IJASRM
International Journal of Advanced Scientific Research and Management, Volume 3 Issue 6, June 2018
www.ijasrm.com
ISSN 2455-6378

Monitoring land use/cover changes during the mining activities in Aravalli Hill Region

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Abstract

A case study was carried out to quantify the Land use/ cover changes during the mining activities in the periphery of Aravalli Hill region. This study delineates the accurate measurements of the changes that have taken place after the closure of mining activities in and around the outskirts of Aravalli hills in Faridabad district of Haryana during 2002 and 2011 using LISS-III and World View images, paramount possibility and matters. Adapted classification of maps and the change elicitation have been carried out by using post-classification comparison using ArcGIS. The images of the study areas are categorized into different major and sub-major categories namely Built-up, Agriculture, Vegetation including Moderate, Sparse, Thick and No vegetation, Ponds with water and Dry lakes, Lakes with water and without water, Mining areas with and without water. The result indicates that Built -up area of 2011 have been increased to 3134.53 acres as compared to 2002. Thus, surface water including ponds and lakes, which are an important source of water to humanity; have been depleted in the region by 14.96 acre All lakes in the Aravalli hills have been decreased by 79.81acres. Moderate vegetation increased by 1252.41 acres and Agricultural area have been reduced by 2164.26 acres. Mining pits with water increased by 108.6 acres due to recharge of aquifer after the closure of mining activities. The paper highlights the importance of digital change detection techniques to analyse the changes take place in mining areas of the Aravalli hills in Faridabad district, Haryana.

Keywords: *Mining , Landuse/land cover , Aravalli hill, and Change detection.*

1. Introduction

Ecosystem disturbance is a situation or a series of situations that changes the relationship of organisms and their habitat (Treweek 1996; McNeelay 1994) with series of time and space. Imbalance in ecosystem caused due to mining activities is the product of increase in industrialization and modern civilization. Forest ecosystem has consequential functions from an ecological point of view and provides accommodation that is necessary to maintain the life-support system on a local and ecumenical scale (Rao & Pant, 2001). The detrimental effects on land use and land cover change are very tremendous in establishing countries because of sundry human activities and need for development. Mining in both state i.e. surface and subsurface causes gargantuan damage to the properties of environmental components i.e. air, water, noise and soil, flora and fauna and also socio-economic conditions of the people living around the mining area. (Kumar & Pandey, 2013). Eradication of forests during mining activities regularly led to an extensive damage and loss to the ecosystem (Priyadarshi, 2012). The waste of mines when dumped in fresh areas generates mine pillage, which conclusively affects the surrounding areas.

Mining processes, include minerals extraction from the earth's crust, transportation of minerals and even drilling & blasting that leads to remarkable transformation on the environment, landscape and biological communities of the earth (Down & Stocks, 1997 and Bell *et al.*2001). Illegal mining of minerals creates a serious threat to the environment, consequence in reduction of biodiversity (UNESCO, 1985). The problem of waste rock and overburden dumps becomes devastating to the landscape around mining areas (Goretti, 1998).

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Mining leads to an irreversible change on the environment. According to Environment Management Plan, every mining plan prepared before the commencement of mining has to indicate limits of reserve, density of trees to be planted during and after closure of mine, assessment of impact of mining activity on environment, forest, topography of the area, scheme for restoration of the area by afforestation, land reclamation and progressive closure plan. The mining plan is prepared by a Recognised Qualified Person (RQP) and is approved by competent authority after the survey of the proposed area. Mining activities in Aravallis has been carried out unscientifically without conducting proper Environmental Impact Assessment of the proposed mines and also without obtaining required clearances from various authorities. The extraction of minerals was done below groundwater table as a result of which the groundwater table has gone down and also got contaminated. In Anangpur mining area water pumped from quarries was poured into Buria *nalla* whereas mining water in Pali and Manger areas are directed into their vicinity lake such as Dhauj Lake through artificial channels, which is connected to natural drainage system of the area and finally flows into Yamuna River. Project proponents operating mines earlier have left the pits/quarries open without any reclamation of mining area, which disturbed the natural catchment area. Therefore, in 2009 Hon'ble Supreme Court put a blanket ban on both major and minor mineral mines in the Aravalli hills spread over 448 sq^2 in Faridabad, Mewat and Gurgaon District of Haryana.

A detailed understanding of the impact of mining activities change in land use/land cover pattern with respect to time and space is mandatory for the district. Consequently, the current study is initiated to analyse the phenomenon of human induced landscape transfiguration in the mine affected zone of the Aravalli Hills district of Faridabad district by describing temporal (2002-2011) changes using remote sensing data and GIS (Geographic Information System). In order to accomplish this objective the land cover categories (dense vegetation, sparse vegetation, thick vegetation, lakes and mining areas) have been depicted. The area under agriculture, built-up, and water-bodies has taken into discussion to know the trend due to the impact of mining activities in different periods.

