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Snapshots from the past: discoveries and destruction in the Jericho Oasis

Pierfrancesco Izzo¹, Michael Fradley ² and Andrea Zerbini[†]

This paper presents a study of the rich archaeological landscape of the Jericho Oasis, drawing on historical aerial photography and more recent satellite imagery to survey this cultural landscape and assess issues affecting its preservation over the past century. The timing of the paper is pertinent as non-U.S. satellite companies have recently begun to produce higher resolution satellite imagery of Israel and the Occupied Palestinian Territories (OPT), and restrictions on imagery resolution in the U.S. have been lowered as a result of research by the EAMENA project. Whilst increasingly widespread availability of high-resolution satellite imagery and orthophotos can effectively support heritage monitoring in this heavily-developed region, this paper demonstrates that it is the use of historical aerial photography that has enabled the identification of a range of previously unrecognized archaeological features. These new data offer a first tentative step in revising our current understanding of the development of human settlement across the Jericho Oasis.

Keywords Aerial photography, Jericho, Palestine, survey, landscape change

Introduction

This paper presents the results of remote sensing analysis of satellite and aerial imagery, and their integration with data derived from ground-based archaeological fieldwork, undertaken as part of the Arcadia-funded Endangered Archaeology in the Middle East and North Africa (EAMENA) project, based at the universities of Oxford, Leicester and Durham. The project uses a combination of satellite imagery and historical aerial photography to record cultural heritage sites and their changing conditions through time (Bewley and Rayne 2016).

In response to the limits of ready access to commercial satellite images, particularly via open-access platforms such as Google Earth, this study developed as a means of exploring alternative imagery sources and to utilize the relatively untapped potential historical aerial imagery sources for the region. The Jericho

Oasis was selected as a study area due to its standing as an important and well-investigated archaeological landscape (Sala 2014: 116), and allowed the research team to draw on the extensive field knowledge of Izzo (as part of his PhD project completed in February 2020; Izzo 2020), who was working as an intern for the EAMENA project in 2017, at the time the study began.

Located west of the River Jordan and 10 km north of the Dead Sea, the Jericho Oasis is a rich archaeological landscape with a range of occupational evidence stretching from the prehistoric period through to the present. Its diverse archaeological heritage includes Tell es-Sultan, the ancient city of Jericho, the Umayyad palace of Qasr Hisham and the Monastery of the Temptation (Deir Quruntal), which have been included in the UNESCO Tentative Lists as ‘Jericho Millenary City, Archaeological and Historical Urban Development’ (<https://whc.unesco.org/en/tentativelists/6491/>). In addition to these proposed elements for the UNESCO submission, the oasis also contains the Hasmonean palace and Herod the Great’s palace at modern

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Tulul Abu el-'Alayiq (Netzer 1993; 2001; 2006), with the hippodrome at Tell es-Samarat (Augustinovic 1951: 177–78; Mellaart 1962: 156, n. 87; Netzer 1993). Today the oasis is part of the Governorate of Jericho.

The trajectory of this paper was affected by the untimely death of Andrea Zerbini in July 2019. Aspects of this research and ideas that he was developing have, therefore, not been considered through to completion. Where possible, we have left parts of this paper that were drafted by Andrea as he first presented them; he may have wished to add more if he had been able.

Accessing aerial and satellite imagery of the Jericho Oasis

This study grew organically out of a need to adapt the standard EAMENA project methodology to the particular conditions of the Occupied Palestinian Territories (OPT). Across the MENA region, the EAMENA project uses high-resolution satellite imagery, freely available through platforms such as Google Earth, to survey, assess and monitor archaeological sites and landscapes. Restrictions in the US on the resolution of commercial satellite imagery covering Israel and Palestine meant that this standard methodology would not be effective for identifying and monitoring archaeological sites, and an alternative approach would be required.

In terms of modern commercial satellite imagery, the Kyl-Bingaman Amendment (KBA) to the US 1997 National Defence Authorisation Act binds US satellite companies to distribute imagery of these areas only at a resolution equal or inferior to the international baseline standard. At the time when the KBA was issued in 1997, the baseline was deemed to be *c.* 2 m Ground Sampling Distance (GSD), although companies were soon achieving a higher resolution of around *c.* 0.5 m GSD across the rest of the globe. A wide-ranging reassessment of the KBA and its impact on archaeological research was produced as an outcome of research into these restrictions (Zerbini and Fradley 2018). Following a continuing campaign by the EAMENA project to push for reform of the KBA, these restrictions were finally lowered in July 2020, prior to the submission of this paper (Whitebloom 2020). This reform will greatly benefit future research in a range of disciplines in the region, but it came too late to have a direct impact on the present study.

While researching the KBA restrictions, the project became aware of a source of digital orthophotos and satellite imagery on the Geomolg platform

(geomolg.ps), the Integrated Spatial Information System of the Ministry of Local Government of Palestine, which was developed by this institution in collaboration with the German International Development Agency (GIZ). Starting in December 2012, but only openly available from January 2017, it is a web mapping application built using Geocortex to store and display geospatial datasets, including administrative boundaries, cadastral data, toponyms, including those of archaeological sites, and, crucially, multiple layers of vertical aerial imagery covering the past 20 years and ranging in resolution from 125 cm (1997) to 10 cm for the most recent imagery. A smaller imagery dataset is also available via the Israeli state service at govmap.gov.il.

For the purposes of archaeological investigation, the key advantage of the Geomolg platform was that it provided comprehensive coverage of the West Bank area, with multiple tiles of very high-resolution imagery. In particular, the resolution of the 2014–2016 imagery was so high (25 cm for 2014–2015 and 10 cm for 2016) that it was possible to spot features as small as cistern heads and wells, although there were issues of exposure saturation that made optical analysis more difficult. There were also problems where sensitive sites were heavily blurred, replaced with innocuous empty fields, or in the case of the landscape of the Dimona nuclear facility, simply left blank as part of Israeli censorship requirements. Unfortunately, following a period marred by repeated server outages, the Geomolg system is now no longer open-access, limiting its future use as an open archaeological tool, although this comes at a stage when the KBA reform should improve the availability of satellite imagery from other sources.

In spite of the value of imagery held on the Geomolg platform, it was decided that a more significant contribution to the survey of the Jericho Oasis could be achieved through the systematic assessment of historic airborne and spaceborne imagery of the region, particularly given how much the area had changed since the late 1940s. As a starting point, we were able to draw on data from the US KH-4 CORONA missions from the 1960s. The lower resolution of this imagery (2 m+ GSD) meant that, as with more recent commercial imagery affected by the KBA, it was of limited value for identifying heritage sites. Nevertheless, it is still a useful tool for documenting settlement expansion and agricultural intensification during the 1960s, as well as its impact on the archaeological heritage of the oasis.

It seemed likely that greater potential lay in aerial photography taken by British colonial units and

other air forces operational over this region during the First and Second World Wars. Unlike the CORONA satellite missions, however, identifying and accessing disparate collections of aerial photography posed a number of issues, requiring more desk-based background research and focus on collections with the highest archaeological potential.

The rapid development of aerial photography as a military tool during the First World War was a critical factor in its subsequent use as an archaeological technique in the post-war period (Fradley 2021). The advance of British and Commonwealth forces through Sinai and into Palestine, and the provision of German air forces in support of Ottoman armies in this theatre, saw the use of aerial photography, on both sides, deployed for a range of tasks, including reconnaissance, bombing records and for incipient photogrammetric map-making (Collier 1994; Gavish and Biger 1985; Napier 2012). On the British side, the potential for the use of aerial photography for archaeological research in the Middle East, was realized by air crews who had served on the Palestine and Mesopotamia fronts (Beazley 1919; Thomas 1920a; 1920b). However, active archaeological flight missions were rare in the inter-war period, as with Glueck's limited work or Stein's Limes project in Transjordan (Glueck 1937a; 1937b; Stein 1940; TNA: CO 831/41/4). No work was undertaken comparable to the concerted aerial survey campaign, led by Antoine Poidebard, in neighbouring Mandate Syria (Poidebard 1934; see Griswold 2019 for a more complex reading of Poidebard's work).

The dominant figure in British aerial archaeology, O. G. S. Crawford, attempted to bring together a national British collection of aerial photographs of Near Eastern archaeological sites, first at the British Museum, and later moved to UCL (Banks 2017; Crawford 1929; TNA: OS 1/384). Crawford visited RAF bases in the region in 1929 and again in 1937, bringing copies back to his nascent collection (see Fradley 2021). Based upon the material he collected, it seems that the options open to Crawford were fairly limited. From Jericho, for instance, Crawford brought back several vertical shots of the occupied settlement outskirts, but none of Tel es-Sultan; although it is not impossible that photographs of the latter have been lost from this collection at a later date.

There is some documentary evidence that aerial photographic mapping missions were carried out over Palestine during the British Mandate period. Aerial photographic mapping was also undertaken to revise 'cadastral' mapping of land ownership

(MECA: GB165-0187), while vertical photograph mosaics of specific areas were also constructed, and archaeological excavations were recorded from the air on behalf of the Department of Antiquities, Jerusalem (TNA: AIR 1/2273/209/71/3/9B). Little of this material is known to survive in any accessible archive. It seems probable that negatives and prints may have been held by the Survey Department of the Mandate government. Its fate under the subsequent Survey of Israel is not known. The most complete set of aerial photography of Palestine from the British Mandate period are the mapping runs undertaken by 680 Squadron RAF, a specialist wartime photography unit, from 1944–1946. These mapping missions covered much of Mandate Palestine (Weizman 2020: 43–44) and a large set of negatives from these missions are now held at the National Collection of Aerial Photography (NCAP), in Edinburgh. Although the commercial nature of the NCAP archive restricts easy access, prints are also held at the Hebrew University of Jerusalem. Neither organization was able to provide full coverage of the Jericho Oasis. Two of these RAF photographs, covering a small portion of the Jericho Oasis, were used in this study to assess the oasis in the mid 1940s (mission references: PS30-M 50901 and PS30-M 50911).

