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Application of GIS for Resource Mapping and Planning of Environment: A Case Study of Bina Village, Takula Block, District Almora, Uttarakhand

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Abstract

The purpose of this paper is to explore the prospective of GIS technology in resource mapping and planning of environment. Since the industrial development we have rapidly extracted earth's natural resources at an excessive amount which causes severe damage to our natural environment and threatened our future survival. The high potential of GIS along with Remote Sensing, GPS, and Computer Cartography, facilitates better and efficient management for resource mapping and environmental planning and also offers us to achieve our goal of Sustainable Development. This paper exemplifies the applications of GIS for resource mapping and planning of environment sectors like Forest management, Soil management, Wildlife management, Water resource management, Water pollution, Air pollution and Climate Change etc. Comparison to traditional methods GIS technology offers accuracy, quick analysis, easy up-gradation, simple access and management of huge volume of data which finally helps planners and decision makers for better and efficient decision making.

Keywords: GIS, Remote Sensing, Sustainable Development, NRM, Climate Change.

Introduction

Since the evolution, we are utilizing earth's recourses for different purposes (Social and Economic development) which are totally different from other creatures found on the earth. However since the 'Industrial Revolution' in mid 1700s till today we have seen drastic changes in our environment, between this period we did immense Social and Economical development without thinking about the consequences which we may have to face in the future. In the late 20th century, governments and policy makers started realizing problems related to Natural Resources Conservation and Energy Requirements; they were not able to fulfill all the increased demands of their citizens, and finally they started thinking about efficient Natural Resource Management (NRM). So, in 1987 a report of *Brundtland Commission* was published by oxford press which stated about "Sustainable Development".

Geographical Information System (GIS) technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. Map making and geographic analysis are not new but a GIS performs these tasks faster and with more sophistication than do traditional manual methods. In addition accessibility, management, up gradation, is very easy in GIS which helps better planning and management of natural resources i.e. Forest, Water, Soil and Wildlife etc. For efficient management and planning of natural resources we should have adequate information of the region such as identifying the right areas, monitoring the activity, assessing the results etc. In addition GIS key feature provides predictive analysis, by which the likely impacts of developments can be assessed before any change in the real environment is made. This facility is powerful since it allows various scenarios to be played out and options evaluated.

This paper will exhibit the use of GIS, Remote Sensing, GPS and Computer Cartography for planning on natural resources conservation, development and management and to move towards sustainable development to save the Earth for better future.

Forest Management

Remote sensing and GIS were taken as tools and techniques for identification, mapping, monitoring and evaluation of all forest vegetation types and land cover categories. The digital database layers of concerned bio-physical parameters were integrated, analysed and modelled under GIS domain for developing the eco-restoration strategy. Forest degradation is a global problem. Accelerated conversion of forests with rapid industrialization and urbanization, intensive agriculture, over-exploitation, overgrazing, mining and other human activities have resulted in the degradation of both the land and water resources. Eco-restoration which means treatment of degraded ecosystems is a key component of a broader subject of Sustainable Development. Satellite remote sensing and GIS has emerged as a vital tool in understanding and

monitoring the spatial and structural changes in vegetation and other earth surface features (Pant and Kharkwal, 1997; Pant and Singh, 1992).

Forests are ecological as well as socio-economic resource. These have to be managed judiciously not only for environmental protection and other services but also for various products and industrial raw materials. Forests play an important role in the country's ecological stability and economic development. Multispectral and Hyperspectral satellite images can provide detailed information about the forest resources, the advanced Image processing technologies provides such kind of information which we cannot collect by manual methods e.g. Vegetation health assessment, Temporal change assessment.

GIS application in Forest Resource Management Includes:

a) Forest type and density,
b) Vegetation Inventory,
c) Lidar based tree delineation
d) Biomass estimation,
e) Identifying degraded sites,
f) Vegetation Health assessment,
g) Timber resource assessment,
h) Forest Fire management, and
i) Calculating Temporal changes etc.

