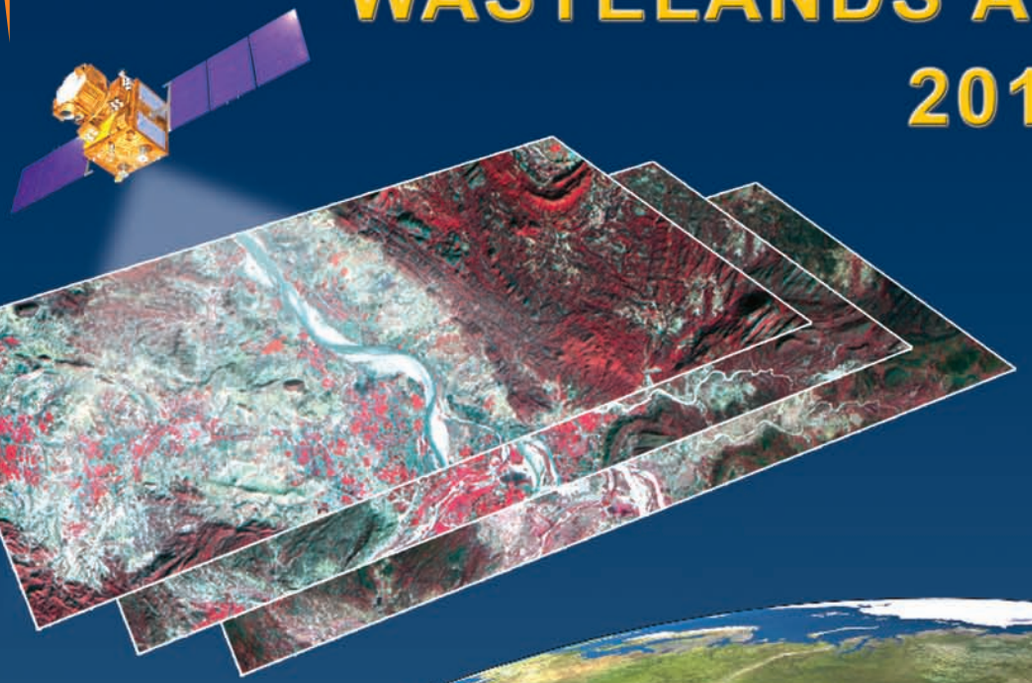
WASTELANDS ATLAS OF INDIA 2010



Ministry of Rural Development
Department of Land Resources
Government of India
New Delhi – 110011

National Remote Sensing Centre
Indian Space Research Organisation
Department of Space, Government of India
Hyderabad – 500625

WASTELANDS ATLAS of INDIA

सत्यमेव जयते

Govt. of India
Ministry of Rural Development
Department of Land Resources
New Delhi

इसरो isro

nrsc

Land Use Division, Land Resources Group
RS & GIS Applications Area
National Remote Sensing Centre
Indian Space Research Organisation
Hyderabad

2010

सत्यमेव जयते

रीता सिन्हा
RITA SINHA

सचिव
भारत सरकार
भूमि संसाधन विभाग
ग्रामीण विकास मंत्रालय
SECRETARY
Government of india
Department of Land Resources
Ministry of Rural Development

FOREWORD

Land resources are under tremendous pressure with growing needs of development and exploding population with attendant increase in the demand for food, fuel, fodder and fiber. The advent of modern age and newer forces, exacerbated by short-term gain driven motives often lead to over-exploitation of natural resources, including depletion of soil fertility and degradation of land resources. Government of India has created the Department of Land Resources (DoLR) in the Ministry of Rural Development (MRD) for development of rainfed areas including wastelands in drought prone and desert prone areas. Having the mandate of developing the valuable land resources of India, the Department endeavors to prevent further degradation of these resources through appropriate management strategies. At the instance of Govt. of India, the Indian Space Research Organisation (ISRO), took the first step in the direction of creating reliable database on the wastelands of the country on 1:50,000 scale. National Remote Sensing Centre (erstwhile National Remote Sensing Agency) has executed the project using satellite data of different periods (1986 – 2000). An atlas showing the spatial distribution and district-wise area under wastelands was released by the Prime Minister of India in 2000. Apart from Department of Land Resources this Atlas is being consulted by various user government departments and non-governmental organizations extensively for implementing various development programmes.

In order to update the information on severity of degradation which helps in wasteland reclamation programmes, DoLR has again initiated a project titled "National Wasteland Updation Mission (NWUM)" in collaboration with NRSC, during 2003. Using Rabi season IRS LISS III of 2003, the status of wastelands with 28 categories was mapped. According to these estimates, wastelands accounted for 55.64 million ha. The collateral data and ancillary information like watershed boundaries, village boundaries and base details such as settlement locations, transport network, drainage, notified forest boundaries are organized in different layers using standard codification system. The results are published as a National Atlas titled 'Wasteland Atlas of India – 2005', providing district level information.

In order to monitor the changes in wastelands in the country, DoLR had initiated a project titled 'National Wastelands Monitoring Project

(NWMP)', in collaboration with NRSC, Department of Space. The emphasis in this project was on the study of the dynamics of wastelands through comparison of spatial statistics of different categories between 2006 and 2003, enabling better understanding of changes in some of the wastelands areas. The results of findings of the project have been brought out as ' Wasteland Atlas of India – 2006 ' which provide category-wise and district-wise information on wastelands in various states in the country along with change over the previous study (2003).

I hope this publication will be very useful for all those involved in the implementation of various wastelands reclamation programme in the country.

Icongratulate all those associated with this national endeavor, which is of great relevance in rural development.

New Delhi
Date:11-03-2010

Rita Sinha

भारत सरकार
अन्तरिक्ष विभाग
अन्तरिक्ष भवन, न्यू बी ई एल रोड
बेंगलूर - 560 231, भारत
तार : स्पेस फैक्स : +91-80-23415328
दूरभाष : +91-80-23415241, 22172333

सत्यमेव जयते

GOVERNMENT OF INDIA
DEPARTMENT OF SPACE
Antariksh Bhavan, New BEL Road
Bangalore - 560 231, India
Grams : Space Fax : +91-80-23415328
Telephone : +91-80-23415241, 22172333
e-mail : chairman@isro.org

Dr. K. Radhakrishnan
Secretary

PREFACE

Optimal management of natural resources in the wake of the ever-increasing demand for food, fuel and fodder pose complex problems for the country's growth and development. Strategies for solving such complex issues lie in understanding the potential of land and water resources, designing appropriate plans to circumvent them, while meeting the basic needs of the nation.

India occupies 2.4% of the global geographical area, shares 16% of human population and 15% of livestock population. This scenario has necessitated proper demarcation of productive and non-productive lands, particularly the wastelands that could be treated and reclaimed for productive use.

Applications of Satellite Remote Sensing have proved to be successful in mapping and characterising the wastelands and prioritising them for reclamation. Wasteland mapping at national level has been done at regular time intervals by ISRO/DOS, during past 2 decades, using data from Indian Remote Sensing Satellites. The area occupied by wastelands, at national level, was assessed as 63.85 mha during 1986-2000; while a similar exercise carried out during 2003 depicted a reduction by 8.21 mha.

The present exercise of mapping wastelands was carried out during 2005-2006, by using three-season satellite data for the first time. This effort resulted in estimating the current extent of wastelands as 47.22 mha, showing further reduction to the tune of 8.41 mha. These figures, along with maps, are being utilised by the Ministry of Rural Development. (MoRD), regularly, towards planning and implementing the reclamation of wastelands.

I compliment the efforts of all the individuals and institutions, who have contributed in successful completion of this project at national level. I am sure; the database generated will continue to contribute towards better management of wastelands in the country.

Bangalore
Date: 01-04-2010

K. Radhakrishnan

भारत सरकार
अन्तरिक्ष विभाग
राष्ट्रीय सुदूर संवेदन केन्द्र
बालानगर, हैदराबाद-500 625, आं प्र, भारत
टेलिफोन : +040-23878360
+040-23884000-04
फैक्स : +040-23877210

सत्यमेव जयते

Government of India
Department of Space
National Remote Sensing Centre
Balanagar, Hyderabad-500 625, A P, India
Telephone : +040-23878360
+040-23884000-04
Fax : +040-23877210

Dr. V. Jayaraman
Director

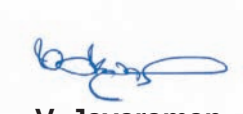
PREAMBLE

The rapid industrialization and economic development in many countries have resulted in achievement of improved standards of living as evident from improved GDP per capita. However, one of the prices to be paid for such a rapid development is environmental degradation by way of soil erosion by water and wind, soil salinization / alkalization / acidification, water logging etc. In order to increase the biomass production and to restore the environmental health, preventive and curative measures need to be employed for rehabilitation of wastelands / degraded lands. Information on the nature, extent, severity and dynamics of degradation is vital in this endeavour. The available estimates of degraded lands in India range from 30 to 175 M ha. These variations are mainly due to the lack of mutually agreed definitions on various classes of wastelands, variations in database used, and the methodologies adopted for deriving information on wastelands.

Realizing the potential of satellite remote sensing and GIS, National Wasteland Development Board, Government of India initiated a collaborative project with NRSC (erstwhile NRSA) to identify wastelands and their location up to village and micro-watershed level on 1:50,000 scale using Landsat – TM, IRS LISS-I, LISS-II and LISS-III images for the periods 1986-1999. Wastelands were grouped into thirteen categories and the maps were prepared for entire country. This database has been extensively used in various wasteland and watershed development schemes by various user departments, including Non-Governmental Organisations (NGOs). Based on the above, an Atlas was also brought out in 2000.

The Ministry of Rural Development, once again requested NRSC in 2003 for a follow-up study to update the wasteland database. Accordingly, a national level project titled “National Wastelands Updation Project” was taken up to generate database for entire country using one time *rabi* season IRS LISS-III data of 2003. Several partner institutions like State Remote Sensing Applications Centres, Regional Remote Sensing Centres (erstwhile RRSSCs), and academia were involved. An atlas on wastelands titled “Wasteland Atlas of India – 2005 “was brought out. This publication, again, proved to be very useful in the implementation of various wasteland reclamation schemes.

To understand the spatial and temporal changes in wastelands, the current project on "National Wastelands Monitoring" was initiated in 2006 with the objective of assessing the status of wastelands and to monitor its changes in their vegetation conditions. The unique features of this project are usage of three season (*kharif, rabi and zaid*) satellite data for deriving information on wastelands, and development of digital database as per NNRMS standards. This exercise is envisaged to improve the delineation of various wastelands categories, and help refining the delineation of wastelands made during the earlier exercise. The development of digital database as per NNRMS standards is yet another improvement. The current Wasteland Atlas provides the status of wastelands of our country during the period 2005-06. The classification scheme adopted, methodology followed for creation of database have been explained in a lucid manner to facilitate the usage of the data for rehabilitation of wastelands. I am sure, as in the past, this Atlas will also be used by many stakeholders involved in wasteland reclamation activities.



