Journal of Applied Sciences

ISSN 1812-5654

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Journal of Applied Sciences

ISSN 1812-5654
DOI: 10.3923/jas.2020.97.103

Research Article
Environmental Management Through the Assessment of Impact of Urban Growth Through Remote Sensing Techniques

[1]Kavita Sharma and [2]Neerav Sharma

[1]Department of Botany, Government Arts and Commerce Girls College, Raipur, India
[2]Indian Institute of Technology, Roorkee, India

Abstract

Background and Objective: The field of remote sensing is growing rapidly giving rise to huge potential applications in almost every domain. Management of environment is one of those application-oriented areas which enable the utilization of remote sensing for the betterment of environment. The objective of the study was to attain sustainable development for the future generations to come using the techniques of remote sensing. **Materials and Methods:** The urban growth has been humongous and with growing population, the resources are getting scarce day by day. This paper utilizes 2 multi-spectral images from Landsat-8 OLI on which remote sensing techniques have been applied for assessing the amount of urban growth and its impact on the environment. **Results:** The indices estimated by using the remote sensing techniques represent the changes as well as the present day status of the available natural resources in the study area. The NDVI and NDBI give an insight to the urban as well as vegetation landscapes in the area. **Conclusion:** The paper portrays a strong conclusion regarding the available water resources and the vegetation landscapes in the study area and opens up gates for further researchers to study on remote sensing based sustainable development of environment.

Key words: Environmental management, sustainable development, remote sensing, landsat-8 OLI, urban management, vegetation indices, urban indices

Citation: Kavita Sharma and Neerav Sharma, 2020. Environmental management through the assessment of impact of urban growth through remote sensing techniques. J. Applied Sci., 20: 97-103.

Corresponding Author: Kavita Sharma, Department of Botany, Government Arts and Commerce Girls College, Raipur, India Tel: +91-9826130100

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Remote sensing basically is the gathering of information from non-physical means about an object[1]. One of the best example of such is "The Human Eye". This phenomenon basically is an essential part of modern day surveying and technologies. Satellites play an essential role of "such eye" which are space-borne and gathers information about the Earth as per their temporal resolution[2]. In general, with the passing days, the space-borne satellites are being launched at a consistent pace with better resolutions.

The two main focus areas of such technological increment are the spatial resolution and the spectral resolution. Spatial resolution basically refers to the domain of 'pixels' which acts as a core component when applying digital image processing techniques[3]. The higher the number of pixels, more is the spatial resolution and vice-versa. Additionally, when applying processing techniques, noise removal and super-resolution techniques for image enhancement are also very popular yielding high quality outputs these days[4,5]. However, the spectral resolution is basically the capability of the satellite-based sensor in differentiating between multiple wavelengths and spectral properties.

Mostly, modern day satellites are well equipped with sensors which offers high amounts of spectral and spatial resolution (2.5 m resolutions are also available in the market today). The field of remote sensing offers flexibility as well as the user-friendly environment for utilizing the never-ending potential of processing techniques in order to extract maximum amount of information from the satellite imageries. The main applications of remote sensing include everything where human intervention is not possible or is impossible to be done manually. It includes temporal changes about a phenomenon which is done through spatio-temporal remote sensing techniques. Another important application is the analysis of land use and land cover[6,7]. This is the most essential application of remote sensing and GIS. Urban feature extraction and modelling acts as another very important perspective of remote sensing technologies[8].

With new innovations and constant advancements in the technological aspect, the authors presented an approach for detecting multiple anomalies through convolution neural network algorithms[9]. Vegetation is another very essential and profound application of remote sensing[10,11]. The components like chlorophyll, leaf area index, presence of contaminants, health of crops and plants, density of vegetation and greenness are some paramount entities that can be effectively sensed through satellite imageries[12]. This forms the basis for a profound study to be carried out in the field on environmental management such that sustainable development is attained. Instead of field-based experimental studies, this study incorporated the techniques of remote sensing and GIS through which the research gaps and the corresponding voids can be fulfilled.

