DETECTION OF SPATIOTEMPORAL CHANGES IN PALAR - PORUNDALAR DAM, DINDIGUL DISTRICT, TAMIL NADU, INDIA USING GEOMATICS TECHNOLOGIES

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Abstract: ***Water is an essential natural resource which indicates the economic growth of a region along with its various sustainable development plans. However, the rapid development on demographic, economic, and technological trends results in demolishing the favorable environment condition for water availability and results it scarcity. Though, the global warming condition and the anthropogenic activities affects the climatic conditions, the natural water resources and its sustainability need to maintain for future generations. The impacts of global warming, climate change and manmade activities affects water resource availability and its quality. It is mandatory to monitor the water resources in order to manage the resource. So, it is important to detect the surface water bodies and to analyze the Spatio-temporal changes of water bodies. It helps to provide sustainable development plans in water resource management. In the recent researches, remote sensing is one of the cost effective technology which used to detect and analyze the changes of spatial features and also to monitor the natural resources present on the earth surface. The study area chosen for the analysis is the Palar-Porundalar Dam which is the largest water body present in Palani Taluk, Dindigul District, Tamil Nadu, India. The present study, strives to detect the water spread of the Palar-Porundalar Dam for the years 1997, 2009 and 2021 using multi temporal satellite images with the help of Normalized Difference Water Index (NDWI) and to identify the changes over the above said periods. The result indicates that for the year 1997 the surface water spread detected upto 4.84 sqkm, for the year 2009 the surface water spread detected upto 4.81 sqkm and in the year 2021 the surface water spread detected upto 4.88 sqkm. Finally, the validation of the result carried out using accuracy assessment method manually by using kappa coefficient formula. The validation result indicates that there is 85.08% of the match detected among the classified and the reference data. The overall accuracy is 92.59%.***

Keywords: Open water change detection, NDWI, Remote Sensing, GIS.

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I. INTRODUCTION

In many sectors, like hydrological studies, development of eco-system, managing the temperature changes and related socio-economic evolution one of the most important phenomena is surface water resource. Due to the growth of population, industrialization and urbanization take turns severely. To ascertain the availability of natural resources for the future aspect, mapping and monitoring surface water resources in high resolution is a prerequisite. It was the primary resource essential for humankind for drinking, farming activities, animal husbandry, floods, drought, and other commercial purposes [1].

To constantly monitor the surface water regarding its managerial aspects, it has two methods to obtain the data; the conventional detailed field survey method next is the Remote Sensing technique. The traditional survey method requires workforce, time-consuming and insufficient data for the extensive coverage. Rather than going for the former way, the remote sensing method gives accurate data and fetches enormous spatial range and temporal resolution. It has become a predominant data source in the research and industrial aspect. The data obtained through the remote sensing method helps to delineate the surface water cover and its change detection. Its supremacy is significant area coverage, enriched information, accurate measurements, rapid data collection, constant speed, and cost-effective facilities made the task easier.

Although various satellite imageries are available commercially, the moderate spectral resolution, Spatio-temporal data availability, and sensitive response to the surface water characteristics of the remotely sensed data like LANDSAT series of imageries play a vital role in surface water extraction [10]. In the desegregated resource investigation, the latest developmental procedures in remote sensing and GIS provide various dimensions to analyze the process efficiently. Since most reliable and precise information on natural resources is obtained through satellite remote sensing technology. Therefore, it is essential for organized and stabilized development at a watershed level. The unique spectral characteristics of water bodies in the visible and infrared bands help effectively detect and delineate the water bodies. It is significant to identify waterbodies efficiently based on the index and threshold-based approach [18].

McFeeters [21] introduced the NDWI method for extracting the water surface features from various LANDSAT series satellite images based on the normalized relationship among the reflection in Green and Near Infrared (NIR) ranges in the electromagnetic spectrum. The below equation help to derive the NDWI map [23].

