Development of Spatial and Attribute Databases for Water Resources Including Relational Database Properties

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Water is a very important input for crop production. It is responsible for crop growth and it also ensures the efficiency of other inputs like seeds, fertilizers and pesticide. This work is an effort to maximize the existing water use through appropriate water management practices using a spatial and attribute database of water resources. Water resources data are scattered in different forms, collected and collated by multiple agencies and institutions employing diverse methodologies that do not match with the dynamic data requirement of complex agricultural environment. A comprehensive information system on water resources has been developed with the objectives of integrating existing databases on water resources, designing and developing a comprehensive database of water resources and developing resource maps of major sources of water resources of the country by integrating attribute and spatial data through GIS which may provide systematic and periodic information to the researchers, planners, decision makers and developmental agencies. The diverse planning, research developmental activities on the present and future use of water resources, a strong database plays a vital and important role. This database consists a comprehensive data related to water resources such as ground and surface water in spatial and non-spatial (attribute) forms. Spatial data is in digitized map form which are digitized using Arc GIS software which are also linked with tabular data as and when required. Non-spatial data is tabular data/ attribute data which has been developed in ACCESS and ORACLE software. This whole information system is a data base of water resources of India.. So this will help in the identification of technologically appropriate, economically viable, socially acceptable and environmentally non-degrading approach for agricultural planning. We have developed water resources information system in which spatial and attribute database contain a huge amount of data related to surface and ground water availability, its utilization, balance, water quality of rivers at different locations and census data of water related devices that are helpful in irrigation in different crops such as dug well, tube well, surface flow irrigation schemes, surface lift irrigation schemes, etc.

Key words: *water resources, GIS, Oracle, Access, database, spatial and attribute data.*

INTRODUCTION

Database is a collection of records or data stored in a computer in a systematic way, so that a computer program can consult it to answer questions. For better retrieval and storing each record is usually organized as a set of data elements. The items retrieval in answer to queries become information that can be used to make decisions. In simple words, the collection of data, usually referred to as the database, contains information about particular organization and database is

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managed by a software which is known as Database Mnagement System (DBMS) which provides an environment that is both convenient and efficient to use in storing and retrieving database information (*Henery F Korth and Abraham Silberschatz*). Lack of proper documentation/storage of data and its availability to intended users has been identified as a major lacuna that hinders the analytical process involved in decision making by planners, researchers, policymakers and field officials. Utility of such database is indicated in maximizing availability of water, modernization of irrigation works, evolving of water allocation works priorities, efficient use of water resources, fund allocation, water pricing, water quality, energy management and numerous other domains.

Computational capability has an important place in analysis techniques and data management. An appropriate presence of computer in data analysis if required for water resource planning and management. A software was developed for the analysis of the important hydrological data, namely precipitation (*S. Mohan and V. Jothiprakash*. In past years a user friendly software for the design of drip irrigation system was very cumbersome and time consuming (*Jones et al*). But now an user interactive computer software DRIPD was developed to provide a tool that can help farmers and researchers who may require to design drip irrigation system for orchards, vegetables or closely spaced field crops (*V.B.S.Rajput and Neelam Patel*). So the use of the system is presented through a typical example of designing drip irrigation system for one hectare citrus orchard. Ground water model 'MODFLOW' (*Mane et al*) has been developed using datasets of various parameters such as surface elevation, bottom elevation, percolation seepage, etc. in ASCII format. An attempt has been made to develop an interface for generating all these data files. A Horticultural Resources Information System has been developed with the objectives of integrating existing databases in horticulture, designing and developing a comprehensive database in horticulture and developing resource maps of major horticultural crops in the country by integrating attribute and spatial data through GIS (*Kotur et al*). A suitable planning and control methods are required for the sustainable exploitation of water resources with incorporation of a great number of spatial and temporal variables (*Belmnote et al*). Geographic Information System seems the most suitable tool for decision making (*Bradley*) in order to better management of available hydric resources. Management of irrigation systems can be improved with the help of appropriate information. A database was developed for data recording and retrieval of information related to the management of agricultural organizations and related irrigation aspects (*Jirachoewee et al*). To support reliable decision making, it is necessary to have a computerized database. After providing appropriate information, farmers may be able to produce maximum yield and profits. Information needed for this purpose requires an extensive database and real time information (*Jensen and Lord*).