The wide range of surviving collections of historic aerial and declassified satellite imagery for the Jericho region clearly had potential when evaluating landscape change, prior to the development of modern commercial satellite imaging. The small set of low-altitude, oblique photographs, taken by the German air force in the later part of the First World War, proved to have the greatest potential for identifying unknown sites. As the air force retreated with Ottoman forces in 1918, German units began explicitly photographing sites of archaeological importance, despite the targets being of no strategic importance (Weizman 2020: 42). The main collections of aerial photographs (Luftstreitkräfte) have been made digitally available online (Mader 2020; Staatlichen Archive Bayern n.d.) <https://www.gda.bayern.de/findmitteldb/Suche/Archiv/>). A selection of these images was first published in the 1920s (Dalman 1925). A comparable collection of images, captured by British forces during the First World War and held by The National Archives in Kew, has been digitized by the APAAME project (APAAME n.d.); these were not used in this study. In total 22 photographs from the Staatlichen Archive Bayern, covering the Jericho Oasis were used for this study (Table 1).

Table 1 A list of aerial photographs used in this study from the Staatlichen Archive Bayern, Germany

Aerial photograph subject description	Archive ID
En en-Nueme, wie Nummer 1011 mit nördlicher Fortsetzung	Bayerisches Hauptstaatsarchiv, BS-Palästina 1012
Wadi en-Nueme südwestlich von Öschsch el-Rurab	Bayerisches Hauptstaatsarchiv, BS-Palästina 1009
Wadi en-Nueme, westliche Fortsetzung von Nummer 1006	Bayerisches Hauptstaatsarchiv, BS-Palästina 1007 a
Nördlich von Jericho bei Chirbet el-Mefdschir, südliche Fortsetzung von Nummer 1002	Bayerisches Hauptstaatsarchiv, BS-Palästina 1015
Dschebel Karantal und Wasserleitungen von En Duk und Tawahin es-Sukkar	Bayerisches Hauptstaatsarchiv, BS-Palästina 1033
Dschebel Karantal und Wasserleitungen von En Duk und Tawahin es-Sukkar	Bayerisches Hauptstaatsarchiv, BS-Palästina 1033
Südlich von Öschsch el-Rurab, fast wie Nummer 1007, südliche Fortsetzung von Nummer 1006 und 1007	Bayerisches Hauptstaatsarchiv, BS-Palästina 1008
Tell es-Sultan (Alt-Jericho) mit Quelle und Gärten, Tell Abu Hindi, Tell es-Samarat, Tawahin es-Sukkar	Bayerisches Hauptstaatsarchiv, BS-Palästina 1031
Nordöstlich von Jericho, wie Nummer 1017 mit östlicher Fortsetzung	Bayerisches Hauptstaatsarchiv, BS-Palästina 1019
Tell es-Sultan (Alt-Jericho) mit Quelle und Gärten, Tell Abu Hindi, Tell es-Samarat, Tawahin es-Sukkar	Bayerisches Hauptstaatsarchiv, BS-Palästina 1031 b
Neu-Jericho und nächste westliche Umgebung, ähnlich wie Nummer 1028	Bayerisches Hauptstaatsarchiv, BS-Palästina 1029 a
Östlich von Jericho, Fortsetzung der Straße zum Jordan und Wadi Abu el-Hamed	Bayerisches Hauptstaatsarchiv, BS-Palästina 1023 a
Östlich von Jericho, Wadi el-Kelt und Straße zum Jordan	Bayerisches Hauptstaatsarchiv, BS-Palästina 1022
Irtah (nicht Irtab) und nordwestliche Umgebung, Straße, Eisenbahn	Bayerisches Hauptstaatsarchiv, BS-Palästina 16
Neu-Jericho und nächste nordöstliche Umgebung	Bayerisches Hauptstaatsarchiv, BS-Palästina 1030
Neu-Jericho und nächste westliche Umgebung, ähnlich wie Nummer 1028	Bayerisches Hauptstaatsarchiv, BS-Palästina 1029 b
Westlich von Jericho, westliche Fortsetzung von Nummer 1038	Bayerisches Hauptstaatsarchiv, BS-Palästina 1039
Südwestlich von Jericho: Nebi Musa-Straße mit östlicher und westlicher Umgebung	Bayerisches Hauptstaatsarchiv, BS-Palästina 1045 c
Westlich von Jericho: Wadi el-Kelt, westliche Fortsetzung von Nummer 1036	Bayerisches Hauptstaatsarchiv, BS-Palästina 1037 a
Westlich von Jericho: Wadi el-Kelt, Jerusalem-Straße	Bayerisches Hauptstaatsarchiv, BS-Palästina 1041 a
Südwestlich von Jericho mit Chirbet Kakun und Wadi Medbah Ajjad, südliche Fortsetzung von Nummer 1049	Bayerisches Hauptstaatsarchiv, BS-Palästina 1050
Südwestlich von Jericho, westlich der Nebi Musa-Straße, westliche Fortsetzung von Nummer 1047 und 1051	Bayerisches Hauptstaatsarchiv, BS-Palästina 1052 a
el-Azarije, Jericho-Straße, Chan Hatrur, Chan el-Meschrab, Der el-Kelt, Dschebel Karantal usw.: südöstlich Der el-Kelt, wie Nummer 899 mit weiterer östlicher Fortsetzung	Bayerisches Hauptstaatsarchiv, BS-Palästina 900 a
Gelände zwischen Wadi en-Nueme und Tell es-Sultan (nicht Tell Abu Hindi)	Bayerisches Hauptstaatsarchiv, BS-Palästina 1020 a
Nordwestlich von Jericho: Tell Abu Zelef	Bayerisches Hauptstaatsarchiv, BS-Palästina 1035
Neu-Jericho (Eriha) und nächste südwestliche Umgebung	Bayerisches Hauptstaatsarchiv, BS-Palästina 1028 a
Südwestlich von Jericho: Ostrand der Gebirgswüste Juda mit Wadi el-Kelt und Serpentina der Jerusalem-Straße	Bayerisches Hauptstaatsarchiv, BS-Palästina 1042
Südöstlich von Jericho: Rudschm el-Merefir und Chor Abu Dahi	Bayerisches Hauptstaatsarchiv, BS-Palästina 1026

Methodology

The methodology is composed of three phases: first, a systematic analysis of aerial and satellite imagery, supported by the analysis of regional maps and published archaeological data; second, a record creation phase, standardizing data as much as possible and entering

it into the EAMENA database, a customized deployment of Arches, the open-source heritage inventory platform developed by the Getty Conservation Institute; and a third, final phase, where the conditions of the archaeological sites were monitored using a combination of remote sensing and field

verification data, to provide adequate documentation of the status of visible remains.

For this study of the Jericho Oasis, our focus on the use of oblique German aerial photography necessitated an initial stage of georectification. The Luftstreitkräfte photographs were georeferenced on the QGIS platform to overlay them on modern satellite images, using the Georeferencer GDAL tool in QGIS with the WGS 84 36N co-ordinates (EPSG 32636) projection. Extensive changes to the landscape over the past century made the identification of control points difficult. Potential errors were accentuated by the fact that the photographs used were oblique views, that were difficult to relate accurately to a vertical satellite image. Depending on the scale of change in the area covered by the photographs, between four and ten matching reference points spread out across different parts of each aerial photograph and the modern satellite basemap were used to geoprocess the images.

Once the historic aerial photographs had been georeferenced, they were systematically analysed for archaeological elements hidden in the subsoil. These can be identified visually as surface marks such as

soilmarks, cropmarks and upstanding structural remains. Anthropogenic action that disrupts the soil leaves traces that can be identified as soilmarks, for instance through building material brought to the surface by the plough, or varying water-retention rates because of the material composition of the soil (Musson 2013: 64). Cropmarks indicate the chromatic difference in cultivated fields created by differential rates of crop growth, potentially resulting from the impact of underlying archaeological deposits that affect fertility or water retention in the soil (Musson 2013: 66). Upstanding remains can include structures and building remains, as well as built features that are now only visible as archaeo-topographical features, which can range from small embankments to large tells (Fradley 2019), and which are often accentuated on aerial images by the shadows they cast. In the arid or semi-arid regions typical of the Near East and North Africa, it is these upstanding features that are most easily detected optically via remote sensing techniques (Bewley *et al.* 2015: 920).

Any site identified was checked against existing gazetteers (Greenberg and Keinan 2009; Nigro *et al.* 2011; PADIS 2011) of documented archaeological

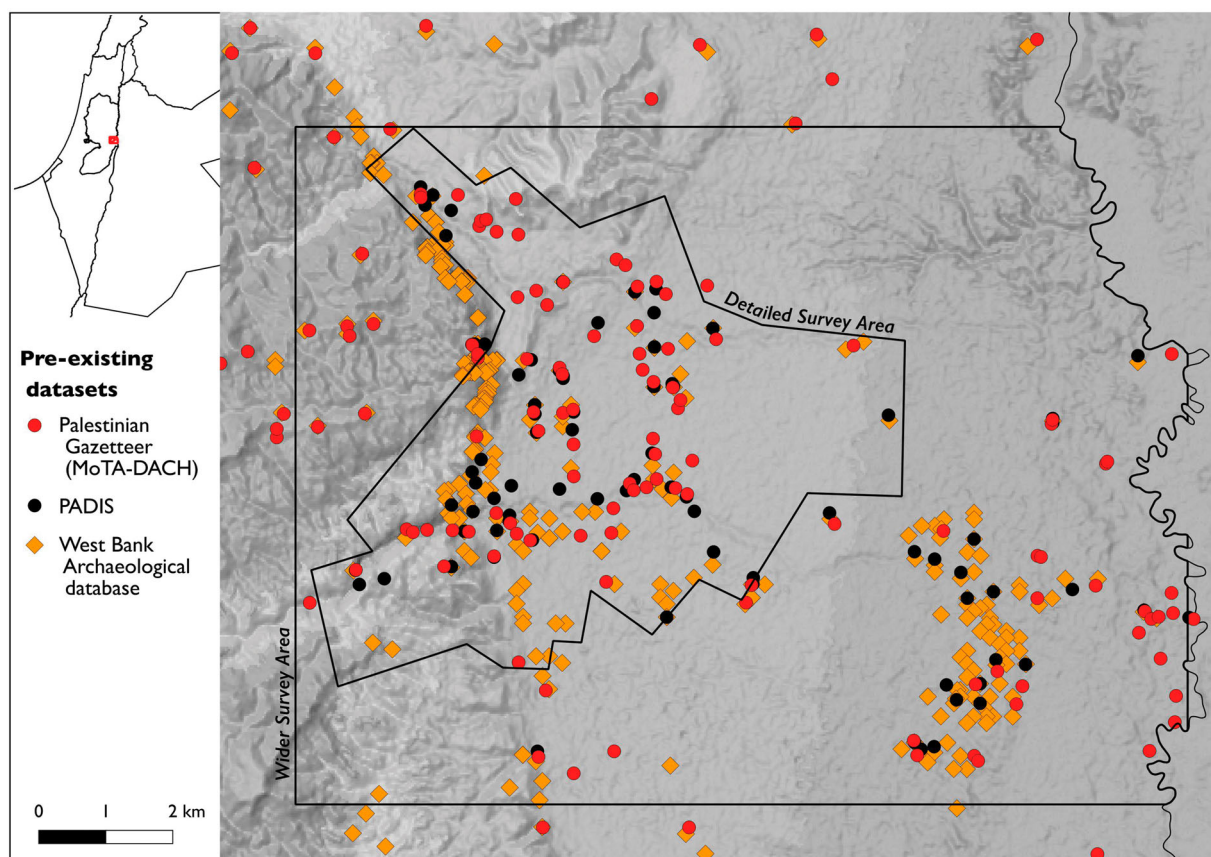


Figure 1 Distribution map of sites documented in the Jericho Oasis in existing gazetteers. The detailed study area delimits the area covered by the German First World War photography.