NDWI = (Green – NIR) / (Green + NIR)

An earlier study conducted in 2014 indicates, among NDWI, MNDWI, NDMI, WRI, NDVI, and AWEI surface water extraction methods, NDWI gives the best result [23]. The threshold values of land and water indicators of NDWI used in the study are (i) < 0.3 - Non-water, (ii) >= 0.3 - Water.

The main aim of this study is to detect the surface water changes of Palar-Porundalar Dam, Palani Taluk, Dindigul District, Tamil Nadu, India. For 1997, 2009, and 2021 the LANDSAT series of satellite images used in the change analyses, which was carried out based on land and water threshold values on the Normalized Difference Water Index (NDWI) to extract the study area's surface water level. The major objectives of the study are to,

1. preprocess the satellite images using ERDAS Imagine software,

2. extraction of surface water using NDWI method carried out based on the Land-Water threshold values for Palar - Porundalar Dam using ArcGIS platform,

3. detect the surface water changes for the years 1997, 2009 and 2021,

4. Validating the classified image with reference to the toposheet derived waterbody for the study area by calculating kappa coefficient value.

TABLE I. PARAMETERS TAKEN DURING SIMULATION

LANDSAT & Sensor	Acquisition Date	Wavelength (µm)	Bands	Resolution in (m)
LANDS AT 5, TM	05-02-1997, 12-01-2009	0.5 – 0.6	Band 1 - Green	30
		0.8 – 1.1	Band 4 - NIR	30
LANDS AT 8, OLI	07-02-2021	0.525 – 0.6	Band 3 - Green	30
		0.845 – 0.885	Band 5 - NIR	30
SRTM DEM	02-12-2000			30

II. STUDY AREA

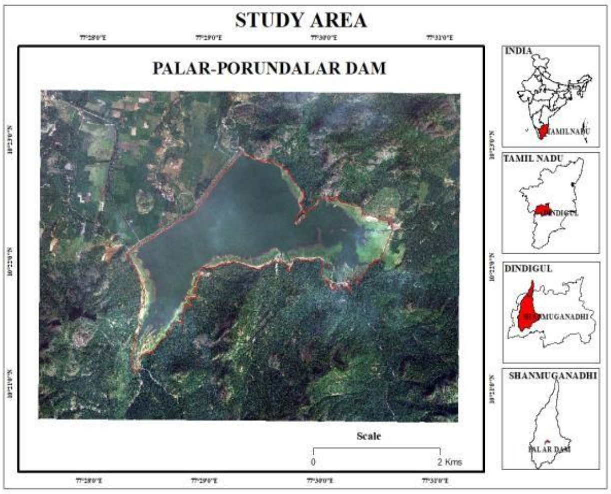

Fig. 1. Study Area

The study area chosen the present study is Palar-Porundalar Dam, situated over Palar and Porundalar rivers at Palani Taluk, Dindigul District, Tamil Nadu, India. It is 2450 meters long and 65 feet tall. It is the biggest dam in Dindigul District. The geological extent of the dam is located between 77°28´E to 77°29´E latitude and between 10°21´N to 10°22´N longitude. The dam is situated 10Km near the Palani town, and over 17,000 acres of agricultural land benefited from this dam water. The study area map showed in Fig.1.

III. MATERIALS AND METHODS

A. Data Used: The USGS website help to download the LANDSAT TM and OLI sensor satellite images for 1997, 2009, and 2021. The SAS planet software provides google earth high definition images for the study area for reference purposes. SRTM DEM data 1 arcsec derived from USGS website for generating drainage map for the study area. The Survey of India website provides the toposheet of the study area for reference purposes. The data was obtained for the post-monsoon period to analyze the present study efficiently.

B. Software Used: The preprocessing works viz., Geometric corrections and radiometric corrections, mosaicking, and subsetting, has been completed using ERDAS Imagine software, and extraction of water bodies using NDWI band calculations performed using Map algebra, integration of layers, visual interpretations, and layout preparations were completed using ArcGIS software. Used SAS Planet software to download the Google earth Image for the study area.

