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Development of Information System on Sustainable Groundwater Irrigation for Odisha

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Sustainable development and efficient management of groundwater resources require an effective information technology tool for the dissemination of information to different stakeholders. This will help to develop appropriate measures in improving the agricultural scenario of the state. The average groundwater development is only 26.14% (including domestic, agricultural and industrial uses) in Odisha as against 58% in India with wide inter-regional variability due to various socio-economic and hydro-geological constraints. There is a need for an information system tool for groundwater scenario in the state. A graphical user information system related to information on different aspects of groundwater development has been prepared. A district-wise information system has been prepared on different aspects such as groundwater availability, utilization, socio-economics, energy use pattern etc. using the available information from different sources. The specific variables included in the database are the groundwater recharge, natural losses, sector-wise utilization, groundwater development, aquifer properties such as draw-down, transmissivity etc. This information system will be useful for taking appropriate decisions for sustainable groundwater development for irrigation purposes in different parts of the state to increase the overall productivity.

(***Key words:*** *Information system, Groundwater status, Energy use pattern)*

Groundwater is the most preferred source of water for various end users on account of its easy availability, dependability and low investment. The demand for groundwater has increased manifold in recent years. Groundwater is annually replenished primarily through the rainfall and subsequently by surface water bodies such as rivers, lakes, tanks etc. The occurrence, movement and availability of groundwater are quite erratic with respect to both space and time. Apart from the human consumption, groundwater is also lost through base flow in the streams and deep percolation etc. Excessive withdrawal of this natural resource can lead to incorrigible degradation of watersheds and the ecosystems. During the last few decades the thrust on groundwater has been exponentially increased, particularly in drinking, agricultural and industrial sectors. Although groundwater is a renewable natural resource, the perennial demands for water of a desired quantity and quality in a particular place warrant its careful management (Pius *et al.*, 2012). The comprehensive understanding of the entire ground water regime is very important for evolving strategies for its optimal usage. The major mismanagement of water resources in an area causes negative effects including depletion of the aquifer storage, decline in groundwater level, quality deterioration and environmental problems in other water bodies. Many concepts (safe yield, optimum yield, groundwater sustainability) are used in the management of groundwater systems (Gau and Liu, 2002). The establishment of a model was considered a reasonable representation of the physical conditions of the plain aquifer and could be used as a tool by the water and environmental authorities in the management of the groundwater in the region (Shammas and Thunvik, 2009). A study was conducted in Balasore coast in Odisha to observe the declining of groundwater levels and intrusion of seawater due to overdraft of groundwater for irrigation purpose (Rejani *et al.*, 2009). It revealed the need of some urgent measures to ensure sustainable utilization of groundwater resources in the basin. Hence, precise assessment of quantity and quality of groundwater resource is a pre-requisite for planning its development. The Ground Water Information System is a web based information system contains water level data and water quality data for the different states of the

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country developed by Central Ground Water Board (GWIS, 2013). District wise water level data on various sites for different months are available in the website. In the present study, an attempt has been made to develop graphical user-friendly information system on groundwater resources particularly in irrigation sector for the state of Odisha, which can be used by different stakeholders to plan and implement appropriate policy decision to improve the groundwater irrigation.

MATERIALS AND METHODS

Information system is a technologically implemented medium for the purpose of recording, storing and disseminating information to the user as well as for supporting decision making. The systems were designed in such a way to accommodate a large number of available information on groundwater availability, utilization, socio-economics, hydro-geological and energy use pattern in this region. Other specific variables like groundwater recharge, natural losses, sector-wise utilization, groundwater development, aquifer properties, groundwater extraction devices and their distribution according to land holding size, ownership, source of finance, pumping hours, electricity consumption for irrigation were also included in the system. The secondary information collected from Directorate of Ground Water Survey and Investigation, Government of Odisha (DGWSI, 2012) and Central Ground Water Board (CGWB, 2000) was used in the study.

Microsoft Visual Basic 6.0 software was used in developing the forms as front-end tool and Microsoft Access software for tables as back-end tool. The whole information system was designed in such a way that it is easily installable and can be operated effectively under Microsoft Windows environments (Nayak *et al.*, 2009). The relational database was organized in two dimensional tables with relationship of the data. The storage and retrieval of the data were mainly based on a data management programme that supports the storage of large data quantities and it was presented through graphical mode as per user's requirement. Forms included menus, command buttons, combo boxes designed for easy access in the system.

