THEME - 3

REMOTE SENSING AND GIS APPLICATIONS IN HYDROLOGY

ADVANCES IN REMOTE SENSING APPLICATION IN HYDROLOGY

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Over the past two decades, remote sensing technique have found increasing use in water science & water resources engineering. From the qualitative state of knowledge and inference about physical environment, the technique has graduated into quantitative information science, capable of measuring system states of hydrologic phenomena in some cases. This is made possible due to newer types of space-based sensor, ready availability of data in spectral-spatial temporal domains, and emergence of advanced image processing, expert system & geo-information technologies. Branches of satellite hydrology where a well-defined school of thought are gradually emerging are : snow & glacier hydrology, limnology, flood hydrology, river morphology, watershed hydrology, urban hydrology, agro-hydrology, arid and semi-arid land hydrology. This paper reviews advances in our knowledge in these areas. A perceptible shift in emphasis from space technology-based mapping & parameter extraction to developing new models, which readily accept remote sensing data, is also noticeable specially in snow hydrology, watershed hydrology & limnology. In the global perspective, better use of this technology may come in foreseeable future in simulating large scale hydrlogic phenomena to study the effect of global climate change on the regional/global hydrologic cycle.

REMOTE SENSING APPLICATION TO HYDROGEOLOGICAL APPRAISAL OF WATER RESOURCES OF KOLAR RIVER BASIN - NAGPUR DISTT. MAHARASHTRA

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Remote Sensing and Aerial Photograph techniques are being widely used by the State Groundwater Organization for the investigation of water resources of the State. In the present paper the authors have applied these techniques for hydrogeological appraisal of water resources of Kolar river basin in Nagpur District of Maharashtra.

The Kolar river basin, an area famous for its orange orchards lies between North latitude 20°11' to 21°29' and East longitude 78°40' to 79°15'. Basaltic rocks constitute the most predominent aquifers in the basin. However, Gondwana sedimentary rocks and sausar metamorphic rocks also constitute the secondary aquifers. Large scale withdrawal of groundwater for agro industrial development and increased population has resulted in the depletion of water table and early drying of wells.

Multispectral false colour composite data of 1:250,000 scale and panchromatic aerial photographs of 1:50,000 and 1:25,000 scale were used to visually interpret various hydrogeomorphological characteristics and fracture trace analysis of the basin to identify groundwater potential zones and to suggest various measures of water conservation and artificial recharge to groundwaer. The comprehensive analysis of the data thus evaluated show that remote sensing and aerial photographs are very useful tools for planning, development and management of water resources.

USE OF REMOTE SENSING SATTELITE DATA FOR WATERSHED MAPPING - A CASE STUDY OF DOHAN RIVER, DISTRICT MAHENDRA GARH, HARYANA

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This study was undertaken to prepare and delineate watersheds and subwatersheds of river Dohan in Mahendragarh district of Haryana using remote sensing technique. Terrain physiography and landuse data have been obtained from IRS-1A LISS-II (1:50,000) with the conjunctive use of topographical map of the area. Each watershed has been divided in to subwatershed with the help of toposheets and sattelite imagery. Mapping units have been delineated based on topography, soil conditions, slope and landuse. Soil loss for each mapping unit has been calculated by using Wischmeir and Smiths soil loss equation published by USDA hand book of Agriculture number 587.

Soil loss has been calculated for each mapping unit. Total soil loss and soil loss per hact. has been calculated. Prioritisation has been done on this basis. Here subwater shed has been considered as the unit for development. Location of structures has been made based on catchment characteristics, drainage patterns, drainage density and run off conditions.

Suitable measures has been suggested for checking erosions and action plan has been prepared for the development of the watershed.

