

# **Spatial Technology based Environmental Modelling for Waste Land Development in Sirsiya Block (Baraich District, India)**

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**ABSTRACT:** Environmental modelling using spatial technology (GIS, RS & GPS), as platform, can support many database queries tied to spatially referenced object and their associated attributes in waste land reclamation and management. Waste lands, which are marginally suitable area in open forest, found after analysis and modeling in GIS as 33.37 sq. km. This waste land area can be developed by considering basic needs like energy and biomass for local community members. Genesis of wasteland and their typologies into degraded forests, undulating land, gullied and ravinous land, degraded pastures, waterlogged, salt-affected and sand-affected areas etc. have been mapped and analyzed with special reference to their relationship to natural environment, other land uses, human response and the problems and potentialities for reclamation. Action plan was developed for management and development of waste lands into forest cover to achieve sustainability.

**KEYWORDS:** waste land, GIS, modelling, degraded forest, ecosystem management.

## **I. INTRODUCTION**

Approximately 175 million hectares of land is degraded India has total 329 million hectares (mha) of land. The extent of land under agriculture is 143 mha & again 56% of this suffers from varying degrees of degradation. Land degradation is a composite term describing the aggregate diminution of productive potential of land. A degraded land may be productive for another aspect e.g. as an economic resource, depending upon site but this is not true for degraded soil. Average fertile top soil composition by volume is: mineral-45 % plus organic matter-5 % makes solid portion; and air- 25 % plus water- 25 % constitute pore space [1]. Soil is supposed to have increased reflectance between 0.4 to 1.1 micro- meter wavelengths [2]. Land and soil degradation processes are site specific. So, it is essential to characterise and map the degraded areas because of site-specific development [3] and management plans could be made. Ecosystem functions are affected broadly due to all human activities.

Remote Sensing (RS) Applications coupled with Geographic Information System (GIS) is extremely useful in the decision and solution [4] for environments management. The application areas for remotely sensed data are both wide and varied [5]. Radiometric data potentially represent a very useful source of information in pedological research and land use pattern [6]. Ready and timely availability of satellite observations of existing land use pattern from various remote sensing satellites now provide a most cost-effective means of identification of different forms of land, status of water resources, quantification of soil moisture content and soil degradation to enable all nations to take appropriate measures for maintaining productive use [7] of environments. An environment may be related topologically with wastelands or forest ecosystems [8-10]; and may be affected by industrial pollution and consequently this may interfere indirectly with community people [11] living in nearby surrounding area and their economic status [12]. Remote Sensing coupled with Geographical Information System (GIS) can be extremely useful [13] for environment management. Soil is basic requirement for maintenance of biodiversity [14].

GIS is computer-based powerful system [15] that provides the following four sets of capabilities to handle geo-referenced data: (a) input; (b) data management (data storage and retrieval); (c) manipulation and analysis; and (d) output. Because of the arid climate, complex geological conditions, and human activities, environmental problems like

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lake of water resources, desertification, salinization, and biogeochemical endemic diseases etc. occur in fragile regions of the environment [16]. Hence, there is an urgent necessity of systematic inventory, mapping and monitoring of land resources [17-18] leading to an ecological balance in an area. The digital data can be used to map various types of wasteland. The spatial distribution and soil nature of these lands can serve as the base for the implementation of various reclamation measures and afforestation programmes [19-20]. Proper monitoring and planning, through spatial technology, leads to management of natural resources and ecosystem for sustainable development [21]. Spectral signatures of water, agricultural land, forest, wasteland etc. differ from each other distinctly [22]. Environmental protection and ecological balance are essential to ensure that development is sustainable in the long run [23]. The physiography, hydrology and chemical characteristics of soils are greatly responsible for the various kinds of land-degradation hazards [24]. Any major disaster affects a wide range of sectors of a society which can include political, social, cultural, environmental, physical, technological and economic aspects [25]. The spectral behaviour of each unit varies according to the nature and percent cover [26]. The characteristics of the pictures reflected on the remote sensing images are formed mainly by the difference in information of the tone and the form characteristics [27].

