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Curious Travellers – repurposing imagery to manage and interpret threatened monuments, sites and landscapes

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The AHRC-funded Curious Travellers project (www.visualisingheritage.org) is a data-mining and crowd sourced infrastructure to help record, manage and interpret archaeological sites, monuments and heritage at risk. It provides a priority response to the globally important challenge of sites that have been destroyed or are under immediate threat from natural disasters, neglect, conflict and cultural vandalism. The project uses two workflows to scrape web-based imagery and crowd-source imagery to recreate 3D models of sites and monuments at risk. Many threats to heritage are linked to issues of access – impacting conservation and site management as well as the safety of individuals. The project offers sustainable solutions – working with extant imagery that does not place individuals at additional safety risk, whilst helping to contextualise visible archaeology by linking to relevant site and landscape data and integrating this into local historic environment record frameworks that make this data freely accessible to all.

1.0 Introduction

This chapter highlights the potential of transformative digital methods to secure geospatially accurate 3D digital records of cultural heritage sites that are under threat, or have already been destroyed. The widespread and irrevocable destruction of global heritage is amongst one of the world's most intractable and pressing challenges – ranging from 1) destruction by natural means (incl. natural disaster and environmental change); through 2) conflict and collateral damage; as a consequence of 3) development pressures (incl. encroachment and intensification of cultivation) and 4) management constraints (incl. neglect, looting, vandalism). Such threats ensue largely without an agreed framework of response or mitigation and thus the potential of safeguarding by record shows the importance and timeliness of digital documentation methods.

2.0 Heritage Threats

Wide-ranging threats to cultural heritage exist (figure 1) (Managing Disaster Risks - UNESCO 2010). These threats are complex and multi-dimensional, and are often intricately linked to fragile socio-political contexts - not simply found in developing countries. Many of these threats span different categories, for instance 'fire' a devastating force of nature can start accidentally, whilst 'arson' a form of vandalism has the same destructive outcome, and may highlight problems in managing heritage assets. Furthermore, the natural heritage and landscape setting can similarly be fragile and subject to many of the same threats. Risk from climate change may amplify the effects of other stresses, including urbanisation, pollution, natural resource extraction and tourism (UNEP 2016). Finally, intangible heritage, representing longstanding language, craft, folk, spiritual and family traditions can be lost within a very rapid timeframe as communities are displaced through population movement.

2.1 Natural Disaster

Environmental change and Flood risk: Threats range from advancing desertification, to inundations, El Niño induced floods and fluctuating water tables. Collectively these risks threaten the sustainability of traditional lifestyles, at the same time as placing archaeological sites at risk. Rising sea level is a global threat, with coastal erosion and climate change putting communities and heritage at risk in many countries. The destruction of natural habitats, such as mangrove swamps and mining of beach sand exacerbates problems of coastal erosion, in turn impacting the historic environment. At many sites the scale of heritage impact remains to be considered or mitigated.

Seismic sensitivity/ tsunami: Heritage sites are at risk from natural disasters, such as the 7.8 magnitude Gorkha earthquake that destroyed large swathes of the built heritage (Basukala, Gutschow et al. 2014) within the seven world heritage zones of the Kathmandu valley, Nepal in April 2015 (Dizhur, Dhakal et al. 2016) which also killed many thousands of people. The scale of such disasters serve as reminders that countries in seismic-sensitive regions benefit from sympathetic use of high quality traditional materials and craft skills during rebuilding and resilience, over poor construction practice and quality (Dizhur, Dhakal et al. 2016).

Fire risk: Given that timber is widely used in construction, fire can be a major threat for many heritage sites where traditional wooden structures have been built, or where construction methods include wood, as with roof trusses.

