International Journal of Research Publication and Reviews

Journal homepage:www.ijrpr.com ISSN 2582-7421

TEMPORAL ANALYSIS OF SONTAL JHEEL USING SATELLITE DATA

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ABSTRACT:

Monitoring of water bodies is an essential part for ecological sustainability.It is the world's most valuable natural resource and has gained importance with the development of remote sensing techniques. This paper presents the capabilities of Sentinel-2 successfully launched in June 2015 for temporal analysis Kathauta Jheel. For this purpose, three different approaches were used, pixel-based, object-based and index-based classification. Additionally, for more successful extraction of wetlands, a combination of object-based and index-based methods was proposed. It was proposed the use of object-based classification for extraction of the wetlands boundaries and the use of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) for classifying the contents within the wetlands boundaries. As a study area in this paper Sakarbasi spring in Eskisehir, Turkey was chosen. The results showed successful mapping and monitoring of wetlands with kappa coefficient of 0.95.

Introduction:

Wetlands as a transitional between terrestrial and open-water aquatic ecosystems (Mitsch & Gosselink, 2015), contains open water bodies, vegetation, and mixture. For classifying these different land covers, a number of researches have been made through the years. Most of the studies use different indexes for distinguishing wetlands from other land covers. Landsat data from 1985 to 2009 has been used for mapping changes in wetland ecosystems in northern Virginia using the NDVI (Normalized Difference Vegetation Index) (Kayastha, Thomas, Galbraith, & Banskota, 2012). Another study (Dong et al., 2014) uses both NDVI and LSWI (Land Surface Water Index) for mapping wetlands in Northwest China. Other indexes as ARVI (Atmospherically Resistant Vegetation Index) (Kaufman & Tanre, 1992), SARVI (Soil and Atmosphere Resistant Vegetation Index) (Huete, Liu, Batchily, & Van Leeuwen, 1997), NDWI (Normalized Difference Water Index) (Dvorett, Davis, & Papes, 2016) in its different forms (Feyisa, Meilby, Fensholt, & Proud, 2014; Gao, 1996; McFeeters, 1996). Geographical Information Systems (GIS) have also been widely used aside with remote sensed data in monitoring wetlands. Czajkowski et. al (Czajkowski, et al., 2007) used GIS rule-based decision tree algorithm to classify four different wetland types of interest. The expert system has been shown to be effective in depicting wetland types. The GEMI (Global Environment Monitoring Index) (Pinty & Verstraete, 1992) gives similar information as NDVI and has been used in wetlands monitoring. Another useful index for monitoring vegetation over wetlands is SARVI2 (Soil and Atmosphere Resistant Vegetation Index) (Huete, et al., 1997). As an addition, other data such as LiDAR data (Huang, Peng, Lang, Yeo, & McCarty, 2014), DEM (Li & Chen, 2005), and microwave data (Morandeira, Grings, Facchinetti, & Kandus, 2016; Moser, Schmitt, Wendleder, & Roth, 2016; White, Brisco, Dabboor, Schmitt, & Pratt, 2015) have been used for wetlands monitoring.

However, researchers had difficulties using some of the satellite sensors with low spatial resolution for mapping homogeneous coastal wetlands (Ramsey & Laine, 1997). Zomer et al. (Zomer, Trabucco, & Ustin, 2009) found that a majority of Landsat pixels were mixtures of several land cover types in various proportion. Civco et al. (Civco, Hurd, Prisloe, & Gilmore, 2006) had difficulty separating upper salt marsh from upland forest due to the spatial resolution of Landsat ETM.

Sentinel-2A was successfully launched on 23 June 2015, as a part of the European Copernicus program (Sentinel). Sentinel-2 Multispectral Instrument (MSI), is considered to be the followup mission to the SPOT and Landsat instruments, intended to provide continuity of remote sensing products (Malenovský et al., 2012). Sentinel-2 offers satellite images with a resolution of 10 to 60 meters (Drusch et al., 2012). In comparison with the latest Landsat OLI/TIRS, Sentinel-2 has a better spatial.

resolution, better spectral resolution in the near infrared region, three Vegetation Red Edge bands with 20-meter spatial resolution, but does not offer thermal data. Sentinel-2 MSI sensor compared to existing satellite sensors require adjustment to allow extending actual time series (D'Odorico, Gonsamo, Damm, & Schaepman, 2013). The frequent use of NDVI compared to other vegetation indices affirms the importance of global monitoring of vegetation (Gobron, Pinty, Verstraete, & Widlowski, 2000). Differences between sensor can vary from 10%-15% for the red and 2%-3% for the near infrared (NIR) reflectance, while NDVI values of vegetated surfaces were found varying across instruments up to 4%-6% (Trishchenko, Cihlar, & Li, 2002). D`Odorico et al. (D'Odorico, et al., 2013) excluded pixels with NDVI value < 0.3, representing nonvegetative surfaces, and then random points with NDVI values typical for vegetated surfaced were sampled above this threshold.