Hyderabad
Date: 05-03-2010

V. Jayaraman
Director, NRSC

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In this context, National Wastelands Monitoring Project team acknowledges the keen interest and support provided by Mrs. Rita Sinha, Secretary and Shri. Chinmay Basu, Additional Secretary, Ministry of Rural Development, Government of India for using satellite remote sensing technology for wastelands updation in scientific manner during the execution of the project.

Our deep sense of gratitude is due to Dr. K Radhakrishnan, Chairman, Indian Space Research Organisation (ISRO) and Secretary, Department of Space, Government of India for his constant guidance and support. The project team is grateful to Dr. V Jayaraman, Director, National Remote Sensing Centre (NRSC), Hyderabad, Government of India for guidance and providing necessary facilities during execution of the mission.

A national level project of this magnitude could not be successfully completed without active support from a large number of partner institutions namely State Remote Sensing Application Centers, Regional Remote Sensing Centers, BITS-Ranchi, NATMO-Kolkata and IRS-Chennai. The project team also acknowledges the support extended by the Heads/ Directors and Scientists of all the partner institutes for taking up and whole heartedly supporting a national mission project and successful completion of the project.

We also place on record our sincere thanks to external quality teams without whose active support, an output of this fine quality would not have been possible.

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Dr S. Sudhakar, Head, Land Use Division and Dr G. Ravi Shankar, Scientist 'SF' has coordinated the project at NRSC. Their contribution is duly acknowledged.

Finally, we sincerely place on record the co-operation extended by various areas / divisions /sections of NRSC for their valuable support in completing the project.

Hyderabad
Date: 29-03-2010

P S Roy
Deputy Director (RS & GIS-AA)
NRSC

PROJECT TEAM

Andhra Pradesh
APSRAC, Hyderabad
Dr. K. Mruthyunjaya Reddy
Mr. G. Mehar Baba, Mr. D V J Sastry
Mr.S. V. Raghava Reddy
Mr. Ch. Tata Babu, Mr. G. Kumaraswamy

Bihar
BIT, Mesra, Ranchi
Dr. M. S. Nathawat
Dr. A. C. Pandey, Dr.V.S.Rathore
Mr. Nitish Kumar Sinha, Mr.Suraj Kumar Singh

Chattisgarh
NATMO, Kolkata
Dr.P.Nag
Mr.A.Mukherji, Dr.Rajendra Prasad
Ms.Madhuri Mukherji, Ms.Sudeshna Bhar

NRSC, Hyderabad
Dr. Manoj Raj Saxena, Dr. G.Padma Rani
Mr. Girish S Pujar, Dr.Arijit Roy
Ms. Shivam Trivedi, Dr.T.R.Kiran Chand

Goa
EOS , ISRO HQ
Dr.J.Krishnamurthy,
Dr. Rajeev Kumar Jaiswal
Dr.M. Sameena, Mr.T.R.S.V.S. Sastry

Gujarat
BISAG, Gandhinagar
Mr.T. P. Singh
Mr.Ajay Patel, Mr. Vijay Singh
Mr. Khalid Mahmood, Mr. Navnit Patel

Haryana
HARSAC, Hissar
Dr. R. S. Hooda
Dr.V. S. Arya
Dr. Sandeep Arya, Mr S S Khatri
Ms. Heena Sharma, Mr. Vijay Singh
Mr. Prem Prakash Sharma

Himachal Pradesh
RRSC, Dehradun
Dr. K P Sharma
Dr. M. Kudrat
Dr. Hitendra Padalia

HPRSC, Shimla
Dr. R. K. Sood
Dr. R. S. Thapa

Jammu & Kashmir
RSAC, J & K
Dr. Ravi Kumar Kesar
Dr. S. A. Naqash
Dr.Tasneem Keng, Mr.Tanveer Shaikh
Ms. Muzammil Amin

Jharkhand
JSAC, Ranchi
Dr. A.T. Jeyaseelan
Dr. Neeraj Kumar Sharma, Mr. Najmul Hoda
Mr. Rahul Kumar Singh, Ms. Swetta Singh
Mr. Mukesh Kumar, Mr Ritesh Kumar Sinha
Mr. Pradip Kumar Swain, Mr. Lakhan Lal Mahto
Mr. Amit Kumar, Mr. Mukesh Boori
Mrs. Jyoti Bala Lamay, Mr. N K Mishra
Mr. Ajay Kumar, Mr. V H Vinod Kumar
Ms. Shashi Poonam Indwar
Dr. Vivek Kumar Singh, Ms. Nishi Jaya Kullu

Karnataka
KSRSAC, Bangalore
Dr. M.H. Balakrishnaiah
Dr. V. Shreedhara
Mr. Mohd. Saleem I. Shaikh, Mr. T. Praveen
Dr. M. C. Jayaprakash, Mr. D.Ramesh Nayak
Mr. B.C. Santhosh Kumar, Mr. D.C.Lingadevaru

Kerala
KSREC, Thiruvananthapuram
Mr. R. P.Sharma
Mr. A.Nizamudeen, Mr. N.Thrideep Kumar
Mr. B. R. Hareesh

Madhya Pradesh
RSAC, Bhopal
Dr.P.K.Varma
Dr. Vivek Katare, Dr. Narendra Shivhare
Mr. S. N. Rajak, Mr. Sanjay Samuel
Ms. Seema Khan, Mr. Kiran Kanungo
Mr. Shailendra Pandey

Maharashtra
MRSAC, Nagpur
Dr. A.K.Sinha
Mr. Vivek Kale, Mr.Sanjeev Verma
Ms. Tutu Sengupta, Mr. Prashant Rajankar
Dr. Ajay Deshpande, Ms. Sapna Deotale
Ms. Neelima Srivastava, Ms. Archana Kolhe
Mr. Bhau Gavit, Mr.Sanjay Patil, Mr.Arun Atkare
Ms. Smita Dhirde, Mr.Sanjay Balamwar, Mr. S.Khandare

Orissa
ORSAC, Bhubaneswar
Mr. A. K. Mohapatra
Mr. P. Mishra, Ms.B.Tripathy
Mrs. S. Devi, Mr.A.Das

Punjab
PRSC, Ludhiana
Dr. P. K. Sharma
Dr. D. C. Loshali, Dr.V.K.Verma
Dr. Anil Sood, Dr.Minakshi
Mr. Narinder Singh, Dr.Ajay mathur

Rajasthan
RRSC, Jodhpur
Dr. J. R. Sharma
Mr. Suparn Pathak, Dr.Rakesh Paliwal

Tamil Nadu
IRS, Anna University, Chennai
Dr. M. Ramalingam
Mr. A. Ravindran, Ms.C.Sivakami
Ms. R. J. Manonmani

Uttar Pradesh
RSAC, Lucknow
Dr. Alok Mathur
Ms.Manisha Mishra, Dr.Manoj Kumar
Mr.Ranjit Singh Rawat, Mr.A.R.Siddiqui
Dr.P.P.S. Yadav, Mr. Sajan A. Punnoose
Mr. Sushil Chandra, Mr.K.K.Mishra,
Mr. Sandeep Singh

Uttarakhand
USAC, Dehradun
Dr. M. M.Kimothi
Mr. Sunil Chandra Dhanwal

West Bengal
RS Cell, WBCST, Kolkata
Dr. P. Chakrabarti
Ms. Subrata B. Dutta
Ms. Komalika Paul, Ms.Maitreyee Banerjee

Union Territories
NRSC, Hyderabad
Mr. Rajiv Kumar

North Eastern States
NESAC, Shillong
Dr.P.P.Nageswara Rao, Dr. K.K.Sarma

Arunachal Pradesh
ARSAC, Itanagar
Dr. G.Ch. Chennaiah
Mr.H. K. Datta, Mr. Chauken Manlong
Ms.Binuta Barua

Assam
Assam RSAC, Guwahati
Mr. Niraj Verma
Mr. Utpal Sarma, Mr. Abhijit Bora
Mr.Jagdish Bhattacharya

Manipur
Manipur RSAC, Imphal
Mr. N. Shamungou Singh
Mr. O.Nodiachand Singh, Mr.Y.Nilakanta
Mr.N.Gaganchand

Meghalaya
NESAC, Shillong
Ms.H.Suchitra Devi, Mr.Victor Saikhom
Mr.Pebam Rocky

Mizoram
MIRSAC, Aizawl
Dr. R. K. Lallianthanga
Mr. Hmingthanpuii, Mr.Robert L Sailo
Mr.H.Lalhamachhuana

Nagaland
NS & TC, Kohima
Dr. Zavei Hiese, Dr.Nesatalu Hiese
Mr. Ditho Katiry

Sikkim
RRSC, Kharagpur
Dr. A. Jeyaram
Dr. V. M. Chowdary
Ms. Swati Singh
Ms. Anju Bajpai

Tripura
TSAC, Agartala
Dr. N. Datta
Mr. Abhisek Dasgupta, Mr.Subrata Paul
Mr.Subrajyothi Choudhury, Mr.Sujit Das
Ms.Banani Bhattacharjee,
Mr. Parthasarathi Goswami

Project Management

Project Director
Dr.P.S.Roy

Technical Guidance
Dr.R.S.Dwivedi

Project Coordinators
Dr. S. Sudhakar, Dr.G.Ravi Shankar

Technical Lead Team

Dr. G. Ravi Shankar –
Rajasthan, North-Eastern States (Meghalaya, Mizoram, Nagaland, Sikkim, Arunachal Pradesh)
Dr. S. V. C. Kameswara Rao –
Bihar, Uttar Pradesh, Maharashtra
Dr. Manoj Raj Saxena –
Orissa, West Bengal, Madhya Pradesh, Jharkhand
Dr. G. Padma Rani -
Andhra Pradesh, Kerala, Tamil Nadu
Mr. Rajiv Kumar –
Union Territories, Tripura, Goa, Jammu & Kashmir
Mr. B. Shyam Sunder –
Gujarat, Haryana, Uttarakhand, Punjab, Karnataka, Himachal Pradesh
Mr. Girish S. Pujar -
Chhattisgarh

Quality Assurance Team

NRSC, Hyderabad
Dr. S. Sudhakar
Dr.G. Ravi Shankar
Dr. S. V. C. Kameswara Rao
Dr. Manoj Raj Saxena, Dr. G. Padma Rani
Mr. Rajiv Kumar, Mr. B. Shyam Sunder
Mr.A.Lesslie, Mr.Arul Raj, Ms.R.Binutha

IIRS, Dehradun
Dr.Jitendra Prasad, Dr.A.P.Subudhi
SAC, Ahmedabad
Dr. R Ghosh, Dr.T.S.Singh

