ISSN: 2321-7782 (Online)
e-ISJN: A4372-3114
Impact Factor: 6.047

Volume 5, Issue 10, October 2017

International Journal of Advance Research in Computer Science and Management Studies

Research Article / Survey Paper / Case Study

Available online at: www.ijarcsms.com

Urban Landscape Assessment Using Spatial Metrics: A Temporal Analysis of Jodhpur City

S. L. Borana[1]
Scientist
DL, Jodhpur
Jodhpur – India

S. K. Yadav[2]
Scientist
DL, Jodhpur
Jodhpur – India

Abstract: ***The present paper attempts to study sprawling of the city using landscape metrics. The study describes and analyzed the behaviour of landscape metrics for detecting changes in Urban Land patterns of the Jodhpur city. Satellite data of 1990, 2000, 2010 and 2015 with 30 m resolution have been used to prepare land use land cover map (five classes) using supervised classification technique. The landscape metrics used to quantify spatial patterns of the changes occurred using Fragstats 4.2. The number of landscape metrics available for such studies are very large. Knowledge of interrelationship and redundancy between the metrics are required for the right selection and interpretation of the landscape change. A set of landscape metrics were calculated that provide overall perspective of the class level changes in the landscape. This has ultimately resulted in increasing environmental problems and degrading quality of life in urban centres. The city is harassed with different environmental and urban problems due to unplanned sprawl. The rising population has transformed agricultural land into industrial zones and urban centres.***

Keywords: Landscape metrics, Urban sprawl, Temporal Analysis, Remote Sensing, GIS.

I. INTRODUCTION

Rapid urbanisation is quite alarming, especially in developing countries like India. Nature and human systems are getting affected due to growing urbanization at all geographic scales (Herold et al., 2005). The unprecedented growth and urban sprawl are often unnoticed by the planners, as they are unable to visualise this type of growth patterns. Since patterns are fundamental to many of the spatial-temporal relationships that we seek to discover, it is important to understand the factors and trend that influence the interpretation of the urbanising landscape. Therefore, characterising and understanding the changing patterns of urban growth is critical, given that urbanisation continues to be one of the major global environmental changes in foreseeable future (Rashed, 2008). Class-level metrics are used and integrated over all the patches of a given type. There are five broad categories of land cover types found in the study area. Therefore, the spatial metrics values for all these types have been generated for all the base years (1990, 2000, 2010 and 2015). FRAGSTAT is a spatial pattern analysis program for categorical maps which simply quantifies the areal extent and spatial configuration of patches within a landscape, contains a summary of statistics from the spatial metrics of the changes obtained using FRAGSTATS. The main interest of this work was the built up landcover class. Therefore, landcover maps were reclassified, so as to analyses the changes occurred and patterns observed. There has been a tremendous growth in the built-up areas and spatial pattern in the study area.

II. STUDY AREA

Jodhpur city is located at a latitude of 26º 18' North and longitude of 73º 1' East and is located in the middle of the Thar Desert tract of western Rajasthan about 250 km from the Pakistan border (Fig.1). The second largest city of the state, Jodhpur is fast growing city surrounded by sand stone mining activities, Rocky area, Fallow land and Industrial Zones. While most of the

commercial activities and unplanned settlement are located in the old city area and planned urban settlement, industries & mining area lies in the outskirts of the city. Its general topography is characterized by the hills located in the North and North-west. The city has a natural drainage slope from North- North East to South-South East towards Jojari River and extensive stone quarries in the Northwest direction.

