GEOSPATIAL TECHNIQUES IN LAND RESOURCE INVENTORY AND MANAGEMENT: A REVIEW

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Abstract

Available natural resources govern the basic development of any country. Among many; land and water resources are most important that support survival of individuals on the earth. Due to rapid increase in population, these resources are over stretched often leading depletion constantly. In recent times, geospatial techniques are being effectively used for more precise mapping and judicious management of land resources. Geospatial technology concerned with spatial information about features at a place or, in space, collected in real time. Geospatial techniques is the combination of Remote Sensing (RS), Geographic Information System (GIS), Global Positioning System (GPS), cartography, and spatial statistics that capture, store, manipulate and analyze to understand complex situations of environment and solve the problems for sustainable development. In the study an attempt has been made to review the application of geospatial techniques in land resource inventory, analysis, mapping and management. The review shows that these techniques have immense potential and being used in various aspects of land resources inventory such as digital terrain analysis, soil resource inventory, land use/land cover mapping, wastelands mapping, water resources and environmental management.

Keywords Geospatial techniques, land resource inventory, remote sensing, GIS, GPS

Introduction

Land Resources refer to a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and land forms, the surface hydrology (including shallow lakes, rivers, marshes and swamps), the near-surface sedimentary layers and associated groundwater and geo-hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc (FAO/UNEP, 1997).The inventory of land resources implies information about their potentials, extent, composition, evolution, including their rate of alteration to other uses. There is need to obtain reliable data about land resources for planning, management, conservation and optimum use for further development in sustainable manner (Shaw et al. 2015; Akike and Samanta 2016). With increasing population pressure and associated need for increased agricultural production (Food, fiber, fuel and fodder) there is great need for improved management of the land resources specially the soils and water; Soils considered as the integral part of the landscape and their characteristics are largely governed by landform on which they are developed. Systematic study of morphology and taxonomy of soils provides information on nature and type of soils, their constraints, potentials, capabilities and their suitability for various uses (Sehgal 1996). Water resources are under major stress around the world. Rivers, lakes, and underground aquifers supply fresh water for irrigation, drinking, and sanitation, while the oceans provide habitat for a large share of the planet's food supply. Today, however, expansion of agriculture, damming, diversion, over-use, and pollution threaten these irreplaceable resources in many parts of the globe.

The inventory of land resources, it includes soil, water and land use/land cover are most important to meet the management strategies. In order to accomplish this, it is pre-requisite to obtain reliable data on not only the types, but also the quality, quantity and accurate location of the land resources. The geospatial techniques plays important role to acquire such information and found best over the conventional methods of data collection (Saxena et al. 2000). Remote sensing is the only means to obtain continuous data over large areas at an effective cost. The products derived from remotely sensed data are typically continuous thematic maps (e.g., land use/land cover). In land resource inventory, there are many high, medium and coarse resolution remote sensing based systems are being used across the globe presented in Table 1. Remote sensing increases the efficiency of the inventory, typically reduces the standard error of the statistical population estimate, and often provides new information, including map products. Bhagia et al. (2016) attempted to carry out national inventory of *rabi* pulse crop using multi date satellite images with pixel accuracy ranging from 50-100% in different parts of India, the result help to have a crop map with its spatial extents. Using advanced remote sensing data like LiDAR it is possible to make nationwide natural resource inventory in the form of high resolution natural resource maps (Blanco et al. 2016). Kumar et al. (2015) reported that remote sensing, GIS and GPS offer an abundant opportunity to monitor and manage natural resources at multi-temporal, multi-spectral and multi-spatial resolution.

