

Customization of freeware GIS software for management of natural resources data for developmental planning - A case study

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Abstract— GIS is a tool for spatial data management, manipulation and analysis. ArcGIS Explorer, a freeware GIS application with 3D display capability, has been chosen in this study for spatially analysing Natural Resource data of the East Singhbhum district of Jharkhand, India for developmental planning. To overcome some of the limitations of the software, new customized tools have been developed, which can be used to classify the map in unique colours, generate legends based on unique colours for all types of layers, and compose maps with map elements (viz. legend, title, north arrow etc.) for printing.

Keywords— ArcGIS Explorer, customization, Freeware, GIS, Natural Resources.

I. INTRODUCTION

Earth Observation (EO) data from different Indian Remote Sensing Satellites (IRS) have been used for mapping and making inventories of various types of natural resources viz. drainage, wastelands, land use, surface water bodies, wetlands, infrastructure etc. These data can be used in many sectors like government, academia, planning and societal. GIS software enables users to view spatially oriented data and make spatial data simple to understand. This technology has enabled users to comprehend complex data for managing natural resources, infrastructure etc. and hence, improve the effectiveness of planning developmental activities. In recent times, decision makers who are not GIS professionals need to have access to GIS databases for better understanding and enhanced decision making. Hence there is a need for customized GIS applications, and that can be achieved by development of domain specific, user friendly GIS tools in a comprehensive GIS environment. The development of customized GIS applications has been carried out in many fields viz. Civil engineering projects [1], tunnel construction site management [2], for spatial assessment of lifeline reliability maps under seismic hazards [3], for optimizing the use of groundwater [4], for water resource contamination due to new developments in the Olympic park in London [5], for Ground Water Quality Assessment [6].

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Over the last few years the world of GIS has experienced many free and open source GIS software and tools which have helped GIS to reach a large number of people and has created a significant impact on the society. ArcGIS Explorer (AGX) has been chosen among available freeware GIS for its 3D display capability. AGX is desktop GIS software with some basic GIS capabilities and it is customizable. Provision is also there to develop additional utility tools (add-ins) in .net and they can be integrated with the main application. In the present study AGX is used to prepare a GIS for natural resource database management and its potential for data analysis has been explored. Some limitations of AGX have been addressed by developing new utility tools. One such crucial issue was with map printing from AGX. Several times this issue has been discussed over online forum and blog of ArcGIS and the only solution that has been suggested is through screen print. The new tool developed in this study overcomes this difficulty to a great extent. Another important limitation was to classify a thematic map and display it in different unique colours for different values of an attribute. The Unique value rendering tool has been introduced to meet this limitation. The legend generation tool is another utility that creates legends based on different colours present in the current map. The detailed descriptions of these newly developed utility tools are discussed in the subsequent section.

II. DEVELOPMENT OF CUSTOMIZED TOOLS AND THEIR FUNCTIONALITIES

In this present study, AGX has been customized for general user settings (Figure 1). AGX_SDK provides necessary support for add-ins development in the .net environment. Utility tools, developed using VB.Net, are described below.



Figure 1: Custom Splash Screen

A. Unique Value Rendering Tool

Classifying a feature layer is a common requirement in GIS for interpreting a map efficiently. AGX displays a feature

layer in a single uniform colour for all features and thus makes visual interpretation difficult. To address this issue, a utility tool has been developed which is capable of classifying a feature layer in different unique colours for different values of a selected attribute. In this tool, the user needs to choose a feature layer and a corresponding attribute to render the map. The output is generated in note format and can be added to the existing map. Users can also modify them as per their convenience. With the unique value rendering tool, the initial output after rendering with a random colour and the modified output with a user defined colour are presented in figure 2 - figure 4 respectively.

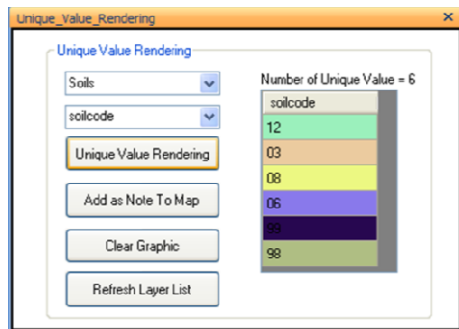


Figure 2: Unique value rendering tool



Figure 3: Initial output after rendering



Figure 4: Modified colour output

B. Legend Generation Tool

To facilitate the visualization of classified feature layers, generally it is been converted to KML and integrated with the map for distribution purpose. But the legend of a KML in the content window picks each and every feature irrespective of the uniqueness of the value/ colour. Figure 5 shows the content window legend of a KML layer indicating some of the repetitions. Similar repetition also can be seen in the case of note layers. Thus the map interpretation

becomes difficult when a particular layer is classified into some unique colours for an attribute value. To overcome this limitation, a legend generation tool has been developed to understand the map properly. The tool is capable of generating legends based on different unique colours for all types of layers. Figure 6 and Figure 7 show the legend generation tool and the corresponding map respectively. The left panel of the legend tool lists all available layers in the current map. Users can select one or more layers at a time and generate a legend for them.