C. Methodology: The USGS website provides the satellite images; with the help of ERDAS IMAGINE software, the preprocessing works like geometric and radiometric corrections, mosaicking, and subsetting works well-performed. The NDWI index was calculated using Raster Calculation in the ArcGIS platform. Based on the land–water threshold value, water bodies are delineated from NDWI images. Using the Google earth images, manual digitization of the dam was carried out using the visual interpretation method to calculate the area. Also, for validation purposes, water bodies from the Shanmuganadhi watershed were digitized manually using a toposheet reference map. Used the NDWI reclassified images to extract the dam using the raster to vector conversion tool. Then the changes in surface water area spread for 1997, 2009, and 2021 were calculated based on map integration method and analysed.

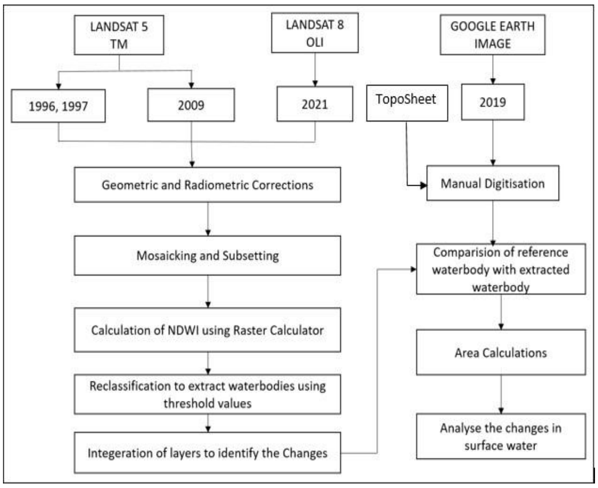

Fig. 2. Flowchart of Methodology

D. Accuracy Assessment: For validating the NDWI classification result, analyzed the recent year 2021 NDWI map generated for the Shanmuganadhi watershed with the toposheet reference along with the Google earth image. Performed the accuracy assessment based on the 80 random ground control points generated using the ArcGIS platform. Finally, based on the user accuracy, producer accuracy, overall accuracy, and the Kappa Co-efficient value, checked accuracy. The formulas are,

$$Overall\ Accuracy = \frac{Total\ no.of\ correctly\ classified\ pixels}{Total\ no.of\ reference\ pixels} * 100$$

$$User\ Accuracy = \frac{No.of\ correctly\ classified\ pixels\ in\ each\ category}{Total\ no.of\ classified\ pixels\ in\ that\ category} * 100$$

$$Producer\ Accuracy = \frac{Total\ no.of\ correctly\ classified\ pixels\ in\ that\ category}{Total\ no.of\ reference\ pixels\ in\ that\ category} * 100$$

$$Kappa\ Coefficient = \frac{(TS * TCS) - \sum(Column\ Total * \ Row\ Total)}{(TS * TS) - \sum(Column\ Total * \ Row\ Total)}$$

IV. RESULTS AND DISCUSSION

The present study attempts to detect the surface water spread changes of Palar-Porundhalar dam using multi-temporal satellite images for the years 1997, 2009, and 2021 which reside in Palani Taluk, Dindigul District. The study used the conventional threshold method to detect the water bodies from the satellite images based on Normalized Differential Water Index (NDWI). For all three years, 1997, 2009, and 2021 obtained the NDWI classification results and detected the surface water spread changes using the vector overlay method. Figures.2, 3, & 4 show the NDWI results. Fig. 5 shows the change detection map.

Fig. 3, representing the 1997 classified NDWI map indicates that when compared to the reference dam area, the surface water spread detected lesser than the total area, particularly in South Eastern and South Western side of the dam was not occupied by water.