Geospatial techniques in land resource inventory

Being the important components of land resources, terrain, soil, water and land use; need to be studied for their optimal utilization and sustained quality of human life on the earth surface. Efficient and effective management of these resources is the major challenge for the scientists, planners, policy makers, administrators and farmers to ensure food, water and environmental security for the present and future generations. Advance tools such as satellite remote sensing, GPS and GIS have been providing newer dimensions to monitor and manage land resources for their effective utilization (Kasthuri and Sivasamy 2013).Land resource information plays a key role in the management of soil resources on scientific principles is essential to maintain the present level of soil productivity and to prevent soil/land degradation (Maji et al. 2001). Therefore, in recent years increasing emphasis is laid characterization of soils, accurate mapping of different kinds of soils and developing rational and scientific criteria for land evaluation and interpretation of soils for multifarious land uses. This calls for comprehensive knowledge on soil resources in terms of types of soils, their spatial extent, physical and chemical properties and limitations / capabilities. Advancement in space and information technology especially in the field of remote sensing has become an important tool in land resource inventory than the conventional surveys (Somasundaram et al. 2000).

Table 1. High, medium and coarse resolution remote sensing based systems in land resource inventory

S No.	Satellite /Tool	Study Area	Purpose	Reference	Country
High resolution images (Spatial resolution: 1 – 15 m)					
1	WorldView-2	Nawalparasi district (Nepal)	Precision Agriculture	Barala 2010	India
2	IRS-IC/ID PAN+LISS III	Pavagada taluk (Karnataka)	Resource management	Vittala et al. 2008	India
3	Resourcesat-1+Cartosat-1	Mohammadabad village (Andhra Pradesh)	Soil fertility assessment	Wadodkar and Ravishakar 2011	India
4	Cartosat-1	Sheo tehsil (Rajasthan)	Demarcation of watershed	Tomar and Singh, 2012	India
5	IRS-P6-LISS IV	Borgaon Manju watershed (Maharashtra)	Soil Resource Inventory	Reddy et al. 2012	India
6	IRS-P6, LISS III, LISS IV	Bandu watershed (West Bengal)	Watershed prioritization	Das et al. 2012	India
7	IKONOS	Experimental plot (Jalandhar)	Soil mapping	Raj and Koshal 2012	India
8	IRS-P6-LISS IV	Phaltan, Maharashtra	Waste land mapping	Ramteke et al. 2013	India
9	IRS-P6-LISS IV	Kakrorasa sub-watershed	resource inventory of hilly terrain	Shaw et al. 2015	India
10	LiDAR	Philippines	Natural resource inventory	Blanco et al. 2016	Philippines
11	ASTER –Level-1A	Eastern Mediterranean Landscapes	LULC mapping	Yuksel et al. 2008	Turkey
Medium resolution images (Spatial resolution: 15 – 30 m)					
12	Landsat ETM + DEM	SE Egypt	Phygiography mapping	Ageeb et al. 2007	Egypt
13	Landsat ETM	Phrae basin	Soil mapping	Myint et al. 2008	Thailand

14	IRS-P6-LISS III	Dhule, maharashtra	Land degradation mapping	Rajankar et al. 2012	India
15	IRS-P6-LISS III	Lakhani, Maharashtra	LULC mapping	Ramteke et al. 2014	India
Coarse resolution images (Spatial resolution: 30 m and above)					
16	Landsat TM and ETM+	Dobrogea region	Climate analysis	Serban and Carmen 2011	Romania
17	Hyperspectral image	La Peyne catchment	Soil mapping	Lagacherie et al. 2012	France
18	SRTM + Nigersat	Gombe State	Terrain analysis	Ikusemoran et al. 2016	Nigeria
19	ASTER	Fawakhir Area, Central Eastern Desert, Egypt	Lithological mapping	Mohi et al. 2016	Egypt

