

Endangered Cultural Heritage

Monitoring and object protection through 3d documentation

Introduction: cultural heritage threatened

Armed conflicts, natural disasters and human infrastructure expansions pose a significant threat to material culture, causing irreversible damage to our shared human history.

The recent civil war in Sudan, civil unrest and the emergence of the so called "Islamic State" in Northern Iraq, as well as the conflict between Armenia and Azerbaijan are examples of threats to cultural heritage. Here, archaeological projects of the University of Münster have been affected. In Sudan, there are reports of indiscriminate shelling and bombing of cultural heritage areas, as well as looting of antiquities. The destruction of monuments and the sale of archaeological objects by the so called "Islamic State" in Iraq are well documented. Less known is the use of archaeological sites as military posts during the Saddam Hussein era. In Armenia, the long-embattled Nagorno-Karabakh region is about 100 kilometres from Artaxata. Furthermore, the Caucasus region is an earthquake zone.

3D modelling and photogrammetry digitally preserves cultural heritage, even if it is heavily damaged physically. In this paper, we will focus on large-scale 3D modelling as comparative material for cultural heritage monitoring using satellite data (Lasaponara and Masini, 2020, pp. 36-43), and 3D modelling combined with an open data policy allowing "protection through transparency" of archaeological finds from being looted.

Material: Examples from Sudan, Iraq, and Armenia

Graveyards in Wadi Abu Dom (Sudan)

The Bayuda Desert is in the great Nile River bend, roughly between Omdurman and Korti. Its central region gives rise to wadis that channel rainfall towards the Nile. One of them, the Wadi Abu Dom, reaches the Nile near the town of Merawi (Karberg and Lohwasser, 2018, pp. 3-17), with archaeological sites and military installations in its vicinity.

Settlements and graveyards in Northern Kordofan (Sudan)

North Kordofan is one of the main battlegrounds in Sudan's ongoing civil war. The sparsely populated north of the region has been less affected by direct military action, but its archaeological sites are threatened by uncontrolled large-scale gold mining as source of income for the warring militias.

Dinka Settlement Complex in the Peshdar Plain (Kurdish Autonomous Region of Iraq)

The Dinka Settlement Complex is located on the Lower Zab and the Zagros Mountains on today's border with Iran. The multi-phase site developed into a large settlement between western Iran and the Mesopotamian lowlands in the early Iron Age. Conflicts since the Iran-Iraq war, looting activities and the natural conditions on the edge of the high mountains pose a direct threat to the archaeological remains of this region.

Artaxata (Armenia)

Artaxata/Artashat was the capital of the Hellenistic Kingdom of Armenia (Lichtenberger et al. 2020/2021, p. 17 f.) located in the Ararat Plain, adjacent to the border with Turkey. Nagorno-Karabakh, whose self-proclaimed republic was dissolved on 1 January 2024, is around 100 km eastward. Up to now the archaeological site of Artaxata was not endangered directly by the war, but the border fortifications with Turkey run through the ancient city area. Nevertheless, looting is observed.

Methodology: Workflows and Software

Monitoring of Cultural Heritage using large-scale 3D data and satellite imagery

In Sudan, DSM were generated from UAV imagery using Agisoft Photoscan 1.4.5. SFM software (Karberg and Lohwasser, 2018, pp. 18-19). TerraSAR-X 3D data are available for North Kordofan, processed using QGIS 3.36 and ERDAS Imagine 2018 (Eger, 2017, p. 25). For monitoring, Sentinel-1 radar data with medium spatial, but sufficient temporal resolution for short-term monitoring are available (Steward, 2020, pp. 69-72; Schreier, 2020, pp. 8-12). Workflows that make data sources of different spatial resolutions comparable are crucial.

In Iraq, 3D models are created in a daily workflow based on drone photos (DJI Phantom 4 and Mavic 3) with Agisoft Photoscan 1.2.6 - Agisoft Metashape 2.0.4 and further processed with QGIS 3.28 (Squitieri and Rohde, 2019, 68-70). Selected finds are documented three-dimensionally with Artec Spider and Artec Studio 17.

In Artaxata the workflow is similar, except that UAVs are only used in exceptional cases due to the proximity to the border. Almost all 3D models are based on photos taken with handheld cameras. The orthophotos and DEMs are processed with QGIS 3.28. Selected finds are scanned with Artec Spider and processed with Artec Studio 17 or documented using Agisoft Metashape 2.1.2.

Use of 3D data for safeguarding archaeological material from looting

Archaeological record is not only informationally preserved, but also safeguarded by transparent research data management policies. Open data and FAIR principles are the foundations of this concept. 3D-record and its public accessibility protects it better against loss than conventional documentation. If lost, through theft or damage, the 3D model offers a certain form of reproducibility. In addition, high-precision 3D models such as those created in our projects can be used in law enforcement and in the search for lost objects.

Results & Conclusions

Monitoring of archaeological sites at Wadi Abu Dom and North Kordofan in Sudan proved that the methodological approach could identify effects of military clashes and gold mining activities on the archaeological record. Work continues co-operatively with the (exiled) Cairo office of the Sudanese National Corporation of Antiquities and Museums.

The documentation of the Dinka Settlement Complex and its excavation status primarily serves scientific purposes. However, it can be used to identify undesirable impacts together with the responsible Sulaymaniyah Directorate of Antiquities and Heritage. The 3D documentation of finds complicates international antiquities trafficking.

The same applies for the Artaxata-Project. In cooperation with the Armenian Academy of Sciences and other partners, the data collected is of particular importance for the protection of the archaeological zone.

Discussion

Our aim is not to develop the most sophisticated solutions, but to provide workflows and best practices that can be implemented by any archaeological project, and to draw attention to the fact that research data may not only serve scientific purposes, but are also generated and processed with the understanding that these data may once be the only ones available for the site when needed as a basis for risk management and monitoring.

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