2.2 Conflict/ collateral damage

Conflict: Conflict results from cultural divisions and deliberate/ direct human action. The destruction of the temples of Bel and Baalshamin and the arch of Septimius Severus at Palmyra (Harrowell 2016) are amongst some of the most striking. However, these destructive and iconoclastic spectacles are only part of a wider war on heritage, which does not meet the narrow vision of acceptable past, that Islamic State launched in areas under their control (Danti 2015, Ömür 2015, Isakhan and González-Zaradona 2017). These sites are added to the list of destructions including Hatra, Dura-Europos, Apamea, Mari and Nimrud (Lawler 2014), with significantly less attention paid to equally destructive acts in other countries including

Libya (Brodie 2015), where specific sites were also targeted (Kane 2015). The wilful destruction at these sites echoes other deliberate damage to heritage sites, such as those throughout Afghanistan where the Bamiyan Buddhas were destroyed in March 2001 (Falser 2011); and previously with the bombing of the Temple of the Tooth, a UNESCO world heritage site in Sri Lanka (Coningham and Lewer 1999). Despite widespread international concern, the unprecedented pace and scale of threats from conflict and terrorism are likely to emerge as a greater problem than we currently appreciate.

Socio-political fragility and crisis: conflict at any scale may be devastating as heritage sites are subject to direct, or collateral damage and the vulnerabilities of fragile governance and social division. Damage can be exacerbated by responses that are not conflict-sensitive and requires appropriate tools to record heritage assets safely and ideally with the involvement of local communities associated with heritage loss.

Population displacement: The challenges of safeguarding intangible heritage, threatened by internal migration linked both with urbanisation and population displacement due to insecurity, should not be divorced from the protection of tangible cultural heritage and may be particularly challenging in fragile or poorly governed areas. These require inclusive agendas for protection of heritage by local and displaced peoples. Furthermore, the value of intangible heritage should be promoted as being of relevance in relief efforts and sustainable development.

2.3 Development pressure

Encroachment & intensification (unregulated urban growth/ cultivation): Intensification of agriculture threatens heritage sites globally - as expanding populations bring new land under cultivation, with irrigation and changed farming methods. Expanding urban centres encroach sites, threatening to damage monuments and erase distinctive architecture, as well as identity rooted in place. The pace of change underlines the importance of establishing heritage inventories as needed in many countries, with the EAMENA project trailblazing this effort in the MENA region (Bewley 2018).

Mining & infrastructure: Industry-scale performance standard 8 (IFC 2012) guides companies in protecting cultural heritage from impacts such as mineral extraction, largescale infrastructure and redevelopment schemes. However, responses may often take inadequate account of political, economic and fragility assessments.

2.4 Management

Weathering, erosion and biodeterioration: Conservation and management practices have long recognised that heritage sites and archaeological deposits are vulnerable to the impact of weathering, fluctuating groundwater, air pollution, erosion, vegetation and biodeterioration, with stonework and earthen architecture particularly susceptible to weathering impact; whilst wood and other organics are susceptible to biodeterioration.

Neglect, looting and vandalism: These problems are intensified in the context of inadequate security and access to justice; with heritage sites no longer protected even by their scale or remoteness, with renewed focus towards the need for novel, trans-national approaches that

encourage individuals to contribute to mechanisms for recording and monitoring heritage. Increased looting in fragile and conflict-affected contexts has long been noted, with new geospatial methods helping to document this (Lawler 2014, Parcak 2015).

Unsustainable exploitation: This ranges from unsympathetic restorations and site consolidation which threaten the fabric and meaning of heritage sites, through to unsustainable tourism that has overwhelmed local communities, threatening intangible heritage connected with traditional livelihoods. Sustainable responses need to take account of context fragility and conflict sensitivity, with opportunities to promote change, where communities can embrace sustainable approaches to living alongside heritage. Increasingly, the planning process is taking account of the long-term picture of urbanism, particularly in relation to locations such as city waterfronts, that have often had lengthy and diverse former uses over archaeological timescales (Hosagrahar, Soule et al. 2016, Price, Ford et al. 2016).

