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The Relationship of Salt Classification with Distance to Shoreline and Elevation, Case Study Lake Urmia, Iran

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Abstract

Increase in salt concentration may have adverse environmental and economic consequences. The Lake Umia is the largest hypersaline lake in the world that is rapidly drying. The drying leaves salt layers in a belt around the shore of the lake. These layers can be source of many damages to the human and the environment. The objective of this research is to investigate for the first in the world the relationship between salt concentration with distance to shoreline and elevation. For this, Landsat satellite image data for salt classification and SRTM imagery for elevation data and shoreline layer for distance to shoreline raster have been used for the analysis as the material. By overlying of the data and selection query the relationships of the parameters have been explored. The results indicate that the salt concentration decreases with increase in elevation and distance to shoreline. This can be concluded that the demonstrated relationships can help make appropriate decisions in planning.

Keywords: Salt Concentration, Classification, Landsat, Orumieh Lake

1. Introduction

As the largest hypersaline lake in the world and the largest lake in the Middle East [5], Lake Urmia (Lake Orumieh) formed in the last glacial period has water level fluctuations about 1 meter and diurnal fluctuations about 4 meters [5]. Due to the fluctuations, a strip of salt is deposited along the shore of the tectonic lake. The lake as a wetland has got international importance in Ramsar Convention in 1971 and it is a seasonal habitat for lots of migrating birds. The surface area of the lake was estimated about 6100 km^2 and it has declined about 7 meters from 1995 to 2011 [5]. As a terminal lake this is a unique place the water come into the basin leaves just by evaporation. As it retreat back from its original shores, a layer of salt mainly sodium chloride is left behind where in extreme condition make the place a playa or a salt desert [2]. This can be origins for many kinds of dust storms and salt storms [3]. The salts left behind after evaporation and the retreat through blowing salts can cause destruction of vegetation, losses in agricultural crops, illnesses for animals, some respiratory and many other health problems in human [5]. Western provinces of Iran have previously encountered with such dust issues from other origins [3, 4].

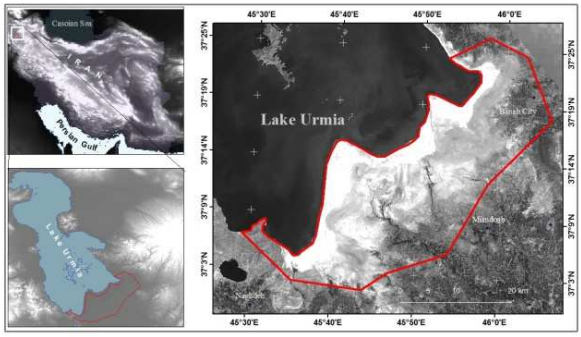

Figure 1: Position of the study area

The main purpose of the study is to investigate salt concentration in southern coast of Lake Urmia and relationship of the concentration with distance of the area to shoreline and the elevation of the coastal portion as a base for water level changes. The research try to explore whether the salt concentration increase as it proximate to the shoreline as the source of evaporative salt deposits and whether the concentration decrease in surfaces of higher areas than those of lower. In other words, we examine the relationship between elevation and distance to the shoreline with salt concentration for the first time in the world by a novel method. From the southern shore of the lake to the beginning of alluvial fans about 12 km from the shore, where the salt decline to minimum, is chosen as the study area of the research. The area is about 978.82 km in some parts of counties including Banab, Malakan, Miandorood, and Mahabad, and Naghdeh (FIGURE 1). The area is mainly covered by salt layers.

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2 Materials and Methods

In the study Landsat ETM+ sensors data, at the date of August 31, 2000, in path 168 and row 34 have been provided from USGS data. The images are 30 m in spatial resolution and 8 bit radiometric resolution. Required correction was performed and preprocessing has been done to prepare the data for analysis [1]. SRTM elevation data, 90 m in spatial resolution, have been used to obtain elevation information. The line of shore has been digitized from the imagery data. The research has been conducted in three stages as following:

2.1 Salt concentration classification

Three bands of the Landsat ETM+, in the range from 0.4 µ to 0.7 µ, images have been combined and the salt concentration has been classified in the combination image from 3 bands. The area by standard deviation method was classified in 5 categories of extremely salty, salty, moderately salty, less salty and non-salty areas (FIGURE 2C).

2.2 Distance to shoreline

Using Spatial Analyst Tool in ArcGIS Software, the distance of all points of the study area have been calculated to the shoreline (FIGURE 2B).

2.3 Elevation

The elevation data of SRTM from CGIAR website have been extracted in border of the study area. The elevation is, indeed, representative of the surface areas where in the past were covered by the lake water and also the inundation surface (FIGURE 2A).

Finally, the relationship salt concentration categories may have with the distance to shoreline and elevation has been explored by the result map layers. For this, the two data layers of distance to shoreline and elevation have been converted into point vector data. By the way, the average distance of the point features to the shoreline and also the average elevation values of the elevation point feature have been measured for each salt category separately by selection query.

3 Results and Discussion

The evaporation from the surface of the Lake Urmia leaves a huge amount of salt in near coast lands. These evaporative deposits can be sources of many kinds of diseases and also environmental and economic damages. The results indicate that the classes with high intensity of salts as Extremely Salty areas, mainly saturated in Digital Numbers of the three visible bands, are located in an average distance of 2.2 km to the shoreline.

The intermediate areas in salt density are in 6 to 7 km to the shoreline while the Non Salty class category is in an average distance of 11 km from the shoreline. Thus, the categories with less concentration of salts have more distance to the line of coast. Therefore, with an increase in distance of the points in the area, the density of salt decreases progressively and the maximum density can be seen in a distance about 2 km to the shore of Lake Urmia (TABLE 1).

As it can be observed from TABLE 1, this can be stated that with an increase in elevation of the points in the area, the density of salt decreases correspondingly.

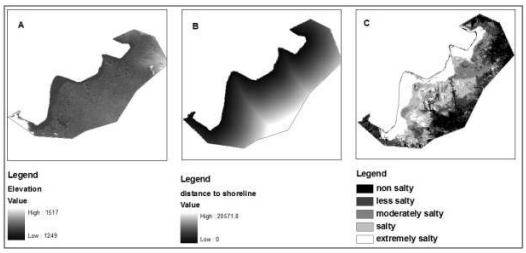

Figure 2: three layers of elevation (A), distance to shoreline (B), and salt concentration classes (C)

From the relationship between the elevation and salt concentration this may inferred that the areas one were covered by the lake water after the water declined they deposited the salts proportional to the depth.

Table 1: the relationship between the classes of salt concentration, distance to shoreline and elevation

	extremely salty	salty	moderately salty	less salty	non salty
Cat.	5	4	3	2	1
Avg. Dis. To Shor. (m)	2213	6433	7102	7149	10977
Avg. Elev. (m a.s.l.) by SRTM	1269	1272	1273	1275	1281

4 Conclusions

The Lake Urmia is drying at a rapid rate whether by climate change or by direct human interventions. This may cause the lake to transform into the playa or salt desert that may have adverse consequences for human society and the environment. The study has documented the relationship between the elevation variations and spatial distance to the shoreline in order to make it possible to take cautious measures against probable hazards. The salt density changes with elevation terrain characteristics may be indicative of previous lake surfaces. Thus, the study confirms the documentations of other studies about the trend of water level decline in the lake. It can also be concluded that the changes in level of the lakes can increase salt density and consequently contribute to intensification of dust storms as hazard previously experienced in the west of Iran. This may be a reasonable suggestion that we must pay lower expenses today in planning for conservation to avoid paying of enormous costs in the future.

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