Mine reclamation planning of Jharia area (Bastacola)
through multi temporal remote sensing and GIS.

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Abstract

Excavated overburden and ensuing from the surface mining activities pose a long term impact on the environment and the land safety measures. Lack of requisite reclamation of the stripped and the exploited coal in the BASTACOLA (Eastern Jharia, area) has resulted in the loss of substantially important agricultural and urban land. Accurate quantification of the extent of the area occupied by the overburden is important for the assessment and proper restoration of the waste land. Substantial quantity of non-urban land monitored can be used to fill the excavated profiles of overburden using the conceptual regarding analysis and, thus providing useful reclamation patterns. This research paper investigates the use of multi temporal remote sensing and satellite imagery for the location of the excavation hinge line of undulating overburden profiles to further their reclamation due to stripping activities. Landsat 5 TM multispectral ASTER DEM images of the area (Nov 1, 2005 and Nov 5 2011) were used for quantification of overburden. The paper embeds the data acquisition though satellite imagery, data presentation via GIS, Land use and Land cover data of the JCF and the final analysis. The interpolation of results and the statistics acquired can be used for the describing, analyzing and predicting the land use change over the considerable timeframe with the help of the Markov model and statistical and stochastic timeline analysis.

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Introduction

Over the decades, drastic and dramatic land use and land cover changes have been observed throughout the demography of the *JHARIA* coal field. The observed biophysical covers of the earth's surface occur due to the variety of human and natural processes have contributed towards the dynamic and the changing face of the *Eastern Jharia area*. However land uses on the other hand have been extensively affected by the surface mining and extensive excavation and exploitation of the mineral and the coal areas. The idea that envisions the evocation of the project is to provide a model for the reclamation and land use analysis of various timeframe and execute the same using analysis of the MARKOV chain model. Remote sensing data has been widely used by the Mining Industry for decades for the exploration, land use and environmental data analysis. There have been numerous researches incorporating mine monitoring problems with the various digital image classification techniques which range from unsupervised classification to supervised classification, parametric classification to non-parametric classification, per pixel classification to sub-pixel classification to characterize the landscape of large regions by means of assigning pixels of different spectral values to classes.

The changes in the land cover occurs even in the absence of human activities through natural processes where the land use change is the manipulation of land cover by human being for various purposes-food ,fuel wood , timber , fodder , leaf , litter , medicine ,raw materials and recreation. So many socio economic factors have been reviewed from different perspectives in order to identify the drivers of change, their process and the consequences. Use of the Markovian analysis for the detection of the change and to find the probability of the change occurrence over a finite area is a new concept applied to the field of the Geomatics. Remote sensing information, in concert with available enabling technologies such as GPS and GIS, can form the information base upon which sound planning decisions can be made, while remaining cost-effective (Franklin et al., 2000). Clearly, however, the fast-paced developmental nature of remote sensing technology often overlooks the needs of end-users as it '…continues to outpace the accumulation of experience and understanding' (Franklin, 2001: 137). As a result, effective real-world operational examples of land-cover and land-use change remain relatively rare (Loveland et al., \2002; Rogan et al., 2003). Geographical information systems (GIS) and remote sensing are well –established Information Technologies , whose applications in land and natural resource management are widely recognized. These technologies provide a cost effective and accurate alternative to the conventional approaches used for the determination of the landscape dynamics. Digital change –detection techniques based on multi-temporal and multi spectral remote sensed data have demonstrated a great potential as a means for the understanding of the landscape dynamics to detect, identify, map and monitor the differences in the land use/land cover pattern over the times, irrespective of the casual factors.

The present paper deals with the presentation and regression of the time series and analysis using the markovian model to analyze the base and the profile line suitable for the reclamation level of the entire area. An understanding can be developed on the basis of the Markovian approach for the predictability of the next profile level /plane in the future and is ascertained by the matrix method applied to obtain it. The present study was undertaken to analyze for the changes that may have occurred on the topography of the Jharia coal field by interpreting the multi temporal remote sensed data.