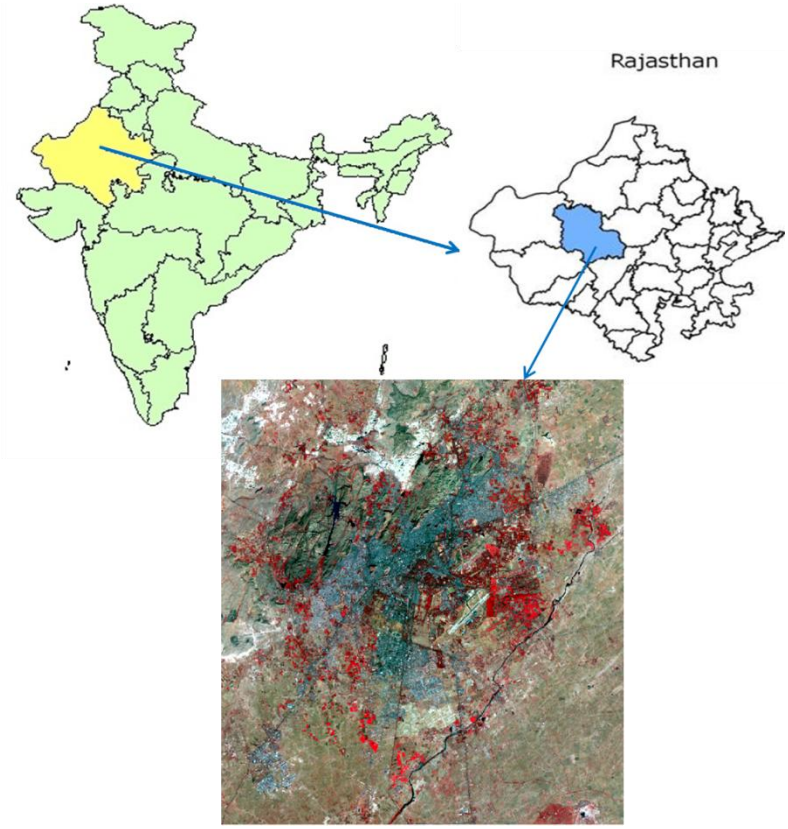

Fig.1. Location Map of The Study Area.

III. Materials and Methods

Geocoded False Colour Composite scene of LANDSAT data (1990,2000,2010 and 2015) on scale 1:50,000 and ENVI software has been used for classification of geometrically and radiometrically images. Nearest-neighbour resampling method has been used to transform the images so that the original pixel value can be retained. For assessing the patterns of sprawl in Jodhpur city, landscape metrics are calculated using FRAGSTAT 4.2. Selected landscape metrics i.e. class area, number of patches, largest patch index and edge density are calculated to analyze the change in built-up areas patch. These indexes are a collection of unit-less metrics that quantify and analyze landscape patches on the basis of geometric shape, complexity and compactness. Methodology adopted for this study is given in Fig.2.

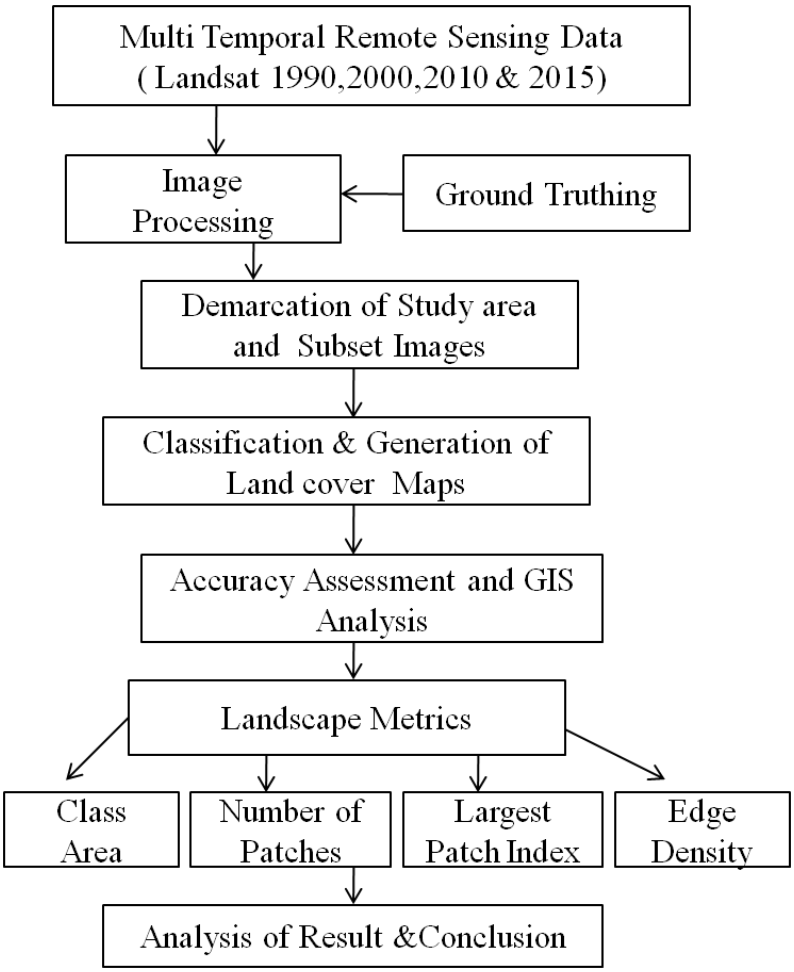

Fig.2. Methodology Flow Chart.