## II. RELATED WORK

Various types of remote sensing data, such as, SAR, MSS, TM, ETM, MOMS, AVHRR and SPOT etc. have been used for earth resources management and development of semi-arid regions by various governmental agencies, institutions, and universities of the world. Remote sensing and GIS are economic and adequate for the land survey and land use classification of semiarid regions of Paraiba state of Brazil [28]. Digital image analysis of Landsat-TM data in eastern Connecticut for regional land use and land cover classification [29] can provide better visualization of the environment. The results were found most satisfactory for regional planning in the state of Connecticut. ERDAS Imagine Software and SPOT data is a good combination for land use and land cover mapping in order to develop the region of the Paraiba state of Brazil [30-32]. GIS system can be extremely useful for land use planning and management of semi-arid regions of northeastern Brazil, using digital image processing on Landsat-TM and SPOT data [33]. Supervised classification for the soil and land use studies for a part of semiarid regions of Brazil [34] and comprehensive work for land use planning in semi-arid regions of NE Brazil, using SPOT HRV data were analyzed in details [35-36].

Wasteland means degraded land which can be brought under vegetative cover with reasonable efforts, and which is currently under-utilized, or land which is deteriorating due to lack of appropriate water and soil management or on account of natural causes [37]. About 16 per cent of the country's geographical area is under wastelands [38]. Information on geographical location, aerial extent and spatial distribution of wastelands is essential for their effective management and sustainable development [39]. The plains of north Bihar in eastern India have recorded the highest number of floods in India in the last 30 years [40]. In India, an estimated 2.46 Mha of land is reported to have suffered from water logging [41]. India is estimated to have about 58.2 million hectares of wetlands [42] many of which are distributed around the Indo-Gangetic plains. Generally regarded as "a water-surplus area" [43] the entire region is characterized by palaeo- levees, swamps or flood basins locally called "Chauras" relict palaeo- channels aggraded to different extents, meander belts, ox-bow lakes, and cut-off loops. Space borne multispectral data, by virtue of providing synoptic views of fairly large areas at regular intervals, have been found to be very effective in providing the necessary information on salt-affected soils and waterlogged areas in a timely and cost-effective manner [44-46].

Areas with high water logging risk in northern Bihar plains corresponds to high flood hazards and vulnerability due to poor socio-economic conditions in these areas [47]. Almost every year, monsoon floods in the Indo-Gangetic Plains cause countless misery to the inhabitants living on the floodplains. Water logging, closely associated with salinization and/alkalinization, continues to be a threat to sustained irrigated agriculture, affecting an estimated 6 million ha of fertile land in India [48]. The Indo-Gangetic Plains are drained by some of the largest river systems in the world. These plains are also severely affected by frequently occurring disastrous floods, and are presently regarded as the worst flood affected region in the world. Water logging in the low lying areas is created due to seepage from irrigated uplands and seepage from canal water with inadequate water management practices [49]. Impact of natural and anthropogenic features on flood induced water logging in parts of Bihar plains were studied, and revealed that canals and railway line induced highest water logging conditions [50]. In visual interpretation of satellite data, high soil moisture and surface waterlogged areas are identified as deep dark grey to light black in color [51].

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## III. METHODS OF INVESTIGATION

Methodology in waste land development and management using remote sensing & GIS is more or less same but many time variable and parameters are different and data set may vary from one place/ habitat to other and for different ecosystems. Methodology followed (in case of waste land development by management of degraded forest ecosystem in Sirsiya Block, Bharaich District, India) include: (i) preparation of base-map from Survey of India topographical sheet; (ii) visual interpretation of Satellite data/ Imagery to study the various aspects of environment like biogeological aspects, vegetation, geology, urban-sprawl, hydromorphogeology, structural features and land use of the area; (iii) digital enhancement of Remote sensing data for delineating vegetation, geomorphic and structural elements; (iv) correlation of digital enhanced Remote sensing data with other data; (v) preparation of vegetation anomaly map, hydromorphogeological & land-use maps from satellite imagery for study of vegetation aspects, land degradation aspects, groundwater potentiality and change in recharge capacity by changed land-use patterns; (vi) imposition of interpreted Remote Sensing data on base-map; (vii) soil samples' analysis to estimate fertility aspects; (viii) field traverses for sample collection of soil, water & chlorophyll data using guide map and analysis; (ix) analysis and modelling in GIS; (x) application of GIS based approach for planning & management of waste land development to take decision as per action plan.

## IV. MODELLING IN GIS

In Analysis/ modelling, equation and syntax used in GIS (INTERGRAPH) for different overlays is:  $\text{Output} = \text{select}\{i1=1,1,0\} + \text{select}\{i2=2,2,0\} + \text{select}\{i3=3,3,0\} + \text{select}\{i4=4,4,0\} + \dots$ , where  $i$  is input and 1,2,3,4, ---  $N$  represents number of layers overlayed. Analysis and overlaying steps for open degraded forest area were done in following steps: Step-1: Open forest map Vs. Ground water potential map; Step-2: Step 1 Vs. Soil texture map; Step-3: Step 2 Vs. Soil fertility map; Step-4: Step 1,2 and 3 repetition for various combinations. Final output was obtained in the form of required manner and combinations as per objectives of research problem for action plan to implement.