APPLICATION OF REMOTE SENSING IN WATER BODIES, IDENTIFICATION, MAPPING AND INVENTORY

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With the advantages of synoptic coverage, repetitive data gathering capability, spatial information, near real time data collection, computer compatibility etc., Remote Sensing is found to be very useful in the water resources applications in comparison to conventional techniques. Due to the strong contrast between water and surrounding surfaces afforded by satellte, near infra-red observations, surface water becomes the most easily delineable parameter in the hydrologic cycle. This satellite ability to map surface water is thus very exciting because it permits the rapid inventorying over a large region of water bodies (as small as half hectare in size with the second generation satellites like SPOT, INDIAN REMOTE SENSING SATELLITE, this ground resolution would be much more improved. Computer analysis of remotely sensed data as to the identification and classification of water and non-water features is a faster and accurate means of the location and aerial distribution of surface water spread. With the satellite derived surface water coverage information over a period of time, inventory can be made either river basin wise or a region as to the location, numbers, aerial extent, periodic fluctuation, water quality status (shallow or deep water) and likely utilisation potential in terms of agriculture, drinking water supply possibility of recharge to ground water reservoirs etc., such an inventory entirely by conventional means is time consuming, costly and impractical. In the present paper a detailed methodology is given to use the remote sensing techniques in surface water bodies identification mapping and inventory. Both visual and digital techniques of interpretation of a satellite derived information (image) are presented. Detailed algorithms are given to find out the surface water bodies and other application, their aerial extent with respect to computer processing of digital data. Finally a case study using the data collected by Indian Remote Sensing Satellite (IRS-IB) is presented.

STUDY OF KOLAHOI GLACIER KASHMIR FROM SATELLITE IMAGERY

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Kolahoi Glacier in Kashmir, India, is one of the earliest Glacier studied by various investigators. Its easy accessibility and the possibility of taking observations for longer periods during summer seasons makes it attractive for extensive study. In the present study Thematic Mapper Satellite Imagery taken in the month of October when the Glacier is fully exposed in analysed and interpretted for various features of Kolahoi and nearby Musa Sabin Glaciers. The required Glacier parameters are then calculated. This process can be extended to other Himalayan Glaciers which many times are inaccessible and Glaciers Inventory can be prepared. Such an Inventory will greatly help in proper water resources planning.

PROCESS STUDIES IN FOREST HYDROLOGY : A WORLDWIDE REVIEW

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An important step in testing of a hypothesis in forest hydrology can involve the use of process studies, in which "cause-and-effect" information is obtained through the use of small, homogeneous plots which are isolated under controlled conditions. Process studies have been utilized in water balance investigations, precipitation-runoff evaluations, and analyses of the effects of vegetative management practices on water regimes. Results of

these studies can indicate a need to "follow up" on a larger scale, such as catchment experiments. Process studies also are formulated to obtain a better "cause-and-effect" understanding and a basis for subsequent interpretations of results obtained from catchment experiments. It is frequently suggested that process plot studies be used to complement catchment experiments as a framework for research in forest hydrology. To illustrate the "hydrological value" of process studies in forest hydrology, a cross-section of investigations that have been conducted in three "geographical-climatological" regions of the world is presented in this paper. Water balance components considered in this review are interception, evapotranspiration, and infiltration. Investigations in temperate regions, humid tropical and subtropical forests, and drylands that estimate quantitatively these components in a water balance are considered. It is impossible to review all of the research efforts in this paper. Nevertheless, the review and summary presented is illustrative of the "breadth and depth" of process studies in forest hydrology in many countries. Importantly, findings obtained from these studies have been, and continue to be, extrapolated to larger water supply basins and incorporated into operational watershed management practices.

WATER QUALITY - A REMOTE SENSING PERSPECTIVE

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There are some uses of water, such as navigation, where the quality is obviously a minor consideration. At the other end of the spectrum, water which moves through a distribution network for human consumption must be of the highest quality. Lake and river water quality may be degraded due to various factors such as point - source water pollution (such as domestic and industrial effluents to lake or river), non-point source (such as sediment run off from erosion prone waters agro-based chemical pollutants from irrigated crop land draining etc.,). Surveilance of water quality is an important activity for both maintenance of public health from water supplies and for the protection of aquatic environments. Water quality standards have been laid out through water pollution control act by Govt. of India which are supervised by State and Central Pollution Control Boards.

Remote sensing of water quality is of very recent origin and is still in experimental mode. The water quality parameters which may be possible to be recognised by remote sensing techniques are water colour, water depth, turbidity, eutrophication, water surface temperature etc., while qualitative nature of these information may be obtained by analysing the spectral response of water in the visible, reflective and thermal infrared ranges of the electro-magnetic spectrum. Quantative information requires statistical correlation of these spectral responses with in-situ water sampling. What is attractive about remote sensing of water quality is identifying source areas of water pollution for enforcing regulatory control measures. In this paper, it is demonstrated about Remote Sensing application to the above said aspects with the correlation with in-situ sampling techniques and with detailed field studies.

