Mapping damage and destruction to archaeological sites in the Middle East and North Africa

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Endangered Archaeology

The Endangered Archaeology of the Middle East and North Africa (EAMENA) Project is documenting archaeological sites and their condition in an online database that spans 20 countries (Fig. 1; see Bewley et al 2016, Rayne et al 2017a and b). Increasingly, sites are at risk from deliberate damage and land use change. The project is working with heritage professionals in each country to promote the recording and protection of cultural heritage at risk using accessible and open-source remote sensing tools. This poster describes EAMENA’s methodology of using high-resolution data to record sites, and lower-resolution multispectral data to monitor changes which put sites at risk.

Monitoring

EAMENA is utilising classification algorithms to monitor the main threats posed by modern land use (Rayne et al 2017a and b). We are using Google Earth Engine (a cloud-based platform harnessing high performance computing power- see Gorelick et al 2017) to map previous and ongoing change across the MENA region in order to identify the most significant land-use impacts affecting each area. In this example we mapped change using NDVI (Normalized Difference Vegetation Index) in the extent of the cultivated area over time in Al-Jufra cases in the Libyan Sahara (Fig. 4). In Al-Jufra we have recorded 90 archaeological sites of all periods including surface, tell and coastal/citadel locations (see Rayne et al 2017b). Our workflow can be seen at http://bit.ly/Jufrachange and comprised:

- Production of composite images using least cloudy, median pixel values from Landsat 5 and 8 collections (calibrated for TOA) representing 2 year periods of interest
- Application of cloud and water masks
- NDVI for each composite and selection of appropriate threshold value
- Cultivated area represented by NDVI calculated (in km²)

In Al-Jufra the vegetation indices revealed that the oasis expanded from 26 km² in the 1985-86 composite to 121 km² in the 2017-18 composite. Of the 90 sites, 47 have been destroyed or damaged by this modern agricultural activity, with the remains of ancient water management particularly affected.

To facilitate monitoring of surviving sites in the MENA region we are now developing a methodology using Google Earth Engine which automates agricultural change detection in the vicinity of each of our sites.

Table 1: Error matrix

<table>
<thead>
<tr>
<th>Reference composite and Google Earth</th>
<th>Vegetation</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAVI classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>30</td>
<td>21</td>
<td>51</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>261</td>
<td>262</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>282</td>
<td>313</td>
</tr>
</tbody>
</table>

User’s accuracy: 30/31 = 97%
Producer’s accuracy: 30/31 = 97%
Overall accuracy: 293/313 = 94%

To use our combined approach we have created over 100,000 site records. So far, we have found mundane human land-use activities such as agricultural and urban expansion to be the most widespread cause of damage to archaeological sites (Fig. 5), despite the high-profile attention given by media to conflict-related destruction and looting. These problems have been exacerbated by the reduction in both the ground-based monitoring of heritage sites and regulatory enforcement by governmental organisations, and the increased salience of state-sanctioned and unauthorised development that result from recent conflicts. Our datasets recording and satellite image monitoring methodologies are providing heritage agencies with tools that will enhance their protection of heritage assets. The next phases of this work will comprise integrating change assessment of urbanism and building a user interface for our monitoring workflow to integrate with our database.

Conclusion

EAMENA is the only project specifically taking an open-source approach using trained interpreters (Fig. 6) to record the archaeological and geological data across the MENA region systemically. This leads to more accurate recording than automated methods of site identification and crowd-sourced data entry. Classification algorithms apply to multispectral satellite imagery than support this by allowing regular monitoring of changes to the recorded sites. Monitoring allows us to understand the kinds of modern activities that threaten archaeological sites.

References

- EAMENA. Available online: http://eamena.arch.ox.ac.uk/ (accessed on 30 July 2018).

Figure 1: EAMENA study area and locations where sites are recorded in our database so far.

Figure 2: EAMENA recording methodology.

Figure 3: Digitised medieval town in Al-Jufra oasis, Libya

Figure 4: Landslips in cultivation in Al-Jufra between 1985-2018.

Figure 5: Kernel Density Estimate of sites in our digitised areas impacted by vegetation change 2016-18

Figure 6: Dr Musa Hermassi and other participants of an EAMENA training course working with GIS