Volume: 2, Issue: 6, 305-312
June 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

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Soil Desurfacing Induced Spatiotemporal Land Use/Land Cover Change in Study Area in the Year 2007 -2012

Priyanka Singh,Rani Devi,Hooda, R.S.

Abstract
Soil desurfacing due to brick kiln activity in study area (INDIA) induced land use change pattern. Study demonstrates thatstudy area is dominantly agriculture and about 85 % of geographical area is under agriculture practices. Major land use / land cover categories, which are underway to enter in the sphere of agriculture land use / land cover category are built-up area and soil desurfacing due to brick kilns because of infrastructural / construction projects in the region. Both these categories are interlinked to developmental process of the region. Agriculture land area: decreased by 4.73 % (162615-155509= -7706 ha) in five years duration from 2007 – 2012. Built-up area: increased by 92.23 % from 6479 ha to 12455 ha (+5976 ha), There is negligible reduction in the forest area from 2007 – 2012, *i.e*. from 1293 ha to 1289 ha. Insignificant decrease was observed in grassy land area, *i.e*., from 5876 ha – 5845 (-31 ha) only 0.02 %. Wasteland area decreased from 2959 ha – 1916 ha (-1043 ha), good development and 35.77 % improvement observed in five years duration (2007 - 2012). In water bodies area, marginal increase observed. In wetland area insignificant, change observed (0.02 %) during 2007 – 2012 period. A significant increase observed from 2884 ha to 4087 ha in desurfaced land area category, inducing different land use change pattern, (+1203 ha) 41.7% increase during 2007 – 2012 period.

Keywords: Remote sensing, land use, / land cover, soil desurfacing

1. Introduction
In an urban environment, natural and human-induced environmental changes are of concern today because of deterioration of environment and human health. The study of land use/land cover (LU/LC) changes is very important to have proper planning and utilization of natural resources and their management. Traditional methods for gathering demographic data, censuses, and analysis of environmental samples are not adequate for multi-complex environmental studies, since many problems often presented in environmental issues and great complexity of handling the multidisciplinary data set; we require new technologies like Remote Sensing and Geographical Information Systems (GISs) [1]. These technologies provide data to study and monitor the dynamics of natural resources for environmental management.

Remote sensing has become an important tool applicable to developing and understanding the global, physical processes affecting the earth. Recent development in the use of satellite data is to take advantage of increasing amounts of geographical data available integrating with GIS to assist in interpretation. GIS is an integrated system of computer hardware and software capable of capturing, storing, retrieving, manipulating, analyzing, and displaying geographically referenced (spatiotemporal) information for aiding development-oriented management and decision-making processes. Remote sensing and GIS have covered wide range of applications in the fields of agriculture and environment. Many scientists have done remarkable work concerning LU/LC studies in the backdrop of adverse effects on ecology and environment due to anthropogenic activities and over-exploitation.

Management of natural resources particularly soil, is very essential for sustainable development of living beings on the land [2]. The effect of ever increasing population pressure, urbanization and industrialization have put a great stress on our natural resources, resulting in decrease in net cultivable land area. To cater to the needs of ever-increasing population for food, fiber, shelter, fodder, and fuel, the natural resources have been over-exploited, due to human interventions causing land degradation and ecological imbalance at a larger scale [3] Therefore, there is an urgent need to pay due attention to such unwarranted problems merely emerging due to over exploitation of natural resources [4].

The Haryana state, which has a total geographical area of 44212 km^2, has a wasteland of 2347.05 km^2 [7]. Conversion of fertile land into wasteland by way of desurfacing is taking place in National Capital Region (NCR) at a faster pace than expected due to increasing demand for construction material for the accomplishment of various housing and other construction projects [4]. The construction and building activities being unavoidable in the sense that lot of precious fertile agriculture land is converted into wasteland due to desurfacing of soil by brick kiln industries. Restoration and methods of amelioration of desurfaced soil are of serious concern under such circumstances to save further damage to soil health, productivity, and fertility of soil [3]. To evaluate actual damage to the soil health, it is important to understand the land use / land cover changing pattern in the study area. With the help of remote sensing technology, spatiotemporal distribution of various land use / land cover categories are to be studied.

Present study area witnessed rapid development during past decades in terms of urbanization, industrialization, and population increase substantially. The main objective of this paper is to detect and quantify the LU/LC in National Capital Region (NCR) of Haryana state, which covers study area.

Problem Statement

National Capital Region has witnessed remarkable expansion, growth and all round developmental activities such as building, road construction, and many other anthropogenic activities in recent past due to economic upsurge in India. This has therefore, resulted in increased land consumption and a modification and alterations in the status of the land use / land cover over time, without any detailed and comprehensive attempt (as provided by a Remote Sensing data and GIS) to evaluate this status, as it changes over time with a view to detecting the land consumption rate and also make attempt to predict same and the possible changes that may occur in this status so that planners can have a basic tool for planning. It is therefore, necessary for a study such as this to be carried out to avoid the associated problems of growing and expanding developmental activities.

