Application of GIS in Environmental Management

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Abstract—*Environmental management is innately a spatial venture. Its data are particularly complex, varied and dynamic with two components which are, the accurate location of what is being described, as well as a clear account of its physical characteristics. From ancient times, explorers produced manually drafted maps which served to association the "where is what" .*

Today maps have evolved from exploratory guides of the world to into management tools for understanding, analyzing and knowing spatial relationships. This new outlook marks a turning point in the use of maps, setting the stage for a paradigm shift in environmental planning and management.What has changed is the purpose for which maps are used. Modern mapping systems provide a radically different approach to addressing complex environmental issues. Hence GIS can act as a powerful tool in virtually collecting , handling , assessing and visualizing the space data and cater to the need of the environmental managers. An understanding of the evolutionary stages of the new technology, its current expression, and probable trends are essential for today's environmental policy-makers and administrators.

This paper will present details on the applicability of GIS in Land use and Land cover change , Climate activity with focus on ozone depletion and Emergency response systems with pivot being the Cyclone warning system by the Indian Meteorological Department (IMD) and Forest Fire warning system by Forest Survey of India (FSI).

Keywords*: GIS, Environment,Management,Data,Climate*

1. INTRODUCTION

Geographic information system is used to sustain and distribute information to environmental managers and the public. GIS allows the arrangement and inquiry of multiple layers of spatial data including environmental data. The environmental application areas of GIS are diverse in requisites of prospective users, environmental spheres etc. GIS is a powerful technology that allows a virtually unconstrained amount of information to be allied to a geographic location. GIS allows a user to witness locations, procedures, features, and environmental changes with extraordinary precision, screening layer upon layer of information such as environmental trends, soil stability, pesticide use, migration corridors, hazardous waste generators. GIS is a great tool for environmental data investigation. It allows better presentation and understanding physical features and the relationships that influence in a given critical environmental condition GIS also helps in managing the environmental hazards and risks. In order to plan and supervise the environmental problems, the assessment of hazards and risks becomes the foundation for planning decisions and for mitigation activities

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Responsible and successful environmental management is necessary for protecting and restoring the natural environment. The interdependency of the earth's ecosystems and the human impact on the environment present complex challenges to governments and businesses as well as scientists and environmentalists in every discipline .GIS can be used as a strategic tool to automate processes, transform environmental management operations by garnering new knowledge, and support decisions that make a profound difference on our environment. GIS is considered enterprise if, by design, it is part of the overall information technology architecture of the organization. GIS can be integrated with most standard corporate systems such as work management, customer service, and reporting systems. Both GIS functionality and data accessing ability can be embedded directly into other agency applications. GIS workflow applications simplify and automate procedures within environmental management operations, resulting in improved efficiency and significant time savings about the environment. Applications of GIS in environmental management outlines the ways that GIS is fulfilling the need of humanity to better manage, protect, and preserve the environment.

2. LANDUSE/ LAND COVER CHANGE

Changes in land use can be categorized by the complex interaction of structural and behavioral factors associated with technological capacity, demand, and social relations that affect both environmental capacity and the demand, along with the nature of the environment of interest. Ecologists pay considerable attention to the land use change impacts predominantly with respect to its effects on biodiversity and aquatic ecosystems . Changes in the land use in a watershed can affect water quality and supply. For instance, land use patterns change due to watershed development frequently resulting in increased surface runoff, reduced groundwater recharge and transfer of pollutants. Thus, the evaluation of land use patterns and their changes at the watershed level is crucial to planning and management of water resources and land use of the particular watershed. Analysis of detected change is the measure of the distinct data framework and thematic change information that can lead to more tangible discernment to underlying process involved in upbringing of land cover and land use changes .Change analysis of features of Earth's surface is essential for better understanding of interactions and relationships between human activities and natural phenomena. This understanding is necessary for improved resource management and improved decision making.

Study Area

Karnataka is situated 11°30' North and 18°30' North latitudes and 74° East and 78°30' East longitude. The peak point in Karnataka is the Mullayanagiri hill in Chikkamagaluru district at an altitude of 1,929 meters (6,329 ft) above sea level. Karnataka has a total land area of 1,91,791 km² that accounts for 5.83% of the total area of the country. With a surface water potential of about 102 kilometers, Karnataka have about six percent of the country's surface water resources. Around 60% of this is provided by the west flowing rivers while the remaining comes from the east flowing rivers. There are seven river basins in all formed by the Godavari, Cauvery, Krishna, the west-flowing rivers, North Pennar River, South Pennar, and Palar

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Area Under Forest

Karnataka's geographical area of 191,791 sq. km. constitutes 5.83% of India's area. Forest accounts for the second largest land use after agriculture. As per Annual Report of 2014-15, the total forests cover in the state is 43,356.47 sq.km. Thus, about 22.61% of the State's geographical area is under forest cover The estimates of Forest Survey of India (FSI 2013) on the basis of satellite data show that the recorded forest area of the State is 38,284 sq.km, which is lower than the State's estimates. Thereby, about 19.96% of the geographical area is under forest cover The estimation of forest cover, classified on the basis of forest canopy density, shows that the State has 1,777 sq. km of very dense forest, 20,179 sq. km of moderately dense forest and 14,176 sq.km of open forest. District wise forest canopy density estimates along with the changes.