MATERIALS AND METHODS

Satellite dataset used: The image acquired for carrying out the research work was the Landsat-8 Operational Land Imaging (OLI) sensor providing information at 30 m resolution. It consists of 11 bands comprising of 3 optical, 1 aerosol, 3 Infra-red, 2 thermal, 1 Cirrus and 1 Panchromatic band. The panchromatic band offers data at 15 m resolution which offers excellent robustness as well as effectiveness into the overall study. The temporal resolution of the Landsat-8 OLI satellite is 16 days.

The study site incorporated in the study was Haridwar district, Uttarakhand, India, as shown in Fig. 1. The coordinates of the study area are 29.9457°N, 78.1642°E and situated at WGS-84 Zone 44 North. In this research, 2 multi-spectral images are incorporated of the years 2014 and 2018, respectively. The images acquired were of May, 2014-2018 as this month contains low amount of cloud cover which significantly affects the satellite imageris. The remote sensing techniques are applied in these 2 datasets and no extra datasets are required for the research implementations. It is globally observed that urban growth has been at an extremely rapid pace and is really necessary for constant monitoring and assessment. To achieve sustainable era and corresponding development, this has to be countered in an efficient manner. Eco-environmental approach is the most effective approach as it covers entire range of diversities which is mandatory for achieving global sustain ability.

Haridwar district lies adjacent to the capital city Dehradun and touches Rishikesh, a mountainous region where majority of land-use-land cover applications have been carried out effectively. In order to achieve sustain ability, urban growth and its corresponding impacts are to be assessed in the first step. The next step is to analyze the sensed urban features and provide corresponding solutions necessary for providing management procedures for eradication and the proper usages of natural resources available.

Process and analysis: The 2 multi-spectral images are shown in Fig. 2. The tiles were first acquired and then clipped as per the vector layer of the study area, so, that the unwanted information may be clipped out and only the essential area