Atlas Compilation Team

Content layout, text and design
Dr. S. Sudhakar, Dr. G. Ravi Shankar

Geodatabase compilation & analysis
Mr. B.Shyam Sunder, Ms. R.Binutha

Technical support
Dr. S.V.C.Kameswara Rao, Dr. Manoj Raj Saxena, Dr.G.Padma Rani, Mr.Rajiv Kumar

Printing Support
Mr.K.Shankar Rao
Mr.E.Vijayasekhar Reddy

Operations Support
Mr.S. Thirunavukkarasu
Mr.D.Janardhan Rao, Mr.P.G.Vijaya Kumar
Mr.P.Venugopal, Mr.Sanjay Kumar Rathod
Mr.O.S.N.Murthy, Mr. A.V.Raju, Mr.K.Sanathanan
Mr.Solomon John, Mr.K.S.Vijaya Kumar
Mr.D.N.Rao, Mr.N.Raghunandan, P.Revathi
Mr.R.N.Bera, Mr.Rajam Raju, Mr.BSS Prasad

Secretarial Support
Ms. Malini Raj Kumar, Mr. K. Narasing Rao

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National Wastelands Monitoring using Multi-temporal Satellite data
Executive Summary

A project titled "National Wastelands Updation Project (NWUP)" was taken up by NRSC at the behest of the Ministry of Rural Development, Govt. of India during 2002-03 to update the earlier wastelands maps (2000) by using one-time dataset of 2003 following a systematic visual interpretation approach. The vector data on wastelands was generated in Polyconic projection and Everest 1956 as a reference datum which was later modified to LCC projection and Modified Everest datum.

To monitor the changes in the status of wastelands during the period 2003 and 2005-2006, a project titled 'National Wasteland Monitoring' using Resourcesat-1 LISS III data was initiated in 2006. To improve the accuracy of wastelands delineation, Resourcesat-1 LISS III data of three season, namely *kharif* (monsoon), *rabi* (winter) and *zaid* (summer) for the period 2005-06 were interpreted following on-screen visual interpretation approach. The database on wastelands was generated in UTM projection and WGS 84 datum to comply with the existing national map policy. In order to facilitate the objective comparison of database on wastelands for the period 2003 and 2005-2006, and to enable change detection, the databases of 2003 and 2005-2006 were brought to a common projection and datum i.e. UTM projection and WGS 84 datum.

The wastelands vector layer of 2003 along with the reprojected three seasons satellite data of 2005-06 were used to update the wastelands database of 2003. However, due to inconsistency in georeferencing of these two satellite datasets, the monitoring exercise could not be carried out. Hence wastelands mapping was carried out using Resourcesat 1 LISS III data of three seasons for the period 2005-06 using wastelands vector layer of 2003 as a reference along with limited ground truth.

The utilization of three seasons' satellite data of 2005-06 has led to substantial improvements in the delineation of wastelands categories. This database on wastelands could be used as a reference for monitoring changes in the spatial extent of wastelands in future. Due to the change in the datum coupled with problems related to georeferencing, registration of two datasets, i.e., 2003 and 2005-06, patch-to-patch comparison of wastelands distribution could not be brought out. However, State-and district-wise comparison in the area statistics of various categories of wastelands during the period 2003 and 2006 has been made.

An estimated 47.22 M ha accounting for 14.91 % of the total geographical area of the country has been mapped as wastelands during the period 2005-06. The changes in the extent of wastelands during 2003-06 have been of the order 8.41 M ha Indicating thereby a reduction in the wastelands to the tune of 2.66 %.These changes in spatial extent of wastelands could be attributed to (i) non-uniform usage of satellite datasets (single season vs. three season); (ii) Differences in the datum and projection of satellite data of the two periods (2003 & 2005-06); (iii) inconsistencies in definition and number of categories of wastelands; and (iv) implementation of reclamation programs on wastelands by the Ministry of Rural Development and other Central and State Government agencies. The spatial changes in wastelands between 2006 and 2009 will be studied and reported in the forthcoming project titled "National Wastelands Change Analysis" sponsored by Ministry of Rural Development.

1.0 Introduction

Land being a non-renewable resource, is the central to all primary production systems. In India, the excessive demand of land for both agricultural and non-agricultural uses has resulted in the development of vast stretches of different kinds of wastelands such as salt-affected land, waterlogged areas, gullied/ravinous lands etc. Planned efforts are needed for their rehabilitation. Over the years, the country's landmass has suffered from different types of degradation caused by biotic and abiotic pressures. An ever increasing population places enormous demand on land resources which are indispensable for a country like India with 2.4 % of the worlds' geographical area supporting over 16 % of the world's population. Further, the country has 0.5 % of the worlds grazing lands but has over 18 % of world's cattle population. The tremendous pressure on land has led to conversion of forest lands into urban and industrial areas.

Spatial information on wastelands with respect to their nature, magnitude of degradation, extent, spatial distribution and temporal behavior is a pre-requisite for development and implementation of plans for their rehabilitation. The spaceborne spectral measurements, GIS and Global Positioning Systems (GPS) offer immense potential in deriving information on wastelands in a timely and cost-effective manner. The demonstration of the potential of coarse spatial resolution Landsat MSS data for generating information on wastelands at 1 : 1 million scale showing 8 categories of wastelands for entire country by NRSC (erstwhile NRSA) in 1984-85 has revealed the fact that 53.30 M ha corresponding to 16.40 per cent of the geographical area of the country are lying waste. Realizing the need to rehabilitate these lands, the National Wastelands Development Board was established in 1986 with the objective of bringing five M ha of land every year under fuel wood and fodder plantations.

At the instance of Ministry of Rural Development, spatial assessment of wastelands across the country was taken up on a larger scale i.e. 1:50,000 scale by Department of Space (DoS) to serve as a useful database for implementing various wastelands developmental schemes.

2.0 Historical Perspective

2.1 National Wastelands Inventory Project (NWIP-2000)

Wastelands mapping was carried out in different phases considering the critically-affected districts on priority. A 13-fold wastelands classification system was adopted for mapping wastelands at 1 : 50,000 scale for entire country in five phases using Landsat Thematic Mapper (TM) IRS LISS II and IRS 1C LISS III data. An estimated 63.85 M ha of land covering 20.17% of total geographical area of the country were mapped as wastelands.

2.2 National Wastelands Updation Project (NWUP-2003)

Since mapping of wastelands was carried out using satellite datasets corresponding to different years (1986 – 2000), the updation of wastelands was taken up by NRSC using one season data set of 2003. A modified classification system, with the inclusion of more classes to indicate the severity of degradation totalling 28 classes, was adopted for deriving information on wastelands. As different categories of wastelands require different treatment to reclaim, the new wastelands classification would help priotrizing them for reclamation. Similar to earlier wastelands mapping exercise, datasets were organized into four geospatial layers, namely base, village, wasteland and watershed. An estimated 55.64 M ha or 17.57% of the country's geographical area was mapped as wastelands.

A wastelands atlas was prepared to present the results emanating from this wastelands mapping exercise using satellite data for year 2003. The Wastelands Atlas describes the project background, wastelands

classification system, definitions of wastelands class and results of the analysis of wastelands. Wastelands area statistics district-, state- and category-wise were presented in the form of tables. A brief description on the spatial variation in the distribution of wastelands in the country and the change between 1986-2000 and 2003 were also discussed.

2.3 National Wastelands Monitoring Project (NWMP-2006)

Ministry of Rural Development (MRD) has been funding many wastelands reclamation programmes to bring them under green cover. MRD had requested NRSC to take up another task to map wastelands using IRS LISS-III data of 2005-2006 to monitor the wastelands over a period of three years i.e., between 2003 and 2006.

To maintain the consistency and integrity of database, the vector layer of wastelands for all the States and Union Territories of 2003 with Polyconic projection and Everest 1956 as reference datum were reprojected to LCC projection and Modified Everest datum to WGS 84 datum. During the course of re-projection, a mismatch was observed in state mosaics in terms of the wastelands polygons and the features in the 2003 satellite images. Several attempts were made using various models to come up with a viable and practical solution to overlay the polygons precisely onto satellite image features. However, the exercise did not yield satisfactory results.

It was finally decided to physically move the wastelands polygons along with the corresponding labels interactively so as to match the features on the digital satellite data to the desired level of accuracy. In view of utilization of three season satellite data during 2005-2006, the precision in delineating wastelands categories has improved but it also increased the incompatibility in wastelands categories between the two datasets, i.e., 2003 and 2006 which was further aggravated by the projection problems. Hence incompatibility in the wastelands categories and the season of satellite data used precluded bringing out the changes in the wastelands patches/ polygons. The spatial changes in the wastelands distribution could not be presented in the current exercise. However, changes in the areal extent of wastelands categories district and state-wise between 2003 and 2006 have been brought out in tabular form.

Table : 1 Comparison of wastelands categories mapped during 2003 and 2005-2006

S. No.	Classes of 2003 Database	Classes of 2005-2006 Database
01.	Gullied and Ravinous Land – Shallow	Merged with Gullied and Ravinous Land – Moderate
02	Land Affected by Salinity / Alkalinity – Slight	Merged with Land affected by Salinity / Alkalinity – Moderate
03.	Sands – a. Flood Plains b. Levees	Merged with Sandy Area – Riverine
04.	Sands Desertic a. Sands – Semi-stabilized to stabilized – low b. Closely spaced Inter-dunal area	Merged with Sandy Area – Desertic
05.	Steep sloping Area	Merged with Barren Rocky / Stony Waste Area

The spatial changes in wastelands between 2005-2006 and 2009 will be studied and reported in the forthcoming project titled "National Wastelands Change Analysis" sponsored by Ministry of Rural Development.

In the wastelands classification scheme followed during 2003, 28 categories of wastelands were identified which have been now brought down to 23 categories in the current exercise. *Table-1* depicts the major changes in the wastelands classification scheme followed in 2006 over that followed in wastelands 2003 database. A technical manual for wastelands mapping and database creation has been prepared.

Nomenclature for two wastelands categories viz., land with scrub and land without scrub has been modified to land with dense scrub and land with open scrub, respectively.