sites (Fig. 1). As sites identified via a remote-sensing survey could not, due to the limited nature of this project, be ground-checked to confirm that they were definitely archaeological features, and the vast majority of sites recorded by the EAMENA project have not been visited in the field, levels of certainty are recorded by the investigator. While still subjective, they provide an indicator of value that can be attributed to a site record. The certainty levels recorded by the EAMENA project and used in Table 2 below are:

‘Negligible’: there is very weak evidence to suggest that the site/feature is archaeological, i.e. an indicative toponym exists, but there is no corresponding imagery data.

‘Low’: there is weak evidence to suggest that the site/feature is archaeological. The site/feature may be unclear on imagery, or alternative explanations may be probable.

‘Medium’: there is evidence to suggest that the site/feature is archaeological. The area has multiple sources of evidence which support each other (e.g., multiple image sets) or is clear enough in a single evidence source to suggest that it is probably a site of archaeological interest.

‘High’: there is strong evidence to suggest that the site/feature is archaeological. The area has multiple sources of evidence that support each other (e.g., multiple image sets) or is clear enough in a single evidence source to suggest that it is a site of archaeological interest.

‘Definite’: the site has been visited and it is confirmed that it is a site of archaeological interest.

Once a potential archaeological feature has been identified, it is also classified, in terms of its physical form, as visible on an aerial or satellite image. Unsurprisingly, given the length and intensity of

Table 2 A list of sites recorded by the EAMENA survey. ‘Overall site certainty’ is used to define the certainty that the feature identified is archaeological

OBJECT ID	Feature Form	NAMES	Overall Site Certainty	WGS84 UTM 36N	
				X	Y
1	Colour/Texture Difference	E35N31-34_000047	Low	35,430808	31,893509
2	Structure; Pit/Shaft/Tunnel	E35N31-34_000048	High	35,433806	31,893295
3	Pit/Shaft/Tunnel	E35N31-34000049	Definite	35,432358	31,89223
4	Small Mound/Cairn	E35N31-34_000050	Low	35,435056	31,87490
5	Structure	E35N31-34_000051	Definite	35,438670	31,87295
6	Depression/Hollow; Pit/Shaft/Tunnel	E35N31-34_000052	Low	35,440156	31,87996
7	Structure	E35N31-34_000053	Low	35,435914	31,87457
8	Structure	E35N31-34_000054	Medium	35,438006	31,87143
9	Structure	E35N31-34_000055	High	35,442793	31,86933
10	Structure; Structure	E35N31-34_000056	High	35,441142	31,86975
11	Structure	E35N31-34_000058	Low	35,433889	31,89335
12	Colour/Texture Difference; Large Mound	E35N31-34_000060	Low	35,448722	31,87520
13	Structure	E35N31-34_000062	High	35,433425	31,84559
14	Depression/Hollow	E35N31-34_000063	Low	35,432426	31,84496
15	Depression/Hollow	E35N31-34_000064	Low	35,462991	31,84701
16	Pit/Shaft/Tunnel	E35N31-34_000065	Low	35,437157	31,84428
17	Structure	E35N31-34_000066	High	35,444196	31,85191
18	Structure	E35N31-34_000067	High	35,434304	31,84747
19	Large Mound	E35N31-34_000068	High	35,447177	31,87377
20	Structure	E35N31-34_000069	Definite	35,444196	31,85191
21	Large Mound	E35N31-34_000070	High	35,449563	31,88640
22	Colour/Texture Difference	E35N31-34_000071	High	35,464324	31,85510
23	Large Mound	E35N31-34_000072	High	35,442076	31,86206
24	Large Mound	E35N31-34_000073	Medium	35,442412	31,86207
25	Structure	E35N31-34_000074	Medium	35,485952	31,86083
26	Small Mound/Cairn	E35N31-34_000076	High	35,472966	31,84699
27	Small Mound/Cairn	E35N31-34_000077	Low	35,450852	31,85224
28	Structure	E35N31-34_000078	High	35,456462	31,87571
29	Structure	E35N31-34_000079	Medium	35,450549	31,88121
30	Small Mound/Cairn	E35N31-34_000080	High	35,450549	31,88121
31	Structure	E35N31-34_000081	Low	35,438923	31,83997
32	Structure	E35N31-34_000082	Medium	35,453688	31,84549
33	Large Mound	E35N31-34_000086	High	35,439057	31,84170
34	Structure	E35N31-34_000087	High	35,438828	31,87444
35	Structure	E35N31-34_000088	Medium	35,430786	31,84816
36	Structure	E35N31-34_000089	Medium	35,43596	31,84810
37	Pit/Shaft/Tunnel	E35N31-34_000087	Definite	35,43280	31,83696
38	Structure	E35N31-34_000090	Definite	35,43235	31,89223

occupation across the Jericho oasis, a wide range of different archaeological features were recorded, from the classic ‘tell’ site to the remains of masonry structures from the Roman era. Negative forms were also recorded, such as pits and shafts which can indicate looting elements and graves.

The condition of these sites was also assessed on modern satellite and aerial imagery, primarily with the high-resolution imagery available at the point of research through the Geomolg platform. Any damage to the sites was documented, with some of the sites potentially undergoing complete destruction since their capture on the 1918 photographs, and with only a chance that subsurface deposits may have survived. The cause of damage to the sites, as far as can be interpreted from an aerial perspective, was also documented, as were any potential future threats to the sites. This is to help inform trends and future management.

The remotely sensed data was combined with field-acquired data obtained via surveys conducted by Lorenzo Nigro, University of Rome — La Sapienza, in the case study areas (Nigro 2020; Nigro *et al.* 2015b). For Jericho, this data formed the basis for PADIS, the Palestine Archaeological Databank and Information System, an online gazetteer of 105 heritage sites (Sala and D’Andrea 2011), functioning as a baseline dataset for the present survey.

An archaeological narrative of the Jericho Oasis

The numerous archaeological investigations discussed above have helped develop a narrative of occupation across the oasis, in which the importance of water sources is a recurring theme (Nigro 2011: 5). As an early centre of Natufian culture (Mazar 1992: 40), the first traces of human occupation date back to the Epipalaeolithic (10500–8500 BC), followed by activity in the Neolithic PrePottery A (9th–8th millennium BC) (Mazar 1992: 30) when the first traces of permanent settlement are recorded on the sites of Tell es-Sultan and ‘Ain Duq, which relate to nascent agriculture in the area (Nigro 2011: 6).

In the Pottery Neolithic (6800–5400 BC), the smaller site of Tell el-‘Alayid South was established along the Wadi el-Qelt, possibly connected to seasonal hunting along the border with the desert of Judah. The River Jericho shifted its course, causing the abandonment of the site of Tell es-Sultan, probably due to seismic activity (Nigro 2016: 8). During the second half of the 5th millennium BC, the data suggest a substantial settlement shift towards the Wadi en-Nu’eima, fuelled by the springs of ‘Ain el-Auja and ‘Ain Duq, in the north of the oasis following the shift of the River Jericho. At the sites of Tell el-

Mafjar and Tell el-‘Alayq South the situation differed and occupation continued between the Chalcolithic and the Early Bronze Age I (3600–3000 BC) (Nigro 2011: 8–9; 2019: 141). Tell el-Mafjar appears to have risen in importance at this time and another small settlement was also established on the slopes of Jebel Quruntul (Nigro 2011: 8). During Early Bronze Age II (3000–2800 BC) Tell el-Mafjar was abandoned, while Tell el-‘Alayq South has traces of occupation continuing until the Early Bronze Age IV period (2500–2000 BC).

From the Early Bronze Age I to the Iron Age (1200–330 BC), there are traces of resumed occupation at Tell es-Sultan, as a community of farmers utilized the waters of the ‘Ain es-Sultan. The wave of Middle Bronze Age II (1800–1600 BC) urbanization affected Jericho, where brick-wall fortifications were built (Nigro 2016: 14). Recorded settlement in the oasis as a whole during this period is limited to Tell es-Sultan and some slight trace of occupation at Suwwanet eth-Thaniya, a situation subsequently reversed during the Late Bronze Age (1600–1200 BC) as occupation at Tell es-Sultan shrank, while other small villages were established in the oasis at Wadi en-Nu’eima. The Iron Age saw colonization by static communities along the margins of the Oasis, close to the desert of Judah and in the Wadi en-Nu’eima (Landes 1975: 5–10), and to the west in the Wadi el-Makhamas. Unfortunately, much of the Iron Age occupation phases have been severely degraded by later occupation phases (Nigro 2011: 16), but it is important to note the presence of a tripartite public building called a ‘Bit-Hilani’, by the German archaeologist Helga Weippert (Nigro 2019: 150).