Data Used

Data primarily obtained from ISRO image analysis. The study comprises of analysis land use land cover change. The data is of year 2005-06 ,2013-14 to 2015-16. In 2005-6 the total agricultural crop land was 51.37%,forest evergreen 5.26%, built-up urban 1.21%.in 2012-13 the total agricultural crop land was 58.19%, forest evergreen 5.23%, built-up urban 1.34%The detail are given in table 1 and Fig. 1. From the following data it is therefore understood that there is a significant change in agricultural area as well as built-up area. Rapid expansion of urban area and increase in agriculture area by rapid conversion of forest land into agriculture.

Land cover land use of Karnataka 2005-2006

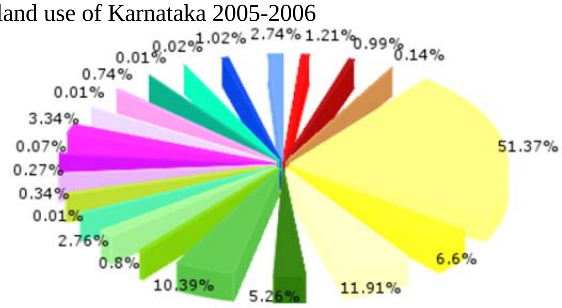

Fig. 1
Annual report 2014-15 of Karnataka Forest Department

Table 1: Landuse/landcover map of Karnataka

Sl. No	Legal Status	Area (Sq. Km.)	% age of geographical area
1	Reserved Forest	29,688.37	15.41.858
2	Protected Forest	3,540.07	0.03
3	Village Forest	49.50	5.23
4	Unclassified Forest	10,024.91	0.03
5	Private Forest	54.07	22.61
Total		43356.47	22.61

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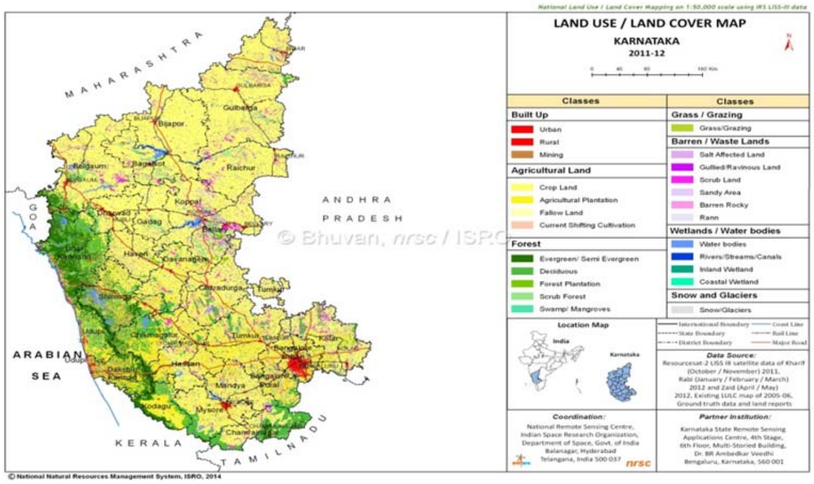

Fig. 2

3. TRACKING CLIMATE CHANGE BY GIS

Earth's average temperature has risen by 1.5°F over the past century, and is predictable to rise another 0.5 to 8.6°F over the next hundred years. Small changes in the average temperature of the planet can transform to large and potentially hazardous shifts in climate and weather. Rising global temperatures have been accompanied by changes in weather and climate. Many places have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more recurrent and severe heat waves.

Monitoring Ozone depletion

Today, there is pervasive concern that the ozone layer is deteriorating due to the release of pollution containing the chemicals chlorine and bromine. Such deterioration allows large amount of UV rays to reach Earth, which cause skin cancer and cataract in humans and impairment of animals as well.

The ozone layer that is above the Antarctic is being impacted by the pollution since the mid-1980s. This region's low temperatures fuel up the conversion of CFCs to chlorine. In the southern spring and summer, the sun shines for longer period of the day, chlorine reacts with UV rays, destroying ozone on a massive scale, up to 65 %. This is what some people refer to as the "ozone hole." In other regions, the ozone layer has been deteriorated by about 20%. About 90% of CFCs currently in the atmosphere were emitted by developed countries in the Northern Hemisphere, counting the United States and Europe. These countries prohibited CFCs in 1996, and the amount of chlorine in the atmosphere is declining now. But scientists estimate it will take another 50 years for chlorine levels to return to their normal levels.