Geospatial techniques in digital terrain analysis

Terrain mapping is a classification system that describes the characteristics and spatial distribution of surface materials, landforms and geomorphological processes. Reddy et al. (2004a) used IRS-P6-LISS III data in conjunction with Survey Of India (SOI) topographical sheets (1:50,000 scale) for systematic analysis of various morphometric, lithological and landform characteristics of basaltic terrain, central India, they analyze the influence of drainage morphometry on landforms, soil depth, drainage, available water holding capacity (AWC) and land erosion characteristics and demonstrated that remotely sensed data and GIS based approach is found to be more appropriate than the conventional methods. Geospatial techniques offers accurate terrain analysis by capturing real time data output through the analysis using various GIS based models and software. Certain remote sensing devices offer unique information regarding structures, such as in the relief expression offered by radar sensors. Comparing surface expression to other geological information may also allow patterns of association to be recognized. For instance, a rock unit may be characterized by a particular radar texture, which may also correlate with a high magnetic intensity or geochemical anomaly. Remote sensing is most useful in combination with complementary datasets. Digital elevation model (DEM) can be used for number of purposes like land use planning, hydrologic modeling, sediment transport, soil erosion estimation, drainage basin morphology, vegetation, and ecology etc., the generation of accurate DEM fully depend on the terrain parameters, like drainage network and watershed boundaries from collateral data and remotely sensed data (Reddy et al. 2012). GIS plays vital role in morphometric analysis of terrain, with the help of survey India toposheet in GIS environment, Mohd.Iqbal et al. (2013) delineated and computed Various linear parameters like Stream order, Stream number, Stream length, stream length ratio, bifurcation ratio, drainage density, texture ratio, stream frequency and shape factors compactness coefficient, circularity ratio, elongation ratio, form factor of the Shaliganga Sub Catchment, Kashmir Valley. Terrain analysis is immensely useful in agricultural planning, drainage, hydrology, settlement, industrial and transportation (Ikusemoran et al. 2016).

Geospatial techniques in soil resources inventory

Soil map is a map of geographical representation showing diversity of soil types and/or soil properties (soil pH, textures, organic matter, depths of horizons etc.) in the area of interest (Legros 2006). It is typically the end result of a soil survey inventory, i.e. soil survey. Soil maps are most commonly used for land evaluation, spatial planning, agricultural extension, environmental protection etc. Traditional soil maps typically show only general distribution of soils, accompanied by the soil survey report. Many new soil maps are derived using geospatial techniques and such maps are typically richer in context and show higher spatial detail than traditional soil maps. Advancement in GPS accuracy and its integration with GIS, the ability to collect accurate spatial data for soil survey components has revolutionized the process of soil survey field data collection. Significant map production time is saved and the number of errors that result from processing and converting the hard copy maps to digital are reduced (Stombaugh et al. 2002). Similarly, Manchanda et al. (2002) describes the role of remote sensing and GIS technologies for mapping and characterizing soils at various scales. With the application of GPS position data into GIS, the surveyor is no longer burdened in order to locate the position on the map. It precisely locates soil sampling points within field and provides more detailed information about the variability of soils. Panhalkar (2011) used the advance navigation tool of