During the Persian period (535–333 BC), the Oasis of Jericho continued to be occupied, but with limited culturally recognizable evidence of occupation or intensive settlement. A Persian barbed arrowhead was found at Tell es-Sultan, while an ostrakon with an Aramaic inscription and some stamp seal impressions attributable to this period have also been recovered. Only one site, a ritual bath in Wadi en-Nueima, was assigned to the Persian period, suggesting a decline of settlement and cultivation across the whole oasis (Nigro 2013: 7). There appears to have been a widespread revival across the oasis in the Hellenistic period: in addition to the creation of aqueducts and water systems to promote agricultural development, several buildings were founded during the 2nd–1st centuries BC at the Tell Abu el-‘Alayiq North site. The latter extended over an area of about three hectares and included the first Hasmonean palace, known as the ‘Buried Palace’, with associated ritual baths (Nigro 2011: 17). Some

small fortresses were also built to protect access to the oasis during this period, as at Tell el-‘Aqaba, Nuseib ‘Uweishira and Jebel Qurtul, and further settlements were established along its natural topographical boundaries at Qasr al-Yehud, Suwwanet eth-Thaniya and Wadi en-Nuemia (Nigro 2011: 18).

From 64 BC the area came under Roman control, a period characterized by the construction of aqueducts and water management features, diverting water from ‘ain Duq and ‘ain en-Nu’eima. The winter residence of Herod the Great, erected *c.* 35 BC in the southern part of Wadi Qelt (Tell Abu al-‘Alayiq North and South), was destroyed by an earthquake in 31 BC; it was rebuilt immediately, incorporating part of the Hasmonean palaces to the north of the wadi (Netzer 1993: 687). Finally, the Third Palace was erected with two long wings along the banks of the Wadi Qelt, connected by a bridge (Hamamrah 2011: 311).

In the Byzantine period Jericho developed as a place of pilgrimage and prayer as numerous monasteries were established throughout the area (Nigro 2011: 21). Many monasteries were constructed in previously uninhabited areas, although some of them were built over the remains of ancient Hellenistic and Roman buildings. A few of these Byzantine buildings survive as standing structures, such as the monastery of the Mount of Temptation (Qebel Quruntal). Although the Arab invasion in the 7th century AD was followed by a substantial reduction in the occupation of the Oasis, it was also a period that saw the construction of a monumental Umayyad palace at Khirbet el-Mafjar, built in the 8th century AD, with mosaics and a complex water system (Nigro 2011: 24). Khirbet el-Mafjar continued in use during the Abbasid and Ayyubid periods (Cirelli and Zagari 2000: 4), but by the time of the First Crusade, in AD 1099, occupation at Jericho had been reduced to a small village on Tell el-Hassan (Sala 2014: 121), directly in front of the monastery of the Mount of Temptation, where the Templars built a fort called ‘Castellum Dock’ (Cirelli and Zagari 2000: 5).

As this brief summary of archaeological activity in the Jericho Oasis up to the medieval period shows, the area has been consistently occupied at varying levels across millennia, but there have been notable shifts in the intensity, form and geographical focus of settlement. It is within this context of existing knowledge that this research, through the analysis of datasets of early aerial photographs, looks to build.

Sites documented by the EAMENA survey

Although this region of the Levant has been intensively studied for more than a century, this analysis

of historical aerial photographs, combined with modern satellite and airborne imagery, has allowed the identification of new and hitherto unrecorded archaeological sites. Many of these sites have been identified as surface features on the georeferenced historical imagery, allowing the recognition of 38 new sites of potential archaeological significance (Fig. 2; Table 2). These should be added to the 105 sites already documented in the PADIS database and on the Geomolg platform for the same study area. The following is a summary of some of the key identifications made by the EAMENA survey, with the full dataset now included in the EAMENA database.

Two of the most striking features have been identified in the vicinity of Tell es-Sultan. Two square features are located respectively 60 m south-west and 200 m west of Tell es-Sultan. The former (E35N31-34_000054, site no. 9), *c.* 40 m x 40 m, is difficult to interpret; consisting of a square, enclosed area, that is prominently defined on its eastern and western sides by broad, undulating banks (Fig. 3). The latter (E35N31-34_000055, site n. 10) consists of a rectilinear series of walls and possible ditches (Fig. 4), and seems to connect to a linear water management feature that continues to the west, perhaps part of the larger water management infrastructure developed in the Hellenistic and Byzantine periods (Nigro 2011: 17–21).

Other archaeological features have been identified, on the First World War photographs, in the northern part of the Oasis, in the vicinity of the known site of Khirbet Abu Lahm/Tell Abu Lahm (Fig. 5), already displaying clear signs of looting at that time (Jennings 2015: 159) as evident from the archive photo. Two new features have been identified, respectively 150 m and 330 m to the north-east of this site, in the upper section of the Wadi en-Nu’emia. The first is a sub-square feature, which appears to contain a number of circular wells (E35N31-34_000048, Site 2; Fig. 6); the second is nearly circular in shape and is located along the wadi slope (E35N31-34_000058, Site 11; Fig. 7). This may have been part of a series of structures controlling access to the Oasis, a function suggested by Conder and Kitchener at Abu Lahm (Conder and Kitchener 1883).

Further along the wadi slope from Abu Lahm are a number of small, dark soil marks, which may be interpreted as the remains of chamber tombs (E35N31-34_000047, Site 1, Bayerisches Hauptstaatsarchiv, BS-Palästina 1009) typical of the area (Kenyon 1960; Polcaro 2005). Similar features have also been spotted near eth-Thiniya, a site located in the vicinity of necropolis K, excavated by Kenyon. In the

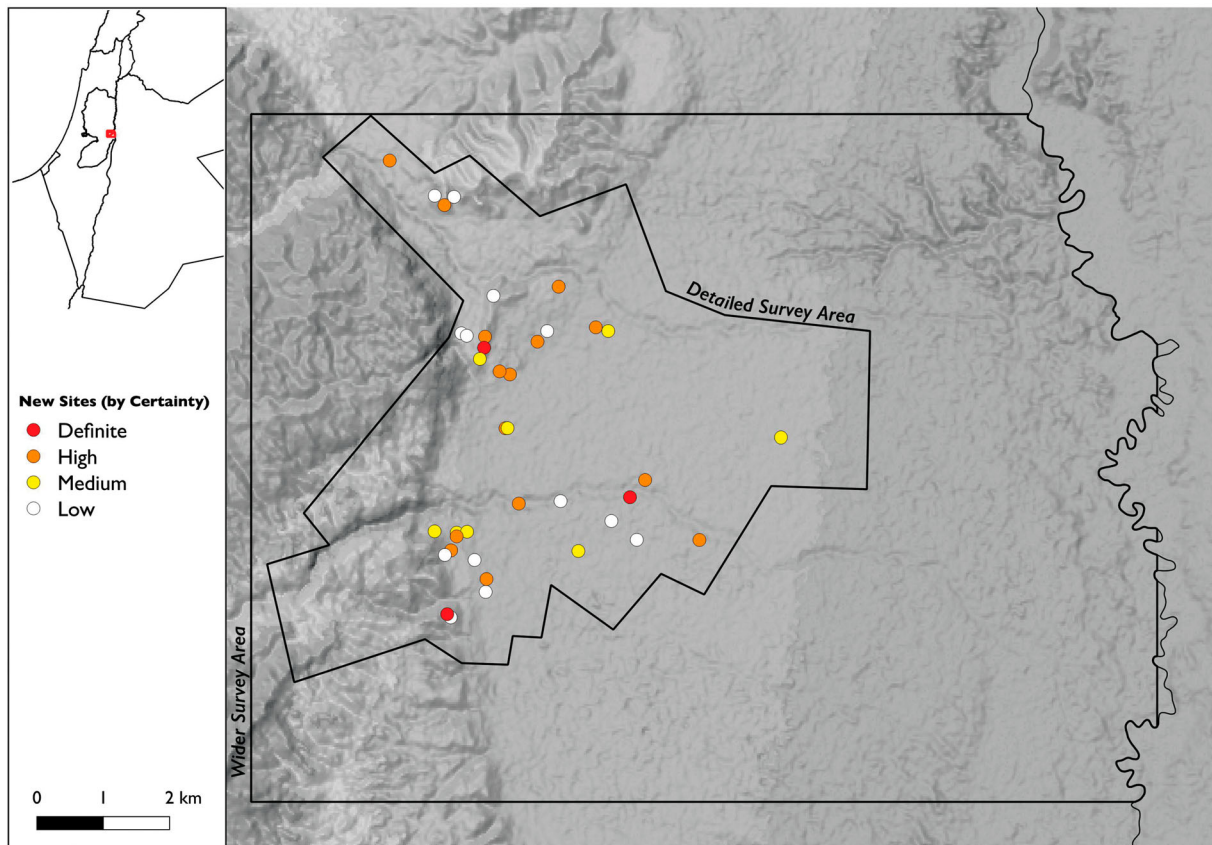


Figure 2 Distribution map of sites documented in the Jericho Oasis. The certainty value highlights the certainty with which the feature identified on an aerial photograph is archaeological.

northern sector of the Oasis, a probable Tell has been identified, approximately 1 km north-west of Kh. Abu Lahm. This sub-quadrangular Tell of c. 40 × 50 m (E35N31-34_000070, site 21; Fig. 8) seems to show

signs of looting and plundering on the German photograph, although image quality is not optimal and it is possible that pit features are part of the abandoned archaeo-topographical form of the mound.



Figure 3 Site 9 west of Tell es-Sultan (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1033 and Geomolg).

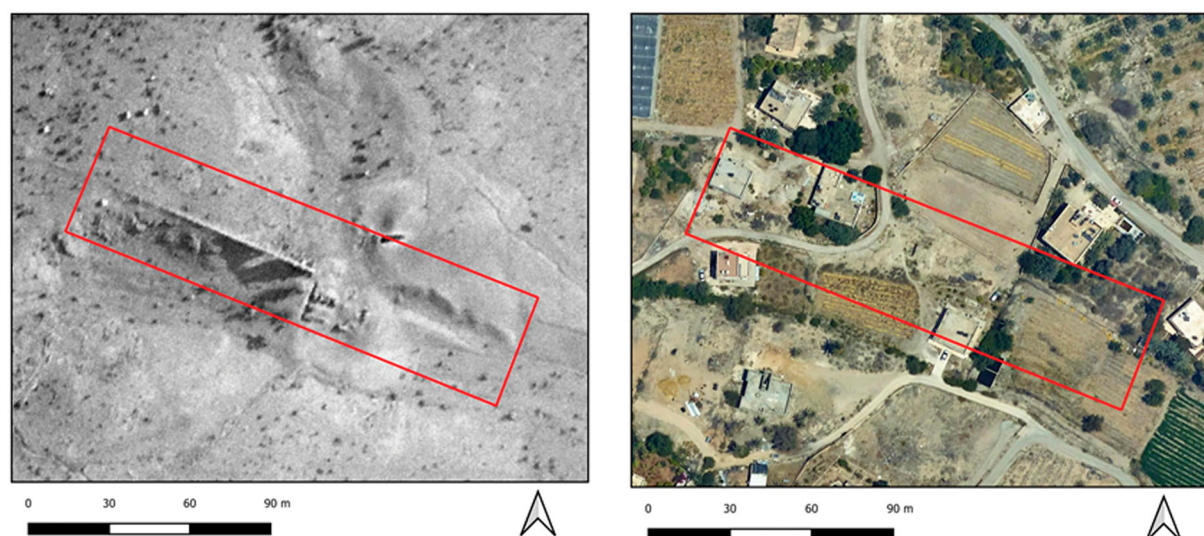


Figure 4 Site 10, west of Tell es-Sultan (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1033 and Geomolg).

