The Impact of the Syrian Conflict on Archaeological Sites in Al-Hasakah Province

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Abstract:

This article assesses the impact of the Syrian conflict on archaeological sites in Al-Hasakah Governorate through a detailed analysis of satellite images. In total, the condition of 340 archaeological sites were examined on satellite images taken between 2004 and 2020. This has allowed us to assess when damage is likely to have occurred; in particular, which damage types have increased in frequency during the current conflict. We have compared these results to previously published information from satellite imagery assessments and field visits by local authorities. The results are consistent with the previous information in terms of damaged sites and types of damage. However, the current study presents a more comprehensive assessment of the timing of damage specific to Al-Hasakah region.

Keywords: Satellite remote sensing; Syrian conflict; Damage to cultural heritage; endangered archaeology; looting.

1. Introduction

In March 2011, a peaceful revolution broke out in Syria that demanded political, economic, and social reforms, but this soon turned into an armed conflict that led to chaos throughout the country. Archaeological sites have been seriously affected by the conflict through direct military action, looting, and the decrease in the regulation of other activities (e.g. agriculture, construction); this has been documented in numerous reports (Casana 2015; Danti 2015; Cunliffe et al. 2016; Tapete et al. 2016; Casana and Laugier 2017; Masini and Lasaponara 2020). In this study, we will focus on assessing the impact of the Syrian conflict on archaeological sites in Al-Hasakah Governorate.

Al-Hasakah Governorate covers an area of 23,334 square kilometres and is bordered by Iraq to the east and Turkey to the north. There are four main districts in

the governorate: Al-Hasakah, Ras Al-Ain, Al-Qamishli and Al-Malikiyah (Fig. 1). The modern population is diverse in terms of ethnicity, language and religious belief (EASO 2021: 158).

Over 1000 archaeological sites have been recorded in Al-Hasakah governorate though fewer than 10% have been excavated (Al-Yusuf 2016: 179). Over the last ten years, various armed groups have fought for control of the governorate and this had an impact on the condition of archaeological sites. Therefore, we have sought to assess the condition of a sample of sites in Al-Hasakah governorate through the use of freely available satellite imagery. The imagery we used, available on Google Earth, covered the period between 2004 and 2020, allowing us to compare types of damage and the frequencies of their occurrence before, and during the conflict. Our team has identified c. 700 archaeological sites on imagery, of which 340 were selected for detailed remote damage assessments using the methodology developed by the Endangered Archaeology in the Middle East and North Africa (EAMENA) Project. Those selected had visible damage that could be attributed to military action or looting, or showed evidence for increased or frequent damage through time. They include previously known sites and those recorded only on satellite imagery. We also prioritised known sites from the least well-represented chronological periods.

2. The political situation in Al-Hasakah during the conflict

The unrest that started in March 2011 soon spread to all parts of Syria, including the cities of Al-Hasakah Governorate (Phillips 2016: 66). In November 2012, the Free Syrian Army (FSA) took control of the city of Ras Al-Ain, and subsequently other parts of the governorate. However, by March 2013, the Syrian opposition (including the FSA) presence in the region lessened. In the autumn of 2013, Syrian Kurds in north-eastern Syria declared independence from the central government; however, they continued to cooperate with regime forces at the local level for certain purposes. The military arm of the Kurdish Democratic Union Party (PYD) and the People's Protection Units (YPG) came to control large parts of Al-Hasakah governorate, gaining support from local Christian and Arab tribal elements to defend the area, when in 2013, the Islamic State of Iraq and the Levant (IS) began its incursions (Cafarella 2014). Gaining control of Al-Hasakah Governorate would have allowed IS to link two areas already under its control elsewhere in Syria and in Iraq (Van Wilgenburg 2014). Some local

Arab clans, rivals to those supporting the YPG, backed IS, reflecting local divisions. By January 2014, IS controlled key areas near Tell Hamis in the north, and to the northeast of the city of Al-Hasakah (Cafarella 2014). On September 10, 2014, a global coalition was announced to fight and defeat IS (McInnis 2016:1). Al-Hasakah was liberated entirely from IS in the spring of 2016, making it the first Syrian province to come under near-total control of forces opposed to IS (Hassan 2017). Al-Hasakah Governorate is currently under the Autonomous Administration of North and East Syria (AANES), with a unified military force, the Syrian Democratic Forces (SDF) and a political council, the Syrian Democratic Council (SDC). The Kurdish Democratic Union Party (PYD) and its armed wing, the People's Protection Units (YPG), have a dominant role in the SDF (Allsopp and van Wilgenburg 2019: 66–67). The Syrian government maintains Qamishli Airport, as well as security pockets inside the cities of Al-Hasakah and Qamishli; however, this represents only 10% of the total area of these cities (EASO 2021:159; Mehchy et al. 2020:10). Syrian government forces and their Russian allies are also present on the Syrian-Turkish border and along the fronts between the SDF and Turkish-controlled areas. In 2019, the FSA supported by Turkey controlled parts of Al-Hasakah Governorate - through Operation Peace Spring - and extended their control over the area between Tell Abyad (in Raqqa) and Ras Al-Ain (in Al-Hasakah) (Al-Hilu 2021).

3. Archaeological sites in the time of conflict

Armed conflict can pose a direct threat to archaeological sites. In Syria, archaeological sites often take the form of mounds (Arabic ‘tell’). Tells are the quintessential site type of lowland regions of the ancient near east (Wilkinson 2003). Because they represent higher points compared to their surroundings, they are often adapted during war time, through significant earth moving, to serve as military emplacements. These emplacements are often key targets for bombardment by opposing forces. In addition, archaeological sites can be damaged when modern settlements located in or near are targeted by bombardment or fighting. Social and political instability, caused by prolonged conflict, and the breakdown of institutions tasked with law and order, can also facilitate illegal excavation, and looting and trafficking in antiquities (Boylan 2002; GAO 2016; Mahnad 2017). Since its independence in 1948, laws have been in place in Syria to define and protect cultural

heritage (Lenzerini 2011). Despite these efforts, illegal activities such as looting, and unauthorised construction have long impacted archaeological sites across the country. However, the recent Syrian crisis has led to an increase in certain types of damage to Syrian heritage as a result of the explosion of armed violence and the spread of extremist groups (Al-Jabbai 2014). Significant damage has been reported, especially in areas where centralised authority has been absent. This includes: illegal excavations carried out by antiquities thieves and dealers; the destruction and removal of statues and human images by extremist organisations such as IS; the use of archaeological sites for military purposes and the use of materials taken from archaeological sites (e.g., stones) in the construction of modern buildings (Abdul Rahman 2016: 10-12). In addition to its direct impact on the condition of archaeological sites (Viejo-Rose 2013), the conflict has also been linked to the smuggling and sale of looted artifacts and the bombing and looting of museums (Cunliffe 2012; Rayne et al. 2018).

In Al-Hasakah, the period between 2011 and 2021 has witnessed damage to many archaeological sites, with many of the parties involved in the conflict contributing. Documentation by local cultural heritage managers shows that sites have been illegally bombed, looted and excavated (Abdo et al. 2017). However, ferocious fighting between conflicting parties, the spread of gangs, the absence of government authorities, and the risk entailed in travelling between cities with documentation equipment (e.g., cameras, GPS), has made it difficult for both government and international initiatives to monitor the condition of archaeological sites on the ground (Al Quntar and Daniels 2016). Some international projects have been launched, such as the Old Aleppo Project (Wolfinbarger et al. 2014), however, such projects are taking place in sites and cities that have returned to the control of the Syrian government. Independent community efforts have also been undertaken, though on a limited scale. For example, villagers at Tell Mozan covered mud bricks with panels and trellises to prevent deterioration and carried out basic repairs on the site in 2014 (Marquez 2014). This highlights the importance of international technical and financial support for civil society and community groups, who can play a key, and often very effective, role in on-the-ground monitoring efforts. These efforts can be an important element in transitional justice and peace-building in post-war Syria (Lostal and Cunliffe 2016).

While access to archaeological sites has become easier in some areas of Syria, it is still difficult and, in some cases, impossible. In addition to political and security concerns, the emergence of COVID-19 has placed new restrictions on archaeological research and site monitoring in the region. The current research, in particular, originally designed to include both a desk-based and field component, had to be adapted to be done entirely remotely. This involved an in-depth exploration of site condition in Al-Hasakah region via satellite imagery. The benefit of this methodology is that we could monitor sites in areas of insecurity and cover much larger areas at a much lower cost than is possible through traditional fieldwork (Danti et al. 2017). However, remote assessments do not always record all those aspects of damage that might be detected during a site visit (Cunliffe 2014; Danti 2015; Tapete and Cigna 2019). However, there is a growing corpus of information (i.e., published articles, photos, videos, reports etc.) being produced by local archaeologists at some archaeological sites in Al-Hasakah Governorate (see Abdo et al. 2017; Abdo and Qassem 2017 for example) that can be drawn upon for comparison with our remote investigations. In this paper, we make use of the information in these studies as a comparison for the evidence obtained through remote sensing of satellite imagery.

4. Methodology

Satellite imaging can be accessible from a variety of high-resolution satellite sensors, which can provide more details for archaeological investigations. The use of satellite imagery to identify and monitor the condition of archaeological sites and other cultural features in a non-intrusive way has been successfully employed in a number of studies (e.g., Wiseman and El-Baz 2007; Parcak 2009; Lasaponara and Masini 2011; Bewley et al. 2016; Casana and Laugier 2017; Danti et al. 2017; UNESCO/UNITAR 2018; Tapete and Cigna 2018, 2019; Rayne et al. 2020; Fobbe et al. 2021; Tapete et al. 2021). The date, cost, resolution, spatial coverage, spectral coverage, and availability of satellite images are all factors in deciding which satellite images to use for a particular study (Tapete et al. 2019).

Many types of damage, including that caused by construction, deliberate destruction, looting, bulldozing, and agriculture can be clearly revealed using high-resolution images. The accessibility and high spatial resolution (down to c. 0.5 m) of images provided by Google Earth (GE) made this freely accessible platform ideal for

use in our study. Another advantage to using GE is its imagery archive. For most sites within our study area, GE hosts multiple, high resolution images dating back to 2004. This allowed us to observe changes to individual archaeological sites over nearly two decades, and as the archive is regularly updated, can support continued monitoring of sites into the future. In addition, imagery from multiple dates increases our ability to detect those sites and features that might only be visible in certain seasons due, for example, to specific ground conditions.

However, there are also limitations to using optical imagery available on the Google Earth platform for site detection and monitoring. While multiple images are usually available for a single site, the number of images and the frequency with which they were taken is highly variable from site to site (Tapete and Cigna 2019). This represents one of the main drawbacks of using such images to understand the timing of events over a large area – that is, the window in which an event occurred could be narrowed down to several weeks or months for one site, but could be several years for another. Also, cloud cover, for example, can obscure ground features, as can trees or buildings, while some damage types, due to their location on the site, or moderate extent, cannot be detected on some satellite images. In such cases, ground-based observations are crucial, though data from other sensors (e.g., Synthetic Aperture Radar or SAR) or medium-resolution satellite imagery could also be employed as an additional data source (e.g., Tapete et al. 2016; Rayne et al. 2020).

For this study, we visually inspected high resolution satellite images covering parts of Al-Hasakah Governorate dating between 2004–2020. Our objective was to:

- locate previously excavated or recorded sites (e.g., Tell Halaf, Tell Baydar) that were visible on satellite imagery
- identify potential archaeological sites that had not, to the best of our knowledge, been previously recorded.
- undertake detailed condition assessments of a sample of these sites.

To facilitate the first objective, the EAMENA project provided us with all the data they had gathered from previously published surveys of Al-Hasakah as a GIS shapefile (.shp). This included c. 750 archaeological sites. This was then converted to a keyhole markup language file (.kml) that could be opened in Google Earth. We then subdivided the governorate into four main areas to facilitate visual inspection. Within each subdivision we located as many previously recorded sites as we could find. To fulfil

our second objective, we also recorded any features that were likely to represent archaeological sites. Because tells are of higher elevation than the surrounding ground surface, they are often identified on imagery by the shadows they cast, or because tell sediments have reflectance properties that differ from those of the surrounding landscape

In total we located more than 700 archaeological, or potential archaeological sites, on satellite imagery. This included sites previously recorded and included in the EAMENA database, and new sites we located only on satellite imagery. However, our third objective, the detailed condition analyses, focused only on a sample (n = 340) of these sites (See Fig. 1). The sites selected for a detailed assessment had visible damage that, on the basis of initial inspection, appeared to have been caused by the military action and looting, which occurred between 2011 and 2020 (the period of the Syrian conflict). This included both known sites, and those that had not been previously recorded in the literature accessible to the project. Secondary considerations included:

- frequent or escalating evidence for damage through time
- the rarity and representivity of known sites (i.e., sites from the least well-represented periods were prioritised)

For these 340 sites we recorded the category and type of the damage, to the best of our ability, and the time when the damage occurred taking in consideration the difficulty and the uncertainty in determining the actual time of the damage occurrence in some sites due to the temporal discontinuity of image collections. The information was compiled in a format compatible with the EAMENA database using the methodology established by the EAMENA project. Annexes 1-5 detail the main categories of information that were recorded for each site.