3.0 The Potential of Imagery

One of the valuable consequences of UNESCO world heritage status is that countries can benefit from the visibility of these sites through increased tourism with associated socio-economic gains. Whilst UNESCO promote the universal value of world heritage sites, such sites often become emblematic to a country and are linked to cultural identity and commodification (Graham, Ashworth et al. 2016). It is because of this widespread familiarity, that sites achieve global recognition – a status that has been abused in fragile contexts because of the potential visibility and notoriety achieved through destructive acts that harm these sites and communities connected to them (Frey and Steiner 2011), serving as a form of propaganda (Gonzalez-Zaradona, Albarran-Torres et al. 2017) and in separating terrorist recruits from societal and cultural norms (Shahab, Isakhan et al. 2018).

Significantly, the visibility of heritage sites also offers the potential to harness digital imagery as a force for good. The development of mobile technologies (Masiero, Fissore et al. 2016), and in particular the widespread adoption of high resolution camera phones and geospatially-referenced imagery, offer opportunities for 3D digital documentation. Such methods combine geospatial imaging practice and computer algorithms (Snavely, Seitz et al. 2006, Goesele, Snavely et al. 2007, Snavely, Seitz et al. 2007, Al-Fugara, Al-Adamat et al. 2016, Remondino, Nocerino et al. 2017, Aicardi, Chiabrando et al. 2018) that have developed alongside conventional photogrammetry practice for use with archaeology and heritage applications (Fregonesea, Achillea et al. 2015, Bedford 2017, Douglass, Lin et al. 2017, Dostal and Yamafune 2018). When used with complementary tools, such as imagery from satellite and UAVs (Hesse 2015, Gomez and Purdie 2016, Howland, Jones et al. 2018, Matini, Andaroodi et al. 2018, Pierdicca 2018), the potential of imagery for heritage protection and new interpretations is fully realised. Where cultural heritage sites have been threatened, or destroyed, it is widely accepted that these new digital recording methods must be one response to the situation of heritage at risk. Furthermore, digital terrain models and photogrammetry are important tools in evaluating damage and structural stability (Forlani, Roncella et al. 2013, Gomez and Purdie 2016, Forlin, Valente et al. 2018).

4.0 The Curious Travellers Project - Recording, Managing and Interpreting Sites Using Extant Imagery

The Curious Travellers project was initiated in the wake of iconoclastic acts in Islamic State-controlled territory within the Middle East, and earthquake destruction in the Kathmandu Valley (Wilson 2016, Faber, Sparrow et al. 2017). A key part of the project has been to use confirmatory measures to assess the accuracy and efficacy of using diverse image datasets to derive 3D data. The ethics of conservation serve to guide our workflow – in striving for authentic representation using high fidelity 3D models built from rich image data. These approaches do not alter, or remodel digital content without clear indication and discussion of the case and merit for such changes. In essence, the workflow follows the same conservation ethos that helped to coalesce support for the protection of architectural heritage in the UK around ventures such as the Weald & Download Openair Museum at Singleton – a reaction to the destruction of vernacular architecture as townscapes were transformed in the 1960s/70s. Instead of the logistically complex process of physically dismantling heritage structures and rebuilding them elsewhere, the practice continues using transformative digital methods, that include structure-from-motion photogrammetry (Bedford 2017) and 3D laser scanning (Boardman and Bryan 2018). This approach complements other responses that relate to multi-scalar efforts with artefact reconstruction (Webb 2017), large scale landscape recording (Bacon 2017), together with geospatial inventories for heritage assets (Bewley 2018).

Through our efforts we recognise that the safeguarding of local participants is of critical importance and that crowd sourcing and voluntary participation for development (Bevan, Daniel et al. 2014, McCarthy 2014, Stathopoulou, Georgopoulos et al. 2015, Vincent, Coughenour et al. 2015, Spano, Hashemi et al. 2016), whilst useful are not suited to every application. For these reasons we have used openly-available web-scraped imagery supplemented by donated imagery to derive high resolution 3D digital models (figures 2-5).