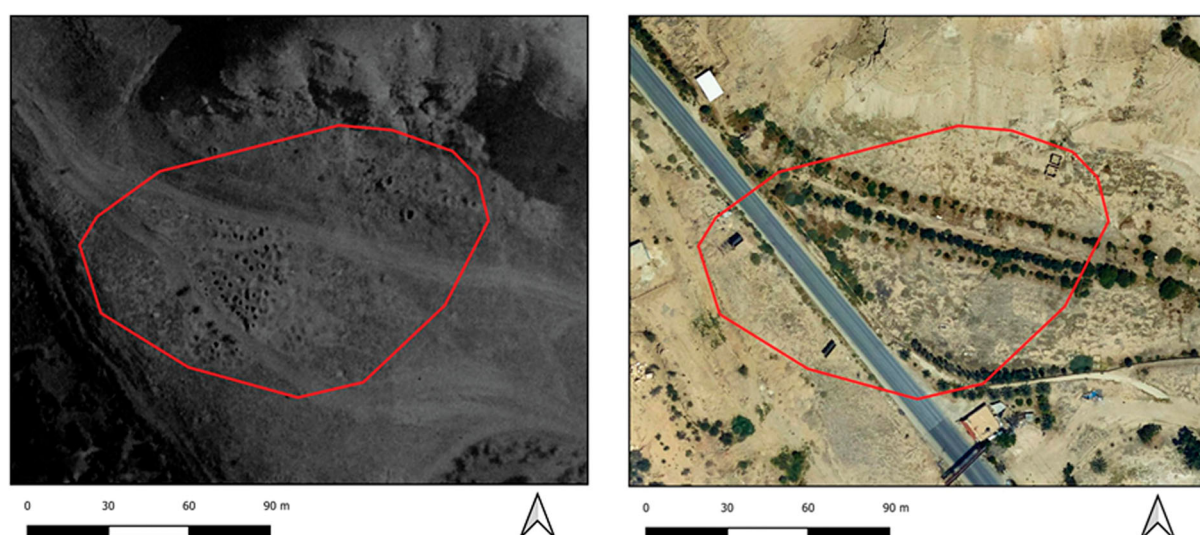


Figure 5 Site 3 at Khirbet Abu Lahm/Tell Abu Lahm (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1009 and Geomolg).

Fortunately, the area is currently used for agricultural use and, therefore, still potentially open to investigation on the ground.

Sites 10 and 17 (E35N31-34_000056 and E35N31-34_000066) highlight how different sections of an aqueduct, developed in the Hellenistic and Byzantine periods, were still visible on the ground, for relatively long stretches, in the early 20th century (Fig. 9). In both cases the sites have been impacted by subsequent construction and agricultural use, although elements may survive at the site.

In the southern section of the Oasis a linear feature was identified along the southern rim of the wadi Qelt,

c. 700 m east of Herod the Great's Palaces II and III (Site 16). This is likely to be a portion of an aqueduct that must have crossed the whole wadi, and, like site 9 (Bayerisches Hauptstaatsarchiv, BS-Palästina 1033) described above, was probably part of the larger water management infrastructure built in the Hellenistic, Roman or Byzantine periods (Nigro 2011: 17–21).

At site 20 (Fig. 10), an almost square form, defined by small sub-circular enclosures, was documented, leading to speculation as to whether it may have been the remains of a qasr. With sides measuring 70 m, it seems comparable to the measurements of

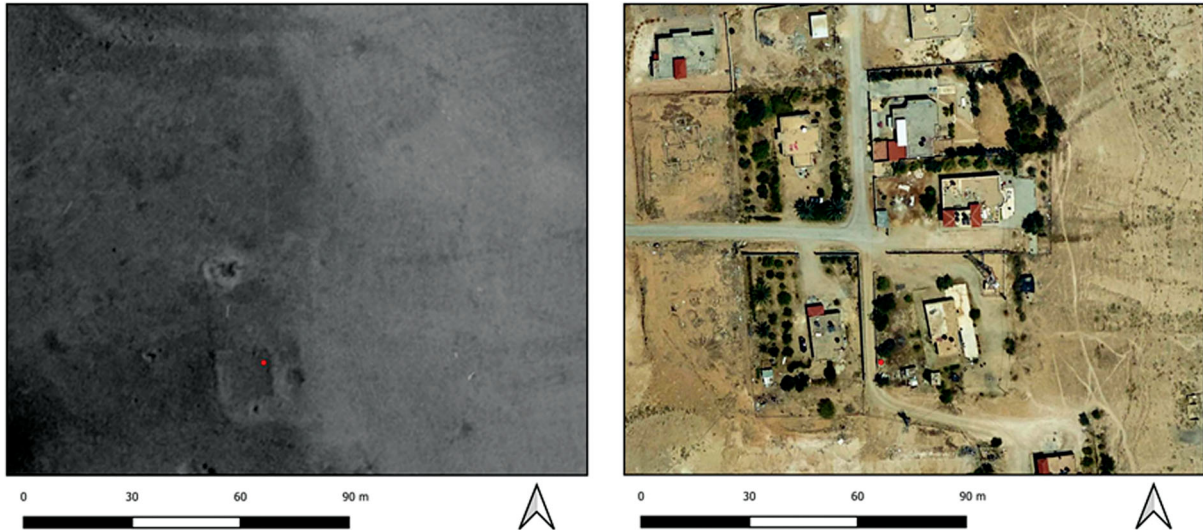


Figure 6 Site 2 on the upper section of the Wadi en-Nu'emia (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1009 and Geomolg).

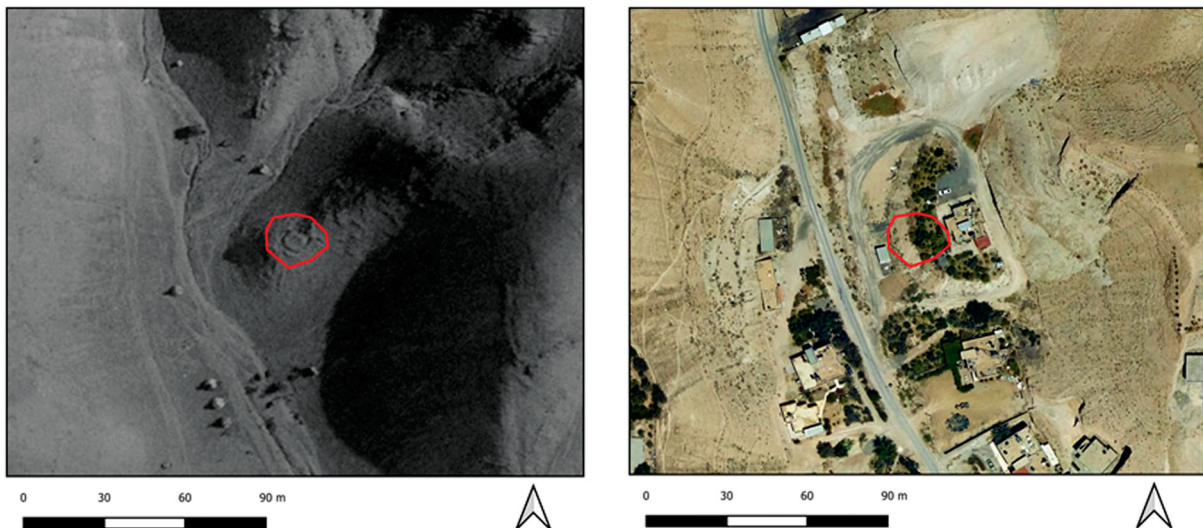


Figure 7 Site 11 on the upper section of the Wadi en-Nu'emia (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1009 and Geomolg).

the qasr of the Umayyad period, Qasr el-Hayr el-Sharqi or Qastal (Genequand 2006: 8–9). A small quadrangular structure, not in line with the walls of the feature, is identifiable in the centre of the area. However, the structure was not visible in the 1945 vertical RAF aerial photograph, even though the area was still free of construction and agricultural activity. A more probable comparison can be identified in one of the contemporary photographs in the APAAME collection, depicting a British military cavalry camp consisting of a rectangular arrangement of tents (TNA: AIR 1/2270/21/2). If it was a temporary

cavalry camp, this would provide a logical explanation for why it was no longer visible from the air in the 1940s.