IV. Result and Discussion

Analysis of the spatial metrics indicated that the urban land cover of study area has increased by 10162.1m. This value was the differences between the CA (Total area, Class Area) of the year 1990-2015.

A. Class Area (CA)

The Class Area sometimes referred as Total Area, is an excellent mechanism to analyze and compare the development and change extent of built and non built-up lands (J.Im 2007). CA, in this context, refers to the spatial extent of the built-up areas (urban land use) obtained using the metrics. According to the CA calculated, urban land use has greatly changed over the study period. Large extent of land use change during the study period was characterized by replacement of agricultural areas, vegetated land including forest and scattered tree plantation, wet and water lands with urban areas. The extent of built areas was 2496.7m in 1990 and increased into 12658.8m in 2015. This reflects that the urban land cover has increased by approximately 10162.1m in a 25 years study period (Fig. 3).

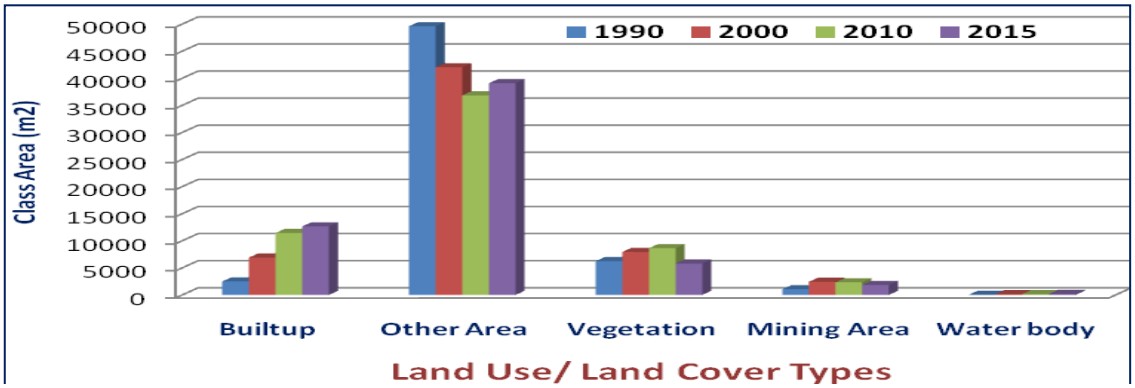

Fig.3 Class Area of the Study Area

B. Number of Patches (NP)

The number of patches (NP) metric quantifies the number of individual urban or built area patch. The number of urban patches in 1990 was 1801 and has increased into 7336 in 2015. This indicates that there has been a development and emergence of a small number of fragmented built up areas. The reason for the fragmentation in the areas could be mainly due to the development of discontinuous urban areas and other artificial or impervious surface features. According to the researcher's knowledge of the study area, discontinuation of urban sprawl was mainly due to rugged terrain, river and valley barrier, forest and swampy wet land cover. This also implies that there was emergence of new urban centers which were of course part and parcel of the main city but for some reason disconnected from the urban core. The numbers of patches, urban blocks in this case, of built-up area has increased over time. Again the decrease of other area, mining area and vegetation is prominent (Fig 4).

