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# Flood Risk Assessment in Chennai Metropolitan Area using Remote Sensing and GIS

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## Abstract

Given the increase in flood events in recent years, accurate flood risk management and assessment is an important component of flood mitigation in urban areas. Floods represent the most frequent and expensive natural disaster affecting most of the countries around the world. They take place when the river exceeds its storage capacity and the water excess overflows the banks and fills the adjacent low-lying lands, producing significant social, economic, and environmental impacts, including: loss of human life and negative effects on population, damage to the infrastructure and essential services, damage to crops and animals, spread of diseases, and contamination of the water supply. Landsat and multispectral imageries provide reliable and accurate data for the detection of changes in the areal extents of surface water bodies in Chennai and its surrounding areas were conducted through water extraction techniques by using indexes, such as WRI, NDWI and MNDWI using GIS software.

**Keywords:** Open Source; Survey of India; Chennai, Disaster Management, Landsat Imagery, MNDWI, NDWI, Remote Sensing and GIS, Surface Water Bodies, Urban Planning, Water Extraction Techniques, WRI.

## 1. Introduction

network of rivers, ponds and lakes. These surface water bodies have since time immemorial served as sources for the irrigation and domestic needs of the population around them. Water resources management, and use and hydrology are important for human beings and are critical for their survival. The GIS layers such as Utility points layer and Road network layers help us to Rescue and Rehabilitate the flood victims and the changes in the surface water bodies were estimated by analyzing and using Landsat images for the pre- and post-monsoon. The changes and their variations in the indexes and the interpretation of these changes are discussed. Urban planners can utilize these results for better planning and disaster management.

## 2. Materials and methodology

### 2.1 Materials used for the project

- Shape file of the study area with administrative boundaries.
- Shape file of the boundary of the study area file.
- Shape files of the study are utility points of the study area.
- Shape file of the Road network of the study area.

- The Landsat satellite images of (Pre & Post flood) of the study area.
- GIS software (QGIS/ArcGIS).

### 2.2 Methodology

- Image Downloading using USGS earth Explorer: One of the sources is Earth Explorer <https://earthexplorer.usgs.gov/> user has to register to login and to download the data. Click **Login** in the next screen enter registered name and password to login if not registered click on **Create New Account** and follow the screen instruction. If you already have an account, then sign in.
- Here you will see search criteria tab on your left-hand side, select it. Enter the coordinates of Area of interest to select the area as shown below:



By adding the coordinates of Area of Interest (AOI), can search for the image of AOI

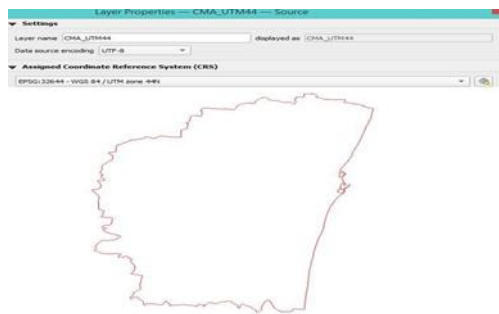


Now, in the same **Search** tab click on **Date Range** and select the appropriate date range, after that click on **Cloud Cover** and set the value to less than 10%. Now click on the Data **Sets** tab and select **Landsat**

**Landsat Collection 1 Level-1** check on Landsat 8 OLI/TIRS c1 Level-1.



Now, to view the imprint click on **Show Footprint** icon and to download the data click on **Download options** icon. Then the following screen displays. Converting the GCS WGS 84 projections to PCS UTM 44N ZONE projections:

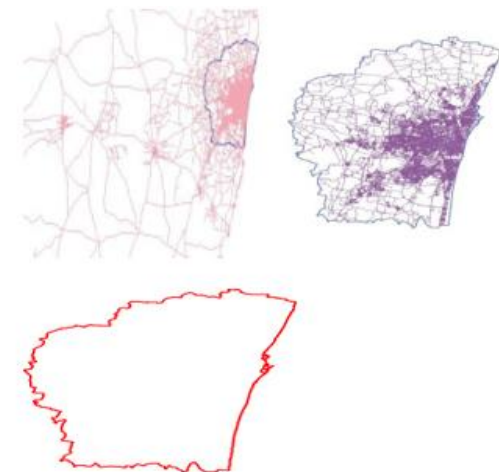


The source file of Chennai Metropolitan Area is in UTM 44 N Projection. All the download files are to be brought from GCS WGS 84 to UTM 44 N Projection using tools in any of the GIS software.

