Role of Geographic Information System (GIS) in Networking Organizations for Irrigation Management

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Background

Where are farmers / users?

Where is their land?

What are the characteristics (soils, productivity, cropping pattern) of their land?

Where is the source of irrigation water?

Where is headwork/intake located?

Where are regulatory works?

Where is the main canal?

How is distribution network laid out in relation to the land?

What is the total capacity of irrigation water supply?

How are those farmers/user groups related to each other?

What is the total command area of the irrigation scheme?

What is the total water demand and how is it fluctuating in relation to cropping pattern, soil characteristics and solar influx?

What are major land cover/use types in the catchment that may affect the discharge and quality of water, cause flood/siltation?

On a small scale -

Where are all the irrigation schemes?

In which irrigation scheme is a particular non-governmental organization involved?

Those are some of the basic questions to be answered for any irrigation management program. The answers to these questions pertain to the location of these features on the ground and the spatial relationships between them.

Our information system so far has been limited only to conventional record keeping on a report or a file which is not very commonly accessible to every organization (GO, NGO, INGO, other users)

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who may need information. Most of the time, it is hard merely by looking at data, to define the spatial relationships of features -such as hydrological linkage of one irrigation system or user to another and spatial distribution pattern of plots of land having similar farming systems. As these complex variables interact in space in such a scheme, an appropriate system for analyzing them is required.

Geographic Information System

When all the characteristics and attributes of a certain activity are systematically referenced with respect to their geographic location, this forms the basis of a Geographic Information System (GIS). All the above information has geographic characteristics - meaning that the attributes can be referenced to their spatial location on the ground. This is carried out by means of a set of appropriate computer hardware and geo-processing software.

Geo-referencing: In a GIS, data is generally arranged in the form of layers; each layer or coverage having different characteristics or attributes for the same geographic area (this area can be extended horizontally). Because such geo-referencing is the basis of a GIS, any point within the spatial coverage can be examined simultaneously with respect to various other characteristics.

Geo-relating: Features on the earth's surface are represented by means of point, line or area on map. A map can represent only some aspects of reality (*a map is not the territory*), but in a GIS's geo-relational model, it is possible to represent a multiplicity of spatial objects (represented by means of their unique identifiers, IDs) and tie to them all necessary set of information or attributes (variables such as crop type, productivity, soil properties etc.). This can be understood by the analogy of bunch of keys hanging on a nail. The nail is one ID and keys are various attributes. Another bunch of keys can be attached to the former key-ring and so on. It is possible to examine attributes by key graphic elements and vice versa in a particular coverage. This forward and backward data mapping capability and other functions of GIS form the crux of complex spatial querying and analytical modelling.

In a GIS perspective, problems and solutions become spatial. The conventional data collection procedure changes without much difficulty and it can be structured for use in a GIS environment which enables multitudes of spatial analyses and multi-disciplinary/multi-user interactions and the sharing of spatial data becomes a reality.

GIS and Irrigation/Facility Management

An irrigation management scheme comprises two main components that can be managed, interrelated and analyzed by means of a geographic information system. These are:

a) System's Component

Firstly, in an irrigation system, there are engineering features such as water source, intake and headwork, pumping stations, canal alignment, regulatory works, cross drainage works, access roads, etc. located at different sites. Their operation and maintenance are critical to the success or failure of irrigation management.

b) Service and Environmental Component

Secondly, an irrigation scheme has a command area, catchment or watershed, drainage and discharge, ground water table, farming system, land use characteristics (both existing and future change caused by the project), and ultimate end-users - the people of a certain area with its own demographic pattern.

Geo-referenced Data

Data source: Various possibilities of data sources for a GIS for irrigation management are remote sensing and aerial photography, ground and household surveys including engineering design data, census survey, and existing digital or manuscript maps. In a GIS, all old and new information can be viewed from a temporal perspective, but in a newer context. Large and small scale data can interact to supplement each other.

Global positioning system: With the advancement of GIS and satellite technology, data collection in the field has been revolutionized to the extent that digitizing data right in the field has become an affordable reality. Global Positioning System (GPS) receiver (available at an affordable price for individual projects) can make very fast and accurate surveys in the field. The basis to this is the capture of a signal from various Global Positioning Satellites by a portable (either backpack or hand-held) GPS receiver to find its position on earth. What was considered a very time consuming and tedious job two years ago has become very simple, fast, accurate and affordable to most geographic information collectors and users today. With this, mapping is no longer a sketch. A survey of a command area which would take a day by conventional method can be completed in a few hours. Even the socio-economic characteristics of a society can be analyzed in a real spatial framework. Each house or location of a user group, each facility of a scheme and each plot of land with seepage problem can be mapped to form a sound data base for irrigation management.

Infrastructures and engineering plans with their arbitrary location can now find their place on maps in relation with other characteristics on a larger area. Any amendment required for the design is a possibility. Any likely mishap can happen only in the computer with a GIS.

Coordination

Data sharing: A common information base would be needed to ensure the effective co-ordination of various agencies involved in a project. A good information system is one of the best ingredients of any successful networking of organizations. GIS's capability to share common database of information leads to better inter-agency co-operation as well as co-ordination and elimination of redundant and inconsistent data, and enhances the usefulness of information. Aggregation: Geographic information collected at a very fine grain that require high accuracy at a local level for local planning can be analyzed, aggregated and used for more general purposes that require less detail, such as regional or national macro planning. Detailed site specific engineering data about an irrigation scheme can be aggregated to the VDC (Village Development Committee) or district for land use planning purposes. This demands co-ordination among field based local organizations and their larger regional and national counterparts.

Interrelating data: Multi-source, multi-scale, multi-date, multi-thematic, multi-type data, as long as they are geo-referenced, can be integrated and interrelated in a GIS. This can lead to new perspectives on a problem and provide an innovative approach to the solution. Thus, nature of a GIS encourages integrated activity amongst multiple agencies so that they can approach problems in a more comprehensive and systematic way. This increases the likelihood of solving problems and delivering benefits to the right people.

Monitoring and Temporal Analysis

A regular feature of any project is its monitoring and evaluation in terms of resources expenditure and further work required to meet the objectives. A management information system (MIS)-based tool to monitor and evaluate is deficient in providing the geographic dimension. Conventional MIS are not well equipped to support the information from the ground, but this can be provided by the Geographic Information System (GIS).

Change over any two periods, time series and trend analysis carried on geographic space, using GIS tools is an effective management need. For example, the change in the extent of cultivated/irrigation land for various farming systems (cropping patterns, cropping calendar) with respect to soil characteristics (texture, fertility, water requirements etc.) can be analyzed and for such site specific problems, site specific help and guidelines can be devised for farmers to maximize productivity.

Conclusions

Irrigation management schemes fall in the geographic domain and demand a much more integrated approach to successfully implement and monitor plans. Geographic information systems can play very effective role from the very beginning of planning and designing the scheme to provide effective service delivery to the users.

Geographic information system (GIS) is a good inventory, data management, processing and decision support tool. As GIS helps integrate data from the field survey and interrelate with multi-source, multi-agency data, it thus creates opportunities to co-ordinate and cooperate to share common information. This reduces duplication of efforts and solves problems more systematically.

Once GIS finds its role in day-to-day project activity, it is possible to monitor the programs not only in monetary and temporal terms but in a more realistic spatial sense. GIS can relate all information systems to management needs.

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