5. Data Analysis

5.1. Damage Types and Causes

Analysis of the data suggests that the most common category of damage affecting archaeological sites in the sample is ‘agricultural/pastoral’ (26%). The next most frequently recorded types are damage caused by ‘domestic’ (17%) or ‘infrastructure/transport’ activity (17%). These terms relate to activities such as the construction of houses and the building of roads, respectively. After this, damage categorised as relating to funerary/memorial, looting, military, or hydrological/natural activity are the next most frequent (10%, 9%, 8% and 7%, respectively). Around 6%

of incidents of damage could not be accurately assigned to a specific category (Fig. 2).

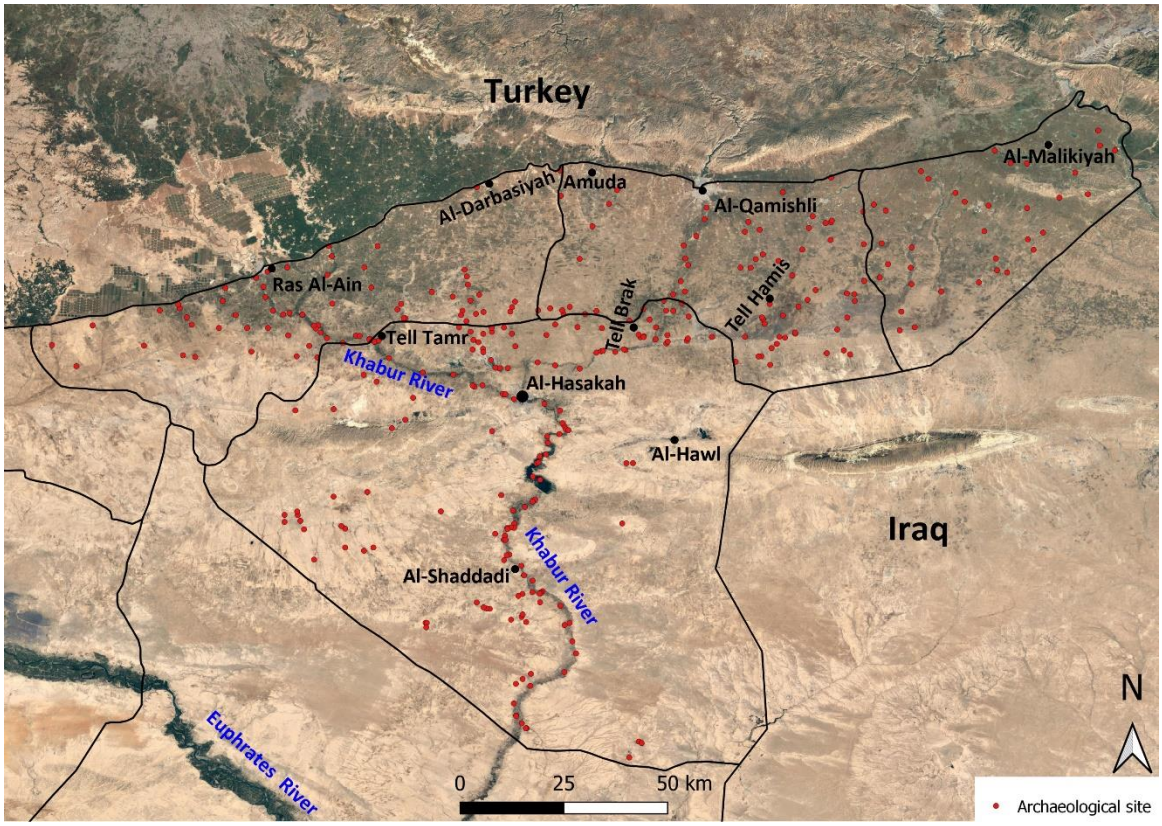

Fig. 1. Map showing the distribution of archaeological sites with detailed condition assessments derived from satellite imagery in the Al-Hasakah region. Imagery ©2021 Landsat/Copernicus. Used in accordance with the Google Maps/Earth terms of service for research purposes.

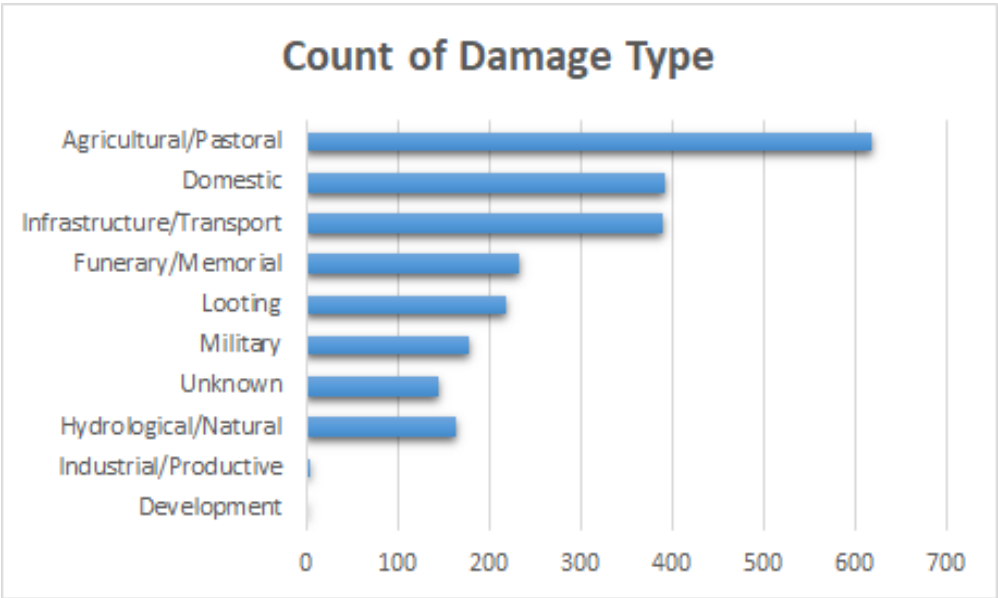

Fig. 2. Chart showing the number of occurrences of damage that fall into each damage type as recorded on imagery between 2004 and 2020. Note that this shows the number

of instances of damage recorded overall, and that multiple instances of damage may have been recorded at a single site.

Within each overarching damage category there are multiple possible causes. For example, within the category of 'Agricultural/Pastoral', we can find damage caused by ploughing, or by the planting of trees. Equally, some damage causes can be categorised in more than one damage type; that is, the damage cause 'Bulldozing/Levelling' can occur as the result of the construction of domestic architecture (e.g., damage category 'Domestic'), road building (damage category 'Infrastructure/Transport') or looting (damage category 'Looting'). Fig. 3 shows the number of occurrences that fall into each damage cause across the entire sample, as well as the number of sites that have been impacted by that cause. Interestingly, while our research has highlighted that significant damage was caused by activities directly relating to conflict (e.g., creation of military lookout points on tells), Fig. 3 indicates that the most abundant causes of damage are modern settlements on archaeological sites, ploughing of fields, and the construction of roads. Of course, some damage causes like 'Gunfire/Light Weaponry', or 'Tunnelling', which are related to active conflict and looting, respectively, are very difficult to detect on satellite imagery. Therefore, they may be underrepresented in our sample. Even so, it seems unlikely they would reach the levels of impact attributable to modern occupation on archaeological sites, or ploughing. Unsurprisingly, the biggest driver behind damage to archaeological sites is human action.

5.1.1. Agricultural/Pastoral Damage

An examination of the most abundant damage types and their causes, provides us with further insight. Figure 4 shows the main causes of damage within the Agricultural/Pastoral category, with ploughing by far the largest contributor. However, as we will discuss below this activity occurred prior to, and continued through the conflict. Fig. 5 shows an example of agricultural/pastoral damage to the site of AH185 (Tell Nasr) which belongs to the Chalcolithic and Bronze ages (Ristvet and Weiss 2005).

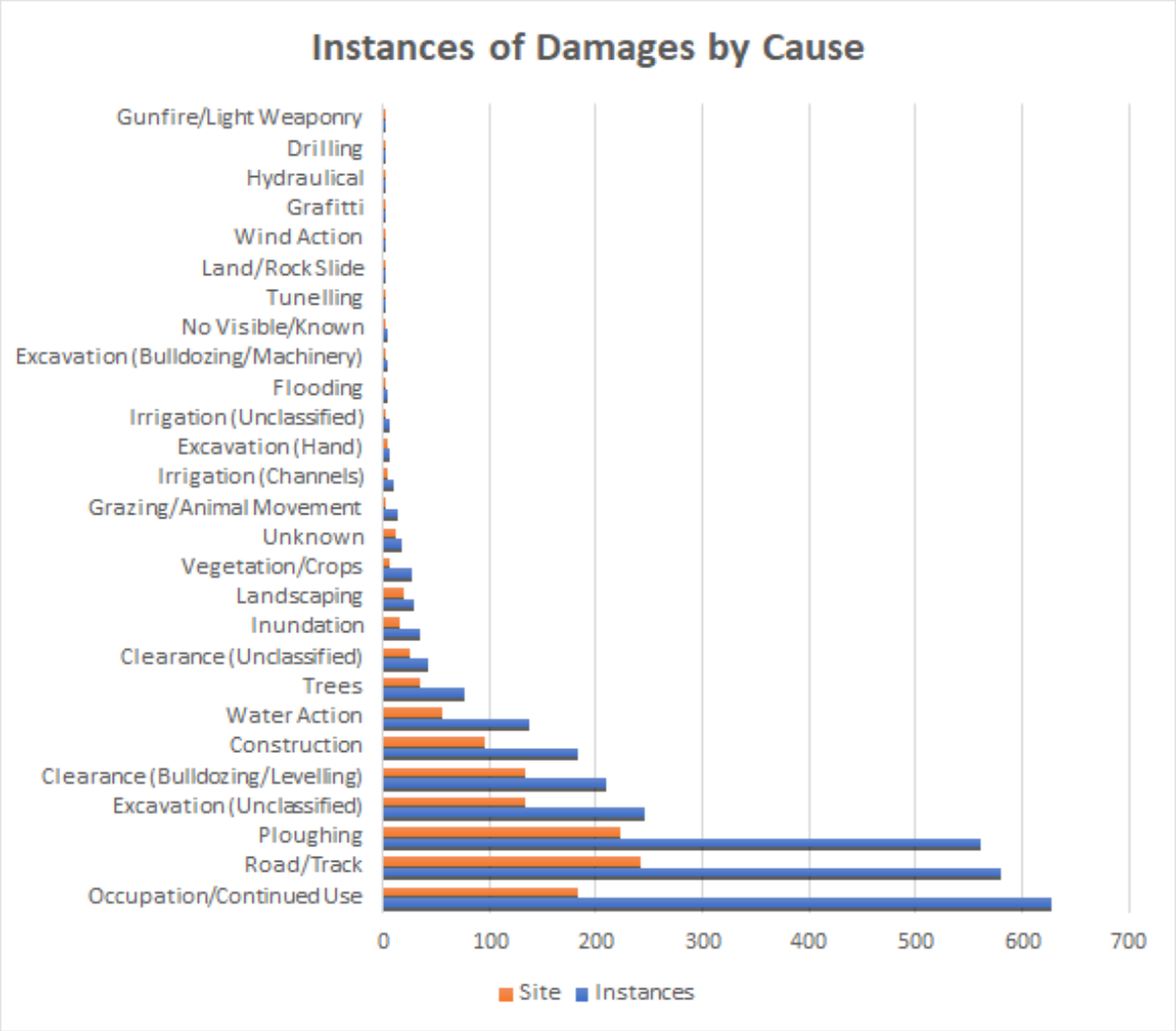

Fig. 3. Damage causes plotted by number of instances (blue), and by number of sites at which that type of damage was observed (red).

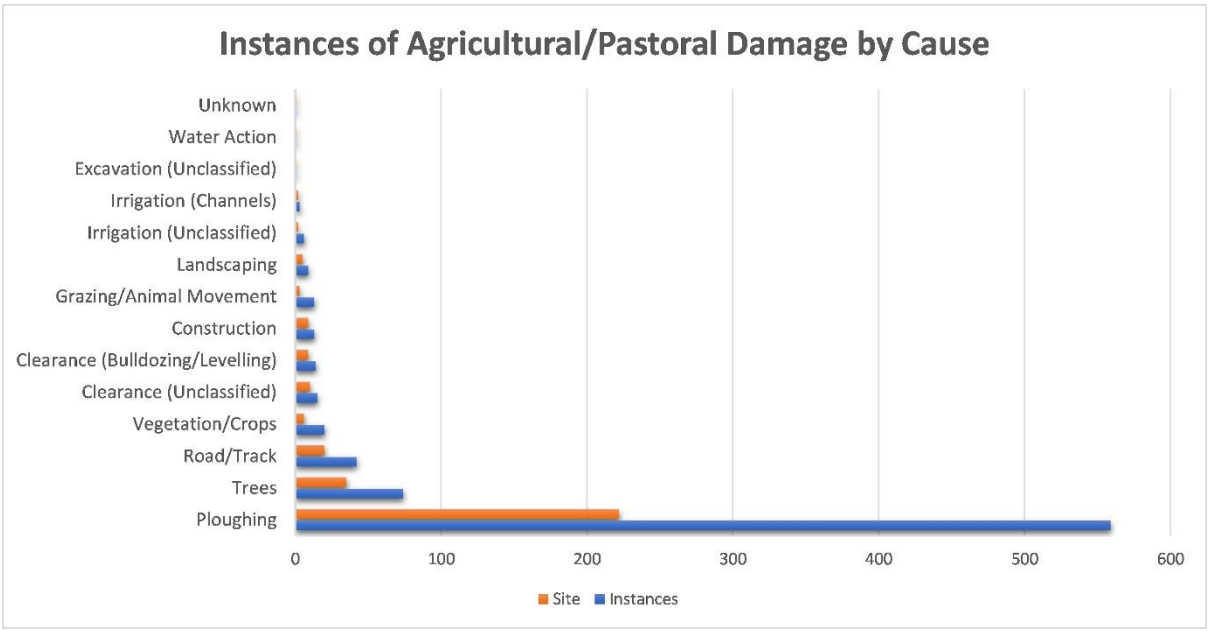

Fig. 4. Instances of agricultural/pastoral damage by cause.