National agricultural production on a sustainable nature depends on the judicious/real use of natural resources in general and water in particular with an acceptable technology management under prevailing socio-economic infra structure. In order to achieve an economically sound society and environmentally benign development and utilization of water resources, it is necessary that a comprehensive information is developed to provide systematic and periodic information to the researchers, planners, policy makers, decision makers and developmental agencies. The diverse planning, research and development activities on the present and future use of water resources, a strong database plays a vital role. This project will help in the identification of technologically appropriate, economically viable, socially acceptable and environmentally non-degrading approach for a land use planning with appropriate use of water resources.

One of the fundamental aspects of resource management is to have information on the extent, nature and properties of the water resources and their utilization for sustainable agricultural production for food security for the growing population of the country. In India, many organizations have proved their excellence in collection, interpretation and utilization of those data in their respective fields of operation, but at the same time it has restricted their application in a holistic mode for development as information are rarely available at one source, and the scattered way of data organization is a bottleneck in data accessibility. Thus, researchers, planners and developmental agencies have always faced a tough time to get data for planning at local and/ or regional level, in bringing out the total perspective of the region in changing the social fabric of the people. The proposed project has strengthened the information system conceptualized by ICAR. Other agencies, in particular, the planning portfolio, are eagerly waiting for such a database. This project aims at giving suitable opportunity on multidisciplinary mode through enhanced linkages among research institutes and other development agencies by providing first hand information on problems and potential in the production systems. The information system will be intensively used with an ultimate aim of enhancing better quality of life of the farming community and society at large.

By harnessing RDBMS and GIS technologies we developed the Water Resources Information System (WRIS) with the objectives of (i) integrating existing databases of water resources,(ii) design and development of a comprehensive database of water resources,(iii) development of water resource thematic maps of the country by integrating attribute and spatial data through Goegraphical Information System (GIS).

METHODOLOGY

Basic structure of Water Resources Information System: A review of existing databases, identification of data needs of different users, availability of data, storage level and data gaps were made. Database structure, data fields and coding structure were identified. Thematic maps to be generated using Geographical Information System were also identified. A detailed requirement analysis document was prepared by compiling the exercise done at all thirteen cooperating centers of INARIS (Sharma *et al*.2002). Six databases were finalized and developed under Water Resources Information System which are Ground water database, Surface water database, Water pricing database, Water quality database, Project database and Technology database. Normalization technique has been adopted in the design of relational database of water resources. When a database is created for online transaction processing system (OLTP) there are generally two concerns, the speed and efficiency of transactions, and overall storage space required by the database. One means of achieving the best result is normalization which is the process of organizing and refining database tables to provide accurate, unambiguous results when the tables are accessed (*Robert G.Freeman and Mark D. Blomberg*).

(A) Development of Water Resources Database

Above six databases were developed in ORACLE 9i using RDBMS technologies for storage and maintenance of data. Data were collected from various government organizations related to water resources. We have followed normalization techniques and adopted 3rd normalization form for database development. Overall structure of database is shown in fig. 2.. Surface water database

contains information about canals, distributaries, dams, reservoirs, tanks, rivers, navigable length, river catchement area, irrigated and un irrigated area for different crops. Ground water database contains information about dug-well shallow tube-well, deep tube-well, private and govt. tube-well, irrigated and un irrigated area for different crops, level of ground water development, different irrigation schemes, etc. Water quality database contains information about pH value, nitrate, sulphate, iron, magnesium, sodium, chlorine, specific conductance, carbonate, hardness of water, etc. of different rivers at different sites of the country. Water pricing database contains information about year wise maximum and minimum rate for irrigation water for different crops. Technology database contains information about water management and irrigation technologies developed for different crops. Project database contains information about different completed and ongoing important projects related to water resources of the country.