**Mask/Clip all the layers for study area:**

Invoke GIS Software (QGIS) → Layer→Add Layer→Add Vector Layer→Add the **CMA\_CHENNAI\_UTM44** layer and also add the layer **tamil\_nadu\_highway\_utm.shp** to be clip.

Now the canvas or data frame looks like below:



From USGS earth explorer was pre- processed before deriving the water index. In this process two stages are involved.

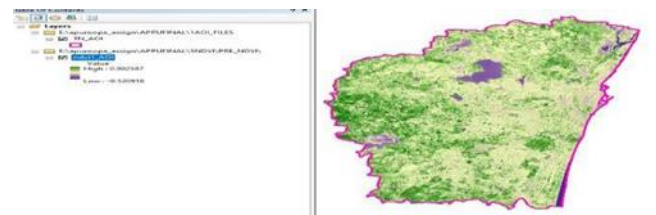
- The image was converted from a digital number (DN) to a top-of-atmosphere (TOA) reflectance value.
- Apply solar zenith correction to the reflectance band (output of the 1 above).
- Before proceeding for image pre-processing, let us know what Landsat 8 Multiband indexes used for water feature extraction from the below table:

Multiband index	Equation	Remarks
NDVI	$NDVI = (NIR - Red) / (NIR + Red)$	Water with negative value
NDWI	$NDWI = (Green - NIR) / (Green + NIR)$	Water with positive value
MNDWI	$MNDWI = (Green - SWIR1) / (Green + SWIR1)$	Water with positive value
WRI	$WRI = (Green + Red) / (NIR + SWIR1)$	Water feature value is greater than 1
SWI	$SWI = 1 / \sqrt{(Blue - SWIR1)}$	Water feature value is less than 5

**The Normalized Difference Vegetation Index NDVI:**  
The Normalized Difference Vegetation Index is called NDVI is constructed from the red band and near Infra-Red (NIR). The standardized vegetation index emphasizes the difference between the visible band of Red and that of the near Infra-Red. This index is sensitive to the vigor and quantity of Vegetation.

$$NDVI = (NIR-R)/(NIR+R) = (B5-B4)/(B5+B4)$$

$$Float("band5scb" - "band4scb") / Float("band5scb" + "band4scb")$$



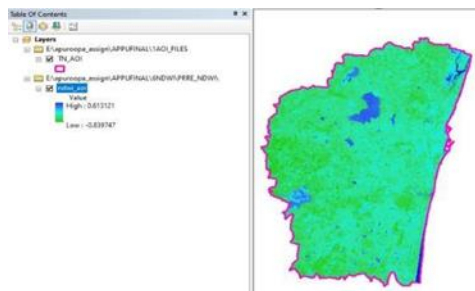
Click **OK** to get **Pre-flood\_ndvi** (ndvi291015) is created. Similarly create **Post flood\_ndvi** (ndvi141115) layers.

**The Normalized Difference Water Index NDWI:**

The Normalized Difference Water Index is called NDWI. The NDWI takes advantage of the fact that water has a high reflectance in the green band while it has strong absorptions in the Near Infra-Red bands. Therefore, it is based on the ratio. NDWI is an analogy of NDVI but for water. A higher NDWI denotes water and lower non-water features.