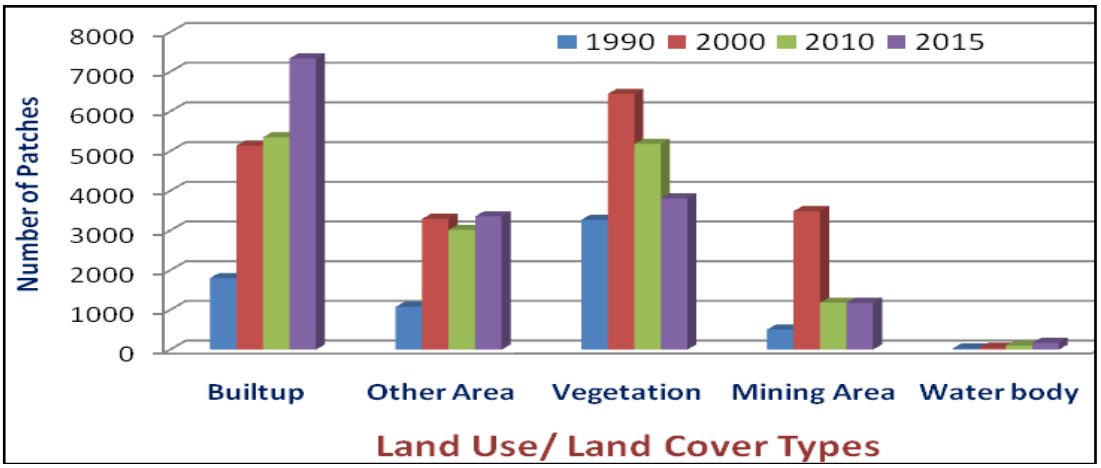

Fig. 4. Number of Patches of the Study Area

C. Largest Patch Index (LPI)

According to Herold et al (2002), LPI (in %) equals the area (m²) of the largest patch of the corresponding patch type divided by total area covered by urban multiplied by 100. The LPI has increased from 2.72 to 11.43. This was related to the contagion of small and isolated urban patches into the largest patch and development of other urban areas around the existing largest patch. LPI of built-up area type is increasing in a high rate and other land cover type is decreasing (Fig.5). This indicates the rapid growth of urbanization within the study area over time (1990-2015).

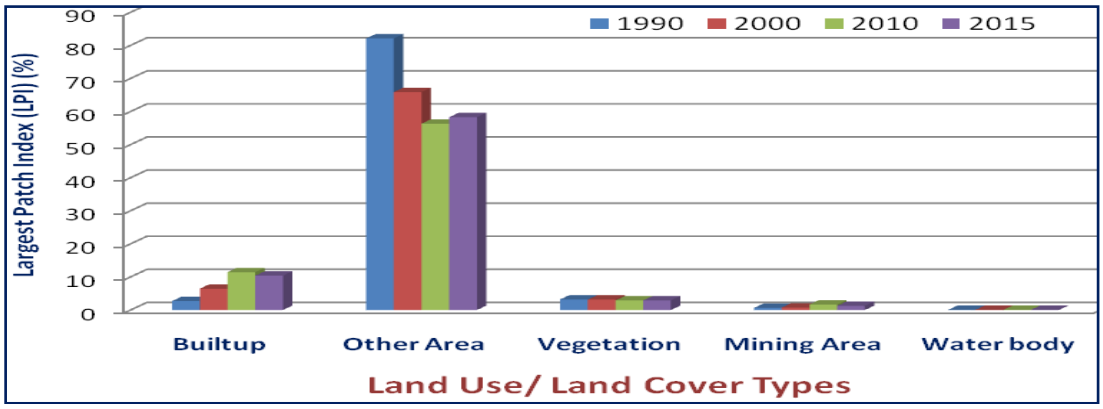

Fig. 5 Largest Patch Index of the Study Area.

D Edge Density (ED)

Another indicator in the expansion level of built up areas is the computation of ED. It is a measure of the total length of the edge of the urban patches, in other words, the length of the urban boundary divided by the total landscape area. The total length of the edge of the land use patches (urban patch) increases with an increase in the land use fragmentation; the increment in number of patches can surely lead to the increment of Edge Density. In this study, the ED has increased from 14.52 in 1990 to 60.18 in 2015 while ED of other area, vegetation and mining area are decreasing. This implies that the study area has a significant development of urban sprawl and emergence of numerous disconnected or fragmented urban centers. Therefore, this gradual increment in built-up area proves an increase in the total length of the edge of the urban patches (Fig.6).

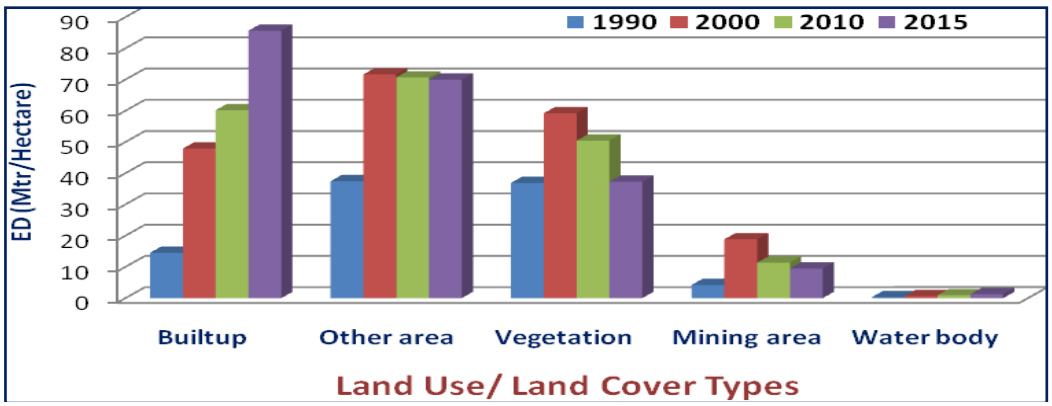

Fig. 6. Edge Density of the Study Area.

