Water Level Changes in Yezin Dam, Zayarthiri Township, Nay Pyi Taw, Using Geospatial Techniques

Mu Mu Than[1], Khin Mar Yee[2], Kyi Lint[3], May Myat Thu[4], Marlar Han[5]
Department of Geography, Dagon University, Myanmar
mumumay2015@gmail.com

Min Maw Zin[6] & Ei Ei Khaing[7]
Department of Geography, Dagon University and Forest Department, Myanmar

DOI: 10.31364/SCIRJ/v7.i8.2019.P0819687
http://dx.doi.org/10.31364/SCIRJ/v7.i8.2019.P0819687

***Abstract* - The Study area is Yezin Dam which is located near Yezin village, on the east of Yangon-Mandalay Highway, Zayarthiri Township, Nay Pyi Taw City. The main aim of the construction of the dam is irrigation for the agricultural areas. The satellite images between 2006 and 2016 are used. Three Landsat Enhanced Thematic Mapper Plus change of water surface area in Yezin Dam are examined over 10 years period. (Landsat 7 ETM+) images were acquired on 05 April, 2006, 03 April, 2011 and on 16 April, 2016. The objectives of the study are to examine the changes of water surface area in Yezin Dam and to compare the different areas between satellite image and field study. The data such as temperature, rainfall, inflow water, outflow water and water level are used. The changes are tracked from the images using Band 2 (Green) and Band 4 (NIR) with the help of Normalized Difference Water Index (NDWI). The accuracy is assessed by using the Normalized Difference Area Index (NDAI) method. Results show that the accuracy assessment is 97% in 2006, 79.15% in 2011 and 92.2% in 2016. Satellite data can point out the water surface changes. The water surface areas decrease more than 75.12% during 10 year period.**

***Keywords* - accuracy, dam, inflow water, outflow water, water level**

I. INTRODUCTION

What is dam? Dams are massive barriers built across rivers and streams to confine and utilize the flow of water for human purposes such as irrigation and generation of hydroelectricity. This confinement of water creates lakes or reservoirs [6].
Droughts and other type of disasters put pressure in the water resources; many countries build up dams and reservoirs for irrigation and the use of human needs. Therefore, storage water (for example in the dam) considers a source of water for many sectors of the economy such as agriculture, domestic and industrial water supply, water transport and others. Dams are structures that are built to create a water reservoir.

RS is a major source of data and widely used to detect changes and update existing maps. It provides a meaningful method for detecting land and water level changes. Moreover, G1S techniques are also used in processing multiple data that are of concern to a dam water storage assessment project. The combined use of RS with GIS has proven useful for the timely assessment of land use dynamics (Mustafa et al., 2012; Wang et al., 2010). The purpose of this work is to determine whether the water surface area of the Yezin dam has noticeably decreased during the last ten years (2006 to 2016). To do this, the change of water level in the Yezin dam over time was investigated using RS, GIS techniques and satellite images.
The NDWI was introduced by Mc Feeters (1996) to delineate the surface water body depending on the normalized relationship between the reflection in the green and the near infrared (NIR) portions of the spectrum [NDWI = (Green NIR)/(Green + NIR)](McFeeters, S.K. (1996). The main objective of the present study is to estimate the surface area change of the Yezin dam in the past ten years using water indices as obtained from Landsat satellite images.

Study Area

Yezin dam is located near the village of Yezin, East of Yangon-Mandalay Highway, Zayarthiri townships, Nay Pyi Taw region. It is situated between latitudes 19° 50' 22" N and 19° 57' 54" N and longitude 96° 16' 04" E and 96° 22' 40" E (Figure 1). Yezin dam is established in 1975 and the main aim of the dam was irrigation of the agricultural areas and to protect flooding from Sinthay stream and Yezin Stream and other water usages.

Objectives

Objectives of the paper are to examine the changes of water surface area in Yezin Dam and to compare the different area between satellite images and field study.