2. Objectives

- To study the land use / land cover change due to soil desurfacing in the study area using remote sensing technique.
- To predict the percentage change in the total geographical area due to soil desurfacing.

3. Material and Methods

3.1 Study area: (Fig. 1 & 2) The study area (Jhajjar district) lies in 29°21' 30" to 29° 51'30" to North Latitude, 76°16' 30" to 76° 58'45" East Longitude in the NCR of Haryana state. Total geographical area of Jhajjar district is 1834 km^2. Cultivable area is 1635 km^2. Uncultivable land is 24 km^2. Canal irrigated land is 4100 km^2 and tube well irrigated land is 798 km^2. Cropping intensity is 140 %, shallow ground water is fresh, and deep ground water is mostly saline.

The Jhajjar district has 265 villages and 5 community development blocks / zones (Fig. 1). Divided into five community developmental blocks / zones:

1.Jhajjar 2. Bahadurgarh 3. Beri Khas 4. Matanhail
5. Sahalawas

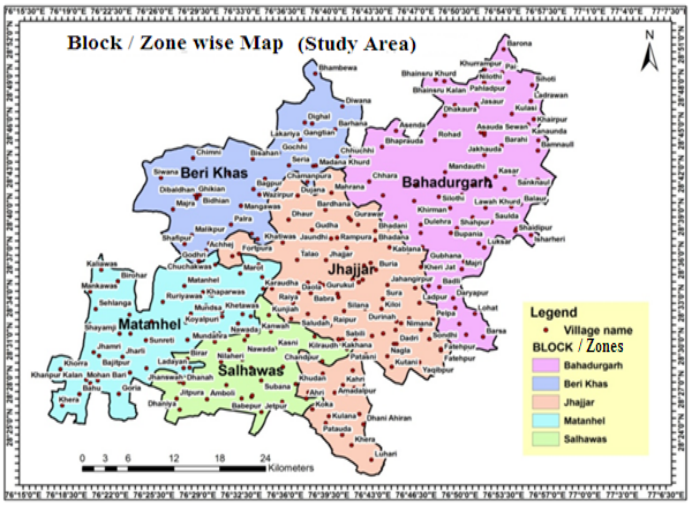

Fig. 1 Study area (Jhajjar district)

3.2 Location of study area in Haryana state (INDIA)

Fig. 2 Location of study area

3.3 Climate

Climate is Sub-tropical, semi arid, continental and monsoon type. Main rainy season resumes from July to September driven by southwest monsoons and average annual rainfall recorded 592 mm. Weather in May and June has been recorded hottest and dry, maximum temperature approaches to 45-46^{o}C and minimum as low as 3- 4^{o}C in the nights of winter. Sandy dust cyclones are common in summer season.

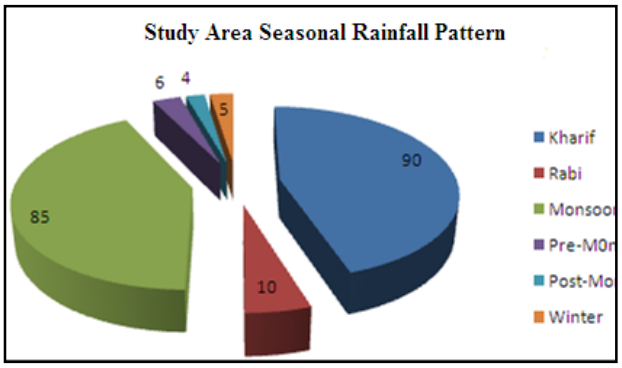

Fig. 3 Seasonal rainfall pattern in study area

Ten million years ago, most of this area, submersing under bay of ocean, hence the quality of ground water is mostly saline at deeper depths because of precipitation of dissolved salts to deeper depths. The intensive canal irrigation and effective drainage system, the quality of ground water near and along the water bodies is comparatively fresh to marginal. As per 2005 report, 13.5% area falls under good quality water, 52% under marginal to semi-marginal saline, and 34 % under saline category. Jhajjar and Bahadurgarh block / zone are just at the western fringe of the national capital, New Delhi, which provides huge market for raw material.

3.4 Geomorphology and soil

The study area falls in eastern zone, which covers around 49 % area of the state. This zone is also called wet zone. More than 70 % of the rainfall received during southwest monsoon. Normal rainy days are >30 per annum. This is further manifested into additional three sub-units because of the Aeolian action in the Holocene period as (a) hummocky phase (fossils and dunes), (b) sandy plains of recent times (c) dotted lack extension along the central track surrounded by waterlogged areas.