2 Study Areas and Methodology

The study area (fig.1) 273 km^2 have been selected from the survey of India topographical sheet No: 53H/3 and 53H/7 on the scale of 1:50,000. The Faridabad district lies between the latitudes 27^o 51' 15" and 28^o 30' 52" North and the Longitudes 77^o 04' 39" and 77^o 35' 50" East. The Mining area in Aravalli hills are taken as a main centre of the study which is located about 10-12 km from the Faridabad city. Aravalli Hills provides open cast mining of Silica, Quartzite, Badarpur sand and other good quality construction material. It also provides employment to a large number of people during the mining activities and hence here is the need to assess the improvement that has been taken place after the closure of mining activities (CGWB, 2002)

The topography of the study area is plain and elevation ranges from approximately 900 to 1050 feet. mainly tropical and brown soils exist in major parts of the Faridabad district. The soils having organic content ranging from 0.41 to 0.75 percent falls in medium category and 0.2 to 0.4 percent is characterised as Low category (CGWB, 2002). The older alluvium comprises of horizontal beds and lenses of brown to yellowish clay silt, brown and grey sand and calcite, which is having lateral facies variation. On surface brown slit and clay, sediment is exposed. The newer alluvium disconformably overlies the older alluvium.

The climate of the study area has mainly characterized by the extreme dryness except during monsoon, intensely hot summers and cold winters. Faridabad district receives about 564mm annual rainfall spread over 27 days (IMD). The southwest monsoon sets in the last week of June, withdraws towards the end of September, and contributes about 79% of the annual rainfall with July and August as the wettest months of the year. 21% of the annual rainfall occurs during the non-monsoon months in the wake of thunderstorms and western disturbances.

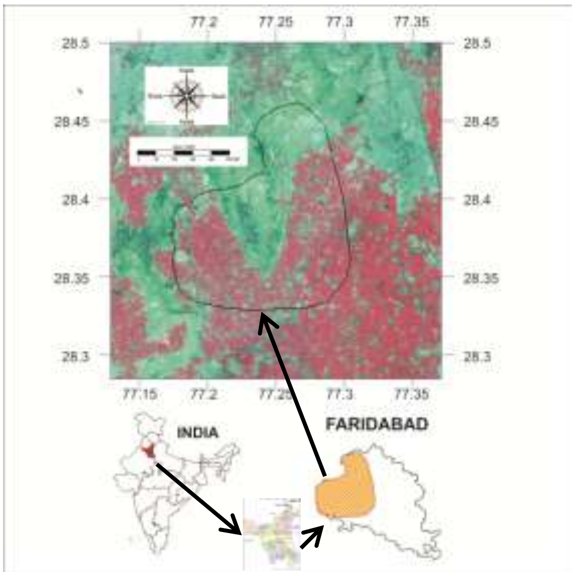

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***Figure 1**: Representation of Location Map of the Study Area on LISS-III Satellite Image in False Colour Composite (FCC).*

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www.ijasrm.com
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3 Materials and Methodology

3.1 Data collection and processing

In the present study, satellite images of the study area have been acquired for the year 2002 and 2011. LISS-III data and World view data is used for 2002 and 2011 respectively (fig 2).

The satellite images are obtained from Haryana Space Application Centre (HARSAC) Hisar, Haryana. Topographical map obtained from the Survey of India (SoI) is used for the ground reference of the area which is rectified using geographical latitude and longitude. ERDAS software version 9.2 is used for the purpose of geo-referencing of topographical map and registration procedure of satellite image for map to image as well as for image to image. Details of satellite data and ancillary data used with their specifications is given in Table 1.