The Central Anatolian region of Turkey is known for its high number of wetland areas. The climate system of the Earth has affected not only globally but also locally. A study has shown that Turkeys` second biggest lake, Salt Lake (Tuz Golu), has lost more than 70% of its water surface area from 1987 to 2005 (Ekercin & Ormeci, 2010). The results from another study from the Central Anatolian region of Turkey, using NDVI and NDWI retrieved from Landsat satellite data, has shown that the Aksehir Lake water area has decreased from 324 km2 in 1987 to 100 km2 in 2016 (Gordana KAPLAN, 2016). This part of Turkey is rich with numbers of different vegetation and wildlife (Vakfi, 1989). Understanding wetland changes using remote sensing techniques is critical to planning ecosystem management and sustainable regional development (Ji, 2007).

In this study, Sentinel-2 satellite data has been used for mapping wetlands. Different remote sensing techniques were used for classifying and separating the wetlands from the other land covers. First, previously mentioned indexes have been retrieved and adjusted to Sentinel-2 data with threshold observation and comparison to other sensors for vegetation and water monitoring. Afterward, unsupervised and supervised classifications have been performed. Finally, an object-based classification with a decision tree model has been developed for monitoring and mapping wetlands. Decision trees have substantial advantages for remote sensing classification problems because of their flexibility, computational efficiency and intuitive simplicity (Ji, 2007). All of the used techniques were then compared. For the index analysis and the pixel-based classification ERDAS Imagine software was used, while for the object-based classification and the decision tree model, eCognition software was used.

2. STUDY AREA AND METHODS

Lahartara Pond is a historical pond associated with the appearance of Saint Kabir Saheb. According to a legend, Saint Kabir Saheb was found floating on a lotus flower in the pond. It is located in Varanasi, Uttar Pradesh in India.In the past, it was a large freshwater lake that spanned 17 acres (0.07 km^2). In the present day, it no longer has its historical grandeur because about 3.5 acres (0.014 km^2) of the pond is under the directorate of archaeology, Uttar Pradesh, while another 8 acres (0.03 km^2) are under Satguru Kabir Prakat Dham.

