Surface Water Area Detection And Extraction By Using Different Techniques Of Remote Sensing And GIS.

Akshay Kshirsagar[1*], Ratnadeep R Deshmukh[2]

[1*]Research fellow Department of Computer Science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. Email: akshay.8kshirsagar@gmail.com
[2] Professor, Department of Computer Science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. Email: rrdeshmukh.csit@bamu.ac.in,

***Corresponding Author:** Akshay Kshirsagar
*Research fellow Department of Computer Science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. Email: akshay.8kshirsagar@gmail.com

Abstract
Jayakwadi dam built in 1976, is located in Jayakwadi village in Paithan taluka of Chhatrapati Smbhaji Nagar district in Maharashtra, India. Monitoring the surface water area of Jayakwadi Dam is important task because the main purpose of dam water is for drinking water as well as supply to industrial area for Chhatrapati Sambhaji Nagar city people and irrigation. The surface water area can be easily estimated with the help of satellite imagery and remote sensing and GIS technique. The data used to estimate surface water area is Landsat-8 satellite multispectral data. Landsat-8 has resolution of 30 Meter. We used mainly data of 8 Years from 2014 to 2022. NDWI and Maximum likelihood classification technique to estimate surface water area. As compare to maximum likelihood classification, NDWI and water pixel extraction is more accurately calculate the surface area of water reservoir. In this paper the maximum likelihood classification as well as NDWI method comparatively used to find out the surface water area by satellite image.

Keyword: List of keyword accepted by authors through their work: Remote Sensing, Water Quantity, Surface Water Area, NDWI, Maximum likelihood classification.

1. Introduction

Water is one of the supreme element from five basic elements. The five basic elements are water, earth, fire, air and space. The chemical formula of water is H_2O and it shows that each molecule contains two hydrogen and one oxygen [1]. Water is important for human body as well as to survival.

Water management, including storage, supply infrastructure, and treatment, is thus becoming increasingly crucial, especially in heavily urbanized environments [2]. Water is mainly store in reservoir, Reservoir is an open-air storage area (often built by masonry or earthwork) where water is gathered and stored in sufficient quantities to be drawn off for consumption and Reservoirs ordinarily are formed by the construction of dams across rivers [3]. To manage the demand of water for farms, city and industrial area the reservoir can help. The area of reservoir can be in square kilometer. It is very difficult to know the status of water. To know the status of water many technique are available that technique are by water level sensors, remote sensing and geographical information system. The remote sensing and geographic information system is easy and cheapest way to detect and extract water surface area. The water scarcity is major problem in Marathwada region of Maharashtra, India. Chhatrapati Sambhaji Nagar, Jalna, Parbhani and Nanded of Marathwada region is totally depend on Jayakwadi dam for water. According to need of Chhatrapati Sambhaji Nagar City, Industrial area and farmer water management is crucial task. To manage the water it is important to know the water level of Jayakwadi dam. There is traditional methods are available to find out the water level of Jayakwadi dam but with the help of satellite images and GIS technique it is also possible to find out surface water area. The active sensor and passive sensor both are used to identify water body. The surface water area estimation of remote location can be easily possible with the help of remote sensing and GIS.

2. Materials and Methods

A. Study Area:

Jayakwadi Dam, built between 1965 and 1976, is located in Jayakwadi village, Paithan taluka, Chhatrapati Smbhaji Nagar district, Maharashtra, India. The lake has a surface area of roughly 350 km2, a height of 40.30 m, and a length of 9998 km. The Jayakwadi dam was developed to irrigate agricultural area in the state's drought-prone Marathwada region. Jayakwadi is one of Asia's longest earthen dams. The total reservoir storage capacity is 102.74 Tmc. The dam has a total catchment area of 21,750 km2. The dam has 27 water gates and is also known as the Nathsagar Dam [4], as shown in Figure 1. The primary goal was to irrigate land for agriculture in the drought-prone Marathwada area; however, another essential goal was to provide water for drinking and industrial use to adjacent cities and villages. 80% of the dam's water is used for irrigation, 5-7% for drinking water, and the remainder for industrial purposes. The yearly rainfall is around

726mm [5].