Study area soil is mostly sandy to sandy loam, tropical arid brown to arid brown with alluvial origin, calcareous in nature, with 7.02 - 8.5 pH, low to medium in organic carbon (<4-4g Mg^{-1}), which is considered index of available nitrogen, low to high in available phosphorus (<10-20 Mg ha^{-1}) and medium to high in available potassium (248 to >248 Mg ha^{-1}). The thickness of column is more than 150 cm and structure varies from massive to angular blocky. The available moisture capacity is good with imperfectly drained and permeability. Water infiltration rate is better and even it is easier to manage brackish waters for growing various crops. Land of this district is not completely flat and plain. There are sand dunes in southwestern part. Mostly soils of study area have concretion of calcium carbonate at lower depth; these concretions hinder the penetration of roots and uptake of micronutrients, which are very important essential nutrients for plant growth.

3.5 Satellite Data Acquisition:

Before the preprocessing and classification of satellite imagery began, an extensive field survey was performed throughout the study area using Global Positioning System (GPS) equipment. This survey was performed in order to obtain accurate location point data for each land use / land cover class included in the classification scheme as well as for signature generation..

The topographic map (1:25,000 scale), data was acquired from Haryana Space Applications Centre (HARSAC)-Hisar-125004 (India), for the year 2007 and 2012. Multi-temporal and spatial geo-referenced Catosat-1 and Worldview-II satellite were used for present study. Generally, a vector layer is digitized over the raster scene. The vector layer consists of various polygons overlaying different land use types. The data obtained by on screen digitization is used [14].

Secondary data used

The land use / land cover data of study area (Jhajjar district) developed for the year 2006-7 by HARSAC was used for depicting land use change due to soil desurfacing. (Fig.4)

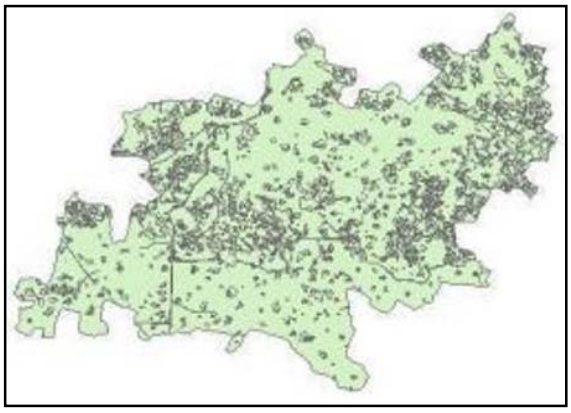

Fig. 4 Land use change map of the Jhajjar District for the year 2006-7

3.6 Survey of India topographical sheet

Survey of India (SOI), Topographical sheet on I: 25,000 scale bearing Nos. 53D/6, 53D/7, 53D/9, 53D/10, 53D/11, 53D/13, 53D/14, and 53D/15 (Fig. 5), were to identify and authenticate the various cultural features on the ground, provided in satellite image coverage [8]

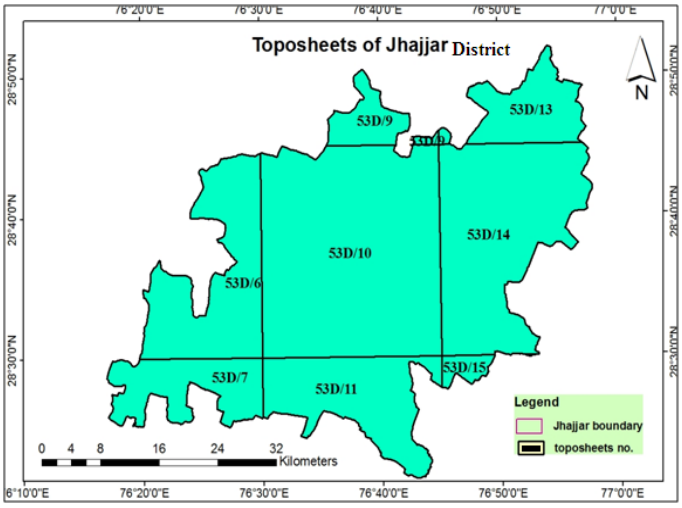

Fig. 5 Map of topographical Sheet Mosaic of Study Area

3.7 Methodology

1. Cartosat-I and Worldview-II satellite images for the year 2007 and 2012 is used to identify and map desurfaced soils in Jhajjar district as depicted in Fig.6 a and b respectively. The red spots are depicting the desurfaced soils in study area. This digitized data has been taken from already published paper by Singh.et.al (2014). [14] This layer of brick kilns is laid down on the land use map to see the change due to soil desurfacing and found the percent change [10].
2.