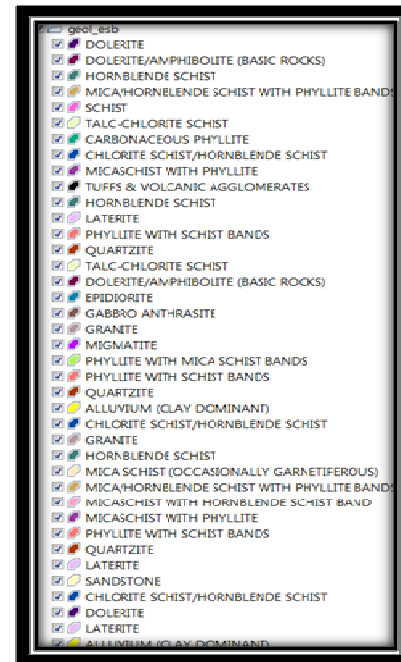


Figure 5: Legend of a KML Layer



Figure 6: legend generation



Figure 7: Corresponding map

C. Print Map Tool

Output generation is an indispensable part of any GIS application. The software does not provide any platform for map composition. The default print option copies the screen shot of the map extent along with title texts and overlaid picture, and passes it to the output device. This serves the purpose to some extent. But in the absence of the legend, interpretation of the map cannot be done. This issue has been addressed in the print map tool (figure 8), which makes provision to compose a map with its elements viz. custom logo, title, subtitle, north arrow and legend. Users can print the map in .pdf format directly. This facilitates the map output generation in a more user friendly way.

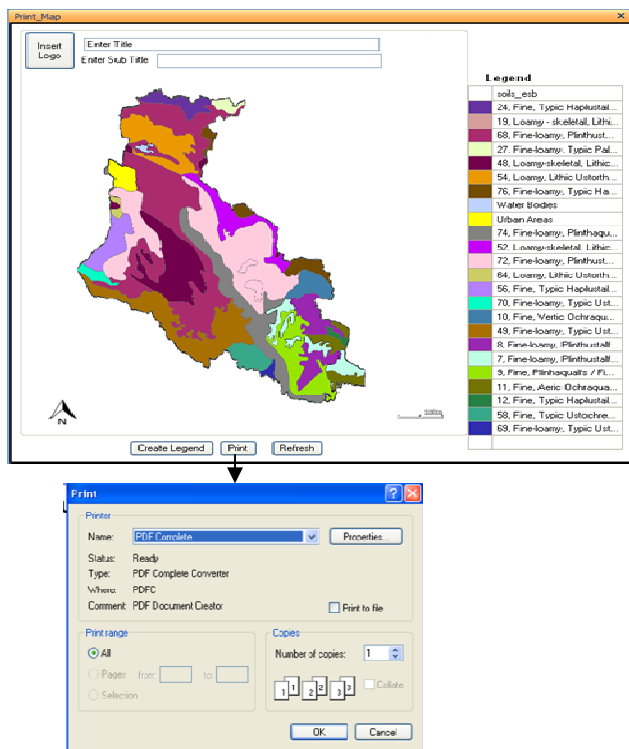


Figure 8: Print map utility tool

D. Attribute Table Tool

The purpose of the tool is to show the attribute table of a selected feature layer. This tool (figure 9) was developed, as in the earlier version of the AGX Attribute table tool it was not provided by default. In later version this issue has been addressed, and hence this tool is only useful if the user is using 1700 or earlier versions of AGX.

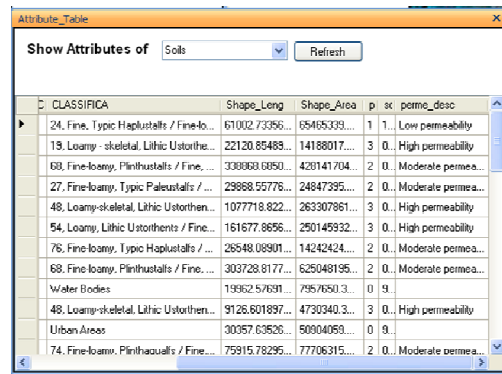


Figure 9: Attribute table tool

III. DATA ANALYSIS AND OUTPUT

A customized GIS enables the user to explore the Natural Resource (NR) database using existing and developed tools. For visualization of spatial data and its subsequent application for land and water resources planning, the proposed software will be highly useful.

A. Case Study

NR maps can be used to produce utilitarian types of maps to serve planning decisions. They are derived in some cases, by direct translation of a single thematic map and in others by combination of two or more thematic maps or chosen parameters of different themes. Plans involve generation of alternate land use, and demarcation of areas suitable for artificial recharge. Thus, the software enables users to combine spatial data from diversified sources together in order to describe and analyse data to provide support for decision makers. The East Singhbhum district is a backward area and marked by increased anthropogenic pressure and extraction of natural resources. Particularly, mining has affected watershed ecosystems and resulted in accelerated erosion resulting in loss of land productivity and siltation of reservoirs. Hence, in the present study, a land and water resources development plan generated after assessing various natural resources of the study area was demonstrated through software.