RELATIONSHIP BETWEEN FOREST COVER AND DRAINAGE DENSITY IN A TYPICAL RAINFOREST : AN INVESTIGATION USING SATELLITE DATA

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The evolution of a drainage basin to its current status is the net resultant of various natural processes acting on its surface. These incessant forces involve flows of matter and energy moving in and out of the basin. Precipitation and insolation are the main sources of inputs of matter and energy into the basin while evapotranspiration, reflectance, infiltration and runoff are the natural output routes. These processes are strongly controlled by a set of variables that include vegetation cover, soil characteristics, slope and lithology of the basin surface. Out of these vegetation cover is of critical importance in more than one way. Its primary effect is in transforming the kinetic energy of the falling water drops into heat by friction which cuts down the transportation capacity of water. Ground surface with sparse or scanty plant cover, for instance, with loose or non-compact soil layer will be subjected to considerable loss of particulate matter and dissolved substances. Thick vegetation on the other

hand, slows down this process promoting infilitration increasing the retention time of water. They also play a critical role in the circulation of matter and energy, geochemicals and sediments, through the earth's biosphere. The development and sustenance of drainage network is the direct manfestation of this influence. A study was conducted to nvestigate the influeace of forest cover on the drainage system development in the tropical rain-forests of Silent Valley on the Western Ghats in Kerala which forms a part of the Nilgiri Biosphere Reserve. Digital data from the Indian Remote Sensing Satellite (IRS-1A, LISS II) in combination with B&W panchromatic aerial photographs formed the database of this work in which a relationship between the Afforestation Coefft. and the Drainage Density of the basin was developed.

GEOMORPHOLOGICAL MAPPING TO STUDY THE PROGRADATION OF CAUVERY DELTA IN THE PALK STRAIT OF TAMILNADU COAST, INDIA

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Satellite remote sensing data are used in geologic and geomorphic mapping of the southern parts of Cauvery and Agniyar river basins of Tamilnadu. The area is covered by alluvium of Quaternary - recent age and the Tertiary lateritic sandstone. It is sub divided into fluvial and coastal geomorphic units as (I) Alluvial plain (2) Natural levee (3) Tertiary up and low lands (4) Erosional surface (5) Coastal plain (6) Beach (7) Crescent beach (8) Beach ridges (9) Swale (10) Swamp (11) Lagoon (12) Spits (13) Extended delta (14) Delta under construction and (15) Off shore bars.

These coastal landforms have been formed over the emergent shorelines due to the aggradational action of the sea waves. These geomorphic units indicate that in the geological past, the area now covered by them should have been occupied by the concave shaped shore margins extending from Manamelkudi to Velankanni in the NE-SW direction where the coast line has developed to its present position in four distinct and successive stages, one after another or simultaneously.

In the remaining portion of the concave shore of the Palk Strait, several small deltas are presently under construction which, perhaps is the fifth stage of the fluvio-Marine landforms under construction. These deltas probably would grow in the Palk Strait in east-west direction parallel to the existing off shore bars.

The present study, through the Satellite pictures clearly indicates, that the Cauvery delta is slowly growing in the Palk Strait, but to predict the periodical growth rate of this delta needs further study by utilising the future multidate satellite pictures for a few seasons.

POTENTIAL OF REMOTE SENSING IN APPLIED HYDROLOGY

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Population growth, extension of irrigated agriculture and intense industrialization are stressing the quantity and quality of water resources globally. Increasingly, the assessment, planning and rational management of water resources requires more and better information on the state of various components of hydrologic systems on a large scale, than ever before. Remote sensing offers a unique approach to fulfil this need. The purpose of the paper is to summarize first the physical principles of remote sensing to provide the basis for understanding the use of remotely sensed data, and secondly to review the most significant applications of remote sensing techniques in hydrology, including estimation of rainfall, runoff, snow cover, soil moisture, groundwater, and water quality.

INTEGRATED USE OF REMOTE SENSING AND GIS METHODS FOR GROUND WATER EXPLORATION IN PARTS OF LALITPUR DISTRICT, U.P.

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Remote sensing provides much of the information that is input to a GIS, from global scale vegetation and climatic data to the ground water exploration. The two technolo-

gies provide complementary capabilities. Remote sensing analyses are improved by the vertification data retrieved from a GIS, and GIS applications can benefit from the information that remote sensing can generate. Often the image data are the most current spatial information available for an area. The use of digital image data offers the additional advantage of a computer compatible format that can be input directly to a GIS.