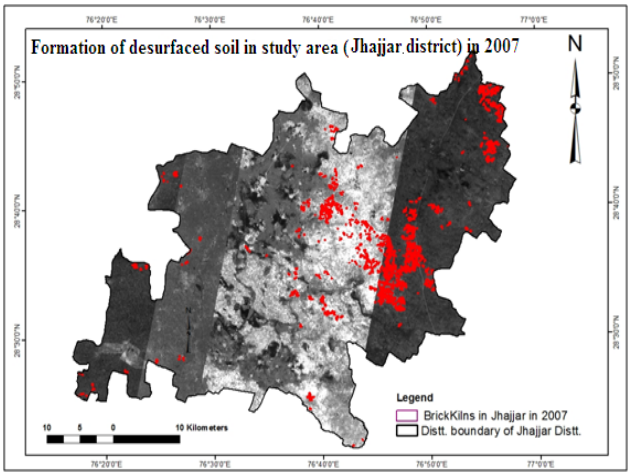

Fig.6a. Map of desurfaced area in Jhajjar District (2007)

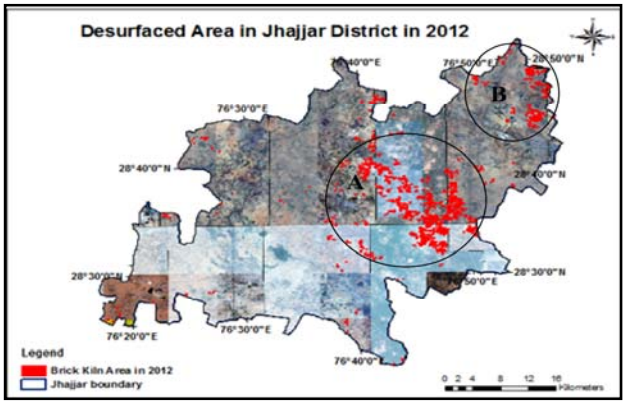

Fig. 6b Map of desurfaced area in Jhajjar District (2012)

Table1. Desurfaced area status of Jhajjar districts in 2007 and 2012

S. No.	District	Desurfaced Area Status						% Change in desurfaced area in 5 years
		2007			2012			
		No. of Brick kilns	DA (ha)	% Geographic Area	No. of Brick kilns	DA (ha)	% Geographic Area	
1.	Jhajjar	492	2884	1.57	579	4086.9	2.23	41.71

DA = Desurfaced Area

In Jhajjar district desurfaced area increased from 2884 ha (2007) - 4087 ha (2012), a net increase of 41.71 % in five years duration. Higher increase in desurfaced area in Jhajjar district may be attributed to higher number of brick kilns and because of its proximity to National Capital, New Delhi and Gurgaon, where developmental activities are more. (Singh et al., Feb 2014)

2. Merging of the classes of land use/land cover

The level I of the land use is required so the different classes merged into single class. Then colors are provided to each class**.** Land use class IV converted to Land use class I of 2006-7 of the land in study area (Jhajjar district), using appropriate software for the purpose (Fig. 7).

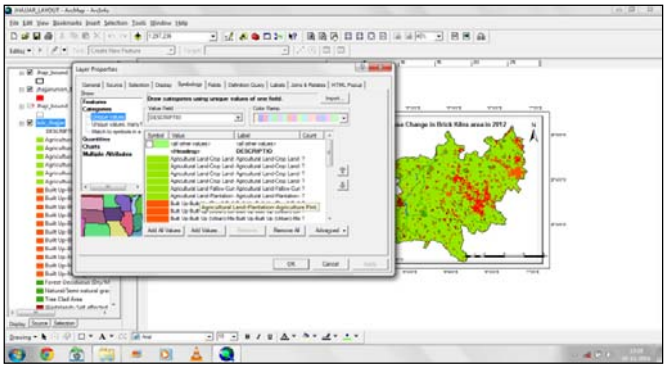

Fig. 7 merging of the classes of land use

3. Change in land use / land cover

The brick kiln shape file laid on composed land use of 2006-7 of the study area (Jhajjar district). This will clearly depict that all the areas under soil desurfacing is agricultural land in the district. This will affect the agricultural productivity and the food grains production in the region.

4. Results and Discussion

4.1 Category Wise Distribution and Temporal Change In Land-Use / Land-Cover Pattern Due To Desurfacing In Study Area [10]

Knowledge about land use/land cover has become important to overcome the problem of biogeochemical cycles, loss of productive ecosystems, biodiversity, deterioration of environmental quality, loss of agricultural lands, destruction of wetlands, and loss of fish and wildlife habitat. The main reason behind the LU/LC change includes rapid population growth, rural-to-urban migration, reclassification of rural areas as urban areas, lack of valuation of ecological services, poverty, ignorance of biophysical limitations, and use of ecologically incompatible technologies. During the past few decades, the study area has witnessed substantial increase in population, urbanization, and industrialization because of economic upsurge in the country.

Fig. 8 indicates land use change in Jhajjar district in the year 2012, yellow spots indicate presence of desurfaced land area in the Jhajjar district scattered in different blocks/zones. Swarming of soil desurfaced area noticed in Jhajjar zone (A) and Bahadurgarh zone (B), falling in close proximity of National Capital, Delhi, and cyber city Gurgoan [10].