Illustration: NDVI (Normalized Difference Vegetation Index) of Bina village based on Landsat ETM+ data (Fig.1). NDVI is a simple formula using two satellite data bands IR and NIR.

$$NDVI = (NIR - IR)/ (NIR + IR).$$

The reason NDVI is related to vegetation is that healthy vegetation reflects very well in the near infrared part of the spectrum. Green leaves have a reflectance of 20 percent or less in the 0.5 to 0.7 micron range (green to red) and about 60 percent in the 0.7 to 1.3 micron range (near infra-red). The Infrared channel gives you some degree of atmospheric correction. The value is then normalized to the range -1<=NDVI<=1 to partially account for differences in illumination and surface slope. NDVI provides a crude estimate of vegetation health and a means of monitoring changes in vegetation over time. The possible range of values is between -1 and 1, but the typical range is between about -0.1 (NIR less than VIS for a not very green area) to 0.6 (for a very green area).

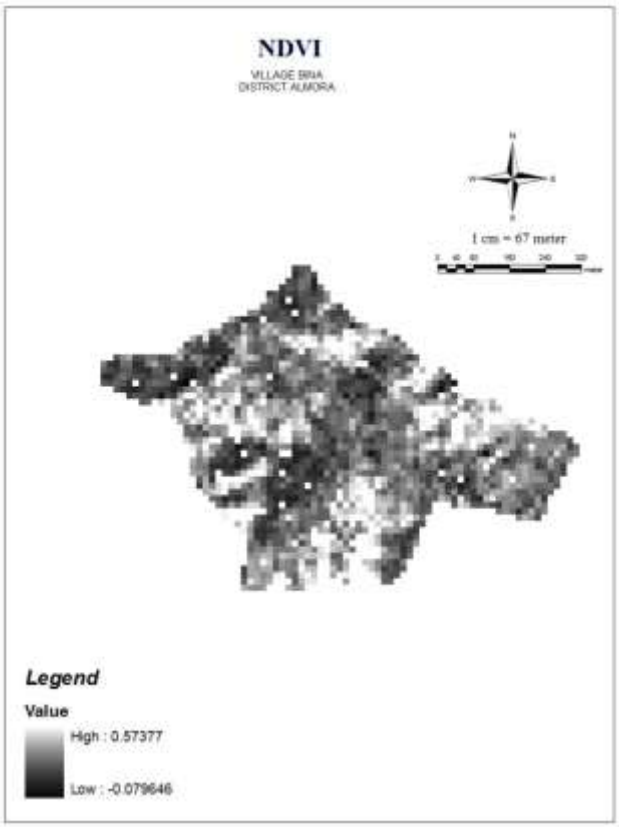


Fig.-1: NDVI of Bina village, Takula, Almora

Water Resource Management

Water is one of the most essential materials in daily life is becoming limited due to various reasons including vanishing glaciers, higher rates of runoff, uneconomical use, over exploitation of the surface resources, land use patterns change, deforestation and lack of interest in public. It is very important to understand the water dynamics for managing the data at basin level and analyzing the data correlation between the various sectors in the basin, GIS has been found to be an effective tool. People have varying goals and values relative to use of local land and water resources, which need to be properly managed.

Water Resource Management is a process of integrated decision-making regarding uses and modifications of lands and waters especially in the Watershed. This process provides a chance for decision-makers to balance diverse goals and uses for environmental resources, and to consider how their cumulative actions may affect long-term sustainability of these resources. Watershed management requires use of the social, ecological, and economic sciences. Common goals for land and water resources must be developed among people of diverse social backgrounds and values. The decision process must also consider the economic benefits and costs of alternative actions, and blend current market dynamics with considerations of long-term sustainability of the ecosystem.

GIS application in Water Resource Management Includes:

- Watershed and Hydrological modeling,
- Rain water harvesting and Artificial recharge areas,
- Site suitability analysis for Reservoir construction,
- Aquaculture,
- Irrigation,
- Household water supply,
- Water based Tourism development, and
- Flood Management etc.

Government of India has an ambitious plan to join all the rivers of India; in this regard GIS can help the government and Ministry of water recourses to achieve its goal.