2.4 Harmonisation of Wastelands

The estimates on wastelands/ degraded lands/soil degradation are available from various national organisations like National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) of Indian Council of Agricultural Research (ICAR), NRSC(erstwhile NRSA) of Department Of Space etc. The area statistics of degraded lands/ wastelands reported by these organisations vary from 187.7 M ha (Sehgal and Abrol, 1994) to 63.85 M ha (Ministry of Rural Development & NRSA, 2000). These variations are essentially because of the differences in objectives, class definitions, approach/methodology, scale of mapping, etc. However, in view of the need for harmonized databases in macro and micro-level planning for various watershed development activities, objective allocation of financial resources and to ensure uniformity of databases across various Govt. departments, it was felt that some level of harmonization is necessary amongst various databases. In 2008, a harmonization exercise was taken up jointly by ICAR and NRSC. After several rounds of discussions, a practical and management-responsive estimate of wastelands/degraded lands has been arrived at. NRSC has been generating spatial statistics on wastelands at different scales under major projects like National Wastelands Mapping, National Land Degradation Mapping, National Land Use/ Land Cover Mapping, etc. It has been observed that there are many wastelands categories common to LULC and land degradation maps. Since a common satellite dataset i.e. Resourcesat-1 LISS III has been used for generating these maps, harmonization of these databases is a pre-requisite, in order to maintain uniformity of information across the databases. Hence, the wasteland categories mapped under this project have been harmonized with those available in Land Use Land Cover Mapping (1:50,000 scale) and National Land Degradation Mapping Project.

3.0 Objectives

The project aims at -

1. Updating the spatial extent and distribution of wastelands of year 2003 using three seasons satellite data of 2005 - 2006; documentation, and
2. Creation of digital database and information system

4.0 Database

A key strategy of the current project is the usage of multi-temporal data sets for delineation of wastelands in a pursuit to achieve improved classification accuracies. The geometrically - corrected Resourcesat-1 LISS III data within the framework of NNRMS specified standards form the primary input for updating the wastelands. Multi-temporal data acquired during September to November, December to March and April to May corresponding to *kharif*, *rabi* and *zaid* cropping season was used for deriving information on wastelands. Base details on major settlement locations, transport network and drainage were overlaid. The wastelands layer of 2003 formed the primary legacy layer to compare the changes of wastelands categories with reference to 2006 data.

Table 2. Wastelands classification scheme

	S.No.	Wastelands Category		S.No.	Wastelands Category
A		**Gullied/Ravinous land**	**F**		**Scrub Forest (Under utilized notified forest land)**
	1	Medium ravine		**11**	Scrub dominated
	2	Deep/very deep ravine		**12**	Agricultural land inside notified forest land
B		**Scrubland (Land with or without scrub)**		**13**	**Degraded pastures/grazing land**
	3	Land with dense scrub		**14**	**Degraded land under plantation crops**
	4	Land with open scrub	**G**		**Sands (coastal/desert /riverine)**
C		**Waterlogged and marshy land**		**15**	Sands – Coastal sand
	5	Permanent		**16**	Sands – Desert sand
	6	Seasonal		**17**	Semi-stabilized to stabilized (> 40m) dune
D		**Land affected by salinity/alkalinity**		**18**	Semi-stabilized to stabilized moderately high (15- 40m) dune
	7	Moderate		**19**	Sands – Riverine
	8	Strong	**H**		**Mining/Industrial wastelands**
E		**Shifting cultivation**		**20**	Mining wasteland
	9	Current Jhum		**21**	Industrial wasteland
	10	Abandoned Jhum		**22**	**Barren rocky area**
				23	**Snow cover and/or glacial area**

5.0 Classification system

The classification scheme adopted for monitoring of wasteland on 1: 50,000 scale is given in *Table- 2*. Wastelands refer to degraded lands that are currently underutilized, and are deteriorating for lack of appropriate soil & water management or on account of natural causes. Wastelands develop naturally or due to influence of environment, chemical and physical properties of the soil or management constraints. The different categories of wastelands delineated in this study are described hereunder:

1) Gullied and/or Ravinous Land

Gully is a narrow channel when surface water flow increases in response to clearing and excessive use of land. Other factors that play a role in gully initiation are the type of landscape, geology, rainfall, soil texture, hill-slope length and seasonal climatic extremes. The intricate network of gullies is referred to as ravines. Two categories of ravines viz., medium ravines and deep ravines could be delineated based on their depth.

Medium Ravines: These are the ravines with a depth of gullies ranging between 2.5 and 5 meters. Generally, these are seen confined to the head region of the stream close to agricultural land.

Deep Ravines: The depth of ravines is more than 5 meters. Deep ravines, generally, occur along the higher order stream areas that are close to the main river.

2) Scrubland

This is the land, which is generally prone to deterioration due to erosion. Such lands generally occupy topographically high locations, excluding hilly/mountainous terrain. Based on the presence of vegetation cover, two sub-classes could be delineated i.e., land with dense scrub and land with open scrub.

Land with dense scrub

These areas have shallow and skeletal soils, at times chemically degraded, extremes of slopes, severely eroded and are subjected to excessive aridity with scrubs dominating the landscape. They have a tendency for intermixing with croplands.

Land with open scrub

This category is same as mentioned in the earlier category except that it has sparse vegetative cover or is devoid of scrub and has a thin soil covers.

3) Waterlogged / Marshy Land

Waterlogged land is that low lying land where the water is at/or near the surface and the water stands for most part of the year. Depending on duration of waterlogging, two sub-classes viz., permanently waterlogged and seasonally waterlogged areas could be delineated.

Permanent: Permanently waterlogged areas are those where the waterlogging conditions prevail during most part of the year. These areas are mostly located in low-lying areas, with impervious substratum along the canals/ river banks, coastal inlands, etc.

Seasonal: Seasonally waterlogged areas are those where the waterlogging condition prevails usually during the monsoon period. These lands are mostly located in plain areas associated with the drainage congestion. Use of multi-season satellite data enables delineation of this category.

4) Land affected by salinity/alkalinity

Land affected by salinity/alkalinity have excess soluble salts (saline) or high exchangeable sodium. Salinity is caused due to capillary movement of water, during extreme weather conditions leaving salt encrustation on the surface. Alkali soils have exchangeable sodium percentage (ESP) values of 15 or more, which is generally considered as the limit between normal and alkali soils. The predominant salts in alkali soils are carbonates and bicarbonates of sodium.

Considering the degree of salinity and or alkalinity, the following two sub-classes viz., moderately saline / alkali and strongly saline / alkali areas could be delineated.

Moderately Saline/Alkali land : These are the areas located in the fluvial plains with the degree of salinity (ECe) ranging from 8 to 30 (dS/m), pH between 9.0 – 9.8 and the Exchangeable Sodium Percentage (ESP) values ranging between 15 – 40.

Strongly Saline/Alkali land : These are the salt-affected lands with ECe values greater than 30 dS/m, pH values more than 9.8 and ESP values of >40.

5) Shifting Cultivation Areas

Shifting cultivation is a traditional practice of growing crops on forested/ vegetated hill-slope by the slash and burn method.

Current : The areas that are used for cultivation by the slash and burn practices and are clearly perceptible on the satellite image in pre-burnt /post-burnt conditions.

Abandoned: Are those areas that were earlier under shifting cultivation but subsequently left idle for more than one year but less than 5 years, thereby giving a scope for the regeneration of secondary vegetation such as bamboo or grasses. This category has a tendency to get mixed with forests.

6) Scrub Forest

Two sub-classes viz., scrub dominated degraded forest land and agriculture land inside notified forest area have been delineated

Scrub dominated: Land, as notified under the Forest Act and those lands with various types of forest cover with less than 20 % of vegetative cover, are classified as degraded forest. These lands are generally confined to the fringe areas of notified forest.

Agricultural land inside notified forest land: This category refers to land that have been notified under the Forest Act, in which agriculture is being practiced, (except for the de-notified forest areas)

7) Degraded pastures/grazing land

These are the lands in non-forest areas that are either under permanent pastures or meadows, which have degraded due to lack of proper soil and water conservation and drainage development measures.

8) Degraded land under plantation crop

These are the degraded lands that have been brought under plantation crops after reclamation, and are located outside the notified forest areas.

9) Sand (coastal / desert / riverine)

This category refers to land with accumulation of sand, in coastal, riverine or inland areas. Generally, these lands vary in size, occur in various shapes with contiguous to linear pattern. These lands are mostly found in deserts, riverbeds and along the shores.

10) Coastal sand

Coastal sands are the sands that are accumulated as a strip along the seacoast due to action of seawater. These are not being used for any purpose like recreation.

11) Desertic sand

Desertic sands are those confined to arid environment where the rainfall is scanty. These lands are characterized by accumulation of sand in the form of varying size of sand dunes and height that have developed as a result of transportation of soil through aeolian processes. The following two categories of desert sands could be mapped based on their vertical approximate heights.

Semi-stabilized to stabilized dunes with >40 m height
Semi-stabilized to stabilized moderately high dunes with heights ranging between 15 and 40 m

12) Riverine sand

Riverine sands are those that are accumulated in the flood plain of the river as sheets, or sand bars. It also includes inland sand which was accumulated along the abandoned river courses or by reworking of sand deposits by wind action leading to long stretches of sand dunes or sand cover areas noticed in Indo-Gangetic alluvial plains

13) Mining /Industrial wastelands

Mine dumps: are those lands where waste debris is accumulated after extraction of minerals. Included in this category is the mine / quarry areas subject to removal of different earth material (both surface and sub-surface) by manual and mechanized operations. Large scale quarrying and mechanical operations result in creation of mine dumps. It includes surface rocks and stone quarries, sand and gravel pits, soil excavation for brick kilns, etc

Industrial: These 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.

14) Barren Rocky Area

These are rock exposures of varying lithology often barren and devoid of soil and vegetative cover. They occur amidst hill-forests as openings or as isolated exposures on plateau and plains. Barren rocky areas occur on 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. The category also includes steep sloping areas devoid of vegetation cover that were classified separately in the earlier exercise.

15) Snow Covered and / or Glacial Area

These lands are under perpetual snow cover and are confined to the Himalayan region. The mountain peaks and slopes and high relief areas are the places where snow/glacial areas occurs

6.0 Methodology

The methodology essentially involves geo-referencing of satellite data, delineation of wastelands categories through on-screen visual interpretation technique based on legacy data and limited ground truth, quality check, harmonization with land degradation, land use/ land cover datasets and seamless database creation.

6.1 Satellite Data

Three season Resourcesat-1 LISS III satellite data viz. *kharif, rabi and zaid* for 2005-2006 were used for delineation of wastelands. Eisht hundred and fifty Resourcesat-1 LISS-III images were used in this exercise.

6.2 Data preparation

The Resourcesat 1 (LISS – III) data were geocoded and rectified using orthorectified Landsat ETM+ images.

6.3 Delineation of Wastelands

The three-season images (normally as FCC) were displayed and the wastelands categories were delineated based on ground truth and legacy data. Resultant output was in vector format, which supports complex GIS analysis. Initially, classification of *rabi* season data was carried out. Resultant vector was overlaid onto *kharif* and *zaid* season's satellite image to incorporate the features which were better delineable in *kharif* as well as *zaid* season's image.

