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Extraction of Waterbodies using Support Vector Machine and Spectral Indices

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ABSTRACT

Water is an important natural resource in our daily life. Water resources play a major role in sustainable development. Surveying and continuous monitoring of water bodies in a vast area is a tedious and time-consuming task by conventional surveying techniques. Keeping track of changes in the areas of waterbodies due to urbanization and industrialization is very important. The present study aims at determining the spatiotemporal changes in the water bodies from 2008 to 2018 in the drought-hit area of Mahbubnagar, Telangana using satellite-derived spectral index namely,Modified Normalized Difference Water Index (MNDWI) and Support Vector Machine (SVM) technique using Resourcesat-1 Data. Extraction of water bodies using MNDWI and SVM can be done very easily with very little effort as compared to conventional surveying techniques. Using the MNDWI technique,the total area of waterbodies is 322.64 square kilometers in the year 2008 and 362.61 square kilometers in the year 2018. Using the SVM technique, the area of waterbodies is 368.17 square kilometers in the year 2008 and 395.72 in the year 2018. The kappa index values of 2018 by MNDWI technique and SVM technique are 0.86 and 0.91 respectively. The kappa index values of 2008 by MNDWI technique and SVM technique are 0.85 and 0.89 respectively. It is observed that the SVM technique is more accurate than the MNDWI technique. The area of water bodies has increased during the study period mainly due to increased awareness among the public on the importance of water and also initiatives taken by the Government of Telangana, like Mission Kakatiya for the revival of water bodies in the study area.

Key words : *Waterbodies, MNDWI, Resourcesat, Support Vector Machine (SVM).*

Introduction

Water is an important resource used for different purposes and the need for monitoring the surface waterbodies is required for better decision making to make it reach the public. The integration of remote sensing and GIS techniques has allowed for the automated or semi-automatic extraction and mapping of water bodies (Frey *et al.,* 2010). These images are very accurate, accessible, and time-saving when compared to conventional surveying techniques. Variations in the patterns of the earth's surface can be resolved by the change detection method. Data processing, analysis, and representation of spatial data can be efficiently handled by using Geographic Information System (GIS) within a very small time and with higher accuracy (Muhammad Ichsan Ali *et al.,* 2019)(Gulcan Sarp *et al.*, 2017). The availability of medium spatial resolution data from the Advanced Wide Field Sensor (AWIFS) onboard Resourcesat-1 with 56 m spatial resolution, 5 days repetivity, and a 740km swath has made near-real-time monitoring of complex resources such as waterbodies possible. In this analysis, IRS AWIFS data was used to detect and delineate spatial-temporal information on water bodies

(Sundaram Subramaniam *et al.*, 2011). Water bodies have been automatically extracted due to distinct spectral reflectance characteristics of water in the four bands of AWIFS Sensor compared to other non-water features (Hanqiu Xu, 2006). Many researchers extracted waterbodies by using remote sensing spectral indices. In this study, we have used the MNDWI as well as the support vector machine model for the extraction of surface water. Xu developed the Modified Normalized Difference Water Index (MNDWI) which is calculated by finding out the differences in the spectral values of green and short-wave infrared bands (Hanqiu Xu, 2006). It diminishes the other land cover features that are often correlated with water pixel in other indices. Waterbodies have been extracted from the image by applying a threshold value of zero. Pixels having positive values of MNDWI is considered to be a water pixel and all negative pixels are considered as non-water features. The Support Vector Machine (SVM) was first proposed by Vapnik. SVMs are a set of related supervised learning methods used for classification and regression. They belong to a family of generalized linear classification. A special property of SVM is, SVM simultaneously minimizes the empirical classification error and maximizes the geometric margin. So SVM is called Maximum Margin Classifiers. SVM is based on Structural risk Minimization (SRM) (Vapnik, 1995). An SVM splits classes with a decision surface that maximizes the boundaries between the classes. The surface is called the ideal hyperplane, and the data points closest to the hyperplane are deemed support vectors. The support vectors are the important elements of the training set (Boser *et al.*, 1992)(Cortes *et al.*, 1995) (G.M. Foody *et al.*, 2007) SVM technique has shown better performance even with the limited number of training samples. We can work with the SVM technique in any band combination, i.e, natural image, false image, etc., but in the case of the MNDWI technique, we can only work with Green and SWIR bands.