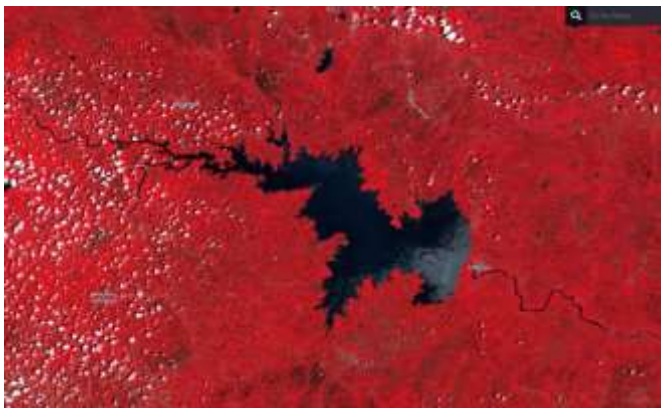


Fig:1 Study Area Jayakwadi DAM.

B. Data Set:

1) Landsat-8

The band names for Landsat-8 data are Band-2 Blue, Band-3 Green, Band-4 Red, and Band-5 NIR, Band-6 SWIR-1, and Band-7 SWIR-2 OF TWO 30 meter resolutions. Thermal band has a resolution of 60 meters, whilst the panchromatic band has a resolution of 15 meters. Users launched the Landsat-8 satellite in 2013. Landsat-8 satellite has a ultra-blue band, often known as band-1, which is beneficial for coastal and aerosol investigations. Thermal bands 10 and 11 are helpful for measuring surface temperature. [6].

Table 1. Data used- Remote sensing data

Sr.No.	Sensor	Acquisition Date
1	Landsat-8	24-11-2014
2	Landsat-8	5-5-2016
3	Landsat-8	6-11-2019

C. Methods:

A) Maximum Likelihood Classification: MLC is based on two principal.

1) Cells in each class sample in the multidimensional space are regularly distributed.

2) Bayes' Therom of decision making.

$Lk=P(\frac{k}{X})=P(K)*\ P(\frac{k}{X})/P(i)*(X/i)$

Where P(k) : prior probability of class k

P(X/k) : conditional probability to observe X from class k, or probability density function

$$L_k(\mathbf{X})=\frac{1}{(2\pi)^{\frac{n}{2}}|\mathbf{\Sigma_k}|^{\frac{1}{2}}}\exp\left|-\frac{1}{2}(\mathbf{X}-\boldsymbol{\mu_k})\mathbf{\Sigma_k^{-1}}(\mathbf{X}-\boldsymbol{\mu_k})^t\right| \quad \text{.....[7]}$$

Where n: number of bands
X: image data of n bands
Lk(X) : likelihood of X belonging to class k
k : mean vector of class k
k : variance-covariance matrix of class k

The maximum likelihood classification technique uses means and covariance of signature class. Signature is class of pixels. In signature class all pixels as assign according to their class. The probability of each class is calculate to determine the pixel belong that class.

Each pixel is assigned to the class in which it is belong to default option for a priori probability weighting. A file priori option is used priori probability file. The weights score for classes are illustrate in priori file.

As shown in table 2 class 1 represent urban area by blue color where class 2 represent bare land area by pink color same way class 3 represent vegetation area by green color and class 4 represent water by red color.

Table 2. Class or Feature

Sr. No	Class	Class Color	Class Label
1	Class 1	Blue	Urban
2	Class 2	Pink	Bare land
3	Class 3	Green	Vegetation
4	Class 4	Red	Water