Contemporary high-resolution aerial imagery was also assessed for undocumented archaeological sites. Orthophotography, hosted on the Geomolg platform, enabled the identification of a possible necropolis (Site 37 E35N31-34_000089), identifiable via open pits resulting from illicit looting (Fig. 11), in the south-western area above the plateaus west of Aqabat Jabr. Nearby is a rectangular structure that appears to be extant and which can, potentially, still

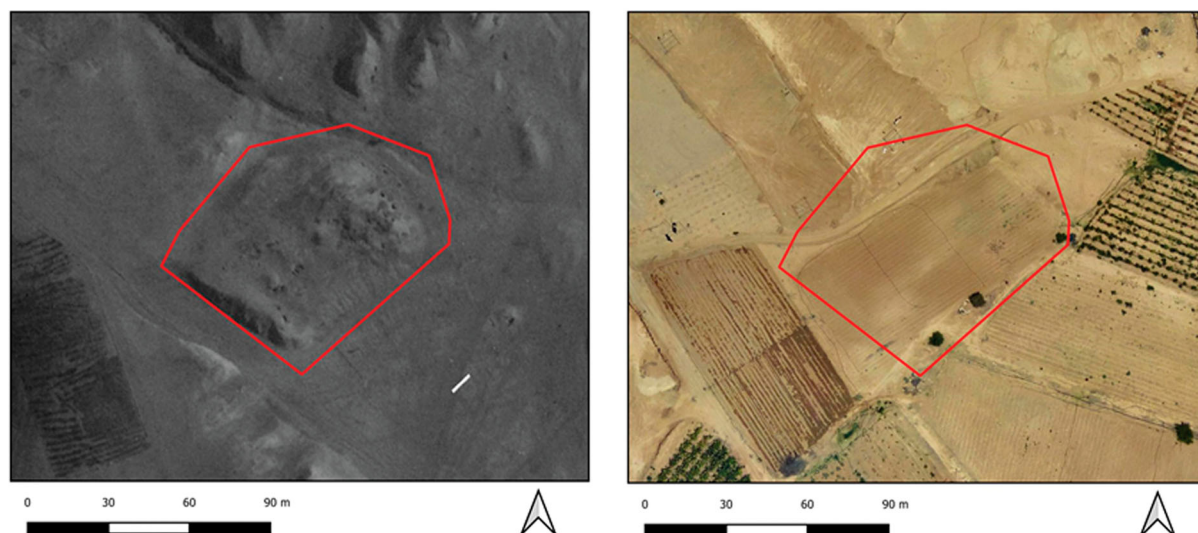


Figure 8 Site 21, a possible tell site in the northern section of the Oasis (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1012 and Geomolg).

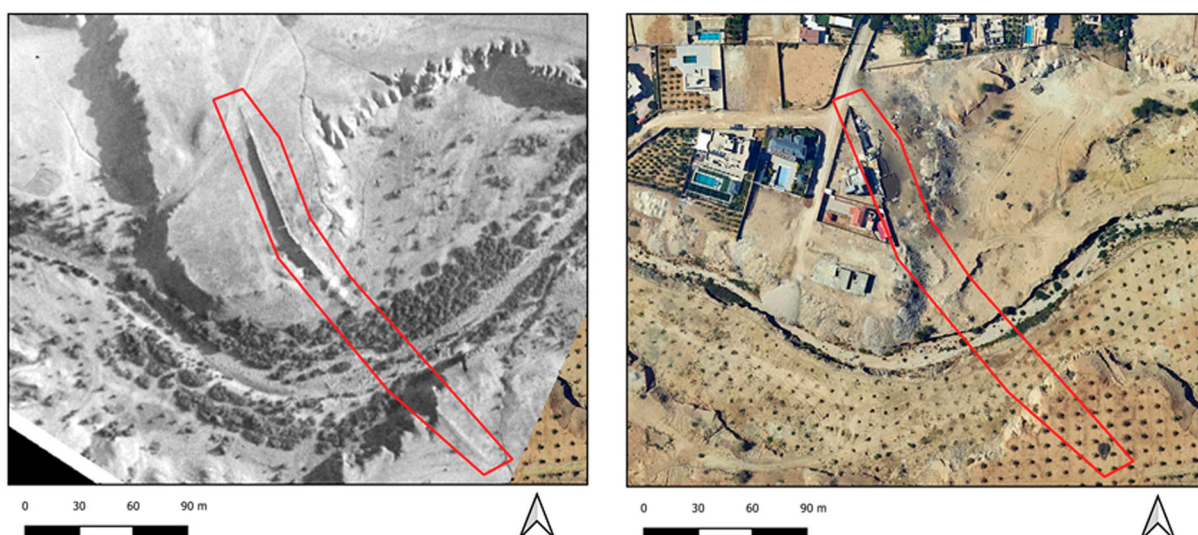


Figure 9 Site 17, a possible section of an aqueduct system (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1041 a and Geomolg).

be investigated on the ground (Site 35, E35N31-34_000087 — Bayerisches Hauptstaatsarchiv, BS-Palästina 1042).

Together with the new sites discussed above, it has been possible to identify features belonging to documented sites which have been totally destroyed or severely altered over the past century. One such example is the remains of the channel and tower (site 5, E35N31-34_000051) which once formed part of the Crusader-Ayyubid sugar mill of Tawaheen es Sukkar (Taha 2011: 297). The mill tower is clearly

visible in the First World War photographs, but has disappeared under the urbanization of the area in the later 20th century (Fig. 12). Another example, which can be identified on both the German (BayHStA BS-Palästina 1041 b) and later 1944 RAF photograph, is the Roman site of Khirbet Kakun (Site 12) (Agustinovic 1951: 50), also completely obliterated by urban expansion over the last half century (Fig. 13). In its vicinity it is possible to identify several circular features (*c.* 60 m south-west of the site) and other structural remains (160 m to the north-east).

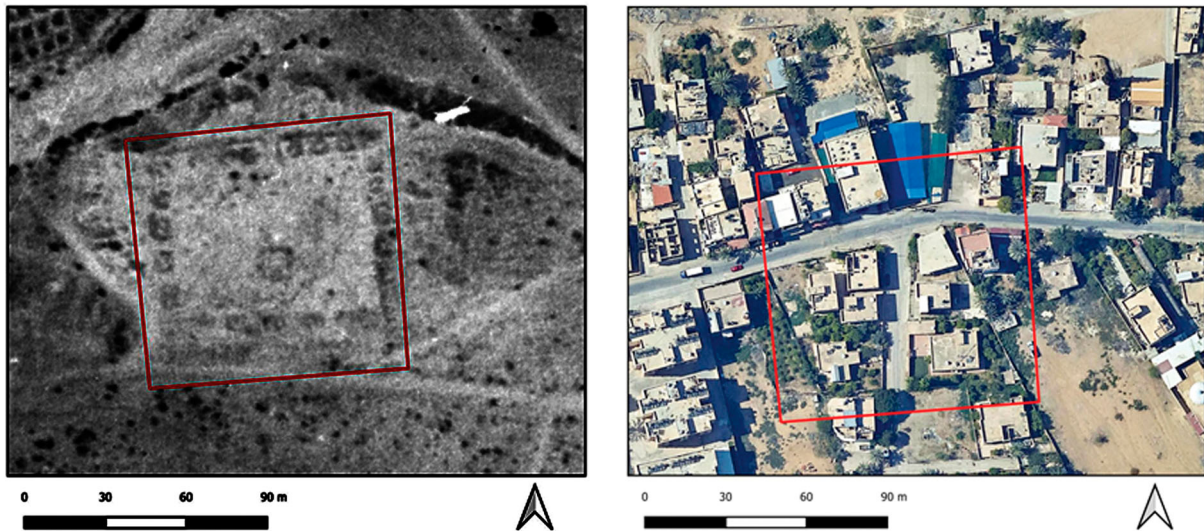


Figure 10 A possible temporary cavalry camp at site 20 (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1026 and Geomolg).

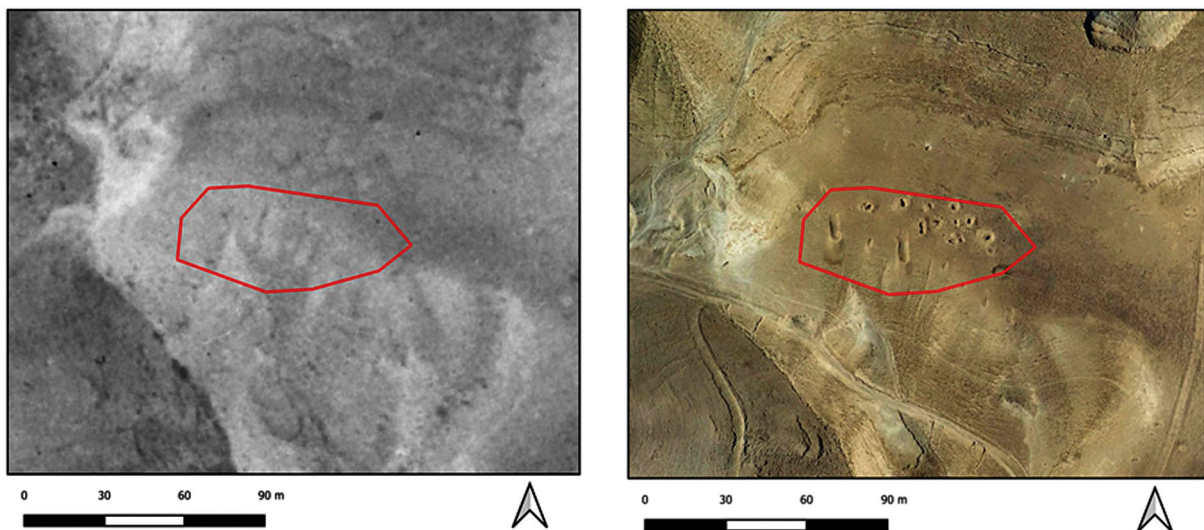


Figure 11 A looted site identifiable on modern imagery west of Aqabat Jabr (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1042 and Geomolg).

Threatened landscapes

EAMENA's objective is to analyse landscape change over long periods of time, to provide analysis and a narrative of the main disturbance and threat factors. This section assesses the main disturbance factors affecting the 38 certain, or potential, archaeological sites identified by our research, contextualizing this in terms of broader landscape change in the Oasis, and within wider trends throughout the region.

The availability of the German First World War photographs has made it possible to chart landscape change across nearly 100 years. One element of continuity during this period is the agricultural

exploitation of the Oasis, which was already significant in the First World War and which grew steadily over the following decades. The urban centre of Jericho in 1918 was, in contrast, still limited to a small nucleated settlement with dirt tracks and outlying dispersed hamlets. Archaeological investigations had begun at sites such as Tulul Abu el Alayiq (as visible on Bayerisches Hauptstaatsarchiv, BS-Palästina 1050), Tell es-Sultan and Tell es-Samarat, whilst others such as Qasr Hisham (Khirbat al-Mafjar) had yet to be studied.

