

Interactive Information System for Irrigation Management

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Abstract

Irrigation management is a key to efficient and timely water distribution in canal command areas keeping in view the crop factors, and for irrigation management adequate and always updated information regarding the irrigation system is needed. This paper illustrates a GIS Tool for Irrigation Management which provides information interactively for decision making process. This Interactive Information System (IIS) has been developed to facilitate the operation and management of the command area development and to calculate the irrigation efficiency in the field level. At the basis of this development is geographic information systems (GIS) but gradually, this is being adapted to the kind of decision and management functions that lie at the heart of the planning process of any irrigation project. It also provides support to the design engineers to assess the impact of the design parameters of the System. This is an Arcview based GIS tool developed with the Avenue Codes by integrating the GIS and Relational Database Management System (RDMS). Effective integration of GIS with RDMS enhances performance evaluation and diagnostic analysis capabilities. For this application real time topographic data are required which stored as

spatially distributed datasets, back end RDMS has been used to store related attribute information, it lets an Irrigation manager to do some real time calculation and analysis which covers a) Drawing of Detailed Canal and Drainage system on the basis of their category along with other spatial layers b) Cross section profile of the canal c) Comparison of cross sections d) Long profile of the canal e) Cut and Fill calculation of a Cross section in respect of the designed cross section of that particular section f) Convince Calculation of a Particular Section g) Calculate Area elevation curve for command area or any drawn area h) Affected areas for the failure of any irrigation structure I) Retrieval of current Irrigation Structure's Information along with image j) calculate the efficiency of the system. Easy updating system of the associated database keeps the system always updated in respect of the real field situation. A very good user friendly Graphical User Interface at the front end helps the manager to operate the application easily. Using these "point on click" functions of this application an irrigation manager is capable to generate outputs in the form of Maps, Tables and Graphs which guide him to take prompt and appropriate decision with in few minutes.

1: Introduction:

A major part of irrigation management is deciding when to irrigate and how much water to apply. Many irrigation projects throughout the world never fulfill the expectations envisioned at planning and design stages. The land eventually irrigated is often less than planned, efficiencies are lower, and crop yields are not as high as expected. A major reason is the lack of incentives and a working knowledge about proper water management, including scheduling at the farm level on the part of project planners, designers, system operators, and agricultural personnel, as well as farmers. To maximize returns from irrigation development and from efficient on-farm water application in developing countries, there is a recognized need for knowing how water deficits and

surpluses influence crop production, how to determine water requirements, and the best methods and proper timing of irrigation applications. Irrigation agencies also recognize that of equal importance is their capacity to evaluate existing irrigation schemes, to analyze systems for rehabilitation, and to improve the management of water on the farm for increased yields and benefits, and for good decision and analysis require good information. This GIS based Interactive Information System will help engineers, agriculturalists, and Irrigation managers at the project level and higher to understand water needs at the farm level and to develop schedules, operating procedures and timely maintenance to maximize the benefits of irrigation. Further, this Interactive Information System will assist irrigation specialists, agricultural extension personnel, Irrigation Managers, and technical supervisors to develop and conduct training programs for technical staff and farmers. The Interactive Information System for

Irrigation Management describe in this paper has been developed for Meghna-Dhonagoda and Pabna Integrated and Rural Development (PIRDP) project in Bangladesh by Surface Water Modelling Centre which is one of the leading modeling firm for water and environment in Bangladesh.

Meghna-Dhonagoda Irrigation Project (MDIP) brought under irrigation scheme in 1987-1988 by Bangladesh Water Development Board (BWDB) financed by the Asian Development Bank (ADB). The objective of the project was to provided flood control and irrigation facilities to the project area. Gross area 16,900 ha and net irrigable area 11,200 ha and Pabna Integrated Rural Development project (PIRDP), another BWDB project funded by ADB and IFAD was also brought under irrigation scheme. Gross area of 33,000 ha and net area 22,000ha. The objective of the project was to provide flood control, drainage and irrigation facilities within the project area. As a result, only 30% in MDIP and 6% in PIDRP could be brought under irrigation. In some of the areas drainage congestion is causing loss if agricultural lands. To attain the objectives, SWMC carried out a detailed topographic survey performed modelling study and developed this Interactive Information System. Now it is found that around 90% of the command area is under irrigation. Both of these Irrigation Projects are based on Pump Stations for Irrigation and Drainage and gravitational flow of water through earthen canals. So IIS becomes the ideal GIS Tool for maintenance and decision making for Irrigation Management.