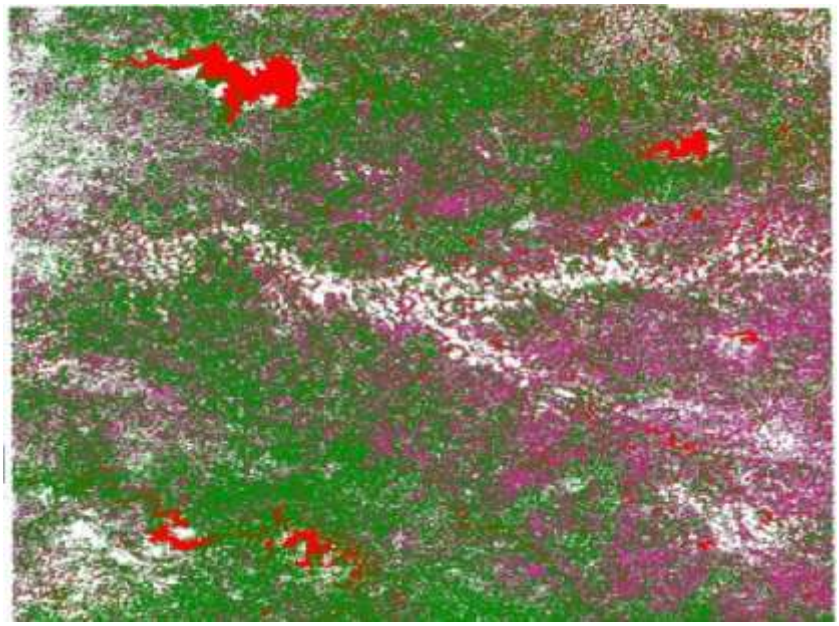


Fig.2: Maximum likelihood classification of 6 Nov 2019

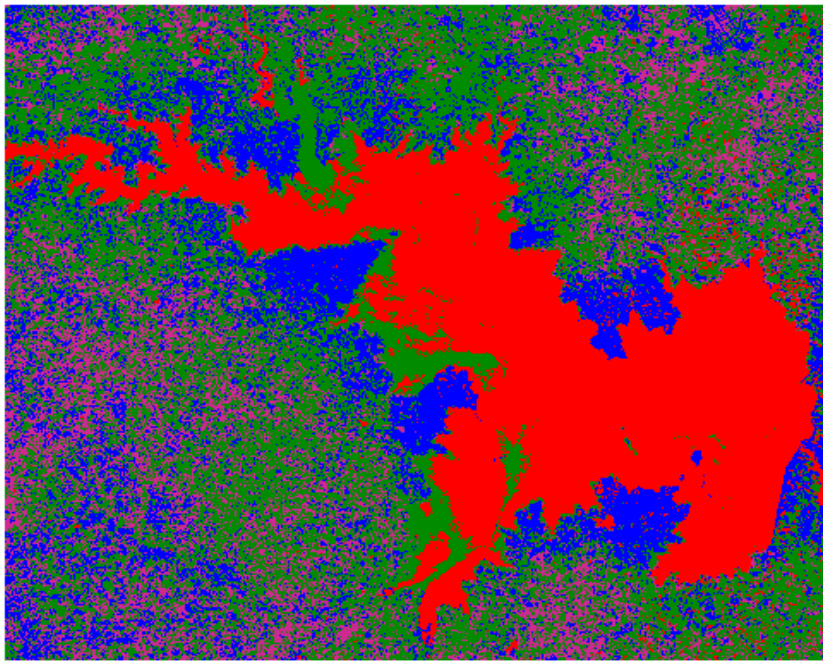


Fig.3: Clipped according to Study Area from Maximum Likelihood classification.

Table 3. Class Pixel Count

Sr. No	Class	Class Color	Class Label	Pixel Count	Surface Area
1	Class 1	Blue	Urban	282708	254.4372
2	Class 2	Pink	Bare land	261090	234.981
3	Class 3	Green	Vegetation	600564	540.5076
4	Class 4	Red	Water	373133	335.8797