(B) Development of Graphic User Interface (GUI)

Graphic User Interfaces (front end tools) has been developed in Visual Basic 6.0 for data entry, modification, deletion and retrieval of data. It is shown in the fig-1. Also reports can be generated through this software. Access level and security of data is assured through password protection mechanism. This software can be customized according to changing needs of user. For example back end (database) can be changed and also form and reports can be easily changed or added to the software. Back end developed in Access 2000. Database is finally converted into Oracle 9i

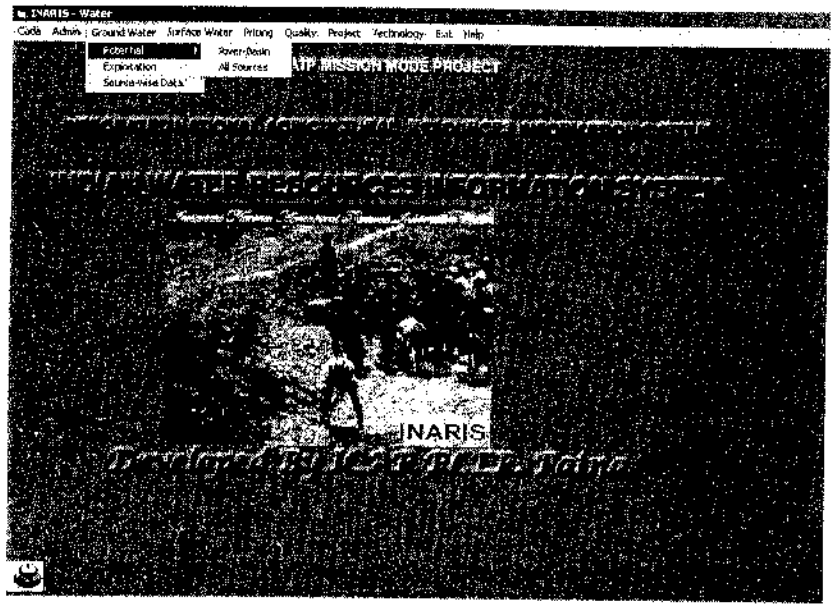


Fig. 1

(C) Application of GIS (Geographical Information System) for the Creation of Thematic Maps and Spatial Database

Thematic maps of various water resources have been created using Arc-GIS software. Scanned maps of water resources have been geo referenced and digitized according to the data availability and requirement using Arc-GIS software. After digitization thematic maps have also been linked with related database tables. Databases have been developed in ORACLE 9i software.