Illustration: The water resource map based on Google image and reveals that the village is rich in water resources. In the north-eastern part this is a perennial stream which flows in the north to north east direction. Apart from that the village is drained by one non-perennial streams. There are as many as three tradition drinking water sources known locally as "naula" which are used for drinking water and two "dharas". There are 5 stand posts and in the village at different sites also there is 1 "gul" on the northern eastern part of the village (Fig.- 2).

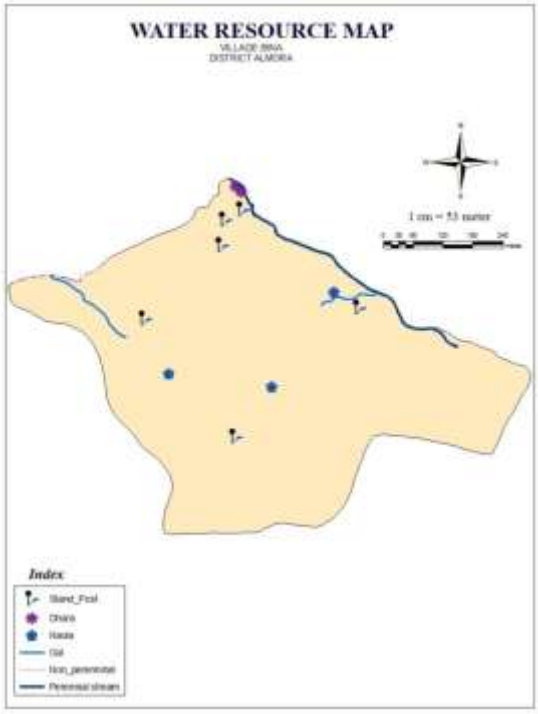


Fig.- 2: Water resource map of Bina village, Takula, Almora, Uttarakhand.

Soil Management

Soil management is very necessary for our agricultural development and also to protect our forests. Now day's high resolution Remote Sensing Images provides several details related to soil, which makes our soil survey very easy and cost effective. Soil survey data can be used in the development of Agriculture, Irrigation purposes, Forestry, and several engineering purposes etc. Land capability, soil irrigability and soil suitability classifications are made based on the soil survey interpretation. Based on the interpretation the potentialities and limitation of the soils can be obtained and such information is used to construct database using GIS.

Soil degradation is the resultant of interplay between watershed environmental factors such as soil topography, drainage, rainfall and land-use pattern, which are available from different sources. In order to study soil erosion, it is important to integrate these data. GIS is the most effective and viable tool for considering the interaction between the spatially distributed resources. By combining useful data via GIS, the watershed resources of soil, land- use, slope, rainfall distribution, drainage buffers and soil erosion model can be created. In addition the multi-disciplinary expertise, the knowledge of the local terrain parameters and field observations assist better decision making.

GIS application in Soil Management Includes:

- Mapping of Soil type, texture and moisture,
- Degraded Soil sites mapping
- Precision farming
- GIS based mapping and Modelling of Soil Erosion
- Monitoring Landuse/Landcover changes
- Farmers and GIS
- Landuse/ Landcover mapping,
- Land Information System
- Thematic Maps.

Illustration: The spatial distribution of Landuse pattern is presented (Fig.-3) and the details of area under different Landuse categories is registered in Table-1.

Table reveals that a 14% of the village is (52615m^2) is being used for cultivation of different crops like, rice, wheat, maize, pulses and vegetables etc. while 30% area (112658m^2) falls under barren condition. Forest covers about 54% (203811m^2) area of the village. The remaining part of the village covered by settlement 1% (3296m^2) and road 1% (1962m^2).