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Ozone Hole Images From NASA

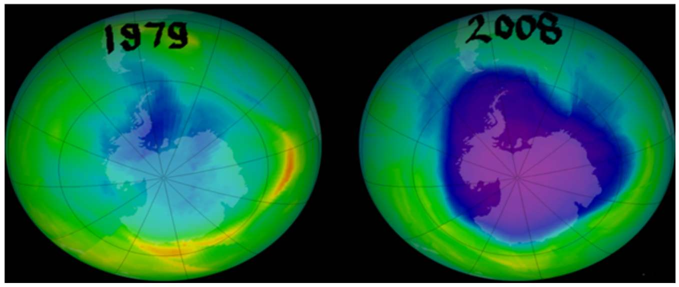

Fig. 3

NASA's Ozone Watch provides the latest imagery and data on global ozone, plus facts on how ozone affects our atmosphere. NOAA uses satellite, airborne and ground-based systems to constantly supervise stratospheric ozone and the chemical compounds and atmospheric surroundings that have impact on its concentration. NOAA's Earth System Research Laboratory: Chemical Sciences Division, Earth System Research Laboratory - Global Monitoring Division, Climate Prediction Center and the National Climatic Data Center are dynamically involved in monitoring and research, which enhances the scientific perception of ozone and the processes that affect its concentration in the stratosphere. The main satellite that monitors the ozone layer is the TOMS (Total Ozone Mapping Spectrometer) satellite. The TOMS satellite measures the ozone levels from the back-scattered sunlight in the ultraviolet (UV) range. Another satellite is NASA's UARS (Upper Atmosphere Research Satellite) which was launched in September 1991. This satellite is unique because it was configured to not only measure ozone levels, but also levels of ozone-depleting chemicals. GOME, launched in April 1995 on the ERS-2 satellite, marked the beginning of a long-term European ozone monitoring effort. Scientists receive high quality data on the global distribution of ozone and several other climate-influencing trace gases in the Earth's atmosphere. Another satellite is NASA's UARS (Upper Atmosphere Research Satellite) which was launched in September 1991. This satellite is unique because it was configured to not only measure ozone levels, but also levels of ozone-depleting chemicals.

4. EMERGENCY RESPONSE SYSTEM

The ERS provides a participatory, well structured, multi disciplinary, multi departmental and systematic approach to guide administrative mechanisms at all levels of the government. It also provides scope for private sector, NGOs, CBOs, PRIs and communities to work seamlessly in the response activities.

Cyclone Warning System

The radar can be utilized to find out the location of the cyclonic storm more accurately when the system comes within radar range. A network of conventional Cyclone Detection Radars (CDRs) has been established at Kolkata, Paradip, Visakhapatnam, Machilipatnam, Chennai and Karaikal along the east coast and Goa, Cochin, Mumbai and Bhuj along the west coast.

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These conventional radars are being phased out and replaced by Doppler Weather Radars (DWRs). Doppler Weather Radar (DWRs) provide vital information on radial velocity from which wind field of a tropical disturbance in the reconnaissance area of DWR can be derived. Number of derived parameters helpful for cyclone monitoring and forecast are also available from DWR.DWR have already been installed and made operational at Chennai, Kolkata, Visakhapatnam and Machilipatnam. An indigenously developed DWR Radar by Indian Space Research Organization (ISRO) has been installed at Sriharikota . IMD is the nodal agency in India for providing cyclone warnings through its Area Cyclone Warning Centres (ACWCs) at Kolkata, Chennai and Mumbai and the Cyclone Warning Centres (CWCs) at Visakhapatnam, Bhubaneswar and Ahmedabad.Data resources are vital to early forecasting of cyclones. Satellite based observations are being broadly utilized. Satellite incorporated automated weather stations have been installed on islands, oilrigs and exposed coastal sites. Buoys for supplementing the surface data network in the tropical ocean have been deployed. The Government has also started a National Data Buoy Programme. A set of 12 moored buoys have been deployed in the northern Indian Ocean to make available meteorological and oceanographic data. Active forecasting of tropical cyclones requires knowledge of the vertical structure of both the Cyclone and the adjoining surroundings. INSAT imagery is used to categorize and locate diverse stages of the cyclone and to estimate the intensity and position using objective Dvorak Technique. The Dvorak technique is based on the assessment of cloud patterns in visible and infrared image

