Spatial Decision Support System

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Abstract*– Spatial decision support system (SDSS) is an assistance tool which helps the users in solving complex spatial problems associated with development, evaluation and selection of policies, plans, scenarios or interventions necessary for sustainable management of resources. Conservation planning is vital for protecting the natural resources and is a challenging task to manage and control increasing human pressures on the ecosystem. Stretching along the south-west coast of India, the Western Ghats mountains range with spatial extent of 1, 64, 280 km2 is known for their rich biodiversity and natural heritage, is one among 35 global biodiversity hotspots. The mountains anticipate the rain-bearing westerly monsoon winds, and the area receives high rainfall which harbors incredible diversity of flora and fauna. Western Ghats are home to more than 4,600 species of flowering plants with 38% endemics, 330 butterflies with 11% endemics, 156 reptiles with 62% endemics, 508 birds with 4% endemics, 120 mammals with 12% endemics, 289 fishes with 41% endemics and 135 amphibians with 75% endemics (http://wgbis.ces.iisc.ernet.in/biodiversity/pubs/ces_tr/TR122/index.htm). This biological haven needs conservation strategies that involve in generating databases on the species, its status, habitats, socioeconomic impacts, threats to its existence by providing a scientific basis for decision making. The current system is designed to enhance the visualization capabilities, help identify the spatial trends and analyze the aspects that are geographically related to the problem and decision making. The Geographical Information Systems (GIS) software's (Geoserver, PostgreSQL, GeoTools, Openlayers) with collaborative Open Geospatial Consortium (OGC) standardized web services are coupled with multi-criteria analysis, for the development of the SDSS. SDSS helps in guiding the land conservation in terms of (i) regions that most need protection, (ii) areas suitable/unsuitable for expansion, and (iii) how best to balance competing objectives across conservation and socio-economic impacts. The multi-criteria decision making enables structuring complex problems well and consider priorities in allocation of resources for various developmental projects towards sustainable management of resources with appropriate planning.

***Keywords*–Geo-visualization, Web based spatial decision support system, Western Ghats, Biodiversity, and Ecology.**

INTRODUCTION

The increased exploitation of the biological resources and landscape transformations leads to the degradation of the ecosystem. Understanding the importance of the intact ecosystems for human sustenance to meet the present as well as the future needs with conservation rules should be mandated in the process of decision making. A framework for the evaluation of multiple functions of landscapes and forests will be helpful in designing protected areas, and creating large scale zonal resource management with relevant significance of the species are to be accounted. Collectively, these outputs support adoption of best planning practices that also promote public participation with traditional knowledge towards conservation. SDSS would be beneficial to large community of users, experts, citizens, analysts and decision makers aiding more informed and optimal decision making. The development of SDSS facilitates an effective interface providing guidance and feedback about matters of content in the planning and information about current activities in the region.

Western Ghats being one of the hottest hotspots in India needs to be conserved to balance the ecological cycle which is important for sustainable living. The regional importance based on the diversity is categorized as ecologically sensitive regions (ESR) that clearly indicate the dimension of the environment that cannot be recovered or restored once it is degraded or lost. Eco-sensitive regions are determined based on biological, economical, socio cultural values relevant to the context and the region for conservation. Ecological sensitive regions are unique treasures that is important but, are vulnerable to disturbances and are irreplaceable if degraded or destroyed. Decisions involving conservation issues consider geographical parameters such as location, distance, direction, proximity, adjacency, topography etc. and spatial dimension to the alpha-numeric decision support system dedicated to biodiversity conservation. The advancement of Geo information systems (GIS) with free and open source software and remote sensing, are powerful tools for handling spatial information, performing analysis and manipulating spatial outputs. Spatial conservation planning of a region providing spatial data and associated information of ecological systems through geo-visualization by displaying the input data and results of a model. The database technologies are used to store, analyze and display large amounts of spatial data, an up-to-date information is provided over a graphical user interface toe the end user. Both spatial and temporal information of region plays major role to undertake management plans and other mitigation measures.

