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Geoinformatics Approach for Groundwater Prospects and Quality Studies - A Review

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ABSTRACT
Water is a prime requirement for all the living and non-living processes. On the earth, 71% is water but the availability of useable fresh water for drinking and other purposes is about 2.8%. Out of this 2.8 % fresh water, the share of groundwater is only 0.6% that makes it more pertinent to conservation, preservation, and management. The urbanization, industrialization, and intensive agricultural practices have put further pressure on the available fresh water. The modern techniques like space technology, GIS and GPS have great utility in mapping, monitoring, planning and management of water resources. The temporal satellite data in different spectral bands and on different spatial resolutions make the remote sensing satellite data highly useful for mapping and monitoring of an area. The geographical information system (GIS) has the capability to store, retrieve, edit and represent the data in informative way. The global positioning system (GPS) gives the real time geo-coordinates, path and altitude of desired object or terrain. Thus, the geoinformatics have huge potential for solving the problems of groundwater availability and quality, and there is a need to harness the potential of these techniques for societal benefits to provide water everyone.
Keywords - Geoinformatics, groundwater, prospects, satellite data, quality.

I. INTRODUCTION

Water is essential for the survival of living beings on the earth. Water is under great pressure due to modern developmental activities. Though, water covers about 71% of the earth's total surface but the availability of useable fresh water is only 2.8%. The developmental activities have put pressure on the availability and quality of groundwater. In arid to semi-arid regions of the world, groundwater is the main source for drinking, agriculture and industrial purposes. As the human population is increasing, the demand for water is also increasing. The modern techniques of remote sensing satellite data, GIS, and GPS, have the potential for delineating groundwater potential sites, monitoring surface water bodies and evaluation of groundwater quality.

II. GEOINFORMATICS APPROACH FOR GROUNDWATER PROSPECTS AND QUALITY MAPPING

Remote sensing (RS), Geographical Information System (GIS), and Global Positioning System (GPS) have high potential for groundwater prospects mapping as well as groundwater quality understanding. The satellite data provides the synoptic view of terrain which helps in understanding the water holding capacity of various geological, structural and geomorphological units. The groundwater quality of the area can be assessed based on natural features, slope, rain fall and land use pattern. As in GIS, the data can be presented in a good spatial form which helps in easy interpretation as well as representation of the huge amount of data. As the groundwater quality is a complex system, but the integration of various natural and anthropogenic layers help in understanding the origin of groundwater quality. The GPS provides the real location of the feature which authenticates the interpreted datasets. The integrated approach of geoinformatics is highly useful for groundwater prospects and quality study.

III. GROUNDWATER PROSPECTS AND QUALITY WORK REVIEW

As the remote sensing satellite data, GIS and GPS have tremendous utilities in groundwater prospects and quality study, number of workers had done a lot of work on groundwater prospects and groundwater quality study in different types of terrains. The following paragraphs mentioned below demonstrate the applicability of geoinformatics technologies in groundwater prospects and quality assessment:
Thomas et al. (1995)[1] had studied the hydrogeology of Talwandi Sabo tehsil in Bathinda district in Punjab 5) using SOI and Indian Remote Sensing Satellite