1999 Super Cyclone in Odisha in the form of INSAT data

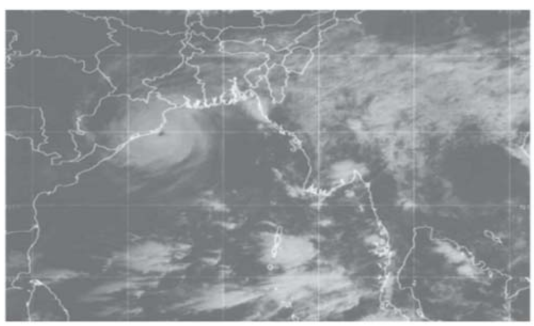

Fig. 3

The cloud patterns obtained from INSAT for the Orissa Super Cyclone is shown in **Fig 3** wherein the eye of the cyclone is evidently seen. A quasi-lagrangian model (QLM) is used by IMD for cyclone track forecast. The model provides track forecast up to 72 hours in advance.

Forest Fire Warning System

Fire is most reoccurring disasters that is posses threats to the forests and the ecosystem all over the world. Fires have adverse effects on soil, forests and human property. All through the process of burning, the soil nutrients are reduced and the soil is left at risk making it more

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susceptible to both soil and water erosion. The forest cover is severely reduced due to the burning of tree species. On average about 50-60% of fires occur yearly and the largest incidences of the fires are due to anthropogenic actions. According to a report it was explained that since 1981 to present time fires have occurred thousands of times and millions of hectares of forests have been damaged and became exposed to erosion .Therefore, it is indispensable to have accurate and suitable knowledge of the total area burned and the type of forest burned in fire. GIS can play an important role in detecting burnt forest and developing a spatial model to predict potential forest for fire.

As per the latest status of forests report of the **Forest Survey of India** the real forest cover of India is 19.27% of the geographic area, equivalent to 63.3 million ha. Only 38 million ha of forests are well stocked . This reserve has to meet the demand of a population of 950 million people and around 450 million livestock. As such, country has to meet the requirements of 16% of the world's population from 1% of the world forest resources. The same forest has also to cater for the 19% of the world livestock population.

The forests of India are under enormous pressure because forest fires is a foremost cause of diminishing of India's forests. While statistical data on fire loss are feeble, it is estimated that the proportion of forest areas prone to forest fires annually ranges from 33% in some states and above 90% in other. About 90% of the forest fires in India are caused by human activities . The normal fire season in India is between the month of February to mid June as country witnessed the most severe forest fires in the recent time during the summer of 1995 in the hills of Uttar Pradesh & Himachal Pradesh. Around 677,700 hectare of area was destroyed According to Forest Survey of India, 50% of the forest areas as fire prone. Very heavy, heavy and frequent forest fire damages are noticed only over 0.8%, 0.14% and 5.16% of the forest areas respectively. Thus, only 6.17% of the forests are prone to severe fire damage. In the absolute term, out of the 63 million ha. Of forests an area of around 3.73 million ha can be presumed to be affected by fires annually.

Fire location in India

Data obtained from MODIS satellite from 19,20,22 march 2017 it is clearly understand that the fires in Indian forests are very frequent and with the help of GIS and satellite imageries it is helpful to detect the fire location and in turn a signal is sent to affected area under 20 minutes of time period.

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Fire Locations For Corresponding Dates

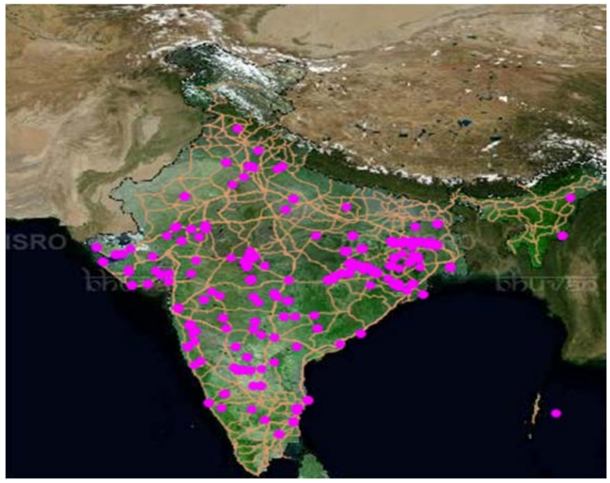

Fig. 4

5. CONCLUSION

This paper was an example of how the GIS is being used in the field of environmental management focusing on few topics of concern . From this paper it can be concluded that the GIS is and will continue to act as a pioneer technology in the field of environmental management .The landuse/landcover change becomes very evident by he analysis of data in the GIS.The ozone depletion phenomenon is being monitored accurately and closely and the policies are formulated to reverse it accordingly .Furthermore the emergency response systems used in India namely cyclone warning system and forest fire warnings have acted as the boon for the stakeholders as they now can prevent and minimize the damage caused by both these disasters. Therefore GIS can be used for environmental management for achieving sustainable development.

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