## V. OUTPUT OF ANALYSIS

Figure 1 shows the results of analysis and modelling in GIS. Analysis and modelling in GIS provide output in desired manner as per objectives for execution and implementation of action plan during decision. Sirsiya block covers total open forest area 46.26 sq. km. Highly suitable, moderately suitable and marginally suitable area in open forest found after analysis in GIS are 1.60 sq. km., 11.29 sq. km. and 33.37 sq. km. (basically waste land) respectively; and hence, the attention for development and management of open degraded forest, basically waste land area, is given as per required suitability prioritization. Figure 1 show GIS based dynamic maps indicating waste lands (open degraded forest) development/ management based on objective(s) to implement action plan and red, pink and blue colours are used to depict waste lands for development as highly suitable, moderately suitable and marginally suitable respectively for execution of action plan.

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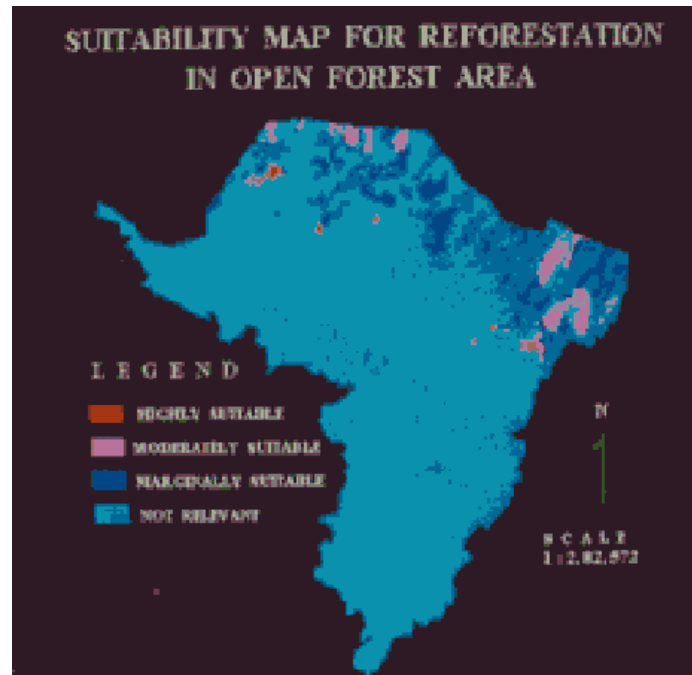


Figure 1: GIS based dynamic map indicating waste lands (open degraded forest) development/ management plan. Red, pink and blue colours are used to depict waste lands for development as highly suitable, moderately suitable and marginally suitable respectively.

## VI. CONCLUSION

Spatial patterns and variations of different attributes relating to landform, land use, wasteland and demographic characteristics and their spatial association are brought out in the study. Spatial technology (Remote Sensing or RS, Geographical Information System or GIS and global positioning system or GPS) opens ways for better monitoring, planning, development and management of waste land development in sustainable manner. For open degraded forests (crown density 10-40%), which includes waste lands, following species are recommended : (i) to increase the crown density, species like *Tectona grandis*, *Shorea robusta*, *Terminalia tomentosa*, *Bombax cieba*, *Bahunia perviflora*, *Adina cordifolia*, *Cassia fistula* etc. are suggested; (ii) to meet the requirement of fuel and fodder of the nearby local people, species like *Su babul*, *Prosopis juliflora*, *Dalbergia sissoo*, *Albizia species*, *Acacia species* and *Ziziphus species* are suggested in the outside notified forest areas; (iii) *Eucalyptus*, *Poplar* etc. are in great demand for pulp and paper and match box industries. So these species are suggested in suitable areas within the notified and non- notified areas for waste land development. GIS can handle huge data sets (spatial & non-spatial data).

All the data (spatial & non-spatial) are integrated and analysis & modeling in GIS using satellite and other data is done for monitoring, planning & management plans and finally for decision making & sustainable development and therefore in biodiversity, ecosystem and environment management. Because reflected electromagnetic radiations are different for different substance or object therefore digital number (DN) value is different for different objects, this DN value is useful for object identification & image interpretation which is done through involvement of shape, size, tone, shadow, pattern, texture, size (location), association and resolution of satellite imagery/ data. Spatial information/ data & distribution pattern of each Parameter/ component of Natural Resources (NRs) & ecosystem is obtained through interpretation of satellite/ Remote sensing data with limited ground truth/ checks (field based).

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