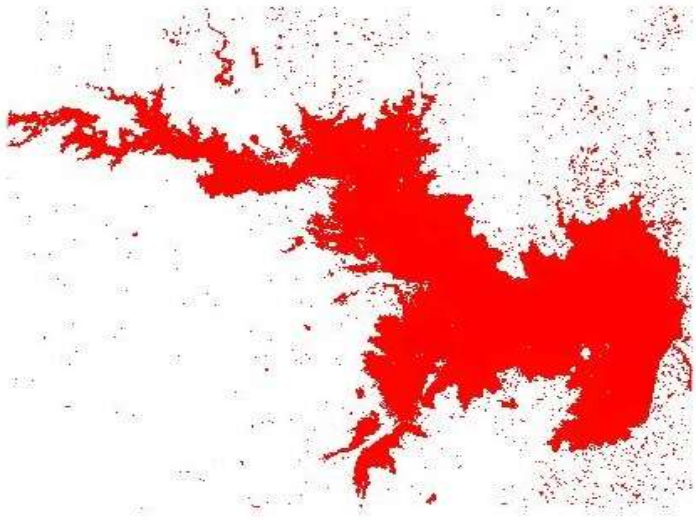


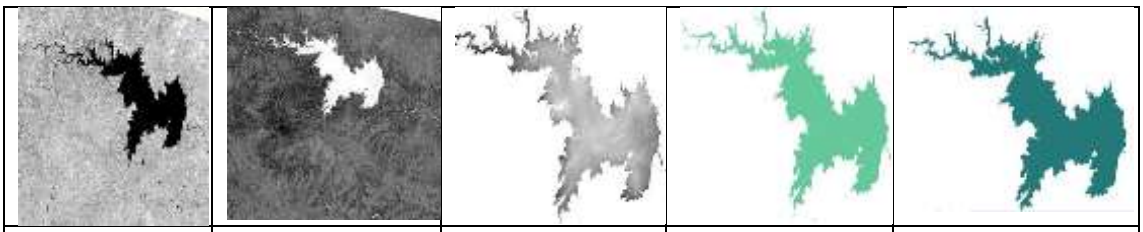
Fig.4: Water Pixel extracted according to Study Area from Maximum Likelihood classification.

The water pixel may be retrieved by applying maximum likelihood classification. We generate a layer stack of satellite images by cutting Band-2, Band-3, and Band-4, and then we choose the characteristics for the four distinct classes: Urban, Bare land, Vegetation, Water. For the class urban, we choose a minimum of 15 pixels from the satellite picture as a feature, and the same is true for bare land, vegetation, and water. Then, utilizing these characteristics, we categorize the picture using the maximum likelihood classification algorithm. Then we received the result shown in figure 3. The colors blue, green, pink, and red symbolize the urban, vegetation, and water classes, respectively. The following step involves extracting the picture as shown in fig.4. The resultant image of maximum likelihood classification clipped according to study area and then the pixel count of respective class is as shown in table 3. The total 373133 water pixels i.e. 335.8797 KM^2 surface area is shown. The landsat-8 satellite image were used for maximum likelihood classification. The landsat-8 satellite image has resolution of 30 meter.

B) NDWI and Pixel extraction:

Step 1: Band3 and Band5 of Landsat 8 Image.
Step 2: Calculate NDWI
Step 3: Extract Image by Attribute
Step 4: Reclassify Extracted Image
Step 5: Extract Image by Mask
Step 6: Count the Extracted Pixel
Step 7: Calculate Surface Area

This approach calculates the normalized differential water index of a satellite picture using bands 3 (green) and 5 (near infrared). The NDWI is a ratio indicator that measures the ratio of two bands. Then, extract the resultant NDWI picture by attribute, i.e., extract just the pixels with a value larger than one, which are all water pixels. In the following stage, reclassify the retrieved picture to distinguish between the classes. Then extract the picture via mask, i.e. using the shape file of the water reservoir. In the second final stage, count the extracted pixels from the picture. The surface area is then calculated using the ArcGIS field calculator and the resolution of the satellite picture.



Step1:Band Image of Green & NIR	Step2:NDWI Calculated	Step3:Extract by Attribute	Step4:Reclassifyed Image	Step5: Resultant Image

Fig.5 Step by Step Surface Area Calculation

3. Results and Discussion

Active and passive sensors are used to identify water resources [8]. Remote sensing and GIS give a technique for identifying rainwater collecting zones using satellite imagery [9]. In Iraq, the groundwater area has been determined using remote sensing and GIs for urbanization research and the administration of water resources. [10]. Remote sensing and

GIS are sophisticated planning tools for groundwater administration [11]. Soil information and soil texture are vital for discharge computation. The radial basis network model demonstrates a relationship between clay and soil [12].
Land use land cover supervised classification done to find out the barren soil, urban area surface water body, and farm land from satellite picture of Al-Rumba city to find out the long-term sustainability of Al Abila dam [13]. All above author shows the surface water area calculation is feasible by satellite imagery and GIS techniques.

3.1. Method A (Maximum Likelihood Classification):
With the help of Maximum likelihood classification water pixel, bare land, vegetation area, urban are pixels can be easily classified. Maximum likelihood classification work on the basis of Bayes therom and Cells in each class sample.