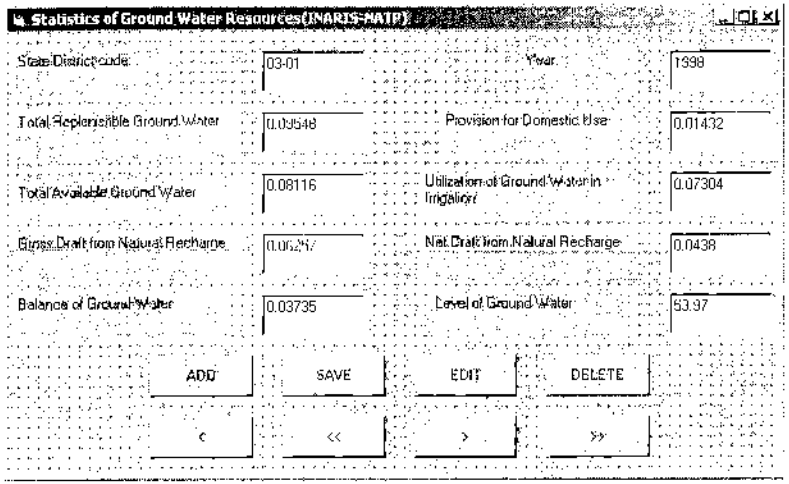


Fig. 1

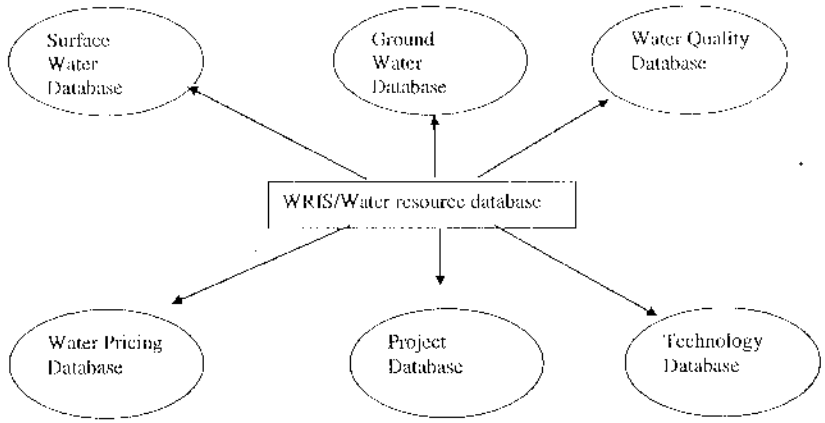


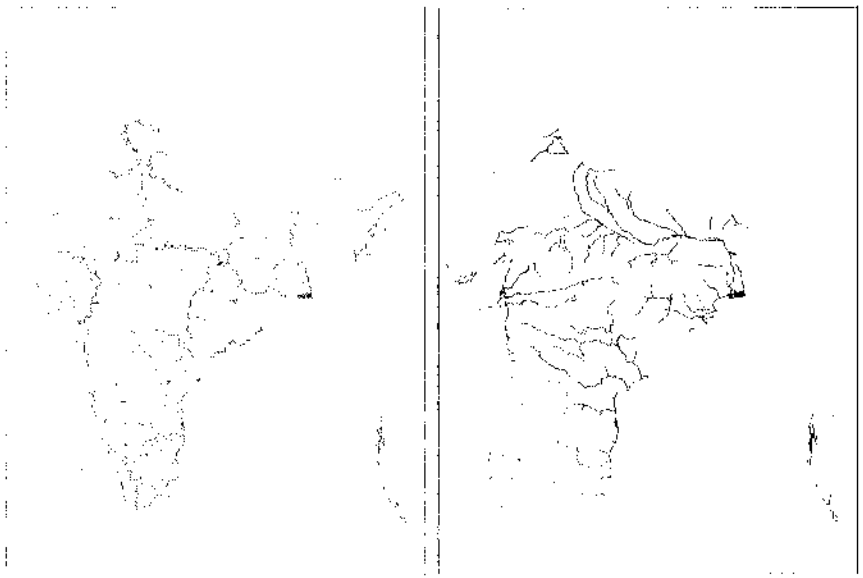
Fig. 2: Overall Structure of Water Resource Information System/Water Resource Database

Digitization through Arc-GIS software: Water resources maps of rivers, reservoirs, tanks, wells have been digitized using Arc GIS 8.0 software. Scanned maps have been geo-referenced and digitized. State-wise and for the country, water resource maps were developed. These maps were linked with related database tables. Some digitized maps are as follows:

(D) Development of Website

A database driven website has been developed for the project "Integrated National Agricultural Resources Information System (INARIS) and our WRIS (Fig.4) is also available on the above website. Access level and security of this web site is assured through user name and password mechanism.

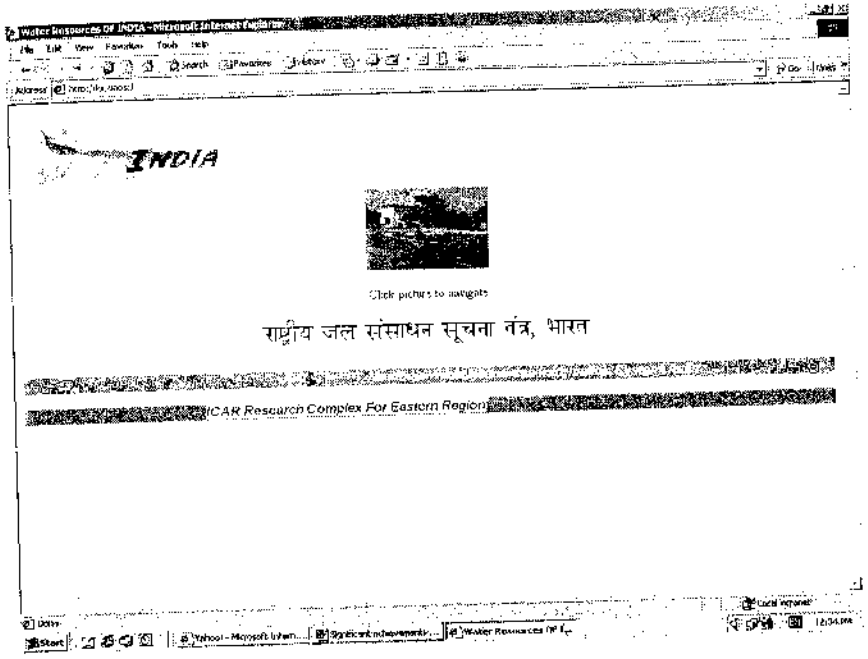
A database driven and a static web site have been created using VB Interdev, ASP, Java Script and VB Script



