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Development of an automated tool in GIS for generating action plans to combat desertification/land degradation

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Abstract: Increasing global land mass under various processes of desertification/land degradation is one of the most alarming issue. Desertification/land degradation combating action plan tool has been developed in GIS environment using model builder utility and inputs parameters like desertification/land degradation status, land use / land cover (LU/LC), ground water prospects, slope and land capability maps prepared for Bellary district, Karnataka, India using satellite data and ancillary data. Multi-criteria based integrated approach has been used in GIS. It is observed that in general north-eastern parts of the Bellary district requires no action as the land is under no apparent degradation. Most of the south-western parts of the Bellary district requires various measures for combating desertification/land degradation. Suggested measures may help planners to arrest and reverse land degradation processes. GIS tool developed in this study can be utilised in other study areas by altering criteria based on local specific requirements.

Keywords: GIS, Model, Thematic data, Combating Desertification

1. Introduction

Land degradation refers to reduction or loss of the biological or economic productivity, resulting from a combination process arising from human activities and habitation patterns (UNCCD, 1994). Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UNCCD, 1994). There is an urgent need to stop and reverse the process of land degradation. Sustainable management of soil, water and biodiversity are required for protecting the land from further degradation.

Remote sensing and GIS techniques have been extensively utilised in mapping and monitoring desertification and land degradation in India (SAC, 2018; Dharmarajan et al., 2018; Nayak et al., 2017; SAC, 2016; Ajai et al., 2009) aimed at providing current status of desertification and land degradation to United Nations Convention on Combating Desertification (UNCCD) based on land degradation processes and severity. The outcome is useful in prioritising areas, where suitable remedial actions are required for arresting land degradation. Three level classification system (land use classes, land degradation processes and severity levels) have been standardized and used for mapping of land degradation and desertification at national and district level (SAC, 2018; SAC, 2016; Ajai et al., 2009). There is a requirement of regularly monitoring desertification / land degradation of the country for planning effective strategies and measures to combat desertification / land degradation.

Recent studies carried out at national level in India using digital IRS AWiFS data interpreted at 1:500, 000 scale shows that 96.40 mha area of the country is undergoing process of land degradation i.e., 29.32% of the Total Geographic Area (TGA) of the country during 2011-13, while during 2003-05 the area undergoing process of land degradation is 94.53 mha (28.76% of the TGA). There is a cumulative increase of 1.87 mha area undergoing process of desertification/land degradation in the country (constituting 0.57% of the TGA of the country) during the time frame 2003-05 and 2011-13 (SAC, 2016). The change analysis carried out for 2011-13 and 2003-05 time frames indicates that around 1.95 mha land has been reclaimed and 0.44 mha land has been converted from high severity to low severity degradation class, indicating improvement. On the other hand, around 3.63 mha productive land has degraded and 0.74 mha land is converted from low severity to high severity degradation class (SAC, 2016). Desertification/ Land degradation status mapping carried out for selected 76 districts and 2 sub-basins using digital IRS LISS-III data on 1:50, 000 scale revealed that out of 49.66 million ha area mapped, 22.80 million ha area (45.92%) is undergoing desertification/land degradation during timeframe 2011-13. The area under desertification/land degradation during time frame 2003-05 is 22.94 million ha (46.20%). A cumulative decrease of 0.14 million ha area (0.28%) in the area undergoing desertification/land degradation is observed (SAC, 2018).

Long term planning is required for arresting land degradation processes in particular for reclaiming degraded lands, conserving soil and moisture as well developing land and water resources in the region. It also includes mitigating measures such as preventing runoff, arresting soil erosion, stabilising sand dunes, moisture conservation measures and constructing rainwater harvesting structures. The preparation of local specific action plans to achieve these objectives require thematic data on natural resources, terrain and socio-economic conditions.

In this study, a tool has been developed to generate desertification/land degradation combating action plans in an automated way by using standard criteria in a GIS environment. It also has a provision to generate and manipulate the desertification/land degradation combating action plans by user defined criteria in an interactive manner.

