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Case Study

Mining Activity Monitoring Through Remote Sensing and GIS- A Case Study from Wani Area of Yavatmal District, Maharashtra

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Abstract Remote sensing (RS) and Geographic Information System (GIS) is a powerful tool for managing and planning the mining activities and has an advantage of synoptic view, temporal capability and can observe the inaccessible areas. Open cast mining activities has direct impact on earth surface which can be studied and quantified using remote sensing technology. In the present paper, we examined the areal expansion of the coal mines and their impact on the surrounding area of Wani using RS and GIS technique. The LANDSAT, IRS and High resolution satellite data of Google, having resolution of 30m, 23m, and 50cm respectively have been used. Changes in the crop land due to mining activities were calculated using heads-up interpretation of satellite data using ArcGIS software. Present study has shown that in Wani area crop land has decreased by 6.46% in the span of 26 years following the expansion of mining activities in the area.
Keywords *Crop land; GIS; Mining effect; Remote sensing*

1. Introduction

Nagpur, Chandrapur, Yavatmal and Wardha districts of Maharashtra hosts large deposits of coal. So far 5576 million tons of coal reserves have been proved in the State. In Yavatmal district, coal is mostly confined to Wani taluka. Due to Coal mining activities in Wani taluka, three important natural resources are affected viz. fertile top soil, crop land and ground water resources. Mining activities cause generation of coal dust which has potential health hazard. Inhalation of coal dust causes black lung disease, cardiopulmonary disease, hypertension and other related ailment in the population living near the coal mine (Finkelman et al., 2002). Open cast mining involves removal of overburden including valuable top soil as well as the natural vegetation cover. These activities are associated with harmful effects on the local environment and also biodiversity (Mahalik and Satapathy, 2016). Regular monitoring and management of such mining area is essential from natural resources and socio-economic point of view through modern technologies like Remote Sensing (RS), Geographic Information System (GIS) and Global Positioning System (GPS) for sustainable development.

2. Study Area

The present investigation covers Wani taluka of Yavatmal district and is bounded by longitudes 78°46'18"E to 79°8'59"E and latitudes 19°45'48"N to 20°11'26"N (Figure 1). The area is bordered by Chandrapur district along eastern and southern side and by Zari-Zamni and Maregaon talukas of

Yavatmal district on the western side. The Wani taluka geographically covers 910.47 km^2 area and includes 162 villages.