6.4 Quality Assurance Standards and Mechanism

The Quality Assurance and Standardization (QAS) mechanism includes checking parameters such as interpretation, classification, area estimation and data base, etc. A two tier i.e. internal and external quality assessment approach was followed to ensure the quality of wastelands delineation. In order to maintain the quality of the outputs, two levels of QAS team i.e. Internal QAS team consisting of experts from participating organization, and external QAS team with experts drawn from NRSC, SAC and other ISRO / DOS centers had evaluated the mapping accuracies. A sample size of approximately 10 per cent of the polygons in a state have been evaluated. An over all mapping accuracy of about 90 per cent has been achieved.

7.0 Spatial Distribution of Wastelands

A seamless mosaic showing the spatial distribution of wastelands in the country is given in *Figure-1*. An area of 18620 sq km covering Rann in Gujarat, and 211.26 sq km in Rajasthan has not been included under wastelands, as it has been considered a separate land cover (seasonally waterlogged category).

State-wise distribution of wastelands is given in *Figure-2* and *Table- 3*. As evident from the figure and table, Jammu and Kashmir has more than 50 per cent of its area under wastelands. There are two States viz., Himachal Pradesh and Sikkim that have wastelands ranging between 40 - 50 per cent. Five States viz., Uttarakhand, Rajasthan, Nagaland, Manipur and Mizoram have wastelands ranging between 20 to 40 per cent while in Meghalaya wastelands occupy only 15 to 20%. There are 9 States that accounted for the extent of wastelands ranging between 10 to 15 per cent. Eight other States have wastelands ranging between 5 to 10 per cent. Only 3 States and Union Territories have less than 5 per cent area under wastelands.

District-wise distribution of wastelands is given in *Figure-3*. In all, there are 9 districts in the country with more than 5,00,000 ha. of geographical area under wastelands. Of these, 4 districts are located in Rajasthan, 3 districts in Jammu and Kashmir, and one district each in Himachal Pradesh and Gujarat. There are 33 districts with an areal extent of wastelands ranging between 2,00,000 ha to 5,00,000 ha. These districts are mostly confined to the southern part of Andhra Pradesh, Western Maharashtra, eastern Rajasthan and northern parts of Uttarakhand and Himachal Pradesh. There are 83 districts with areal extent of wastelands ranging from 1,00,000 ha to 2,00,000 ha. These are located in Andhra Pradesh, Himachal Pradesh, Uttarakhand, and 4 districts in the North Eastern Region. There are 106 districts with area of wastelands ranging between 50,000 to 1,00,000 and 109 districts with areal extent of wastelands ranging between 25,000 to 50,000 ha that are predominantly confined to the Deccan Plateau and the central highlands of the country. 254 districts of the country have an areal extent of less than 25,000 ha of area under wastelands. These are mainly confined to the districts in the Indo-Gangetic Plains of Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal; coastal districts of Kerala and Tamilnadu and eastern part of Arunachal Pradesh.

The distribution of wastelands with respect to the percentage to total geographical area of each district is given in *Figure-4*. There are 10 districts in the country which accounted for more than 50 per cent of the geographical area of the district under wastelands. Of these, 4 districts are located in Jammu and Kashmir, three districts in the north eastern region, two districts in Himachal Pradesh and one district in Rajasthan. 81 districts of the country have accounted for wastelands ranging between 20 to 50 per cent. These are confined to the States of Rajasthan, districts located in the western Himalayan foothills in the States of Jammu and Kashmir, Himachal Pradesh, Uttarakhand and the north eastern states of Mizoram, Manipur, Nagaland and eastern Meghalaya. There are 312 districts that have an areal extent ranging between 5 to 20 per cent of the geographical area under wastelands. The districts are predominantly confined to the Deccan Plateau, the Central high lands and to some extent the Gangetic Plains of the country. There are 191 districts that have less than 5 per cent of the geographical area under wastelands. These are located in the Indo-gangetic plains, eastern Arunachal Pradesh, eastern Tamilnadu and Kerala.

Category-wise distribution of wastelands with respect to area and percentage to the total geographical area are given in *Table- 4*. Of the 23 categories of wastelands delineated in the country, 5 categories of wastelands viz., land with dense scrub (2.95 %), land with open scrub (2.89 %), under-utilized degraded notified forest – scrub dominated (2.71 %), barren rocky (2.19 %) and snow covered/glacial area (1.29 %) are the dominant categories prevalent in the country. The other categories of wastelands are having an areal extent of less than 1 % of the geographical area under wastelands. State-wise and category-wise distribution of wastelands is given in *Table- 5*.

State-wise distribution of wastelands along with changes in wastelands during the period 2003 and 2006 is portrayed *in Table- 6* and category-wise changes in wastelands in *Table- 7*. The sub-categories of wastelands have been collapsed to level 1 to facilitate analysis which is detailed below. Wastelands category-wise changes with respect to area and percentage to total Wastelands area for entire country are given in *Figure-5*.

8.0 Category-wise distribution of wastelands

8.1 Gullied and ravinous land (Medium and deep)

There are 228 districts that have a spatial extent of less than 5 per cent of this category spread across the country barring the north eastern region (*Figure-6)*. This category is predominantly distributed along the Chambal and Yamuna river courses. The State of Rajasthan has the maximum area under this category accounting to 1884.92 sq km of the area. This is followed by Madhya Pradesh (1502.06 sq km), and Uttar Pradesh (1481.11 sq km). There are seven districts in Rajasthan viz., Alwar, Baran, Bundi, Dhaulpur, Karauli, Kota and Sawai Madhopur; three districts in Madhya Pradesh viz. Bhind, Morena and Sheopuri - Kalan; 7 districts in Uttar Pradesh, viz., Agra, Banda, Firozabad, Hamirpur, Jalaun, Jhansi and Kanpur in which the areal extent of this category is more than 100 sq km in each of the district.

8.2 Scrub land (Land with dense Scrub and open scrub)

This category has the tendency to be associated with all the physiographic regions in the country. There are 338 districts with less than 5 per cent of this category spread across the country. While in 184 districts that have a spatial extent ranging between 5 to 20 per cent of the geographical area under this category. There are 16 districts with 20 to 50 per cent of the area scattered across the country. This category, is confined mostly to the States of Rajasthan, Maharashtra, Madhya Pradesh, Gujarat and

Andhra Pradesh wherein more than 15,000 sq km of the area has been estimated under this category in each of the State *(Figure-7*).

8.3 Waterlogged / marshy land (seasonal and permanent)

This category has been found to be with in the districts located in Gangetic Plains, the Brahmaputra Valley, Eastern Coastal plain and the districts located in western Rajasthan (Indira Gandhi canal command area). It is clear from *Figure-8* that 202 districts that are affected by waterlogging. Of these, there is one district in Bihar that account for an area ranging between 10-15 per cent under this category; 6 districts have an area ranging between 5 – 10 per cent of the area under this category distributed in Bihar, Orissa and Assam. Remaining have less than 5 per cent of the area under this category.

8.4 Land affected by salinity and alkalinity (Moderate and strong)

This category is mainly found inthe districts located in Gangetic Plains. It was estimated that 142 districts are affected by soil salinity/ or alkalinity, and are distributed in the States of Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh, Karnataka, Andhra Pradesh and Tamilnadu (*Figure-9*). Of these, 3 districts that account for an area ranging between 5 to 10 per cent are located in the State of Uttar Pradesh.

8.5 Shifting cultivation – current and abandoned

It is a land use practice prevalent in the Eastern Himalayan States and to some extent in the State of Orissa. There are 20 districts located in the north eastern states with 5 to 50 per cent (7 districts with 15 to 50 per cent and the remaining 13 districts with 5 to 15 per cent) of the geographical area. Contrastingly there are 44 districts accounting for less than 5 per cent of the geographical area that are distributed in Orissa and NE States (*Figure-10*).

8.6 Under Utilized Degraded Notified Forest Land – Scrub Dominated

This category is confined to notified forest areas. There are 15 districts with percentage of this category ranging between 15 to 50 per cent, 102 districts with percentage varying between 5 to 15, and 329 districts that have an areal extent of less than 5 per cent. (*Figure-11*).

8.7 Degraded pastures / grazing lands

Degraded pastures / grazing lands occur in the districts of west, north-west and northern States of the country viz., Gujarat, Rajasthan, Jammu and Kashmir and Uttarakhand. There are 111 districts having Degraded pastures / grazing lands. The spatial distribution of which is shown in *Figure-12*.

8.8 Degraded land under plantation crops

These are the areas mostly under agricultural plantations that are distributed in the peninsular states of Tamilnadu, Andhra Pradesh, Karnataka, Maharashtra and Gujarat and to some extent in Haryana and Jammu and Kashmir. There are 61 districts that accounted for less than 5 per cent of the geographical area under this category *(Figure-13).*

8.9 Sands (desertic, coastal and riverine)

This category is seen distributed in 167 districts located in western Rajasthan, Punjab, Gujarat, east coast and few districts in the Gangetic plains *(Figure-14*). Of these, there are 4 districts in Rajasthan with an area ranging between 10 – 50 per cent under desert sand.

8.10 Mining and Industrial wastelands

This category has an areal extent of less than 5 per cent of the geographical area of the state and are distributed in 128 districts. However, it is predominant in southern Rajasthan, eastern Himachal Pradesh, northern Orissa, eastern Maharashtra, Karnataka and western Tamilnadu (*Figure-15*).

8.11 Barren rocky/stony waste

This category is distributed in almost all the districts in the country except the Indo-Gangetic Plains and the Brahmaputra valley. There are 319 districts with less than 5 per cent of the geographical area under this category. However, there are only 7 districts with 5 - 10 per cent of the area accounted for this category and there are 5 districts with an areal extent admeasuring more than 10 per cent under this category (*Figure-16*).

8.12 Snow covered / glacial area

There are 39 districts spread in the States of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh that have snow covered / glacial areas (*Figure-17*). Of these, 1 district in Sikkim has an areal spread of more than 50 per cent of the area under this category; 9 districts of Jammu & Kashmir, 4 districts each in Uttarakhand and Himachal Pradesh with areal extent ranging between 10 to 50 per cent of the area. There are 3 districts wherein area under this category occupies 5 - 10 per cent of the area.

9.0 State-wise distribution of wastelands

State-wise distribution of wastelands along with their temporal changes during 2003 and 2005-2006 are given as figures and tables.

9.1 Andhra Pradesh

An area of 38,788 sq km corresponding to 14.10 % of the geographical area of the State has been estimated to be under wastelands (*Figure-18, Table- 8*). There has been a reduction in the spatial extent of wastelands to the tune of 2.36 % with reference to the year 2003. In terms of predominance of wastelands category, degraded land under notified forest has a maximum areal extent - 13123 sq. km (20097 sq. km in 2003 period). Kadapa district ranks first in the area under wastelands with 27.15 % while West Godavari district, located in the East Coast deltaic region has the least (1.59 %). Changes in wastelands with respect to 2003 are given in Table- 9.