RESULTS AND DISCUSSION

The geographical area of Odisha is 1,55,707 km^2, out of which around 40% is under cropped area. Even though the state is blessed with average annual rainfall of 1482 mm, more than 80% of rainfall occurs in monsoon season only. Hence, groundwater is being utilized during non-monsoon season to sustain the agricultural activities. The hydro-geological situations are quite conducive for steady replenishment of groundwater. The groundwater development in different parts of the state is not uniform. The average groundwater development in the state is only 26.14% leaving a vast scope to further utilize the resources. The highest level of development was observed at Bhadrak district (55.49%) and the lowest in Malkangiri district (8.76%) due to varying hydro-geological and socio-economic conditions. Considering the high potential of groundwater development, Government has been encouraging groundwater exploitation by announcing several subsidy schemes in the specific regions. But while developing groundwater structures for irrigation use, it is necessary to ensure its sustainable use in long term basis. Like in case of coastal areas groundwater pumping options should be restricted within the safe limit to check the salinity ingression.

The developed information system after installation automatically starts in a welcome window where the title of the application appears with two active buttons in order to “Enter” or “Exit” from the system with username and password. After entering into the database, another window opens with command button to find the number of groundwater structures, potential created and utilized over the years as shown in Fig. 1. The district names and year were created in combo boxes for retrieval of accurate information easily. The database contains other modules to find out year-wise groundwater assessed, drafted and percentage of development in a particular district. This information is available for the survey year 1999,

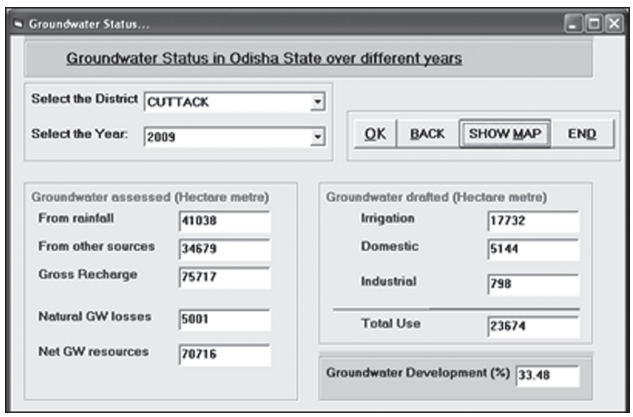

Fig. 1. Groundwater structures created over the years

2004 and 2009. The groundwater assessed from different sources and natural losses, groundwater drafted for different usage like irrigation, domestic and industrial were also included in the system as described in Fig. 2. The information system also contains the groundwater status in different basins over the years, total basin area, groundwater resources and their usage with percentage of development as shown in Fig. 3.

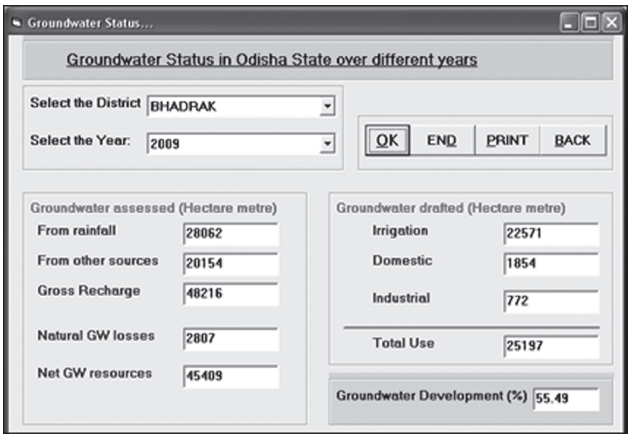

Fig. 2. Groundwater status in Odisha over different years

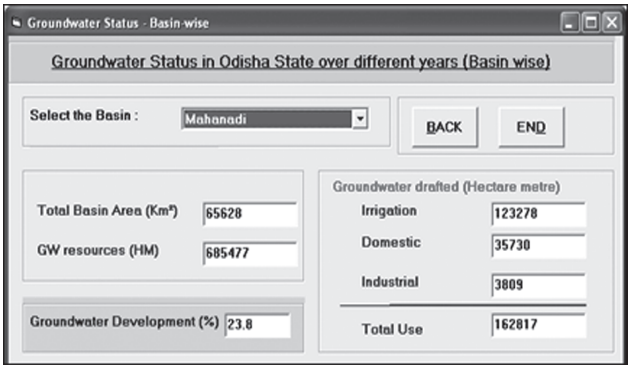

Fig. 3. Groundwater status in Odisha over different years (Basin wise)

Aquifer properties show the potential of aquifer for future exploitation of groundwater. The groundwater can be exploited safely in the presence of a good aquifer and source of groundwater recharge in the region (Das and Dutta, 1999). The district-wise aquifer properties like discharge, draw down and T value with mean, standard error, number of observations, range, minimum, maximum, standard deviation and variance were included in the system for the selected district as shown in Fig. 4.

GIS maps were also included in the database for easy interpretation of groundwater data in a graphical mode. The user can find out the percentage of groundwater development in a GIS map as shown in Fig. 5.