Material and Methodology

Study Area

Jharia Coal field area has always attracted people over the past centuries due to its large number of the bituminous coal (suitable for the coke) production in INDIA. It shares most of the coking coal production in INDIA. Mining activities has been practiced in the Jharia coal field since eighteenth century. The extraction of coal has been carried out by open cast mining and underground mining methods. The present area of the eastern Jharia located on the out skirts of the district is a region located on the latitude of 23.755266447N and 86.4214699E. The DEM of the area on the USGS explorer belonged to the path 140 and row 44.
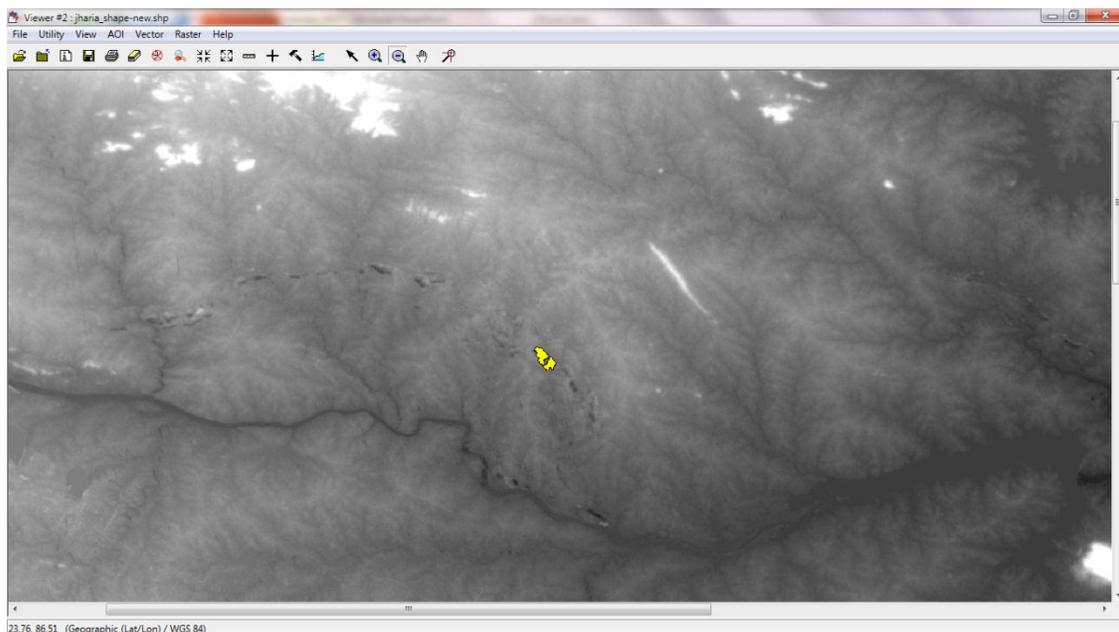

Figure 1 Shape file superimposed on the DEM of the study area Source: (www.usgs.org)

Methodology

In the present study of the detection of the profile level for the monitoring and filling of the excavated profiles of the over burden was found out using the comprehensive study of the ASTERDEM geo tiff of the LAND SAT 5 TM images website. The images were reprojected into the geographical coordinate system. The area of interest of the Jharia coal field was obtained using the topographical and geological map of jharia coal field. The KMZ file (fig. 2.2) obtained from the Google earth was them formatted to be superimposed on to the present DEM of the area to get the required area of interest. Unsupervised classification was done to obtain the two land classes besides obtaining areas and the volumes of the non urban and the overburden lands. The ASTER DEM (fig. 2.3) obtained was used to prepare the rastin, thus calculating the area above and below the mean reference levels using the ESRI Arc Scene program. The optimum level of the reference plane level required for the reclamation was calculated using the method of C/C++ programming using bisection method and the volume of the

area above the reference plane to be shifted to the desired depression/ basin formed due to the undulation of the overburden proceeding the previous years.

Fig 2 KMZ file of the Jharia (Bastacola area) obtained from Google earth.