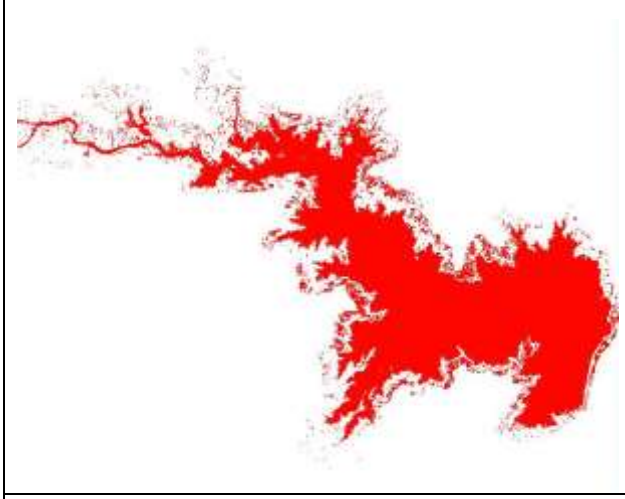


Fig:6 : 24-Nov-2014

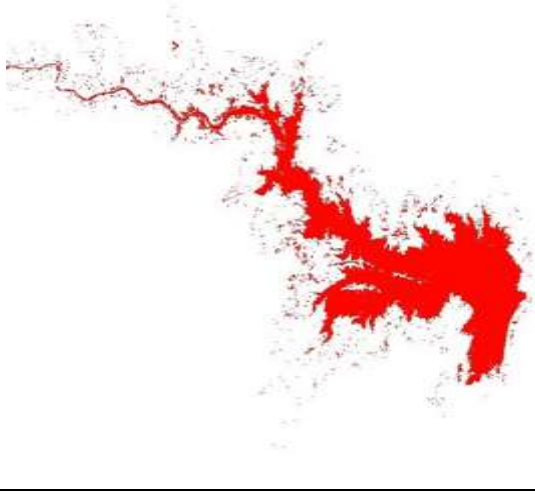


Fig:7 : 5-May-2016

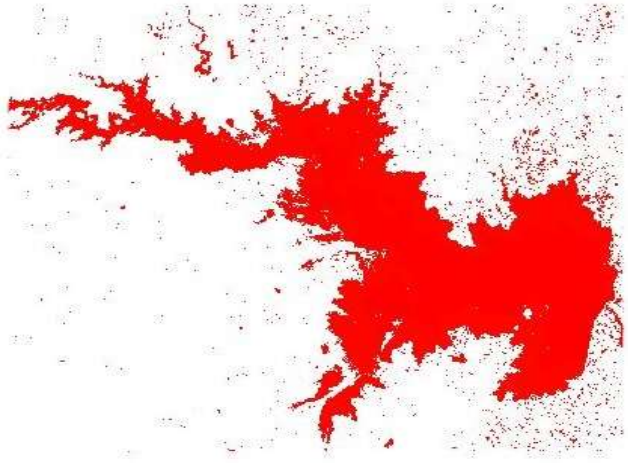


Fig.8 : 06-Nov-2019

Table 4. Pixel Count and Surface Area.

Sr. No.	Date	Pixel Count	Study Area in KM^2
1	24-Nov-2014	268627	241.7643
2	05-May-2016	134690	121.221
3	06-Nov-2019	373133	335.8197

By using maximum likelihood classification fig 6 24-Nov-2014 shows 268627 water pixels and the surface water area was 241.7643 $KM^{2.}$ In the fig 7 shows 134690 water pixels and the surface water area was 121.221 KM^2 but in fig 8 shows 373133 water pixels and the surface water area is 335.8197KM^2.

3.2. Method B (NDWI and Pixel extraction): The highly absorption show's on water body. So water body easily can be map with the help of Normalized water index.