IRS-1B-LISS-II FCC on 1:50,000 scale of 4th October 1992 and 7th March, 1993. They prepared geology, structure, geomorphology maps and collected water table depth at selected tube wells and prepared water table contour map. The study demonstrated the utility of satellite data for the hydrogeological study. Jana and Dutta (1996)[2] studied groundwater potential zones in Mechi Mahananda interfluve in Darjiling district of West Bengal using SOI on 1:50,000 and IRS-1A-LISS-II and SPOT-1 data of 1991 and 1992 and prepared geomorphology maps. Depth and fluctuations data of tube well and dug well were collected. They concluded that the groundwater prospects map was helpful in identifying artificial recharge sites. Ravi Prakash and Rajiv Mohan (1996)[3] mapped hydrogeomorphology of Panwari area in Hamirpur District of Uttar Pradesh state using Landsat TM and IRS-1A-LISS-II satellite data and prepared geology, lineament, geomorphology and hydrogeomorphology maps. They observed that moderately and deeply weathered buried pediplains were the good prospective zone in the Panwari area. Tiwari and Rai (1996)[4] studied groundwater prospects using Landsat-MSS data in part of Dhanbad district, Bihar using Landsat-5 MSS data on 1:2,50,000. Geology, structure and geomorphology maps were integrated and prepared hydrogeomorphology map and concluded that the hydrogeomorphological map was useful for groundwater exploration and detailed geophysical surveys. Das et al. (1997)[5] mapped hydrogeomorphology for groundwater exploration using remote sensing data in Keonjhar district, Orissa using Landsat TM FCC of March 18, 1987 on 1:2,50,000 and prepared lithology, lineament, geomorphology and hydrogeomorphology maps. Water table depth observed in hydrogeomorphic units and carried out geo-electrical resistivity survey. They concluded that the hydrogeomorphological map was suitable for groundwater exploration in the area. Ravindran and Jeyaram (1997)[6] studied groundwater prospects of Shahbad tehsil in Baran district of Eastern Rajasthan using Survey of India Topo sheets and IRS-1B-LISS-II FCC of October 1992 and January 1993 on 1:50,000 and prepared lithology, geomorphology, lineament and hydrogeomorphology maps. They found that Vindhyan sandstone had huge potential for groundwater exploitation and suitable for deep tube well and dug-cum-bore wells. Kumar and Tomar (1998)[7] studied groundwater potential in Godavari sub-watershed in Giridih, Bihar. They prepared hydrogeomorphological map using IRS-1B-LISS-2 satellite data of November 6-7, 1992 and February 24, 1993 data. Geophysical resistivity data of fifty-five sites used for understanding top soil resistivity which could help for recharge sites selection in hydrogeomorphic units. Venkateswara Rao (1998)[8] studied hydrogeomorphology in chondritic terrain in Kandivalsa river sub-basin near Cheepurupalli of Vianagaram district of Andhra Pradesh. They used Landsat Thematic Mapper (TM) FCC on 1:50,000 and prepared hydrogeomorphology map and conducted eighty vertical electrical soundings in the study area. They concluded that high groundwater prospects occurred in wash plains and shallow buried weathered pediplains and areas between two lineaments had greater groundwater prospects than those on or near the lineaments. Murthy and Venkatesara Rao (1999)[9] studied hydrogeomorpholoy of Varaha river basin using SOI and IRS-1A-LISS-II FCC of 1992 year. They prepared geology, lineament, geomorphology and hydrogeomorphology maps. They concluded that hydrogeomorphological map was helpful in knowing the groundwater potentiality in different landforms. Thomas et al. (1999)[10] studied hydrogeomorphological mapping in assessing groundwater in Lehra Gaga block, Sangrur district, Punjab using IRS-1B-LISS-II FCC of October 1992 and March 1993 on 1:50,000 and prepared hydrogeomorphology map and assessed hydrogeological conditions in the area. They found that alluvial plain had good groundwater prospects with marginal groundwater quality while along canals the groundwater quality was good. Obi Reddy et al. (2000)[11] evaluated groundwater potential zones in Gaimukh watershed, Bhandara district, Maharashtra using SOI on 1:50,000 and IRS-1C-LISS-III FCC and prepared geomorphology, geology, lineament and hydrogeomorphology maps. They found that deep valley fills had excellent, shallow valley fills and deeply weathered pediplains had very good and moderately weathered pediplains had good groundwater potential while lineaments were acting as conduits for groundwater movement. Jai Shankar et al. (2001)[12] studied hydrogeomorphology of Agnigundala mineralised belt in Andhra Pradesh using SPOT and IRS-1B data and prepared geology, geomorphology and hydrogeomorphology maps. They concluded that wells in the plain areas showed very shallow to shallow water table whereas in hilly area the water table was moderately deep. The groundwater depth data indicated that shallow wells had low fluctuation in water levels while deep wells had more fluctuations. Sarkar et al. (2001)[13] evaluated groundwater potentiality of Shari micro-watershed in the Shimla taluk, Himachal Pradesh using SOI on 1:50,000 and IRS-1C-PAN and LISS-III merged FCC on 1:25,000 scale of November, 1999 and IRS-1C-LISS-III digital data and prepared geomorphology, drainage, lineament, land use, digital elevation model. They concluded that lineaments and slope were the main controlling parameters for groundwater occurrence in the area. In gentle slope, the area had more groundwater prospects than steeply slope area. Flood plains and river terraces had good groundwater potential. Subba Rao et al. (2001)[14] studied groundwater potential in Guntur town, Andhra Pradesh using SOI and IRS-1D-LISS-III FCC on 1:50,000 of September 16, 1999 and prepared physiography, geology, lineament and hydrogeology maps. They found that deeply weathered pediplain had good, moderately weathered pediplain had moderate and shallow weathered pediplain had poor to moderate groundwater prospects while the residual hill had poor groundwater prospects. Khan and Moharana (2002)[15] delineated groundwater potential zones in Neem-Ka-Thana region in Sikar district of Rajasthan using SOI and IRS-1D-LISS-III geocoded FCC of April 1999 on 1:50,000 and prepared lithology, structure, geomorphology, hydrology and drainage maps and by integrating these maps prepared the groundwater prospects map. They found that buried pediments and valley fills had moderate to good groundwater prospects while the high groundwater prospects confined to alluvial plain and valleys. Lineaments influenced the drainage change and sub-surface flow. Sankar (2002)[16] evaluated Upper Vaigai river basin, Tamil Nadu for groundwater potential zones using SOI and IRS-1D-LISS-III FCC on 1:50,000 and prepared geology, lineament, geomorphology and hydrogeomorphology maps. The result showed that moderate to deep