5.0 Sustainable development and future perspectives

Natural disasters and human destruction have highlighted the immediacy of threats to cultural heritage and a collective desire to offer safeguards through a combination of measures that can secure a lasting record of this heritage. Cultural heritage is key to social cohesion, and a rich resource that can be developed to challenge extreme poverty in the Global South. Where damaged or destroyed, the loss of cultural heritage also represents lost opportunities for communities across the world to benefit economically, or to take comfort socially, from their heritage assets. Seen within a global context – the challenge is most apparent not with UNESCO world heritage sites, but within communities and their ability and resilience to respond to threats. The emphasis thus needs to shift towards capacity building and sustainable development, using a combination of conventional and innovative pathways.

Challenges facing cultural heritage are multidimensional, increasingly urgent, and intractable, where situated in fragile and conflict-affected areas. Although not explicitly referenced in the UN's Sustainable Development Goals (SDGs), heritage cuts across several of these goals (table 1) (Roders and van Oers 2011, Hang, Ishwaran et al. 2016, Hosagrahar, Soule et al. 2016, Price, Ford et al. 2016, UNESCO 2016, Doempke 2017, Leal Filho, Azeiteiro et al. 2017, Potts 2017, Riganti 2017, Xiao, Mills et al. 2018).

UN SDG	Descriptor	Heritage impact

SDG4	**Quality education**	Recognising the universal value of heritage to enhance cultural relations at an international scale and community relations at a local level - seeing heritage as a learning tool; promoting shared values and the importance of conservation through education.
SDG8	**Decent work and economic growth**	Providing support to sustainable tourism/ heritage conservation/ innovation/ entrepreneurship - giving communities the tools to be self-reliant.
SDG11	**Sustainable cities and communities**	Recording historic environments in support of regulated development, preserving heritage assets to maintain a focus for community pride.
SDG13	**Climate action**	Providing an infrastructure for use in assessing vulnerability of heritage assets to environmental change and identifying effective responses in fragile or conflict affected areas.
SDG16	**Peace, justice and strong institutions**	Providing conflict-sensitive protection strategies and restoring universal value to heritage threatened by conflict/ poor governance and inadequate systems of dispute management and rule of law.
SDG17	**Partnership for the goals**	Approaching heritage needs within a multi-disciplinary framework to ensure that methods are both responsive to local, regional and national needs and directly involve partnership with grass-roots organisations.

Of course, other SDGs also touch upon heritage, including - **SDG2 – Sustainable agriculture/ SDG15 – Life on land:** acknowledging that many of the pressures facing life on land impact heritage. **SDG7 – Affordable and clean energy:** highlighting potential for unintended impacts on heritage assets through the installation of renewables/ related infrastructure without appropriate recording or safeguarding.

Whilst much of the emphasis has been on tangible cultural heritage – monuments, buildings, sites and landscapes – the physical threats to the fabric of these structures and setting should not be divorced from the people who live alongside fragile heritage legacies. In development terms fragility refers to challenges of governance, societal division, insecurity and inadequate access to justice and the rule of law. In matters of heritage, fragility takes on added significance, with the threat of incalculable loss both to the tangible and related intangible heritage (local knowledge, craft/ folk traditions) (Lenzerini 2011, Scott 2011). This critical resource offers context and meaning in a rapidly changing world and should be preserved alongside physical remains to promote societal resilience and peace-building.

Cultural heritage contributes to the economic, social and psychological well-being, resilience and identity of communities globally (UNESCO 2016). The loss of heritage assets without record has an enormous cost to future economic and social wellbeing. In developed countries heritage directly generates more than 2% of national GVA, whilst related activities, including the globally significant, and rapidly growing, cultural and creative sector (EY 2015), suggest the opportunity cost of heritage loss may be significantly more (Hayes 2017).

Heritage has 'economic, social and environmental value' (DCMS 2017), and reflects national policy in the cross-party group on cultural protection with the establishment of a National Heritage Council in Britain, May 2018 (Ellis 2018). Yet, the universality of heritage is critically important as a criterion for strengthening fragile communities globally through economic empowerment as part of urban renewal, planning and environmental protection (Price, Ford et al. 2016); education and as a focus for civic pride through community engagement (DfID 2017).