2. Study Area

Bellary district, located in Karnataka in south India has been selected as study area (Figure 1). It covers an area of 8,461 sq. lm area. District has population of 24,52,595 with 290 population density, 983 sex ratio and a literacy rate of 67.43% (Census, 2011). Area is covered mainly with black cotton and red soil. The main river in the district is Tungabhadra. Bellary is observed with 41.88% and 41.82 % of total geographical area under land degradation/ desertification for the time frames 2011-13 and 2003-05 respectively as per IRS-LISS-III data interpretation carried out on 1:50, 000 scale, showing marginal increase (SAC, 2018). The processes of desertification/land degradation observed in the district are vegetation degradation, water erosion, man-made (mining/industry), salinity/alkalinity and settlements.

3. Data used

GIS database prepared on 1:50, 000 scale comprising Desertification/Land Degradation Status Map (DSM), land use / land cover, ground water prospects, slope and land capability available at SAC (SAC, 2018; SAC, 2013) have been used as inputs for generating desertification/land degradation combating action plan map.

4. Methodology

Overall methodology for generating action plans to combat desertification/land degradation is given in Figure 2. In order to integrate various themes, firstly, desertification/land degradation status layer was integrated with land use/ land cover layer. The resultant integrated output of these two layers was integrated with ground water prospect and resultant output of these three layers was integrated with slope and finally with land capability layer. The output composite layer has the basic information of all the five layers. Various combinations known as Composite Land Development Units (CLDU) are created in this composite layer. Decision rules (criteria) have been defined based on type of desertification/land degradation process, evaluation of existing landuse/land cover, ground water prospect, slope and land capability in the region (Table 1, modified from SAC, 2013). Suitable measures to combat desertification/land degradation are assigned based on above mentioned decision rules for each of the CLDU. ArcGIS based model (GIS based tool) developed for generating desertification/land degradation combating action plan in GIS environment is shown in Figure 3.

5. Results

Desertification/land degradation combating action plan generated based on integrated approach in GIS environment using different thematic parameters is shown in Figure 4. It is observed that in general north-eastern parts of the Bellary district requires no action as the land is under no apparent degradation. Most of the south-western parts of the Bellary district requires various measures for combating desertification/land degradation. This region is mostly affected by water erosion and vegetation degradation. In most of the region ground water targeting may help in getting double crop and thus help reduce exposure of land to processes of land degradation. Construction of farm ponds/rain water harvesting structures are also suggested in parts of this region for irrigation purpose as well to reduce water erosion. Agro-horticulture is suggested mostly in southern parts of the district to improve vegetation cover. Afforestation along with contour bunding is suggested in various parts of the south-western region of the district to improve vegetation cover as well reduce soil erosion.