The present study demonstrates that the integrated use of remote sensing and GIS methods in ground water exploration not only improves the quality of geographic information but also enable information previously unavailable to be economically produced. Integrated use of remote sensing and GIS has also revealed existence of a strong geobotanical relationship in the study area and offers a powerful tool for ground water exploration. In the present study various sets of information layers such as geological, geophysical, topographical, vegetational have been applied along with IRS-1A, LISS-I and LISS-II data for ground water exploration in parts of Lalitpur district.

ROLE OF REMOTE SENSING AND SATELLITE TECHNOLOGY IN HYDROLOGY

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In the existing system of water resources information, data collection and generation for hydrological studies is tedious, time consuming and difficult for remote and inaccessible areas. Under such situations, remote sensing technology in conjunction with the satellite technology can be gainfully used particularly for surveying and monitoring of water resources. This technology integrated with conventional methods is fast emerging as an important and cost effective tool in hydrological studies with an ultimate objective of appraisal of water resources. Remote sensing renders informaton on water resources from orbital platforms through spatial, special and temporal attributes. Through further research and development in this area, remote sensing would be of immense use in updating the existing water resources information and developing a sound data base for hydrological studies in the way to achieve the goal of effective and optimum water resources planning.

A review of the remote sensing and satellite technology being used for various hydrological studies have been presented in this paper.

FOREST INFLUENCE ON HYDROLOGICAL PARAMETERS

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The history of forest influence on hydrological parameters dates back to the thirteen century which led to the evolution of the specific field of forest hydrology. Interest in the forest influences on hydrological parameters increased rapidly in the nineteenth century when Marsh (1863) devoted a long chapter in his famous book "Man and Nature" to forest influences, a term he apparently coined, and thus called attention to the hydrological role of forests.

Following Marsh's alarming descriptions of the evils of deforestation there occurred a "propoganda period" of forest influences in the United States. The public's perception of these influences played a large role in the forestry and conservation movements.

In the late nineteenth century since the foundation of International Union of Forest Research Organization (IUFRO) problem regarding forest hydrology have been main topics of discussions. During the first Congress of IUFRO (1893) terms like 'forest and climate' 'forest and springs' or the influence of forest on water level were used. At the Fourth Congress (1903), the term 'forest water' was established. Afterwards research activities such as 'water balance techniques', 'forest influence', 'forest hydrology' took place quickly all over the world. Forest influences include all the aspects resulting from the presence of forest upon the parameters of hydrological cycle, erosion and climate. The present paper provides an up-to-date review of global works done on the forest influences on hydrological parameters.

SEDIMENTATION STUDIES FOR HIRAKUD RESERVOIR

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The applicability of the Remote Sensing Study to reservoirs was examined for the Hirakud Reservoir on Mahanadi river in Orissa. The imagery maps for the sedimentation in the reservoir was analysed by three methods namely; Planimeter method, Dotgrid method and Graph method. The results obtained by these methods do fairly tally with the results obtained from Hydrographic method of survey taken over years. Therefore to predict the sedimentation in a reservoir the Remote Sensing results can be depended upon fully and the costly method of hydrographic survey can be dispensed with.

Also the method of Inflow-outflow of Sedimentation for the Reservoir was analysed for the years 1957 to 1985. It was found that the percentage of bed load is to the order of 85% to the suspended load instead of the generally assumed value of 10% bed load to the suspended load. Thus this percentage may be suitably increased for different river reservoirs in Indian conditions.

GROUND WATER FEASIBILITY IN BLOCK JAGNAIR, DISTT. AGRA, U.P. — A CASE STUDY OF VISUAL REMOTE SENSING APPROACH

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In this case study an attempt have been made to locate and demarcate the water prone areas, using the most dependable and sophisticated air photo interpretation technique, for the development of various ground water structures, chiefly for irrigation and drinking purposes, in the drought affected and under developed block Jagnair of district Agra, belonging to rocky terrain.

The present study area lies in the western most part of Uttar Pradesh, bounded by latitudes 26°44'30"" to 26°55" N and longitudes 77°23" to 77°45" E falling in the Survey of India Toposheet No. 54F. The study area covers a total of 316 Sq. km. and is located in rocky terrain of Vindyan formation.