Statistics for suggested conceptual regrading

The total coverage may not always be the most effective method of analysis for the portion through which the required area would be taken to fit in for the present void. Instead of taking up the area coverage for the land use land cover pattern for each of the category at each date into account, pixel based comparison was used to locate the area required to be shifted with the pixel change analysis. The data of the findings associated with the following pixel analysis is shown in the chart fig 3.1. Using the method of iteration equipped with the programs in C++ the, altitude was interpolated to find the required volume of land fill above the reference plane using the table 3.1. Equation used (eqn. i) followed by the repeated results over the recursion yielded the 160.830 m as the reference plane and the volume of the over burden that needs to be moved is 33464867.98 m^3 over a surface area of 932369.79m^2. The volume of the landfill occupying the region above the landfill has been depicted in the legend of fig 2.3 as **white** and the **basin/depression** as green or pale yellow.
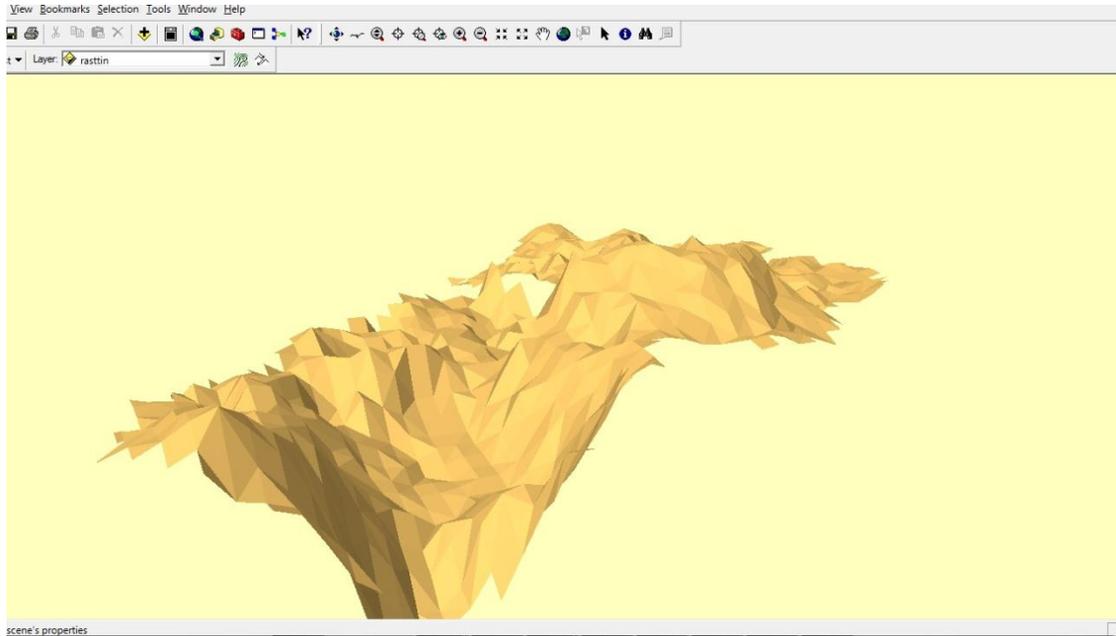
$$935100 \times h = V_{a} + V_b$$

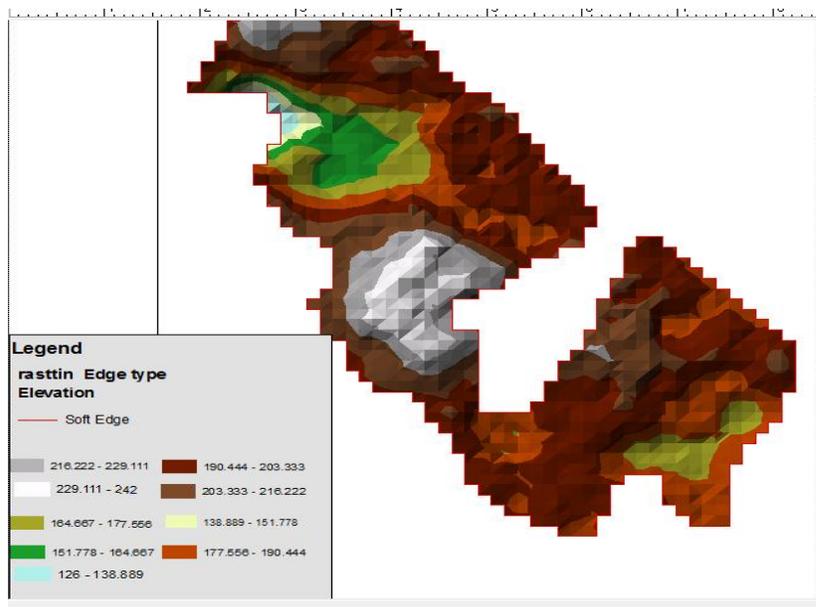**Fig 3 RASTIN of the area of interest as depicted in ARC scene**

Fig 4 TIN of the area of interest with the legend extracted from ArcScene

Table 1. Cut and Fill volumes; Buffer surfaces located above and below the excavation hingeline

Volume above the reference plane (V_a)	Volume below the reference plane (V_b)	Total lease hold area (A)	Height of the reference plane (h)
65744441.07	0	935100.00	126
61070396.34	455.21	935100.00	131
56404336.46	10895.38	935100.00	136
51750942.83	330001.76	935100.00	141
47109812.15	67371.07	935100.00	146
33311769.16	116460.13	935100.00	151
37876192.04	184750.97	935100.00	156
33311769.16	295828.08	935100.00	161
28864320.91	523879.84	935100.00	166
24523263.67	858322.60	935100.00	171
20323816.23	1334375.76	935100.00	176
16330824.75	2016883.68	935100.00	181
12590761.70	2952320.62	935100.00	186
9219435.60	4256494.53	935100.00	191
6480593.71	6193152.63	935100.00	196
4467231.31	8805290.24	935100.00	201
3048348.06	12111906.99	935100.00	206
2002057.26	15741116.18	935100.00	211
1274616.78	19689175.71	935100.00	216
762935.09	23852994.02	935100.00	221
385562.14	28151121.06	935100.00	226
143123.33	32584182.26	935100.00	231
30360.93	37146919.86	935100.00	236
0	42727158.93	935100.00	242