OBJECTIVE

The paper aims at offering benefits of scientific methods and models in the process of decision-making. Development of spatial decision support system specific to biodiversity conservation models based on empirical relationships between ecological parameters. To program the multi-criteria decision making rules so as to present information for better and simplified form of geo-visualization to the users and decision makers. The interactive 'Graphical User Interface' (GUI) so as to ensure effective use of system to the user.

STUDY AREA

Western Ghats with spatial extent of 1, 64,280 km^2 (<5% of India's geographical area) is chain of hills and undulating terrain running in the North-South direction for about 1600 km parallel to the Arabian Sea from river Tapti (22˚26'N) to Kanyakumari (about 8˚0' N) is a repository of endemic flora and fauna. It is one of the 35 hotspots with rich flora and fauna. Uttara Kannada district is located in central Western Ghats with 76% of its 10,291 sq.km area covered with forests has the distinction of having highest forest area. This is the northernmost coastal district of Karnataka State (13.9220 º N to 15.5252º N and 74.0852 º E to 75.0999 º E). Web based SDSS designed with various spatial information related to land, water, biodiversity, ecology and hydrology helps in identifying local hotspots of biodiversity with an ecological dimension referred as structures, processes, technological and economic aspects are considered for decision making. Figure 1 shows the Western Ghats boundary and Uttara Kannada districts located in central Western Ghats.

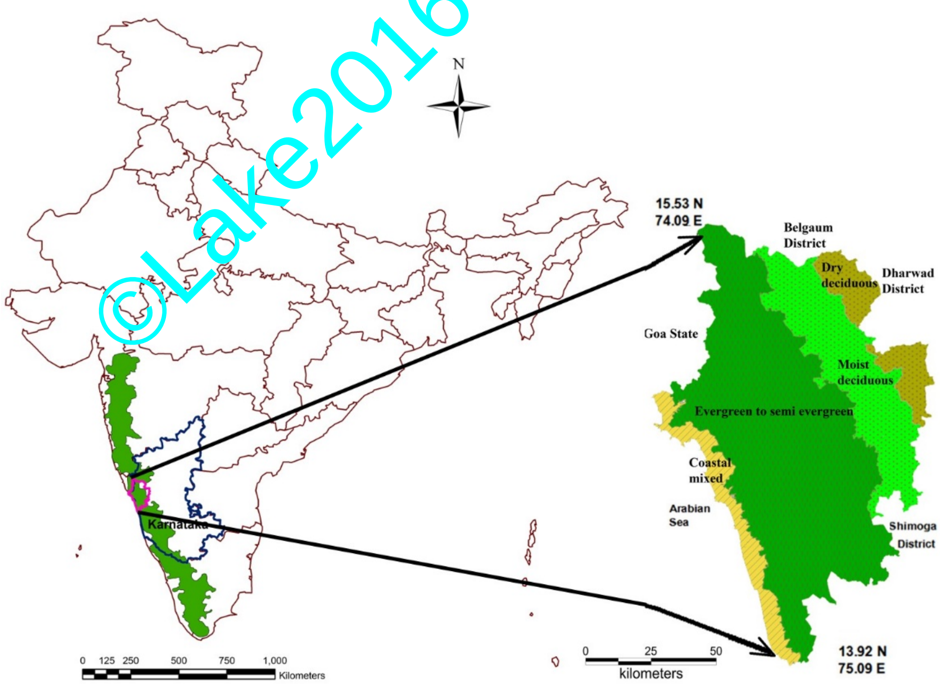

Fig1: Study area Western Ghats - Uttara Kannada.