We recognise the universal value of heritage and its power to influence the behaviour of

others and obtain desired outcomes through cooperation (UNESCO 2013, Hill and Beadle 2014, Larson 2018). Responsible heritage tourism is seen as a catalyst for peace (Turner and Freiermuth 2016). The benefits that cultural heritage, together with the digital and creative sector, can achieve are well-documented (DCMS 2016, UNESCO 2016, Hayes 2017) and are based on: 1) **intrinsic value**: the enriching value of cultural heritage in and of itself; 2) **social value**: improving educational attainment, reducing societal division, promoting inclusivity and wellbeing; and 3) **economic value**: the contribution culture makes to economic growth and job-creation (building a sustainable and resilient heritage sector).

Technology offers potential to deliver aid in novel and impactful ways, to mitigate disasters and build resilience in the cultural heritage sector (Macalister 2015). The 'Culture is Digital' report (DCMS 2018) emphasises the creative potential of technology for cultural organisations and builds on the UK Digital Strategy. The importance of digital skills and the transformational role of technology to support business model development and to grow stronger creative sectors is increasingly recognised (British_Council 2016). Furthermore, the use of digital technologies is an important part of education and communication and thus another key way of engaging with young people and making heritage more accessible to them. The economic gain from community-based activity, linked to the cultural environment, can be measured together with peace building and derived social benefits (Hayes 2017).

6.0 Conclusions

Heritage threats and destruction are not restricted to well-known sites or regions. The destruction of globally important heritage is often overshadowed by the associated human tragedies inflicted through associated societal change. The fragile geopolitical situation in the Middle East and North Africa, and aftermath of the Gorkha earthquake has served to highlight the plight of civilians caught up in conflict and mass disaster, providing the world with distressing images on a recurrent basis.

The immediate scale of damage is often hard to quantify regionally and whilst it remains difficult to envisage the logistical efforts needed to physically rebuild monuments impacted by wideranging threats, the heritage community has a responsibility to mitigate against damage in whatever form it takes. International organisations including UNESCO and ICOMOS provide a significant monitoring role, individual states may offer support and academic groups may act in an emergency response mode. Yet, realistic responses to heritage at risk remain complex, particularly where endangerment to life is a real possibility. Transformative approaches using 3D digital documentation offer the potential for preservation by record. When also routinely used, digital documentation as part of risk preparedness serve as important concepts in conservation management. Collectively these measures provide substantive support in anticipation of sustainable futures in which such data may assist in social reconstruction, economic empowerment and the easing of post-conflict tensions.

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Table legend

Table 1: The relevance of cultural heritage in service of the UN's Sustainable Development Goals

Figure legends

Figure 1: Major threats to both tangible and intangible heritage

Figure 2: Orthographic projection of a point cloud generated by web-scraped images of Vatsala Temple, which was destroyed during the April 2015 Magnitude 7.8 Gorkha Earthquake, Nepal, with elevation line drawing of Vatsala Temple (Basukala et al. 2014) as comparison. Camera positions are shown within Bhaktapur Square, with the blue square showing Vatsala Temple. From 9,821 images downloaded, 2,758 images were matched to generate the resultant point cloud.

Figure 3: Details (Plan, Front elevation and isometric view) of the Temple of Bel, Palmyra, Syria, partially destroyed by explosives in August 2015. From 26,931 images these were filtered down to 13,001 after removal of cropped or stitched images, with 5,929 images matched to generate the resultant point cloud.

Figure 4: Orthographic projection of the Church of St. Benedict, looking East across the Piazza San Benedetto, Norcia, Umbria, Italy. The Church of St. Benedict was partially destroyed by two Magnitude 6+ earthquakes in October 2016. From 30,946 images downloaded, 1,640 images were matched to generate the resultant point cloud.

Figure 5: Detail of Brimham Rocks, North Yorkshire, UK, subject to vandalism during June 2018. View looks north towards one of the main groups of rock formations. From 12,707 images downloaded, 3,449 images were matched into a cluster to generate the resultant point cloud.