Materials and Data

The study is primarily based on the ground data and Landsat 7 ETM+ data from April 05, 2006 to April 16, 2016. The ground data were used to calibrate RS results and to assess differences. The accuracy is assessed by using the Normalized Difference Area index (NDAI), and the change in water surface area analyzed by comparing it with the related meteorological data of the dam.

Ground Data:

Data such as temperature, rainfall, inflow water, outflow water and water level were collected from the Yezin dam station. Hand-held GPS is also used to determine some boundary of the dam. These data were used to draw graphs.

The graphs can be used to assess the water surface area by comparing information from RS images.

RS data:

To determine the temporal changes in the water surface area of Yezin **dam,** three Landsat 7 ETM+ images acquired on 05, April 2006, 03 April 2011 and on 16, April 2016 were used. Landsat satellites are the most common satellites used for the examination of natural phenomena.

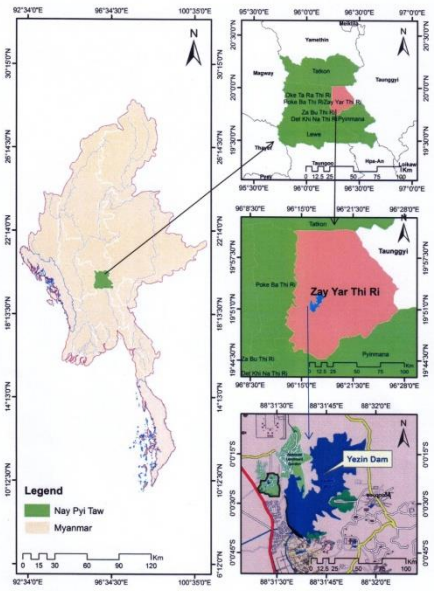

Figure 1: The Location of Yezin Dam

Source: MIMU and Google Map (placemap.net/MM/Yezin-Dam-11582)

Although this satellite has a low spatial resolution, it has a higher spectral resolution than that of other satellites. Data from the three images cover a time period of 10 years. The Landsat ETM+ images of the study area are shown in Figure (1), data of satellite image are shown in Table 1, resulting from a combination of (bands 4, 3, and 2) in order to classify water body by using ENVI software has shown in Figure (2). The datasets are cloud-free scenes acquired, relatively, during the summer of the year.

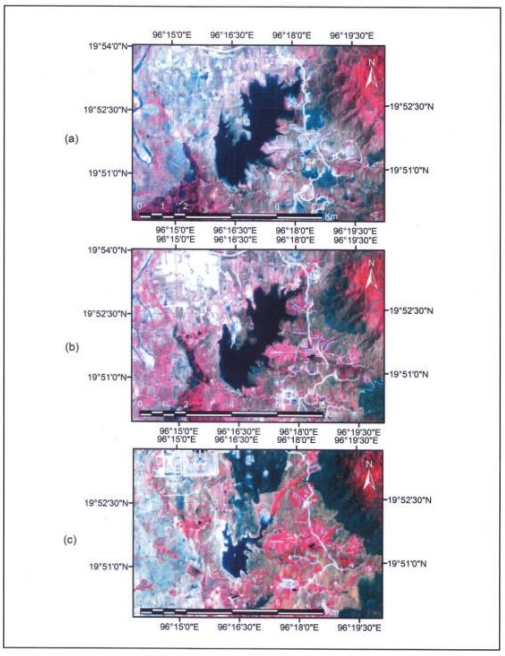

Figure 2: Colour Composite Landsat ETM+ Images of the Study Area, (a) 5th April 2006, (b) 3rd April 2011 and (c) 16th April 2016