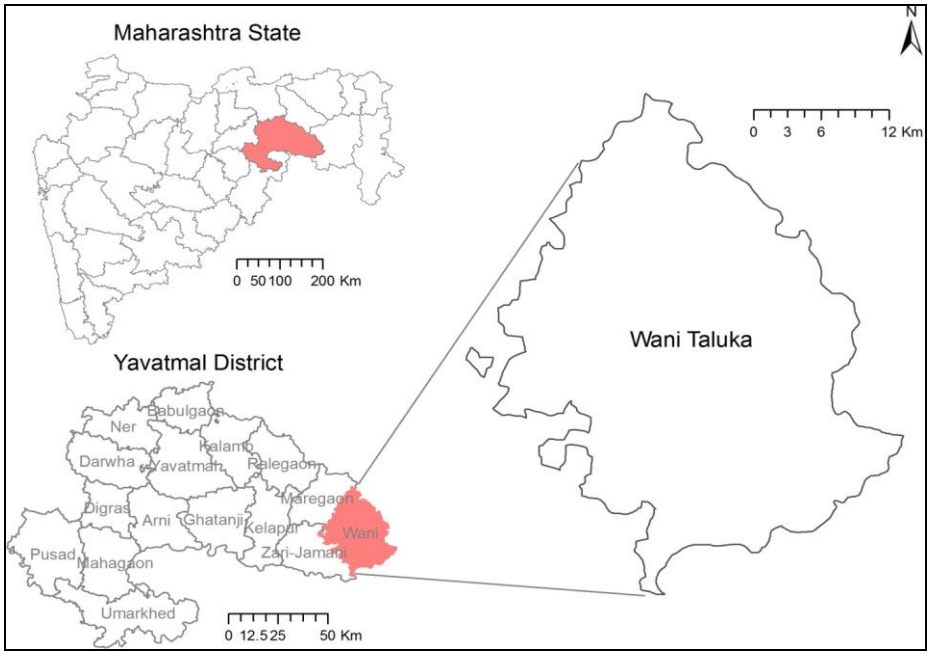

Figure 1: *Location map of study area*

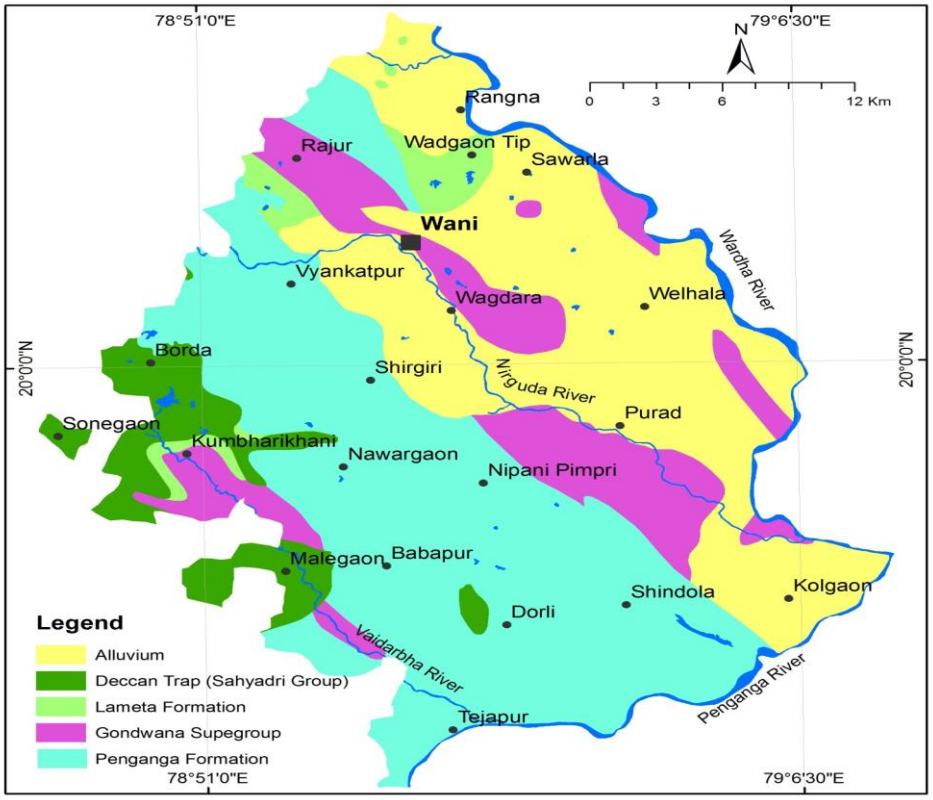

Figure 2: *Geological map of Wani taluka*

Geologically Wani taluka is covered by Neoproterozoic Penganga Group rocks represented by limestone and shales, which are overlain by Carboniferous to Permian Lower Gondwana rocks. Gondwanas are represented by sandstone, shale and coal beds of Barakar Formation and sandstone of Kamthi Formation. They are overlain by buff, pink and violet coloured clays and cherty limestones of Lameta Formation of uppermost Cretaceous age. All the older formations are overlain by Deccan Traps of Deccan Volcanic Province of uppermost Cretaceous to Eocene age. Alluvium is present mostly along eastern side of the area along Wardha and Penganga Rivers (Figure 2). The economic mineral present in the Wani taluka are coal, limestone, dolomite and clay.

3. Materials and Methods

In the present work, multi temporal LANDSAT TM and IRS P6 LISS-III data (Table 1) covering kharif (Aug-Nov), rabi (Jan-Mar), zaid (April-May) seasons for the year 1989, 2005-06, 2011-12 and single season high resolution data (Google) for the year 2009 and 2016 have been used to address spatial and temporal variability in land cover classes like crop land, coal depot, active mining area and mining plantation. The land cover polygons as seen on the satellite data are delineated on screen, using ArcGIS software and a land use land cover map is prepared. Geo-referenced cadastral village boundary maps available with Maharashtra Remote Sensing Application Centre (MRSAC), is used as vector layer for analysis purpose. This cadastral map is combined with land use land cover map and village wise statistics is generated. Village wise area for land use land cover is calculated for the year 1989, 2005, 2009, 2012 and 2016 for Wani taluka.