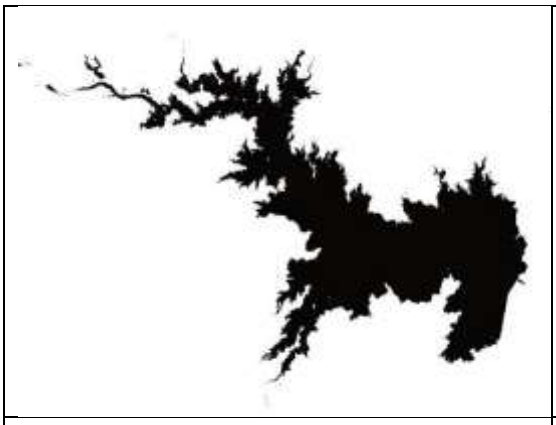


Fig.9: 24-Nov-2014

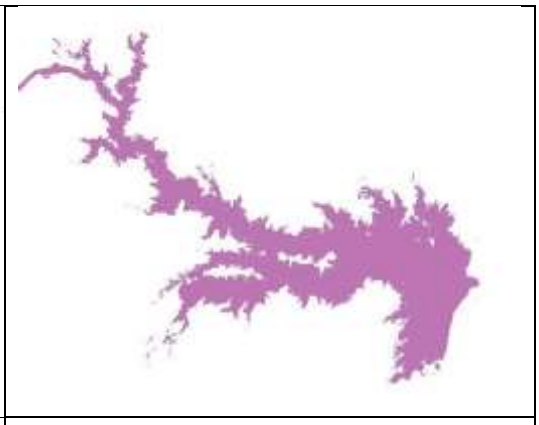


Fig.10: 05-May-2016

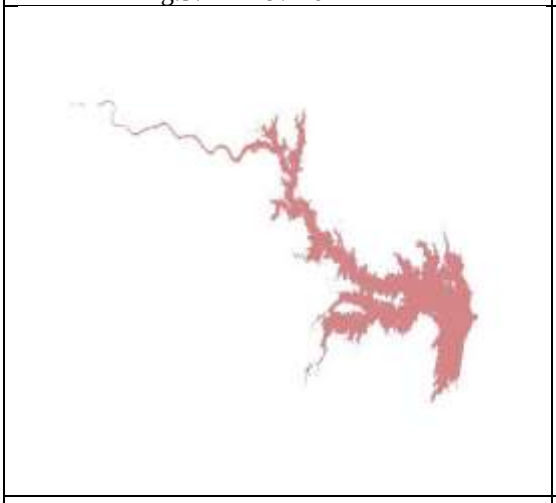


Fig.11: 14-May-2019

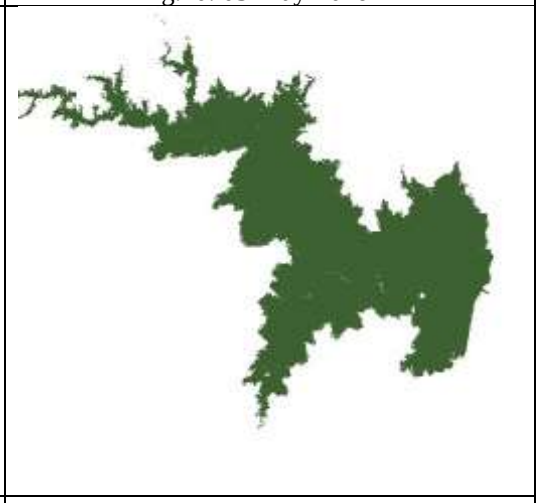


Fig.12: 06-Nov-2019

Table 5. Pixel Count and Surface Area.

Sr. No.	Date	Pixel Count	Study Area in KM^2
1	24-Nov-2014	225531	202.9779
2	05-May-2016	101573	91.4157
3	14-May-2019	101371	91.2339
4	06-Nov-2019	367041	330.3369

As shown in fig.6 resultant image of 24 Nov 2014 and table 5 shown, which is extracted by maximum likelihood classification the pixel count of water class is 268627 pixels and it indicate by red color but as shown in fig.9 resultant image of water pixel extraction by NDWI the count is 225531pixels. Both the results of same image but method is different. Method A shows more pixels than the method B because in method A shows the pixels among the all extracted study area and surrounded area of dam while method B shows the pixels according to the shape file and shape file select only water body of Dam area. Same way in fig.7 and fig.10shows the difference in water pixels fig 7 shows 134690 pixels and 121.221 square kilometer water surface area while fig 10 shows 101573 Pixels and 91.4157 square kilometer surface area. In resultant image of fig.12 6-Nov-2019 by method A shows 373133 pixels and 335.8197 square kilometer water surface area but be method B shows 367041 pixels and 330.3369 square kilometer water surface area.

4. Conclusion

Water is important resource for urban planning and development, so it is very important to know the how much amount of water is present in the reservoir or in water resources, surface water area of water reservoir can be easily find out so we apply two method on same satellite images. First method is classification of satellite image and another method is calculation of NDWI and extract the water body. With the help of classification method we can find out the water pixels form total satellite image but with the help of NDWI method and shape file we can extract only those pixels which is present only in water reservoir. Classification method can be find out water pixels of all satellite image but its show all water pixels of study area.. In this paper we can easily say that the NDWI and extraction of water pixels according to shape file give more accurate result than the classification method.

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