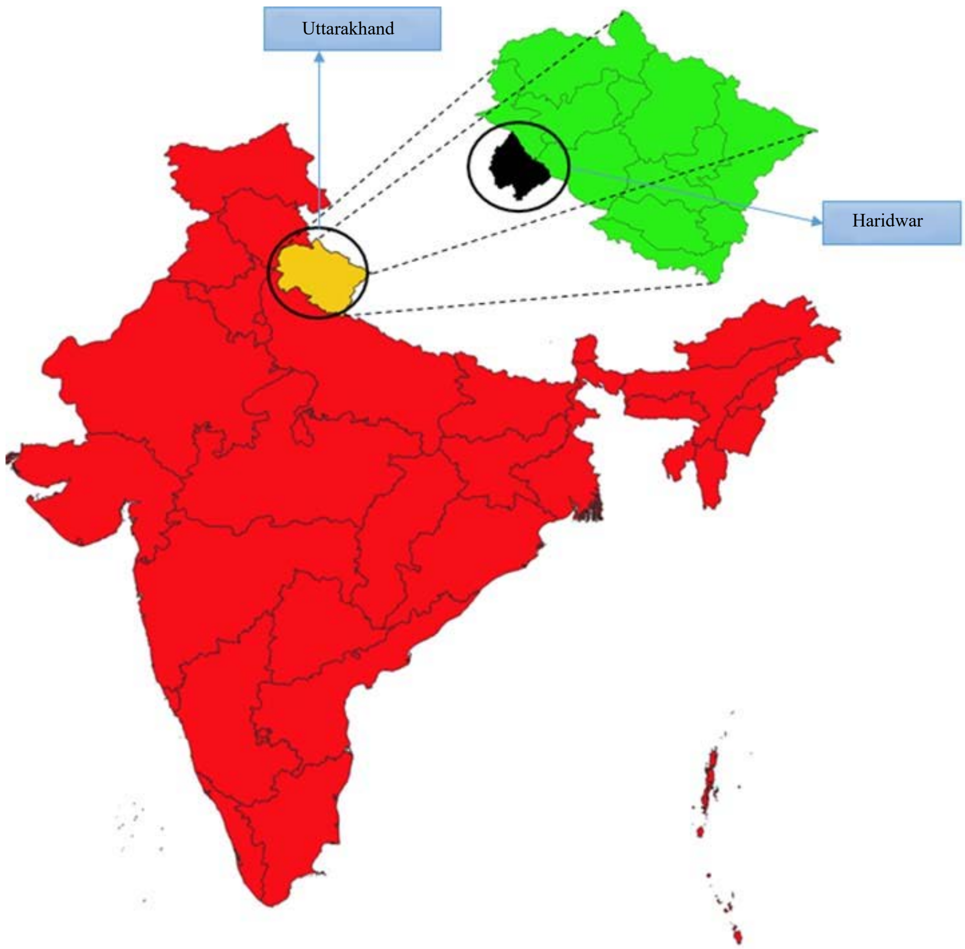

Fig. 1: Study area of Haridwar district, Uttarakhand, India

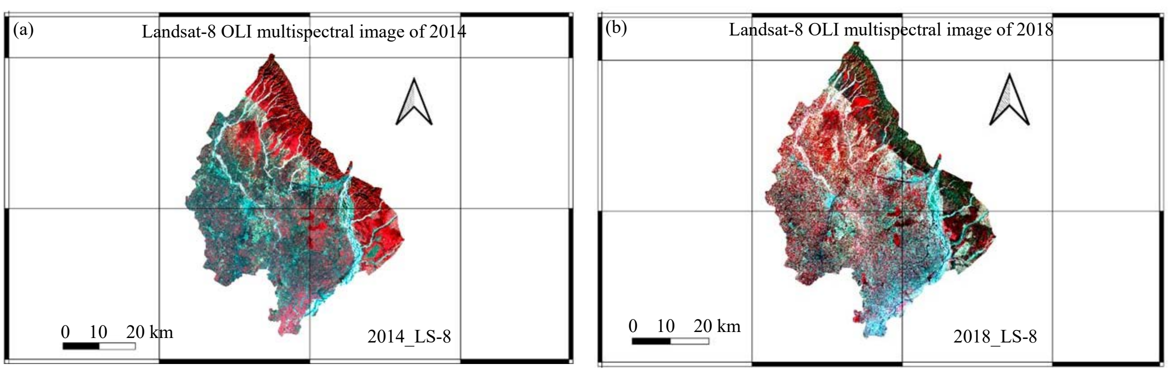

Fig. 2(a-b): (a) 2014 multispectral image and (b) 2018 multispectral image

remains in the dataset. The false color composite (fcc) image was then created by using Near Infra-red (NIR), red and green bands which as shown in Fig. 2, where vegetation is depicted by red, water by cyan and terrain by greenish color. This acts as the necessary input for the analysis to be carried out.

Once the fcc image was made as per the vector shape file layer, stacking was carried out. This is basically the spectral stacking of bands which created a RGB image. Now, the analysis can be carried out by using this color image. The main part of remote sensing techniques is the assessment of different indices and then analyzing them. The indices used in this study are Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI) and Modified Normalized Difference Water Index (MNDWI). As per the names itself, NDVI describes the vegetation state through grayscale composition, NDBI describes the built-up area by using grayscale composition and the MNDWI describes water state through grayscale composition. All these compositions are float based outputs. Figure 3 shows the schematic methodological process.

RESULTS

The result in Fig. 4 shows the NDVI map of the study area. The bright fringes are the vegetation density present while dark fringes resemble lack of them. The Red and NIR bands are used for the estimation of NDVI.

Figure 5 shows the MNDWI map which is basically estimated through Green and SWIR bands. The areas with high moisture content are illuminated while the areas with shortage of moisture appear as dark in the output. For managing water resources and reservoirs, MNDWI outputs are very efficient.

Figure 6 shows the NDBI map which is estimated through SWIR and NIR bands. The areas with urban built up areas appear as bright while terrain landscape areas with no built up areas appear as dark in the image.