Table 1: *Details of satellites data used in mapping mining activities*

Year	Path Row - 100-58/ satellite/sensor	Date
1989	Landsat - sensor - TM	5 November 1989
2006	IRS P6 - sensor - LISS III	4 November 2005, 15 January 2006, 21 April 2006
2009	IRS P6 - sensor - LISS III	29 April 2009
2011	IRS P6 - sensor - LISS III	November 2011
2012	IRS P6 - sensor - LISS III	January 2012, April 2012
2016	High Resolution Satellite data - Google	April 2016

4. Results and Discussion

The results of the study area are given below:

Coal Depot

The coal depots are the places where coal is stored and transported to other places in the country. In the study area, coal depots are mainly situated in 12 villages along Major State Highway No. 14 (MSH-14) and State Highway No. 314 (SH-314). The list of 12 villages and their area is listed in the Table 2.

The large collection of past and present satellite images makes it possible to analyze spatiotemporal pattern of environmental elements and impact of human activities in past decades (Gong et al., 2008). Ghose and Majee (2001) studied the air pollution caused due to coal mining and suggested that the volume and variety of air borne dust particles in the ambient air is increasing due to coal mining and causing air pollution problems in the surrounding areas.

Table 2: *Villages affected by coal depot in Wani taluka of Yavatmal district*

S. No.	Village Name	Village Area (km^2)	Year Wise Area of Coal Depot (km^2)			
			2006	2009	2012	2016
1	Bramhani	6.03	0.12	0.12	0.15	.07
2	Kasbe Wani	16.16	0.37	0.37	0.11	0.10
3	Lalguda	3.25	0.12	0.12	-	-
4	Nilapur	6.70	0.20	0.20	.026	-
5	Nimbala	5.04	0.11	0.11	.026	.08
6	Parsoda	3.99	0.16	0.16	0.081	.11
7	Zarpat	2.74	0.05	0.05	.060	.02
8	Wanjari	12.22	0.08	0.08	0.01	-
9	Rajur	6.64	0.49	0.64	.099	.03
10	Chikhalgaon	7.18	0.35	0.56	0.47	0.46
11	Kalmana Kh	5.28	0.42	0.67	0.28	0.27
12	Bhandewada	2.24	-	-	0.03	0.014
	Total	77.47	2.47	3.08	1.34	1.20
	Taluka area	910.47 km^2	0.27%	0.34%	0.14%	0.13%

In the present area, the coal dust and particulate matter created during coal storage and transportation is causing air pollution which resulted in respiratory problems in the rural population in the affected area. It is also affecting agricultural areas, vegetation health and land productivity. Our studies showed that the total area affected due to coal dust in the ambient atmosphere while transportation from mine to coal depot is about 13.75 km^2 along the route especially in the North and North West side of Wani town. Another observation is that, the area under coal depot is decreasing from 3.08 km^2 (0.34 % of taluka) in the year 2009 to 1.20 km^2 (0.13 % of taluka) in 2016. Despite this decreasing trend, its impact in the form of coal dust in atmosphere is remarkable in the adjacent areas with blanket of coal dust (Figure 3 and 4). New permanent fallow land mainly falls in this impact zone. Similarly, fertile land is converted into fallow land and new layouts are also coming up in the impact zone.