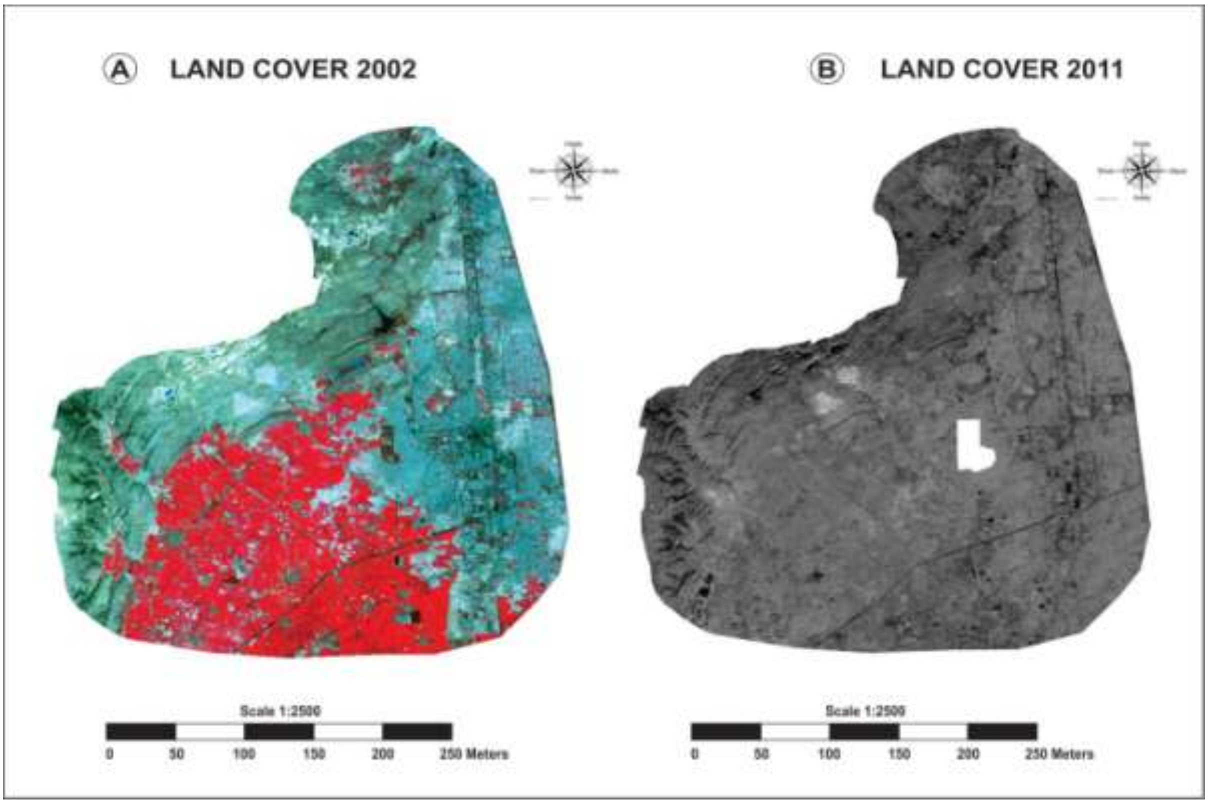

Figure 2. Land use/cover status in and around the Aravalli hills of Faridabad district; (a) in 2002, (b) in 2011 (based on Satellite Imagery).

Table1. *List of Data used and their specification*

Land Sat Image	Data of Product	Resolution	Source	Image Quality
LISS-III	12/02/2002	50M	HARSAC	LISS-III
World View	15/11/2011	25M	HARSAC	World view
Topographical map	53H/3 and 53H/7	1:50,000 Scale	Survey of India	

3.2 Methodology

Land use/land cover changes can be identified by either image-to-image comparison or map-to-map comparison (*Koster R.D., et al).* In the present study map-to-map comparison is used for LULC change detection. The classification is categorized into 12 major and sub- major categories with abbreviation (Table 2). On screen digitization technique is adopted to digitize the maps using ArcMap software (version 9.3) and further area statistics of various land use categories was calculated.

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ISSN 2455-6378

Land use/land cover statistics is used to compute percentage changes, trend and rate of LU/LC changes in each category among the data of 2002 and 2011.The area and percentage of LU/LC changes for the two selected years is computed for each class (*Table 3*) and the changes are compared for initial and final LU/LC area coverage according to the following formula:

$$\textbf{Percent LU/LC Change} = \frac{\textbf{Present LU/LC} - \textbf{Pervious LU/LC area}}{\textbf{Previous LU/LC area}} \times 100$$

Table 2. An unsupervised classification is performed on the image with the following land use classes with their abbreviations:

Abbreviation	Categories
BL	Built-up land
TV	Thick vegetation
MV	Moderate vegetation
SV	Sparse vegetation
NV	No-vegetation
AL	Agriculture land
PWW_1	Pond with water
PWW_2	Dry water pond
MWW_1	Mining pit with water
MWW_2	Mining pit without water
LWW_1	Lake with water
LWW_2	Lake without water

Where area is extent of each LU/LC type, positive values suggesting an increase whereas negative values imply a decrease in extent. Detailed methodology adopted in the study is given in the flow chart below (Fig 4).

Transition Probability Matrix

The process of land transformations involves comparison of the area that has changed, by comparing land use/land cover classes to another class. (Table 4 and fig 3) The land transformation matrix has been created by using UNION function in ARC GIS and the cross-tabulation method.

The transition probability matrix records the probability of each category to change into another category. This matrix is prepared by multiplying each column in the transition probability matrix to the number of cells of corresponding land use in the later image. For 12 by 12-matrix table presented below, the rows represent the older LU/LC categories and the column represents the newer ones. Although this matrix have been used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery.

4. Results and Discussion

Area falling under different land use/land cover categories are obtained by satellite image based on interpretation of LISS III data for 2002 (*Fig* 2a), Worldview data of 2011 (*Fig* 2b) and Land transformation status of both data 2002 and 2011(*Fig 5 and 6*). The changes in LU/LC statistics in Acres and percentage are shown in *Table 4*. The results of the LULC changes statistics have also been represented by Bar Graph (*Fig7*).

4.1. Spatial Distribution of Land use / Land cover

The land use and land cover in the study area exhibits in various patterns due to rapid changes in the relief and Geo-morphological land form including marked difference in the climatic conditions. The various categories of land use – land cover mapped in the area using Satellite image of 2002 and 2011 (*Fig 5 and 6*) indicating marked changes in the agriculture and vegetation areas primarily after the closure of mining activities. Built up area has been increased due to increasing industrial settlement, residential, institutional, recreational etc. in the study area.

The six major categories have been compared such as Build up land, Water bodies including Ponds only, Vegetation land, Aravalli major lakes including Surajkund, Badhkal and Peacock lake only Mining pits, water bodies,vegetation and lakes are further classified into sub-categories i.e. Mining pits with water and without water, Ponds with water, Ponds without water, Thick vegetation, Moderate vegetation, Sparse vegetation, No vegetation, Lakes with water. Temporal changes occurring among various LU/LC categories are discussed below to give a clear view about the scenario after the closure of mining activities and land improvement taken place in this area.