For having an in-depth analysis, change detection was carried out between the images of 2014-2018. The indices of NDVI and NDBI were the basis on which change detection was carried out. The basic thumb rule of change detection is that the output map consists of red and green indicators. Red color indicates the decrease while green indicates increase in that particular domain of attribute. The vegetation is clearly seen to depreciating as red color is dominant in the output map in

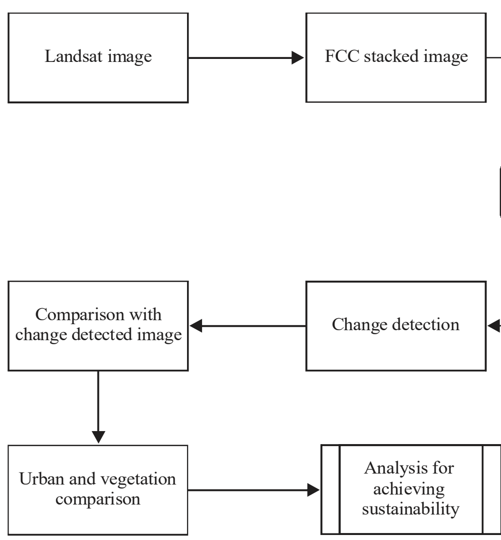

Fig. 3: Methodological flow chart

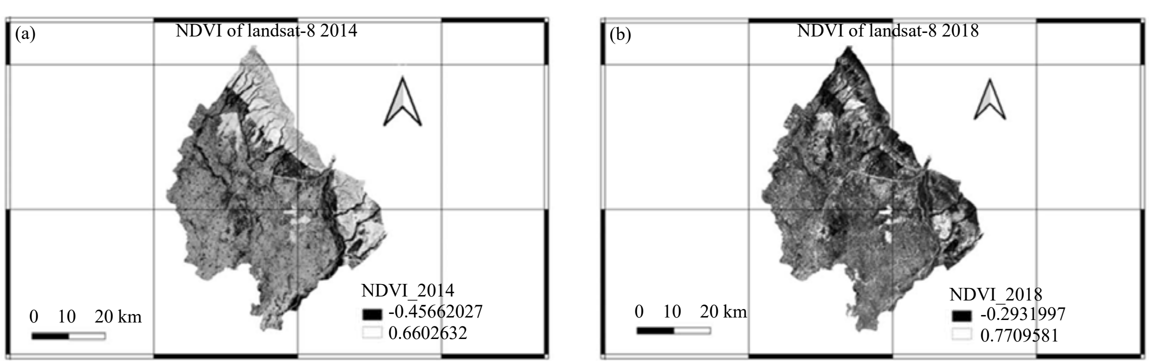

Fig. 4(a-b): NDVI maps of (a) 2014 and (b) 2018, respectively
NDVI: NIR-Red/NIR+Red

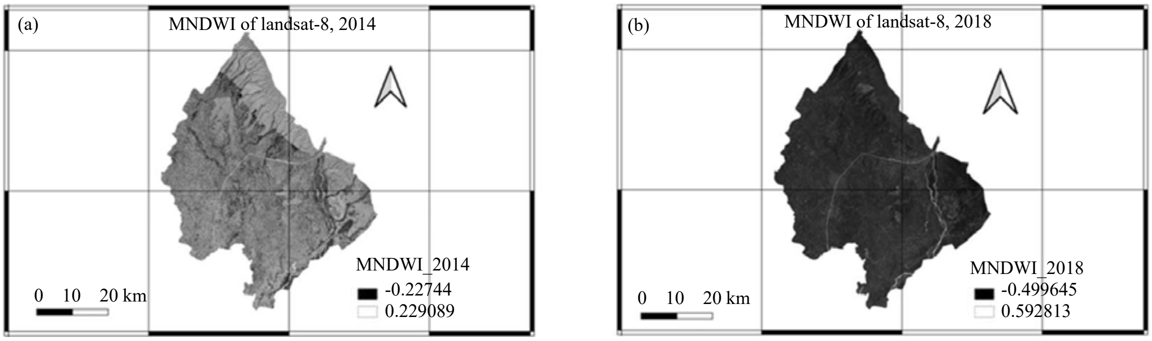

Fig. 5(a-b): MNDWI maps of (a) 2014 and (b) 2018, respectively
MNDWI: Green-SWIR/Green+SWIR