2: What is Irrigation Management?

Irrigation Management can be defined as the process of implementation of suitable operation and maintenance in order to meet the objectives of the concerned irrigation system and monitoring of the activities to assure that the objectives are met.

It also can be defined as a process of making decisions about using an organization's resources in order to achieve the organization's objectives.

Three implications can be drawn from the above definition. First of all, that irrigation management is not a routine job. The management decisions have to be made with great care, as they have to match with the operation and maintenance objectives. Secondly, even though the overall goal may be the same, O&M objectives varies from system to system, hence management decisions have to take account of these inter system differences. Thirdly, that monitoring is an integral part of management thus management decisions have to be continuously refined according to the feed back obtained from monitoring and evaluation.

Irrigation Management is one of the major challenges for the irrigation professionals. It is important as it decides

the benefit derived from the irrigation system. The job is difficult, as it can not be conducted with any blueprint approach. Moreover, shortcomings of the different phase of irrigation development e.g. identification of system characteristics, system design and construction are reflected while conducting this job. Hence, if to be done properly, it is complex task as a lot of factors have to be taken into consideration. This Interactive Information System can help the irrigation professionals to take timely better decision for proper Irrigation Management.

3: Irrigation Projects at a Glance

Meghna-Dhonagoda Irrigation Project (MDIP)

MDIP is located at the confluence of the Meghna and Ganges Rivers in the north of Chandpur district covering more than half of Matlab Thana. The combined flows of Meghna, Ganges and Dhonagoda make the project area a veritable river island.

*Pabna Integrated Rural Development Project (PIRDP).*The entire PIRDP is located in three north-eastern districts of Bangladesh, However, CADP encompasses only the Eastern part. This part is located in parts of three thanas (Bera, Santhia and Sujanagar) of Pabna District, near the confluence of the rivers Ganges and Jamuna.

Table 1 : Complete Features of MDIP and PIRDP Irrigation Projects.

Item	MDIP	PIRDP
Gross Area	16,900 ha	33,000 ha
Net Irrigable Area	11,200 ha	22,000 ha
Total Command Area	11,848 ha	25,728 ha
Population in command area	1,39,900	1,76,000
Pump Stations and pumps.	4 (6 pumps in each station)	2 (5 and 10 respectively)
Pump's capacity	7.22 m ³ /Sec	500and110cusec
Irrigation Canals	201.557 Km	249.817 Km
Drainage Canals	238.428 Km	142.260 Km
Major Roads	147.937 Km	470.039 Km
Flood Protection Embankment	60.882 Km	35.176 Km
Structures (Irri.)	516	748
Highest Land Level	5.667 m	12.221 m
Lowest Land Level	0.925 m	4.925 m
Difference Between Highest and lowest land Level(RL)	4.742 m	7.296 m
Major crops	Paddy, Vegetables	Paddy, vegetables

4: Functions of Interactive Information System

This tool has been developed using Avenue Programming Language in Arcview. The Spatial Analysis Extension has been used to handle the raster data, Using Dialog Designer Extension front end dialogs have been made for easy access of users for analysis and operation. The simple relational database are being maintained for storing and updating of related attributes.

4.1: User Friendly Graphical User Interface.