A. Built up Land Land reflects the population settlement. The urban spreading and situation of population growth have related to decline in Agriculture and Vegetation area. It includes urban

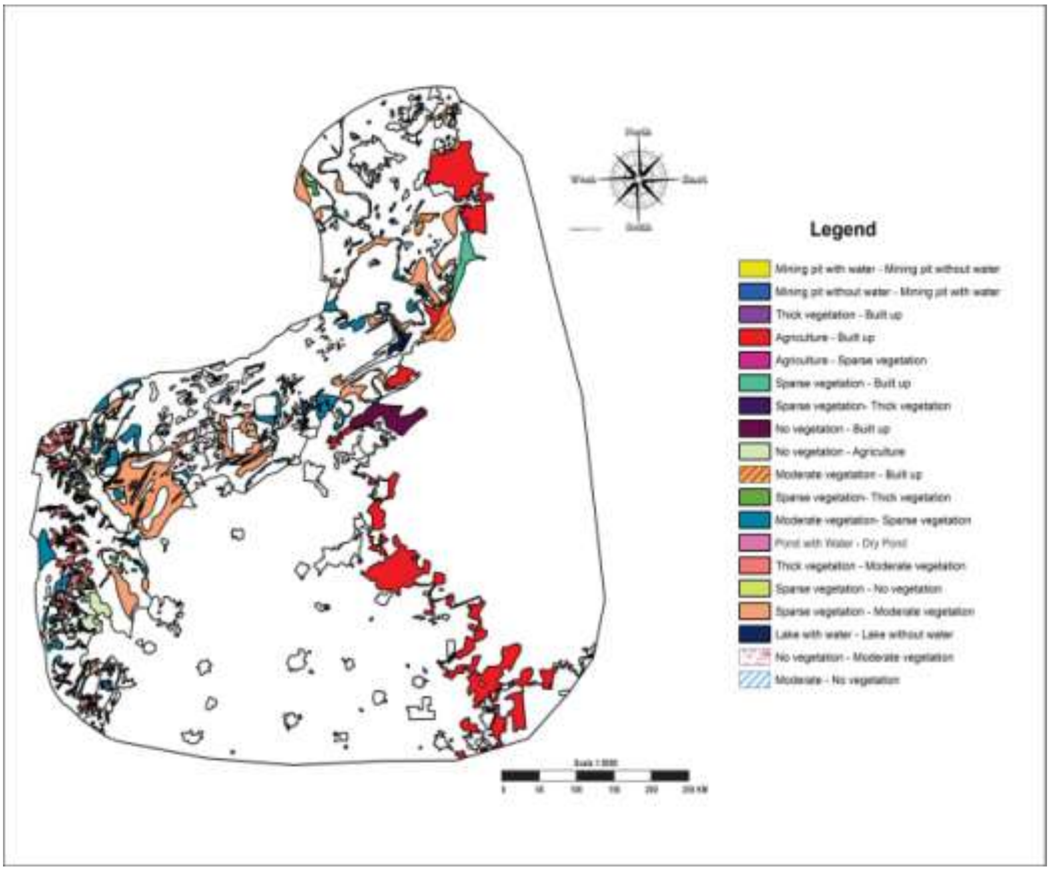

Figure 3 *Maps of different time were overlaid to determine the change*

Table 3: Land use/Landover (LU/LC) Statistics and its Dynamic

Major-categories	Sub-categories	2002 Area in (Acres)	2002 Area in %	2011 Area in(Acres)	2011 Area in %	%Change in Area
Built-up	BL	20799.73	30.80	23934.26	35.44	+4.62
Water body	PWW1	67.96	0.10	53	0.08	-0.02
	PWW2	3.32	0.00	18.28	0.03	+0.02
	MWW1	133.8	0.20	242.4	0.36	+0.16
Mining pits	MWW2	1341.08	1.99	1232.48	1.82	-0.16
	TV	987.51	1.46	686.1	1.02	-0.45
Vegetation	MV	13265.22	19.64	14517.73	21.50	+1.85
	SV	5574.19	8.25	4292.78	6.36	-1.90
	NV	949.14	1.41	309.18	0.46	-0.95
Aravalli major lakes	LWW1	84.24	0.12	4.43	0.01	-0.12
	LWW2	134.35	0.20	214.16	0.32	+0.12
Agriculture land	AL	24197.06	35.83	22032.8	32.62	-3.20
		67537.6	100	67537.60	100	+3.20