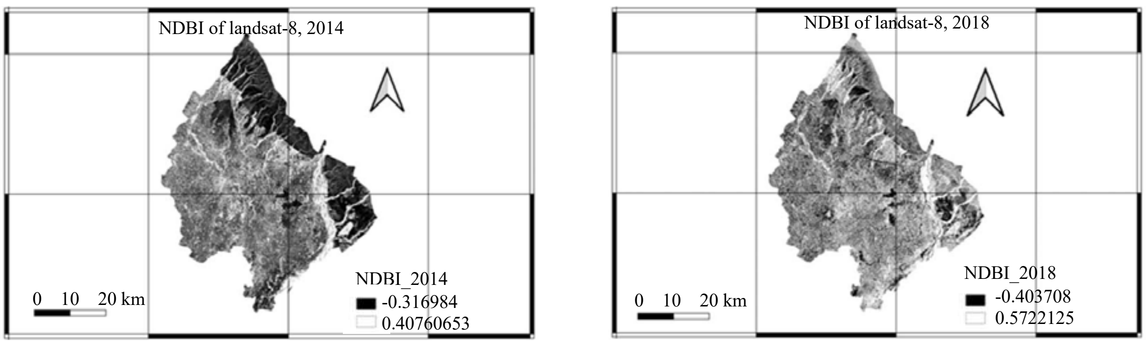

Fig. 6(a-b): NDBI maps of (a) 2014 and (b) 2018, respectively
NDBI: SWIR-NIR)/SWIR+NIR

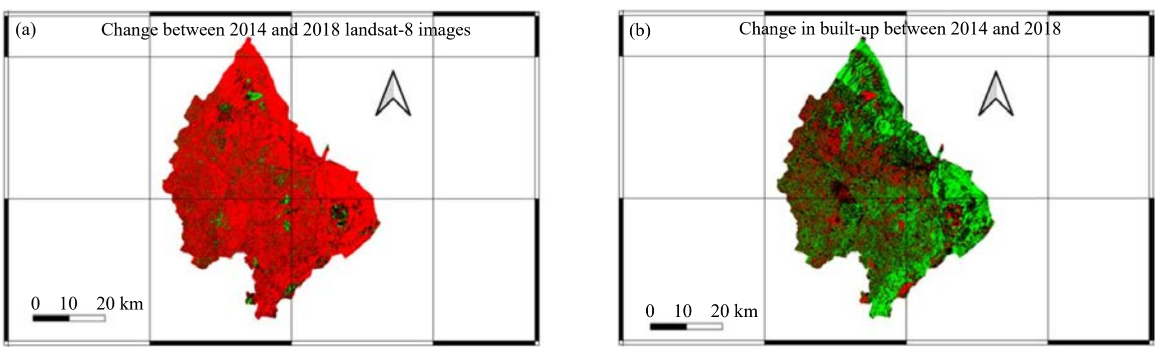

Fig. 7(a-b): Change in (a) Vegetation and (b) Urban, respectively between 2014 and 2018

Fig. 7. On the other hand, the urban growth is prominent as its change detection shows increment with green as the dominant indicator. Figure 8 shows the extracted urban and vegetation features.

DISCUSSION

It is clearly validated that vegetation and urban are inversely proportional to each other as one grows, the other diminishes simultaneously. It is high time for the researchers to work on this concept of sustainable management as with the current pace, the urban growth may just cross-out the vegetation and resource availability. This would lead to a havoc creating cases of jeopardies and humongous loss of bio-diversities in the present ecosystem.