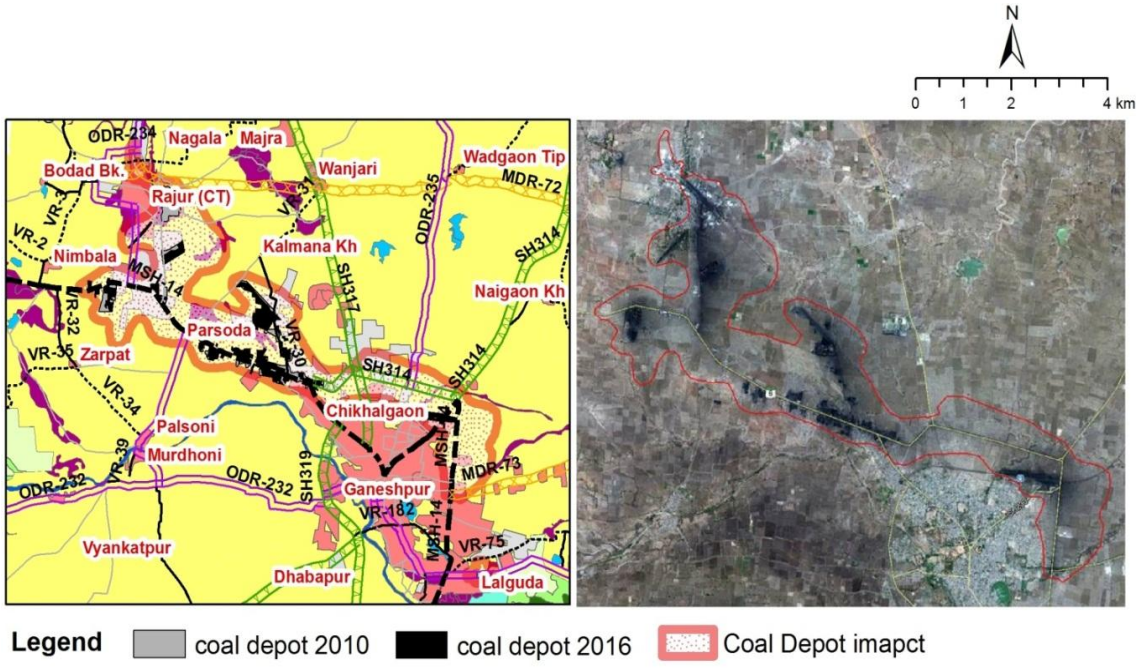

Figure 3: *Impact of coal depot near Wani town, Yavatmal district, Maharashtra*

Figure 4: *Feld photos showing impact of coal dust on vegetation in study area*

Mining and Crop Land

In the study area it is observed that, the mining activity (including mine plantation) acquired only 7 villages in the year 1989 with an area of 2.72 km^2 (0.29% of taluka) under mining. The area of mining increased to 38.82 km^2 during the year 2006 and total villages under mining were 26 (4.26 % of taluka). In the year 2012, mining area in Wani taluka has been increased to 47.98 km^2 (5.26% of taluka), while in the year 2016, mining area in the taluka has increased to 56.66 km^2 (6.22% of taluka) and total 37 villages (partially or fully) comes under mining activities (Table 3, Figure 5). The average rate of mining in this region is 2.1 km^2 per annum.

Table 3: *Villages affected by coal mining activity (including mine plantation) in Wani taluka of Yavatmal district*

Year	No. of villages under Mining	Area under Mining activity (km^2)	% With respect to Taluka area (910.47 km^2)
1989	7	2.72	0.29
2006	26	38.82	4.26
2012	34	47.98	5.26
2016	37	56.66	6.22

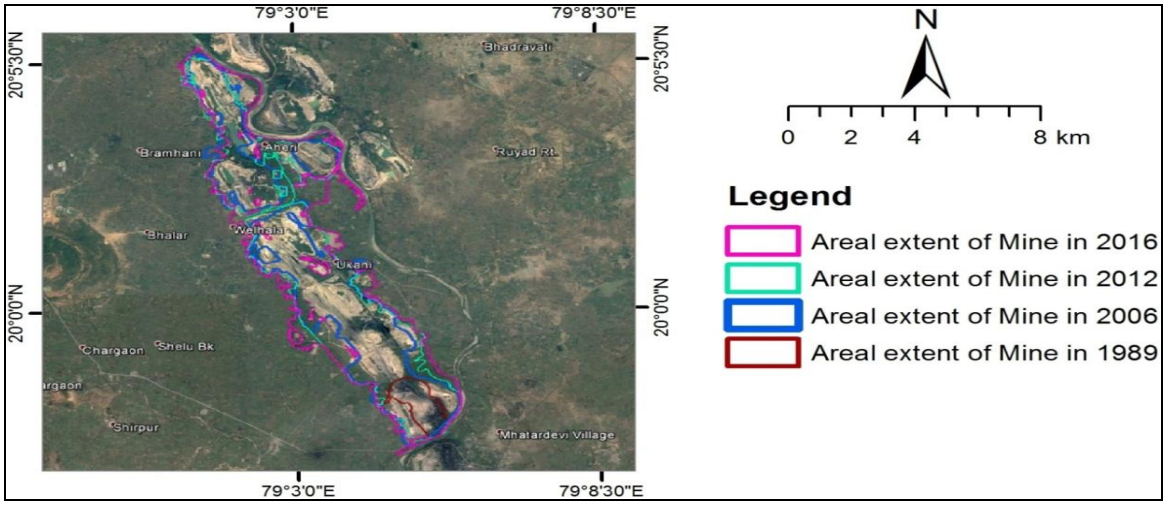

Figure 5: *Areal extent of coal mining near Wani town, Yavatmal district, Maharashtra during 1989-2016*