9.2 Arunachal Pradesh

The State shares international boundary with Bhutan, Tibet, China and Myanmar to the west, north-east, north and east respectively, and has boundaries with Assam and Nagaland. The terrain consists of sub-montane and mountainous ranges, sloping down to the plains of Assam, divided into valleys by the rivers Kameng, Subansiri, Siang, Lohit and Tirap.

The spatial database on wastelands generated for the State reveals an area of 5743.84 sq km accounting for 6.86 % of total geographical area of the State (*Figure-19, Table- 10*) under wastelands. There has been a decrease in the area under wastelands to the tune of 14.85 % as compared to 2003. *Table- 11* depicts the changes in spatial extent of wastelands in

the state with respect to 2003. The district of Tawang accounts for 48.44 % of area under wastelands while Upper Subansiri district has 1.15 %.

9.3 Assam

Assam is the sentinel of north-east India and gateway to the North-Eastern States. The State is close to India's international borders with Bangladesh and Bhutan. Assam is surrounded by Bhutan and Arunachal Pradesh on the north, Manipur, Nagaland and Arunachal Pradesh on the east and Meghalaya, Tripura and Mizoram on the south.

An area of 8778.02 sq km corresponding to 11.19 % of the total geographical area of the State has been delineated as wastelands (*Figure-20, Table- 12*). This estimate is less by 6.7 % as compared to that of 2003. Details of changes in the spatial extent of wastelands are given in *Table- 13*. North Cachar Hills district recorded the maximum area of 30.47 % under wastelands while Darrang district recorded the minimum.

9.4 Bihar

Bihar is bound on the north by Nepal, on the east by West Bengal, on the west by Uttar Pradesh and on the south by Jharkhand. An estimated area of 6841.09 sq km equivalent to 7.26 % of the area of the state is under wastelands (*Figure-21, Table- 14*). There has been a marginal increase (1.48 %) in the areal extent of wastelands (*Table- 15)*. Jamul district with 25.57 % area of the state under wastelands while Nalanda district has the least (0.15 %).

9.5 Chattisgarh

Chattisgarh is a state in central India, it takes its name from 36 (Chattis is thirty-six in Hindi and Garh is Fort) princely states in this region. Chhattisgarh is bordered by Bihar, Jharkhand and Uttar Pradesh in the north, Andhra Pradesh in the south, Orissa in the east and Madhya Pradesh in the west

The total geographic area of Chattisgarh is 135194 sq. km, out of which 11817.82 sq km is under wastelands (*Figure-22, Table- 16*). Degraded forest-scrub dominated is the major wasteland category that covers an area of 3616.45 sq. km. In terms of the change in the wastelands as compared to 2003, there has been an increase of 0.38 % in the area under wastelands (*Table- 17)*. The district with maximum area under wastelands is Surguja with 17.80% of its area and the district with least area is Bastar with 3.55% of its total geographic area.

9.6 Delhi

Delhi became the centre of all activities after the capital was shifted from Kolkata (Calcutta). It was made a Union Territory in 1956. Lying in the northern part of the country, Delhi is surrounded by Haryana on all sides except the east where it borders with Uttar Pradesh. The 69th Constitutional amendment is a milestone in Delhi's history as it got a Legislative Assembly with the enactment of the National Capital Territory Act, 1991.

The total geographic area of Delhi is 1483 sq. km out of which 83.34 sq. km is under wastelands which accounts for 5.62 % of its area (*Figure-23, Table- 18*). Land with open scrub is the major wasteland category which covers an area of 58.09 sq. km. In terms of the change in the area under wastelands as compared to 2003, there has been a marginal increase of the order of 15.18 sq. km (*Table- 19*)

9.7 Goa

Goa is situated on the western coast of the Indian Peninsula. On its north runs the Terekhol river which separates Goa from Maharashtra and on the south lies North Canara district of Karnataka. On the east lie the Western Ghats and in the west the A*rabi*an Sea. Panaji, Margao, Vasco, Mapusa and Ponda are the main towns of Goa.

The total geographic area of Goa is 3702.00 sq km, out of which 496.27 sq. km is under wastelands which accounts for 13.41% of its geographical area (*Figure-24, Table- 20*). Spreading over an area of 216.38 sq. km, land with open scrub is the major wasteland category. In terms of the change in the wastelands as compared to 2003, there has been a decrease to the tune of 35.02 sq. km which is 0.95% of the geographical area of the State (*Table- 21*). North Goa district has maximum area: 15.76 % of its total geographic area, under wastelands.

9.8 Gujarat

Gujarat is situated on the west coast of India. The state is bound by the A*rabi*an Sea on the west, Pakistan and Rajasthan in the north and north-east respectively, Madhya Pradesh in the south–east and Maharashtra in the south.

The total geographic area of Gujarat is 196024.sq. km out of which 21350.38 sq. km is under wastelands which accounts for 10.89% of its geographical area (*Figure-25, Table- 22*). Land with dense scrub is the major wasteland category which covers an area of 11,614.83 sq. km. In terms of the change in the wastelands as compared to 2003, there has been an increase in the wastelands to the tune of 972.64 sq. km (*Table-23*). The district with the maximum area of wastelands is Valsad with 38.36 % and Kheda, the least 6.07 % of its total geographic area under wastelands. The Rann area in Kutch district admeasuring an area of 18,620 sq km has not been considered in estimating the wastelands of the State.

9.9 Haryana

Haryana is bound by Uttar Pradesh in the east, Punjab on the west, Himachal Pradesh on the north and Rajasthan on the south. National Capital Territory of Delhi juts into Haryana.

The total geographic area of Haryana is 44212.00 sq. km, out of which 2347.05 sq. km is under wastelands which accounts for 5.31 % of its geographical area (*Figure-26, Table- 24*). Degraded pasture/grazing land is the major wasteland category that cover an area of 914.58 sq. km. There has been shrinkage to the tune of 919.40 sq. km as compared to 2003 in wastelands (*Table- 25*). The district with the highest percentage of wastelands is Mewat with 15.81 % of its area and Kurukshetra with 1.41 % of its total geographic area, the least.

9.10 Himachal Pradesh

Himachal situated in the heart of the Western Himalaya, identified as “Dev Bhumi” is believed to be the abode of God and Goddesses. The shadowy valleys, rugged crags, glaciers and gigantic pines and roaring rivers and exquisite flora and fauna are the hallmark of Himachal Pradesh.

Out of the total geographic area of 55,673 sq. km, 22,470.05 sq. km is under wastelands which accounts for 40.36 % of the geographical area (Figure-27, Table- 26). Apart from snow and glacier cover which accounts for 21% of the total wastelands, barren and rocky area is the major wasteland category covering an area of 5314.17 sq.km in the State. The areal extent of this category generally depends upon the presence and

absence of snow cover at higher reaches and, in turn depends on the use of season of satellite data used (Jan-Feb peak snow period and March on wards snow melts and barren rocks exposes), and availability of cloud-free satellite data. Since the satellite data was of March, 06 most of the areas are exposed and depicted as barren. In terms of the change in the wastelands as compared to 2003, there has been a decrease to the tune of 5866.75 sq. km which is 10.54% of its geographic area (*Table- 27*).

9.11 Jammu and Kashmir

Geographically, the State can be divided into four zones. First, the mountainous and semi-mountainous plain commonly known as Kandi belt, the second, hills including Shivalik ranges, the third mountains of Kashmir Valley and Pir Panjal range and the fourth is Tibetan tract of Ladakh and Kargil. Geographically and culturally the state has three distinct regions - Jammu, Kashmir and Ladakh.

Out of the total geographic area of 1, 01,387 sq. km, 73,754.38 sq.km is under wastelands which accounts for 72.75 % of its total geographical area (*Figure-28, Table- 28*). Barren Rocky area covering an area of 46,379.45 sq.km constitutes the major wasteland category. In terms of the change in the wastelands as compared to 2003, there has been a increase in the extent of wastelands by 3,552.39 sq. km corresponding to 3.5 %. (*Table- 29*).

9.12 Jharkhand

Jharkhand largely comprises of the forest tracks of Chhotanagpur plateau and Santhal Parganas. The State is characterized by thickly wooded areas and succession of hills.

The total geographic area of Jharkhand is 79,706 sq. km, out of which 11670.14 sq.km is under wastelands which accounts for 14.64% of its total geographical area (*Figure-29, Table- 30*). Under utilised / degraded notified forest land-scrub dominated is the major wasteland category, which covers an area of 4400.59 sq. km. In terms of the change in the wastelands as compared to 2003, there has been an increase of 504.88 sq. km (*Table- 31*). The district with the highest percentage of wastelands is Simdega with 28.00 % of its area under wastelands and Godda district with 4.84% of its total geographic area, the least.

9.13 Karnataka

Karnataka is one of the southern states' and the topography is varied with the low lying coastal plains the rugged Western Ghats The total geographic area of Karnataka is 1,91,791 sq. km, out of which 14438.12 sq. km is under wastelands which accounts for 7.53% of its geographical area (*Figure-30, Table- 32*). Under-utilsed /degraded notified forest land-scrub dominated is the major wasteland category, that covers an area of 5245.32 sq.km. In terms of the change in the wastelands as compared to 2003, there has been an increase to the tune of 901.54 sq.km (*Table-33*). The district with the highest percentage of wastelands is Bellary with 17.37% of its area under wastelands, while Dakshin Kannanda with 2.13% of its total geographic area, has the least, wastelands.

9.14 Kerala

Kerala is in the extreme south-west of the Indian subcontinent. In between the high Western Ghats on the east and the Arabian Sea on the west, the width of the state varies from 35 km to 120 km. According to the geographical features, the state can be divided into hills, valleys, midland plains and costal belt.

The total geographic area of Kerala is 38863 sq. km, out of which 2458.69 sq.km is under wastelands which accounts for 6.33% (*Figure-31, Table-34*). Covering an area of 787.78 sq. km, land with open scrub is the major wasteland category. In terms of the change in the wastelands as compared to 2003, there has been an increase of 669.89 sq.km which is 1.72 % of its geographical area (*Table- 35*). The district with highest percentage of wastelands is Kasargod (16.45 % of its area) while Alappuza district has the minimum area under wastelands.

9.15 Madhya Pradesh

Madhya Pradesh is the second largest Indian Sate in size in the country. Geographically it occupies pivotal position in the country. Madhya Pradesh came into being on 1 November 1956. It was re-organised on 1 November 2000 to create a new Chhattisgarh state. The successive state is bound in north by Uttar Pradesh, east by Chhattisgarh, south by Maharashtra and west by Gujarat and Rajasthan.