B. Map Content Generation

Indian Remote Sensing Satellite (IRS) data viz. IRS-P6 LISS III, LISS IV and CARTOSAT satellite data were extensively used by the Jharkhand Space Application Centre for generating spatial databases and were used in the present study. The custom freeware GIS has been integrated with NR data pertaining to the East Singhbhum district of Jharkhand, India for data analysis and software capability demonstration. The NR database has been grouped into the following categories which eases the searching of a

particular layer in the content window and provides for improved management and access.

- (1) Primary layers: City/Town, Settlement, Village, Block, District.
- (2) Infrastructure Layers: Railway station, Highway, canal, Rail, Other road.
- (3) Thematic Layers: watershed, wasteland, wetland, geology, geomorphology, structures, mineral location, soil, drainage network, land degradation, land use/land cover.
- (4) Derived Layers: Land Resource Development Plan, Recharge structures, Water resource development plan, water harvest, and slope, Ground Water Potential, drain order.
- (5) 3D Visualization: Annotation layer for settlement and mineral location, Multispectral (LISS III & IV) raster image, Panchromatic image (Cartosat I) and Digital Elevation Model layer.

C. Case I

A Water Resource Development Plan that involves identifying suitable zones for artificial recharge assumes importance and holds the promise of making watershed management simpler and more effective. The water resource development plan in the software helps to identify suitable zones for taking up locale specific activities in the study area. Local area specific activities are generally those areas where certain type of water resource activity is recommended for implementation. Water conservation measures like check dam, percolation tank, underground barrier etc. fall under location specific activities. For example, software shall be able to do analysis such that the number of villages that are likely to be benefitted if a particular check dam is constructed at a suggested location. The attribute query tool and buffer tool and spatial query tool have been used for this analysis. For a selected check dam a location buffer of 1 km is drawn and 9 settlement locations have been found, which can be benefitted (figure 10). Location of the check dam site can be visualised in 3-D perspective that helps identify the suitability of the exact location, which otherwise is a tedious activity (figure 11). Software help to identify the villages that are likely to benefit under various buffer zones around habitations, which will be a key input for decision makers whether to take up a water conservation structure at that particular location or not.

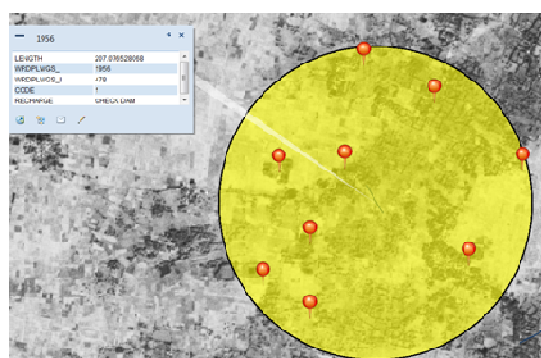


Figure 10: 1km buffer from selected check dam

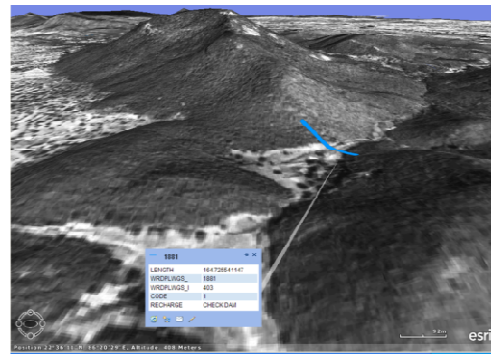


Figure 11: Query output visualisation in 3D

D. Case II

A water resource development plan is shown for an area, where ground water potential is poor (figure 12). Multiple queries that involve poor groundwater potential zones, settlement locations, and recharge zones were performed through the spatial query tool for the selected area (figure 13). The resultant output of the multiple queries can be visualized with respect to WRD and LRD, so that decision makers can plan sustainable development of the area. Thus, the software provides information to the user, how the existing land use/cover can be converted to alternate land use patterns considering the suggested water resource development plan.

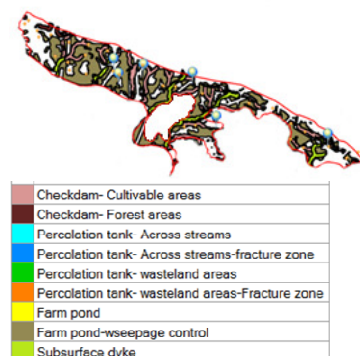


Figure 12: Surface water resource development plan



Figure 13: Settlements point and water recharge points overlaid on a selected poor groundwater potential zone

IV. CONCLUSION

District administration of every district carries out different development activities and coordinates various welfare programs viz. MGNREGS, Watershed development, Rural road construction etc. This kind of GIS tool has the capability to help them in taking decisions as it opens up a

window through which they can access the natural resource database sitting at their desk. Free GIS software is a noble attempt, which provides user the freedom for customization as well as reaches the user community very fast. Critical analysis of thematic maps and socio-economic parameters through GIS reveals the potential or weakness of a geographical area under study. Thus GIS helps in using natural resources optimally through proper planning and implementation.

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