E Findings of the Landscape Analysis

1. The extent of (Class Area) a built area was 2496.7m in 1990 and increased into 12658.8m in 2015. This reflects that the urban land cover has increased by approximately 10162.1m in a 25 years study period.

2. As PA (Patches Area) indicates, the number of urban patches in 1990 was 324 and has increased into 367 in 2015. This indicates that there has been a development and emergence of small number of fragmented built up areas.

3. As LPI (Largest Patches Index) indicates that LPI has increased from 26.6 to 43.2. This was related to the contagion of small and isolated urban patches into the largest patch and development of other urban areas around the existing largest patch

4. ED (Edge Density) has increased from 29.9 in 1990 to 47.4 in 2015. This implies that the study area has a significant development of urban sprawl and emergence of numerous disconnected or fragmented urban centers.

V. Conclusion

This study has demonstrated the role of satellite remote sensing and Spatial Metrics in producing accurate LU-LC maps and change statistics of the Jodhpur for the past 25 years between 1990 and 2015. The study shows that the land cover in between

two different times showed significant change. Most of the changes in land cover occurred in the peripheries of the urban sprawl. Spatial Metrics was the best quantifier and indicator of the level of growth and pattern of the built up areas.

ACKNOWLEDGEMENT

The authors are thankful to the Director DL, Jodhpur for help and encouragement during the study. The authors are also thankful to Head Mining Department for his critical suggestion and encouragement.