5.1.2. Domestic Damage

Damage attributed to the domestic category is predominantly caused by continued occupation, and the associated construction activity (Fig. 6). While the occupation and continued use of settlements on or around archaeological sites predates the conflict and continued through it, the absence of government and civil authority may have contributed to an increase in uncontrolled construction of domestic buildings since 2011 (See Figs. 7 and 8).

5.1.3. Infrastructure/Transport Damage

The building of roads or tracks is the most common damage cause in the 'Infrastructure/Transport' category. The majority of these instances appear to have happened prior to 2004. However, several instances of road construction were recorded post-2011 (see Fig. 9). In this figure we can see the shift from a track with a gravel surface, visible in the 2015 image, to high reflectance road material visible in February 2017, and finally to black tarmac in the images from October 2017 and August 2020. The road was built before/in February 2017 but had not yet cut through the tell. Then, in October 2017 it appears the tell material that was displaced from the road cutting has been ploughed into the site. This was presumably done to increase the area of cultivable land for planting later in the year. Overall, this series of images provides an excellent example of the level of detail that can be obtained from a time-series of images taken over the course of several years.

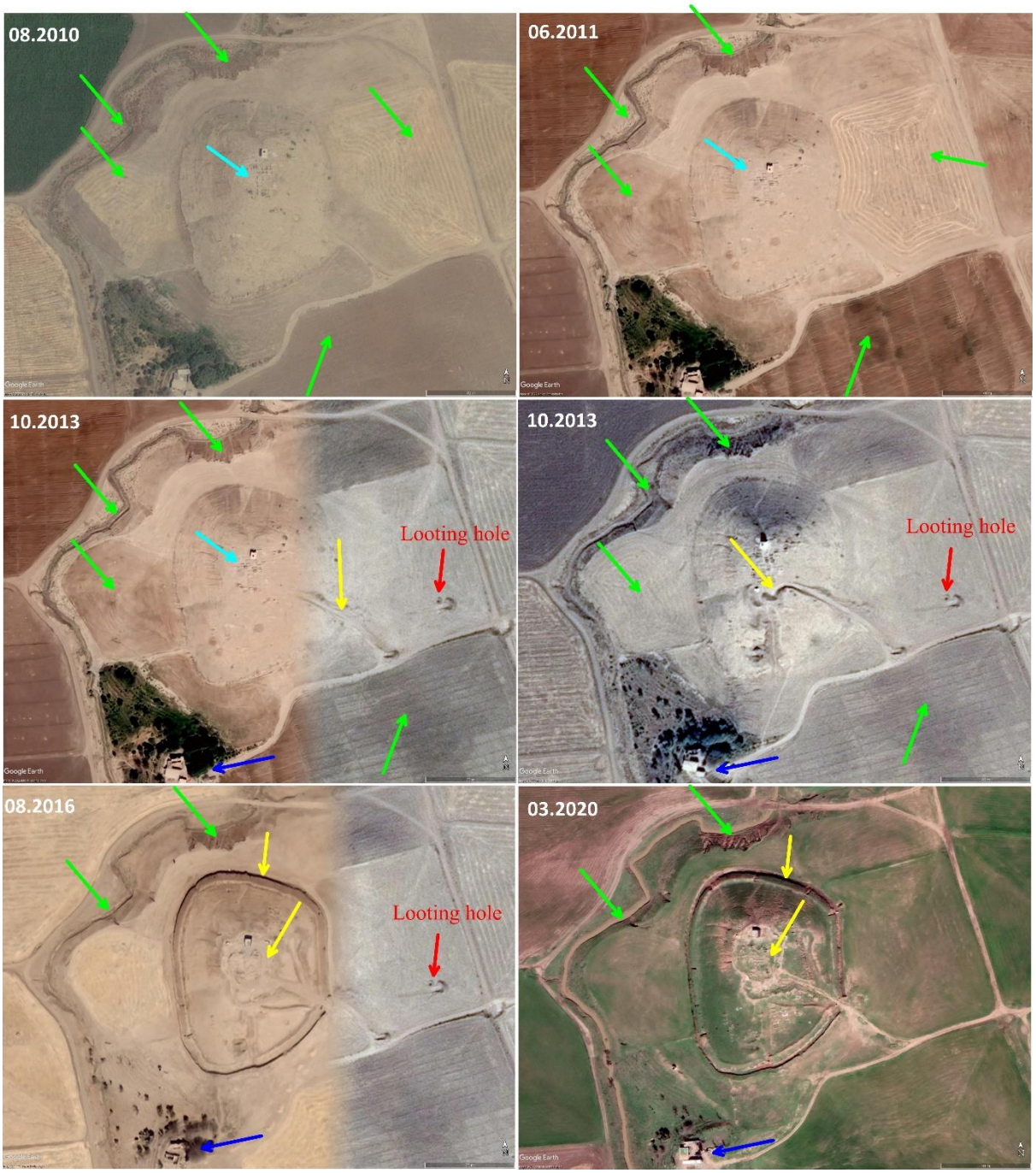

Fig. 5. Six images of site AH185, taken between August 2010 and March 2020. At AH185 ploughing has impacted the site prior to 2004 and through to at least 2016 as seen on this image from Google Earth. In 2013 military activity started to alter the terrain of the site, and it appears agricultural activity related to ploughing slowed. Looting activity can be also seen on the image from October 2013. Image © 2021 Maxar Technologies and CNES/Airbus. Used in accordance with the Google Maps/Earth terms of service for research purposes.

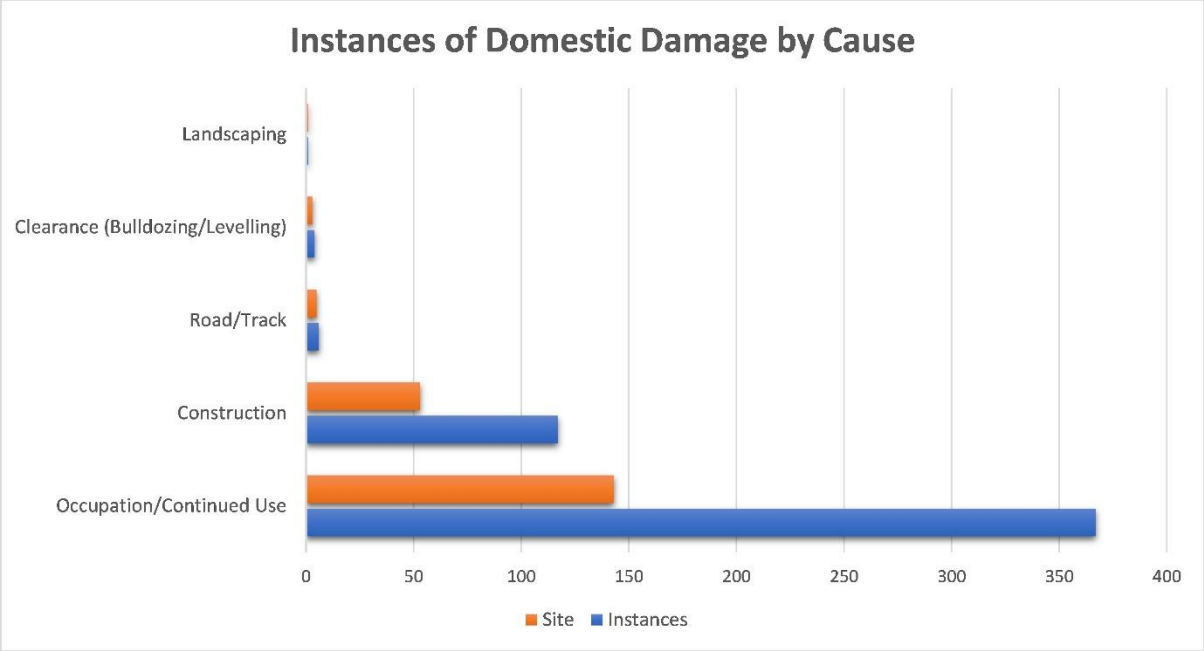

Fig. 6. A chart showing the instances (blue) of, and the number of sites (orange) affected by, damage related to domestic activity.

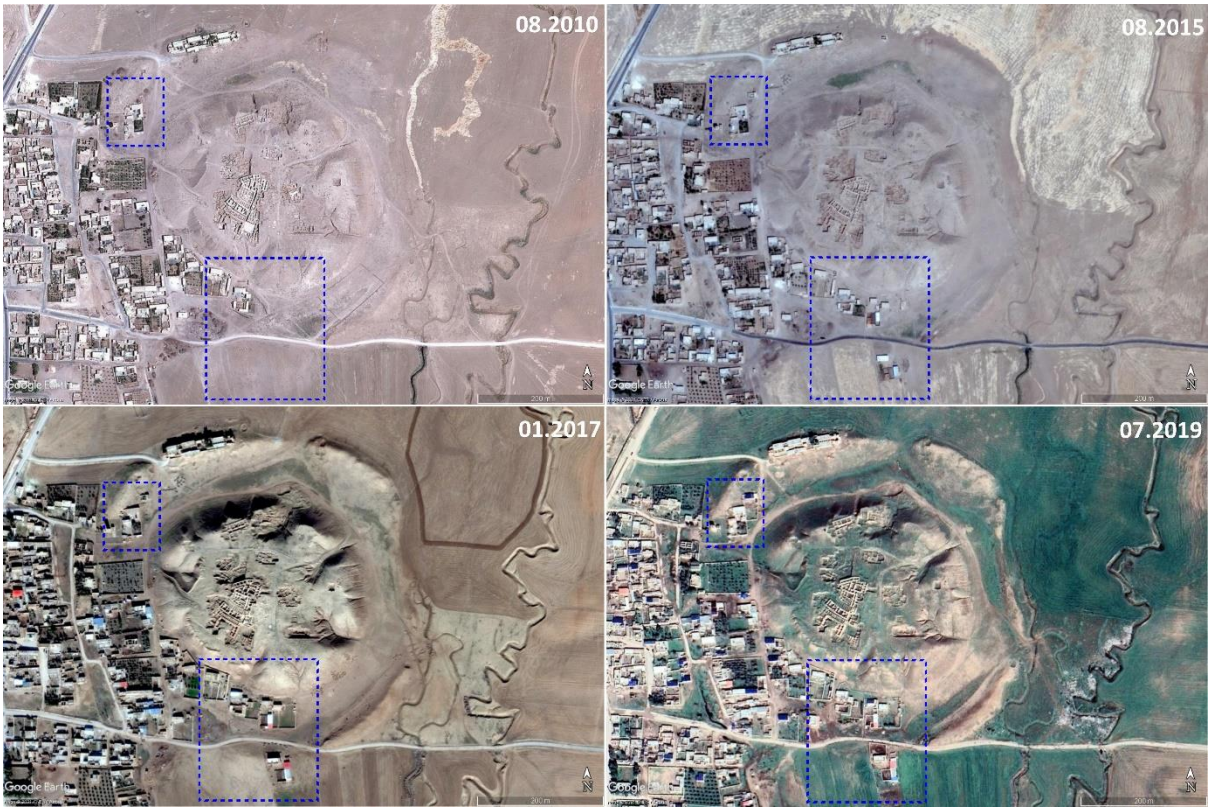

Fig. 7. At the well-known site of Tell Beydar (AH002), there appears to have been an increase in domestic construction on the site between 2015 and 2019. Image © 2021 CNES/Airbus. Used in accordance with the Google Maps/Earth terms of service for research purposes.