Table- 1: Distribution of area under different landuse categories of the village Bina,

Land use categories	**Area**	
	in m^2	**in %**
Forest Land	203811	54
Agriculture land	52615	14
Barren Land	112658	30
Settlement	3296	1
Road	1962	1
Total	**374342**	**100**
		Source : Study

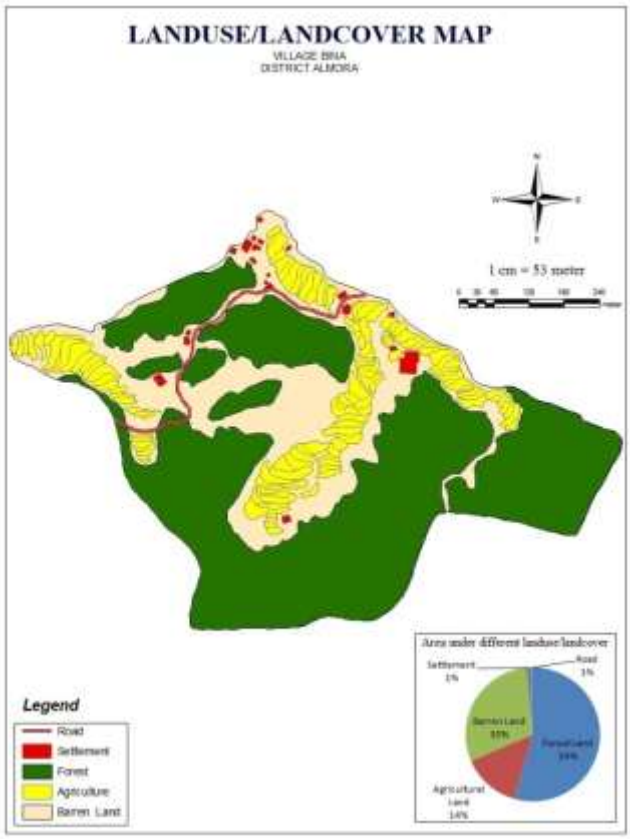


Fig.-3: Distribution of area under different land use categories of the village Bina, Takula block, Almora district, Uttarakhand.

Wildlife Management

Worldwide, Remote Sensing, GIS and GPS is being used to solve problems associated with wildlife management. From calculating existing wildlife densities, assessing sustainability of habitat for wildlife populations, to evaluating human impact on the wildlife and land, GIS can prove to be an invaluable tool.

GIS can be used to create a computer model of the wildlife habitat. The natural environment of animals is modelled in a GIS by the use of spatial databases, in which species, habitats and all other factors can be stored. Equipped with comprehensive databases and geographical query, analysis and presentation function the GIS forms an environmental management support tool. With GPS we can do real time monitoring of wild animals which helps us to protect endangered species.
GIS application in Wildlife Management Includes:

- Habitat demarcation,
- Real time GPS tracking,
- Wildlife density calculation,
- Wetland protection etc.

Pollution

Pollution is the introduction of a contaminant into the environment. It is created mostly by human actions, but can also be a result of natural disasters. Pollution has a detrimental effect on any living organism in an environment, making it virtually impossible to sustain life. The pollution level throughout the world is increasing at a rapid rate and the responsible factors are burning fossil fuel, population explosion, urban growth etc. To overcome from this danger GIS technology can be very helpful. With Remote Sensing and GIS we can quickly identify the major polluted areas and other information which will make the mitigation process easier.

a) **Air Pollution:** Unfortunately in India, no serious efforts have been made to accurately determine the emission factors for different categories of in-use vehicles as a function of vehicle speed, engine technology, fuel quality and age of the vehicles. Various researchers had used emission factors, which were obtained from limited experimental data on chassis dynamometer under laboratory conditions or directly adopting emission factors which are applicable to European vehicles.

b) **Water Pollution:** Contamination of drinking water has become a major challenge to the Environmentalist in the rapid developing countries. A GIS based water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is

to turn complex water quality data into information that is understandable and useable by the public. Water Quality Index (WQI) based on some very important parameters can provide a simple indicator of water quality, it gives the decision-makers and public a general idea of the possible problems with water in a particular region. The WQI, has twelve physico-chemical parameters namely ph, Conductivity, Turbidity, Total hardness, Mg hardness, Ca hardness, TDS, Chlorides, Alkalinity, Sulphate, Nitrates, and Iron. (Veerabhadram. K)

c) **Soil Pollution:** Soil pollution is mainly caused by solid waste generated by households, commercial establishments and industrial or agricultural waste. Household solid waste management is the biggest issue in this concern and rapidly growing population is increasing soil pollution. GIS site suitability analysis can provide us the facility to find out the best site for waste management. With GIS we can also identify the major polluting localities or industries, so the government or concern authorities can take action against them.