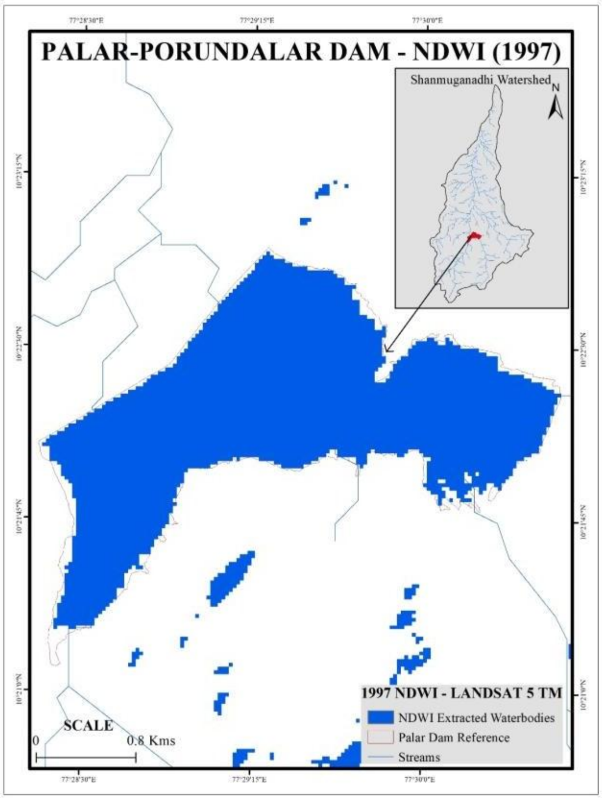

Fig. 3. NDWI Classified Image - 1997

Fig. 4 shows the 2009 NDWI classified map, which indicates a reduction in surface water compared to the total reference area of the dam. In the Eastern part of the dam and the South-East part of the dam, reduced water. Also, decrement was identified in the Western and South West region water surface.

Fig. 5 shows that there is 4.88 sq km open water surface area detected in the year 2021.

Using SAS planet software, obtained the dam's high-definition Google Earth image. Based on the visual interpretation method, the reference data of the dam was generated by a manual digitization process.

Using the vector overlay analysis change detection was carried out, and the water spread change map for 1997, 2009, and 2021 was prepared using the map integration technique, shown in Fig. 5.