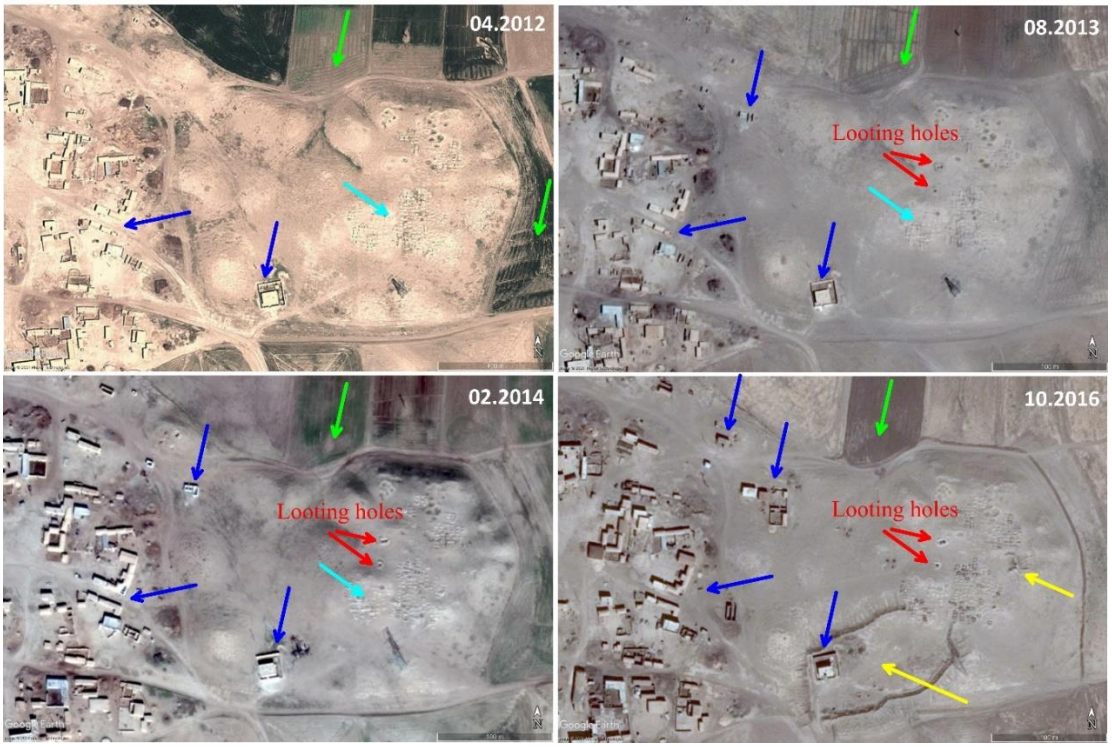

Fig. 8. At AH087, we can see the encroachment of domestic activity on the site between 2012 and 2016 (e.g., the large enclosure in the bottom of the image), along with other damage (looting, agriculture, and military). Image © 2021 Maxar Technologies. Used in accordance with the Google Maps/Earth terms of service for research purposes.

Fig. 9. This site (AH329) has been bisected by a road built between 2015 and 2017. Image © 2021 Maxar Technologies. Used in accordance with the Google Maps/Earth terms of service for research purposes.

5.1.4. Looting Damage

In our analysis we faced difficulty in distinguishing between the mechanisms of looting in some cases (e.g., whether digging was done by machine or by hand). This is a particular problem in built up areas (e.g., where a tell is located within a modern settlement) where buildings and other features can make it difficult to detect how the looting activity was undertaken. Therefore, the most recorded cause of damage is excavation (unclassified). Following this, looting done via heavy machinery (bulldozing/levelling) was the most common. The latter was primarily observed in previously recorded archaeological sites where they represent 73% of the sites damaged by bulldozing (looting). This suggests that sites that are well-known locally, and have previously been the target of archaeological excavations are more likely to be targeted for illegal excavations. However, this needs to be tested through continued documentation, and at a wider sample of sites. Fig. 10 shows an example of a combination of several damage types.

5.1.5. Military Damage

Clearance (by bulldozing or levelling) is the most common damage cause attributed to the category of military activity in the district of Al-Hasakah (Fig. 11). Of the 77 sites with this damage type, 27 sites (35%) had been previously recorded in the EAMENA database, while 50 sites (65%) were only recorded on satellite imagery. Tells are often the highest points in the surrounding landscape, so various military forces have used them as lookout points, or defensive positions. This is usually executed by bulldozing in order to build up earthen banks known as berms (Fig. 12). Trenches also appear to have been dug into several tells (see Fig. 13). Whereas other damage types were found to have occurred before the war, and to have continued through it (sometimes increasing in frequency), military damage was not recorded in images predating 2011 in the Al-Hasakah region.

5.1.6. Funerary/Memorial Damage

Damage attributed to the Funerary/Memorial category is common in the area, because it is a local tradition to bury the dead on tells (refer to Figures 5, 8, 10, and 13). The continuous use of tells as cemeteries is the most common damage cause. However, several roads/tracks have also been constructed on sites to allow access to these cemeteries.

Fig. 10. Satellite images from Google Earth of site AH021 show that several looting pits appeared in the site between 2011 and 2016. The tombs shown on the top of the tell in 2011 were removed in order to establish a military point. Later, looting damage occurred in 2016 at several loci on the top of the tell. Image © 2021 Maxar Technologies. Used in accordance with the Google Maps/Earth terms of service for research purposes.

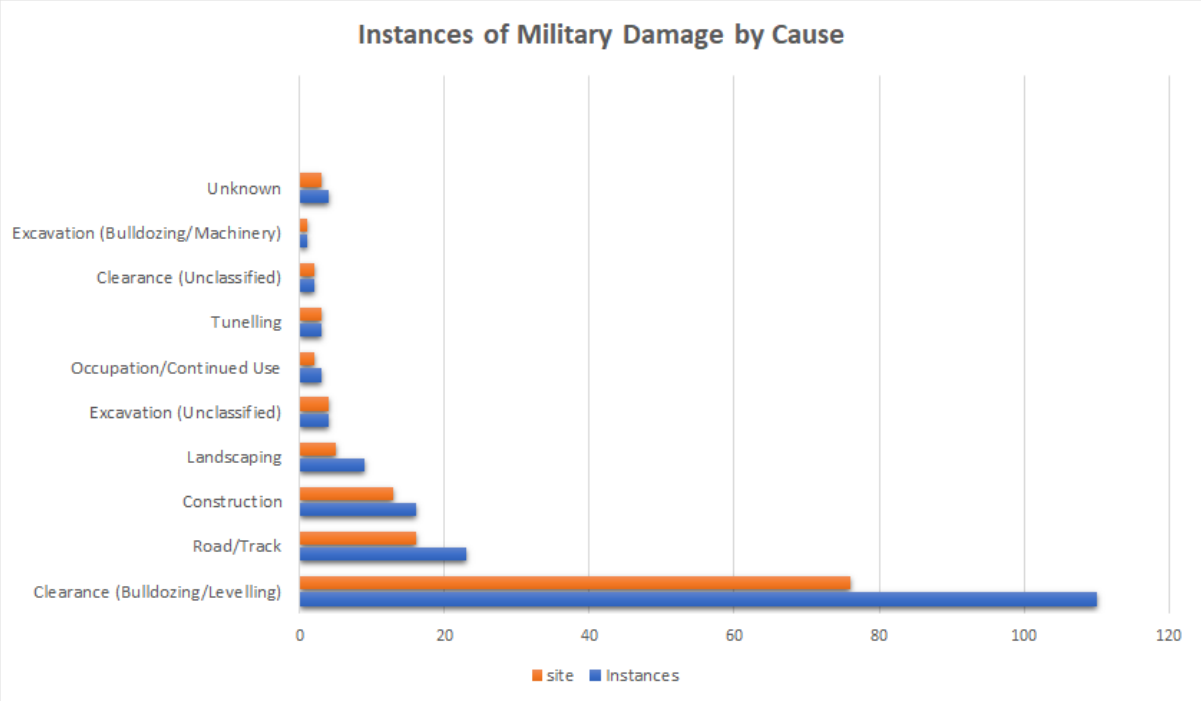

Fig. 11. A chart showing the number of instances of (blue), and the number of sites (orange) affected by damage related to military activity observed on satellite imagery dating between 2004 and 2020, for all 340 sites in the sample.

5.1.7. Hydrological (anthropogenic inundation) Damage

Flooding or inundation of parts of the landscape for the creation of artificial dams has led to damage to archaeological sites in Al-Hasakah, as in other parts of Syria. The successive alternating process of inundation and exposure of tells causes erosion of the deposits (and loss of artefacts) and collapse of the archaeological structures. Figure (14) shows an example of this damage. This also makes them easy targets for thieves (e.g., looting damage) especially with the absence of the formal authorities. Tell Kashkashuk, Tell Abou Hafur, Tell Tuneinir, and Tell Kunaidig represent examples of such damage in this sample. Satellite remote sensing has the potential to play an important role in determining the temporal variations of such damage instances (e.g., Titolo 2021) and help in providing some approaches to rescue archaeological sites in dams areas (e.g., Zaina and Tapete 2022).

5.2. Geographical distribution of disturbance causes

Because we chose to focus on sites with evidence for conflict-related damage, severe damage, or those of archaeological significance (see Methodology), this has had an impact on the geographical distribution of damage types in our sample. However, we can still make several general observations about both looting and

military damage as these sites are well-represented. The distributions of other damage types, however, may not reflect the distribution of the entire area.

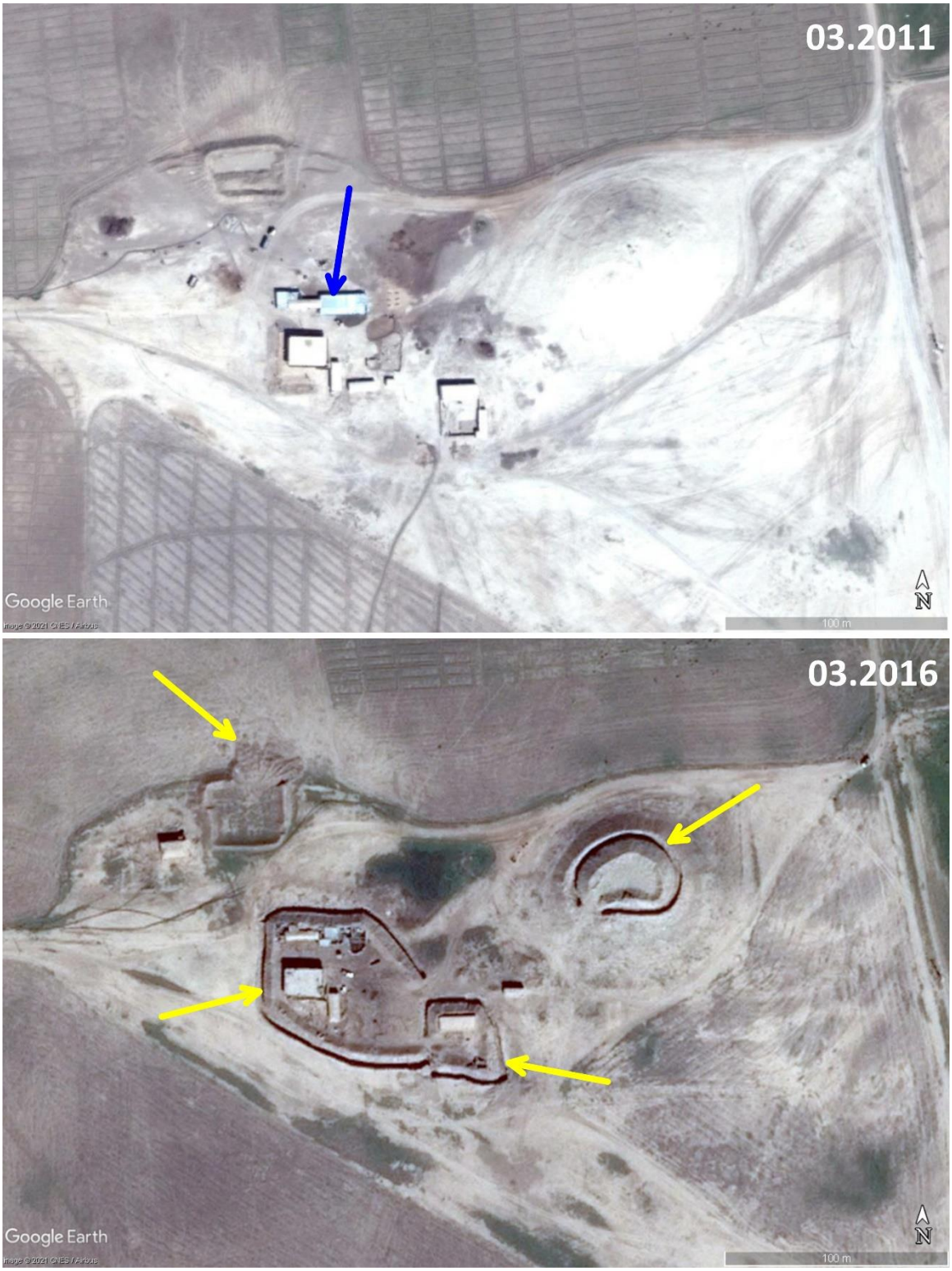

Fig. 12. An example of damage caused by the construction of berms for military purposes at Tell Zahara (AH011) between March of 2011 and March of 2016. Image © 2021 CNES/Airbus. Used in accordance with the Google Maps/Earth terms of service for research purposes.