GPS for collecting the training site data and to field check classified datasets. The geographic coordinates latitudes/longitudes can be collect by GPS and easily link the field information to the corresponding area on the satellite image, which supports classification and interpretation with accuracy and confidence. This positional information can be saved for further applications while satellite data processing and interpretation purpose (Reddy et al. 2012). The spectral behavior of soil and its components are fundamental to derive information from remote sensing data. Delineation of soil boundaries require more technical and scientific involvement along with detail knowledge of subject, the satellite image and GIS help greatly by offering synoptic view of landscape. Reddy and Maji (2003) delineated and characterized different geomorphic units of Tundiya river catchment, north eastern part of Nagpur district, Maharashtra using IRS-ID LISS-III satellite data (bands 2, 3 and 4). McBratney et al. (2003) demonstrated the relationship between major soil properties and their correlation with remote sensing images like iron-oxide content, soil organic matter content, salt content, parent material differences, soil moisture content, and some chemical and physical properties like pH, calcium-carbonate, mineral N, total carbon, total and available phosphorus, clay-silt-and sand contents. Some soil properties are directly related to the surface colour and thus relatively easy to map when the soil is bare and visible spectra is used to detect the colour. Iron-oxide and organic matter content, and partly the soil moisture contents and soil texture are good examples of that. He reported that the establishment of relationship between soil properties and vegetation on satellite image is possible, Srivastava and Saxena (2004) proposed the physiography-land use concept (PLU) for large scale mapping of soils in basaltic terrain using PAN merged LISS III data. Similarly, Sarkar et al. (2006) used IRS-1D LISS-III fused with PAN data on 1:12,500 scale and interpreted the physiographic units based on image characteristics to identify upland (tarn), medium land (Baid) and low land in Patloinala micro watershed of purulia district, west Bengal. Behrens and Scholten (2006) developed a digital soil map as a tool to generate spatial soil information which provided solutions for the growing demand for high-resolution soil maps worldwide. Place specific availability of information about soil and its suitability helps the farmers and planners in decision making and land use planning. Jayasinghe and Machida (2008) generated an interactive web-based GIS consulting portal with crop-land suitability analysis, which provides information on Tomato and Cabbage cultivation in Sri Lanka. Similarly, Eric et al. (2011) developed a digital soil map and interactive geodatabase with crop-land suitability analysis on the growth and production requirement of oil palm, cassava, and citrus. Authors also reported that the choropleth map developed in the study is able to provide a visual view of all potential areas within the study area of Adansi West District. Johar et al. (2013) carried out analysis of soil suitability for industrial development using GIS in part of Uttar Pradesh state (i.e. Banda and its surrounding), with the help of GIS environment they find out the suitable sites for industries, and thus suitability map is prepared showing different suitability classes for industrial development. Similarly, Deshmukh et al. (2016) explored the application of GIS that provides a technical platform for management of geographic data and inherent location information to support application of spatial statistical and location econometric tools. Nagaraju et al. (2015) studied the soils of Saraswati watershed in Buldhana district of Maharashtra and identified four physiographic units viz. plateau, pediments, broad and narrow valley using satellite image data in GIS environment and differentiate the Soils of plateau are shallow to moderately shallow (Lithic Ustorthents/Typic Haplustepts/VerticHaplustepts); soils of pediments are very shallow to shallow (Lithic Ustorthents/VerticHaplustepts) and soils of broad and narrow valley are deep (VerticHaplustepts/ Typic Haplustepts). Singh et al. (2014) interpreted IRS-1C LISS-III data of Mohanrao watershed exists between two states Haridwar district of Uttarakhand and Saharanpur district of Uttar Pradesh at the scale of 1:50000 to delineate different physiographic unit's viz. Siwalik hills, Piedmont plain, Alluvial plain and Residual hills. Advancement in remote sensing that providing stereo images, which help to generate DEM extensively used by researchers in soils and landform assessment, Nagaraju et al. (2014) used a high-resolution DEM with a posting of 10 m generated from a Cartosat-1 stereo pair to derive terrain attributes. Based on erosional and depositional processes, five major landforms, namely plateau top, escarpment, pediment (erosional), alluvial plain, and narrow valley (depositional), have been delineated using 3D perspective viewing of the landscape. Similarly, Sahu et al. (2014) interpreted IRS-P6 LISS-IV with DEM derived from Cartosat-1 stereo data of two seasons in Miniwada Panchyat, Nagpur district on basal.tic terrain of central India. They identified seven major landforms viz. plateau top, scarp slopes, plateau spurs, pediments, undulating plains, valley and floodplain.

Geospatial techniques in land use/land cover (LULC) mapping

Geospatial techniques now a day's become basic tool for mapping and monitoring LULC associated with agriculture, urbanization, identification of different sites of human interest and its impact on flora and fauna. In addition, with the remote sensing techniques one can study the complex LULC system of a difficult terrain and prepare comprehensive management plans. Space borne multi-spectral data can be use to generate LULC maps at various levels showing categories of land under different uses both in spatial and statistical form for the entire country at a time is great achievement offered by geospatial techniques.

