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Inflow Analysis of Lake Uromiyeh, Iran

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SUMMARY

Lake Uromiyeh is a shallow lake in north-western Iran currently threatened by retreating water levels. The lake has experienced recent drought and unsustainable use by the surrounding human population and the dropping lake levels not only affect the local population. As the lake recedes, it leaves behind salt deserts, and has caused the lake to become hypersaline, destroying a lot of the previous flora and fauna in the lake and creating an environment for halophilic organisms. The lake has no outflow, making the evaporation of this semi-arid environment the main outflow in the water balance equation of Lake Uromiyeh. In this case study, remote sensing was used to quantify the water balance equation parameters of Lake Uromiyeh for water management and monitoring.

Introduction

Lake Uromiyeh is a shallow lake in north-western Iran currently threatened by retreating water levels. It has a basin covering over 5400 km², including high mountains and flood plains where the lake has experienced recent drought and unsustainable use by the surrounding human population (Alkema, 2012). The main goal of this case study is to compare the estimates of the inflow in both a wet and dry hydrological year and compare these values to the lake volume, as well as the effect on the surrounding basins vegetation health. This required the examination of several factors including lake area, volume, precipitation input, evapotranspiration output, as well as the calculation of NDVI and inflow water balance.

Methods and Theory

Data Acquisition

The Data was taken from a project initiative by WaterWatch in cooperation of other companies from both Iran and the Netherlands. However, the data was originally supplied through several Iranian ministries and departments (Alkema, 2012). Two images were taken from both a wet year and a dry year from the NOAA-AVHRR satellites. For the wet hydrological year, two NOAA-AVHRR 11 satellite images from September 24th, 1993 and September 10th, 1994 and for the dry hydrological year, two NOAA-AVHRR 14 satellite images from September 29th, 1999 and September 13th, 2000. WaterWatch also did previous image analysis resulting in actual evapotranspiration maps and rainfall maps for both hydrological years. A Digital Elevation Model (DEM), and a basin outline was also acquired as a part of this project. All of these files were geometrically corrected to UTM project (zone 38) with spheroid Clarke1866.

Area and Volume calculation

The Volume-Area equation was obtained using the Surface Volume tool from ArcGIS 3D Analyst Tool Set and MATLAB curve fitting toolbox shown below in the following equation:

$$V = a * \exp(b*x) + c * \exp(d*x)$$

Where: $a = 1.3e-8$, $b = 0.003571$, $c = 1.234$, $d = 0.0005147$

Figure 1 Graphed Volume versus Area.

Total precipitation and Evapotranspiration

The total actual evapotranspiration and precipitation were both determined in the same process. Using the 36 layers for each decadal image, the sum of all the values was derived using raster calculator. The output images were the total evapotranspiration and precipitation for the whole of both hydrological years (wet and dry). Looking at the metadata, the mean of digital number values were taken from each output map. These numbers were used to derive the total volumes through multiplication with the corresponding areas in the 1993, 1994, 1999 and 2000 images.

Table 1 Precipitation and Evapotranspiration Volume.

Year	1993 – 1994	1999 – 2000
Precipitation Volume	2.68	1.03
Evapotranspiration Volume	7.97	6.75

In order to calculate the lake inflow following equation was used:

$$I = dV - P + ET$$

Where I is lake inflow, dV is lake volume difference, P is precipitation and ET is evapotranspiration.

Table 2 Inflow calculation.

Date	Inflow (km ³)
Sep. 1993 to Sep. 1994 (Wet)	19.0716
Sep. 1999 to Sep. 2000 (Dry)	2.5625

Figure 2 Lake Uromiyeh basin in dry and wet years.

NDVI Change

Generally it is understood that the mountains in north-west of the basin increased in vegetation over a wet year, however vegetation around the lake area has decreased. This loss of vegetation could be due to changing water levels, possibly in relation to the amount of salt left behind which affected the surrounding vegetation. Another notable difference is the change in NDVI is in the lake itself. According to the results, it seems to be increasing in both years, this could possibly be due to the halophilic organisms that could be thriving due to increased salinity in the lake (Alkema, 2012).

Conclusions

This studies shows that the inflow of the lake was highly affected by the precipitation during different years and the evapotranspiration values in both years were relatively similar. Due to the hypersalinity of the lake, it is crucial for future management to monitor and influence the lake water volume, as sediment salt are extremely dangerous for the agricultural lands and environment.

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