By 1944, RAF photographs reveal the significant development of the town of Jericho, particularly its

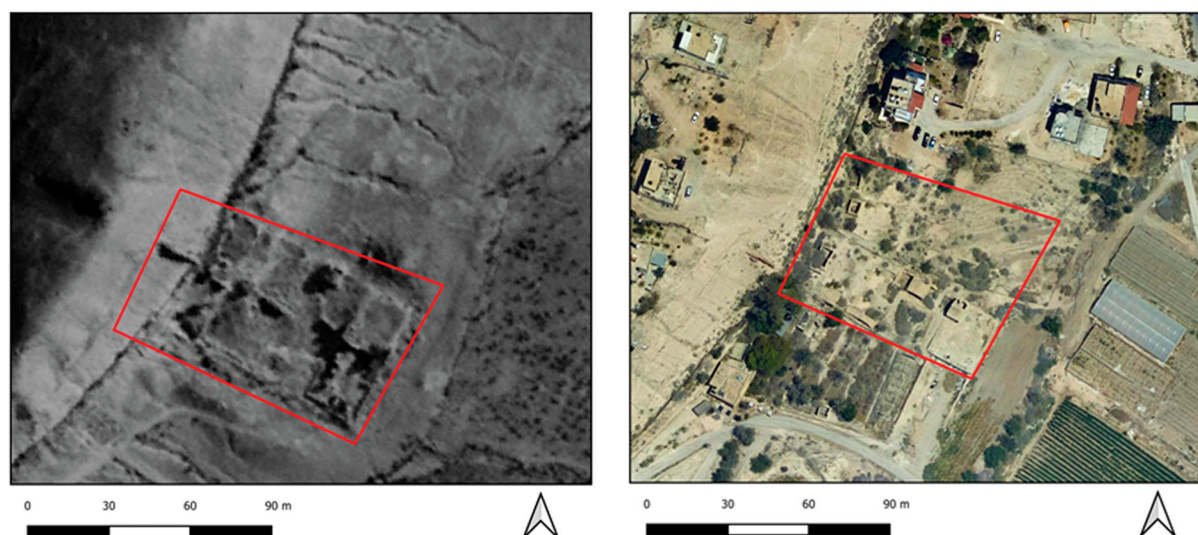


Figure 12 The sugar mill of Tawaheen es Sukkar (Site 5), which has largely disappeared under urbanization (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1033 and Geomolg).

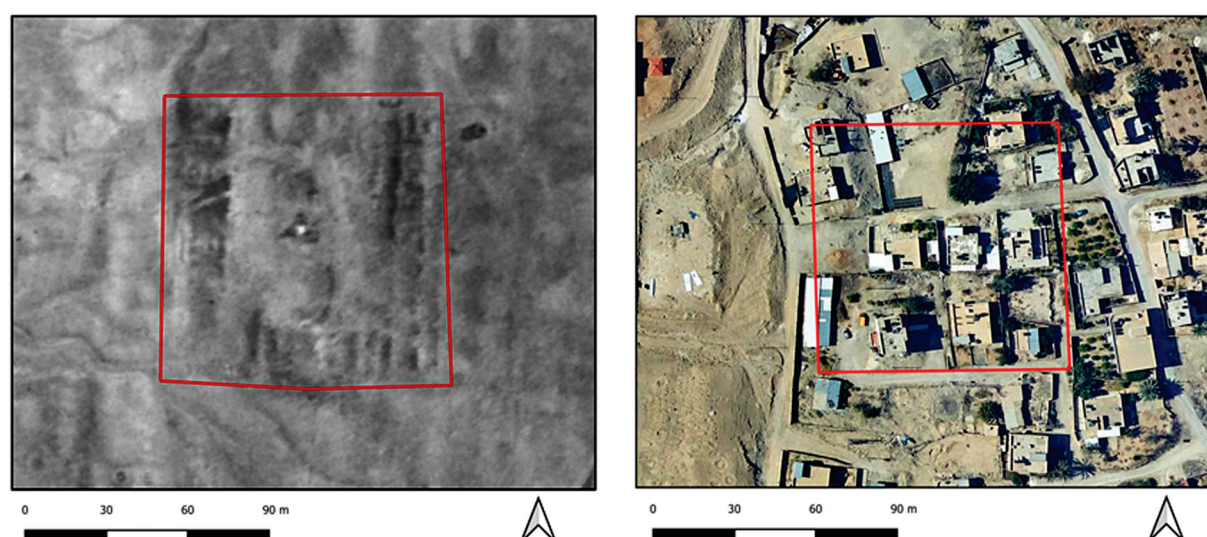


Figure 13 Site 13 at Kh. Kakun, lost under urban settlement over the last century (imagery source: Bayerisches Hauptstaatsarchiv, BS-Palästina 1050 and Geomolg).

western quarter, and the appearance of the first paved roads. The RAF photographs pre-date the Nakbah by a few years, and consequently do not record the establishment of the Aqbat Jaber and 'Ain es-Sultan refugee camps. CORONA satellite imagery provides our next snapshot of the Oasis, between 1967 and 1971, when Aqbat Jaber has already reached its full extent, swallowing up, amongst others, the large site of Kh. Kakun. The CORONA imagery also demonstrates increased agricultural intensification across the Oasis. Such urban and agricultural expansion has completely transformed the landscape of the Oasis, as witnessed on near-contemporary aerial and

satellite imagery. This fits with trends visible in official census data that show an increase in population growth, both urban and rural, over the past 10 years (Palestinian Central Bureau of Statistics [n.d.](#)). From 2007 to 2016 the population of the entire Governorate increased by about 12,000 inhabitants, requiring further construction and the installation of infrastructure, such as water supply systems, to meet the requirements of the expanding population.

Some of the most dramatic changes to the landscape of the Jericho Oasis have taken place since the 1948 Arab-Israeli war, following an influx of refugees and the establishment of refugee camps (Kersel [2008](#):

25). In 1918 the landscape of the oasis was largely clear of buildings, a situation altered by the construction of the camps of Aqbat Jaber and 'Ein as Sultan. The Aqbat Jaber camp, located approximately 3 km south-west of the city of Jericho, was built in 1948 by the United Nations Relief and Occupation Agency, who rented the land from the Kingdom of Jordan, to give accommodation to refugees from more than 300 villages, becoming, in 1968, the largest camp in the entire Palestinian area (The Applied Research Institute 2012a: 2). It lies close to several archaeological sites and its construction led to the disappearance of several archaeological sites, such as Kh. Kakun.

The 'Ein as Sultan camp was also built to house Palestinian exiles in 1948, mainly from the cities of Jaffa, ar-Ramla, Gaza and Bir al-Sabi' (The Applied Research Institute 2012b: 5). Located 2.5 km north of the city of Jericho, it extends to the village of Nu'weima and incorporates several archaeological sites, published or discovered through remote sensing. Again, the construction of the village had a strong impact on the landscape and archaeological sites: the site of Tell es Sultan was partly damaged on its northern side by the expansion of the village; destroying the site's necropolis (Polcaro 2005) and a probable archaeological element identified by the EAMENA survey (site 35).

Many archaeological sites have been affected by the range of urban growth across the Oasis. For example, Tell Samarat was disturbed by agricultural activity and archaeological excavation in the late 1960s, and, in the last two decades, has been encroached on by private housing. Imagery on the Geomolg platform shows that one structure was built against the cavea between 2006–2007. Urban expansion has also affected the site of Tell es-Sultan and its vicinity. New roads and buildings have obliterated necropolis K and tombs A, K1 and K2, immediately west of the tell (Polcaro 2005: 49–50).

Urban and agricultural development are also key factors in damage documented at the sites of Tell el-Hassan and Tell el-Mafjar. The former is now completely covered by modern housing, while the latter, a Chalcolithic and Early Bronze Age site dug in 2002–2003 (Taha 2011: 274) is threatened by agricultural development in the shape of a reservoir dug along its eastern border before 1997, as identifiable on the earliest Geomolg imagery layer. At Tulul Abu Alaiyq, erosion related to the degradation of the Wadi Qelt and urban expansion are equally serious disturbance factors. Herod's palaces and the remains of the Hasmonean palace are located on the wadi

banks and it is possible to trace significant erosion of this area by comparing the form of the wadi between 1918 and 2016.

Discussion

Following this review of archaeological data for the study area, it is possible to establish the main factors of disturbance affecting different types of archaeological sites in the Oasis (Fig. 14). In the following analysis, disturbance causes and effects are termed using standard EAMENA terminology, which will be published, online, in full, in the future. The main disturbance causes are, unsurprisingly, directly related to urban and agricultural development. The most frequently attested disturbance cause is 'vegetation/crops', affecting 28% of sites in the Oasis; 'construction' comes in at second with 26%, while 'water action' and 'road/track' affect 14% and 10% respectively of all documented sites.

It should be noted that, overall, looting has not been documented as a major factor in the deterioration of archaeological sites in the Oasis, with only 2% of sites having been affected by looting from 1918 to 2016 (Fig. 15). Notably, and in common with so many areas across the MENA region and around the world, it is the expansion of human settlement and the intensification of agriculture that are the key disturbance factors (Bewley and Rayne 2016).

The EAMENA damage assessment also considers the effects of such disturbances on the heritage sites of the Oasis. The impact of construction is frequently recorded as having led to archaeological features becoming 'covered' (Fig. 16). The 'covered' effect (defined as 'deposits burying/concealing features of archaeological significance, this can include the effects of sedimentation, rock falls, dumping of non-local material and/or the erection of new buildings or structures') is attested at 33% of all sites, followed by 'artefact displacement' (defined as 'the dispersal/spread of archaeological material/objects across the surface or subsurface of an archaeological site; this is often the result of ploughing') at 27% and 'erosion' at 17%. 'Relocation of archaeological material' and 'loss of archaeological material' make up an aggregate 10%, in line with the aggregate of disturbance categories such as 'archaeological activity', 'looting', 'tourism/visitor activities' and 'religious activity'. A final 11% of disturbance effects is classed as 'unknown', a term used when the imagery on which a given disturbance was detected was not clear enough to conjecture its outcome.

