical user interface developed with the Avenue Codes by integrating the GIS and Relational Database Management System (RDMS). This interactive tool is specially designed and customized to help irrigation managers at the project level for irrigation planning and management. This Interactive Information System assists irrigation specialists in decision support especially in design stage and also can facilitate the operation and management processes of the command area development. It provides support to the design engineers to assess the impact of the design parameters of the system and also can calculate the irrigation efficiency in the field level. It can perform real time computation and analysis of irrigation components and capable to generate outputs in form of maps.

Another GIS based tool was developed and used in Apulia region, Italy for handling spatial and non spatial irrigation data for evaluation of the irrigation scenarios under different soil, climatic and management conditions (Todorovic and Steduto, 2003). The aim of the system was to provide support for irrigation authorities on evaluating irrigation scenario and identifying the areas with water deficit. ArcView GIS was customized with Avenue programming language to design and develop, the irrigation water management system, a new tool for modeling irrigation water requirements. Spatial Irrigation requirements can be estimated by taking into account different scenarios of cropping pattern, climatic conditions, applied irrigation method, volume of water available for irrigation and hydraulic characteristics of the water distribution system. As ArcGIS database is used as an input in this system and integrated for the irrigation computation, outputs can be shown in the form of maps. The system has wide area of application farm scale to region scale. The climatic database was prepared using historical data in this case and using crop, soil and distribution system data irrigation water requirement was computed and mapped for the region.

Raut et al. (2008) used a GIS-based Decision Support System developed at the Centre for Research in Water Resources (CRWR) in conjunction with ESRI for conjunctive irrigation management in India for basin planning of Jaunpur Branch Sub-basin format for hydrologic applications including all spatial and time series data. It is handy tool for basin planning and real-time operation of canal systems, particularly run-off river system. Various scenarios can be evaluated related to change in canal operation and management, agriculture practice and land use, climate and so on.

Rao et al. (2004) developed a GIS-based decision support system for real time water demand estimation in canal irrigation systems in India. This decision support system computes the field irrigation requirement and water requirement on distributaries on real time basis. The system uses current season data, weather forecast, crop and soil data to compute water and irrigation requirement and can compute water delivery required in distributary in canal network. The system allows users to select distributary and real time computation of water demand over the area covered by distributary network and further helps in decision making in operation of canal. The ability of the system to quantify the water delivery required for canal network has strong decision support in canal operation and overall irrigation management.

**REMOTE SENSING WITH GIS IN IRRIGATION MANAGEMENT**

Recent advances in Remote Sensing technology offers potential improvement in various disciplines along with water resources management through important water resource-related information. This information is potentially useful in legislation, planning, water allocation, performance assessment, impact assessment, research, and in health and environment-related fields (Bastiaanssen and Bos, 1999). GIS and Remote sense data have many similar attribute are concerned with the digital representation of geographic phenomena and often both employ the same spatial analytical techniques to manipulate the data.

The remotely sense data in conjunction with other traditional data provides valuable information on topography, land use/cover, geological feature useful in irrigation planning and management. The space and time based earth observation in remote sensing provides unique opportunity in handling spatial and temporal irrigation data for better irrigation management. Remotely sense data can be used by two ways regarding irrigation management, first accessing land cover in different cover and other is through estimation of water requirement parameters. When we deal with relatively large area/surface, remote sensing is more useful and there is always large area when dealing with irrigation management. Remote Sensing could be important future technology for better irrigation water management.

Remote sensing data to determine actual evapo-transpiration and crop water stress for managing irrigation systems was started during the eighties (Bastiaanssen and Bos, 1999). Remote sensing has been able to provide information with varying degrees of success and accuracy on; irrigated area, crop type, biomass development, crop yield, crop water requirements, crop evapo-transpiration, performance diagnosis, salinity and water logging (Choudhury et al., 1994; Bastiaanssen and Makin, 2000). Available remotely sensed data remain underutilized by practicing water resource managers although remote sensing has several advantages which can be complementary to field measurements. Spatially distributed information on soil water availability of crops can contribute to enhance the statistics on water availability in space and time.
Remote Sensing techniques and its data use in India for irrigation management has been suggested by previous researchers (Ray and Dadhwal, 2000; Ray et al., 2002). Remote sensing technique can be used for assessment of water availability in reservoir for optimal management of water to meet the irrigation demand. It can also be used in determination of irrigation water demand over space and time, water logging and salinity problems in irrigated land. Further it can be used for performance evaluation of irrigation system through identification, inventorying and assessment of irrigated crops.