A New graphical user interface (GUI) has been introduced

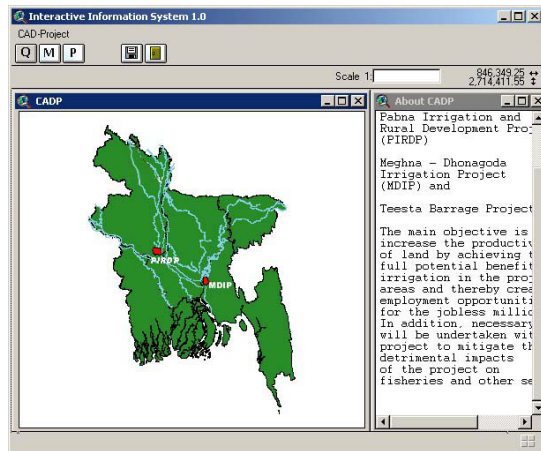


Figure 1. Main window

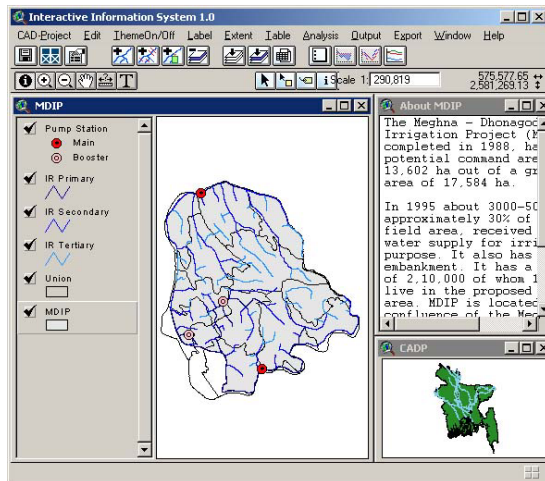


Figure 2. Project Level window-MDIP

instead of default Arcview's GUI. The menu buttons and tools are designed according to the purpose and needs for the application, during drawing each feature become automatically symbolized with the same symbol every time. The menu, buttons and tools are self descriptive according to their purpose.

4.2: Cross section profile of canals

Each Cross Section location is having an unique Identification Number and the section profile data are stored in a Relational Database. The common item between this spatial and Relation Databases is those unique Identification Number.

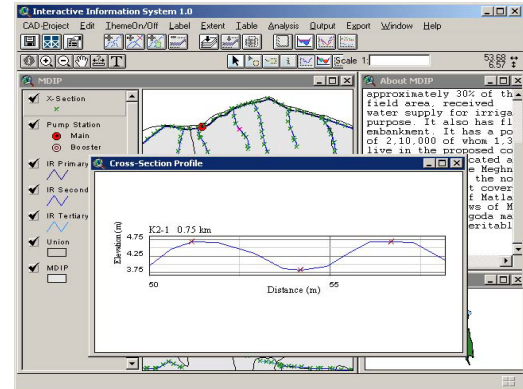


Figure 3. Cross Section of a Canal

On click of this tool for Cross Section Function will first select the Cross Section location on View then get the Unique Identification Number from the spatial dataset then based on this ID number select the profile data from attribute database and draw the profile graph on a new View. The three cross marked points indicate the highest level on Left Bank, the lowest level on Bed and Highest level on Right Bank on that particular cross section of the Canal.

4.3: Comparison of cross sections

This will allow user to compare several consecutive cross section profile of a canal. First it will select the

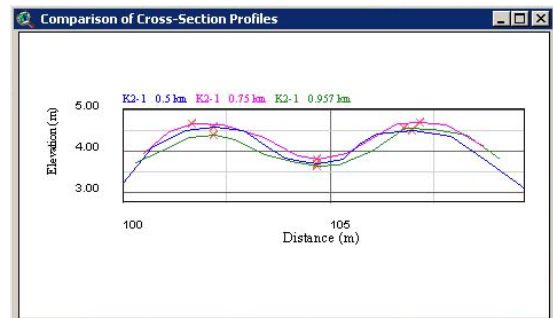


Figure 4. Comparison of Cross Sections

Cross Sections location on a view then draw cross section profile on a same view one by one. It will center align all the drawn profiles based on the lowest bed level location and then distribute the left and right profile data respectively which will allow the user to compare the profile easily.

4.4: Long profile of canals

This long profile of a canal is very helpful to see the situation of an earthen canal at a glance which is completely related to the water flow of the canal. First it

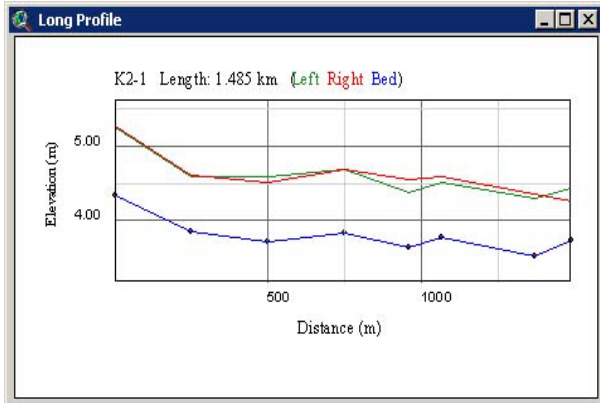


Figure 5. Long Profile of a canal

will select a canal then get the canals name, then run a query for this canal name on section profile dataset and select all the cross section profile data of that canal and then get only three points (Highest Left bank, Lowest Bed Level and Highest Right Bank points) from each cross section profiles, and draw a graph on a new view adding the respective points of all sections on that canal. It will also create a table showing the dataset used for the graph.