Source: Satellite Image from USGS

TABLE 1

DATA OF SATELLITE IMAGE

ORIGIN	**IMAGE COURTESY OF THE U.S GEOLOGICAL SURVEY**
LANDSAT_SCENE_ID	LE71330462006095PF500
LANDSAT_PRODUCT_ID	LE07_L1TP_133046_20060405_20170110_01_T1
DATA_TYPE	L1TP
ELEVATION_SOURCE	GL2000
SPACECRAFT_ID	LANDSAT_7
SENSOR_ID	ETM
DATE_ACQUIRED	4/5/2006, 4/3/2011, 4/16/2016
SCENE_CENTER_TIME	03:50:57.2803026Z
CLOUD_COVER	0
CLOUD_COVER_LAND	0
IMAGE_QUALITY	9
MAP_PROJECTION	UTM
DATUM	WGS84
UTM_ZONE	46

Climate:

The Koppen Climate Classification subtype for this climate is AW (Tropical Savanna Climate). The average temperature is 26.8° C. The average total rainfall for these three periods is 116.59 cm. The driest month is February, with 0.18 cm of rain. Most precipitation falls in August, with an average of 23.6 cm. April is the warmest month of the year. The average temperature in April is 31.2° C. It is the highest average temperature of the whole year. There is a difference of

http://dx.doi.org/10.31364/SCIRJ/v7.i8.2019.P0819687

23.49 cm of precipitation between the driest and wettest months.

METHODS AND TECHNIQUES

Methods:

The data processing and manipulation were conductted by using ArcGIS (Version 10.1) and ENVI (Version 5.1) (Gap fill tool) for Scan Line Corrector (SLC) error. For NDWI calcualtion, reserchers use raster calculator in ArcGIS (Version 10.1) and Normalized Difference Area Index (NDAI) method.

On the other hand, field survey was carried out in December 2017 to collect ground data. The processing procedures which are adopted in this work are summarized in Figure (5) and will be discussed in the following section.

Scan Line Corrector (SLC) Off Correction and Gap Filling Techniques:

On May 31, 2003, the Scan Line Corrector (SLC), which compensates for the forward motion of Landsat 7, failed. Subsequent efforts to recover the SLC were not successful, and the failure appears to be permanent. Without an operating SLC, the Enhanced Thematic Mapper Plus (ETM+) line of sight now traces a zig-zag pattern along the satellite ground track. As a result, imaged area is duplicated, with width that increases toward the scene edge (**https://landsat.usgs.gov/slc-products-background**'). Researchers used the technique of Scaramuzza, et al (2004) to solve the problem Scan Line Corrector (SLC) of using ENVI software.

Since that time all Landsat ETM images have had wedge-shaped gaps on both sides of each scene, resulting in approximately 22% data loss. Scaramuzza, et al **(2004)** developed a technique which can be used to fill gaps in one scene with data from another Landsat scene. A linear transform is applied to the "filling" image to adjust it based on the standard deviation and mean values of each band, of each scene. ENVI software is used and has been installed the plugin tool Landsat gap fill in the proper ENVI install folder(s).

The result of the technique can be seen as shown in Figure (3) and Figure (4).

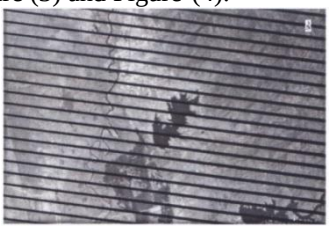

Figure 3: Scan Line Correction Off Satellite Image
Source: Satellite Image from USGS

