Document Control Sheet

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Title	**WASTELANDS ATLAS OF INDIA 2011 (WEB VERSION) (Change analysis based on multi-temporal satellite data of 2005-06 and 2008-09)**
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Abstract	The study was taken up at the instance of Department of Land Resources(DoLR), Ministry of Rural Development, Government of India, to map the wasteland extent of the country in 2008-09 and record the spatial changes in wastelands between 2005-06 and 2008-09, using three-season resourcesat-1 LISS III data on 1:50000 scale. The digital wasteland layer of 2005-06 was overlaid with the geo-rectified satellite data of 2008-09 and the wasteland polygons of 2005-06 were updated where change areas were identified. Limited ground checks were carried out and the updated wasteland layer of 2008-09 was generated. The database provide spatial information on the distribution, extent and temporal behaviour of wastelands useful for various user agencies involved in planning and implementation of development strategies for reclamation of wastelands.
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WASTELANDS ATLAS OF INDIA 2011

(Change analysis based on multi-temporal satellite data of 2005-06 and 2008-09)

INTRODUCTION

Department of Land Resources (DoLR, formerly National Wasteland Development Board - NWDB) under the Ministry of Rural Development (MRD), Government of India, vested with the responsibility of wastelands development in the country, requested Department of Space, Government of India to generate spatial information on wastelands, using remote sensing techniques, with respect to their distribution, extent, nature, degree of degradation and temporal behaviour to facilitate the planning and implementation of development strategies for reclamation of wastelands.

National Remote Sensing Centre at the instance of NWDB initiated mapping of wastelands at 1:50000 scale in 1986 and completed the mapping task for entire country in the next 14 years in a phased manner using satellite data. Later, two more mapping cycles were executed by NRSC in 2003 and 2006 with an objective to update the status of wastelands, using satellite data of different time periods. The present study has been taken up to report the spatial changes in 23 categories of wastelands between 2005-06 and 2008-09 using three-season Resourcesat-1 LISS-III data on 1:50000 scale. To facilitate this, uniform mapping procedures and digital database standards, have been adopted in the study. The three-season (*Kharif, Rabi* and *Zaid* seasons of 2008-09) satellite data was geo-rectified with that of 2005-06. The wasteland vector layer of 2005-06 was overlaid with the geo-rectified satellite data of 2008-09. The wasteland polygons of 2005-06 were updated using satellite data of 2008-09 and the change areas / categories / polygons were identified. These changes were later confirmed using limited ground checks and the wasteland change vector layer of 2008-09 was generated. The project had been completed and atlas was published and distributed for the use of various departments central, state and others. Wasteland classes were regrouped for web users as shown in the following table:

Description of categories of wastelands

Table 1: Regrouping of 23 fold Wasteland classification into 12 fold

S.No	Wasteland Class		Regrouped Class
1	Gullied and/ or ravinous land (Medium)	1	Gullied and ravinous land
2	Gullied and/ or ravinous land (Deep)		
3	Land with Dense Scrub	2	Scrub Land
4	Land with Open Scrub		
5	Waterlogged and Marshy land (Permanent)	3	Waterlogged Area
6	Waterlogged and Marshy land (Seasonal)		
7	Land affected by salinity/alkalinity(Moderate)	4	Salt affected Area
8	Land affected by salinity/alkalinity (Strong)		
9	Shifting Cultivation - Current Jhum	5	Shifting Cultivation
10	Shifting Cultivation - Abandoned Jhum		
11	Under-utilised/degraded forest (Scrub domin)	6	Degraded Forest
12	Under-utilised/degraded forest (Agriculture)		
13	Degraded pastures/ grazing land	7	Degraded pastures/ grazing land
14	Degraded land under plantation crop	8	Degraded land under plantation crop
15	Sands - Riverine	9	Sandy Area
16	Sands - Coastal		
17	Sands - Desertic		
18	Sands - Semi Stab. - Stab > 40 m		
19	Sands - Semi Stab. - Stab 15 - 40 m		
20	Mining Wastelands	10	Mining/ Industrial Wastelands
21	Industrial Wastelands		
22	Barren Rocky Area	11	Barren Rocky Area
23	Snow Covered/ Glacial Area	12	Snow Covered/ Glacial Area