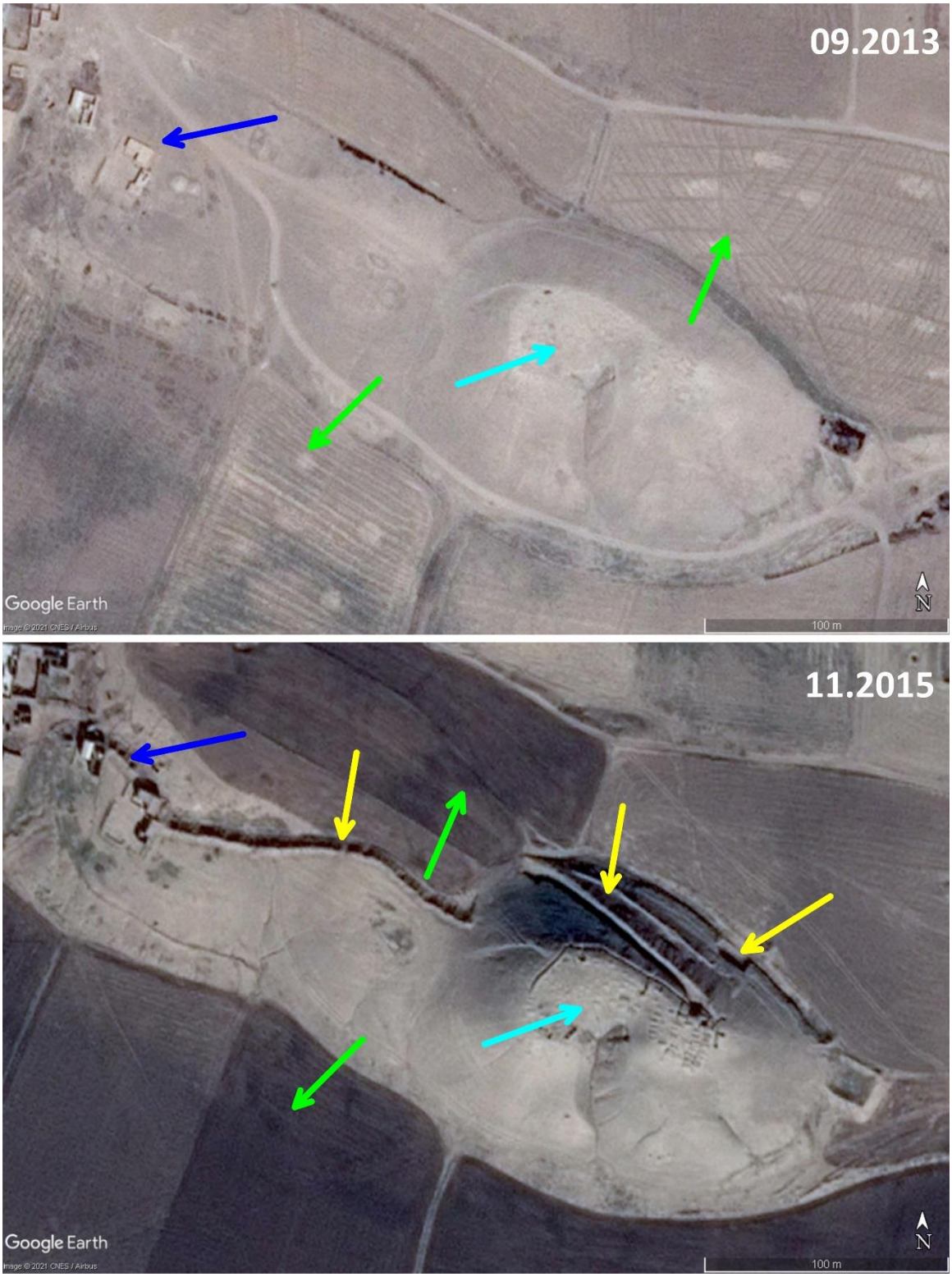

Fig. 13. At this site (AH007) we can see that the flat area on the top of the tell has been used as a cemetery in recent times. In addition, there has been earth moving (bulldozing and levelling) for military purposes. Image © 2021 CNES/Airbus. Used in accordance with the Google Maps/Earth terms of service for research purposes.

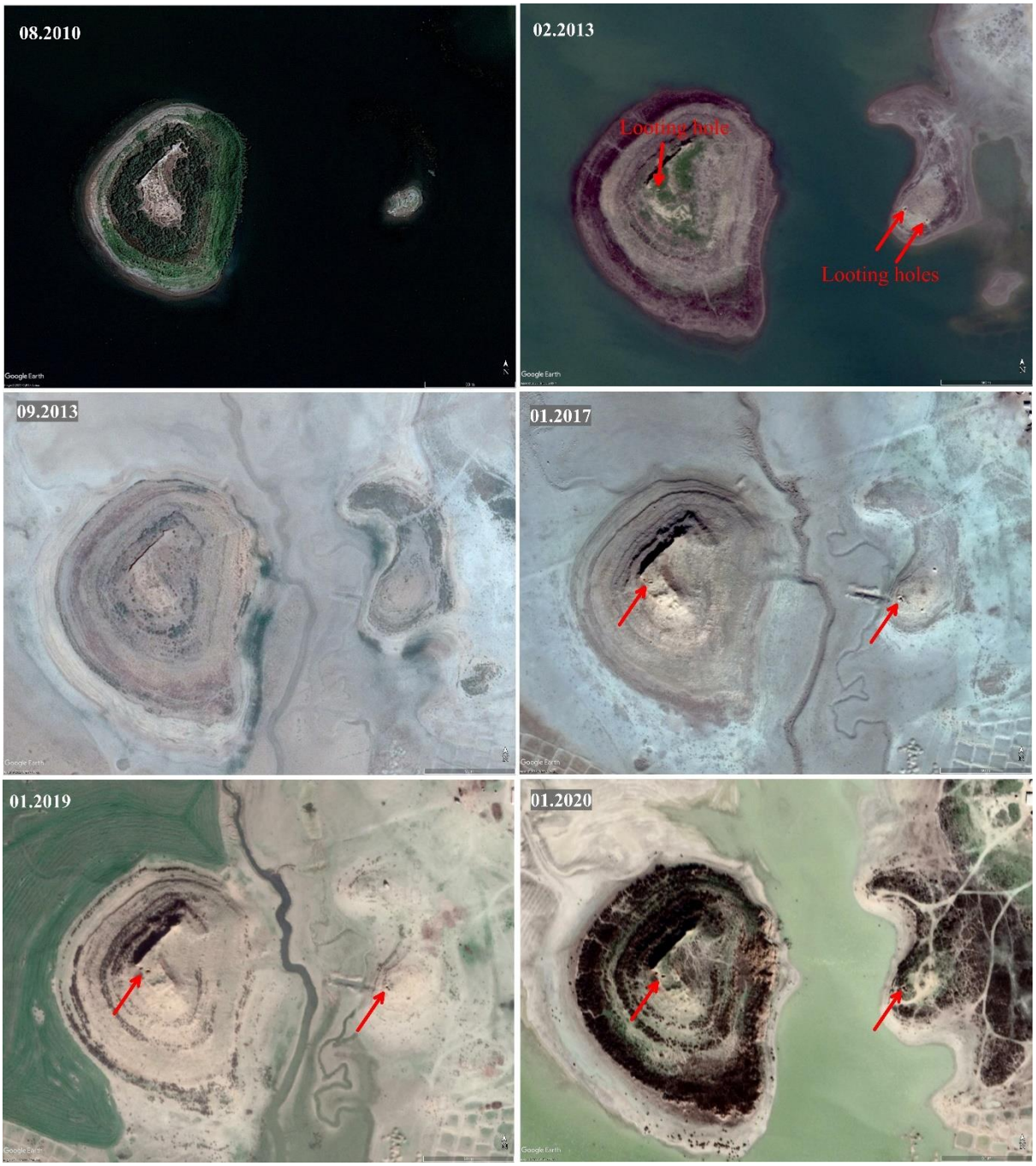

Fig. 14. The impact of dam construction on Tell Abou Hafur. Looting activity can clearly be seen after the receding of the water from the archaeological site. Image © 2022 CNES/Airbus. Used in accordance with the Google Maps/Earth terms of service for research purposes.

Instances of looting appear to be concentrated along rivers (where many modern settlements are located) (Fig. 15). Several of the sites where we recorded looting damage correspond to sites identified in previous reports focused on ground-based data (Al-Yusuf 2016; ATPA 2016). However, our analysis presents a more

comprehensive overview of the types of damage caused by looting and includes sites that may not have been previously recorded in publications - that is, sites located only on satellite imagery. This study uses a larger site sample than published reports based on field visits, and therefore provides new insights into the spatial distribution of looting in Al-Hasakah. Remote sensing studies encompassing much larger areas (i.e., Syria and neighbouring countries) also indicate instances of looting in the Al-Hasakah region up to 2016 which appears to follow similar patterning (Casana and Laugier 2017). In the literature, several similar approaches using the integration between satellite imagery and on ground reports have been successfully applied in areas of conflict (e.g., Casana 2015; Zaina 2019; Tapete et al 2021).

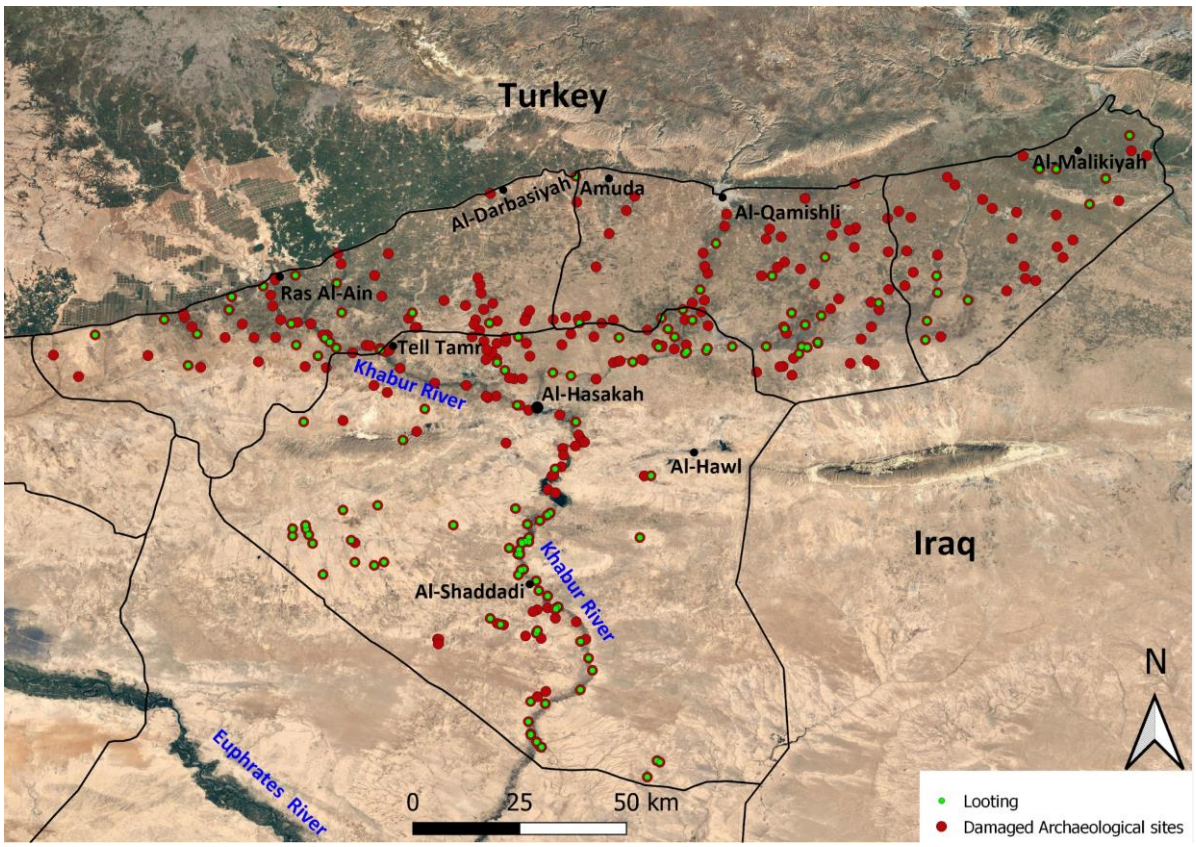

Fig. 15. A map showing the distribution of looting damage occurred compared to all documented damaged archaeological sites in the study area. Used in accordance with the Google Maps/Earth terms of service for research purposes.

Military damage (Fig. 16) primarily occurs in areas where there were military encounters between the various warring parties (e.g., Ras Al Ain and Al Qamshli). The area to the northwest of Al-Hasakah city along the Khabur river appears to be the area most impacted by the military conflict. This is probably explained by this region having been a front between the SDF and IS. However, there is no evidence that damage of

a military nature occurred along the Khabur River south of Al-Hasakah city. Interestingly, the spatial distribution of looting and military damage (Figs. 15 and 16) is very similar in the northwest part of the province, but less so in the south.