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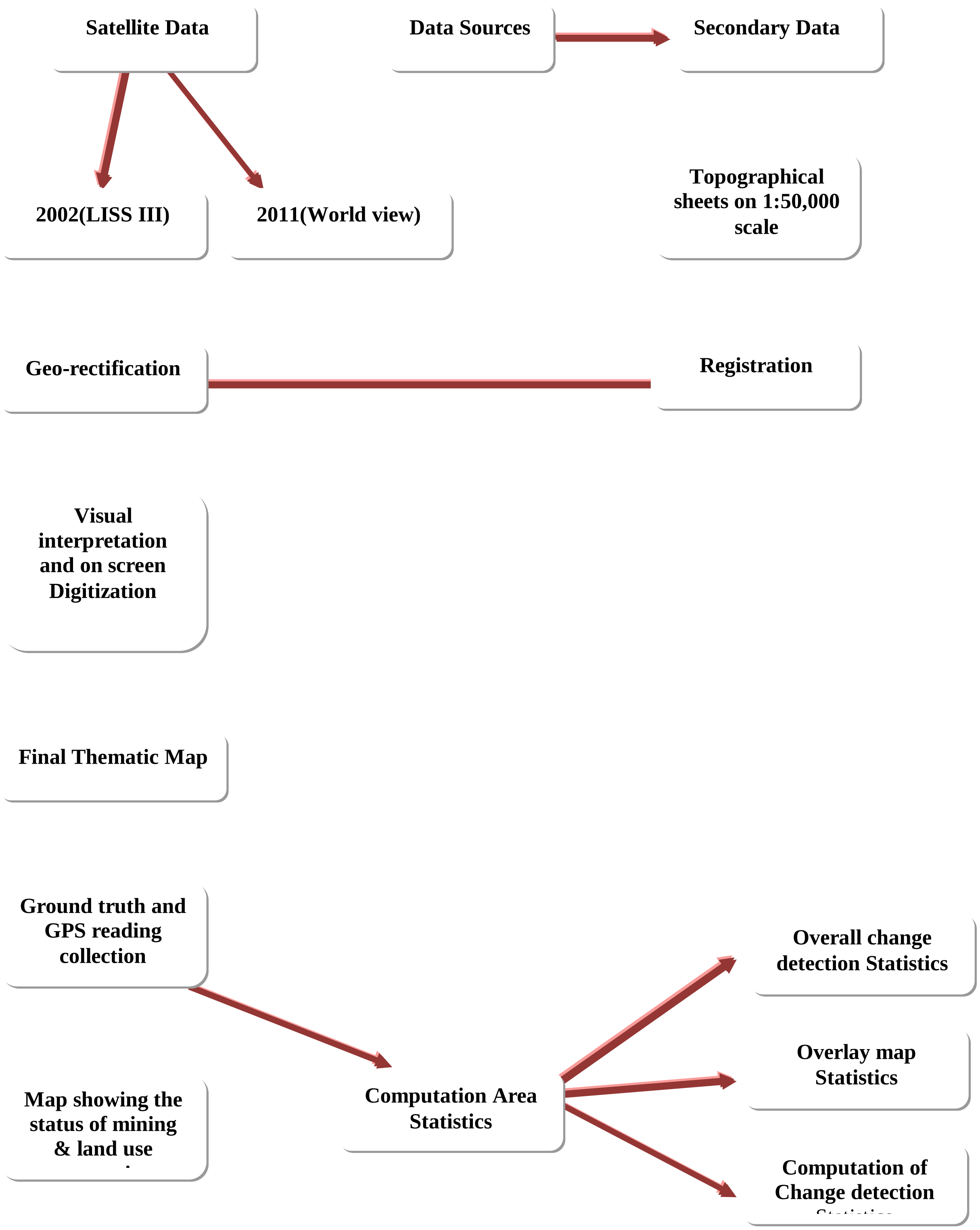

Figure 4: Methodology adopted for the identification of changes occurring in Land use/Land cover through on screen digitization and interpretation Techniques.

Table4: Change matrix show the land Transformation from 2002 to 2011

Categories	BL	PWW_1	MWW_1	MWW_2	TV	AL	SV	LWW_2	LWW_1	NV	MV	DWW_2
Bl	20799.73	-	-	-	-	-	-	-	-	-	-	-
PWW_1	-	53.00	-	-	-	-	-	-	-	-	-	14.96
MWW_1	-	-	125.45	8.35	-	-	-	-	-	-	-	-
MWW_2	-	-	116.95	1224.13	-	-	-	-	-	-	-	-
TV	0.21	-	-	-	382.24	-	-	-	-	-	605.06	-
AL	2346.36	-	-	-	-	21652.89	29.05	-	-	-	168.76	-
SV	180.36	-	-	-	16.00	-	3297.67	-	-	14.89	2065.27	-
LWW_2	-	-	-	-	-	-	-	134.42	-	-	-	-
LWW_1	-	-	-	-	-	-	-	79.81	4.43	-	-	-
NV	293.73	-	-	-	-	379.41	-	-	-	271.31	4.69	-
MV	314.39	-	-	-	287.86	-	966.06	-	-	22.96	11673.95	-
PWW2	-	-	-	-	-	-	-	-	-	-	-	3.32