The total geographic area of Madhya Pradesh is 308252 sq. km, out of which 40,042.98 sq. km is under wastelands corresponding to 12.99 per cent of the geographical area of the State (*Figure-32, Table- 36*). Land with open scrub is the major wasteland category, accounting for an area of 16231.47 sq.km. There has been a decrease in area under wastelands to the tune of 17091.05 sq.km (5.54%) as compared to 2003 (*Table- 37*). Shyopur and Kalanl district recorded a maximum of 28.44 % of its area under wastelands while Hoshangabad district with 3.13 %, the least.

9.16 Maharashtra

Maharashtra forms part of the Deccan plateau, its western upturned rims rising to form the Sahayadri Range parallel to the sea-coast and its slopes gently descending towards the east and south-east. Satpura ranges cover northern part of the State, while Ajanta and Satmala ranges run through central part of State. A*rabi*an Sea guards the western boundary of Maharashtra, while Gujarat and Madhya Pradesh are on the northern side. Chhattisgarh covers the eastern boundary of the State. Karnataka and Andhra Pradesh are on its southern side.

The total geographic area of Maharashtra is 3,07,690 sq. km, out of which 38,262.81 sq.km is under wastelands accounting for 12.44% of the geographical area of the State (*Figure-33, Table- 38*). Land with open scrub is the major wasteland category, accounting for an area of 13,242.14 sq. km. There has been a decrease in the areal extent of wastelands to the tune of 11012.60 sq. km (*Table- 39*). The district with the highest percentage of wastelands is Raygad with 29.92% while Gondia district with 5.28 %, has the least percentage of wastelands.

9.17 Manipur

Manipur is situated on the eastern frontier of India. It is bound on the east by Myanmar (Burma), on the north by the State of Nagaland, on the west by the State of Assam and on the south by the State of Mizoram and Myanmar. Physically Manipur comprises of two parts, the hills and the valley. The valley is at the centre surrounded by hills on all sides. Manipur Valley is about 790 metres above the sea level. The hill ranges are higher on the north and gradually diminish in height as they reach the southern part of the State. The valley itself slopes down towards the south.

The total geographic area of Manipur is 22,327 sq. km, out of which an area of 7,027.47 sq. km corresponding to 31.48 per cent of the geographical area of the State under wastelands (*Figure-34, Table- 40*). Land with dense scrub is the major wasteland category which accounts for an area of 3,718.87 sq. km. There has been a decrease in the area under wastelands to the tune of 6,147.27 sq. km corresponding to 27.53

per cent of its area (*Table- 41*). Senapati district has the maximum area under wastelands (35.10% of its area), while Bishnupur district (2.70 % of its area), has the least.

9.18 Meghalaya

Meghalaya literally means 'the Abode of Clouds' is essentially a hilly state. It is bound on the north and east by Assam and in the south and west by Bangladesh. The Khasi Hills and Jaintia Hills which form the central and eastern part of Meghalaya is an imposing plateau with rolling grasslands, hills and river valleys. The southern face of the plateau is marked by deep gorges and abrupt slopes, at the foot of which, a narrow strip of plain land runs along the international border with Bangladesh.

Meghalaya has an areal extent of 22,429 sq. km out of which an area of 3,865.76 sq.km accounting for 17.24 per cent of the geographical area of the State is estimated under wastelands (*Figure-35, Table- 42*). Land with open scrub is the predominant wasteland category with an estimated areal extent of 2640.10 sq. km. There has been an increase in the areal extent of wastelands to the tune of 454.35 sq. km as compared to 2003 (*Table- 43*). Jaintia Hills districts with 25.36% of its area under wastelands, ranks first in the areal extent of wastelands with 25.36 %, while the South Garo Hills district has the least (10.11 % of its area).

9.19 Mizoram

In between Myanmar in the east and the south and Bangladesh in the west, Mizoram occupies an area of great strategic importance in the northeastern corner of India. Mizoram has great natural beauty and an endless variety of landscape.

The total geographic area of Mizoram is 21,081 sq. km, out of which 6,021.14 sq. km accounting for 28.56 per cent of the geographical area of the State is under wastelands (*Figure-36, Table- 44*). With an area of 3,367.26 sq.km, Under utilised/degraded notified forest land-scrub dominated is the predominant wasteland category. There has been an increase in the area under wastelands to a tune of 1,551.26 sq.km as compared to 2003 (*Table- 45*). Champai district recorded a maximum extent of wastelands (43.21% of its area), while Mamit district (22.47 %, of its area) has the least.

9.20 Nagaland

The State is mostly mountainous except those areas bordering Assam valley. Mount Saramati is the highest peak in Nagaland with a height of 3,840 metres and its range forms a natural barrier between Nagaland and Myanmar.

Nagaland has an areal extent of 16,579 sq. km, out of which an area of 4,815.18 sq. km corresponding to 29.04 per cent of the geographical area of the State is under wastelands (*Figure-37, Table- 46*). Admeasuring an areal extent of 1,588.65 sq. km, Abandoned shifting cultivation is the predominant wasteland category. There has been an increase in the areal extent under wastelands to the tune of 1,105.78 sq. km (*Table- 47*). Mon district with 58.66 % has the maximum area under wastelands, while Wokha district, has the least areal extent with 18.29 %.

9.21 Orissa

Orissa is situated in the north-eastern part of the Indian peninsula. It is bound by the Bay of Bengal on the east, West Bengal on the north-east, Jharkhand on the north, Chhattisgarh on the west and Andhra Pradesh on the south. The state may be broadly divided into four geographical

regions-the northern plateau, central river basin, eastern hills and coastal plains.

Orissa has a geographical extent of 1,55,707 sq. km, out of which 16,648.27 sq. km corresponding to 10.69 per cent to the total geographical area of the State is under wastelands (*Figure-38, Table-48*). The predominant wasteland category comprises land with dense scrub accounting for an area of 5445.08 sq. km. A decrease in the areal extent in wastelands to the tune of 2,304.47 sq. km was observed in comparison to 2003 (*Table-49*). It was observed that Gajapati district has maximum area under wastelands with 25.02 %, while Bhadrak district, accounting for 1.37 % of its geographical area, the least.

9.22 Punjab

Situated in the north-western corner of the country, Punjab is bound in the west by Pakistan, in the north by Jammu and Kashmir, in the north-east by Himachal Pradesh and in the south by Haryana and Rajasthan.

The State has an areal extent of 50,362 sq. km, out of which 1,019.50 sq. km corresponding to 2.02 per cent of the total geographical area of the State is under wastelands (*Figure-39, Table-50*). Admeasuring an area of 394.35 sq. km, Sands-Desertic is the predominant wasteland category. There has been a decrease in the areal extent of wastelands in the State to the tune of 153.34 sq. km (*Table- 51*). Rupnagar district with 7.08 % of its area ranks highest in the areal extent of wastelands while Fatehgarh Sahib district with 0.04 % of its area, ranks the least.

9.23 Rajasthan

The entire western flank of the state borders with Pakistan, while Punjab, Haryana, Uttar Pradesh and Madhya Pradesh bind Rajasthan in north-east, south–east and Gujarat in south-west.

Out of 3,42,239 sq. km the total geographic area of Rajasthan, 93,689.47 sq. km corresponding to 27.38 per cent of the total geographical area of the State is under wastelands (*Figure-40, Table-52*). With an area of 15,586.44 sq. km, Sands-semi-stabilised- stabilised moderate high (15-40m) is the major wasteland category in the State. There has been a decrease to the tune of 7,764.39 sq. km in the area under wastelands as compared to the year 2003 (*Table- 53*). Jaisalmer district in western Rajasthan recorded the maximum extent under wastelands with 68.34 % while, Churu district the minimum (4.24 % of its area). An area admeasuring 211.26 sq km covering the districts of Jalore (162.86 sq km) and Barmer (48.40 sq km) has not been considered for estimating the wastelands of the State as the area is an extension of Rann of Kachchh from Gujarat State.

9.24 Sikkim

Sikkim is a small hilly state, bounded by vast stretches of Tibetan Plateau in the North, the Chumbi Valley of Tibet and the Kingdom of Bhutan in the East, the Kingdom of Nepal in the West and Darjeeling district of West Bengal in the South.

The State has an areal extent of 7,096 sq. km, out of which 3,280.88 sq. km of the area corresponding to 46.24 per cent of the total geographical area of the State is under wastelands (*Figure-41, Table- 54*). Admeasuring an area of 2,633.66 sq. km, snow covered and glacial area is the major wasteland category followed by barren rocky area with an areal extent of 579.90 sq. km. There has been a decrease in the areal extent under wastelands by 527.33 sq. km as compared to 2003 (*Table- 55*). North Sikkim has the maximum area (67.49% of its area) under wastelands while South Sikkim accounted for 6.88%, with the lowest extent.

9.25 Tripura

Tripura is strategically situated between the river valleys of Myanmar and Bangladesh. Encircled almost on three sides by Bangladesh, it is linked with Assam and Mizoram in the North-East.

Tripura has an area of 10,486 sq. km, out of which 1315.17 sq. km corresponding to 12.54 per cent of the total geographical area of the State is under wastelands (*Figure-42, Table- 56*). Under utilised/degraded notified forest land-scrub dominated is the predominant wasteland category, which account for an area of 522.52 sq. km. There has been a marginal decrease in the spatial extent of wastelands to the tune of 7.80 sq. km as compared to 2003 (*Table- 57*). West Tripura district recorded the maximum area with 15.56 % of its geographical area under wastelands while South Tripura with 8.72 %, ranks the least.

9.26 Tamilnadu

Located in the south-eastern part of the country, Tamil Nadu is bounded in north by Andhra Pradesh and Karnataka in west by Kerala, in east by the Bay of Bengal and in south by the Indian Ocean.
The State has an areal extent of 1,30,058 sq. km, out of which an area admeasuring 9,125.56 sq. km is under wastelands corresponding to 7.02 per cent of the geographical area of the State (*Figure-43, Table- 58*). The predominant wasteland category covering an area of 2600.55 sq.km is underutilized degraded notified forest-scrub dominated category. There has been a decrease in the extent of wastelands to the tune of 8,177.73 sq. km corresponding to 6.29 per cent of its geographical area. (*Table-59*). Erode district with 18.06 % accounted for the maximum area under wastelands , while Chennai (1.26 % of its area), ranks the least.

9.27 Uttarakhand

Located in the foothills of the Himalayas, the State has international boundaries with China (Tibet) in the north and Nepal in the east. On its northwest lies Himachal Pradesh while in the south it is bound by Uttar Pradesh.