The study area witnessed large amount of agriculture land converted into desurfaced land due to brick kiln activity and settlements and other urban development activities. Both, Delhi and Gurgoan being mega city, provide huge market for the consumption of raw material like bricks needed for various ongoing infrastructural/construction projects. Gurgoan being newly developing city of Haryana state and quite close to National Capital, more over sharing appreciable chunk of housing and office requirement of many multinational companies looking for developing their establishments in

Delhi, have developed training centers and offices here. As a result, agriculture land becomes easy victim to be acquired for the purpose. Most of the adjoining agriculture land has been converted in to urban areas. Jhajjar district is just adjacent to Gurgoan and best option for off loading excess pressure from national capital, Delhi. This is the most valid point responsible for temporal and spatial land use change taking place in the region [14].

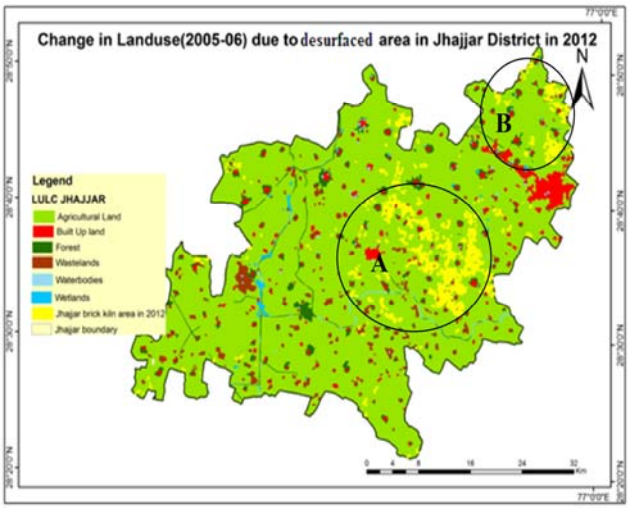

Fig. 8 Change in land use due to soil desurfacing in Jhajjar district (2012)

Table1. Category wise distribution and temporal change in land-use / land-cover area (Jhajjar district)

S. No.	Categories	2011-12 (ha)	% of Geo-Area	2006-7 (ha)	% of Geo-Area	Temporal Change 2007-2012	% Difference
1	Agri-Land	155509	84.79	162615	88.67	-7706	-3.88
2	Built-up	12455	6.79	6479	3.53	5976	3.26
3	Forest	1289	0.70	1293	0.71	-004	-0.00
4	Grassy	5845	3.19	5876	3.21	-031	-0.02
5	Wastelands	1916	1.04	2959	1.61	-1043	-0.57
6	Water bodies	1814	0.99	840	0.46	974	0.53
7	Wetlands	485	0.26	451	0.24	034	0.02
8	Desurfaced	4087	2.23	2884	1.57	1203	0.66
9	TGA	183400	100.00	183400	100.00	000	0.00

TGA=Total Geographic Area (ha), Geo area=Geographic area, ha=Hectare, Desurfaced soil=Top soil removed (approximately 100 cm)

According to Table 1, various categories like agriculture land, built-up area, forest, grassy, wastelands, water bodies, wetlands, and desurfaced land area, spatiotemporal change values have been depicted, in the year 2007 and 2012

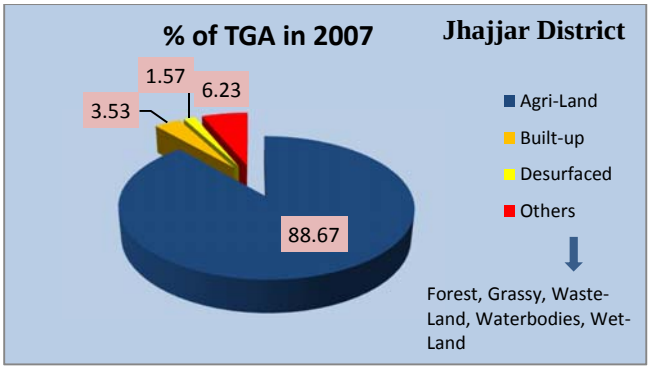

Fig. 9 Category wise distribution and percent share in TGA and temporal change in Land-use / land-cover area (ha) in 2007 (Jhajjar district)

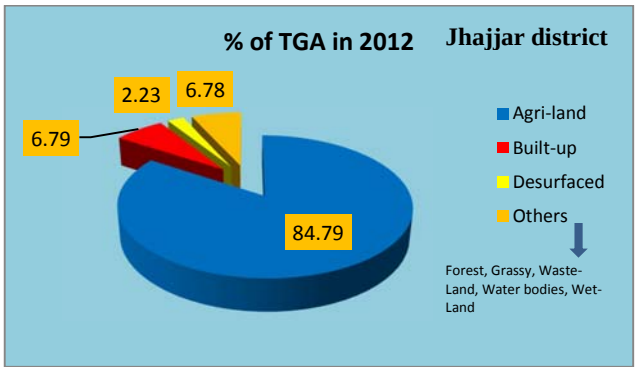

Fig. 10 Category wise distribution and percent share in TGA and temporal change in Land-use / land-cover area (ha) in 2012 (Jhajjar district)

In pie-diagram (Fig.9), all other categories like built-up, forest, wastelands, grazing, water bodies, and wetlands pooled to show exclusive impact of desurfaced soil area in Jhajjar district in the year 2006-7. During that period, soil-desurfaced area was 1.57 % of the total geographical area, i.e. 183400 ha. In the year 2012, (Fig. 10), the desurfaced area increased to 2.23 % from 1.57 % in 2006-7. This increase amounts to 4087 ha from 2884 ha, which is statistically significant. Because of this, agriculture-land (Cultivable area) decreased from 162516 to 155509 ha. There is urgent need to arrest further expansion of desurfaced area due to brick kiln activity in the region.

