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A Study on Remote Sensing and GIS Application for Water Resources Studies

Dr. Siddharam. S. Hangaragi[1*]

[1] Associate Professor, Dept. of Geography, S.R.N. Arts and M.B.S. Commerce College, Bagalkot – 587101, Karnataka State, India. E-Mail ID : sshangaragi66@gmail.com

Abstract

An important issue in hydrological and water management research is the scarcity of available data, which is particularly true in underdeveloped nations where funding is limited. Remote sensing has shown to be an effective option for water resources management since it delivers geographically and temporally consistent information. For water resources research and management in data-poor locations, this study focuses on remote sensing (RS) and geographic information systems (GIS). RS may be utilized for crop categorization, rainfall and snowfall estimate, soil moisture analysis, surface and groundwater usage, as well as water resources planning and management, when combined with GIS.

Keywords: Remote Sensing, GIS, Water, Resource.

INTRODUCTION

One of the most crucial natural resources and a basic physiological need for all living things is water. Having access to clean water is essential to sustaining life. Due to the constant growth in water emergencies, sustainable water use and development is critical in today's world. Using remote sensing and geographic information systems (GIS) to analyze and manipulate data for water resource development and management is an extremely effective tool. Large and complicated datasets may be

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effectively managed with GIS technology. In terms of hydrological modeling and monitoring, Remote Sensing data is the most useful because of its capacity to create information in both the geographical and temporal domains. The use of GIS and remote sensing technologies has been proven to be effective in reducing the amount of time, effort, and money spent on water resource management while also enabling rapid judgments. When integrated with numerical modeling, geographic information systems, and on-the-ground data, remote sensing data may be quite beneficial. Short version: Both strategies play an important role when it comes to hydrology and the management of water resources.(Tiwari & Shukla, 2015)

Remote Sensing

The term "Remote sensing" refers to the process of gathering information about target area from distance. Measure, monitor, and simulate complex natural, hydrological, and human-made aspects using data collected in a regular sequence and at regional, continental or global scales. Sensors mounted on satellites (and sometimes airplanes) collect pictures that are remotely detected using one of two fundamental methods. In the Passive System, electromagnetic energy reflected from the Earth's surface is recorded. Source of this energy is Sun's radiation. When a pulse is reflected back to the Active System, it is recorded as a signal. In most cases, radars that generate radiation in the microwave region of electromagnetic spectrum are used in conjunction with active remote sensing systems. Images obtained by passive systems are often obstructed by cloud cover since floods occur often during the monsoon season, which is usually always accompanied by a strong cloud cover. When it comes to determining the magnitude of a flood, radar-based devices can pierce cloud cover and provide a clear image.(Kumar & Singh, 2018)

For the purposes of Remote Sensing, it involves collecting data on an item, place, or phenomena without actually touching or being in proximity to it. If we use this definition of "Remote Sensing," a variety of instruments, like as seismographs and fathometers, would fall under the category of "Remote Sensor." Seismographs can assess earthquake intensity even if they are not directly in touch with the earthquake's epicenter. Fathometers, on the other hand, can estimate the depth of the ocean without ever touching it. Modern Remote Sensing, on other hand, refers to collection of data on Earth's land and sea surfaces via the use of electromagnetic radiation that is reflected or transmitted. A better grasp of remote sensing may be gained by looking at the following definitions: A wide range of techniques are included in the field of remote sensing, including the collection, storage, transmission, analysis, and interpretation of images or other types of electromagnetic recordings of the Earth's surface... When it comes to remote sensing, electromagnetic radiation from the target locations in the sensor's range of view must be detected and recorded. The energy reflected from the target area's components, the sun, or the sensor itself may have been the source of this radiation. It's also possible that the sensor itself was the source of this radiation.(Waghmare & Suryawanshi, 2017)

Geographical Information System (GIS)

Usage of Geographic Information Systems (GIS) in spatial mapping combines space science with survey and mapping. It is possible to use the GIS to organize and analyze data as well as to combine and analyze geographical data gathered from numerous sources (field surveys, remote sensing). In past ten years, the use of GISandremote sensing for water resource management has muluplied. Satellites may be used to gather information on the hydrology of an area. Concerning irrigation water issues, high to moderate resolution imagery from satellites provides critical information on diverse hydrological components that may be used to improve water resource management strategies.(Masud & Bastiaanssen, 2017)