The State of Uttarakhand has a geographical extent of 53,483 sq. km, out of which 12790.06 sq. km corresponding to 23.91 per cent of the geographical area is under wastelands (*Figure-44, Table- 60*). Three major categories of wastelands viz., snow cover and glacial area with a spatial extent of 9,216.87 sq km, land with open scrub and barren rocky/ stony waste area accounting for a spatial extent of 1,142.16 sq km each are the major categories occurring in the State. There has been a decrease in the areal extent of wastelands to the tune of 3307.40 sq. km as compared to 2003 (*Table- 61*) Pithoragarh district with 48.88 % of its geographical area has the maximum extent of wastelands in the State while Udham Singh Nagar district with 0.64 % of the area has the least extent of wastelands.

9.28 Uttar Pradesh

Uttar Pradesh is bound by Uttaranchal and Himachal Pradesh in the north, Haryana in the west, Madhya Pradesh in the South and Bihar in the east. Uttar Pradesh can be divided into two distinct regions (i) Southern Hills (ii) Gangetic Plain.

The State has a geographical extent of 2,40,922 sq.km, out of which an estimated of 10988.59 sq. km corresponding to 4.56 per cent of the geographical area of the State is mapped as wastelands (*Figure-45, Table- 62*). Land affected by salinity/alkalinity-moderate is the predominant wasteland category that covers an area of 2,193.28 sq. km. There has

been a decrease in the spatial extent of wastelands by 5995.57 sq. km corresponding to 2.49 per cent as compared to 2003 (*Table- 63*). Etawah district has a maximum extent of wastelands (12.50 % of its area), while Bijnor district (0.09 % of its area) has the minimum area under wastelands.

9.29 West Bengal

The land frontiers of the State touch Bangladesh in the east and are separated from Nepal in the west, Bhutan lies in the north-east, while Sikkim in the north. On the west are the states of Bihar, Jharkhand, while in the south lies Orissa, and the Bay of Bengal washing its southern frontiers.

The State of West Bengal has a spatial extent of 88,752 sq. km, out of which 1994.41 sq. km corresponding to 2.25 per cent of the geographical area of the State is under wastelands (*Figure-46, Table-64*). With an area of 802.46 sq. km, Land with open scrub is the predominant wasteland category . There has been a decrease in the spatial extent of wastelands to the tune of 2,403.15 sq. km which is mainly due to the usage of three season satellite data (*Table- 65*). Puruliya district has maximum area (9.66 % of its geographical area) under wastelands while Koch Bihar, Murshidabad and Nadia districts (0.01 % of its area), ranks the least.

9.30 Union Territories

There are 6 Union Territories, namely, Andaman and Nicobar Islands, Chandigarh, Dadra and Nagar Haveli, Daman and Diu, Lakshadweep and Pondicherry (*Figures-47, 48)*.

i) **Andaman and Nicobar Islands** The group of 572 islands/ Islets lies in the Bay of Bengal, 193 km from Cape Negaris in Myanmar, 1,255 km from Kolkata and 1,190 km from Chennai. Two principal groups of islets are the Ritchie's Archipelago and Labyrinth Islands. The Nicobar Islands are situated to the south of Andaman Islands, 121 km from Little Andaman Island. There are 38 inhabited islands, including 25 in the Andaman district and 13 in the Nicobar district.

ii) **Chandigarh** is a fully grown town of most modern architectural splendor. The city nestles in a picturesque setting in the foothills of Shivalik hills and enjoys the popular epithet the "City Beautiful".

iii) **Dadra** has an area of 491 sq km and it is surrounded by Gujarat and Maharashtra. It consists of two pockets namely, Dadra and Nagar Haveli.

iv) **Daman and Diu** It is bound on the east by Gujarat, on the west by the A*rabi*an Sea, on the north by the Kolak river and on the south by Kalai river. The neighboring district of Daman is Valsad in Gujarat. Diu is an island connected by two bridges. The neighboring district of Diu is Junagadh (Gujarat).

v) **Lakshadweep** a group of coral islands consist of 12 atolls, three reefs and submerged sand banks. Of the 27 islands, only 11 are inhabited. These lie scattered in the A*rabi*an Sea about 280 km to 480 km off Kerala coast.

vi) **Pondicherry** is bound on the east by the Bay of Bengal and on the three sides by Tamil Nadu. About 150 km south of Pondicherry on the East Coast lies Karaikal. Mahe is situated on the Malabar Coast on the Western Ghats surrounded by Kerala. It can be reached from Calicut Airport, which is 70 km from Mahe. Yanam

is situated adjoining the East Godavari district of Andhra Pradesh and is about 200 km from Visakhapatnam airport

The total geographical area of all the Union territories is 9490 sq km, of which of 337.30 sq km corresponding to 3.55 per cent of its geographical area is under wastelands (Table- 66) There is an increase to the tune of 22.92 sq km under wastelands in these areas as compared to 2003 (Table-67). Change in area under wastelands in each of the union territories is given in Tables 68 to 74. It is observed that the percentage of land under wastelands in all the union territories is marginal, with the maximum in Dadra (accounting for 10.85 % of its area), followed by Daman (8.72% of its area).The remaining Union Territories have an average of less than 3% with Lakshadweep Islands having only 1.87% of wastelands.

10.0 Change analysis

As mentioned earlier, wastelands mapping was carried out earlier for two time periods i.e. 1986-2000 and 2003. During the first time, analysis carried out in five phases using three period satellite data sets i.e. 1986-88, 1991-92 and 1997-98 in fourteen years. The second cycle of mapping was carried out using satellite data acquired during February-March 2003. The third cycle has now been completed with the satellite data of 2005-06. However, there has not been consistency in satellite data used, definition and number of categories of wastelands and methodology followed for their delineation. In the first cycle spanning from 1986-2000, Landsat – TM data with 30m spatial resolution, IRS-1A LISS-II data with 36.25 m resolution and IRS-1C & ID LISS III data with 23.5m spatial resolution acquired during *rabi* (dry) season at 1:50,000 scale was interpreted visually. Furthermore as mentioned earlier, the mapping exercise was carried out in five phases spanning over a period of 14 years. In the second cycle of 2003, IRS 1C & ID LISS III digital data of *rabi* (dry) season was used to delineate wastelands through on-screen visual interpretation.

The minimum mappable area in the first cycle works out to be 2.25 ha considering 3x3 mm as a minimum mappable unit whereas on-screen visual interpretation of LISS-III digital data enabled not only enlarging the image to 1:35,000 scale but also provided the scope for various kinds of image enhancements that helped improved delineation of wastelands categories particularly those exhibiting poor spectral contrast.

Another major difference between these two cycles of wastelands mapping was in the classification scheme followed. Whereas 13 categories of wastelands were mapped in the first cycle (1986-2000), further division within each of these categories indicating the magnitude of the problem, very important from rehabilitation of wastelands, were made in the second cycle (2003) in which a total of 28 categories were mapped.

The present cycle involves generation of wastelands maps at 1:50,000 scale for the entire country from three cropping seasons i.e. *kharif*, *rabi* and *zaid* from Resourcesat- 1 LISS-III digital and georectified data for 2005-06. The LISS-III data of 2005-06 was brought to UTM projection and WGS 84 datum to comply with the national map policy. In the first two cycles of mapping i.e. 1986-2000 and 2003, the satellite data used were in polyconic projection and Everest 1956 datum. The vector layer of wastelands for 2003 period was subsequently converted to LCC projection and modified Everest datum.

In order to study the temporal behaviour of wastelands during 2003 and 2005-06, the vector layer of wastelands of 2003 which was in LCC projection and modified Everest datum was re-projected to UTM projection and WGS84 datum. As evident from the preceding, efforts were made to make both the datasets i.e. IRS-1C/1D LISS-III of 2003 and Resourcesat-

1 LISS-III to a common projection and datum, still there is a substantial difference in these two datasets. The differences are as follows:

- **Seasonality of satellite data:** While only dry season (rabi) data was used in 2003, three cropping season data formed the database for delineation of wastelands during 2005-06.

- **Definition and categories of wastelands:** Whereas 28 categories of wastelands were delineated in 2003, in 2005-06, based on previous experience, some of the categories with very little spatial extent were merged with corresponding major categories, thus making the total number of wastelands categories as 23. For instance, slightly salt-affected land has been merged with moderately salt-affected land. Similarly, shallow ravines have been merged with medium ravines category. Conversely, the category land with or without scrub was segregated into 'land with dense scrub' and 'land with open scrub' (Table-2).

- **Satellite data projection and datum:** The two datasets i.e. 2003 and 2005-06 differed in map projection and datum. Whereas LCC and Modified Everest datum was maintained in 2003 dataset, in case of 2005-06, the satellite data had UTM projection and WGS84 datum. As mentioned earlier, though the efforts were made to change the projection and datum of the LISS-III data of 2003, in consonance with LISS-III data 2005-06, required precision in terms of positional accuracy could not be achieved. Hence, instead of change detection with the help of 2003 vector layer of wastelands, a fresh mapping of wastelands was carried out using three season i.e. *kharif*, *rabi* and *zaid* season LISS-III data.

In view of the above mentioned differences in two datasets i.e. 2003 and 2005-06, a patch-by-patch comparison of wastelands could not be carried out. Consequently only area statistics in a tabular form has been provided.

A comparative analysis of the areal extent of wastelands shows a reduction of 8.21 M ha (63.85 to 55.64 M ha) area between first and second cycles. Furthermore, in the current cycle, there is further reduction in the area under wastelands to the order of 8.41 M ha (47.22 M ha.) over the 2003 cycle.

11.0 Conclusions

The analysis of three cropping season Resourcesat-1 LISS-III images has enabled improved delineation of various categories of wastelands with limited field checks (*Figures-51, 52, 53)*. During 2003, only single season (*rabi)* satellite data was used that precluded discrimination of categories like fallow lands, seasonally waterlogged, scrubs or pastures, snow-covered areas displaying intra-annual variations in the spectral response pattern (*Figures-50)*.

An estimated 47.22 M ha. has been found to be under wastelands in 2006, which is 14.91 % of the total geographical area of the country.

The temporal analysis of the areal extent of wastelands between 2005-06 and 2003 shows a reduction of 8.41 M ha which is equivalent of 2.66% of the wastelands in 2003. (Figure-5). This is in comparison to the change reported during 2000 and 2003, wherein there was a shrinkage in the area under wastelands by 8.21 M ha, which is equivalent to 2.60 per cent of the wastelands area in the year 2000.

The differences observed in the area of various wastelands categories during 2003 and 2005-06 could be attributed to one or a combination of the following:

- Changes in the datum and projection of satellite data.
- Usage of single (dry) season satellite data versus three season satellite data. (*Figure-50).*
- Inconsistencies in the definition and the number of categories of wastelands, and
- Reclamation efforts made by various central, state and non-governmental organisations.

The unique feature of the current project has been on-screen interpretation of three-season satellite images with projection and datum compatible with Open Series Map (OSM) of Survey of India which will facilitate dissemination of the data to a wider user community. Furthermore, the database, thus created, will serve as the sound reference base on wastelands for studying their temporal behaviour.

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