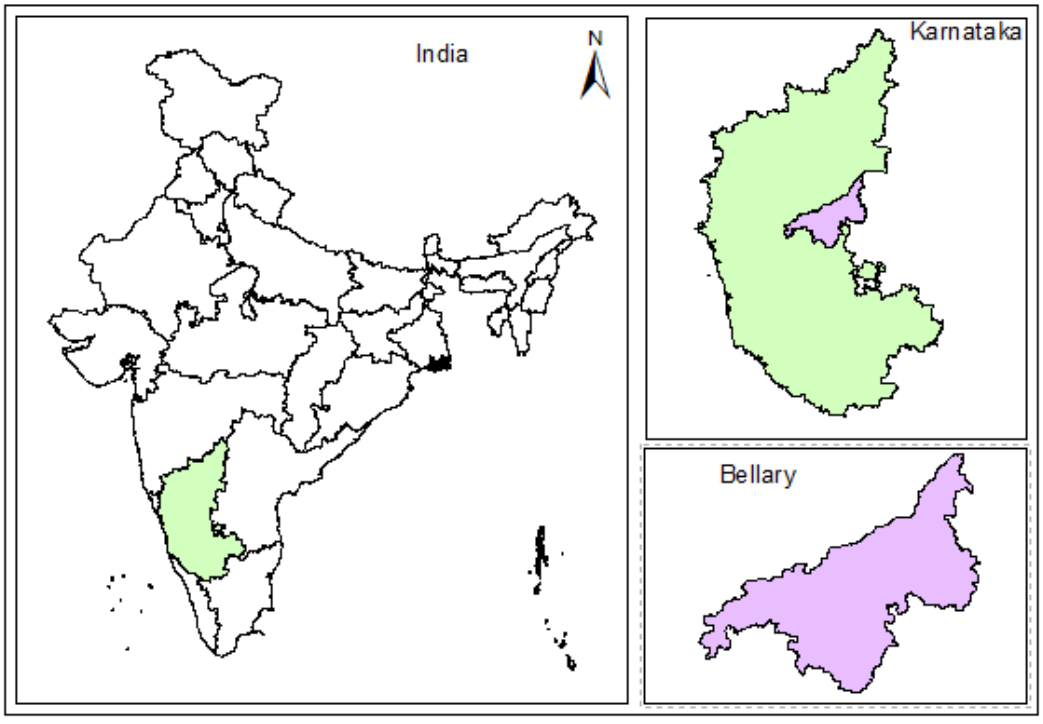

Figure 1: Location map

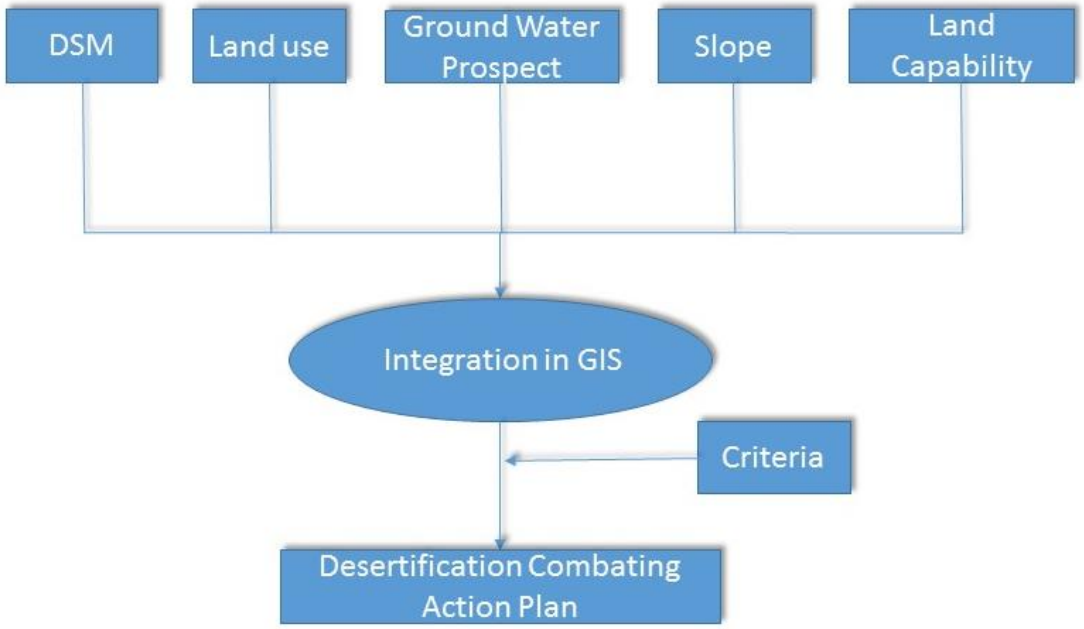

Figure 2: Methodology to generate desertification and land degradation combating action plan

Table 1: Decision rules for generation of desertification/land degradation combating action plan

Sr. No.	Desertification/land degradation Process	Land Use/ Land Cover	Ground water Prospect	Slope in per cent	Land Capability	Measures
1	Vegetation degradation	Open Forest	Moderate	3-5	VI	Afforestation
2	Vegetation degradation, Water erosion	Open Forest	Moderate - Poor	3-5	VI	Afforestation with contour bunding
3	Vegetation degradation, Water erosion	Scrub Forest	Poor	5-10	VI	Afforestation with proper soil and water conservation
4	Vegetation degradation	Open Forest	Moderate	>35	VI	Afforestation with staggered trenches
5	Vegetation degradation	Open Forest	Moderate-Poor	5-10	VI	Protection and Gap Filling
6	Water erosion	Kharif Crop	Moderate	3-5	IV	Agro-horticulture with groundwater irrigation
7	Water erosion	Kharif Crop	Moderate	0-3	III & IV	Double cropping with ground water usage
8	Water erosion, Salinity	Wasteland, Salt affected land	Moderate	3-5	III	Drainage treatment
9	Water erosion	Double Crop	Good- Moderate	0-1	III	Minimal action - farm ponds
10	Vegetation degradation, Waterlogging, Salinity	Land with scrub & Land without scrub	Moderate - Poor	10-15	IV	Silvipasture
11	Barren, Rockey	Barren rocky/Stony waste/ Sheet rock area	Poor	5-10 & 10-15	VIII	Natural regeneration
12	No Apparent Degradation	Kharif+Rabi, Dense Forest	Good	3-5	III	No action