Materials and Methods

Study area

Mahbubnagar is located in the southern part of Telangana, India. It has 64 mandals. It is locatedat a distance of 98 km from Hyderabad. Two major rivers Krishna and Tungabhadra flow through the study area. Though the study area has two major rivers, it is drought-hit many times.

Data collected

The datasets were downloaded through the Bhuvan, Indian Geo-platform of ISRO. The description of the images used is given below in Table 1.

Table 1. Details of Satellite Images

Spectral band	Wavelength (µm)	Resolution (m)
Green	0.52 – 0.59	56
Red	0.62 – 0.68	56
NIR	0.77 – 0.86	56
SWIR	1.50 – 1.70	56

Methodology

The current research adopts the below methodology.

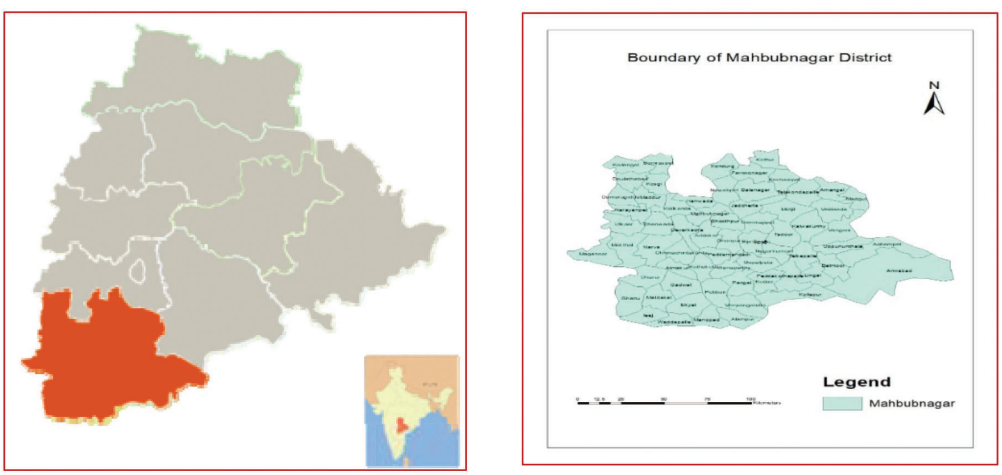
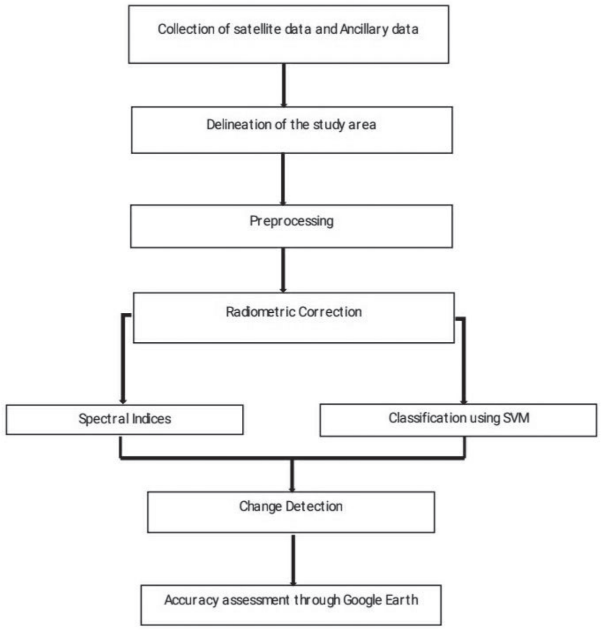