4.5: Cut and Fill calculation

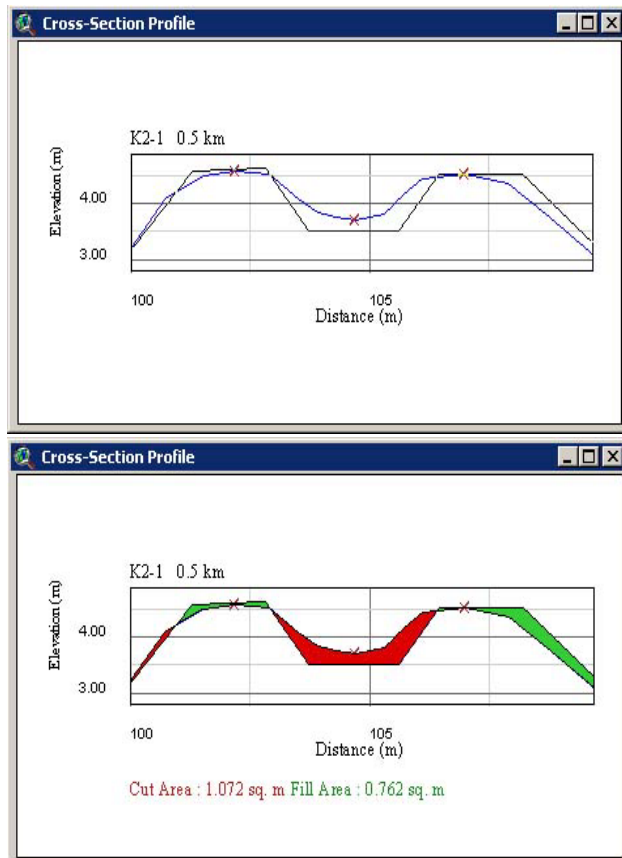


Figure 6. Cut/Fill area Calculation

This is a very useful function for maintenance work specially for earthen canal. It is to calculate the needed Cut and Fill area for an existing cross section on a canal which is not like a designed section of that canal. First It will draw the section profile of any particular section then ask for designed section, it will allow user to input design section data either as a point (distance@depth) or drawing the design section on existing section.

4.6: Conveyance Calculation of a Particular Section of a canal.

This tool is to calculate the Conveyance of a particular section for any supply level of water.

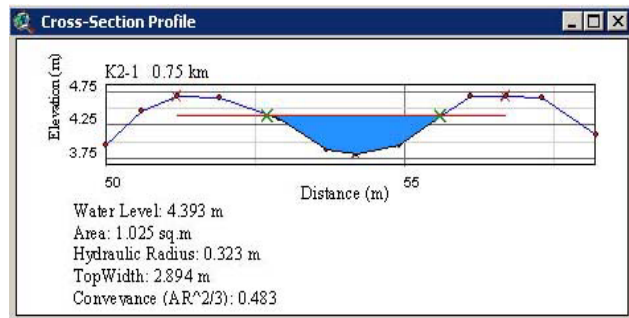


Figure 7. Conveyance Calculation

$$\text{Conveyance} = \text{Area} * \text{Hydraulic Radius} ^ 2/3$$

For any section profile it will ask for supply level of water then calculate conveyance of that particular section.

4.7: Calculate Area elevation curve for command area or any drawn area

First it will let the user to select a polygon for drawing area vs elevation curve, this polygon may be in a

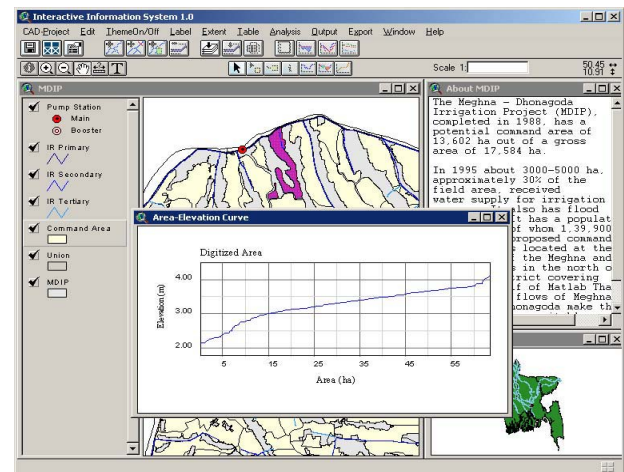


Figure 8. Area – Elevation Curve

shape file of any graphics drawn by the user. This tool

will clip the DEM digital Elevation Model for the selected polygon then generate a virtual table for each unique RL value and number of cell in the DEM having that RL value, then using this table it generates the area vs elevation curve graph.