Brief description of wasteland classes are given hereunder:

The term wasteland means low-quality land from an agricultural point of view, often referred to as degraded land. According to National Wastelands Development Board, waste land is defined as "degraded land that can be brought under vegetative cover' with reasonable effort and which is currently under-utilized and land which is deteriorating due to lack of appropriate water and soil management or on account of natural causes".

1. Gullied and Ravine Land

Gullies are formed as a result of localized surface run-off affecting the unconsolidated material resulting in the formation of perceptible channels causing undulating terrain. Gullies develop from rills which are tiny water channels with a few centimeters deep, formed as a resultant impact of heavy rainfall and wearing action of run-off generated there from. These are the first stage of excessive land dissection followed by their networking. Ravines are basically a extensive systems of gullies developed along river courses.

2. Scrub Land

These areas possess shallow and skeletal soils, at times degraded, extremes of slopes, severely eroded and lands subjected to excessive aridity with scrubs dominating the landscape. They have a tendency for intermixing with cropped areas. They appear in light yellow to brown to greenish blue depending on the surface moisture cover and vary in size from small to large having either contiguous or dispersed pattern. The vegetal cover on scrub lands may be dense or sparse.

3. Waterlogged Area

Waterlogged land is that land where the water is at/or near the surface and water stands for most of the year. These lands are distinctly seen in light to dark blue tone of varying size and shapes on satellite image. By virtue of their location in flood plains, coastal tidal flats, lagoons and river plains, these can be delineated with good accuracy. Subtle variations in tones depending on the presence of aquatic vegetation, irregularity in shape, textural behavior of the vegetation – smooth or mottled depending on the duration of waterlogging may sometimes share common spectral properties with that of crops. The duration of water logging may be for less than 6 months to more than 6 months in a year.

4. Salt Affected Area

Lands that are affected by salinity/alkalinity portray the qualities that have adverse effect on the growth of most plants due to action or presence of excess soluble salts (saline) or high exchangeable sodium. Salt affected lands appear in different tones of dull white to bright white on the satellite data in different geographical conditions.

5. Shifting Cultivation

It is the traditional practice of growing crops on forested / vegetated hill-slopes by 'slash and burn' method. Known by different names in different regions like bush-fallow jhuming, podu cultivation etc, this is a commonly observed practice in the North-Eastern states, parts of Orissa, Andhra Pradesh and the tribal areas of Chattisgarh. They appear in light yellow or greenish tone in color in small, scattered patches, irregular in shape, non-contiguous and dispersed and located on hill slopes. These are associated with mountainous / hilly areas midst forest cover and forest-cleared areas. This class consists of current Jhum and abandoned Jhum.

6. Degraded Forest land

Lands within Notified Forest boundaries, with various types of forest cover, in which vegetative cover is less than 20 % are classified as degraded / underutilised. These lands are generally confined to the fringe areas. Such lands appear in dark gray to light red tone during the maximum green period. The tonal variations are subject to change with the foliage cover and the season of data acquisition.

7. Degraded Pasture/Grazing land

These are the areas in non-forest areas, whether or not they are permanent pastures or meadows, which have become degraded due to lack of proper soil conservation and drainage measures. They appear in light brown to light red in tone, which may vary, depending on the amount of grass cover associated with the feature. At times they exhibit dull red tone and never reach the bright tone during any season. They are small in size, irregular in shape, scattered and associated with village fringes and flood plains.

8. Degraded land under plantation crop

These are the degraded areas that sustain the growth of plantation crops located outside the notified forest areas. This category can be better delineated using multi-season satellite data in conjunction with ground data. They exhibit dark brown to light red tone, especially during peak growing season; however, the tonal variation is controlled by the foliage cover percentage vis-à-vis the season of satellite data acquisition. These are small in shape exhibiting a regular pattern and scattered.