4.2 Agriculture-Land Area

Land use / land cover observations in Table 1 reveals that the major land use is agriculture, constituting 88.67 % of the geographic area in the year 2006-7 in Jhajjar district, *i.e*., 162615 ha, decreased to 155509 ha (Fig. 12), reducing cultivable agriculture area to 84.79 % after five years in 2012 (-3.88 %) [5].

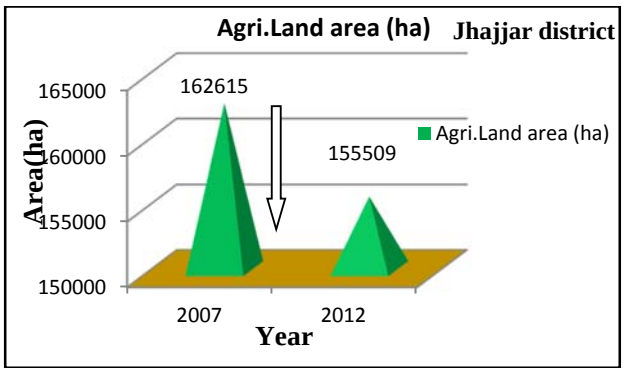

Fig. 11 Agri-Land area in Jhajjar District in 2007 and 2012

This is because of conversion of agriculture-land to non-agriculture use like increased built-up area due to construction of housing and other projects, helping to boost more brick kiln activities giving rise to temporal land use change from 2007-2012. There was 4.73% decrease in over all agriculture land area of Jhajjar district due to soil desurfacing or any other human intervention in the region in five years duration, *i.e*. from 2007-2012 (Fig.11) [6].

4.3 Built-up area

Built-up area in Jhajjar district, which includes residential, non-residential, built-up, open, vacant, recreational airport, railway station, yard, landfill sites, *etc*. constituting 6.79 % (12455 ha) of geographic area and is the second largest use of land in the district (2012) (Fig. 13). Haryana sub-region has the highest concentration of built-up category in NCR. The temporal land use analysis indicates that during the period 2007-2012, built-up area has increased by > 92.23%, almost double, *i.e*. from 6479 ha to 12455 ha, adding 5976 ha more to built-up category, while the area under agriculture use has significantly decreased by 4.73% (7706 ha) (Table 1 and Fig. 12).

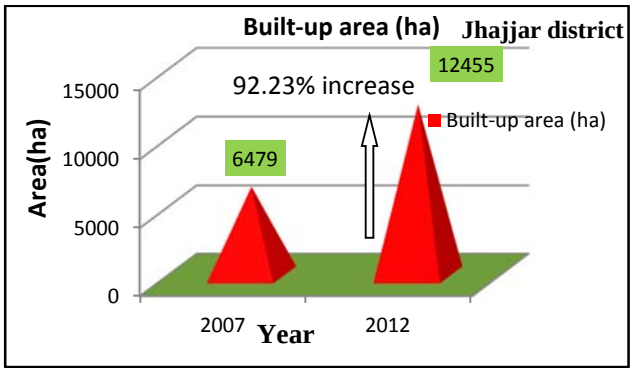

Fig. 12 Built-up land area in JhajjarDistrict in 2007 and 2012

4.4 Forest area

Green areas are non-agriculture vegetated areas, which include dense vegetated area including forests, plantation and open scrub and constitutes 0.71% (1293 ha) of the total geographic area (TGA) in 2007, which slightly decreased to 1289 ha in 2012, which is quite insignificant, (Table 1 and Fig. 13) in Jhajjar district. It seems people have great value for forest its conservation is conspicuous and they will definitely get dividend in return from nature [9].

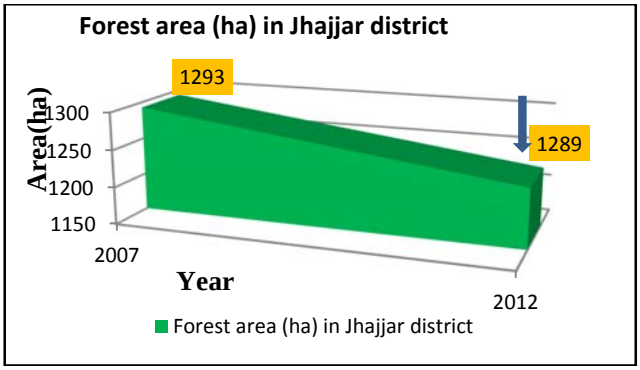

Fig. 13 Forest area in Jhajjar District in 2007 and 2012

4.5 Grassy area

It includes pastures, and analytical data in Table 1 reveals that there is slight temporal change in this area in Jhajjar district, *i.e*. 5876 ha was in 2007, which decreased to 5845 ha in 2012 (Fig. 14), and grassy area constitutes about 3.21 % of the total geographic area of the district. Slight decrease is insignificant in absolute terms.