weathered buried pediments, flood plains, and bajada zones were the good groundwater prospective zones. The intersection of lineaments also had good groundwater potential. Bahuguna et al. (2003)[17] studied groundwater prospective zones in basaltic terrain in Bhikangaon area of Khargone district in Madhya Pradesh. They prepared geology, landform and lineaments maps with the help of IRS-LISS-II satellite data of Kharif season (September 1992) and Rabi season (January 1994). They concluded that fractured rocks and thick weathered mantle were more the productive aquifers in the study area. Murthy et al. (2003)[18] studied groundwater potentiality in Bhamini Mandal in Vamsadhara river basin in Srikakulam district, Andhra Pradesh using SOI and IRS-1A- LISS-II FCC of March 1994 and prepared geology, slope, drainage, soils, land use/land cover and hydrogeomorphology maps. They found that integrating the thematic maps in GIS give more and near accurate results. Gopinath and Seralathan (2004)[19] studied the groundwater prospective zones in Muvattupuzha river basin in Kerala state using IRS-1D-LISS-III of the year 1999 geocoded false colour composite and prepared lithology, lineament, geomorphology and hydrogeomorphology maps and did pumping test at few sites. In the study area, valley fills had good groundwater prospects followed by a moderately dissected plateau and pediments. Nag (2005)[20] studied groundwater potential zones in Baghmundi block in Purulia district of West Bengal using SOI and IRS-1B-LISS-IIA satellite data of March 27, 1994 on 1:50,000 and prepared lineament, and hydrogeoorphology maps and concluded that good to excellent groundwater potential zone occurred in and around Ajoydha village. Srinivasa Vittala et al. (2005)[21] evaluated groundwater potential in sub-watersheds of north Pennar river basin around Pavagada, Karnataka using SOI and IRS-1C and IRS-1D-LISS-III geocoded FCC of March 18th, 2001 and PAN of March 15th and 18th, 2001fused satellite data and prepared slope, geology, geomorphology, lineaments and groundwater prospects map. The integrated groundwater potential map indicated that valley fills and moderately weathered pediplains had good to very good; shallow weathered pediplains had moderate to good; pediment inselberg complex and pediments had poor to moderate and denudational, residual hills and inselberg had very poor to poor groundwater prospects. Thakur and Raghuwanshi (2008)[22] assessed groundwater resource in Choral river basin, Indore and Khargone districts, Madhya Pradesh using Survey of India Toposheets and IRS-1C- LISS-III FCC on 1:50,000 and prepared geology, geomorphology and lineament maps. The groundwater prospects were evaluated using hydrogeological characteristics and aquifer parameters. Vijay Kumar et al. (2009) [23] delineated groundwater potential zones in Solipur Vagu Sub-basin of Kongal River using SOI and IRS-1D-LISS-III data on 1:50,000 scale and prepared geomorphological, geological, lineament maps and other collateral data for preparation of hydrogeomorphological map. The study showed the interrelationship between hydrogeomorphological and topographical features. Dar et al. (2010)[24] evaluated groundwater prospects in Kancheepuram district, Tamil Nadu using SOI and digital data of IRS-P6-LISS-III on 1:50,000 of March 2005 data and prepared geology, lineament, geomorphology maps and assigned weightage to each thematic layer and the layers were integrated in ArcGIS 9.2 software to demarcate groundwater potential zones. The groundwater potential was categorized on the basis of cumulative weightage assigned to different features of thematic layers. The integrated map could be useful for sustainable groundwater development planning in the area. Goyal et al. (2010) [25] studied variability in groundwater levels in Kaithal district using geographical information system. They had used Survey of India Toposheets on 1:50,000 scale, historical rainfall data and groundwater level data from 1987 to 2007 for Pre-monsoon (June) of seventy nine observation wells of Ground Water Cell, Haryana. The data were analyzed in ILWIS 3.6 GIS environment and applied inverse distance interpolation (IDW) technique to know the spatial distribution scenario of groundwater level in the area. The data interpretation showed that groundwater level was depleting very fast in the Kaithal district. Mohanty and Behera (2010)[26] studied groundwater potential in Khallikote block, Ganjam district, Orissa using SOI on 1:50,000 and ortho-rectified Landsat Thematic data and prepared lineament, landuse/landcover, geomorphology maps and water table depth map from secondary available data. In 22.7% area had poor; 65.3% area had medium, and 7.2% area had very high and 1% area had excellent groundwater potential. Harish (2011)[27] studied groundwater in Chamarajanagar district in Southern part of Deccan Peninsula and Southern most of Karnataka state using available secondary groundwater data. In the study, the secondary data were spatially represented and interpreted. It was observed that rate of availability of water depends on rainfall but also varied with the type of vegetation cover and its abundance. Khodaei et al. (2011)[28] studied groundwater potential sites in Northwest of Iran and Southwest of Urmieh Lake using SOI and geological maps, Landsat TM data of August, 1990, SPOT Panchromatic (2005), IRS Panchromatic (2004) and prepared lineaments, vegetation, lithology, slope and drainage density maps. They concluded that remote sensing and GIS techniques were highly useful for groundwater exploration targeting areas which were confirmed by geophysical investigations in the area. Mayilvaganan et al. (2011)[29] delineated groundwater potential zones in Thurinjapuram watershed using geospatial techniques in Tamil Nadu using IRS-P6-LISS-III geocoded FCC and SOI and prepared groundwater prospects map. They concluded that groundwater occurrence in the area was controlled by rock type, lineaments and landforms. Preeja et al. (2011)[30] studied groundwater potential zones of Ithikkara river basin- a tropical river basin in Kerala using SOI and Landsat ETM+ satellite data of 26th October, 2010 and prepared lithology, geomorphology, landuse/landcover, drainage, soil and groundwater potential maps. The overall results demonstrated that remote sensing and GIS were potentially powerful tools for studying groundwater in the area. Rekha et al. (2011) [31] studied groundwater potential and quality in Koduvan Ar Sub-watershed of Meenachil River basin, Kerala using SOI and IRS-P6-LISS-III geocoded satellite data of 19th February 2004, geology map and prepared geomorphology, lithology, slope, land use/land cover maps in ArcGIS 8.3 software. They assigned weightage to individual theme depending on groundwater holding capability. The groundwater quality parameters were within the desirable limit except pH.

