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Investigating Surface Water Extent and Quality Dynamics of Lake Chad using Multitemporal Remote Sensing Approach

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Usually, the size and distribution of lakes present a challenge for traditional water management due to the time, cost, and logistical constraints. To overcome this challenge, Landsat imagery has been used to monitor the changes in quantity and quality of this natural resource. The Gravity Recovery and Climate Experiment (GRACE) satellite mission is known to provide estimates of terrestrial water storage anomaly (TWSA) variations at basin levels. Lake Chad is located in a rural area and lies at the center of the livelihood of more than 30 million people. The Lake lost about 90% of its water from 24,000 km^2 to $\sim$1400 km^2 in recent times. Its spatiotemporal variations are poorly known.

The objective was to evaluate the capability of Landsat Enhanced Thematic Mapper Plus (ETM+) and Operational Land Imager (OLI) sensor in providing estimates of surface water and water quality. This work seeks to evaluate lake fluctuation patterns and identify hot spots of potential risk.

This paper provides information on the spatiotemporal changes and driving forces for Lake Chad in different seasons using 416 Landsat ETM+ and OLI images captured from 2003-2016. For the area extraction process, The Automated Water Extraction Index (AWEI), Normalized Difference Water Index (NDWI), Modified Normalized Difference Water Index (MNDWI) and Normalized Difference Vegetation Index (NDVI) were compared to find out which performed well in extracting clear and turbid water features. The Otsu threshold method of segmentation was used to separate water from non-water features. MNDWI had an overall accuracy greater than 96% and a kappa coefficient of 0.9. This was the highest when compared with the other indices. As such, MNDWI was used to extract Lake Chad area changes from 2003-2016. The results showed an increasing trend in lake area. The lake area shrinks from the Northern to the Southern part. A permanent open water was recorded in the Southern part of the lake during this period. Estimated area ranged between 1231-2182 km^2. Indicating high variability in area fluctuation. Extracted lake area from the TM/OLI images were analyzed with GRACE TWSA. TWSA confirmed the increasing area trend.

As a follow-on, water quality models for estimating suspended solids (SS), BOD, total nitrogen (TN), chlorophyll-a (Chl-a) and total phosphorus (TP) will be applied to Landsat 8 images. Judging from the model, areas recording high levels of SS, BOD, TN, Chl-a and TP will be identified.

This study demonstrates the application of different satellite data in the management of natural resources in remote areas. The findings of this study enables the evaluation at broader spatial scales and longer temporal scales of the Lake Chad using freely available and consistent high-quality data.