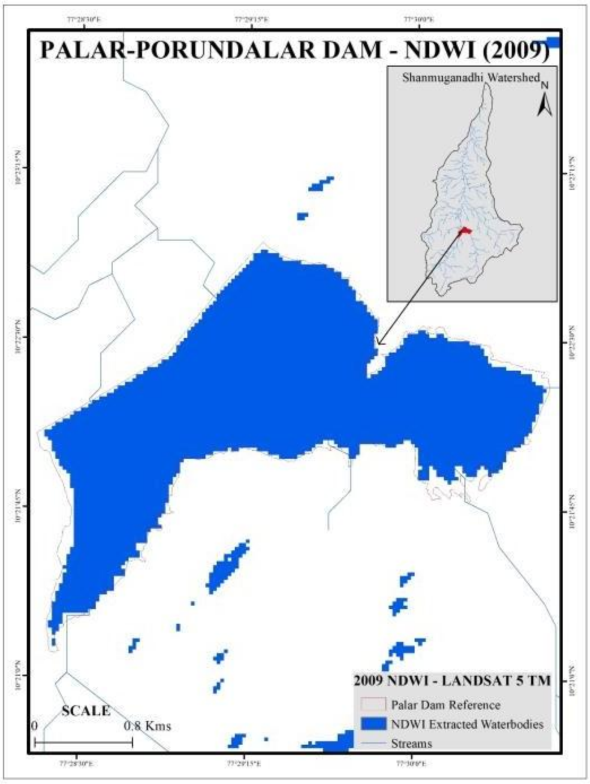

Fig. 4. NDWI Classified Image – 2009

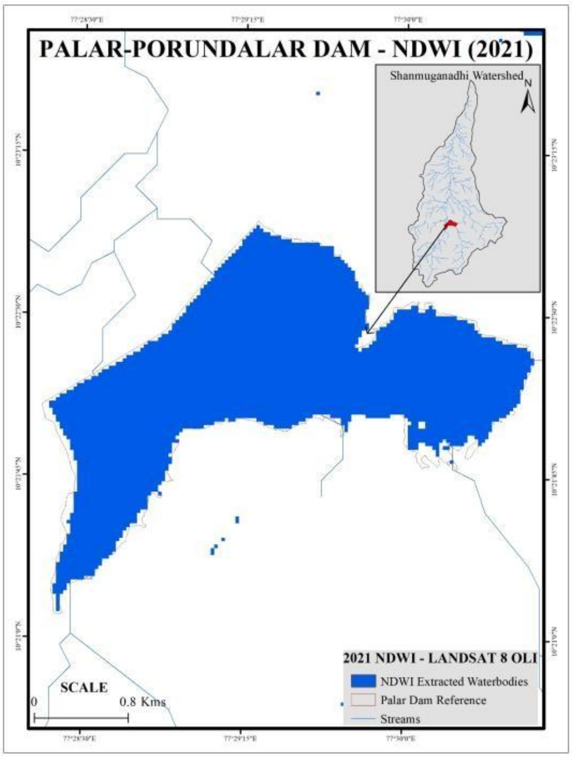

Fig. 5. NDWI Classified Image – 2021

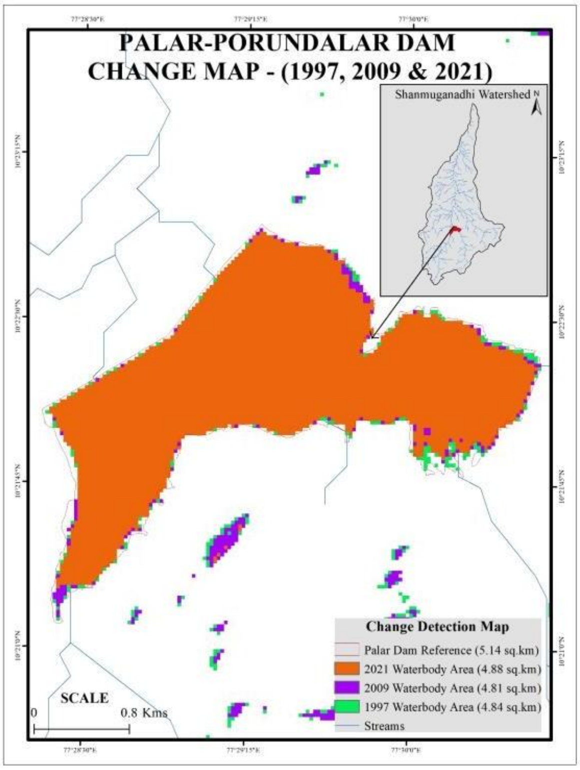

Fig. 6. NDWI Classified Image (Change Map) – 2021

The result indicates that the surface water changes indicate that for the year 1997, the detected area is 4.84sq.km, for the year 2009, the surface water area spread seen 4.81 sqkm, and for the year 2021, the surface water area detected is 4.88 sqkm. Used the digitized toposheet reference data to validate the NDWI classification of the Shanmuganadhi watershed. That is shown in Figure.7.

The Figure. 8. Represents the area specification of the reference and NDWI derived water surface changes. The result shows that compared to the reference data, in the year 2009, the surface water spread area reduced up to 4.81 sqkm. In 1997, changes detected up to 4.84 sqkm water spread area. Whereas, in the year 2021, changes detected up to 4.88 sqkm. The reference data indicates that the total area of the dam is 5.14 sqkm.