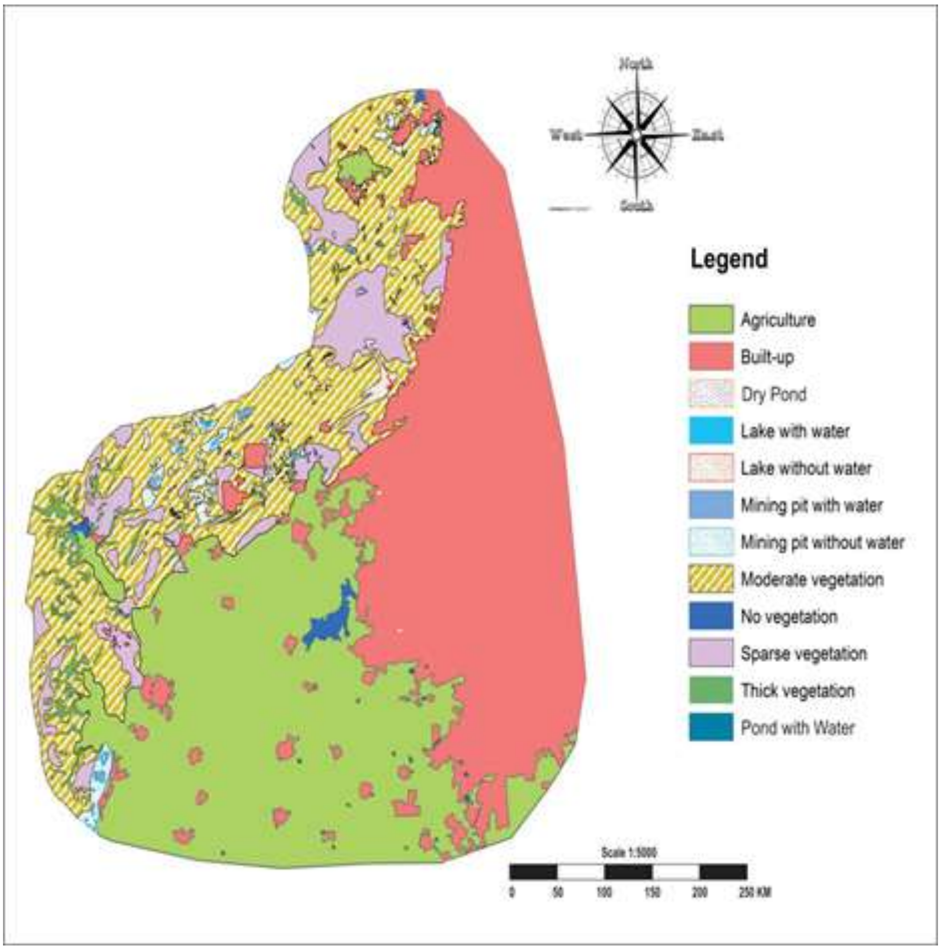

Figure 5*: World View Image of Landuse / Landcover of 2011*

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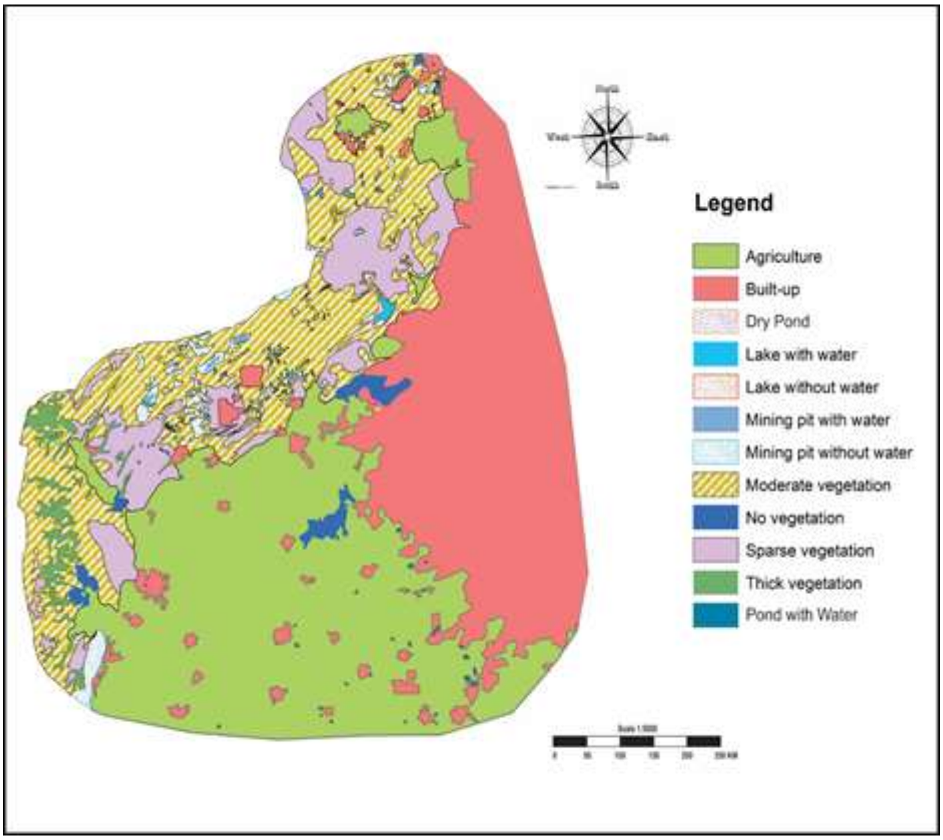

Figure 6: LISS-III Image of Landuse / Landcover of 2002

settlement, industrial settlements and outside urban. Urban settlement is an area of larger land covered by human construction. These areas are non-linear and consist of impervious structures, which are adjoining to connected streets. Rural settlement represent land used for anthropogenic activists of size comparatively less than the urban settlements here, more than 80% of the people incorporate themselves in agriculture. During the aforesaid period of 10 years the changes that are observed, areas formerly occupied by thick vegetation, agriculture, which has converted into built-up land. This development has observed along the foothills North-West corner of the study area with urban sprawl towards East & South of Faridabad. The area under built-up land has increased upto 3134.54 acres from 2002 to 2011(*Table 3*).

B. **Agricultural Land**, which is mainly to produce food and fibre. It is mainly categorize in following classes such as cropland, Fallow lands and plantation area. Croplands are the areas with standing crop; fallow lands are the land that is mainly used for farming but that is left with no crops on it for a season in order to let it recover its fertility. The agricultural land has showed decreasing trend of area 2164. 26 acres from 2002 to 2011. The decreasing trend attributed to the conversion of agriculture land into built up area. This sprawl of built up land is due to increase of population over the years. (*Table 3* and *Table4*).