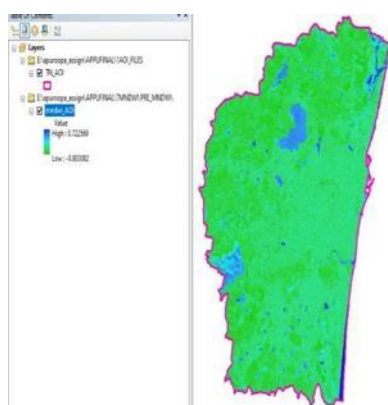
$$NDWI = (GREEN-NIR) / (GREEN+NIR) = (B3-B5) / (B3+B5)$$

$$Float("band scb" - "band 5cb") / Float("band scb" + "band 5cb")$$



**Modified Normalized Difference Water Index**  
**MNDWI:** The Modified Normalized Difference Water Index is called MNDWI

$$MNDWI = \frac{(GREEN-SWIR1)}{(GREEN+SWIR1)} = \frac{(Band\ 3 - Band\ 6)}{(Band\ 3 + Band\ 6)}$$

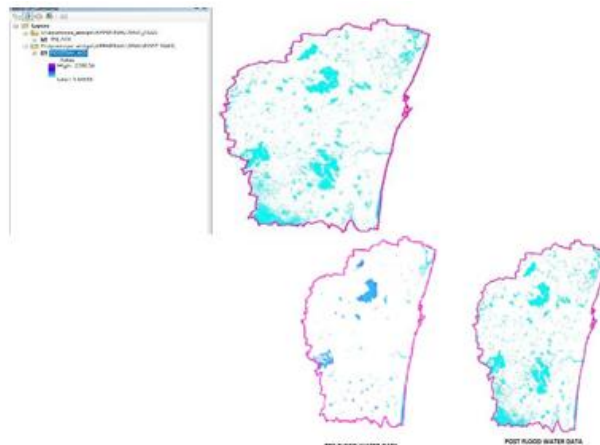
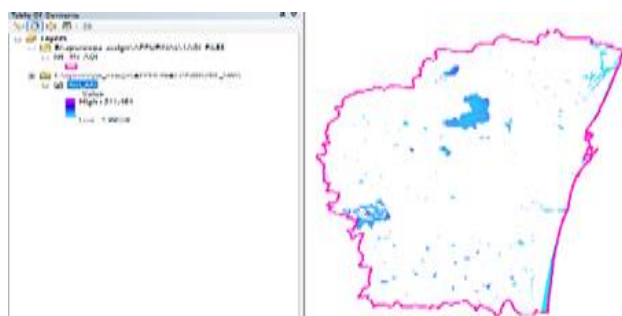


**Simple water Index(SWI):** Simple Water Index (SWI) for surface water extraction, and their changes using Landsat images. SWI is good for stagnant lakes but not for water bodies with shifting features. The model can be very useful in quickly understanding the changes in water bodies and taking the necessary measures to planners, but not much in accurate mapping.

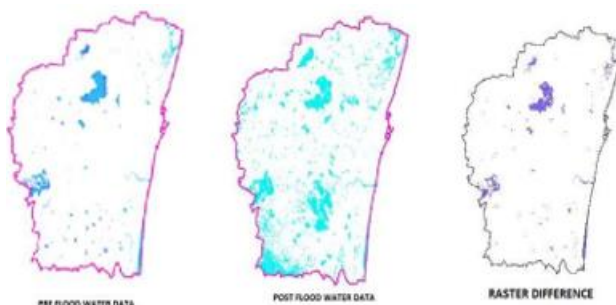
Simple Water Index (SWI) method, in which vegetation pixels with negative values are suppressed automatically (nullified), whereas water pixels are enhanced, and differentiation requires no threshold determination or input.

$$SWI = \frac{(1)}{(\sqrt{(BLUE-SWIR1)})} = \frac{(1)}{(\sqrt{(BAND2-BAND6)})}$$

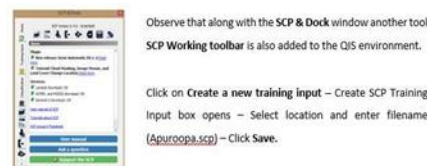
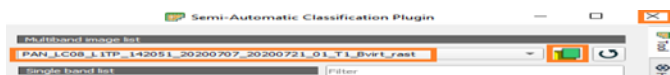
$$Float((1) / Float( (Square\ Root(Float("band2scb" - "band\ scb")))))$$



From the study it is clearly evident that to know water stagnant areas SWI is very much useful, and by making difference in pre and post flood SWI images we are able to identify the water stagnated areas due to flood.