Fig. 1. Maps showing the study area



1) Satellite images were clipped as per the boundary of the study area and radiometric corrections were applied to enhance the quality of images.
2) Modified Normalized Difference Water Index (MNDWI) is calculated by using the below equation

$$MNDWI = \frac{(Green - SWIR)}{(Green + SWIR)}$$

3) Water Pixels are identified by the pixel intensities and a threshold value is applied to separate the water pixels from other pixels.
4) Water pixels have positive values because their reflectance in band 2 is higher than in band 5, whereas non-water pixels have negative values.
5) For classifying using SVM, we have to create the training samples of the classes required i.e., waterbody and non-waterbody.
6) The training samples will be the input for the SVM to classify the pixels into waterbody and non-waterbody.
7) An accuracy assessment has been performed through Google Earth by generating 1500 points to find out the accuracy of the classified image.
8) Change detection has been performed to find out the changes in the area covered by waterbodies.

Results and Discussion

The images taken from the resourcesat-1 using remote sensing technique are very accurate to note down the features like surface waterbodies and calculating their areas in a very less time and cost. The data has been processed using MNDWI spectral index. The minimum and maximum values of MNDWI are -0.716 to 1, and -0.632 to 0.996 in 2008 and 2018 respectively. Higher values of MNDWI represent waterbodies and lower values indicate other features. The maps of MNDWI 2008 and 2018

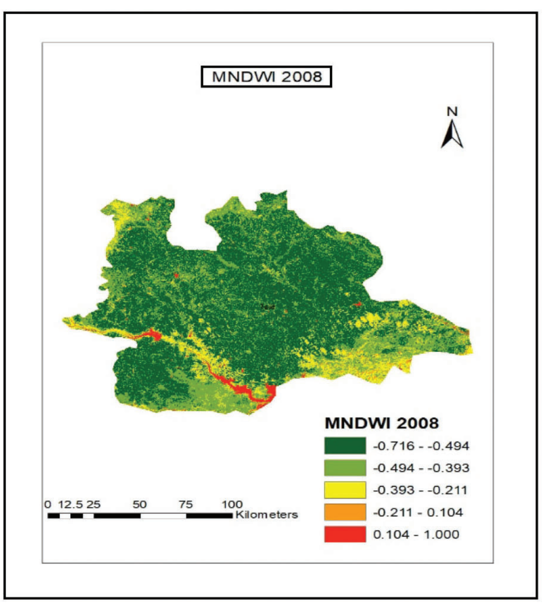


Fig. 3. Map showing MNDWI 2008

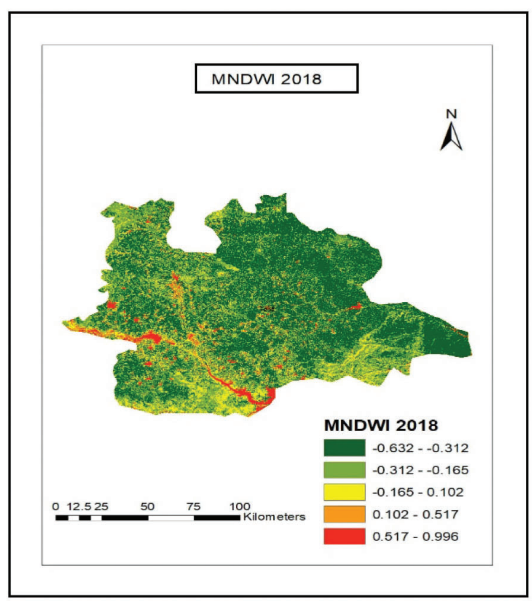


Fig. 4. Map showing MNDWI 2018

are shown in figures 3 and 4 respectively.According to this technique, the area of water bodies in 2018 is 362.61 square kilometers and 322.64 square kilometers in 2008.