d) **Noise Pollution:** Noise pollution is also a serious concern in the urban areas. Education institutes, Hospitals are badly affected with noise pollution from Vehicles, Air traffic etc. Here GIS helps to find out the Education institutes and Hospitals etc so we can demarcate buffer zones around these buildings to reduce the pollution effect.

e) **Ground water pollution:** Ground water quality pollution is a serious concern in India majority of our rural population is affected by contaminated drinking water. Sewage, Landfill sites, chemical Industries, Oil refineries are mainly responsible for Ground water pollution. Remote Sensing and GIS can be very useful to identify the Ground water pollution areas and its management.

Climate Change

To analyze environmental change, change-detection technologies that use multi-resolution and high resolution satellite is very useful. GIS based strategy and methodology for revealing global and local environmental change. In the pre-processing step, we performed geometric correction using satellite, auxiliary, and training data and created a new classification system. We also describe the available technology for connecting global and local change-detection analysis.

Application of Remote Sensing and GIS In Global Warming:

a) **Earth Observation:** Satellite sensors with different spectral ranges and spatial resolutions regularly record the state of the earth's surface. EOS & GEOS satellite studies our planet's ozone, air quality and climate. Like ***Landsat, IRS Series, QuickBird, OrbView, Cartosat, Geoeye, SPOT and WorldView*** etc.

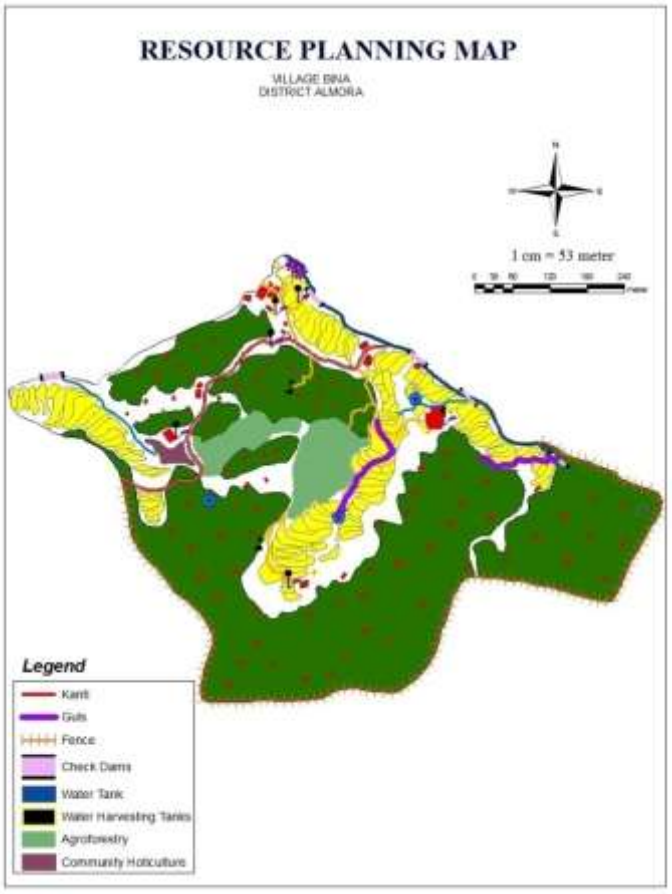
b) **Coastal Ecosystem Management:** Detailed mapping of coral reef geomorphology and other coastal habitats, monitoring historical and recent changes in coastal ecosystems is now possible with Hyper-spectral satellite images. We can examine the growth and health and other temporal changes with the help of advance GIS and Image processing technologies.