In order to understand the above discussed scenario, the urban and vegetation features were extracted from the 2 corresponding datasets. The extracted image neutralizes the

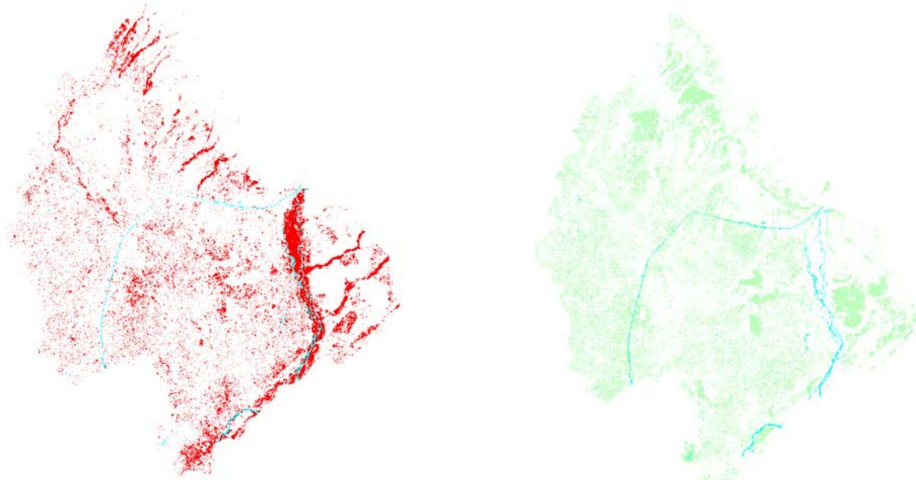

Fig. 8: Urban and vegetation compared to the main-stream water availability

effects of pollutants as well as acids present in the landscape's soil[13]. The features were post-classified and the resultant images portray the information regarding urban as well as vegetation phenomenon present in that particular ecosystem[14,15]. The urban features are depicted by red in color while the vegetation part is indicated by green color which is the common convention in the remote sensing environment, however, different researchers use different nomenclatures[16]. Although, both of the images portrayed the idea that the features present are somewhat similar, the difference is in classification and understanding. Mostly, this is due to the presence of mixed urban and green landscape together and the presence of various chemicals might be present in the entire extracted landscape which draws immediate attention towards optimizing the current scenario of scarcity[17]. A blue-cyan layer (resembling the river flow stream line) can be easily visualized. This layer is the major river line present in the study area. It can be clearly seen that due to the urban growth, vegetation has been deceased and the available water resources have come to a more pressurized situation. This will lead to the loss of bio-diversities and the ecosystem entities. It is a spotlighted time now for saving the natural resources as well as the proper management of the environmental ecosystem present.

The overall study focuses on delineation of vegetation as well as urban features and their corresponding extraction in order to attain sustainable development. The multispectral landsat-8 sensor yields coarser resolution as compared to hyperspectral sensors like hyperion. Thus, use of hyperspectral satellite datasets can also be included in this study to attain high efficiency in outputs. Also, the study can be integrated for further analyzing attribute wise extracted outputs for yielding optimized criteria's necessary for forming the solid and robust basis to achieve sustainable environments for future generations.

CONCLUSION

The techniques of remote sensing consist of great features and potential in remedying the present states of jeopardies. Proper analysis through effective approaches would result to precise and accurate results. Urban growth is an essential field of research which requires constant monitoring and satellite-based studies are the best possible countering solutions available. This is due to the fact that it covers a large area based on its swath width. The technique yielded extremely precise results in terms of feature extraction and the indices generated portrayed an in-depth content present in the satellite image.

The process of change detection provided a great extent of information regarding the changes occurred in the two respective images of 2014-2018. The urban growth was impeccable and showed a huge increase while the vegetation landscape was a bit on the depreciating side. The comparative analysis between the urban-vegetation versus the change detected image presented quite impressive results with context to the growth as well as the extent of achieving sustain ability in terms of ecosystem and environment.

SIGNIFICANCE STATEMENT

This study in corporates the use of multi-spectral sensors and remote sensing techniques for analyzing the current trend of environment based on urban growth and impact.

Estimation of indices as well as the detected changes in the sensor data sets give a strong idea about the declination in the environmental part as compared to the ever-growing status of urban part. This research enables the researchers to study the environment through remote sensing approach reducing their efforts to visit fields which is always rigorous and time consuming. Also, the addition of different remote sensing data sets like hyperion and sentinel would provide flexibility as well as efficiency for managing the environment to achieve sustainable development of the same.