'A Geographic Information System (GIS)' is computer software that stores both spatial and non-spatial data digitally. Maps of a region often include spatial information about the area shown. Attributes, another name for non-spatial data, include things like a town or village's population distribution, a road's width or identifying tag, or a river's daily flow at a specific location, among other things. Thus, a Geographic Information System (GIS) is able to store all kinds of data about a certain area in a single computer file. Due to the fact that all information is readily kept and accessible through computer, this is beneficial to any regional planner, including those responsible for the Water Resources Project.(Kumar & Singh, 2018)

Water Resource: Role of GIS and Remote Sensing

Every part of life depends on water, which is one of the most abundant natural resources on the planet. Groundwater, rainfall, and surface water bodies such as rivers, ponds, and lakes are the primary sources of consumable water, but the competition from home, agricultural, infrastructural, and industrial sectors is too great. As the population continues to rise, fresh water supplies are becoming scarcer, although in many places, there is enough water to meet demand. Heavy rain and flooding may occur simultaneously in different parts of the country. Because of the limited availability of natural water resources, it has become necessary to utilize them as efficiently as possible and to distribute subsurface water resources using GIS (Geographic Information System) and satellite remote sensing methods in order to ensure that the needs of each sector are met in a justifiable manner. Furthermore, it is the job of water scientists, hydrologists, and engineers to educate the public about the underlying phenomena, the prevailing ecology, and the interrelationships between the many components. The usage of GIS and Remote Sensing in field of natural resource management and water resource engineering has become more commonplace. GIS is the finest instrument for water resource and flood risk management, presentation, visualization, and publishing education, while remote sensing offers key data sources for mapping water resources and changes.(Kumar & Singh, 2018)

The gathering, compiling, storing, retrieval, and manipulation of geographical data are only some of the time-consuming tasks in water resources modeling before the simulation can begin. When it comes to managing water resources, the geographical aspect of the data is single important component adding to the complexity of data management. GIS software has the potential to revolutionize water resources modeling because of its ability to aggregate a wide range of data into an understandable manner. GIS for water resources challenges begins with acquiring field data, which may be broken down into two steps. Establishing scale and positional linkages throughout the project area is the primary goal of gaining ground control. It's also possible to use photogrammetric location methods on projects that include characteristics that aren't visible from aerial pictures such as inlet casting and the size of culverts and manholes to get the positions and attributes of specific objects in the field. GIS is a helpful and usually vital tool for water-related environmental planning and management. It is used to record, organize, store, and visualize geographical data, as well as to parameterize models. Traditional hydrologic analysis may be enhanced using GIS applications, while other hydrologic datasets can be combined using GIS's integration capability. Stormwater and nonpoint source pollution modeling for urban and agricultural areas are only a few of the many GIS-based applications that have been created in this context, both with and without model interfaces. In the following sections, we'll go through each of these uses in further depth.(Tsihrintzis et al., 1996)

Recent years have seen a tremendous push for use of RS and GIS in natural resource and environmental monitoring. A two-day workshop was arranged in light of this. The main topics of discussion at the workshop were how to use remote sensing and GIS management to look at things like water resources, glacier retreat, groundwater reservoirs, and polluted water resources, if any. They also talked about how to make GIS, DEM, and other hydrological models to look at things like how to protect water resources and how to use them.(Nain, 2014)