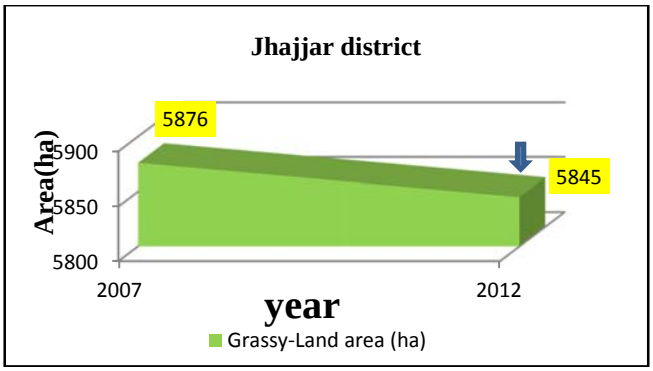

Fig. 14 Grassy land area in Jhajjar District in 2007 and 2012

4.6 Wasteland area

Wastelands include gullied land, saline land, waterlogged, barren, and rocky and river sand.

Table 1 reveals that in 2007, the wasteland in Jhajjar district was of the order of 2957 ha (1.61 % of total geographic area), reduced to 1916 ha in 2012, constituting 1.04 % of total geographic area with net reduction of 0.57 % in wasteland category. Reason may be new initiatives taken by the farmers and government agencies in reclaiming degraded soil in Jhajjar district (Fig.15), reducing net wasteland area by 35.25 %, which is a good development from soil productivity point of view.

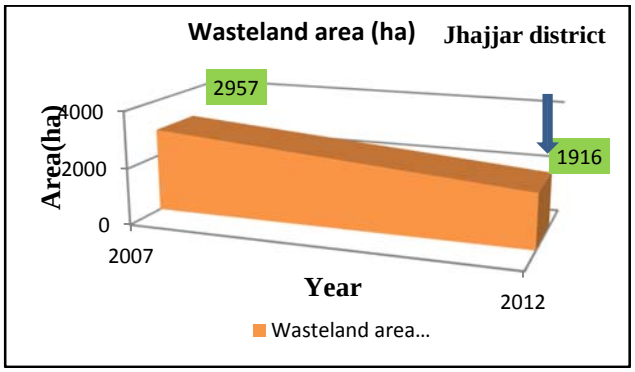

Fig. 15 Wasteland area (ha) in Jhajjar District in 2007 and 2012

4.7 Water bodies

There is significant increase in water bodies in Jhajjar district during five years duration, *i.e.* from 2007-2012 (Table 1 and Fig.16). The effective area under this category in 2007 was 840 ha constituting about 0.46 % of total geographic area, which increased to 1814 ha in 2012 in five years duration, constituting 0.99 % of total geographic area. This may be ascribed to the reason increasing interest of farmers in fishery and government initiating new irrigation projects for the area.

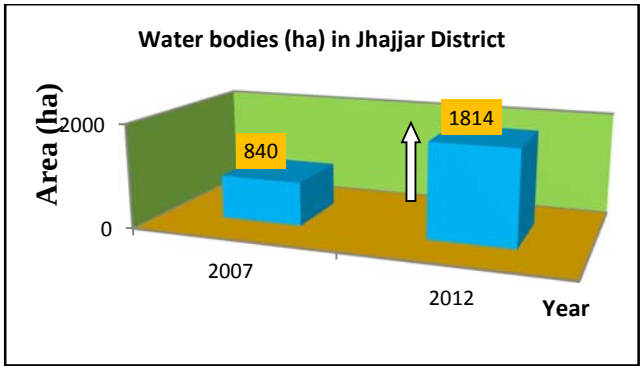

Fig. 16 Water bodies area (ha) in Jhajjar District in 2007 and 2012

4.8 Wetland area

This category includes marshy land and waterlogged areas. Not much change was observed from 2007 to 2012 in study area. In 2007, the wetland areas was 451 ha, constituting 0.24 % of total geographic area and slight insignificant increase was observed after five years in 2012, *i.e. 451*-485 ha, about 0.26 % of total geographic area.