Land use/ land cover classes in Gaur Ganga Watershed in Uttaranchal state was analyzed by Bisht and Kothyari (2001) using toposheet and visual interpretation of Landsat 5 TM image bands 2, 3 and 4 using GIS software. Loss of vegetation cover was estimated to be 5.07 and 8.1 per cent during 1963-1996 and 1986-1996, respectively. Singh et al. (2004) observed the changes in Mangrove forest cover from 1994-2001 by using IRS-IB LISS II and IRS-ID LISS III data and found an increase of 44.0 per cent Mangrove vegetation in coastline forest of Goa. Vijaykumar et al. (2004) prepared land use map of Kandi Belt of Jammu region using IRS-IC-LISS III data. Supervised classification combined with rule-based classification was used to delineate various land use classes and they recognized seven various categories of land use classes. Gomathi (2007) used IRS-ID PAN merged LISS III data at 1:50,000 scale and prepared land use/land cover map of Nagapattinam district. Medium resolution satellite data (IRS-P6-LISS-III, 23.5 m) used by Bose et al. (2008) and prepared major land use land cover map of Sundarban area, West Bengal, India; study shows agricultural land dominating the northern part, where as mangrove forest dominating the southern part comprising 2280 sq km and 3736 sq km area, respectively. Patil et al. (2010) used IRS-1D LISS-Ill data of November and February 2004 to prepare land use/land cover map of Lendi watershed of Chandrapur district of Maharashtra. They identified major land use/land cover classes as single crop, double crop, forest, wasteland with scrub and rock outcrop. Similarly Bante et al. (2012) prepared land use/land cover map of Taroda watershed Katol tehsil of Nagpur district of Maharashtra using IRS-1D LISS-III and IRS-P6 LISS-IV data. By visual interpretation of satellite data, they reported that 54.8% of the total geographical area (TGA) is under cultivation followed by wastelands with scrub and degraded forest. High resolution satellite data offers higher level of classification, Pachpor et al. (2012) prepared LULC map of Savli micro-watershed in Wardha districts of Maharashtra using IRS-P6 LISS-IV (5.8 m). Based on image characteristics, the major land use/ land cover identified are cultivated land, wasteland and habitation. Cultivated land is again delineated into single and double crop with orange orchards based on temporal satellite data. Das et al. (2013) studied nine villages of Doomdoma sub division of Tinsukia district of Assam using IRS-P6 LISS-IV and Cartosat-1merged image and classified land use and land cover as agriculture (field crops and tea garden), wastelands (scrubland), built up forest plantations and water body where in 81.0% area of the study area was under agriculture use that includes kharif crops, double crop (i.e. kharif and rabi) and tea gardens. Area under tea gardens was the highest and occupies 50.0% of the total study area and 62.0% of area under agricultural land. Sahu et al. (2014) delineated six land use/land cover classes namely single crop, double crop, orchard, land with and without scrub and degraded forest using IRS-P6 LISS-IV data in Miniwada Panchayat, Nagpur district. Nagaraju and Gajbhiye (2014) prepared land use/land cover map of Kukadi Command of Ahmednagar district of Maharashtra and classified LULC classes viz. cultivated crop (single and double crop), degraded and moderately dense forest and wasteland with scrub. Effectiveness of geospatial technology demonstrated by Ramteke et al. (2014) used temporal IRS-P6 LISS-III data in identification, mapping and assessment of land use/land cover in Lakhani tahsil of Bhandara District, Maharashtra. In his study, by adopting on-screen visual interpretation techniques delineated broadly sixteen categories within three major categories vis. Agriculture, wasteland and forest with spatial statistics of respective categories. Multi-resolution satellite data offers to choose the mapping scale in land use map preparation, the medium resolution LISS-III (23.5 m) images successfully utilized by Nagaraju et al. (2015) to prepare land use/land cover map in Saraswati watershed, Buldhana district, Maharashtra based on FCC of IRS-P6 LISS-III data. They identified and mapped land use/land cover classes as single crop, double crop, wasteland, water body and habitation.

The process of identifying differences in the state of an object or phenomenon by observing it at different time intervals is considered as change detection (Singh 1989). This process is usually applied to Earth surface changes at two or more times. It is not only necessary to have the information on existing land use land cover but also their dynamics, trends, patterns, forms and intensity of alteration over the period of time are much important as the growing demand by the increasing population. In recent years, geospatial techniques have proved to be of immense value for preparing accurate land use/land cover maps and monitoring changes at regular intervals of time. In case of inaccessible region, this technique is perhaps the only alternative of obtaining the required data on a cost and time effective basis.