C. **Vegetation land** which comprises of thick vegetation, moderate vegetation, sparse vegetation and no-vegetation. Thick vegetation covered an area of 987.51 Acres in 2002 and 686.1 acres in 2011. Thick vegetation decreased by 301.41 acres. Decreased thick vegetation attributes to the conversion of 16 acres into sparse vegetation and 287.86 acres into moderate vegetation may be due to felling of tress for mining purpose or urban development according to land transformation probability matrix. Moderate vegetation covers an area of 13265.22 acres in 2002 and 14517.73 acres in 2011. Moderate vegetation has showed increasing trend by 1252.51 acre, which attributes to the area conversion of 605.06 acres from thick vegetation, 168.76 acres from Agriculture land, 2065.27 acres from sparse vegetation and 4.69 acres from no-vegetation area. Sparse vegetation covers an area of 5574.19 acres and 4292.78 acres in 2002 and 2011 respectively. Sparse vegetation have showed a decreasing trend by 1281.41 acres which attributed that this area undergone a conversion of 180.36 acres into built-up land, 16 acres into thick vegetation (it can be possible if area remained untouched from 10 years), 14.89 acres into no vegetation, 2065.27 acres into moderate vegetation. It happened due to the forestation activities have started after the closure of mining activities. The occurrence of degrade or no-vegetation area around human settlement indicates their development from degradation of dense and moderately dense vegetation primarily due to human interference in the form of infrastructure development. It occupies an area of 949.14(2002) acres and 309.18 acres (2011) indicates overall increasing trend by 639.96 acres due to conversion 293.73 acres of No-vegetation area into built-upland, 379.41 acres into Agriculture area and 4.69 acres into 4.69 acres into moderate vegetation.

D. Water Bodies comprises an area, which is accumulation of surface water. The term most often refers to ponds, lakes, wetlands or more rarely puddles. Here, Water bodies delineated the ponds with water and ponds without water or dry ponds.

Ponds with water occupies an area of 67.96 acres in 2002 and 53 acres in 2011 indicating overall decreasing trend by 14.96 acres due to more demand of water with increasing population growth.

Ponds without water or dry water ponds occupy an area of 3.32 acres in 2002 and 18.28 acres in 2011 indicating overall increasing trend by 14.96 acres from 2002-2011.

E) Mining pits are largely located in the Aravallis hills of Faridabad district. Mining and land use/land cover changes are compared with each other. Here, mining pits are categorized into mining pits with water and mining pits without water (Rathore and Wright, 1994; Prakash and Gupta, 1998).

Mining pits with water have formed due to collection of rainwater/stormwater or ground water in the quarry areas of mines. Large numbers of such water bodies are located in and around the Aravalli hills. These pits occupies an area of 133.8 acres (0.20%) in 2002 and 242.2 acres (0.36%) in 2011 indicating overall increasing trend by 108.4 acres (0.16%). This shows that after the termination of mining activities in Aravalli region the underground aquifers recharges by the water accumulated in quarries. This projects a positive impact of mining on groundwater recharge. (Reported, CGWB).

Mining pits without water or dry mining pits are the pits formed due to pumping out of water from pits, these pits occupies an area of 1341.08 acres (1.99%) in 2002 and 1232.48 acres (1.82%) in 2011. This shows a decreasing trend from 2002-2011 by 108.6acres (0.16%). It formed due to increasing groundwater water level (Reported, CGWB). Percentage change detection observed in (*table 5)* where number of mining pits remains the same but mining pits with water increase after the closure of mines.

Table 5: Percentage change detection in Mining pits

	2002		2011		Change
	Area(Acres)	% Area	Area (Acres)	% Area	% Change
Mining pit with water	133.8	9.07	242.4	16.43%	7.36
Mining pit without water	1341.08	90.93	1232.48	83.57%	7.36
Total	**1474.88**			**1474.88**	

F) Major lakes in Aravalli region include three main lakes Surajkund Lake, Peacock Lake and Badkal Lake. During mining activities, water pumped out from pits and drained into their nearby surface water body such as Buria nalla, Dhauj lake and also an artificial lake which is connected with natural drainage of the area. Mining activities disturbed the catchment area of the natural drainage system and hence Badkal and Surajkund Lake dried out. Lakes in Aravalli region are classified into two categories: Lake with water and Lake without water or Dry Lake.

Lake with water occupies an area of 84.24 acres in 2002 and 4.43 acres in 2011 overall change indicating decreasing trend by 79.81 acres from 2002 to 2011. It is an evitable change that is seen due to mining activities. Unscientific mining method results in decrease in groundwater level and thus water table of the area goes down. To recharge the underground aquifers the water from these lakes moves down to groundwater rendering them dry.

Lake without water occupies an area of 134.35 acres in 2002 and 214.16 acres in 2011 overall change indicating increasing trend by 79.88 acres from 2002 to 2011. It occurred due to disturbance of natural drainage system of the area due to mining activities.

From *table 3* and *4*.The built-up area are showing positive impact from 2002 to 2011, which indicates the increase of population and infrastructure development in the region. During initial stage, when mining had been done mostly in Thick forest area and it have exploited for mining and but now, after the termination of mining activities moderate vegetation area increased by 1252.51 acres. It finds that 1281.41 acres sparse vegetation have converted into moderate. Mining leads to the degradation of soil quality, fertility and make it toxic. Natural vegetation is adversely effected due to leached trace element. The major consequences of mining is the deforestation which results in loss of flora and fauna.it is clearly indicates that after the banning of mining in the Aravalli region have given positive impact to the surrounding areas.

Land use/land cover distribution during the years taken for the study area under mining pit with water and mining pit without water is calculated. Area under mining pit without water is 1341.08 acres in 2002 which gets reduced to 1232.48 acres in 2011. It indicates that groundwater table recharge has taken place in some part of mining areas but on the other hand lakes had been dried out. It is due to the disturbance of catchment area of natural drainage system during the mining activities.