"Remote sensing (RS) is the science and art of acquiring information about an item, region, or phenomena by the analysis of data obtained by a device that is not in physical touch with the object, area, or phenomenon under investigation." In the field of remote sensing, data about the Earth's surface may be gathered without ever having to leave the comfort of one's home or office. For this, the energy is gathered, and information is processed and utilized. Objects emit and reflect varying amounts of radiation. Different sensors record the radiation that is emitted or reflected. Various sensors record electromagnetic radiation in a specified range using different types of bands (EMR). Electromagnetic energy underlies all electromagnetic radiation and is reflected differently depending on the surface or item it encounters. The light tones recorded by the sensors are caused by flat surface reflecting more radiation. Because so much of the sun's rays are reflected off the water's surface, the color of the water seems dark. Water resources may be managed and developed using remote sensing data, which can be used to conduct an initial survey quickly. Although only a small number of remotely sensed data may be used directly in hydrology, this information is very valuable since many hydrologically important data can be gleaned through remote sensing. While RS technology may be used to manage vast amounts of geographical data, it is necessary to have a system that is capable of handling big amounts of data efficiently.(Tiwari & Shukla, 2015)

Multiple sorts of spatial data must be handled while conducting water resource evaluation and management operations. We'll need a variety of GIS and simulation model combinations to get a better

handle on these topics.While GIS provides strong new tools for storing and organizing map-related information, simulation models may give interactive analytical tools to assist decision-makers understand the physical system and determine how management actions may effect that system. There will be a variety of GIS applications for water resources. Atmosphere-lithosphere hydrosphere-biospheric systems interplay is at the center of a number of pressing concerns. Because many essential hydrologic processes have local, national,regional, and global aspects, solutions must be able to serve a variety of competing groups of users at the same time. Many basic hydrologic studies are undertaken at particular locations or on tiny plots of land, which makes translating research findings into policy and management initiatives challenging. Several of the management and policy solutions, on the other hand, are targeted at particular watersheds and/or administrative areas, rather than the overall population.(Wilson et al., 2000).

'GIS and Remote Sensing' Application in Water Management in Agricultural Field

Each farm's agricultural fields have specific irrigation needs, which are met by customizing irrigation systems that are installed, maintained, and controlled to meet those needs. In the globe, irrigation accounts for around 70% of all freshwater withdrawals. 17 % of the world's arable land is irrigated, which generates 30% to 40 % of the world's food crops. We must improve our water resource management if we are to satisfy future food demand in a world where water is becoming more limited. Water managers may afford to be careless when supplies are plentiful and pollution and destruction of the environment aren't a concern. In the next century, there will be fewer and fewer areas where we may enjoy this luxury because of the increasing population and the resulting need for water for food, health, and the environment. Good information is needed for management and planning, but trustworthy information on water resources utilization is currently in short supply. When it comes to delivering precise data on anything from individual agricultural fields to vast river basins, it's not an easy process. Agricultural and hydrological conditions over large swaths of land may be monitored regularly using space-borne remote sensing sensors. In the past 20 years, remote sensing and GIS applications have made considerable advances in their capacity to detect and monitor crop development and other biophysical factors, despite the fact that there are still many unsolved challenges. 'Geographic Information Systems GIS' and remote sensing techniques have become increasingly popular tools for irrigation water management because of their ability to acquire and analyze information. Irrigation systems may benefit from GIS's ability to analyze information across time and space.(Taher, 2020)

When it comes to agricultural applications in the early stages of satellite remote sensing, crop types are a significant concentration among those interested in the use of information for land cover classification. Agricultural remote sensing research has shifted emphasis in recent years to better characterize the biophysical features of plants. Agriculture has long been monitored and analyzed using remote sensing. A variety of agronomic characteristics may now be better understood through remote sensing of agricultural canopies. The benefit of remote sensing is its capacity to offer repeated information without the need for damaging sampling of the crop, which may be utilized to provide useful information for precision agricultural applications such as precision planting and crop management. Remote sensing is a cost-effective method for collecting data across huge expanses of land. Satellite remote sensing is mostly employed in India to estimate agricultural crop acreage and output. Based on the biophysical characteristics of crops and/or soils, remote sensing technology has the potential to revolutionize agricultural production measurement. Remote sensing satellite data may be utilized for yield estimates, agricultural phenological information, and the identification of stress conditions and disturbances in crops. For a variety of purposes, remote sensing and GIS may be utilized to build spatio-temporal fundamental information layers that can be used in a broad range of applications including flood plain mapping, hydrologic modeling and surface energy flow. Remote sensing systems have progressed as a result of the development of narrow band or hyperspectral sensors and the increased spatial resolution of aircraft and satellite-mounted sensors. Crop classification analysis has also been enhanced by hyperspectral remote sensing. Data mining techniques such as principle components analysis, lambda–lambda models, stepwise discriminant analysis, and derivative greenness indices of vegetation were used to examine hyperspectral sensors (400 to 2500 nm) for crop categorization. It is common for researchers to use a variety of sensors that can provide quick, accurate data for a fraction of the expense of conventional methods of data acquisition.(Shanmugapriya et al., 2019)