Future Work Using Markov Chain Analysis

Cross tabulation is a means to determine quantities of conversions from a particular land cover to another land cover category at a later date. The change matrices based on post classification comparison were obtained and are shown in Tables 2. The change of different land class into another land class for the study area can be observed from the matrix if instead we used **h** number of the land use category. Then the transition count matrix of land use category between two different time periods is given as:

$$N = \begin{bmatrix} n11 & \cdots & n1h \\ \vdots & \ddots & \vdots \\ nh1 & \cdots & nhh \end{bmatrix} .(1)$$

Give the observed count matrix, the maximum likelihood estimate of the transition matrix is simply the row proportions of N

$$M_t = \{\Theta_{ij}\} \quad \Theta_{ij} = n_{ij} / \sum_{j=1}^{h} n_{ij}$$

M_t is the transition matrix of the Markov chain for the unit time interval is given as ,

$$M_l = M_t^{(1/t)} = PD^{1/t} P^{-1}. (3)$$

Where, P and D are the orthogonal and diagonal (Eigen values) matrices respectively and,

$$D = \begin{bmatrix} \lambda 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \lambda h \end{bmatrix} .(4)$$

To model a change for the land reclamation level profile and the land cover monitoring by markov chain , the land cover distribution at a time t2 was calculated from the initial land use distribution at a time t1by means of a transition matrix (Lambin 1994). The Markov chain can be expressed as:

$$V_{t2} = M*V_{t1}.$$

Where V_{t1} is the input land use/cover proportion column vector, V_{t2} is the output land use /cover proportion column vector and M is an *m x n* transition matrix for the time interval t = t1- t2. When the transition probabilities depend only on the time interval t, and if the time period at which the process is examined is of no relevance, the markov chain is said to be stationary or homogeneous in time (Karlin and Taylor 1975). If the two estimates of the transition matrix of a land use /land cover change process are available for two calibrations time intervals, these estimates must be adjusted to an equivalent calibration time period to allow for comparisons and to assess the stationary of the process (Bell and Hinojosa 1977). For this study , in future the shift in the reference reclamation level would be find out with the probability indexes of the Barren land and Overburden to approximate the location and the coordinates of the level plane. The transition

Conclusion

The monitoring of the area with multi temporal satellite imagery provides the information about the land use /land cover pattern. The DEM obtained has been classified under different color schemes for different altitudes in fig 3.1. The White and gray portions indicative of higher altitudes are overburden that need to be moved and the basin /depression for the cut and fill sites for creating the excavation regarding profile. The total over burden area shown in red 40.96% needs to be shifted in levels to the adjacent basins to create a 3buffer of 160.830 m. The total volume and area that needs to be drifted is 33464867.98 m3 and 932369.79m2 respectively. Regrading technique applied in this paper using the Newtonian iteration method allows analysis of proposed soil and vegetation reclamation plan by concerning the issues like volume and mass of material required to be shifted and the resulting footprint of the reclaimed and regarded feature .This type of consideration would allow the cost issues for regrading, while taking into account the profile of the resulting footprint and finally analyses the effect of regrading on features near the present perimeter of the existing stockpile. The scheme presented is useful in

evaluating the potential increase in the footprint of a stockpile after regrading. Poor planning of over burden disposal of the large open cast mine of BASTACOLA has in turn contributed adversely to increase the barren land.

The application of Markovian analysis as the future work will help to provide the approximate reclamation level for the near future due to ongoing mining activities in the neighboring regions. Transitional probability matrix for the year 2011-2020 will provide the change prediction for near future and an empirical equation in terms of larger lease hold area **eqn.a** and the reclamation level. Jharia Coal field is the third largest coking producing area in the world. It has a rapid and extensive changing landscape and topography in terms of mining activities as well as in terms of barren land and over burden in last two decades. Optimum reclamation of the topography is the dire need prior to the advantage of the region. In this case prediction of the optimum reclamation level plane is required for establishing selective, planning and implementation of reclamation strategy and rehabilitation plan to meet the growing needs and welfare in the state of increasing mining activities in this area.

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