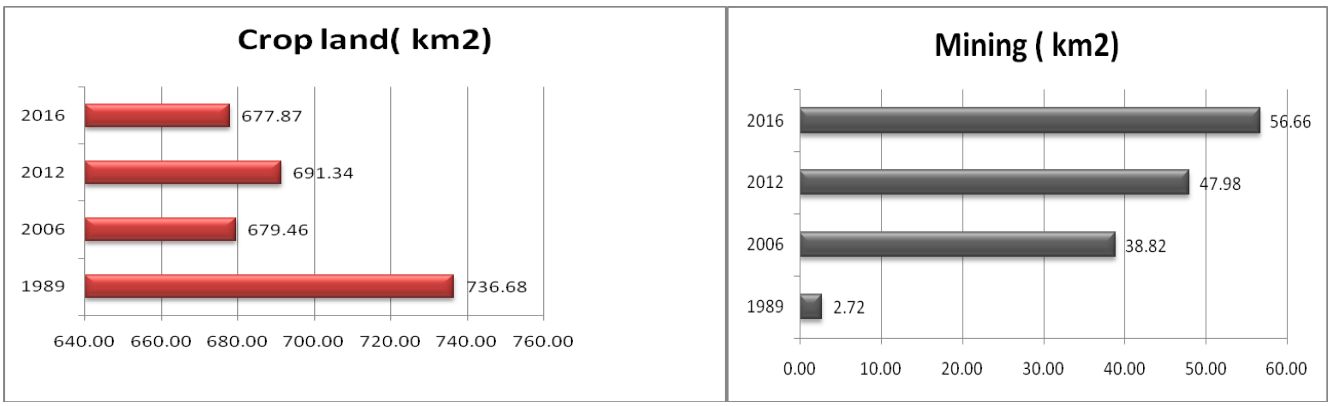

Figure 6: *Comparison of crop land, mining activity during 1989 to 2016*

Table 4: *Comparison of Land Use Land Cover in Wani taluka, Yavatmal district, Maharashtra*

	1989		2006		2012		2016	
Level 1	**Area (km^2)**	**Area (%)**	**Area (km^2)**	**Area (%)**	**Area (km^2)**	**Area (%)**	**Area (km^2)**	**Area (%)**
Built up	10.28	1.13	13.04	1.43	17.78	1.95	19.94	2.19
Crop land	736.68	80.91	679.46	74.63	691.34	75.93	677.87	74.45
Fallow land	3.80	0.42	18.12	1.99	1.86	0.20	4.77	0.52
Wasteland	24.38	2.68	25.98	2.85	19.58	2.15	19.19	2.11
Dense Forest	31.15	3.42	30.58	3.36	23.08	2.54	23.08	2.54
Open Forest	39.48	4.34	39.52	4.34	45.20	4.96	45.17	4.96
Scrub Forest	47.83	5.25	48.11	5.28	47.54	5.22	47.27	5.19
Tree clad	0.19	0.02	0.33	0.04	2.84	0.31	2.83	0.31
Coal depot	0.19	0.02	2.64	0.29	1.34	0.15	1.21	0.13
Mining area	2.73	0.30	30.10	3.31	30.19	3.32	31.63	3.47
Mining Plantation	---	---	8.40	0.92	16.68	1.83	24.96	2.74
River	12.08	1.33	12.08	1.33	10.58	1.16	10.55	1.16
Water body	1.69	0.19	2.12	0.23	1.91	0.21	2.01	0.22
Total	910.48	100.00	910.48	100.00	910.48	100.00	910.48	100.00

Land Use and Land Cover

The comparison of land use and land cover of Wani taluka between1989 to 2016 showed that the fertile agricultural land and good soil cover is coming under mining activities (Table 4, Figure 6). The main crop land situated adjacent to river and Wani town have been decreased from 736.68 km^2 in 1989 to 677.87 km^2 in the year 2016 (Figure 6). There is an increase in built-up area from 10.28 km^2 to 19.94 km^2. We observed decrease in wasteland, increase in open forest and increase in mining area. Remarkable increase in Mining plantation from 8.40 km^2 to 24.96 km^2 in and around mining area has been observed (Figure 6). This plantation is mainly observed around coal mining areas for waste dump stabilization.