Food and water security are two of most pressing issues confronting many nations. Remote sensing for agricultural water management is a relatively new use of remote sensing, and there have been several breakthroughs in this field over the previous two decades. Satellite data may be used for anything from water usage monitoring to irrigation effectiveness evaluation. Water usage efficiency may be improved by monitoring water consumption at several sizes, most particularly at the basin scale, where water distribution to different sectors occurs. Irrigation uses up a disproportionately large portion of the water available, often as much as 70%. To ensure that water is adequately distributed in a sustainable way, monitoring water availability, irrigation, and consumption at the basin level will be crucial. Many growing and impoverished countries have a shortage of ground-based monitoring systems, which demands regular maintenance. Often from the non-governmental or government sectors, water specialists in these countries lack the requisite experience when it comes to using current remote sensing technologies to extract information from pixels. As a result, it's critical that professionals in this field learn how to better use GIS technologies for agricultural water management. Short courses or customized trainings based on the "pixel for people" concept must be extensively disseminated in order to encourage these capacity development initiatives. Adoption of the project and networking with partners accelerate the impact of educational activities in a short period of time.(Karimi et al., 2018)

Conclusion

Natural resource management may be done quickly and cost-effectively using 'Remote sensing and GIS' techniques. Additionally, remote sensing data are key resource for groundwater exploration and management. In hydro-geomorphological research and the delineation of land features, remote sensing data may be used to a degree that can be reasonably precise. The use of remote sensing for ground water

monitoring is not feasible. An indirect investigation of certain immediately seen terrain elements such as geological or geomorphic structures and their hydrologic characteristics of lithology, hydro-geomorphology or lineament is used to identify and locate groundwater occurrences. The systematic observation and analysis of groundwater potential zones is made possible by the integration of satellite remote sensing data into a 'Geographic Information System (GIS)'.Remote sensing methods may also be used to monitor water quality, at least to some degree. (i) the investigation and assessment of groundwater resources and potential zones; (ii) the application of RS and GIS methodologies for data collecting and analysis in the field of groundwater hydrology. (iii) GIS-based modeling of subsurface flow and contaminants, which includes the selection of artificial recharge areas. The rising potential of RS and GIS technologies, which will enhance and standardize present applications as well as develop into new techniques and uses in the future, necessitates more applied groundwater research; this research must be conducted in combination with field studies. Groundwater monitoring and management might be transformed by the use of remote sensing technology, which can provide new and unique data to supplement existing field data. It is thus necessary to use remote sensing and GIS tools to manage and enhance the research area's groundwater potential.

Because software and computer technology are always improving, geographic information systems (GIS) software can manage massive volumes of satellite data sets in a user-friendly window-based interface. The fact that satellite photos can be incorporated into geographic information systems (GIS) makes the process much easier to complete. GIS and remote sensing may be used to effectively address water resource engineering issues that span wide regions. It has become easier to deal with issues in real time because of the availability of frequent time-based data. As a result of these factors, GIS and remote sensing are becoming more popular among hydrologists as well as water scientists and managers. It's clear that GIS and remote sensing technologies will be more useful in the future when it comes to water resource management issues of all kinds.

Water consumption habits are changing as a result of increasing demand on limited water supplies. Long-term plans must be developed and rethought in order to face problems. Legislation and policies are used to accomplish strategic or long-term planning. The strategic use of water requires knowledge of irrigated regions, agricultural patterns, evaporative usage, and past water use. Ground-based information is generally based on design data rather than real data. However, studies on irrigated regions derived from remotely sensed data and geographic information systems (GIS) applications show greatest results, while AUTOCAD may also be utilized to design the irrigation strategy in certain cases.

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