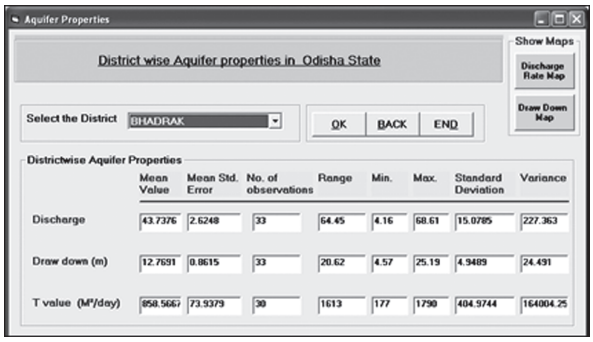

Fig. 4. District wise aquifer properties in Odisha

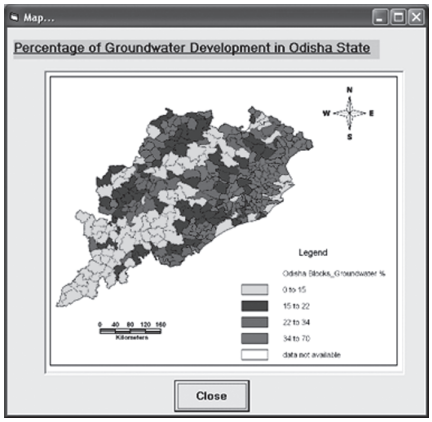

Fig. 5. Block-wise groundwater development (%) in Odisha

The GIS maps for trend in water table at block level both pre- and post-monsoon period were also included in the system. The results showed that in 140 blocks (45% of the total administrative blocks), there was no significant change in water level, whereas in 92 blocks water table was found to be increased in pre-monsoon season during 1997 to 2009 as shown in Fig. 6. This indicated the scope for accelerating groundwater utilization in the blocks with no change/increase (232 blocks) in water table. On the other hand, in 77 blocks, water table witnessed declining trend in pre-monsoon season during 1997-2009. This necessitates implementation of groundwater recharge activities in these 77 blocks to ensure sustainable development of groundwater (Srivastava *et al.*, 2013). This information system also contains specific modules for water level and discharge, groundwater extraction devices and their distribution according to land holding size, ownership, source of energy, power of lifting device and constraints in utilization as shown in Fig. 7. Another important aspect of the database is to find out the suitable reports according to the user requirements. The reports have been created by report module of the database (Siler and Spotts, 2000). These reports have been linked in the program and according to the queries of the users.

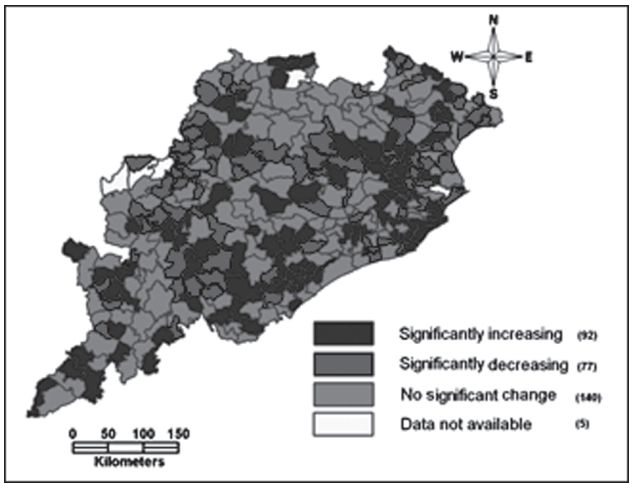

Fig. 6. Block-wise trend in water table in pre-monsoon season during 1997-2009

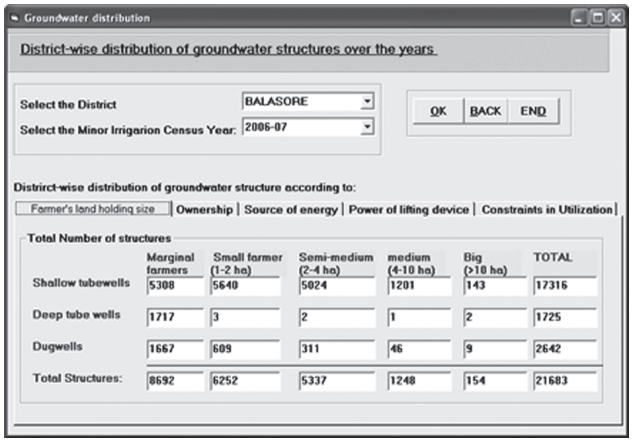

Fig. 7. District-wise distribution of groundwater structures

CONCLUSION

This information system on sustainable groundwater utilization in Odisha is composed of a database and software for supporting decision-making in groundwater exploration and its management particularly in irrigation sector. This district-wise information system on different aspects of groundwater availability, utilization, socio-economics, groundwater recharge, aquifer properties and energy use pattern will give guidelines for proper planning of these resources efficiently for improving the irrigation scenario of Odisha.

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