Sarup et al. (2011)[32] delineated groundwater prospect zones and artificial recharge sites in Kalwan Taluka of Northern part of Nasik district in Maharashtra state using Survey of India Topo sheets, IRS-1D-PAN geocoded data on 1:12,500 and prepared lithology, geomorphology, soil, land use/land cover, structures/lineament, slope, drainage and hydrology maps and by integrating these maps prepared groundwater prospects and artificial recharge site maps. The study showed that geology, geomorphology, soil, land use and land cover, slope, drainage and lineament density, frequency and intersections had great promise for identifying and delineating favorable groundwater potential zones and artificial recharges sites. Ahmadian and Chavoshian (2012)[33] studied Hamadan province for spatial variability zonation of groundwater table by using geo-statistical methods. The analysis of groundwater level with the help of cross-validation method showed that Co-krigging method had the least error in comparison with other interpolation methods. The study showed that spatial variability zonation by using geo-statistical methods was highly useful in showing the spatial variability of the water table in the area. Chandra Pal et al. (2012) [34] delineated groundwater prospect zones in Gandheshwari sub-watershed in Bankura district using SOI and Landsat ETM+ of November 18th, 2006. Geomorphology, lithology, drainage, drainage density, slope and land use/ land cover maps were prepared. These thematic maps were integrated to generate a groundwater prospects map of the study area. Neelakantan and Yuvaraj (2012)[35] evaluated groundwater potential zones using geospatial data in Salem taluk in Tamil Nadu. They prepared various thematic layers with special reference to groundwater and prepared the groundwater potential map. High groundwater potential zones were falling in major portions of Veerapandi blocks. Sudarsana Raju. G. (2012) [36] delineated groundwater potential zones in and around Kadiri Anantapur district in Andhra Pradesh using IRS-P6-LISS-III satellite data and SOI and prepared lithology, geomorphology, structure, and groundwater prospects maps on 1:50,000. The groundwater prospects in the study area were classified as high, medium, low and poor. Kumar et al. (2013)[37] studied groundwater prospects zonation in Khoh River watershed, Pauri-Garhwal district in Uttrakhand using multi-date IRS-1D/P6-LISS-III, IRS-P-6-AWiFS, Landsat ETM+ and Landsat TM data, other published maps and reports. Thematic layers were prepared using satellite data and topo sheets and found that Khoh River watershed showed diverse hydrogeomorphological conditions where the groundwater regime was controlled by geomorphology, slope, lithology, land use/land cover. In the watershed four groundwater prospects zones were categorized into good, moderate to good, poor to moderate and poor were delineated.