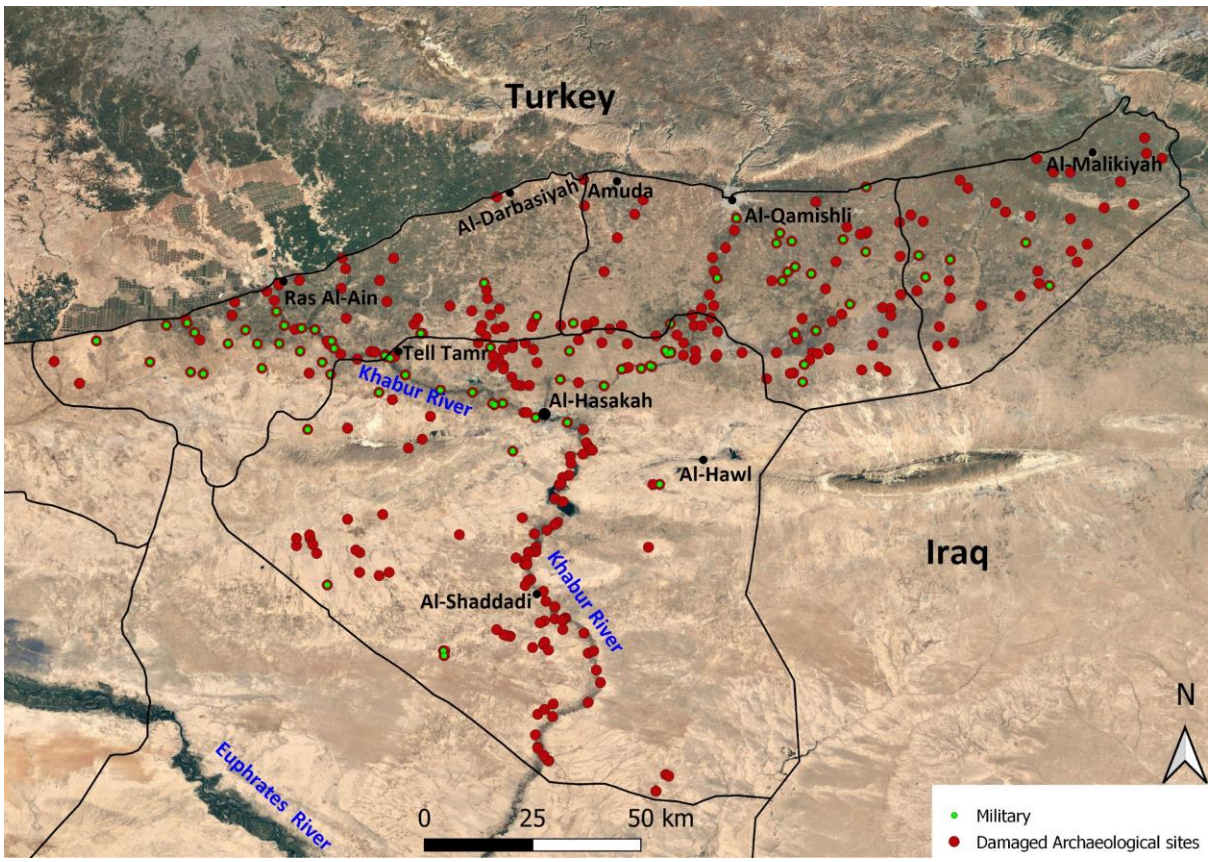

Fig. 16. A map showing the distribution of damage due to military activity compared to all documented damaged archaeological sites in the study area. Used in accordance with the Google Maps/Earth terms of service for research purposes.

5.3. Temporal variations in damage types

The EAMENA methodology records damage to archaeological sites as occurring before a certain date, on a specific date or between two dates. Because of the time-coverage available when using freely available satellite imagery, the third of these categories is most common. This can make it complicated to identify specific periods during which there are increases or decreases in damage types across a large sample of data, and in particular to quantify incidents of damage along a temporal axis. A probabilistic approach taking into account the severity of the looting (assigned a numerical value), divided by the time range in which a looting incident occurred has been used to deal with this problem in similar studies (Casana and Laugier 2017). We have opted to use a basic aoristic model (e.g., Palmisano et al. 2021) which allows us to assign a probability weight to each calendar year within the possible span of a

particular event. However, we did not include any assessment of severity in our calculations. By collating the data for all sites with a particular type of damage we can produce a qualitative visualisation. This is meant to provide an impression of the increases and decreases in particular damage categories over time. In these plots, the magnitude of the changes is more important than the actual values (which simply represent a probability). However, by doing this, we are able to identify periods of time in which certain damage types appear to be increasing, and because we have an understanding of the changing social and political contexts, we can then consider the possible mechanisms behind that (e.g., actual increase in damage events, imagery availability etc.).

Both this approach, and that taken by Casana and Laugier (2017) have pitfalls. They observe that the level of severity assigned to a looting incident could affect the weighting of an event. However, their approach may better deal with the issue of the variation in the number of images available for different sites by using a cumulative severity score; this is likely even more important when using such a large sample over a significant geographical area (all of Syria, parts of Iraq, Turkey and Lebanon). While our study area is smaller, there is still variation in how many images are available for each site, and where imagery frequency is high, it may allow us to estimate the window of a particular event more tightly. This could result in a higher peak during periods with more images (resulting in the ability to more closely date events). Even so, we would suggest that the broad trends are relatively robust, especially as we used year intervals as opposed to months. Our results for looting damage for example, at least up to 2016, appear roughly congruent to the previous study mentioned above. In future, more refined methodologies for dealing with inconsistencies in image availability and less than exact dating will be explored.

Fig. 17 compares the data for the two most frequent damage categories in the sample (Agricultural/Pastoral and Domestic), along with the damage categories that are most frequently associated with the conflict, namely, ‘Looting’ and ‘Military’. For all four categories, there is some increase in instances of damage after the outbreak of the conflict. However, these increases are not nearly so dramatic for ‘Agricultural/Pastoral’ and ‘Domestic’ damage types as they are for ‘Looting’ and ‘Military’. It should also be borne in mind that there is an increase in image availability after 2009, but especially between 2014 and 2016. This will have some impact on the

visibility of these trends and therefore the magnitude of the peaks. The trends apparent in each of these categories will be discussed in more detail below.

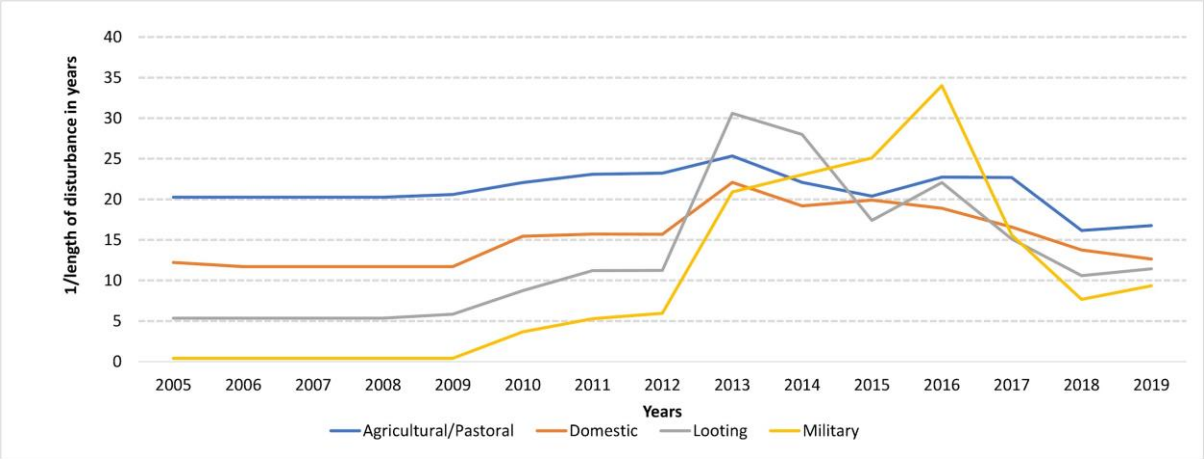

Fig. 17. Instances of damage caused by Agricultural/Pastoral, Domestic, Looting and Military disturbances by year in the dataset across the entire study area. The y axis represents the probability weight of the event occurring in each year of its span determined using aoristic methods.

Interestingly, damage related to 'Agricultural/Pastoral' activities remains relatively stable through the time period observed in this study. Agriculture is a main source of livelihood for many in this area of Syria, and it seems reasonable to assume that it always did, and continues to, impact archaeological sites.

Equally, it is clear that damage caused by activities in the 'Domestic' category were being carried out before the outbreak of the conflict, and have continued through it. Breaking this data down into damage causes provides further insight (Fig. 18a). Occupation/Continued - that is where a modern settlement is situated on top of an archaeological site remains relatively steady, though there is some decrease after 2017. This could be due to forced displacement or the fact that fewer images are available for this date. Interestingly, damage in the 'Domestic' category caused by construction does clearly show an increase following the conflict, with a peak in 2013 (Fig. 18a). Presumably this reflects collapse in administrative control.

The peak in instances of looting also appears to occur in 2013 (Fig. 17). While further research is needed to understand the details of this trend, it seems likely that a lack of state oversight, that is the inability of state institutions to enforce various laws during periods of conflict may have allowed for looting and construction to occur in places it had previously not. Other estimates based on satellite imagery over a much wider area, including Syria, suggest a similar peak and then decrease in occurrences

of looting, and by extension the rate at which looting is occurring from late 2014 (Casana and Laugier 2017).

Obviously, damage related to Military activity coincides with the start of the Syrian conflict and continues throughout (Fig. 18b). This is primarily in the form of bulldozing and levelling of tells to create military positions. There is a considerable increase between 2012 and 2013, and again in 2016. While this is partly related to imagery availability, it does suggest periods of escalating military activity, something that has reduced in the area since 2016.

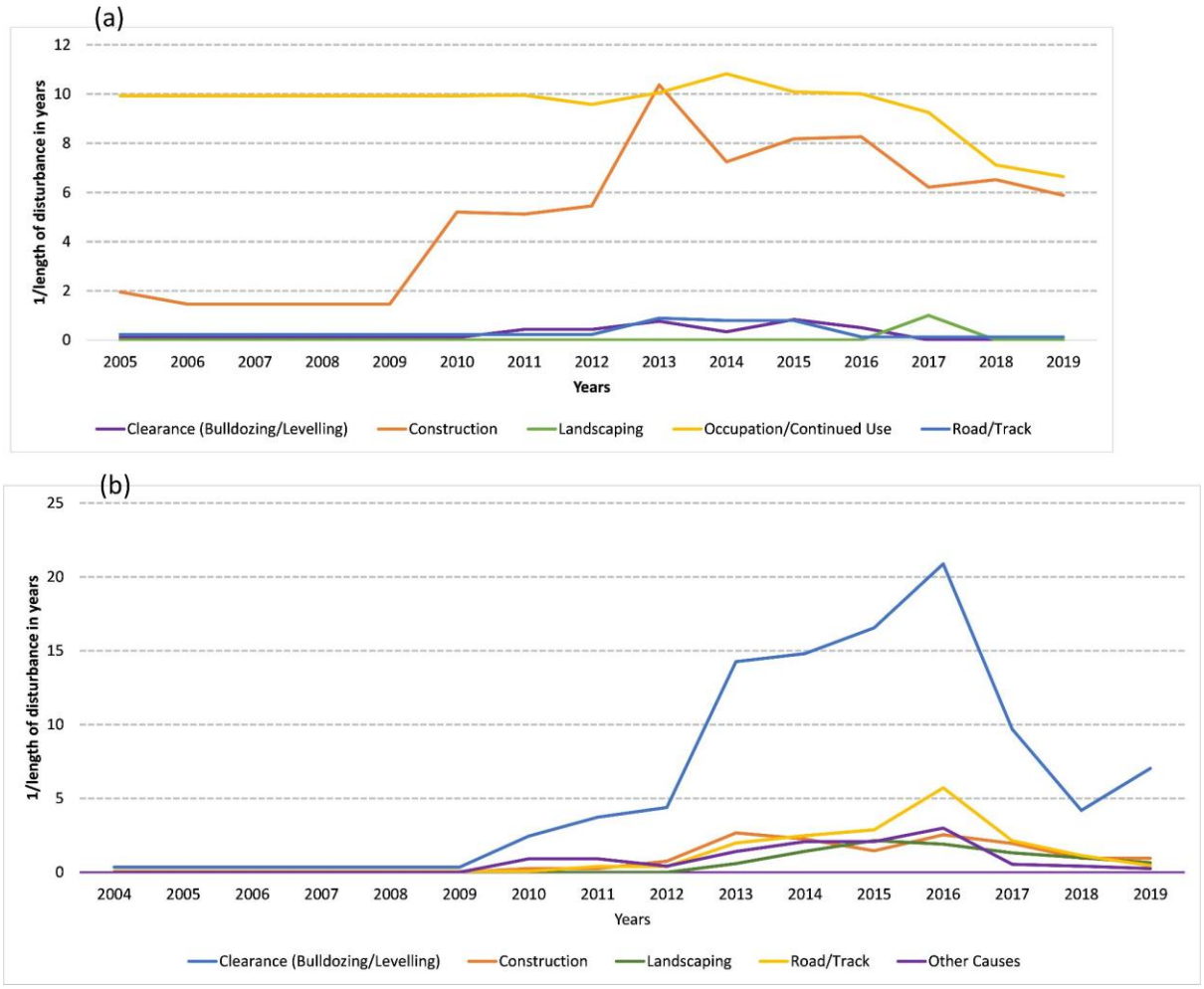

Fig. 18. Instances of damage broken down by cause type for the category of (a) domestic, (b) military damage. The y axis represents the probability weight of the event occurring in each year of its span determined using aoristic methods.