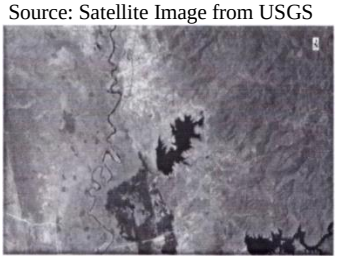

Figure 4: After Gap Filling Technique
Source: Satellite Image from USGS

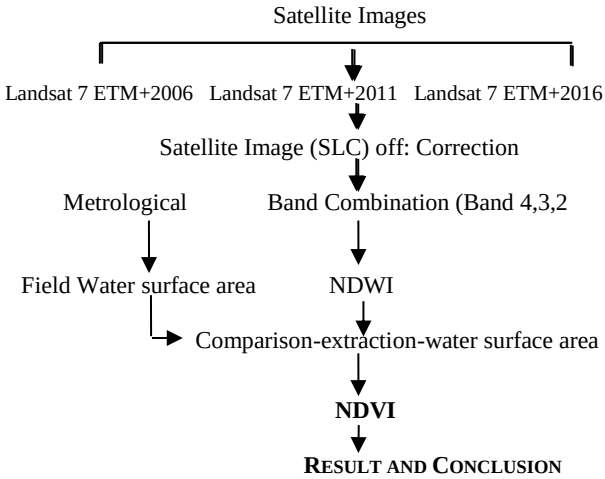

Figure 5: Work Flow

II. WATER SURFACE AREA

There are different techniques to detect water in the RS image. The enhanced RS image was a blue and infrared image where water bodies are represented in blue**.** However, NDWI normally uses to estimate vegetation and water content. The NDWI are computed for each pixel using the following equation Mc Peeters (l996):

$$\text{NDWI} = \frac{\text{Band 2 (Green)} - \text{Band 4 (NIR)}}{\text{Band 2 (Green)} - \text{Band 4 (NIR)}}$$

This formulation of NDWI produces an image in which the positive data values are typically open water areas while the negative values are typically non-water features (i.e. terrestrial vegetation and bare soil dominated cover types). Like NDVI, NDWI has a native scaling of - 1 to +1. The NDWI products were processed at a spatial resolution of about 463 meters per pixel. These products offer a means to view water bodies (Normalized Difference Water Index (NDWI)-(USGS)). Image of study area after processing NDWI model for the years 2006, 2011 and 2016 has shown in Figure (6).

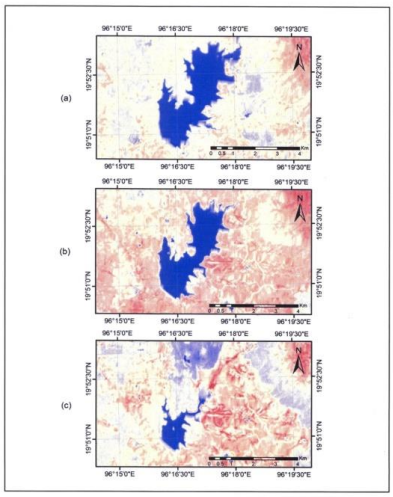

Figure 6: Image of Yezin Dam after processing NDWI model for the years (a) 5th April 2006, (b) 3rd April 2011 and (c) 16th April 2016
Source: Satellite Image from USGS

http://dx.doi.org/10.31364/SCIRJ/v7.i8.2019.P0819687

III. FINDING AND RESULTS

Difference in Area Estimation

The area determination is one of the classification methods. The Normalized Difference Area Index (NDAI) is used to study how the area of dam showing in RS is different from the area of the dam occurring in the ground. NDAI is calculated using the following formula:

$$NDVI = \frac{Area_{FD} - Area_{SAT}}{Area_{FD} + Area_{SAT}}$$

$Area_{FD}$ = Water surface area of field
$Area_{SAT}$ = Water surface area of satellite

NDAI values have a potential range from -1 to +1. If NDAI values of the water surface area of the dam close to 0, it has the best match between $Area_{FD}$ and $Area_{SAT}$. Negative values denote that $Area_{SAT}$ is greater than $Area_{FD}$ and positive values represent that $Area_{SAT}$ is less than $Area_{FD}$. The determined water surface area is shown in Figure (7). These values are small differences in the water surface area estimation (Table 2). The small difference, however, considered as errors. The reason for this level in accuracy can be related to the spatial resolution of the image. Another reason can be that the ground data may have some mistakes on the water level daily recordings that affected the estimated area. Overall, for this work, the differences between the $Area_{SAT}$ and $Area_{FD}$ are small and close to zero which indicates that the method is reasonable and acceptable. It is relative to the spatial resolution of the satellite images. Using RS imagery to determine the water surface area in dams has some advantages that RS imagery assisted in the easy recognition of reservoirs since the spatial resolution of the images enables the mapping of water, wetland and the surrounding area.