Dhoble et al. (2014) [38] studied groundwater quality for watershed management in North-East Region of Pune District using Survey of India topo sheets; IRS-P6-LISS-III data of 27 March, 2007 on 1:50,000 and

ASTER data of 30m resolution and prepared geomorphological, soil, structure and groundwater prospect maps and verified with field data and concluded that geoinformatics approach was very important to identify the groundwater occurrence and movement. The groundwater prospects map could be used for identification of the location of wells in the study area. Khames and Nagaraj (2014) [39] studied the groundwater quality of Al Thirthar valley basin in Iraq using remote sensing techniques. They collected secondary data and did groundwater quality zonation using inverse distance weighted (IDW) interpolation technique in ArcGIS 9.2 software. The study was highly useful for understanding the groundwater quality in the area. Kumar and Dev (2014)[40] studied groundwater potential zone in Karwi area, Mandakini river basin, Uttar Pradesh using SOI, MODIS, Landsat and SRTM data (MODIS Terra scene 17 March 2012; Landsat ETM+ scene October 2005 and 22 February 2006 and SRTM scene). Geomorphology, lithology, soil, land use/land cover, slope, drainage and lineaments maps were prepared and prepared the groundwater potential zone map. They concluded that the groundwater prospects map was highly useful for management of groundwater and siting well locations for drinking and other purposes. Mahalingam et al. (2014)[41] studied groundwater quality in Mysore city using GIS techniques. They used secondary groundwater quality data for pre-monsoon and post-monsoon seasons and prepared groundwater quality maps using inverse distance weighted (IDW) interpolation technique. The study was highly useful in showing the groundwater quality data in the spatial form. Ramakrishn et al. (2014)[42] studied groundwater prospects in Tattekere watershed in Piriyapatan and Hunsur taluks of Mysore district. They used Cartosat-1, PAN data and Resourcesat-LISS-IV, multispectral data; SOI; existing geology, hydrogeology and geomorphology maps; field observations on wells, geology, landforms, land use/land cover and soils. They concluded that remote sensing and GIS techniques proved vital tools in delineating groundwater potential zones. In the study area, 66 % area had excellent, and 18 % area had very good to good groundwater potential. Venkateswaran et al. (2014)[43] delineated groundwater potential zones in Upper Tirumanumuttar Sub-basin in Narnakkal district of Tamil Nadu using SOI and SRTM satellite data and prepared groundwater potential map by integrating lithology, slope, lineament, drainage and soil maps. The result showed that groundwater potential map was helpful in better understanding, planning and management of groundwater resources in the Upper Tirumanimuttar sub-basin.

IV. CONCLUSIONS

Geoinformatics play vital role in mapping, monitoring, planning, management and development of groundwater resources in an area. There is urgent need to use geoinformatics in water resources planning and management.

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