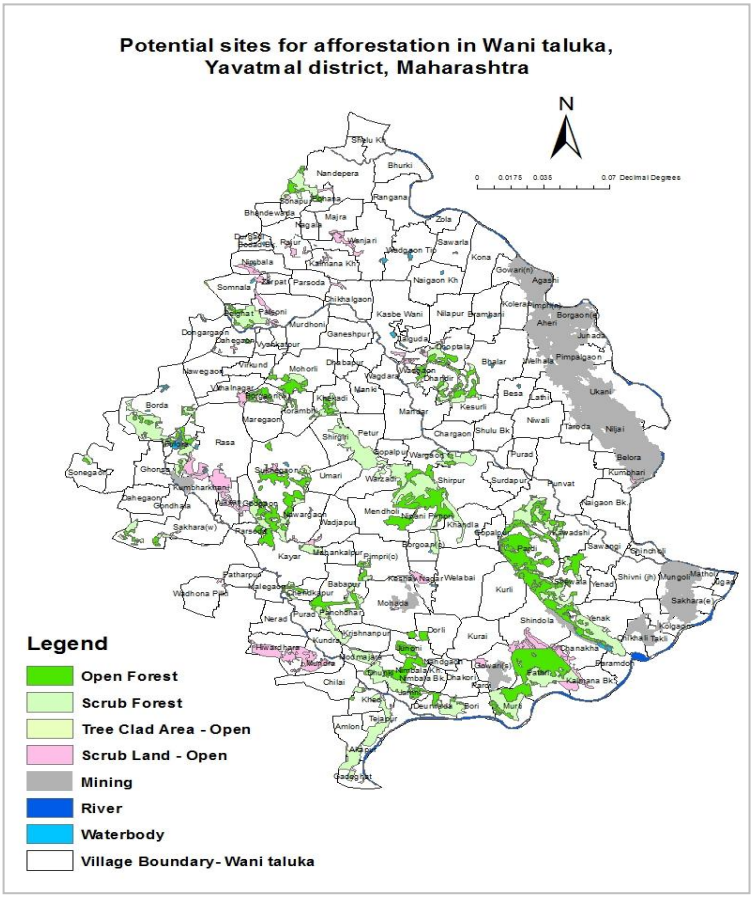

Figure 7: *Potential sites for plantation in Wani taluka, Yavatmal district, Maharashtra*

5. Conclusion and Recommendations

The land use-land cover map of Wani taluka of the year 2016, indicate that the open scrub is 19.19 km^2 (2.11% of the taluka). The open forest and scrub forest in the taluka is 45.16 km^2 and 47.27 km^2 respectively, while the mining area in the taluka is 56.66 km^2 (6.22 % of taluka) out of the geographical area (910.47 km^2). In the study area, there is a scope for development of 111.62 km^2 (12.26 % of area), which comes under open forest, scrubs forest, tree clad open and wasteland.

It is recommended that, various afforestation programmes can be undertake in such identified location in taluka to compensate the loss of cropland, fertile soil and environmental degradation caused due to mining activities. Recommended potential sites for afforestation are given in Figure 7. During afforestation programmes native faunal species should be planted and for better results, ecological variables must be considered while selecting species for plantation. This can help in stabilization of soil and enrichment of soil organic matter and soil nutrients. In the initial stages of afforestation quick growing grasses with short life cycle, legumes and forage crops shall be planted, which will improve soil nutrients and organic matter. Plantation of mixed species of economic importance should be carried out after 2-3 years of grass plantation (Kolhe and Khot, 2015).

Special monitoring and management techniques are required for village or parcel around coal depot. It is recommended to restrict the location of new coal depot along roadside. They should be located within identified zone near Wani town with good infrastructure facilities and may be declared as industrial zone. Such identified areas play a key role in restricting the land, air and water pollution. Constant research and development efforts are required to find out newer and latest technologies and methodology for the sustainable development.

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