Geospatial techniques in land degradation/waste land mapping

Land degradation in terms of soil erosion is a major environmental issue and posing threat to fertile soil sustainable livelihood. Geo-spatial technology could greatly enhance the inventory of degraded lands over large areas by providing multi temporal data when used along with ground truth information of high positional accuracy. Soil erosion is a major concern in landscape management and conservation planning. Geospatial technologies play a critical in the generation of spatial data layers and their integration to estimate soil loss by adopting the suitable models like Universal Soil Loss Equation (Wischmeier and Smith 1978). Many factors such as rainfall, wind and anthropogenic activities are responsible for soil erosion and can be studied their occurrence, intensity, severity and spatial extent using geospatial techniques. Raina et al. (1993) used Landsat Thematic Mapper sub-scenes to map the type, extent and degree of degradation in an area of over 5000 km2, 42% was affected by wind erosion and 50% by accelerated water erosion.GIS helps in integrated analysis of USLE parameters in quantification of potential and actual soil loss (Vittala et al. 2004; Reddy et al. 2004b). Reddy et al. (2016) assessed soil loss in Goa state of India through integrated analysis of rainfall erosivity (R), soil erodibility (K), slope length (LS), cover (C) and management (P) factors of USLE using Gaussian kriging model in GIS. Similarly, Fadhil (2009) used geo-information technology to monitoring, mapping, and assessing the land degradation in the upper Mesopotamian plain of Iraq using Landsat TM and ETM+ imageries, outcome showed a clear deterioration in vegetative cover, an increase of sand dune accumulations, and a decrease in soil/vegetation wetness, accounting for 12.9, 5.0, and 8.5 percent, respectively, of the total study area. He found the increased risk land degradation in the study area by 111.0% during the study period.

Remote sensing has long been recommended for its potential role to detect, map and monitor degradation problems with spatial and spectral resolution and for the detection of degraded areas including their spread effects with time (Sujatha et al. 2000; Reddy et al. 2002). Quantitative analysis of land degradation through different vegetation indices Baugh et al. (2006) using a Landsat TM dataset spanning 17 years over the San Luis Valley, Colorado, USA to find the best VI for use in sparsely vegetated arid regions and showed effectiveness of NDVI offset index. Similar study carried out by Begzsuren (2007) of land degradation and desertification at Bulgan area, Mongolia using remote sensing technique, with application of many soil and vegetation indices. His results showed that the land degradation in the study area increased from 1990 to 2005 and 94% of the area is considered to be degraded to varying degrees. Mutua and Klik (2004) studied the soil erosion and its management using the RUSLE-GIS for Masinga catchment, Kenya to evaluate viable management options. they suggested comprehensive methodology integrating the Revised Universal Soil Loss Equation (RUSLE) with GIS for estimating soil erosion. GopalKrishan et al. (2009) used vegetation cover, slope and erosion status derived from remote sensing data to delineate four major land degradation categories viz., un degraded, moderately degraded, degraded and severely degraded. Nagaraju et al. (2011) carried out soil loss mapping in Warora Tehsil of Chandrapur District, Maharashtra using remote sensing and GIS as an integrated approach. The study area has been delineated into very slight (<5 t/ha/yr), slight (5–10 t/ha/yr), moderate (10– 15 t/ha/yr), moderately severe (15–20 t/ha/yr), severe (20–40 t/ha/yr) and very severe (>40 t/ha/yr) soil erosion categories. Indian remote sensing data of IRS-P6 satellite with 23 m resolution offered by LISS -III sensor for the year 2005-06, combined with ancillary data such as land use land cover, slope, and soil erosion status used by Rajankar et al. (2012) for identification and delineation of land degradation categories in Dhule district of Maharashtra. About 43.25 per cent area of the district was under different process of land degradation, out of the total degraded land in the district sheet and gully erosion contribute about 97.60 per cent, whereas anthropogenic activities and barren rocky / stony waste area accounts meagerly 0.03 and 2.37 per cent, respectively. The spatial maps are also an ideal input for spatially distributed models, Ramteke et al. (2013) carried out village wise spatial distribution of wastelands using high-resolution satellite data of IRS P6, LISS-IV (Mx) (5.8 m resolution) combined with ancillary information using onscreen digitization techniques and results indicate that 17 villages falls in high priority class and are spread over an area of about 208.05 sq km, accounting for 10.19 % of the Phaltan tahsil, Satara district of Maharashtra.