6. Discussion

Documenting damage to archaeological sites via satellite imagery can provide an objective source of information about their condition, define a time-window for its occurrence and thus support ground-based assessments. Some researchers have doubts about the effectiveness of imagery-based analysis for recording damage to archaeological sites in time of conflicts (Wolfinbarger et al. 2014). Here, it is worth noting that we have mainly concentrated on forms of damage that can be clearly visible from space. While ground-truthing is desirable, it is not always practical in terms of access, human resources, time and cost. This research highlights the usefulness of satellite remote sensing for monitoring damage to archaeological sites in places of ongoing conflict and/or inaccessible areas.

In terms of the timing and intensity of damage related to the conflict, there appears to have been peaks in looting activity in the Al-Hasakah region between 2013 and 2014, and again in c. 2016. Control of parts of the governorate has alternated between various military forces (e.g., IS, Syrian Regime, FSA, and Syrian Democratic Forces (SDF) over the last 10 years, and this lack of stability has made it difficult for authorities to focus on the prevention of looting; the result, as demonstrated by our analysis is an increase in looting overall between 2012 and 2017 (Fig. 17). Field-based investigations confirm looting at sites such as Tell Brak and Tell Halaf (Al-Sakaf and Ahmad 2016), Tell Mabtouh Sharqi, Tell Taban, Tell Ajaja, and Tell Seker Al Aheimer (ATPA 2016: 44,20,23,38) in this period. Abdo and Qassem (2017) also confirmed illegal excavations in Tell Taban and Tell Knediig. Consequently, while the results of our remote sensing study are congruent with the previously published information, our data provides further evidence on the mechanisms of the looting (cause) and the timing of peaks in looting between 2004 and 2019 for this particular region. Furthermore, both field work and remote sensing data are in agreement that sites that have been largely undocumented are being heavily targeted (Al-Yusuf 2016; ATPA 2016; Casana and Laugier 2017). In sum, looting activities appear more frequent than before the conflict, increasing between 2011 and 2014, and subsequently decreasing from that point to 2020.

In many cases, defensive or outlook positions are set up on the highest locations in a region; given that many archaeological sites in Al-Hasakah are tells, they

are often co-opted for this purpose. Examples of military damage can be found in Figs. 5, 12, and 13. Their transformation into military points is often achieved using heavy machinery resulting in significant damage to the surface of the site, and can potentially lead to near-complete demolition of the site through bulldozing. Fig. 19 shows that military activities at the site of Mohammad Diab occurred between October 2013 and April 2014. Destruction of the village and parts of the archaeological site occurred between April 2014 and April 2017. Moreover, most of the rest of the archaeological site was almost completely demolished, and several military buildings were built, in the period between April 2017 and August 2019. Bulldozing, the digging of trenches and tunnels, as well as stealing from, and the destruction of, the mission house were confirmed by ATPA (2016: 36-37). Instances of damage related to military activity have, unsurprisingly, increased in number since the outbreak of the conflict. Indeed, it is likely that they were minimal to absent in the years prior to 2011 within the study; however, the nature of the data (i.e., events may only be attributed to a window between two dates) means we can only say that there is an increase from as early as 2009, but which may have actually occurred after 2011. Military damage appears to peak in 2016.

Geographically, the area to the west of Al-Hasakah city along the Khabur river has been the region most impacted by military conflict (refer to Fig. 16). Generally, military damage caused by bulldozing occurred mainly in the period between 2012 and 2017 (Fig. 18b). This is likely due to its location as a front during the period 2014-2016 between SDF and IS forces, where the SDF was controlling the northern bank and IS the southern one. Published reports using on-the-ground observations provide corroborating evidence. Examples of military damage have been reported at sites such as Tell Brak, Tell Mohammed Diyab, Tell Leilan, and Tell Mabtouh Sharqi (ATPA 2016: 5,36,42,44). Tells, especially those in the north of Al-Hasakah city (e.g., in the Tell Brak district and Qamishli district), are specifically mentioned, but exact dates for the damage are not given, though they must have occurred before 2017 (Abdo et al. 2017: 9-10, 13-14). By comparing the fieldwork documentation (Abdo and Qassem 2017; Abdo et al. 2017; ATPA 2016; Al-Yusuf 2016) with our remote sensing data, we can therefore provide a more comprehensive overview of this damage type along with a better sense of the chronology of the damage. Often, however, fieldwork reports only

mentioned the type of damage without noting its date; in some cases, there was no mention of whether the damage was caused by heavy machinery or other means.

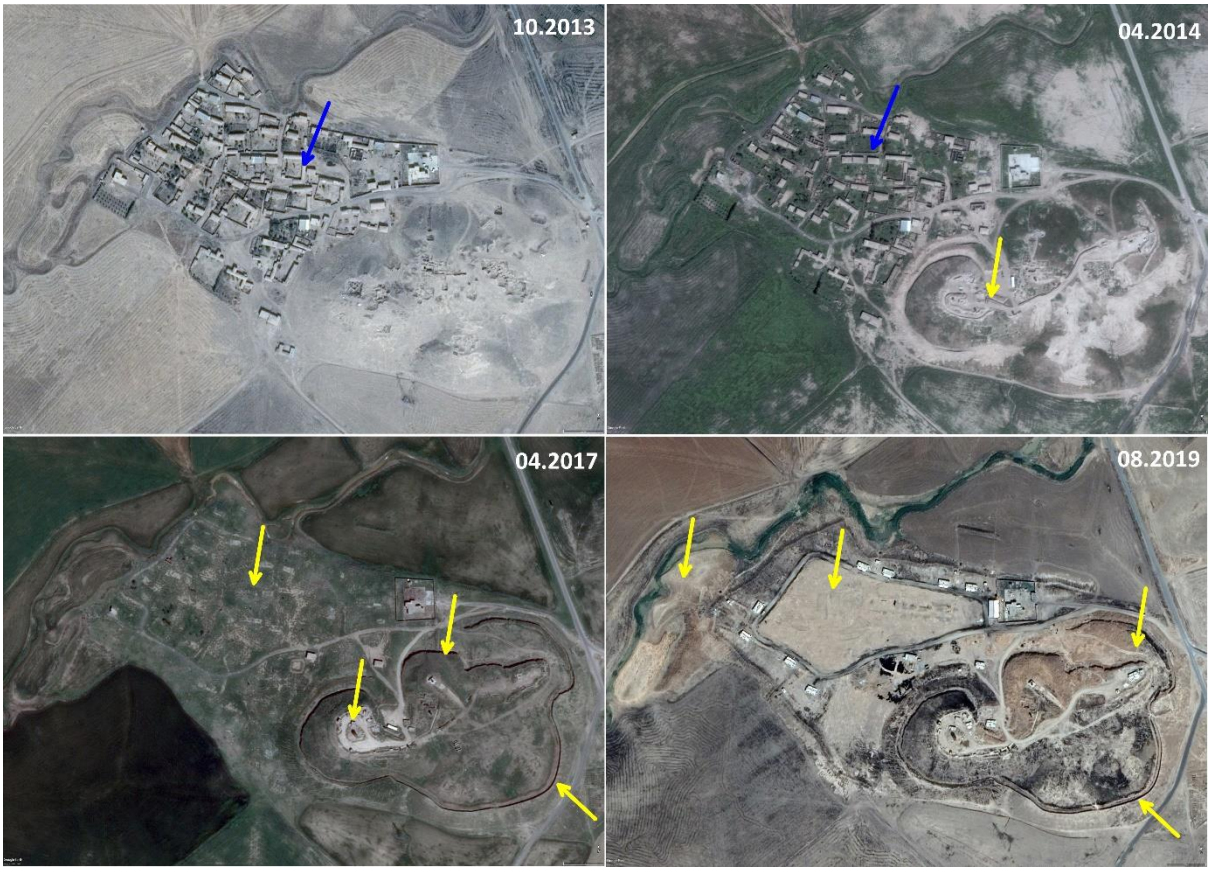

Fig. 19. A chronology of military damage caused by using bulldozers in order to shape a military point led to near-complete demolition of the Mohammad Diab site. Destroying the neighbouring village and establishing new military buildings can be obviously seen in this figure. Image © 2021 CNES/Airbus. Used in accordance with the Google Maps/Earth terms of service for research purposes.

Previously published reports using field data have primarily focused on activities that appear directly related to the conflict, e.g., looting and military damage. However, the conflict has also had an impact on other damage types, for which there has been comparatively little discussion. For instance, Casana and Laugier (2017) looked at trends in damage caused by construction between 2011 and 2016, determining that there was a large amount of new construction taking place on archaeological sites. In our study we have also recorded damage associated with both domestic and agricultural activities. It suggests a slight increase in the number of recorded incidents related to both agricultural/pastoral and domestic activities over the course of the conflict. These could include the construction of houses and ploughing over tells. While this may be, in part, a product of increased data points in recent years,

it may also indicate that the absence of authorities has resulted in a lack of regulation of various activities on archaeological sites. Agricultural and domestic activities, regardless of conflict, represent two of the main threats to archaeological sites and have been documented elsewhere in the Middle East and North Africa region by Rayne et al. (2018).

Ultimately, the results of our analysis show that while looting and military activities have had a critical impact on archaeological sites in Al-Hasakah region, the most common causes of damage both before and during the conflict remain agricultural/pastoral and domestic related activities. However, there is a difference in the severity of the damage caused and the period of time over which it has occurred. Looting and military activities can often cause severe damage over short periods of time. However, agricultural/pastoral activities can also cause severe damage, but this can occur over a longer time compared to other damage types.

7. Conclusions

The results of this study demonstrate the efficiency of remote sensing for recognizing various types of damage to archaeological sites which occurred after 2004 and during the Syrian conflict. Valuable information about the distribution of damage to 340 archaeological sites in Al-Hasakah Governorate between 2004 and 2020 has allowed us to gain geographical and chronological insights. The results clarify that:

a) Looting and military activities have a significant impact on both well-known and previously unexcavated archaeological sites in the Al-Hasakah region in the last ten years, and increases in these two damage types were driven by military confrontations or the absence of authorities. The data also demonstrates that the area west of Al-Hasakah city - along the Khabur River - has been the area most affected by the military conflict due to its location as a front between the Syrian Democratic Forces and IS between 2014 and 2016.
b) It is difficult to determine the mechanism of looting using satellite imagery alone. On the contrary, military damage was clearly visible as they are often represented by clearance, using bulldozing or levelling.
c) Damaged sites are located within areas held by multiple military groups within very short time periods, and so it is difficult to attribute this damage to any one group.

d) Damage caused by agricultural/pastoral and domestic activities are more frequent than any other damage type in the region. This suggests that a gradual attrition rather than episodes of sudden catastrophic damage is the most frequent. This parallels the situation in other case studies from the Middle East and North Africa (MENA) region.

In future we aim to expand the assessment to cover a larger sample of sites, and to incorporate other sources of freely available remote sensing data. This includes lower resolution optical imagery such as Sentinel 2 or Landsat, and other sensors (e.g., Synthetic Aperture Radar or SAR), which have proven useful for change detection and identifying disturbances in other studies. Ultimately, field visits, particularly to largely undocumented sites, will be crucial to validating our results. We encourage using similar methodologies in other areas of Syria, particularly adjacent regions like Raqqa and Deir ez-Zor, which would be useful for understanding regional differences and similarities in these patterns. Overall, we hope that the results of this study can contribute to helping the local and national authorities in future planning for the protection of cultural heritage in Al-Hasakah.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The data that support the findings of this study are available upon reasonable request from the corresponding author

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Annex 1: Key data categories