9. Sandy Area

These are the areas that have stabilized accumulation of sand in coastal or inland areas that can be either desertic or riverine. They appear as white to light yellow/bluish depending on moisture content and at times light red when vegetation is associated with the class, vary in size, with regular to irregular shape with contiguous to linear pattern Mostly they are located in deserts, riverbeds and along the shores.

10. Mining/industrial wasteland

These are the lands where large-scale mining operations bring about the degradation of land and resultant mine dumps, industrial wastelands, which are subject to degradation caused by large scale industrial effluent discharges. The features exhibit dark gray (coal mining areas) to light bluish to back (iron ore waste) tone subject to the color of the mine dump, small to medium in size, depending on the extent of mining area, irregular in shape with mottled texture, located at or near active mining areas and industrial complexes. These areas are subjected to removal of different earth material (both surfacial and sub-surfacial) by manual and mechanized operations. Large scale quarrying and mechanization results in mining and mine dumps. It includes surface rocks and stone quarries, sand and gravel pits, brick kilns, etc.

Mining / Industrial wasteland are areas of stockpile of storage dump of industrial raw material or slag/effluents or waste material or quarried/mixed debris from earth's surface. These are the lands which have been deteriorated due to large scale industrial effluent discharge. These areas are seen conspicuously around urban areas and other areas where industrial activity is prominent. Mining wastelands are those areas where waste debris is accumulated after extraction of required minerals. Generally these lands are confined to the surroundings of the mining area.

11. Barren/Rocky/Stony Waste

These are rock exposures of varying lithology often barren and devoid of soil and vegetation cover. They occur amidst hill-forests as openings or as isolated exposures on plateau and plains. Such lands can be easily discriminated from other categories of wastelands because of their characteristic spectral response. They appear in greenish blue to yellow to brownish in color depending on the rock type. They vary in size with irregular to discontinuous shape with a linear to contiguous or dispersed pattern. They are located in steep isolated hillocks/hill slopes, crests, plateau and eroded plains associated with barren and exposed rocky/stony wastes, lateritic out-crops, mining and quarrying sites. These areas appear in light gray to black tone due to hill shadow on one side and light red on the other side due to vegetation, the tonal variation is subject to degree of soil erosion.

12. Snow Covered/Glacial Area

These are the areas under snow cover confined to the Himalayan region. They appear in bright white to white in color depending on the moisture and thickness of the snow spread in large areas. They possess irregular shape with a contiguous pattern, located in mountain peaks and slopes and high relief areas.

METHODOLOGY

The following input data have been used for carrying out the study.

- Wasteland vector layer created using multi-temporal satellite data of 2005-06
- Resourcesat-1 LISS-III imagery for year 2005-06 belonging to all three major cropping seasons of India (*kharif, rabi and zaid)*.
- Resourcesat-1 LISS-III imagery for year 2008-09 belonging to all three major cropping seasons of India (*kharif, rabi and zaid)*.
- Survey of India topomaps on 1:50000 scale for reference
- Ancillary data like earlier land use maps, reports, atlases etc.
- Limited ground truth

Input Data Preparation

Geo-rectification: The radiometry-corrected satellite data products for 2008-09 were geometrically corrected before they were used in the analysis.

The coordinate system parameters like projection, datum, ellipsoid etc. of the input data used in this study (2005-06 wasteland vector layer, 2005-06 satellite data and 2008-09 satellite data) have been maintained uniform for facilitating the geo-referencing of satellite data, overlay of vector data onto the images and generation of spatial statistics. The projection system followed is LCC / TM with the following parameters:

Projection	: Lambert Conformal Conic / TM
Spheroid	: WGS84
Datum	: WGS84
1st Parallel	: 35 10 22.096000 N
2nd Parallel	: 12 28 22.638000 N
Longitude of Central Meridian	: 80 E
Latitude of origin of projection	: 24 N
False easting	: 4000000 metres
False Northing	: 4000000 metres

Approach

The approach basically involved overlay of wasteland vector data of 2005-06 onto the 2008-09 LISS-III geo-referenced imagery and updating of wasteland categories by redrawing the boundary of 'change' areas through on- screen visual interpretation techniques (fig.1).