(Fig. 3)

RESULT AND DISCUSSION

Development of Water Resources Database/ Information System: The overall structure of Water Resources Information System (WRIS) is shown in fig. 2. This database gives information about data fields, it types, source, frequency, periodicity, data gaps, storage level, data structure items, parameters, etc. and geo-reference for each parameter has been specified. Total ground and surface water available for irrigation, utilization in irrigation, domestic use of water, irrigated, un-irrigated area for different crops, over exploited area, dark area in blocks in different districts of



(Fig. 4)

different states ,reservoir capacity, FRL of reservoirs, total navigable length of rivers, catchement area of rivers, water quality of rivers at diffferent sites, water quality contains information about pH value, sulphate, nitrate, iron, chlorine, carbonate, magnesium, specific conductance, sodium percentage, residual sodium carbonate and sodium absorption ratio, etc are the major information are in this database. This database/data warehouse contains huge amount of water resources data which are useful for researchers, planners, policy makers, decision makers, other end users etc.

A Graphic User Interface (GUI) is useful for data entry, data modification, deletion, updation and retrieval of data. Any one can do above mentioned work with the help of this GUI who have a little knowledge of computer software and hardware.

A clear and visual interpretation and self explanation of water resources data can be done with the help of thematic maps of water resources.

Thematic maps of river, reservoir, tanks, lakes, etc .: One of the important aim of WRIS (INARIS) is to provide geo-informatic information at district, state and country level as per availability and requirement of data of water resources. Thematic maps of water resources have been developed by integrating different databases and applying different decision criteria. Some example are following:

(a) Thematic maps of rivers of the country identifies origin of river, flow direction, total length, navigable length, average annual potential and catchement area ,reservoirs, lakes and tanks

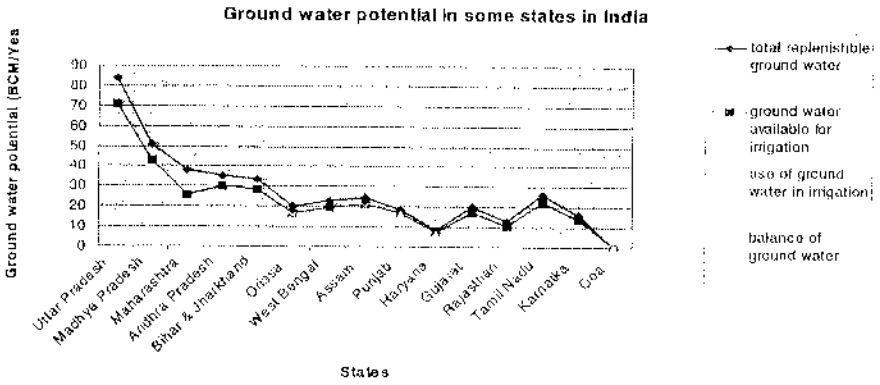
identify their full capacity, area and their location. This can be used for future planning for the use of water resources.