Geospatial techniques in water resource studies and mapping

Water as a natural resource is essential to support human existence. The availability of fresh water for human use has been declining over the years, whereas the demand of growing population is increasing. In this context, there is an urgent need to monitor and obtain a better understanding of its use, which will provide information that can assist towards the development of effective water management strategies and infrastructures (Kumar et al. 2015). GIS and simulation models can be used to advance knowledge of water resource assessment and management. GIS can support in hydrologic modeling and development of water resource decision support systems (Wilson et al. 2000). Remote sensing data serve as tool in groundwater prospecting, that help in accurate hydro-geomorphological analysis, identification and delineation of various land features (Reddy et al. 1994). Integration of remote sensing and GIS help in demarcating the groundwater potential zones through better observation and more systematic analysis of underground rock types, various geomorphic units, lineament features, which have direct and indirect relationship with groundwater potential zones (Reddy et al. 2003).

Water resource management become important issue from several angles such as development of water bodies for future, protection of available water bodies from pollution and over exploitation. A paramount issue is water-its availability, quality and management. Extensive hydrological information is necessary to develop water resources and protect them, geospatial techniques with its capability of providing information about place specific, above and below of surface features, terrain type, drainage morphometry, slope, gradient, soil morphology that directly or indirectly related to water resource study and analysis for effective management. With the help of geospatial techniques Chaudhary et al. (2009) generated water resource development plans of Mayurakshi watershed, India by adopting Integrated Mission for Sustainable Development (IMSD) guidelines. Using the overlay operation and decision tree concepts water resource development plan was generated. IRS-1C- LISS-III satellite data along with other field and collateral data on lithology, soil, slope, well inventory, fracture have been utilized for generating land use/land cover and hydro geomorphology of the study area.

In situ water conservation and ground water recharge can be achieved by watershed management activities effectively. Watershed prioritization is one of the best step that suggest the critical areas that have to treat on priority to take conservation measures, Saharkar et al. (2015) prioritized the watershed to take relevant conservation measures in Talegaon Dabhade and Rural area around it, in Maval Taluka, Pune District of Maharashtra state, using remote sensing and GIS based software for processing the topographic and collateral data to suggest various groundwater recharge and water storage structures. Similarly micro watershed prioritization carried out by (Gosain and Rao 2004) using criteria cutting across hydrological, demographic and socio-economic parameters with geospatial techniques in Doddahalla watershed. Biswas et al. (2002) used remote sensing and GIS in watershed prioritization for a subwatershed constituting a major portion of a watershed enveloping Nayagram Block, Midnapore District, West Bengal, and a small portion of Mayurbhanj District, Orissa. The micro watersheds under this subwatershed were prioritized based on three conventional methods viz., morphometric analysis method, standard Sediment Yield Index (SYI) method, and Soil Conservation Service (SCS) runoff curve number method and by a newly proposed method which is a combination of morphometric method and SYI named as Silt Morphometry Index (SMI) method. The SMI method appears to be a better alternative for prioritization out of all the methods in view of non-availability of all the information regarding soil, land use, hydro geomorphology and the storm characteristics and can be used instead of conventional methods for prioritization of watershed components. Ali et al. (2014) carried out detailed investigation of linear, shape and relief morphometric parameters like stream length, stream order, drainage density, stream frequency, bifurcation ratio, Length of overland flow, basin perimeter, form factor, compactness coefficient, elongation ratio, basin relief, ruggedness ratio, shape factor and texture ratio in five micro-watersheds of Romushi-Sasar Catchment and their prioritization using Remote sensing and GIS technology. Stream network along with their order was extracted from survey of India toposheets 1961 (1: 50,000 scale) and ASTER DEM 30m in GIS (geospatial) environment and stream order up to 6 has been examined. Based on morphometric analysis and the ranking of each parameter, the sub-watersheds have been classified into three categories high, medium and low in terms of priority for conservation and management of resources. Reddy et al. (2004b) have delineated the drainage lines from topographic maps and updated with satellite imagery and carried out quantitative morphometrical analysis for sub watersheds independently using GIS techniques. They conclude that the conventional methods of morpohometric analysis are time consuming, tiresome and error prone, while the use of GIS techniques allows for more reliable and accurate estimation of parameters of a watershed. The morphometric analyses of different sub-watersheds show their relative characteristics with respect to hydrologic response of the watershed. Such studies indicate that morphologic parameters coupled with integrated thematic maps can help in decision making process for water resources management. Similarly, Sameena et al. (2005) have carried out quantitative morphometrical analysis for 30 sub-basins of Bhadra river basin, Karnataka south India. They have studied the applicability of Horton’s laws with listing the relationship between morphometric parameters and observation on IRS-ID LISS-III data. According to Stetson (2008) a digital mapping technology provides exciting opportunities to expand databases such as the U.S. Fish & Wildlife Service’s (FWS) National Wetlands Inventory (NWI) as well as to tap into new applications for wetlands. GIS users are also changing the way wetland mapping is done making improvements to data layers, for example, or integrating river and floodplain mapping. Wetland managers are using GIS as a tool to identify wetlands and priority areas, conduct studies, undertake conditional and function-based assessments, and explore sea level rise scenarios, among other potential impacts of climate change. Rebelo et al. (2009) with the help of satellite data and GIS quantified the condition of wetlands along the western coastline of Sri Lanka and outlined the trends in land use due to changes in agriculture, sedimentation and settlement patterns. Also land cover and the extent of inundation at each site is being determined in GIS environment.