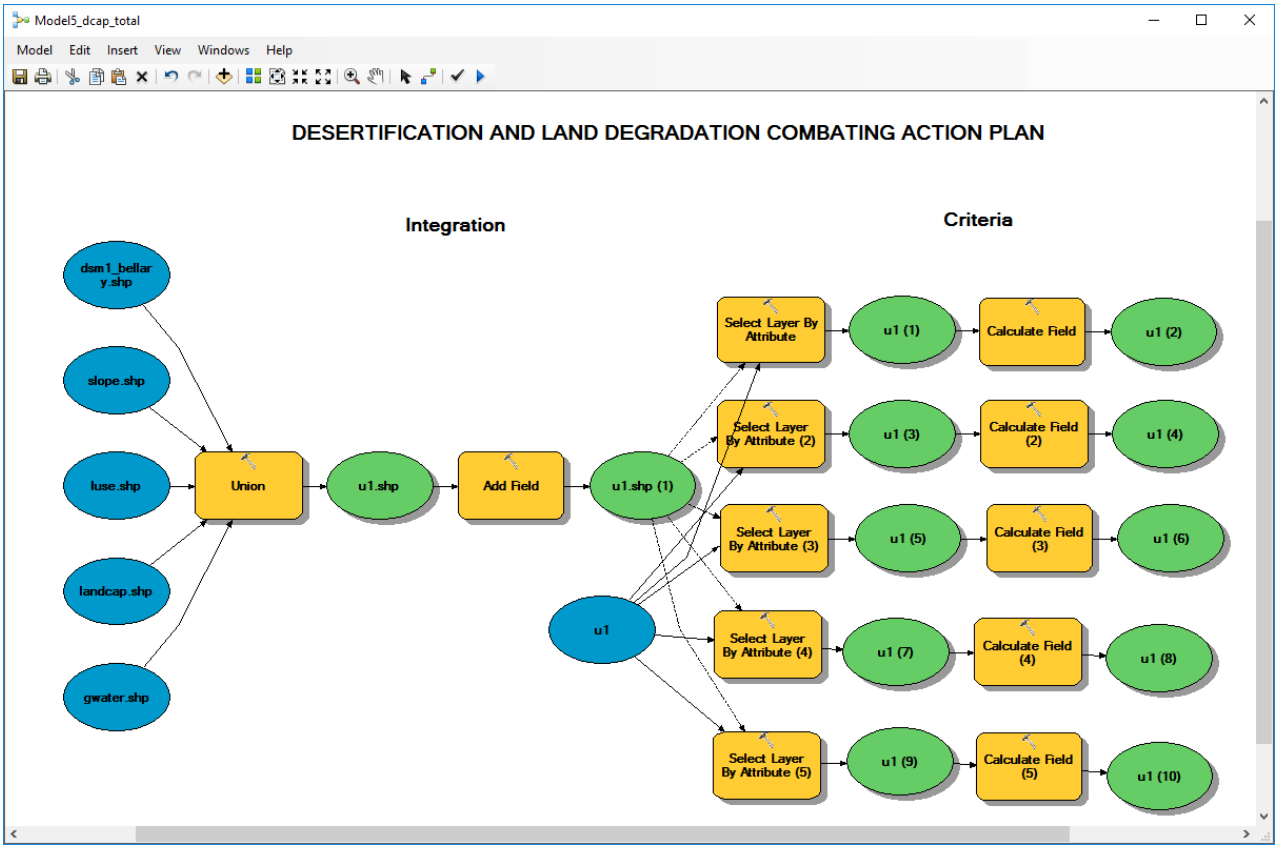

Figure 3: Model to generate desertification/land degradation combating action plan