4.8: Affected areas for the failure of any irrigation structure

This tool will show the affected areas due to the failure of any irrigating Structure.

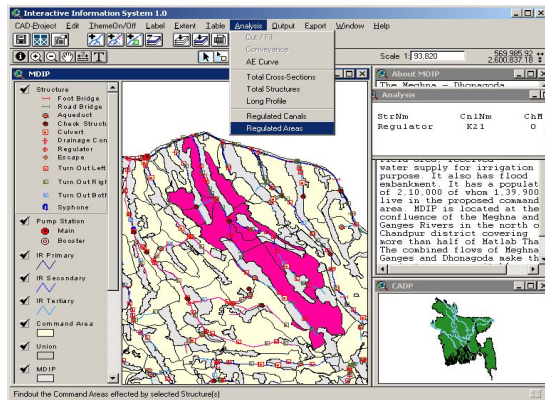


Figure 9. Affected areas for Structure failure

4.9: Retrieval of current Irrigation Structure's Information

This tool is to get the detailed information regarding the Irrigation Structure including photo, this will help the irrigation manager for maintenance work.

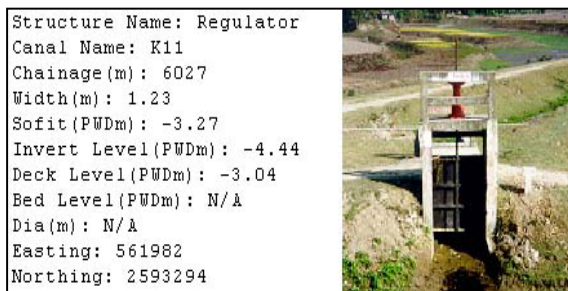


Figure 10. Structure's Information

4.10: Calculate the efficiency of the system.

Irrigation efficiency is a key measure of the effectiveness of irrigation management. High levels of irrigation efficiency translate into lower operating costs, improved production per megalitre of water used and improved environmental management, all of which help to provide a competitive advantage. Using this interactive Information System the Irrigation manager can endorse the approach currently being developed by ICID

(International Commission on Irrigation and Drainage) as set out in a paper "Methodologies for Assessing Performance of Irrigation and Drainage Management" Bos et al 1993 for Irrigation Efficiency measurement.

One of the essential elements of this approach is that it tracks and accounts for water use from the point of supply all the way through to the crop and provides the following overall definition of project efficiency. This definition is suitable for all irrigation systems.

$$\text{Overall Project Efficiency} = \frac{\text{Crop Water Use}}{\text{Total Inflow into Supply System}}$$

This is further broken up into following sub-components.

$$\text{Conveyance Efficiency} = \frac{\text{Total Out Flow for the Supply System}}{\text{Total Inflow into Supply System}}$$

$$\text{Distribution Efficiency} = \frac{\text{Water Delivered to Irrigation Field}}{\text{Total Inflow into Supply System}}$$

$$\text{Field Application Efficiency} = \frac{\text{Crop Water Use}}{\text{Water Delivered to Irrigation Field}}$$

Therefore, calculation of overall irrigation efficiency involves two estimates: Crop Water Use and Total Inflow. Total Inflow is readily understood and accurately measurable by metering, however the term "Crop Water Use" is not uniformly defined and also not so readily measurable.

The most common and traditional method of estimating crop water use is a theoretical approach of estimating crop water requirements based on the approximate relationship between plant evapotranspiration and evaporation from a free water surface as measured by a "pan" or as estimated by an equation such as "Penman". Application of this approach to calculating irrigation efficiency can lead to gross errors.

So in IIS user could get the information for structure's and field situation for different command areas and using that user could calculate the different types of efficiency of the system. Though this part is not fully automated but still it helps the user.

5: Conclusion

It is clear that Geographic Information System (GIS) is one of the most simple and straightforward way of providing a management tool for planning of water allocation policy in Irrigation System. The main result of IIS development is a user-friendly ArcView application which allows user to access information and spatial analysis and produce results in the form of maps, tables and graphs to support planning and decision making process. It also allows to make queries (What - If

questions) to the database in order to extract an answer for the future planning under wide range of different scenarios. Another important result is the effective integration of GIS with RDMS enhances performance evaluation and diagnostic analysis capabilities. Since the implementation has been completed and the IIS needs only the maintenance and updates of spatial as well as attribute data if changes occur in existing set, it has become a valuable and cost-saving tool for decision making.

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