TABLE 2: WATER SURFACE AREA FROM FIELD SURVEY ($AREA_{FD}$), ESTIMATED WATER SURFACE AREA ($AREA_{SAT}$), and NORMALIZED DIFFERENCE AREA INDEX (NDAI) of the YEZIN DAM between 2006 and 2016

Criteria		2006	2011	2016
	Area FD	9307769	8619804	2363364
Surface Area	Area SAT	8654543	6758294	2153782
	NDAI	0.036	0.12	0.046
Average Temperature °C		26.97	28.11	28.14
Total Rainfall (cm)		139.47	152.09	137.39
Total Inflow (m3)		48716	58473	19938
Total Outflow (m3)		46391	36683	4778

Source: Yezin dam station in Nay Pyi Taw

Meteorological Data and Water Surface Area

The average monthly rainfall and temperature graphs for the study area are shown in Figure (8) and (9). The average annual rainfall and temperature graphs are shown in Figure (10) and (11). The total average rainfall for the 10 years period was 1279.93 cm in Yezin dam and its environs. According to the date of the satellite images used in this work, the total average rainfall was 139.47 cm in 2006, 152.09 cm in 2011 and 137.39 cm in 2016 (Table 2). In this study, the total inflow and outflow were 48716 m^3 and 46391 m^3 respectively in 2006, 58473 m^3 and 36683 m^3, respectively in 2011, and 19938 m^3 and 4778 m^3, respectively in 2016 (Table 2). It is clear that the total inflow is always higher than the total outflow. The inflow in 2016 is, however, lower than that of 2006 and 2011**.** In addition, the inflow in 2011 is higher than 2006 and 2016. Thus, the increase in water surface area is a result of the high rainfall and the high inflow. The average temperature was 26.97° **C** in 2006, 28.11° C in 2011 and 28.14° C in 2016 (Table 2).

In addition, the minimum and maximum temperatures for the period first 5 years from 2006 to 2011 are 10.5° C and 44.0° C respectively, and 11° C and 42.2° C respectively for the period of 2011 and 2016 (Table 3). Thus, it can be stated that the water surface areas of the Yezin dam during the period of 2006 to 2011 and during the period of 2011 to 2016 are much not different. This result can, however, be solely related to the other meteorological data, in particular the rainfall and evaporation. There is also some other factors including drainage channel built in the region for agriculture and for irrigation, and water supply for rural and urban.

There are important factors causing the change. They are climate conditions (rainfall, temperature and evaporation). But, in this study evaporation could not be described. Comparing the climate changes over the period from 2006 to 2016, the average temperature increased by 4.16%, average rainfall decreased by 9.67% can be seen in Table 2. In this study the average temperature didn't change significantly. According to satellite image date of the study, it's in the summer of the year.

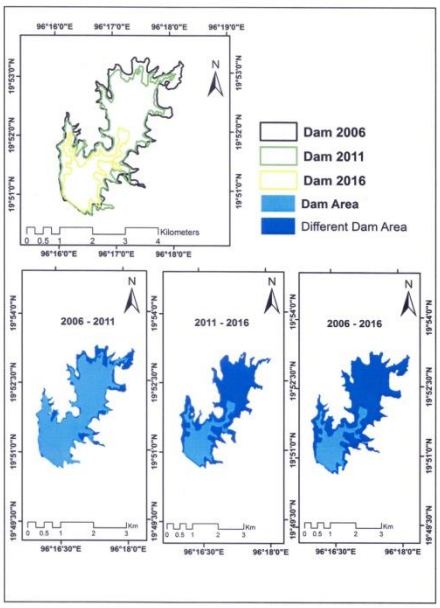

Figure 7: Water Surface Area of the Yezin Dam, estimated by RS Images
Source: Satellite Image from USGS