References

1. Bhatta, B. 2009. Analysis of urban growth pattern using remote sensing and GIS: a case study of Kolkata, India, International Journal of Remote Sensing 30(18): 4733–4746. https://doi.org/10.1080/01431160802651967
2. Bhatta, B. 2010. Analysis of urban growth and sprawl from remote sensing data. Chapter 4. Heidelberg: Springer-Verlag, 49–64. https://doi.org/10.1007/978-3-642-05299-6
3. Bhatta, B. 2012. Urban growth analysis and remote sensing: a case study of Kolkata, India 1980–2010. Chapter 2. Dordrecht: Springer, 9–32. https://doi.org/10.1007/978-94-007-4698-5
4. Bhatta, B; Saraswati, S; Bandyopadhyay, D. 2010a. Quantifying the degree-of-freedom, degree-of-sprawl, and degree-of-goodness of urban growth from remote sensing data, Applied Geography 30(1): 96–111. https://doi.org/10.1016/j.apgeog.2009.08.001
5. Bhatta, B.; Saraswati, S.; Bandyopadhyay, D. 2010b. Urban sprawl measurement from remote sensing data, Applied Geography 30(4): 731–740. https://doi.org/10.1016/j.apgeog.2010.02.002
6. Brown, S. R. 1995. Measuring the dimension of self-affine fractals: example of rough surfaces, Chapter 4 in C. C. Barton; P. R. La Pointe (Eds.). Fractals in the Earth Sciences. New York: Plenum Press.
7. Dewan, A. M.; Corner, R. J. 2014. Spatiotemporal analysis of urban growth, sprawl and structure, Chapter 6 in A. Dewan; R. Corner (Eds.). Dhaka megacity: geospatial perspectives on urbanisation, environment and health. Dordrecht: Springer. https://doi.org/10.1007/978-94-007-6735-5_6
8. Feng, J.; Chen, Y. 2010. Spatiotemporal evolution of urban form and land-use structure in Hangzhou, China: evidence from fractals, Environment and Planning B: Planning and Design 37(5): 838–856. https://doi.org/10.1068/b35078
9. Hegazy, I. R.; Kaloop, M. R. 2015. Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt, International Journal of Sustainable Built Environment 4(1): 117–124. https://doi.org/10.1016/j.ijsbe.2015.02.005
10. Hu, S.; Tong, L.; Frazier, A. E.; Liu, Y. 2015. Urban boundary extraction and sprawl analysis using Landsat images: a case study in Wuhan, China, Habitat International 47: 183–195. https://doi.org/10.1016/j.habitatint.2015.01.017
11. Jaeger, J. A. G.; Schwick, C. 2014. Improving the measurement of urban sprawl: Weighted Urban Proliferation (WUP) and its application to Switzerland, Ecological Indicators 38: 294–308. https://doi.org/10.1016/j.ecolind.2013.11.022
12. Jat, M. K.; Garg, P. K.; Khare, D. 2008. Monitoring and modelling of urban sprawl using remote sensing and GIS techniques, International Journal of Applied Earth Observation and Geoinformation 10(1): 26–43. https://doi.org/10.1016/j.jag.2007.04.002[Crossref], [Web of Science ®], [Google Scholar]
13. Kaya, S; Seker, D. Z.; Tanik, A. 2012. Analysis of urbanized areas using V-I-S components model, Fresenius Environmental Bulletin 21(11): 3243–3248.[Web of Science ®], [Google Scholar]
14. Kumar, J. A. V.; Pathan, S. K.; Bhanderi, R. J. 2007. Spatio-temporal analysis for monitoring urban growth – a case study of Indore city, Journal of the Indian Society of Remote Sensing 35(1): 11–20. https://doi.org/10.1007/BF02991829
15. Li, F. 2012. Investigation of urban sprawl on the basis of remote sensing data: a case study in Jiangning, Nanjing City, China: PhD Thesis. University of Stuttgart, Germany.
16. Ramachandra, T. V.; Bharath, A. H.; Sowmyashree, M. V. 2015. Monitoring urbanization and its implications in a mega city from space: Spatiotemporal patterns and its indicators, Journal of Environmental Management 148: 67–81. https://doi.org/10.1016/j.jenvman.2014.02.015
17. Ramachandra, T. V.; Bharath, H. A.; Durgappa, D. S. 2012. Insights to urban dynamics through landscape spatial pattern analysis, International Journal of Applied Earth Observation and Geoinformation 18: 329–343. https://doi.org/10.1016/j.jag.2012.03.005
18. Sudhira, H. S.; Ramachandra, T. V.; Jagadish, K. S. 2004. Urban sprawl: metrics, dynamics and modelling using GIS, International Journal of Applied Earth Observation and Geoinformation 5(1): 29–39. https://doi.org/10.1016/j.jag.2003.08.002
19. Herold, M., Scepan, J. and Clarke, C. (2002). The use of remote sensing and landscape metrics to describe structures and changes in urban land uses. Environment and Planning A 34(8): 1443-1458.
20. Herold, M., Goldstein, N., and Clarke, K. 2003. The spatio-temporal form of urban growth: measurement, analysis and modeling. Remote Sensing of Environment, vol. 85, pp. 95-105.
21. Herold, M, Couclelis, H., & Clarke, K. (2005). The role of spatial metrics in the analysis and modeling of urban land use change. Computers, Environment and Urban Systems, 29(4), 369-399.
22. Herold M, Couclelis H, Clarke KC (2005a). The role of spatial metrics in the analysis and modeling of urban change. Comput Environ Urban Syst 29(4):369–399.
23. Rashed, T. (2008). "Remote sensing of within class change in urban neighbourhood structures." Computers, Environ. & Urban Systems, 32, 343-354.

24. Jensen, J.R. and Im, J. Remote Sensing change detection in urban environments. Geospatial Technologies in urban environments: Policy practice and pixels, 2nd ed., Springer-Verlag, Heidelberg, pp 7-30, 2007.
25. Borana S.L., Yadav S.K., Parihar S.K. and Paturkar R.T. - Integration of Remote Sensing & GUS for Urban Land Use / Cover Change Analysis of the Jodhpur city, 33rd INCA International Congress , 19 - 21 September, 2013, Jodhpur, Rajasthan, India.
26. Borana S. L. (2015). Urban Settlement, Planning and Environmental Study of Jodhpur City using Remote Sensing and GIS Technologies, JNV University, Jodhpur, PhD Thesis, pp.225 (Unpublished).
27. GLCF – http://www.glcf.umiacs.umd.edu
28. USGS - http://glovis.usgs.gov.

AUTHOR(S) PROFILE

Dr S.L Borana, received ME (Electronics & Communication) and PhD from JNV University, Jodhpur. Presently he is working in Defence Laboratory, Jodhpur and has experience of 13 years in the area of remote sensing and GIS. His research interests include: Remote Sensing & GIS, Disaster Mgt, Image Processing

Dr S.K Yadav, received MSc (Geology) and PhD from JNV University, Jodhpur. Presently he is working in Defence Laboratory, Jodhpur and has experience of 18 years in the area of remote sensing and terrain analysis. His research interests include: Remote Sensing Geology, GIS & Urban Planning, Risk Analysis & Disaster Management.