REFERENCES

1. Navalgund, R.R., V. Jayaraman and P.S. Roy, 2007. Remote sensing applications: An overview. Curr. Sci., 93: 1747-1766.
2. Shi, W., Z. Mao and J. Liu, 2018. Building extraction from high-resolution remotely sensed imagery based on multi-subgraph matching. J. Indian Soc. Remote Sens., 46: 2003-2013.
3. Chen, X.L., H.M. Zhao, P.X. Li and Z.Y. Yin, 2006. Remote sensing image-based analysis of the relationship between urban heat island and land use/cover changes. Remote Sens. Environ., 104: 133-146.
4. Sharma, N., P.P. Dash and P. Saxena, 2018. GCD based blind super-resolution for remote sensing applications. Proceedings of the 2nd International Conference on Power, Energy and Environment: Towards Smart Technology, June 1-2, 2018, Shillong, India, pp: 1-6.
5. Sharma, N. and K. Sharma, 2019. Application of change detection techniques in the fields of environmental management and sustainable development. Int. J. Res. Anal. Rev., 6: 75-81.
6. Shao, Q., Y. Shi, Z. Xiang, H. Shao and W. Xian *et al*., 2018. Monitoring the grassland change in the Qinghai-Tibetan plateau: A case study on Aba County. J. Indian Soc. Remote Sens., 46: 569-580.
7. Zhang, J., C. Han and Y. Li, 2010. The effects of sulphur dioxide on the spectral curves and chlorophyll concentration of rice canopy. Int. J. Remote. Sens., 31: 4257-4264.
8. Hussain, E. and J. Shan, 2016. Urban building extraction through object-based image classification assisted by digital surface model and zoning map. Int. J. Image Data Fusion, 7: 63-82.
9. Saito, S., T. Yamashita and Y. Aoki, 2016. Multiple object extraction from aerial imagery with convolutional neural networks. J. Imaging Sci. Technol., 60: 10402-1-10402-9.
10. Blaschke, T., G.J. Hay, M. Kelly, S. Lang and P. Hofmann *et al*., 2014. Geographic object-based image analysis-towards a new paradigm. ISPRS J. Photogram. Remote Sens., 87: 180-191.
11. Cai, D., Y. Guan, S. Guo, C. Zhang and K. Fraedrich, 2014. Mapping plant functional types over broad mountainous regions: A hierarchical soft time-space classification applied to the Tibetan Plateau. Remote Sens., 6: 3511-3532.
12. Richardson, A.D., S.P. Duigan and G.P. Berlyn, 2002. An evaluation of noninvasive methods to estimate foliar chlorophyll content. New Phytol., 153: 185-194.
13. Wang, C., D. Xing, L. Zeng, C. Ding and Q. Chen, 2005. Effect of artificial acid rain and SO_2 on characteristics of delayed light emission. Luminescence: J. Biol. Chem. Luminescence, 20: 51-56.
14. Wu, C., 2004. Normalized spectral mixture analysis for monitoring urban composition using ETM+ imagery. Remote Sens. Environ., 93: 480-492.
15. Kuzera, K., J. Rogan and R. Eastman, 2005. Monitoring vegetation regeneration and deforestation using change vector analysis: Mt. St. Helens study area. Proceedings of the American Society for Photogrammetry and Remote Sensing (ASPRS) Annual Conference, March 7-11, 2005, Baltimore, MD., USA.
16. Shao, H., M. Liu, Q. Shao, X. Sun, J. Wu, Z. Xiang and W. Yang, 2014. Research on eco-environmental vulnerability evaluation of the Anning River Basin in the upper reaches of the Yangtze River. Environ. Earth Sci., 72: 1555-1568.
17. Wang, D., Z. Liu, Y. Dian, Z. Zhou and S. Fang, 2018. Potential of detecting the sulfur dioxide stress on landscape plants in spectral reflectance data. J. Indian Soc. Remote Sens., 46: 561-568.