Using the support vector machine (SVM) technique we have to train the classifier such that it knows the pixel values of different classes. By this technique, the area of water bodies in 2018 is 395.72 square kilometers and 368.17 square kilometers in 2008. Accuracy assessment of the classified image and MNDWI image has been performed by creating 1500 points through google Earth, the results are given below in Table 2.The area of water bodies through the MNDWI and SVM technique is shown in Table 3.

The classified images using the SVM technique of 2018 and 2008 are shown in Fig 5 and Fig 6 respectively.

The final images of waterbodies of Mahbubnagar district of 2008 and 2018 using the MNDWI technique are shown in Fig 7 and Fig 8 respectively.

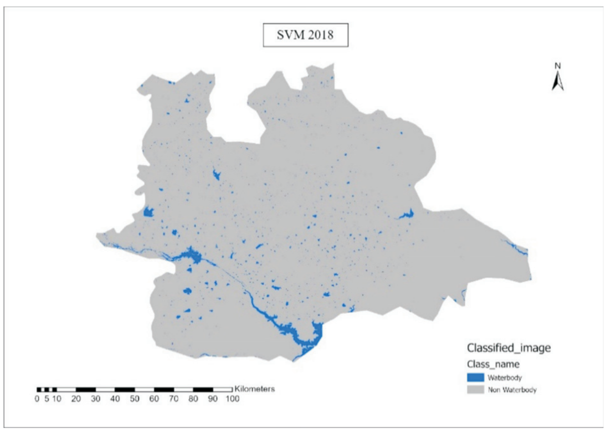


Fig. 5. The classified image of waterbodies (the year 2018)

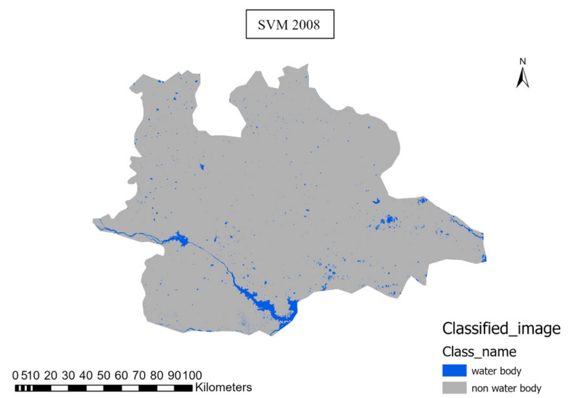


Fig. 6. The classified image of waterbodies (the year 2008)

Fig. 7. Waterbodies in Mahbubnagar in 2008 using MNDWI

Table 2. Accuracy assessment

	2018		2008	
	MNDWI	SVM	MNDWI	SVM
Users' Accuracy	0.89	0.96	0.88	0.94
Producer's Accuracy	0.87	0.95	0.86	0.93
Kappa Index	0.86	0.91	0.85	0.89

Table 3. Area of Waterbodies

Technique	Area of water bodies in 2008 (sq.km)	Area of water bodies in 2018 (sq.km)
Modified Normalized Difference Water Index	322.64	362.61
Support Vector Machine	368.17	395.72

Fig. 8. Waterbodies in Mahbubnagar in 2018 using MNDWI

Conclusion

The study area is one of the fast-developing regions in Telangana, India. Traditional methods are very time-consuming when it comes to quantifying spatial and temporal phenomena, so multi-temporal satellite imagery comes in handy. The study reveals that there is a huge increase in the area of water bodies due to sustainable water development projects by the Telangana government. The study also clearly indicates that there are good chances of groundwater recharge due to the increase of reservoirs and reclamation of waterbodies in the study area. The perennial rivers Krishna and Tungabhadra are the major sources of water in the study area.The study highlighted the use of remote sensing techniques in extracting the waterbodies easily compared to conventional surveying techniques. And Support Vector Machine model is highly accurate compared to Modified Normalized Difference Water Index (MNDWI).

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