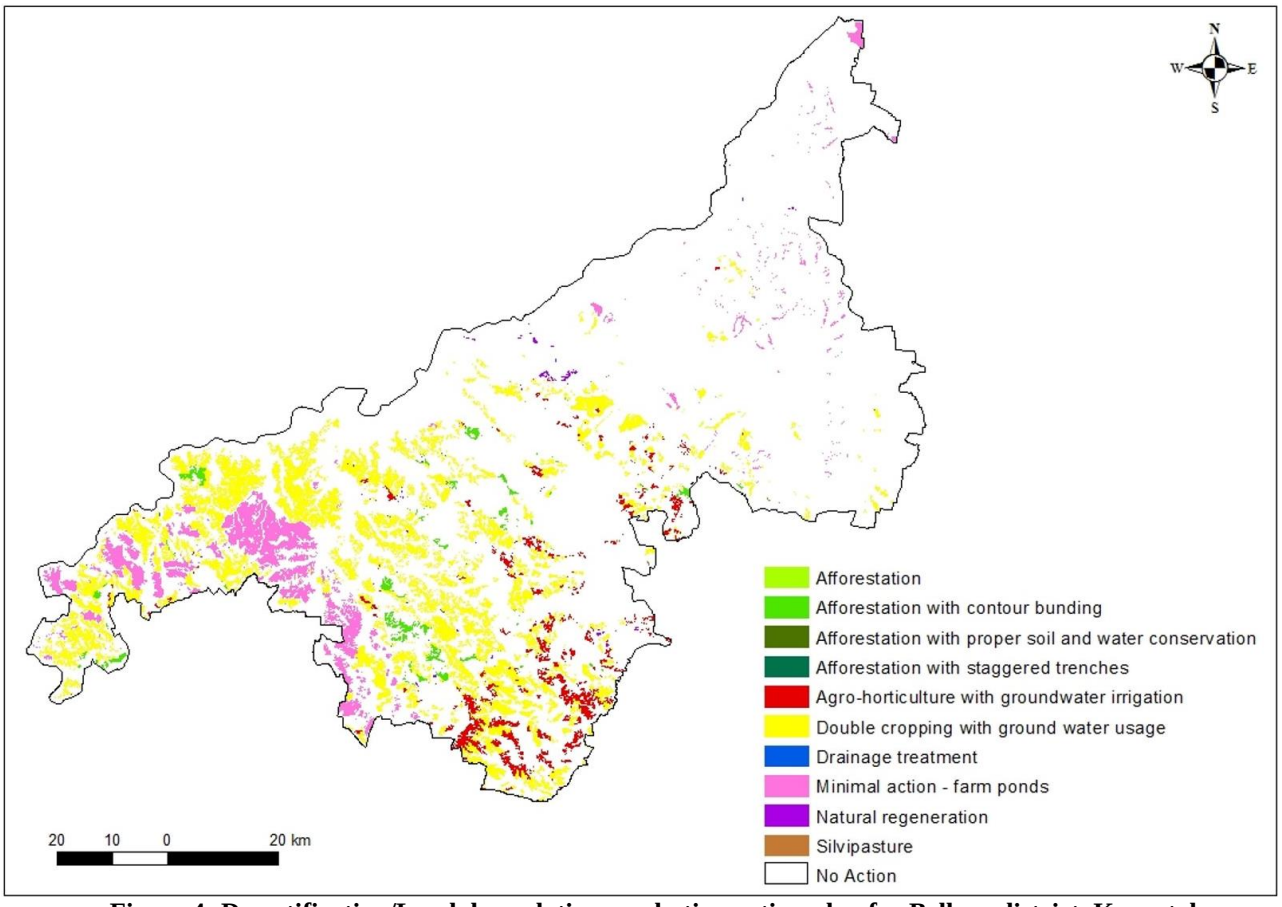

Figure 4: Desertification/Land degradation combating action plan for Bellary district, Karnataka

6. Conclusion

This study has demonstrated development of a tool in GIS environment to generate desertification/land degradation combating action plan automatically. Its utility has been demonstrated for a selected district. GIS tool developed in this study can be utilised in other study areas by altering criteria based on local specific requirements.

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