(b) Many types of information can be obtained from attribute databases, some are following:

Application

Ground Water Potential in States in India

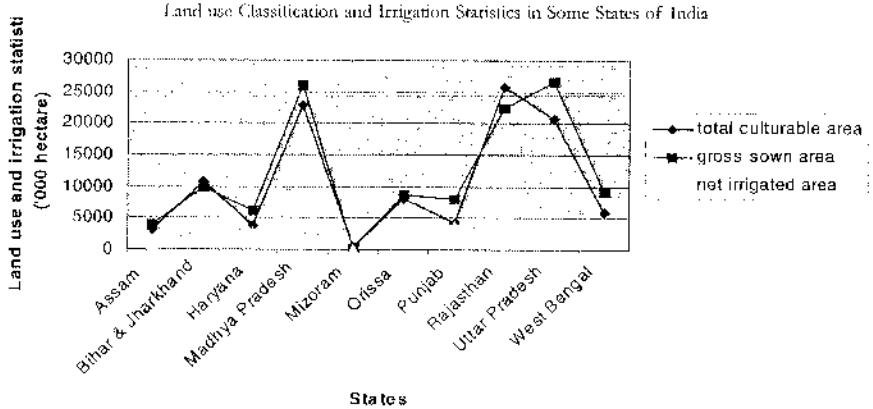
state	total replenishble ground water	ground water available for irrigation	use of ground water in irrigation	balance of ground water
Uttar Pradesh	83.82	71.25	26.84	44.41
Madhya Pradesh	50.89	43.26	7.13	36.12
Maharashtra	37.87	25.47	7.74	17.73
Andhra Pradesh	35.29	30	7.09	22.91
Bihar & Jharkhand	33.52	28.49	5.47	23.03
Orissa	20	17	1.43	15.57
West Bengal	23.09	19.63	4.75	14.88
Assam	24.72	21.01	0.94	20.07
Punjab	18.66	16.79	15.76	1.03
Haryana	8.53	7.25	6.08	1.17
Gujarat	20.38	17.32	7.17	10.15
Rajasthan	12.71	10.71	5.42	5.29
Tamil Nadu	26.39	22.43	13.56	8.87
Karnatka	16.19	13.76	4.43	9.46
Goa	0.22	0.19	0.02	0.17



From the above graph it is clear that the total availability utilisation and balance of ground water are highest in Uttar Pradesh and lowest in Goa.

Land use Classification and Irrigation Statistics in Some States

state	total culturable area	gross sown areanet irrigated area	
Assam	3257	3904	572
Bihar & Jharkhand	10859	10012	3624
Haryana	3821	6143	2793
Madhya Pradesh	22899	26070	6304
Mizoram	446	113	8
Orissa	7975	8645	2090
Punjab	4250	8042	3847
Rajasthan	25692	22325	5421
Uttar Pradesh	20739	26522	12012
West Bengal	5836	9208	1911



Total culturable area is highest in Rajasthan total gross sown area is highest in Uttar Pradesh net irrigated area is highest.

A. The Tools that have been used

- Database Tools: MS-Access, Oracle 9i
- GUI Development Tools: Visual Studio 6
- Connectivity Tools: ODBC, ADO, DAO,OLEDB
- Server Tools: Internet Information Server, Personal Web Server, Oracle Server, and Microsoft Transaction Server.
- Scripting Tools: JavaScript, VBScript.
- Editors: word, Visual Interdev, Notepad
- Page Development tools: Active Server Page, Java Server Page, HTML/DHTML, XML
- Other tools: ActiveX Controls, COM/DCOM
- Protocols: TCP/IP.

- Arc GIS
- OS: (Windows 2000), Windows XP.

CONCLUSION

Water Resource Information System (WRIS) is the part of Integrated National Agricultural Resources Information System (INARIS-NATP). This information system is available at our center (ICAR-RCER, Patna) as well as lead center IASRI, New Delhi. This database contains water resource information of our country such as surface and ground water availability, its utilization in irrigation and balance. It also contains information about total numbers and their capacity of canals, distributaries, wells, dug-well, shallow tube-well, deep tube-well, surface flow and surface lift irrigation schemes, FRL of reservours, tanks, water pricing ,water quality, irrigated and un-irrigated area for different crops, level of ground water development, ground water recharge, total navigable length and catchement area of rivers, water quality of rivers at different sites etc. This database has been developed in MS-ACCESS and then converted in ORACLE 9i. Now it is available in ORACLE 9i. Graphic User Interface has been developed in Visual Basic 6.0. Some water resource (rivers, reservoirs, tanks etc.) maps have been geo-referenced and digitized in Arc-GIS and attribute data have been linked with spatial data for getting required information in map form. WRIS is useful for researchers, planners, policy makers, decision makers and other users.

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