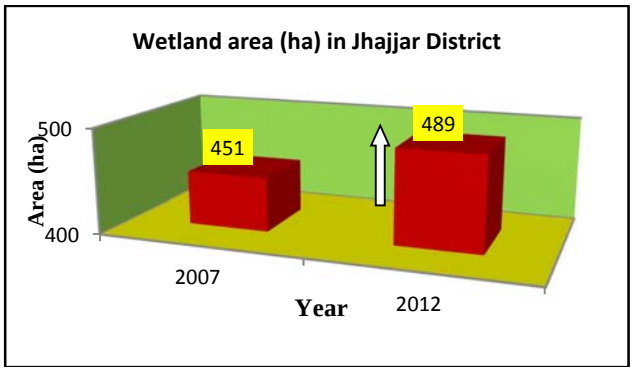

Fig. 17 Wet land areas (ha) in Jhajjar District in 2007 and 2012

4.9 Desurfaced land area

In Jhajjar district according to Table 1 revelations, soil desurfacing due to brick kiln activity is the fourth most prominent activity, after agric-land, built-up, grass/grazing area, representing 4086 ha area, which is 2.23 % (Fig.10) of the total geographic land area available in the district.

In pie-diagram (Fig.9), all other categories like built-up, forest, wastelands, grazing, water bodies, and wetlands pooled to show exclusive impact of soil desurfacing in Jhajjar district in the year 2006-7. During that period, soil-desurfaced land area was 1.57 % of the total geographic area, *i.e.* 183400 ha.

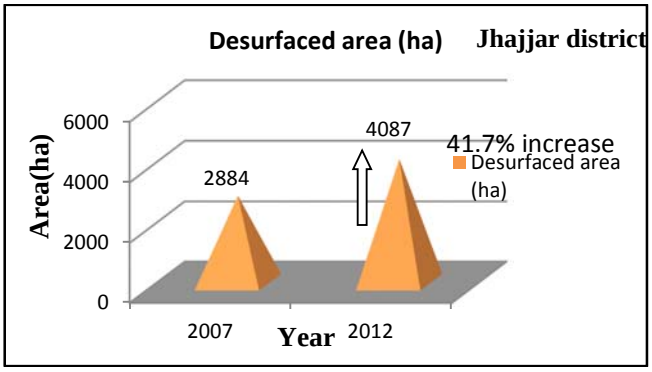

Fig. 18 Desurfaced land area (ha) in Jhajjar District in 2007 and 2012

In the year 2012, (Fig. 18), the desurfaced land area increased to 2.23 % from 1.57 % (2006-7, Fig. 10). This increase amounts to 41.7% in absolute terms (from 2884 ha to 4087 ha), which is statistically significant. Because of this, agriculture-land (Cultivable area) decreased from 162615 to 155509 ha (-7706, Table 1), 4.74% in absolute terms. There is urgent need to arrest further expansion of desurfaced land area due to brick kiln activity in the region to save fertile cultivable land [14].

Conclusion

This paper focuses on LU/LC changes in National Capital Region of Haryana state (INDIA), using remotely sensed data, and applying digitization process, and GIS technology. Our results clearly show that LU/LC changes were significant during the period from 2007 to 2012. There is significant expansion of desurfaced and built-up land area. On the other hand, there is decrease in cultivable agricultural land area by 4.74%. This study clearly indicates the significant impact of population and its development activities on LU/LC change. This study proves that integration of GIS and remote sensing technologies is effective tool for planning and management aspects.

Study demonstrates thatstudy area (Jhajjar district) is dominantly agrarian and about 85 % of geographic area is under agriculture. Major land use / land cover categories, which may encroach in the domain of agriculture land use / land cover category are built-up area and soil desurfacing due to brick kiln activity. Both these categories are interlinked to developmental process of the society and may be perceived as unavoidable. Built-up area due to housing requirement and Soil desurfacing due to brick kilns, spreading claws slowly but surely, which may result into an unsustainable menace in time to come, the pace with which the demand of bricks (a basic material for developmental projects and housing) is growing due to urbanization and industrialization in the National Capital Region (NCR). Comparative results of the study are reflected as follows:

- Agriculture land area: decreased by 4.73% (162615-155509= -7706 ha) from 2007 – 2012
- Built-up area: increased by 92.23 % from 6479 ha to 12455 ha (+5976 ha) due to economy upsurge in this period and more infrastructural development
- Forest area: There is negligible and insignificant decrease in forest area from 2007 – 2012, *i.e*. from 1293 ha to 1289 ha
- Grassy area: Insignificant decrease observed, *i.e*., from 5876 ha – 5845 (-31 ha) only 0.02 %
- Wasteland area: decreased from 2959 ha – 1916 ha (-1043 ha), good development and 35.77 % improvement in five years duration (2007 - 2012) in absolute terms
- Water bodies: Increase observed from 840 ha to 1814 ha (+974)
- Wetland: Insignificant change observed (0.02 %) during 2007 – 2012 period
- Desurfaced land area: Significant increase observed from 2884 ha to 4087 ha, (1203 ha addition) 41.7 % shift during 2007 – 2012 period, a waking call for the planners

Acknowledgment

One of the authors, Ms. Priyanka Singh, is highly grateful to the Haryana Space Applications Centre (HARSAC-CCS HAU Campus-Hisar)-125004, Government of India, for providing technical and scientific assistance and guidance in pursuing research work.

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