Short Paper

The Submerged Archaeological Sites of the Mosul Dam Reservoir

Evaluating Emergence Patterns with a New Cost-Efficient Tool

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Introduction

Resource extraction projects, on a par with major events such as natural catastrophes and armed conflicts, herald alteration to or destruction of both natural and cultural landscapes. Dam construction, in particular, has become a topic of pivotal concern in modern archaeological discourse on Western Asia, since it represents one of the major threats to cultural heritage as a whole (Marchetti et al., 2020, and Eidem, 2020 with further references). Thus a single event may involve the intentional obliteration of hundreds of archaeological signatures. Most of them will never resurface, while others face a different destiny in that they periodically re-emerge due to annual or other cyclical water fluctuation processes. The destruction of such sites is ongoing, and a constant assessment of the damage is necessary, alongside planning documentation and maintenance strategies. This paper addresses this issue by proposing a new set of tools for the management of contiguous terrestrial and lacustrine cultural zones and, more widely, a new paradigm for their future safeguarding.

Dataset

As a case study, Iraq's largest hydroelectric basin, the Mosul Dam reservoir on the upper Tigris in Iraq, is discussed (Figure 1), as it provides various insights into tackling endemic issues of site recording, monitoring, and threat assessment in a constantly shifting environment.

In recent years the area of this reservoir has returned under the spotlight thanks to a new wave of archaeological projects begun on its eastern bank (Pfälzner and Sconzo, 2015; 2016; Sconzo, 2019; Morandi Bonacossi and Iamoni, 2015; Morandi Bonacossi, 2018) and an unexpected drought in 2018 that brought back to light several archaeological sites and villages that had been considered lost for good. The present research makes use of what can be considered the largest currently available archaeological dataset for the Upper Tigris Iraqi region, incorporating data from old archaeological surveys (Sconzo and Simi, 2020) and excavations, and from several new enterprises carried

out since 2010 in the Kurdistan region of Iraq, consequently providing an unprecedented, detailed overview of the loss and rediscovery of especially significant cultural landscapes.

Methods

Methodologically speaking, this paper proposes a new set of cost-efficient tools (based on free software and medium resolution satellite images) for observing the "emergence patterns" of archaeological sites and quickly assess damage timescales and site areas (Titolo, 2021). The set combines Landsat and Sentinel-2 medium-resolution time-series images (taken at the Bottom-of-Atmosphere Reflectance), cloud processing platforms and open-source GIS.

These sources are coupled with the distinction between water and land surfaces through the Normalized Difference Water Index (NDWI) to provide an accurate and quick way of distinguishing between water and land surfaces, thus making it possible to assess the emerged extent of an archaeological site. First, we generated the monthly time-series NDWI images for the years 1993 to 2020 in Google Earth Engine (Sagar et al., 2017), adopting a modified version of the index ($NDWI_{xu}$, Xu, 2006).

A threshold of 0.05 was chosen for the reclassification to eliminate background noise. We then applied the Zonal Histogram algorithm in QGIS, which counts the number of unique pixels for each of the two classes (land and water areas) within each polygon feature (i.e. site extension). By calculating the percentages of unique pixels, and by applying the analysis over a long time-frame on each site shapefile we are then able to assess the percentage of site area impacted by water fluctuations during the years (Figure 2).

Results

In practice, the change detection technique presented here has turned out to be a powerful post-flooding assessment tool. The results of the analysis on the ad-hoc created archaeological dataset have allowed, in fact, the determination of which sites have never resurfaced from the lake, which are cyclically affected by fluctuating water levels, and which are endangered by a possible unexpected and previously unrecorded rise of the lake (Figure 3).

Fig. 1. Left: River Tigris in Dec 1984; Right: Mosul Dam Reservoir in May 2020 (© Landsat/Copernicus accessed through Google Earth Pro).

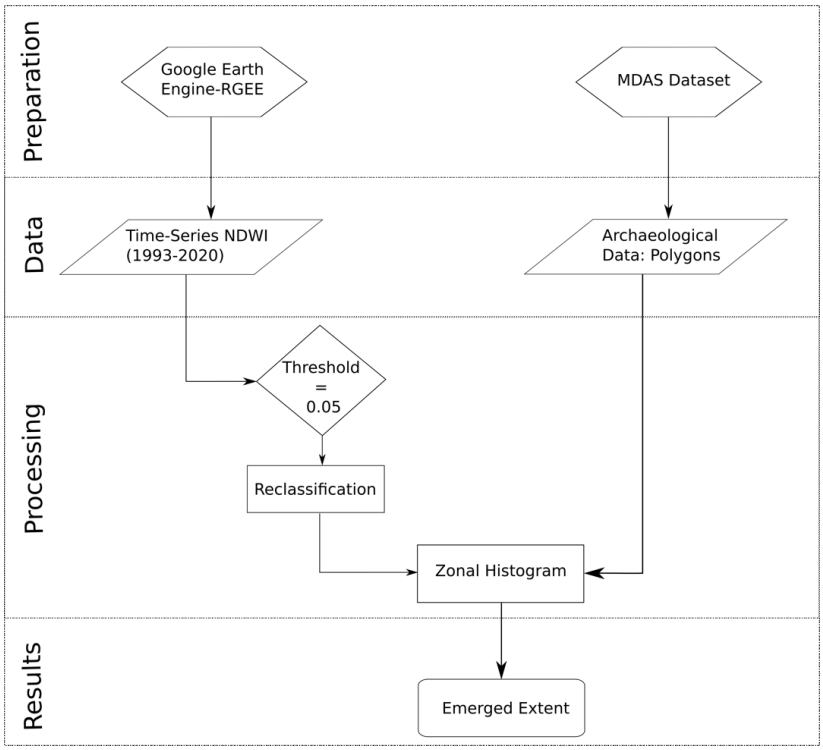

Fig. 2. Workflow (© Andrea Titolo).