FRAMEWORK: Figure 2 shows the architecture of WSDSS using open source softwares such as Geoserver, Apache Tomcat 8, Postgresql and Postgis. Apache Tomcat 8 together as a web server and servlet engine connect with the database technologies Postgresql and Postgis as an extension for the spatial data management, PgAdmin is a graphical user interface used to manage the data without a console. GeoServer is an application server used to share, process and publish the geospatial data with Open Geospatial Consortium (OGC) web service. GeoServer connects existing information to web-based maps such as OpenLayers and reads a variety of data formats: PostGIS, Oracle Spatial, ArcSDE, DB2, MySQL, Shapefiles, GeoTIFF, GTOPO30, ECW, MrSID, JPEG2000. It produces KML, GML, Shapefile, GeoRSS, PDF, GeoJSON, JPEG, GIF, SVG, PNG and more. All the softwares and application used are interoperable and loosely coupled. The reference implementation of the Open Geospatial Consortium services like Web Feature Service standard (WFS), Web Map Service (WMS), Web Coverage Service (WCS) and Catalog Service Web (CSW) with Geoserver and Openlayers helps the users in geo-visualization. WFS allows querying and retrieval of features, WMS serves the georeferenced map images using the stored data from a GIS database. WCS is a coverage service, the information representing space/time-varying phenomena are retrieved through this service. CSW catalogue service of geospatial data with the indexing feature which enable the quick search process. The Styled Layer Descriptor (SLD) is an XML-based mark-up language using for styling both vector and raster data, Quantum GIS (QGIS) is used for SLD creation.

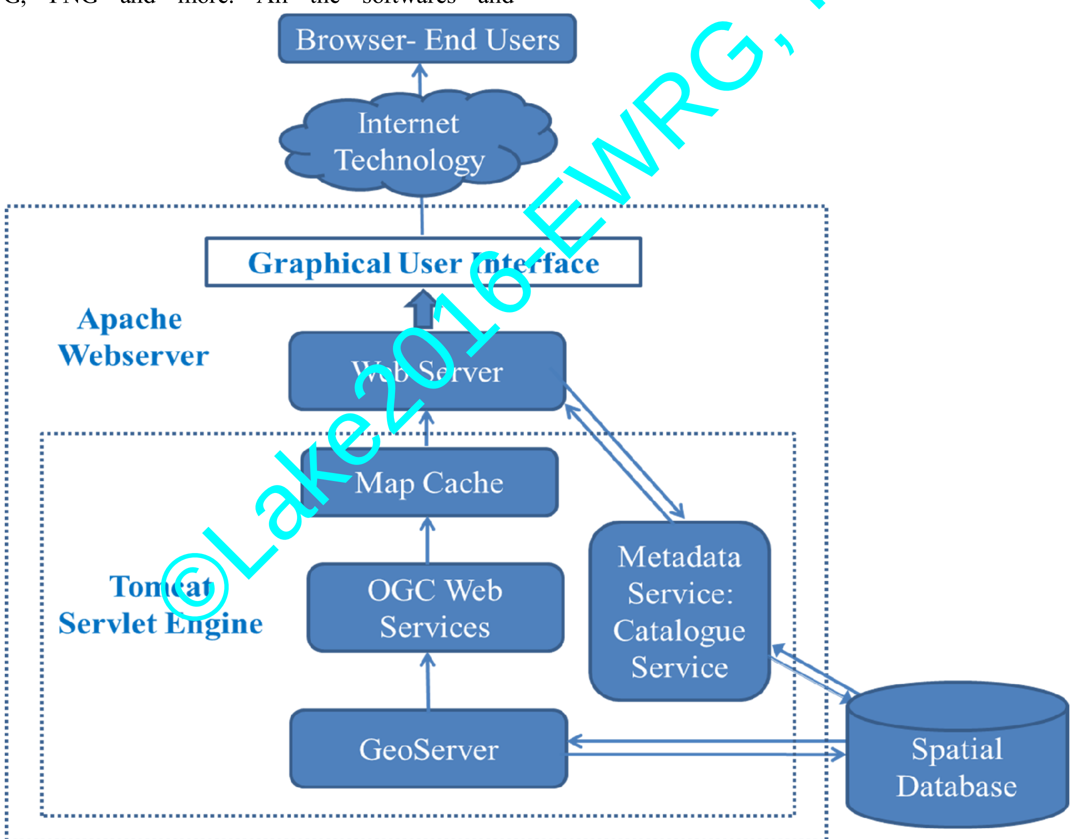

Fig2: Architecture of SDSS.

Remote sensing data is a real or near real time data provided by the satellites and can be interpreted in ways relating to the biodiversity conservation. Interpretation from images include forest cover mapping, forest type mapping, water bodies etc. The satellite data provides information on quantitative aspects of forests such as estimation of biomass, productivity, locations of the important/endangered and endemic species, hotspots, habitats, administrative boundaries, management zones etc. The non-spatial information such as attribute parameters and metadata are helpful in indexing and searching.