For quick and correct appraisal of ground water conditions in the problematic areas of block Jagnair district Agra a programme based on photohydrogeological interpretation was taken up during the year 1992-93. Panchromatic aerial photographs of 1:50,000 scale for the year 1975 were utilized and the following approach has been adopted.

- Interpretation of aerial photographs for identifying the detailed landform features and structural elements.
- Interpretation of field ground water data.
- Integration of remote sensing data with ground information and preparation of ground water potential map.

Geologically, the area is composed with rocks of Vindhyan Super group as well as alluvial sediments of Quaternary age. To decipher the hydrogeology of the area, various geomorphological features have been identified and their hydrogeological setting were studied. The different structural features which control storage and movement of ground water such as joints, fractures, have also been identified. In rocky terrains ground water occurs in localised pockets generally under water table conditions in sandstone formations but in alluvial areas ground water occurs under water table as well as confined conditions. Water table generally rests between 3.00 to 14.00 mts. b.g.1. in the summer season.

The study reveals that the yields from dug wells constructed along the fracture trends and intersections of several fractures/joints in the weathered sandstone formations are appreciably high. It was also observed that ground water propsects are variable in different geomorphic units. Authors have tried to demarcate different suitable zones for construction of ground water structures with variable capacity in the area.

REMOTE SENSING AS A TOOL IN HYDROLOGY AND WATER RESOURCES

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Remote sensing is a relatively newcomer to the arsenal of methods for acquiring hydrological data. It can provide distributed data as opposed to the point data that most models have been designed to use. The recent advances in computational (computer) and measurement (remote sensing) technology have provided an opportunity for implementing new model concepts that could significantly enhance the hydrologic modelling capacity. Remote sensing can also provide input data on landuse, soils, drainage pattern and water features for remote and inaccessible areas which otherwise are cumbersome and tedious task to collect. Remote sensing data due to their synoptic and repetitive coverage are also used in mapping and monitoring the land-water boundary, geomorphic and geologic features, and landuse with respect to consumptive use of water.

This paper attempts to describe the utility of remote sensing data for the extraction of some of the common input parameters required by most hydrological models. Advantages of distributed types models as opposed to lumped models are listed, as remote sensing provides data spatially and temporally. The types of remote sensing data products which can be used in hydrology and water resources such as surface water modelling, snowmelt runoff modelling, soil moisture studies, and landuse and landcover mapping are also given. At the end, the Geographic Information System (GIS) approach is described which provides a new dimension for the storage, analysis and management of large volumes of data required in hydrology and water resources.

UTILITY OF REMOTE SENSING TECHNIQUES IN LANDSLIDE INVESTIGATIONS : AN APPRAISAL

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The conventional methods of landslide investigations are time-consuming and are sometimes extremely difficult due to various problems such as accessibility of the area, weather conditions, field hazards etc. Remote sensing can play an important role in landslide investigations, both in the identification of landslide-prone areas and in the analysis of any specific landslide event. The major advantages of remote sensing technique are the synoptic view offered by the satellite images, studies without risking to field hazards, reproducibility of results, availability of multi-band data, and possibility of enhancement techniques to reveal desired information. However, the satellite data (Landsat, IRS etc.) pose some limitations in landslide mapping due to constraints of scale and resolution.

APPLICATION OF VARIOUS TRANSFORMATIONS FOR LANDUSE CLASSIFICATION IN DIGITAL IMAGE PROCESSING

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The utility of satellite data for multiple earth resources start beginning to unfold the information contained in these data, in the areas, such as agriculture, landuse, water resources, forestry, urban development planning and monitoring, and other allied subjects. The potential of these data for landuse studies had started in recent years and there is notable increase in the acceptance and utilization of Landsat and IRS satellite data for classification, monitoring and mapping the landuse.

With the advancement in digital image processing technique, so many new techniques is coming out and it is very difficult to pre-assume the effect of any particular transformation. Therefore, two frames have been selected, one in plane and another in hills to see the effect of various transformation.

This paper presents the results of the application of various transformation for preparing the landuse classification map by digital image processing technique. The transformation which have been used in this study are ratioing, sum normalisation, principal component transformations and MMI transformations. The GIS/Image Processing System, namely ILWIS has been used to get a classified map. Confusion matrix were prepared to analyse the classification results, and this process was repeated for all the images resulting by various transformations and each time the same checking samples map was used.