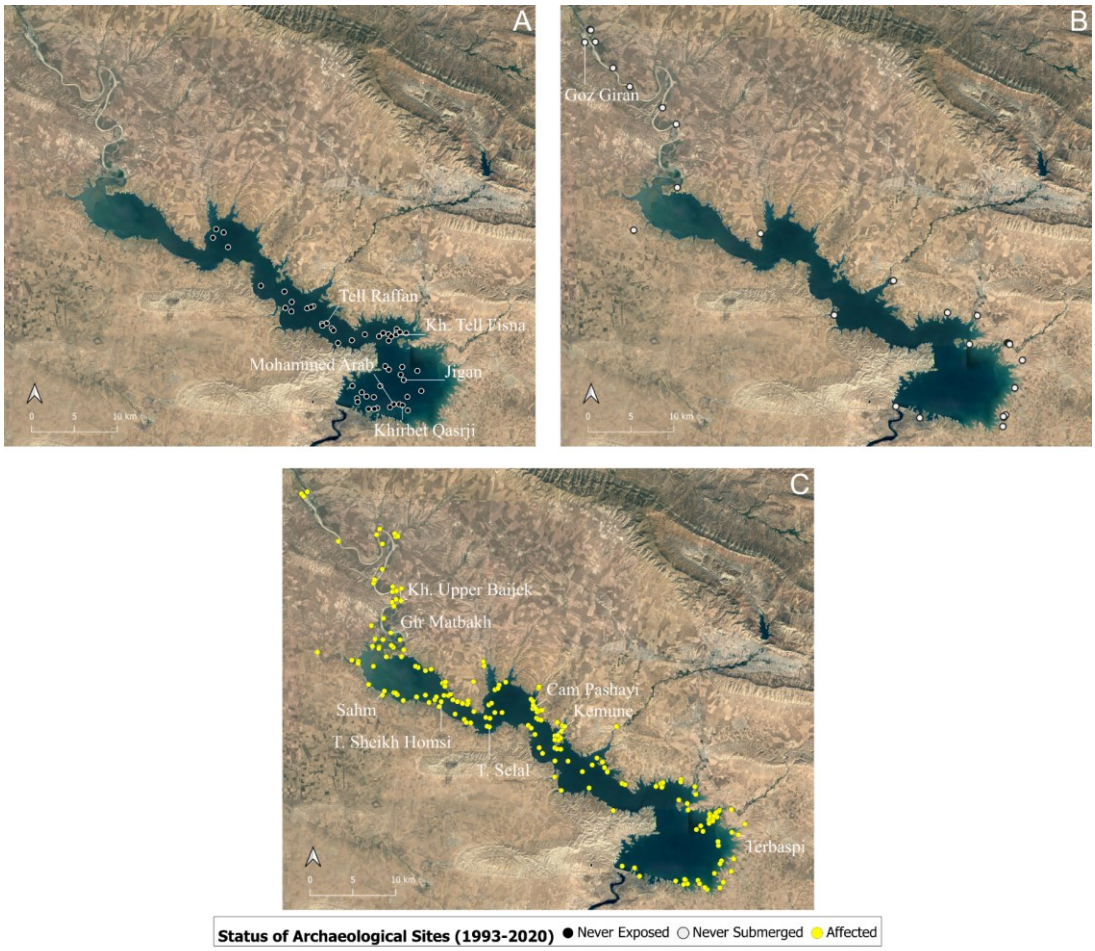

Fig. 3. Spatial distribution of emersion pattern categories: A) Never Exposed; B) Never Submerged; C) Affected (© ReLand).

It was then possible to establish at what absolute level each site emerges (either partially or completely), so as to identify the archaeological signatures which were more strongly impacted. The technique has further enabled calculation of the percentage of the total area exposed for each site. Moreover, the application of the workflow to the Mosul Dam reservoir's behaviour on an annual basis has enabled the reconstruction of cycles of site emergence patterns that are strongly linked to its complex history

Conclusions

The main research outcome is what we believe to be a new approach, easy to reproduce and also affordable, of particular use to Antiquities Directorates. It provides evidence to support effective decisions regarding the documentation and management of archaeological sites that lie in a reservoir's drawdown zone. The recommended workflow could also be applied to the wider heritage impacted by dam construction, such as for instance, modern villages and monuments, from the perspective of rescue documentation of memoryscapes. Moreover, it could also be employed and further developed by the wider scientific community, as well as by international institutions working in the culture protection field, since it can be potentially applied to any region (in Western Asia and beyond) where natural or artificial reservoirs are threatening the local heritage. Finally, regarding river development, these insights may provide background data for future research, which might lead to more inclusive decision-making processes, as well as more informative monitoring of already submerged areas.

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