By applying the integrated approach of remote sensing and GIS, Prasad et al. (2008) delineated groundwater potential zones in hard rock terrain. The remotely sensed data at the scale of 1:50,000 and topo- graphical information from available maps have been used for the preparation of groundwater prospective map by integrating geology, geomorphology, slope, drainage-density and lineaments map of the study area. Optical as well as microwave remote sensing can be utilized successfully in water resource study, Schmugge et al. (2002) used various satellite data to map the hydrological status over the large area considering surface temperature from thermal infrared data, surface soil moisture from passive microwave data, snow cover using both visible and microwave data, water quality using visible and near-infrared data and estimating landscape surface roughness using lidar. Sitender and Rajeshwari (2011) delineated the ground water potential zones in Mewat district of Haryana using IRS P6-LISS IV image with using Survey of India toposheets and some other collateral data by preparing thematic layers like geology, geomorphology, percent slope, drainage density, lineament density and land use/land cover, by integrating all thematic maps in GIS environment a composite groundwater potential map was prepared. Study on watershed characteristics and its prioritization made by Mehra and Rajeshwari (2013) for further growth of resources for sustainable development in one administrative unit of Haryana comprising two sub-watersheds of Dohan and Krishnawati rivers using LISS-IV satellite images and GIS along with different thematic maps. Radoslaw et al. (2014) developed the Water Observation and Information System (WOIS) is an open source software tool for monitoring, assessing and inventorying water resources in a cost-effective manner using Earth Observation (EO) data under the TIGER-NET project, which is a major component of the TIGER initiative of the European Space Agency (ESA) and whose main goal was to support the African Earth Observation Capacity for Water Resource Monitoring. TIGER-NET aims to support the satellite-based assessment and monitoring of water resources from watershed to cross-border basin levels through the provision of a free and powerful software package, with associated capacity building, to African authorities.

Conclusion

The review on geospatial techniques in land resources inventory shows that these techniques enable to capture, storage, manage, present and display the land resource features through various analysis and integration of large quantities of spatial data as well as non-spatial data. It is also evident that as compare to conventional methods, the geospatial techniques found more convenient, less time consuming and more precise in generation of database on land resources. In the context of ever increasing human activities and over exploitation of land resources, there is an immediate need to precisely map and manage the available land resources using the latest geospatial techniques, which have immense potential in generation of location-specific spatial database for evaluation of their potential and limitations. Easily available open sources GIS softwares enable the users to develop various applications for sustainable management of land resources especially in agricultural land use planning and livelihood security.

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