Digital Elevation Model

Rapid habitation growth like high moderate and low over the study area has categorized based on the digital elevation model (DEM) as shown in Fig. 8. Major habitation growth is on surface having elevation from 80 to 280m.

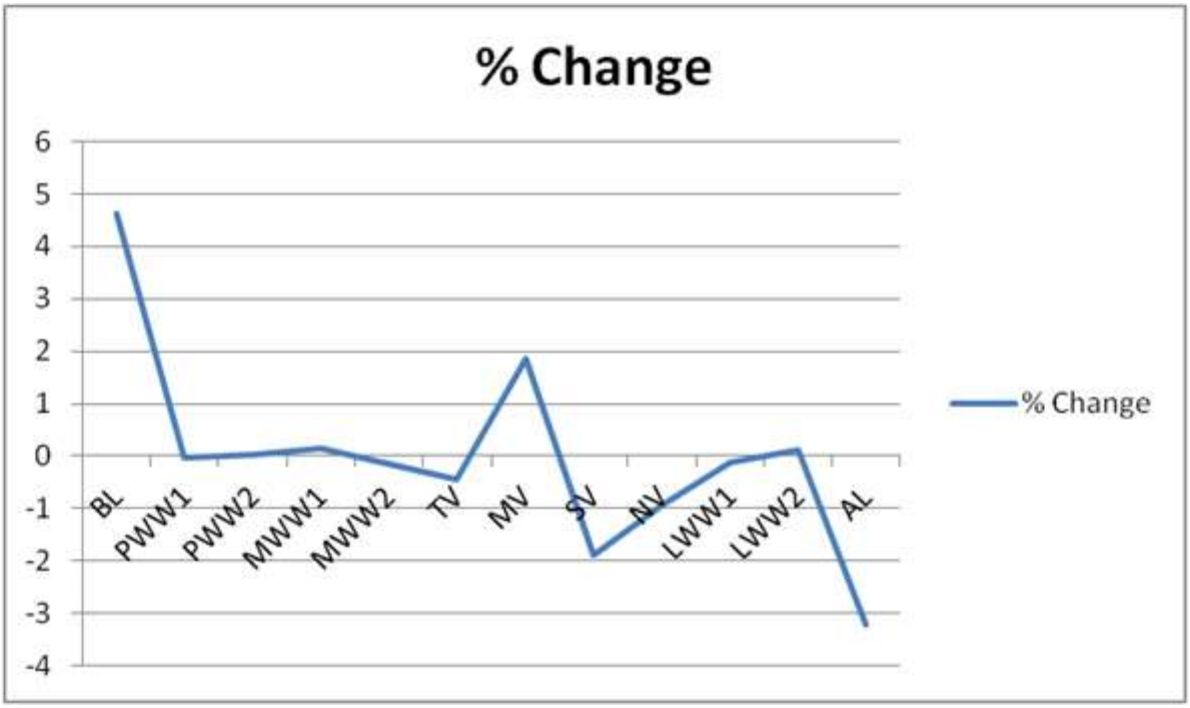

Figure 7: Percentage Change in Area under Various Land Use/Land Cover Categories of 2002 and 2011

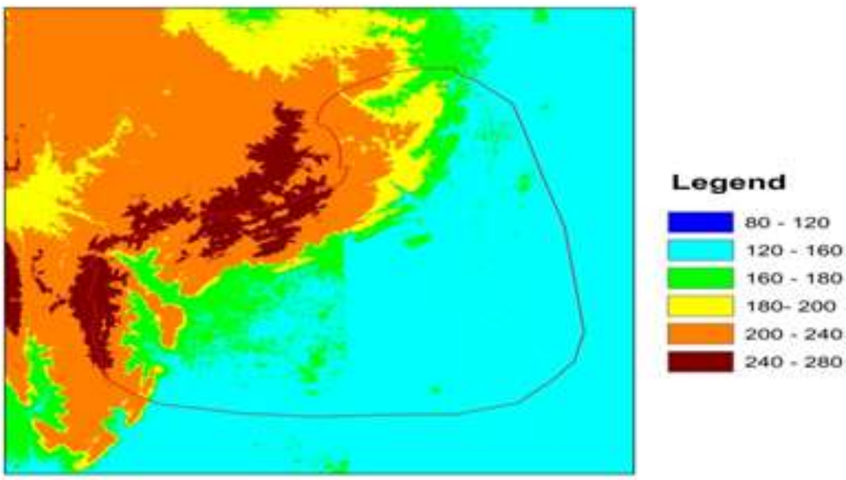

Figure8. Digital Elevation model of the study area in metres.

Conclusion

The study demonstrated that changes in land use and land cover pattern in an area can be identified by the application of GIS and image processing tools. The existing Built-up land use/land cover has been dynamic in nature. Different types of human activities such as mining practices have resulted in vast change in the natural cover. The surface water bodies have depleted around the Faridabad city, which is a matter of great concern. These changes are likely to alter the structure, function and the complexity of the local ecology prevailing in the study area with critical implication for the maintenance of the biodiversity, genetic species and landscape. After the closure of mining activities in the Aravalli hills, mining pits with water have been increased which the result of recharge of aquifers, which is somewhere having a positive impact on environment. This happened due to the closure of mining activities because during the mining activities, mineral were extracted below the groundwater level in an unscientific manner and water from pits have been drained into their nearby tunnel which is connected with Yamuna river. Mining activities also disturbed the catchment areas of natural drainage pattern and hence with respect to time all lakes in Aravalli hills such as Surajkund and Badkal lakes are dried out.

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