Methodology involved the following steps:

1. Overlay of 2005-06 wastelands vector layer on to the georectified images of 2008-09 with same projection (LCC / TM) and datum
2. Updating of wasteland categories depicted in 2005-06 layer with that of 2008 – 09 satellite data to find out the 'change' areas
3. Extraction of wasteland change areas
4. Random sample ground checks
5. Extraction of area statistics and tabulation
6. Atlas and reports.

Image Interpretation

WL05-06 vector layer was overlaid on the 2008-09 Rabi data. Changes in the polygons - decrease, increase, new areas and change from one class to another class are observed and polygons are modified accordingly. The procedure is followed for the entire image grid-wise using the 15' x 15' grid. For new areas from non-wastelands category to a wasteland class, the new polygons are drawn and appropriately recoded. For change from one wastelands class to another, the polygons are selected and the attribute table is updated to an appropriate class. Once the modification of the wasteland polygons is complete for rabi season, then the data is updated using the satellites images of other two seasons. The change map between 2005-06 and 2008-09 was made ready after updating with 3-season satellite data, and the new attribute codes of wasteland polygons are generated. Change statistics and change matrix tables are generated from the attribute data.

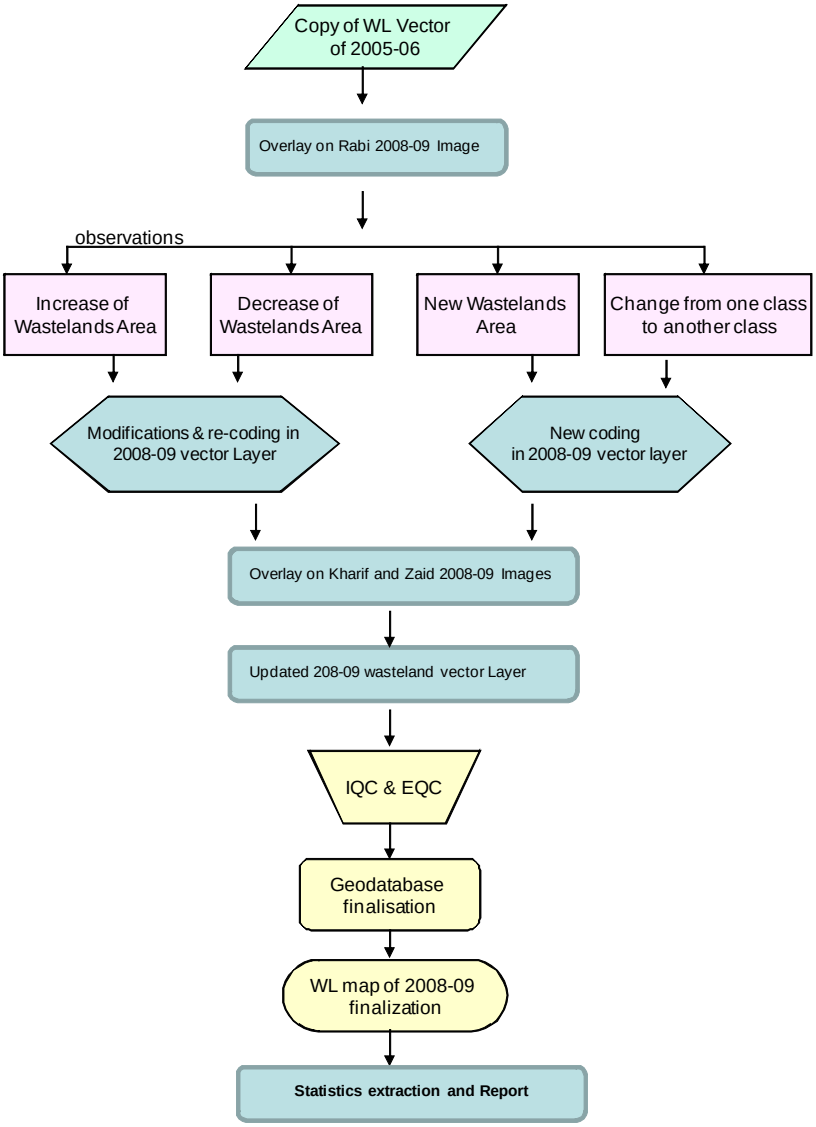

Figure 1: Methodology of the study

Ground Truth Collection

Once the polygons were updated with a WL_Code, the doubtful classes / areas in the database were verified on the ground for improving the accuracy of interpretation. It was ensured that at least 20% ground truth collection of the change areas was done

Geodatabase creation

Geodatabase consists of vector data on various wasteland categories and an associated metadata, which describes the data content. The outputs are stored in LCC / TM projection system using WGS84 datum.

Quality Assurance Mechanism

A two-fold quality assurance mechanism involving in-process quality control by the Internal Quality Checking (IQC) team members at Partner Institutions and external quality audit by

External Quality Assurance Team (EQAT) was adopted. The digital database quality standards finalized under NNRMS Programme of Natural Resources Repository (NRR) were followed in this project. The QAS standards included parameters such as geo-rectification accuracy, interpretation, classification, area estimation, geodatabase etc.