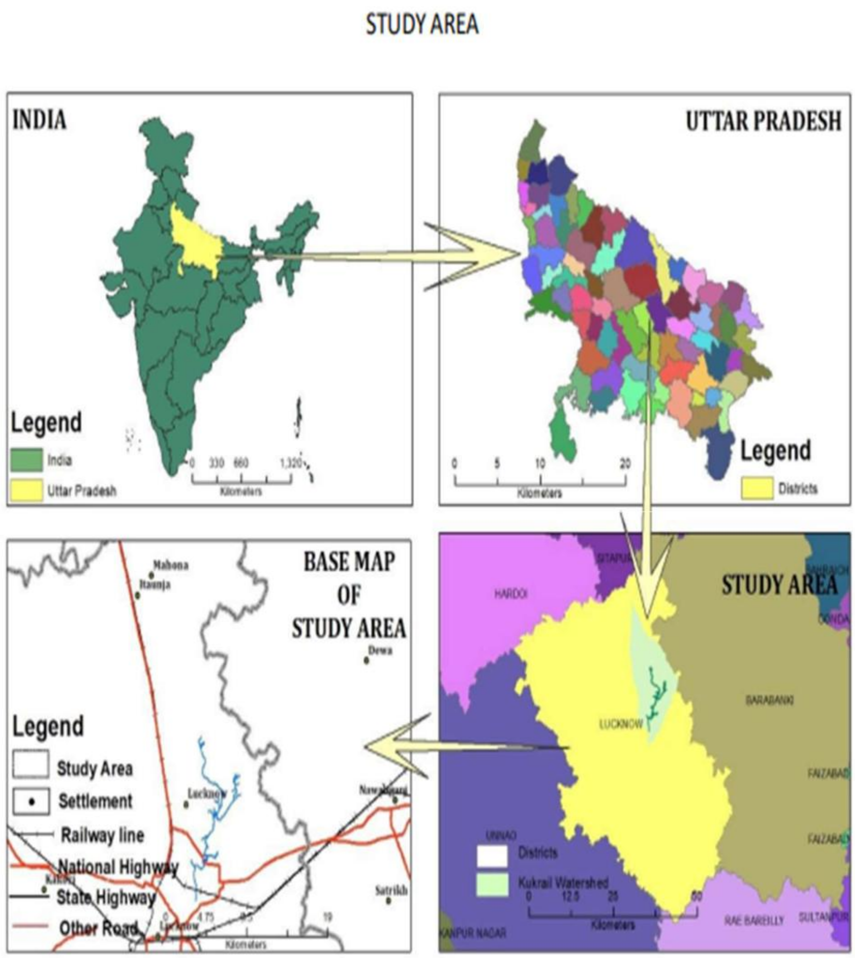


Fig: Study area of research

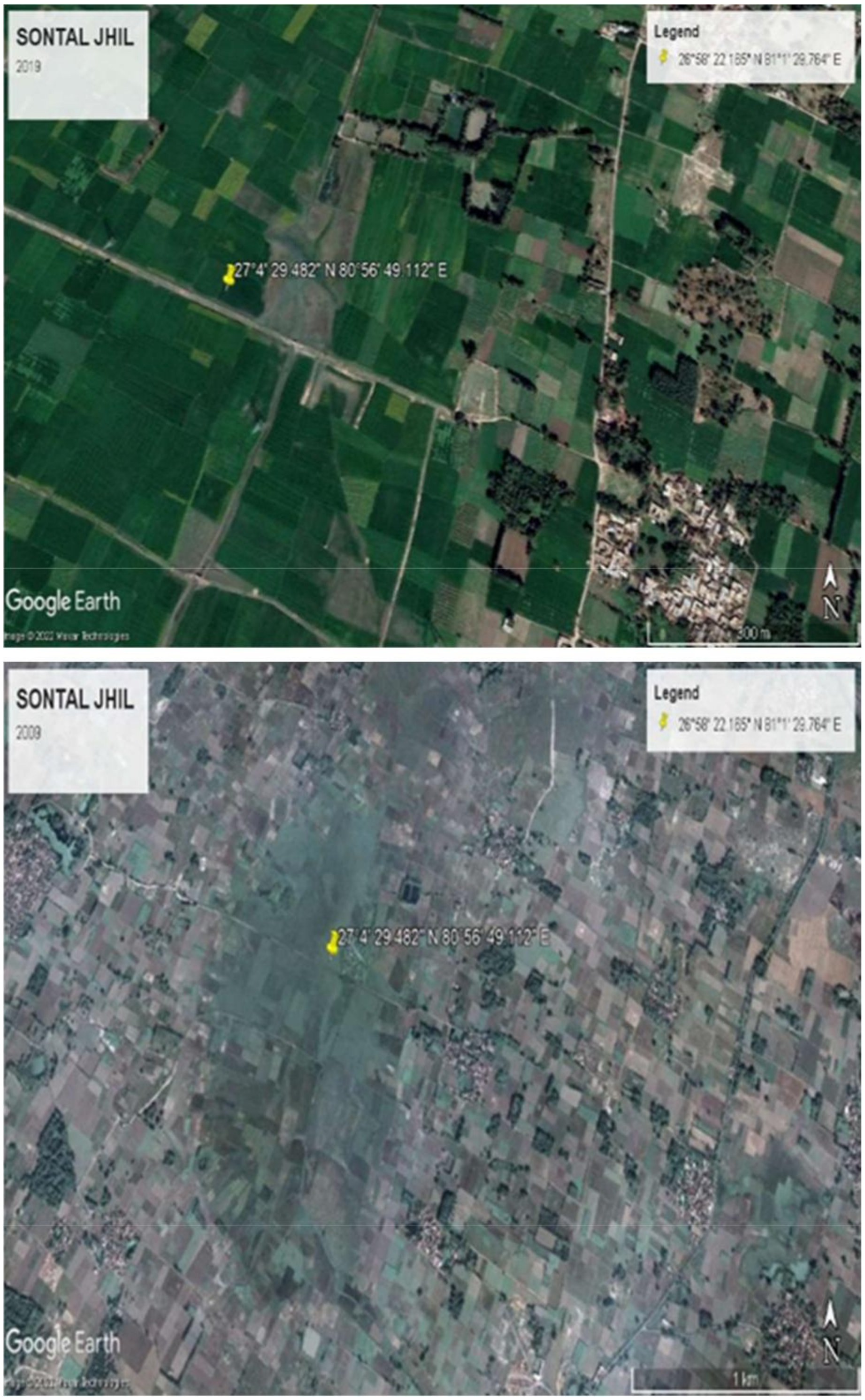


Fig: Images from google earth

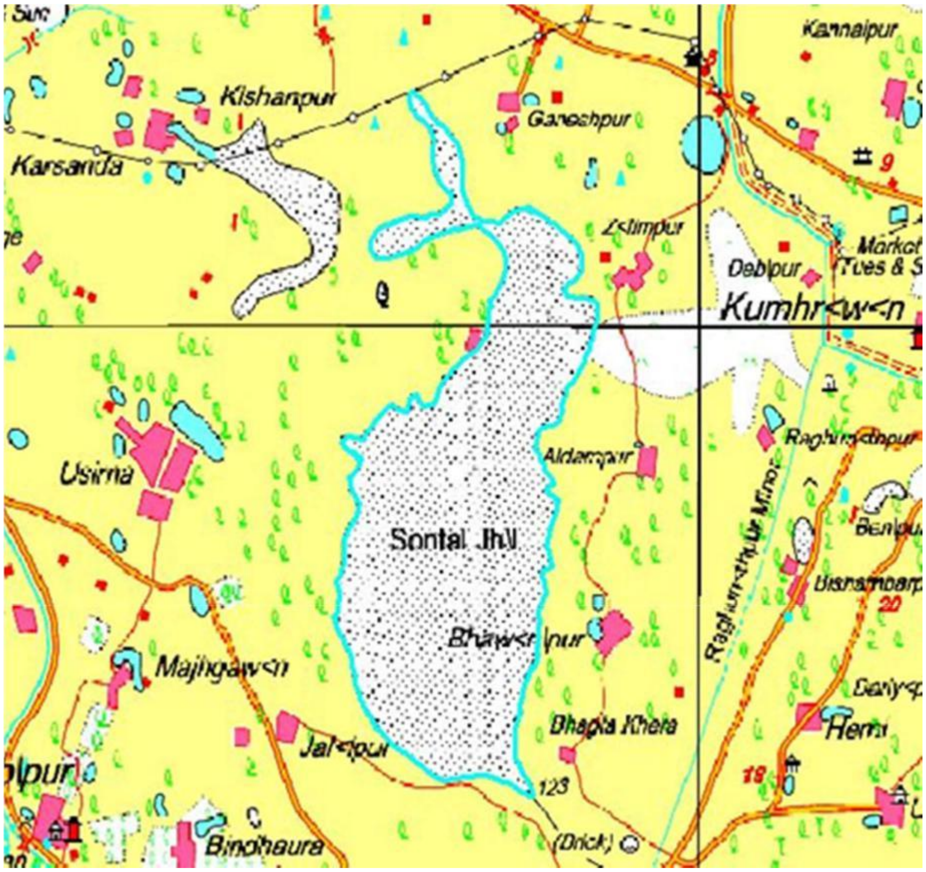


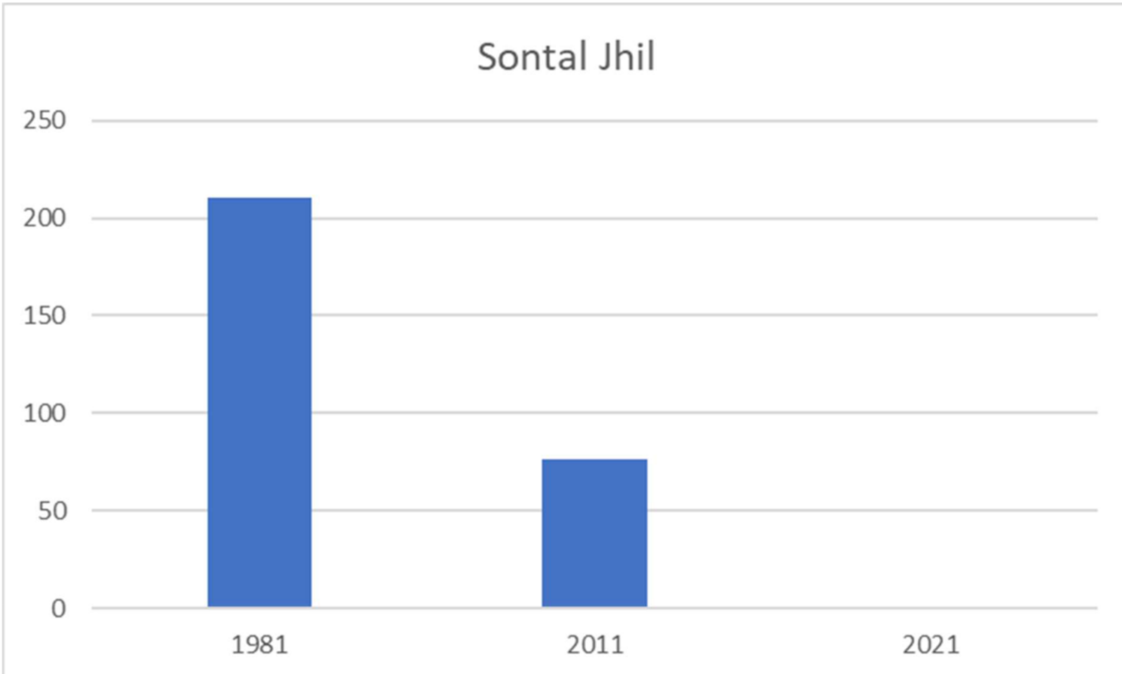
Fig :Image of the jheel in toposheet

Methods

Sentinel-2 data from 31 July 2016 were used in this study for monitoring Sakarbasi wetlands. Sentinel- 2 is an Earth observation satellite by the European Space Agency launched on 23 June 2015 (Sentinel-2A) and as part of the Copernicus Programme to perform terrestrial observations in support of services such as forest monitoring, land cover changes detection, and natural disaster management. Sentinel-2 sensor records 13 bands in the visible, near infrared, and short wave infrared part of the spectrum. It has a spatial resolution of 10 m, 20 m, and 60 m. The satellite images can be downloaded free from the Copernicus Open Access Hub (https://scihub.copernicus.eu/). The methodology in this study contains three different approaches for mapping and monitoring wetlands.based classification and index based classifications were performed.

RESULTS

Pixel-based classification Digital classification of wetlands from satellite image data is widely used because of the less time consuming and the source data that provide a high temporal resolution (J. R. Jensen, 1996). In this study, both supervised and unsupervised classifications were performed. The results from the classification are presented .The results showed that under unsupervised classification with 20 different classes it was hard to separate wetlands from other dark areas such as foret, clouds etc. The supervised classification gave better results successfully extracting the water bodies from the other dark objects. However, it was impossible