**Image classification in QGIS:** Add \*.vrt layer to the QGIS canvas by SCP → Bandset→Select Bvirt\_rast file and close.



check on the SCP Dock panel --? Also check on for SCP working toolbar→

- 1) Now from SCP working toolbar - Select Create a ROI polygon and digitize a polygon of a particular classification (example water area) goon placing data till the last but one vertex and right click to close the polygon.



Click on **training input - ROI Signature list** - Now at the bottom of the SCP & Dock enter **MC ID, MC Info, C ID, C Info (for first polygon MC ID 1, C ID 1, MC INFO WATER, C INFOR LAKE WATER)** as per the knowledge of image identification, and click on **Save temporary ROI to training input** (icon at lower right of the box). Now the drawn polygon disappears, and a row is added to the ROI Signature list with the specified parameters. One can change the Color (to

select color double tap, color table opens and select the color to display).



- Draw another feature polygon and repeat step 15. Similarly draw other features.
- At the end, select all the rows (click on No.1 and press shift button and click on Last number in this case it is 5) and click on **calculate signatures for highlighted items** a message appears, click **Yes** and wait till the process completes.

Now, to check the classification preview, in the **SCP**



Simple water stagnated areas shortest route to the affected area

### Conclusion and Future Scope

#### Conclusion:

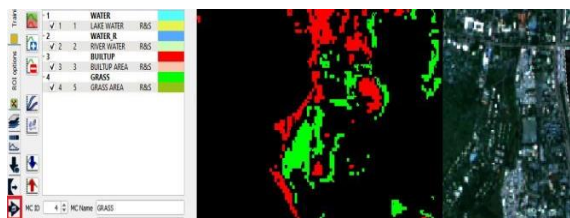
1. The classification of the area in respect of pre-flood water and post flood water Areas are identified out rescue operations using other GIS vector files. An evaluation of risk based analysis on project formulation, project economic justification, & minimum engineering & safety standards. The new techniques are a significant step forward & the crop should be greatly commended in areas having lower chance of risk.

#### Future Scope:

By Image classification it is easy to find out the affected areas due to disasters such as floods, fire etc. by classification of Pre & Post disaster images. Comparison of pre disaster and post disaster classification can be used to priorly alert the risk prone areas in the future so that there would be no loss of life. Flood risk assessment using GIS has played a vital role in announcing compensations for the victim by different governments.



Activate classification **preview pointer** and **click on canvas** to get preview of classification.



- Now, the preview shows that the classification part is working well. Can proceed for classification → Click on Band Processing icon on SCP Dock window (shown in above figure)
- Semi-Automatic Classification Plugin – Classification tab

Select the appropriate algorithm (in this case Minimum Distance is used)

- and check on the boxes shown in the below image.
- To limit the classified raster to the AOI (CMA\_CHENNAI), Apply Mask and select the mask layer in this case it is CMA\_CHENNAI\_UTM44.shp click **Run**. Prompts for folder and \*.tif file name.
- The report \*.csv (in this case CMA\_CLASS\_report.csv) can be opened in excel in a table format.



Pre-flood data with admin boundaries post flood data with admin boundaries

- Similar classification is done with post flood data.
- By comparing these two i.e, pre flood and post flood data, water stagnated areas can be identified.

### References

Potential flood hazard assessment by integration of ALOS PALSAR and ASTER GDEM: a case study for the Hoa Chau commune, Hoa Vang district, in central Vietnam Do Thi Viet Huong,\* and Ryota Nagasawa, 2014, vol 8, pp.9 [https://www.researchgate.net/publication/286320988\\_Flood\\_risk\\_assessment\\_and\\_mapping\\_using\\_re](https://www.researchgate.net/publication/286320988_Flood_risk_assessment_and_mapping_using_remote_sensing_data)

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