The annual average rainfall in 2015 is the lowest of the ten years period. Therefore, it is likely that climate conditions affected the surface area of the dam. However, climate conditions are not the only reason why the water surface area of the dam decreased by more than 74%. The other factor is needed to be examined such as domestic consumption (for

http://dx.doi.org/10.31364/SCIRJ/v7.i8.2019.P0819687

universities, hospitals and national park and village water usages etc.).

The temporal change in water surface area of Yezin dam was nearly the same in the 2006 and the 2011. By comparison, the water surface areas in 2011 and 2016, it can see that in 2016 the water surface area had decreased by 74%. All these analyses indicate the decrease in water reserves in the dam.

TABLE 3: SIGNIFICANT STATISTIACS OF RAINFALL AND TEMPERATURE WITHIN TWO PERIODS (2006-2011 and 2011-2016)

	Period	Max	Min	Average
Rainfall (cm)	2006-2011	34.42	0.10	17.25
	2011-2016	36.9	0.05	18.72
Temperature (C)	2006-2011	44	10.5	27.5
	2011-2016	42.2	11	26.35

Source: Yezin dam station in Nay Pyi Taw

TABLE 4: CONDITION of PADDY CULTIVATION in YEARLY (2005-2006 to 2016-2017)

No.	Year	Planting Area (hectare)	
		Paddy (Monsoon)	Paddy (Summer)
1	2005-2006	4219	2575
2	2006-2007	4058	2676
3	2007-2008	3805	2632
4	2008-2009	3738	5963
5	2009-2010	3896	2307
6	2010-2011	3864	565
7	2011-2012	3611	1523
8	2012-2013	3611	1620
9	2013-2014	3618	1552
10	2014-2015	3565	1369
11	2015-2016	3565	-
12	2016-2017	3591	-

Source: Yezin Dam Station in Nay Pyi Taw

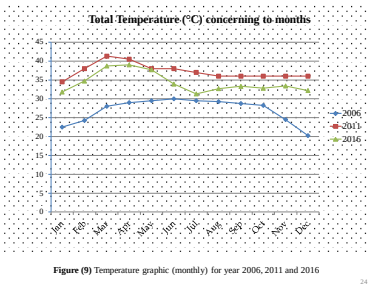

Figure (9) Temperature graphic (monthly) for year 2006, 2011 and 2016

Figure 8: Average Monthly Temperature for Year 2006, 2011 and 2016
Source: Yezin Dam Station in Nay Pyi Taw

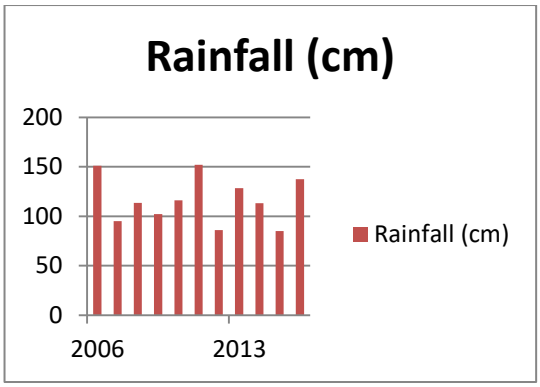

Figure 9: Average Annual Rainfall (2006-2016)
Source: Yezin dam station in Nay Pyi Taw

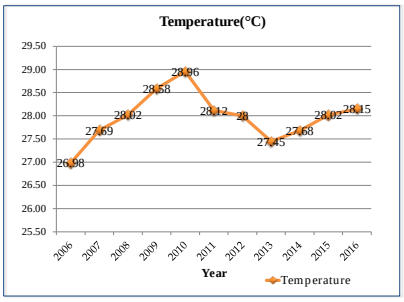

Figure (11) Average Temperature (yearly) between 2006 and 2016

Figure 10: Average Annual Temperature (2006-2016)
Source: Yezin dam station in Nay Pyi Taw