IQC was done for all the input and output products. Once the IQC Team cleared the outputs and other intermediate products, the EQAT evaluated the quality assurance of the product, by evaluating a minimum of 20% of the products. The products whose samples did not meet the quality standards were reworked for incorporation of necessary corrections in the sample as well as in rest of the products. On incorporating the suggested changes in all the products based on the advice of the EQAT, the IQAT gives a certificate to that effect and then the products are accepted. Only those outputs meeting the accuracy standards were cleared for incorporation in the geo database.

Database Organisation

All the databases were first checked for edge-matching across inter-district and inter-state borders so that data gaps and overlaps are eliminated amongst the datasets of different states. The wasteland feature classes are also matched across these borders to maintain the data continuity and to facilitate generation of a seamless dataset for the entire country. NNRMS spatial framework has been used to create the seamless data.

Spatial Statistics Generation

The area statistics on various wasteland classes for 2008-09 and changes observed in wasteland status during 2008-09 *vis-a vis* 2005-06 (Category-wise; and state-wise at national level; category-wise and district-wise at state level; and category-wise at individual district level) were generated. A change matrix table depicting the inter-class change during 2008-09 and 2005-06 has also been generated at national and state levels. The area estimation has been done adopting individual district geographical area as per earlier Wasteland Atlas 2010 (based on multi-season satellite data of 2005-06) records.

SUGGESTED USE:

The wasteland maps should be used at broad level for the following purposes:

- watershed management,
- agricultural productivity improvement and
- scientific research involving carbon cycle, hydrologic cycle, energy budget studies, weather / climate prediction etc.

LIMITATIONS

Database should be used at scales smaller than 1:100,000

DISCLAIMER

- Different wasteland class accuracies are subject to availability of appropriate biological windows of satellite data.

- Data cannot be used for any legal purpose.
- Maps should not be used for commercial purpose.
- User shall exercise reasonable skill, care and diligence while using the information and will keep indemnified NRSC/ISRO in respect of any loss, damage or claim howsoever arising out of use of this information.
- User of this data/information will consult NRSC to commercially exploit / use the intellectual property generated in the Projects.

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Apart from the above citation use of this information in any form (statistical, GIS layer, Links etc.) are to be duly acknowledge as following;

I/we have used the Wasteland information on my/our research work from the Wastelands Atlas of India 2011 published by the Department of Land Resources, Ministry of Rural Development, and the National Remote Sensing Centre (NRSC), ISRO, Hyderabad, India

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