to separate vegetated areas in the wetland from the open water areas.Object-based classification The results from the object-based classification showed good results in the boundary extraction section. The training data from the wetland areas helped for classifying other similar objects with the same spectral characteristics. After the multiresolution segmentation, a set of conditions were applied to the classification. It was observed that wetlands areas have near infrared values (B8 – band 8) higher than 900 and lower than 390. The same observation was made for the other bands. It was observed that the biggest mislead could occur from small dark areas, such as parts of forests, but they were eliminated by setting the area condition. The exported results in a vector file overlapped with the wetlands boundaries observed from high resolution imagery. Using the object-based classification, we were able to detect all of the wetlands within the Sentinel-2 frame. The results were then compared with high-resolution images and it was concluded that the only mislead came from clouds shadows.



Area Calculated

Area in 1981:210 ha
Area in 2011:73.29 ha
Area in 2021:0

DISCUSSION

Although different methods have been used for mapping wetlands, using remote sensing data from satellite images, due to the medium spatial resolution of the Landsat legacy, ASTER, or other satellites, separating wetlands from the other land cover has been hard without using additional data, as field measurements, Digital Elevation Models, LIDAR, etc. (Tiner, et al., 2015). In this paper, three different approaches have been used for mapping and monitoring wetlands over Sentinel-2 data with 10 m spatial resolution and three vegetation red edge indexes with 20 m, resampled to 10 m. While the unsupervised