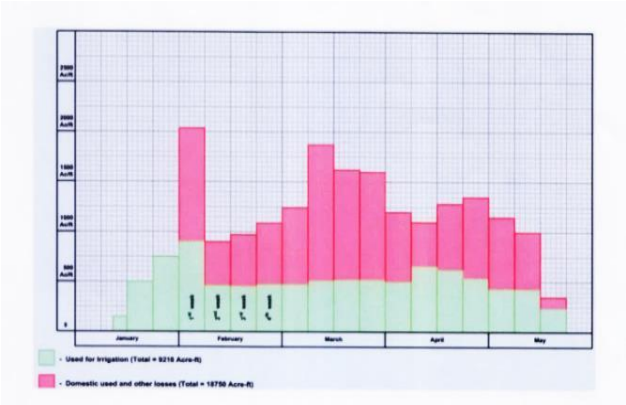

Figure 11: Water Supply for Domestic Uses and Irrigation in Summer 2015
Source: Yezin Dam Station in Nay Pyi Taw

IV. CONCLUSION

The change in water reserves in Yezin dam is important for agriculture, ecology and domestic use. Over a 10 year period is investigated by using RS and GIS techniques. Landsat images in 2006, 2011 and 2016 are assessed and the results were interpreted with related meteorological data. Over the 10 year period an increase in water surface area is detected in 2006, while a decrease in water surface area in water reserves is detected in 2016. This decreasing rate is caused by weather (El-Nino) in 2015 and it affects the low inflow rate and rainfall but it is not the only reason of the changes.

Moreover, the use of domestic is higher than that of irrigation in 2015 (Figure 11). In 2015-2016 and 2016-2017,

http://dx.doi.org/10.31364/SCIRJ/v7.i8.2019.P0819687

there are no water supplies for paddy (summer) as shown in Table 4. Among the reasons for the decrease and increase are climate changes and human external interference around the dam (drainage channels, irrigation and other domestic uses). In addition**,** this study showed that satellite data are useful for monitoring and estimating changes in the environment. It can also point out the causes of the water surface changes.

REFERENCE

[1] Mc Feeters, **S,** K. (1996), The use of Normalized Difference Water Index (NDWI) in the delineation of open water **features,** International Journal of Remote Sensing, 17 (7): 1425-1432

[2] Mustafa YT, All RT, Saleh RM (2012), Monitoring and evaluating land cover change in the Duhok city, Kurdistan region-Iraq, by using remote sensing and CIS, Int. J. Eng. Inv, 1(11):28-33

[3] Ouyang W Uao F1L Zhao C, Lin C (2010), Vegetation response to 30 years hydropower cascade exploitation in upper stream of Yellow River Commun. Nonlin. Sci.Numer. Simul. 15(7): 1928-1941

[4] Wang S-Y, Liu J-S, Ma T-B (2010), Dynamics and changes in spatial patterns of land use in Yellow River Basin, China. Land Use Pol. (27) 2:313-323

[5] Yaseen T, Mustafa and Mohamad J Noori, Satellite remote sensing and geographic information systems (GIS) to assess changes in the water level in the Duhok dam

[6] Yunus DS, Fidelia NN (2012), Reservoir storage variations from hydroiogical mass balance and satellite radar altimetry, Int. J. Water Resour. Environ. Eng. 4(6):201-207

[7] Normalized Difference Water Index (NDWI), USGS
http://deltas.usgs.gov/fln/data.ndwi.aspx
www.arch.mcgill.ca/prof/sijpkes/arch374/winter2001/dbiggs/what.html, Sept, 6,201

http://dx.doi.org/10.31364/SCIRJ/v7.i8.2019.P0819687