The spatial and GIS technique can be used to develop thematic maps of irrigation requirements to be used by decision-makers to define the maximum allowable irrigation withdrawals for a region (Heinemann et al., 2002). Ray and Dadhwal (2000) used remote sensing and GIS for estimating seasonal crop evapotranspiration. The methodology can be used for estimating weekly evapotranspiration and a real-time irrigation scheduling. The integration of RS data and GIS tools can be used to compute performance indices (Ray et al., 2002). The regular computation and monitoring of performance indicators could provide irrigation managers with the means for managing efficiently the irrigation system. Bastiaanssen and Bos, (1999) as described in his paper quantified irrigation performance indicators based on remotely sense data in cost effective manner. He suggested irrigation experts to use remote sensing techniques in evaluation of irrigation performance indicators for better irrigation management.

Benchmarking (BM), using a set of defined indicators to determine the performance of various components of irrigation system is very important to evaluate the irrigation performance and the applied management for the irrigation project. Suresh et al. (2012) used various components of irrigation systems namely Irrigation Infrastructure (IIS), Agricultural System (AS) and Water Delivery Dynamics (WDD) as performance evaluation indicators for benchmarking study of the Nagarajuna Sagar Leftbank Canal (NSLC) using geospatial approach. Remote sensing techniques can provide benchmark dataset of cropping, water distribution, baseline data and other data for comparing among the fields to evaluate the performance of irrigation or other management input. Geospatial approach for benchmarking of irrigation systems could be useful to evaluate the performance of irrigation through different performance indicators and compare the performance indicators within the command to identify the problem for better management (Suresh et al., 2012). The geospatial approach for Benchmark study in irrigation management enables the improvements in data collection methods over time consuming conventional field survey of large area providing alternative mechanism, diagnostic analysis, spatio-temporal visualization of BM indicators. Thus, the use of satellite data combining with field data on water deliveries could be an alternative to the conventional non-spatial approaches for BM Study useful for decision support for better management of irrigation projects and further better water resources planning and management. The benchmarking study can be very useful to diagnose how performance is varying along the space and facilitate quick diagnostic analysis of the problem for improved irrigation management.

FUTURE TOOL FOR IRRIGATION WATER MANAGEMENT

When dealing with spatial and temporal irrigation data, the tools without GIS support have major limitation that they cannot give output in the form of maps which are found to be very useful to visualize and understand by the farmers and irrigation experts. Tool, such as CROPWAT, ISAREG can provide wide range of facilities to carry out standard calculation for design and management of irrigation schemes, do not give input and output maps for use of the regional scale and basin scale.

GIS, since many years, has been focused on analyzing remotely sensed data and only few tools have been developed in relation with irrigation management. With advances in sophisticated GIS tool and accurate methodology developed by irrigation requirements, experts are looking for new tool where visual maps, database and decision support system is available in single platform. Integration of remotely sense data is equally important to handle temporal irrigation data in irrigation management.

In spite of development of few irrigation tools, both GIS based and no integration with GIS, are not popular among farmers and irrigation experts because of complexity involved in many parameter and temporal data. The main limitation of these models is that they do not simulate in real time basis and are not user friendly. There is still need of work on development of irrigation management tool to fulfill the demand of irrigation experts and farmers which can give answer on spatial water requirements and water surplus/deficit of the command area.

There is an easy way to develop to fulfill the gap of irrigation management tool inside ArcGIS using Integrated Development Environment. All spatial and non spatial irrigation data can be stored, analyzed and visualized using ArcGIS and these data can be customized using Integrated Development Environment to present all needed spatial water demand maps, irrigation map and water surplus/deficit maps. By using ArcGIS and the python language and ArcObjects for customization of GIS applications new tools for modeling of irrigation water requirements spatially and identifying corresponding water deficit/surplus can be designed. The tool may be used by irrigation authority and irrigation management consortia to analyze the water requirements and to take decision quickly and easier way.

Automated weather stations, advance remote sensing technology, web technology to spread information, and sophisticated computer applications can further be combined to develop an effective tool for irrigation management. The next generation of irrigation management software will need to address the spatial and temporal data with automation. Further, the tool should be user friendly, efficient, automated and should address multitask associated with irrigation management. But the software to do that is inherently complex, and development of such software is beyond the resources of most individual states or agencies.

CONCLUSION

GIS is one of the easiest ways of providing management tool for irrigation. Integration of Remote sensing technique data
with GIS is useful when dealing with irrigation management. GIS is a versatile and user-friendly application that can be employed to provide an appropriate framework through the manipulating, visualizing and spatial analysis to support planning and decision making process relevant to irrigation management. The integration of GIS with the available irrigation management tools is more powerful and effective when dealing with large area and complex temporal data. Although few tools/systems have been developed in the past to simulate irrigation models, still there is need of development of new tool with the aim of analyzing spatial irrigation water requirement and can be developed by customizing ArcGIS.

REFERENCES

1. ArcGIS Resource Center.

2. ArcGIS Help, 9.3.


8. ESRI Developing Network, Customizing ArcGIS Desktop 9.3 using VBA.


13. Heinemann, A. B., Hoogenboom, G. and Faria, R. T., 2002. Determination of spatial water requirements at county and regional levels using crop models and GIS and example for the state of parana, Brazil. Agricultural Water Management, 52: 177-196