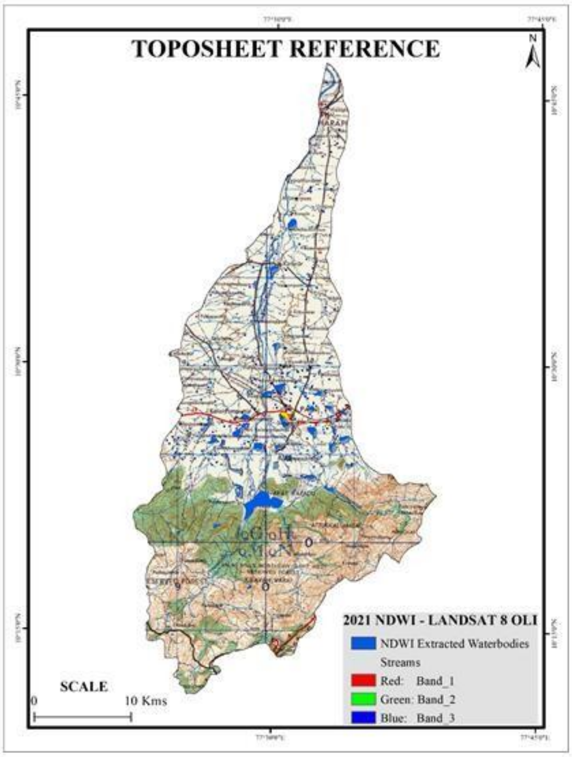

Fig. 7. Toposheet Reference Map Overlaid with NDWI -2021 Map

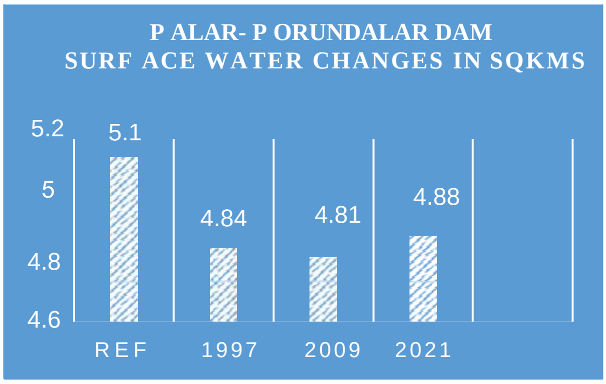

Fig. 8. Area specification of water surface changes

Validation of the Result: 80 random ground control points were generated within the study area concerning the points raster values extracted for the reference image. For the identical ground control points, extracted raster values for the 2021 NDWI image and accuracy assessments were carried out using the formulas. The validation result indicates that the classified and reference images were coherent. The overall accuracy obtained was 92.59%, and the kappa coefficient value is 0.85, showing an almost perfect match.

TABLE II: ACCURACY ASSESSMENT

Accuracy Assessment for 2021 NDWI and Toposheet Reference Map						
	User Accuracy		**Producer Accuracy**		**Overall Accuracy**	**Kappa Coefficient value**
NDWI 2021 & Reference data	Waterbody	Others	Waterbody	Others	92.59 %	0.85
	95.35%	89.47%	91.11%	94.44 %		

II. CONCLUSION

The present study attempt to detect open surface water changes for the Palar-Porundalar dam residing in Palani Taluk, Dindigul District. Change detection was carried out using Multi-temporal satellite imageries with the help of the NDWI index method. The changes were calculated using the vector overlay technique. The open water surface area changes were estimated for 1997, 2009, and 2021. The results respectively are 4.84 sqkm, 4.81 sqkm, and 4.88 sqkm. Using the toposheet-derived reference data and the Google earth reference, the classified image of 2021 was validated. The kappa coefficient value indicates an 85.08% match between the reference and classified image. Therefore, the study clearly shows that Remote Sensing and GIS technology efficiently delineate natural resources. The multi-temporal data accessing facility in Remotely Sensed data can also help detect the changes over time.

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