RESULTS

Spatial decision support system combine emerging methods and tools for the visual exploration, analysis, synthesis and presentation of geospatial information required by natural resource managers, land-use planners, and individual stakeholders. The interface is a menu-driven graphical user interface, which is user friendly and the map layers are fully driven with select/deselect options for visualization. Fig. 3. shows options visualizing (state/district) with the Western Ghats districts overlaid with backend layers (OpenStreetMap or Bhuvan). The user can select various thematic layer provided in the selection panel for visualizing Uttara Kannada district with various variables information (Fig. 4a-e) for analysis and evaluation of the parameters. The map layers with protected areas, estuaries, endemic flora and fauna, lithology, forest zones of the districts are presented where the user/decision makers can easily understand the location and the areas with rich diversity to be conserved with policies and plans.

Fig. 3: Western Ghats states overlaid with, district boundary and Uttara Kannada panchayats

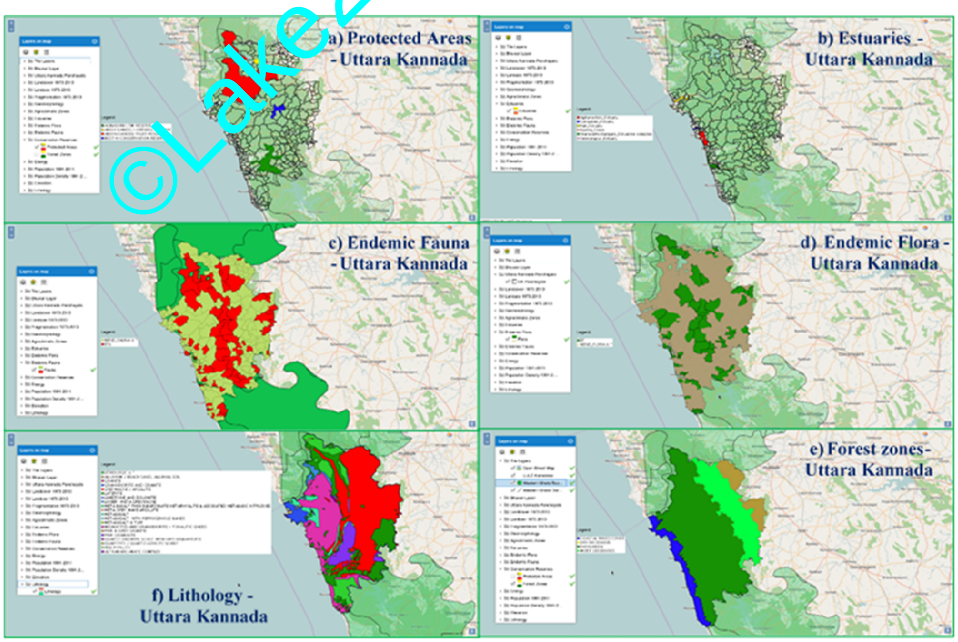

Fig. 4: Thematic maps of Uttara Kannada

CONCLUSION

The Spatial Decision Support System is a powerful information dissemination tool which offers decision making capabilities based on integration of information with geographical parameters. SDSS offers scientific relevance, knowledge and information integrated with the technology and made available with various multi-decision making criteria's to be considered while decision making. Geo-visualizing the map layers are interactive, iterative and systematic where the resultant information is presented in the form of maps, textual, table, graphical form. The ecologically sensitive regions in Uttara Kannada region at panchayat level depict the priorities to be considered and conservational measure to be planned. The district is categorized as ESR1& ESR2 as a 'no go area' where no developmental projects are allowed and is kept undisturbed, ESR3 if disturbed can cause major impacts on the ESR1 & ESR2 so it is considered as an well-ordered sustainable developmental area where decisions should made involving more stake holders and regulatory authorities, ESR4 as the area with the distributed development can take place to conserve the highly sensitive regions or can also be kept restricted, but anticipated by public and private partnership of sustainable use. The Resource managers and policy decision makers can use this information for effective management and conservation in relation to the environmental status of the region.

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