Considering how the trends in the Jericho Oasis compare with other areas of the OPT, a comparison

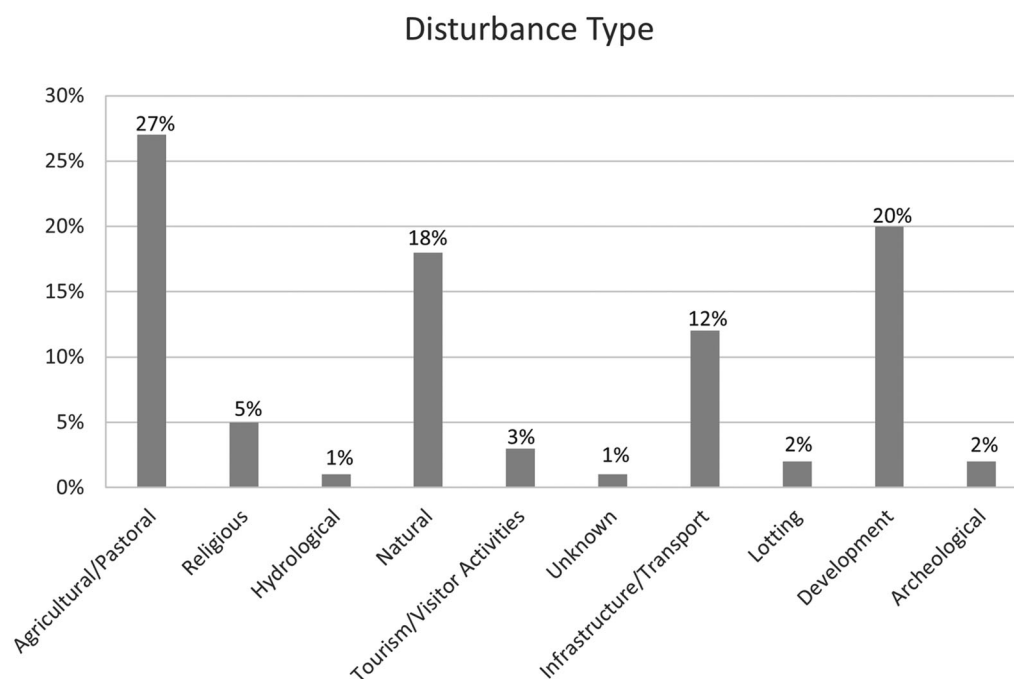


Figure 14 Incidence chart of ‘Disturbance Cause’ across the archaeological sites documented by EAMENA in the Jericho Oasis.

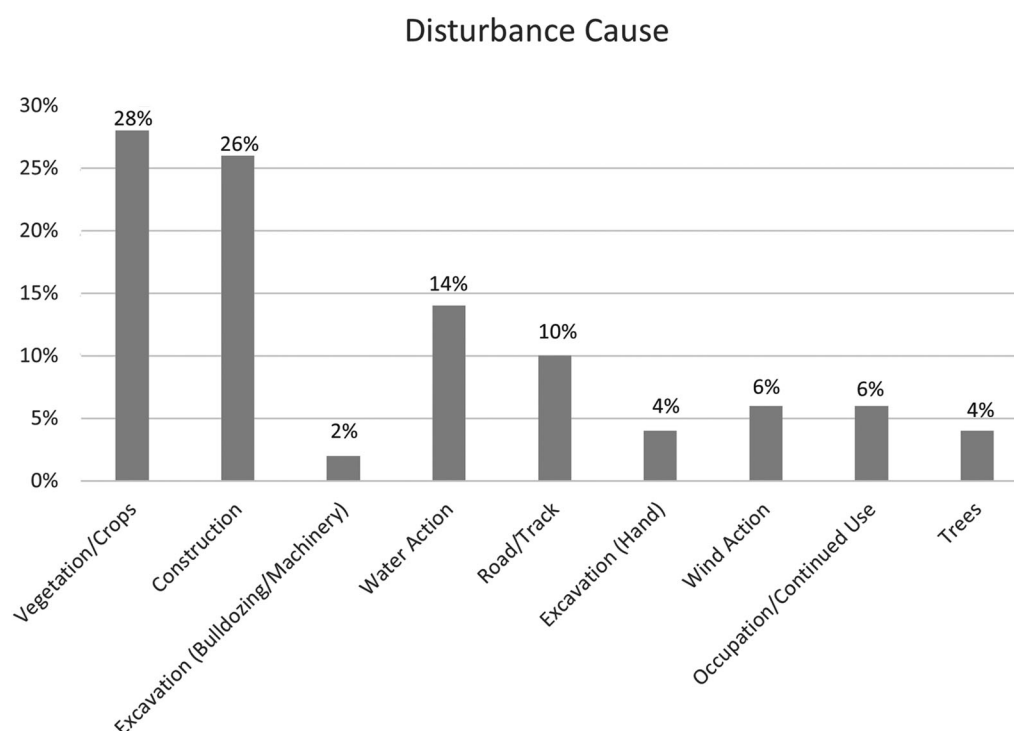


Figure 15 Incidence chart of ‘Disturbance Type’ across the archaeological sites documented by EAMENA in the Jericho Oasis.

was made between the disturbances and threats found in the hinterland of the archaeological site of Tell Abu Zarad (Governate of Salfit), under investigation by Sapienza University of Roma (Izzo 2020; Nigro

et al. 2015a: 139–83). In general, the major issues affecting the two areas were found to be comparable, though some differing issues were found relating to regional environmental factors. For instance, the

Disturbance Effect

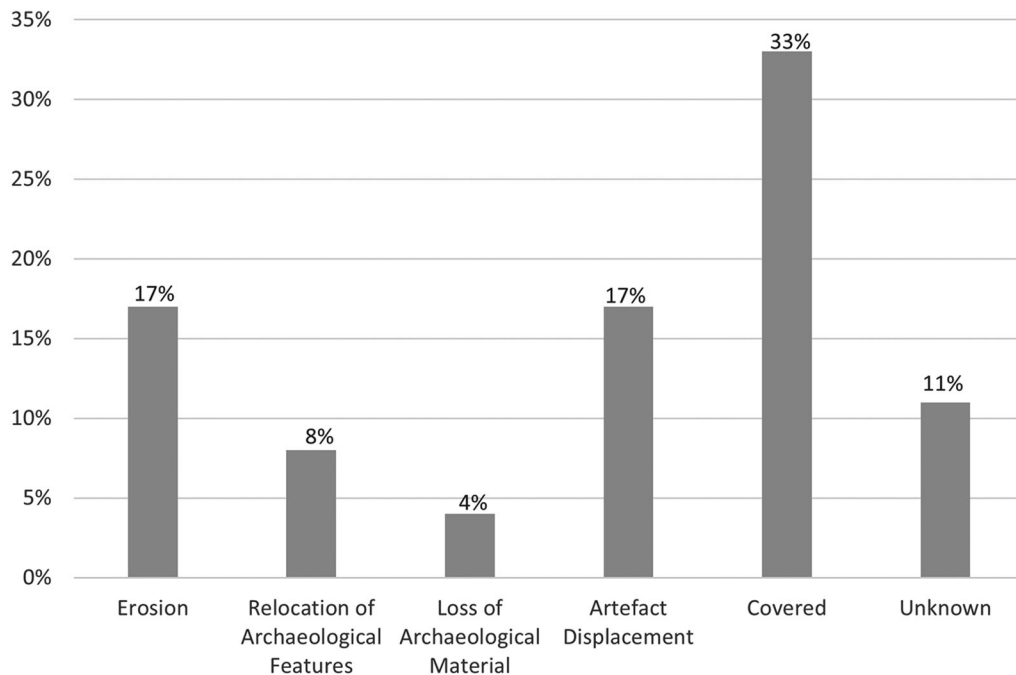


Figure 16 Proportion of ‘Disturbance Effects’ across the archaeological sites documented by EAMENA in the Jericho Oasis.

Jericho Oasis has little tree cover, so consequently the disturbance type ‘Vegetation/Crops/Trees’ is significantly lower. Additionally, in the Jericho Oasis, given the strong religious significance of the area to multiple groups, issues relating to functional categories such as ‘religious activities’ and ‘tourism/visitor activities’ are documented, these categories have not been identified in the southern Samaria study area (Izzo 2020: 245). In spite of these differences, the primary disturbance factors in both areas relate to settlement and agricultural intensification.

Another development in the Jericho Oasis is the abandonment of rural settlement in favour of urban settlement (Bshara 2015: 95). Following analysis of the different threats and disturbances affecting the archaeological heritage of the Occupied Palestinian Territories, it is evident that archaeological sites require greater protection, as they risk being damaged if they are not monitored (Al-Houdalieh 2012: 124).

A model for more detailed future study of the Jericho Oasis can be drawn from the high-resolution analysis of recent urban expansion at Ramallah, capital of the State of Palestine. A recent study integrated socio-demographic and economic data, with a remote-sensing analysis of the evolution of the landscape using aerial orthophotos covering the period from 1994 to 2015. This study was able to show that

land used for construction has increased from 11.4% to 20.7% and road paving from 4.3% to 6.7%, to the detriment of agricultural areas which showed a drop from 33.1% to 25.6%, while uncultivated land had also dropped, from 46.6% to 41.9% (Nazer *et al.* 2019: 7–9). Agricultural exploitation continues to be a determining factor in landscape change and disturbances in the territory, but agricultural activity itself is decreasing, due to the passive position of the Palestinian authorities towards the role of agriculture as an income stream (Bshara 2015: 95).

Conclusions

This study has shown that, as expected, historic aerial photography has a clear value as an earth-observation tool in the identification of potential archaeological sites that have subsequently been lost beneath, or encroached upon by, modern agriculture and development. Although many features have been covered by subsequent development, in some cases sub-surface deposits, which could be investigated in the future, may still survive. It has also been demonstrated that difficulties remain regarding access to surviving collections of historic aerial photography. Of the imagery used, the German photography from 1918 proved to be the most valuable in terms of identification of ‘lost’ sites. Only a small fraction of the surviving archive was utilized in our focus on the


Jericho Oasis. There is a substantial untapped archive of imagery covering modern Israel, the OPT and Jordan still to be explored in the Bavarian archives, along with a small print collection held at the UK's National Archives, as well as other collections that may come to light in the future.

Perhaps unsurprisingly, the pressures of land development and agricultural intensification are major factors threatening the rich heritage of the Jericho Oasis, particularly over the last 50 years. The current management situation can be improved, at least in terms of consistent monitoring of sites, by increasing access to higher-resolution satellite and aerial imagery. This has been made possible due to the development of the open-access Geomolg platform, as well as through the work of the EAMENA project in reducing the KBA restrictions in the United States. The impact of the latter will probably increase over time, as more legacy satellite imagery collected by US companies is made accessible, providing a longer-term view of landscape change, as well as through the further declassification of Cold War satellite imagery also covered by the KBA.

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Abbreviations

MECA: Middle East Centre Archive, St Anthony's College, Oxford, UK

TNA: The National Archives, Kew, UK

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