c) **Urban Heat Detection:** Urban areas behave as heat islands due to very high emission of thermal radiations their temperature remain higher than surrounding non-urban areas-basically due to high energy consumption. Thermal imaging devices help in detecting relative warmness/coolness of urban islands. High energy consumption areas and hot spots can be mapped using thermal remote sensing images. As we all know vegetation reduces ambient temperature significantly so thermal imaging can help in identifying urban areas where plantation is required to cool down the hot spots.

d) **Sea Level Rises:** Remote Sensing and GIS also facilitate the tracking of sea level rise, and also it helps to assess the possible impact on specific landmasses and its larger impact on the population in these areas.

e) **Disaster Management:** Monitoring, Cyclones, Tsunami, Flood, Drought etc. Supporting disaster management decisions such as probable Evacuation maps, Resource mobilisation maps, and Mitigation, etc.

f) **Forest Resources and Ecological Management:** GIS database of the forest resource, Landuse change detection maps. Vegetation Health assessment, etc. facilitate to analysis the temporal impacts and to identify the potential areas of development.



Natural Resource Development Planning

a) **Integrated Resource Mapping:** All the information layers (i.e. polygon, Segment, and point) of village Bina were integrated and one village

resource map of the village was prepared. Figure 4 depicts the spatial distribution of all the resouces of the village integrated by GIS technology.

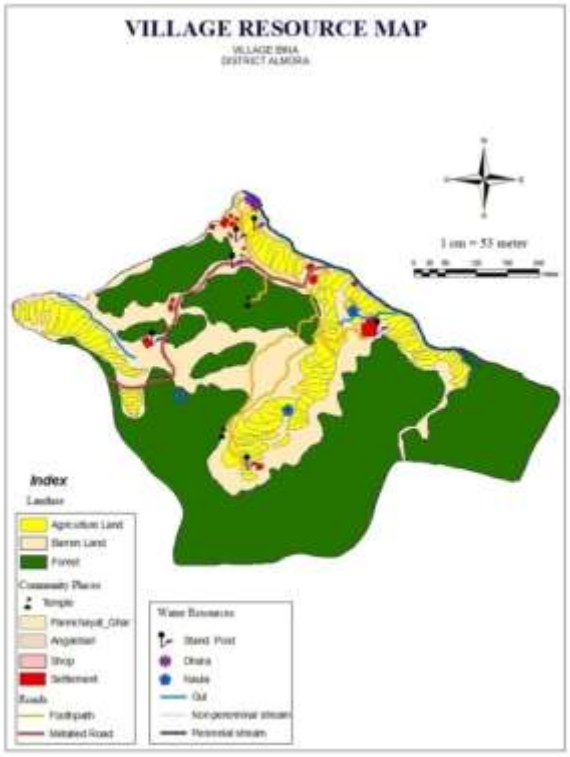


Fig. 4: Village resource map of Bina village, Takula block, district Almora, Uttarakhand.

b) **Integrated Village Resource Planning:** A final Resource Planning Map was prepared with the help of the locals for development of different resources. Figure 5 dipicts the site of proposed khanti (Trenches), guls, check dams, roads and bridges; and areas for development of community hoticulture, agro-forestry and comminity forest in the village. Thus the integrated resource plans map of the village was prepared by integration of GIS, RS, GPS and Computer Cartography technologies and the villagers. The villagers were advised to show their village resource map to different concern line departments for implementation.

Fig. - 5: Resource planning map of Bina village, Takula block, district Almora, Uttarakhand.

Conclusions

The objective of this project is to demonstrate the application of GIS for natural resources management, and planning" i.e. Forest resource management, water resource management, Soil management, Pollution, Climate Change etc. The usefulness in planning and management of resources, GIS technology cannot be ignored. Bina village conditions provide opportunity to implement this technology. However, some barriers to effective utilisation do also exist, such as cost of the software, and institutional and organisational weakness and the present-day requirement for skilled personnel to handle GIS software, but these barriers do not lessen the appropriateness of this technology. It is hoped that this work will bring awareness among all the Government authorities and concern departments on the importance of GIS based natural resource management and planning.

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