and supervised classification gave good results about the wetlands location with some misleads from dark areas such as forests, object-based classification gave better results about the location and boundaries of the wetlands. However, none of the methods gave information about the contents of the wetland areas. Using the index based classifications, we were able to extract the amount of vegetation, water, and mixture areas, but not the boundaries of the wetlands. In this paper, we propose using both object-based and index based classifications for successful mapping and monitoring of wetlands. Using this method, within the Sentinel-2 frame five potential wetland areas were found. From the image, it was clear that one of the potential places is misled from cloud shadows. The other areas were confirmed using high-resolution imagery from Google Earth. The accuracy assessment made for the used method gave a kappa value of 0.95. It has been concluded that the proposed method is suitable for mapping and monitoring wetland area from Sentinel-2 satellite images with no additional data

CONCLUSION:

In this paper, we propose using both object-based and index based classifications for successful mapping and monitoring of wetlands. Using this method, within the Sentinel-2 frame five potential wetland areas were found. From the image, it was clear that one of the potential places is misled from cloud shadows. The other areas were confirmed using high-resolution imagery from Google Earth. The accuracy assessment made for the used method gave a kappa value of 0.95. It has been concluded that the proposed method is suitable for mapping and monitoring wetland area from Sentinel-2 satellite images with no additional data.

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