Site	Name, EAMENA ID, Unique ID for Al-Hasakah Survey
Morphology	Negative/Cut/Dug Feature; Positive/Built Feature; Surface Feature; Unknown
Overall Site Shape	Circular; Curvilinear; Irregular; Polygonal; Rectangular/Square; Rectilinear; Semi-circular; Straight; Sub-circular; Sub-rectangular; Triangular; User Defined; Winding; Zigzag; Unknown
Archaeological Certainty	Negligible; Low; Medium; High; Definite
Site Location Certainty	Negligible; Low; Medium; High; Definite
Site Size/Extent Certainty	Negligible; Low; Medium; High; Definite
Topography	Alluvial Fan; Lake Bed; Lake Shore; Ocean/Sea Bed; Ocean/Sea Shore; Plain/Plateau; Precipice/Edge; Slopes; Summit; Unknown; Valley Bed; Valley Terrace Watercourse Banks; Watercourse Bed
Form	Bank/Earthwork; Bank/Wall; Cave; Cleared Area; Colour/Texture Difference; Depression/Hollow; Ditch/Trench; Large Mound; Modified Rock Surface; Multi-Component; Object; Paved/Laid Surface; Pit/Shaft/Tunnel; Plant/Tree; Platform/Terrace; Pyramid/Ziggurat; Rubble Spread/Architectural Fragments; Scatter; Small Mound/Cairn; Structure; Tower; Unknown; Upright Stone; Wall
Form Certainty	Negligible; Low; Medium; High; Definite
Form Shape	Circular; Curvilinear; Irregular; Multiple; Polygonal; Rectangular/Square; Rectilinear; Semi-circular; Straight; Sub-circular; Sub-rectangular; Triangular; Winding; Zigzag; Unknown
Arrangement	Adjoining; Concentric; Clustered; Dispersed; Discrete; Isolated; Linear; Multiple; Nucleated Parallel; Perpendicular; Overlapping; Rectilinear; Unknown
Estimated number of forms	1; 2 to 5; 6 to 10; 11 to 20; 21 to 50; 51 to 100; 100 to 500; 500+; Unknown
Interpretation	Altar; Amphitheatre; Aqueduct; Barrack; Barrage/Dam; Basilica (Roman); Basin/Tank; Bath-house; Boundary/Barrier; Bridge; Building; Building/Enclosure; Bunker; Burnt Area; Camp (temporary) ; Canal; Caravanserai/Khan; Cemetery; Channel; Church/Chapel; Circus/Hippodrome; Cistern; Clearance Pile; Column/Obelisk; Dolmen; Education/Athletics Building; Emplacement/Foxhole; Enclosure; Farm; Farm Building; Field System; Flooring/Mosaic/Paving; Fort/Fortress/Castle; Fountain; Crossbar Arrangement (Gate); Gateway/Arch/Intersection; Gathering Area; Grove/Garden/Orchard; Hearth/Oven; House/Dwelling; Hunting Hide/Trap; Inscription/Rock Art/Relief; Kiln/Forge/Furnace; Kite; Large Circle; Latrine/Toilet; Managed Site; Market; Megalithic Feature; Midden/Waste Deposit; Mill (water); Mill (wind); Mill; /Quern/Grindstone Element; Mine/Quarry/Extraction; Monastic Complex; Mosque/Imam/Marabout; Mosque/Madrasa Complex; Palace/High Status Complex; Pendant; Port/Harbour; Press/Press Element; Production/Processing (Agricultural);Production/Processing (Animal/'Kill site'); Production/Processing (Glass); Production/Processing (Knapping Floor/Stone Processing); Production/Processing (Metal); Production/Processing (Pottery); Production/Processing (Salt); Production/Processing (Unclassified); Qanat/Foggara (falaj); Railway; Railway Station Stop; Ramparts/Fortification/Defensive Earthwork; Reservoir/Birka; Road/Track; Sarcophagus/Coffin; Sculpture/Statue; Settlement/Habitation Site; Ship/Wreck; Significant Building; Standing Stone; Storage Facility; Sub-surface Material; Synagogue; Tell; Temple/Sanctuary; Theatre/Odeon; Threshing Floor; Tomb/Grave/Burial; Wadi Wall; Watchtower/Observation Post; Water wheel; Waymarker; Well; Wheel/Jellyfish; Unknown

Interpretation Certainty	Not Applicable; Negligible; Low; Medium; High; Definite
Functional Interpretation	Agricultural/Pastoral; Defensive/Fortification; Domestic; Entertainment/Leisure; Funerary/Memorial; Hunting/Fishing; Hydrological; Industrial/Productive; Infrastructure/Transport; Maritime; Military; Public; Religious; Status/Display/Monumental; Trade/Commercial; Unknown.
Functional Categories Certainty	Not Applicable; Negligible; Low; Medium; High; Definite
Period	Chronological period (if known)
Period Certainty	Not Applicable; Negligible; Low; Medium; High; Definite
Condition Scale	Good; Fair; Poor; Very Bad; Destroyed; Unknown.
Damage/Disturbance Extent	No Visible/Known; 1-10%; 11-30%; 31-60%; 61-90%; 91-100%; Unknown.
Disturbance Type	Agricultural/Pastoral; Archaeological; Building and Development; Defensive/Fortification; Development; Domestic; Entertainment/Leisure; Funerary/Memorial; Hunting/Fishing; Hydrological; Industrial/Productive; Infrastructure/Transport; Looting; Maritime; Military; Natural; Public; Religious; Status/Display/Monumental; Tourism/Visitor Activities; Trade/Commercial; Utilities; Unknown
Threat/Disturbance (Cause)	Animal/Pest Infestation; Clearance (Bulldozing/Levelling); Clearance (Hand); Clearance (Unclassified); Conservation; Construction; Demolition; Drilling; Dumping; Excavation (Bulldozing/Machinery); Excavation (Hand); Excavation (Unclassified); Explosion/Heavy Weaponry; Fire; Flooding; Graffiti; Grazing/Animal Movement; Gunfire/Light Weaponry; Inundation; Irrigation (Unclassified); Irrigation (Channels); Irrigation (Centre Pivot System); Land/Rock Slide; Landmines; Landscaping; Maintenance/Preventative Measure; Mining/Quarrying (Unclassified); Mining/Quarrying (Surface); Mining/Quarrying (Open Trench/Pit); Mining/Quarrying (Underground); No Visible/Known, Occupation/Continued Use; Ploughing; Pollution; Precipitation; Railway; Reconstruction; Road/Track; Seismic Activity; Stationary Vehicle; Structural Robbing; Temperature/Humidity Change; Trees; Tunnelling; Vegetation/Crops; Volcanic Eruption; Water Action; Wind Action, Unknown.
Threat/Disturbance Cause Certainty	Not Applicable; Negligible; Low; Medium; High; Definite
Disturbance Date Type	Occurred on; Occurred between; Occurred before
Dates of Disturbance (s)	Dates disturbance occurred on, before or between
Disturbance Effects	Access Restriction; Alteration of Terrain; Artefact Displacement; Burning; Chemical Leaching; Collapse/Structural; Damage; Compacting; Covered; Earth; Displacement; Erosion; Loss of Archaeological Material; Relocation of Archaeological Features; Structural Alteration; Water Damage; Unknown
Effect Certainty	Not Applicable; Negligible; Low; Medium; High; Definite
Threat Certainty	Not Applicable; Probable; Possible; Planned

Annex 2: Definitions of Disturbance Types

Disturbance Types	**Definitions**
Agricultural/Pastoral	Relating to the farming of land and/or the rearing of animals
Archaeological	Relating to the scientific investigation of an area/site/object

Building and Development	Relating to the expansion/enlargement/spread of activity, construction etc. Particularly in relation to urban expansion.
Defensive/Fortification	Relating to the security or protection of people or an area, but not military in nature
Domestic	Relating to the habitation of people
Funerary/Memorial	Relating to activities concerning the memorialisation of individuals, events and/or the treatment of the dead
Hunting/Fishing	Relating to the exploitation of (mostly) non-domesticated species
Hydrological	Relating to the management and movement of water
Industrial/Productive	Relating to the production of goods or other commodities, at large or small scale
Infrastructure/Transport	Relating to the organisation and provision of facilities and services, particularly those associated with the movement of people, animals and goods, which are necessary for a society to function
Looting	Relating to activities associated with ilicit removal of goods from archaeological sites and their possible sale
Maritime	Relating to the sea, in particular shipping and/or the exploitation of maritime resources where these resources cannot be further defined.
Military/Armed Conflict	Relating to an organised and/or official group of armed forces
Natural	Relating to non-anthropogenic activities
Public/Institutional	Relating to facilities and services which are intended for use by the community as a whole. Often, but not necessarily officially provided or sanctioned e.g. markets, courthouse, official/government etc.
Religious	Relating to activities of a ritual nature
Status/Display/Monumental	Relating to structures which serve no functional purpose except to express a statement, usually relating to wealth, status, power etc.
Tourism/Visitor Activities	Relating to the management, organization and specific use of archaeology/archaeological sites for educational/pleasure
Trade/Commercial Use	Relating to facilities and or services which are predominantly economically orientated or mercantile in nature.
Utilities	Relating to activities supplying useful features, or something useful to the home such as electricity, gas, water, cable and telephone.
Unknown	Unknown

Annex 3: Definitions of Disturbance Cause

Disturbance Cause	**Definition**
Animal/Pest Infestation	Invasion/inhabitation by living organisms in numbers or quantities large enough to be harmful. This includes burrowing.
Clearance (Bulldozing/Levelling)	The act of clearing and/or flattening/destroying ground or archaeological features/modern buildings etc., using mechanised machinery.
Clearance (Hand)	The act of clearing and/or flattening/destroying ground or archaeological features/modern buildings etc., by hand/using hand tools.
Clearance (Unclassified)	The act of clearing and/or flattening/destroying ground or archaeological features/modern buildings etc., where it is not clear whether this has been carried out using mechanised machinery or by hand.
Conservation	The act of trying to prevent or limit the loss of archaeological material using scientific methods. This does not cover actions or processes that attempt to **maintain** access to or create walkways etc. as a way of maintaining archaeological sites for tourism etc.

Construction	The act of building, including structures, such as housing, infrastructure etc., and the resulting product/s. These activities can be on an industrial/public scale, or at a much smaller 'domestic' scale.
Demolition/Destruction	The act of destruction or tearing down of archaeological structures. This act can be carried out both in a controlled and uncontrolled manner, but also using both mechanised and/or hand machinery
Drilling	The act of making a hole using a boring or rotating mechanism. Drilling can be associated with activities such as Oil extraction and the sinking of well systems.
Dumping	The action of disposing of unwanted material, including scrap material and waste.
Excavation (Bulldozing/Machinery)	The act of digging or creating a hole/trench with heavy duty machinery for a purpose other than mining/quarrying. This term can be used to cover archaeological excavation or excavation for the purposes of looting.
Excavation (Hand)	The act of digging or creating a hole/trench by hand/hand tools for a purpose other than mining/quarrying. This term can be used to cover archaeological excavation or excavation for the purposes of looting.
Excavation (Unclassified)	The act of digging or creating a hole/trench for a purpose other than mining/quarrying where it is not clear whether this has been carried out using mechanised machinery or by hand. This term can be used to cover archaeological excavation or excavation for the purposes of looting.
Explosion/Heavy Weaponry	The release of energy in an often sudden and violent way. This can lead to the sudden shattering or blowing apart of objects/features.
Fire	An exothermic process involving the oxidation of material, sending out light and heat and possibly producing smoke.
Flooding	A **natural** act involving an overflow from a water body, beyond its normal limits. This can lead to archaeological features being covered or submerged under a body of water. This term is differentiated from inundation
Graffiti	The act of writing or drawing (can be scratched, painted etc.) something onto a surface. In this case the surface of an archaeological object, feature or site.
Grazing/Animal Movement	The act of animals consuming vegetation/and or being moved across an area of land whether that vegetation be natural or planted.
Gunfire/Light Weaponry	The act of firing or letting off small scale weaponry e.g. guns as opposed to the use of artillery.
Inundation	An **anthropogenic** act involving an area being covered/overwhelmed with water. This is differentiated from flooding by being defined as a deliberate and anthropogenic act.
Irrigation (Unclassified)	The artificial and deliberate provision of water by the means of pipes, sprinklers, drains, ditches etc.
Irrigation (Channels)	The act of digging trenches across a landscape and the provision of water through that system to an area.
Land/Rock Slide	The collapse/movement of a mass of earth or rock, generally down a slope.
Landmines	An explosive charge laid on or just under a surface (anthropogenic or natural)
Landscaping	The deliberate act of changing the contours of the land/earth's surface. This can include landscaping in order to produce terraces, as well as the deposition of imported soil, raising the level of land surface/
Maintenance/Management Activities	Includes the implementation of upkeep and maintenance activities to look after sites. This category also includes both implementation of tourism and management strategies (such as the addition of modern features e.g. walkways, dedication of human resources and development of conservation plans, etc.) on a heritage site. This does not, however, include actual conservation activities for which there is a separate term.

Mining/Quarrying (Unclassified)	The extraction of natural resources/geological materials i.e. metals, stone etc. from the earth, by unknown means
Mining/Quarrying (Surface)	The extraction of natural resources/geological materials i.e. metals, stone etc. from the earth by scraping or working the surface of the ground, often with machinery such as bulldozers. Most often in alluvial contexts.
Mining/Quarrying (Open Trench/Pit)	The extraction of natural resources/geological materials i.e. metals, stone etc. from the earth by excavating pits or trenches into the surface.
Mining/Quarrying (Underground)	The extraction of natural resources/geological materials i.e. metals, stone etc. from the earth by excavating under the surface of the ground, accessed through tunnels, shafts, or caves.
No Visible/Known	This term should be used to indicate that, given the current evidence, there is no evidence for damage and/or threat to the archaeological site mentioned in published imagery or identifiable from imagery sources.
Occupation/Continued Use	The act of living, inhabiting or continuing to utilise a certain place
Ploughing	The act of turning/breaking up the earth, predominantly in preparation for the planting of crops.
Pollution	The contamination of the land, water, air etc., by the presence or introduction of poisioness or harmful substances. This can cover pollution arising from natural disasters, as well as pollution caused by dense urbanization etc.
Precipitation	The condensation of water vapour in the earth's atmosphere which leads to water falling in the form of rain, snow, sleet etc. and being deposited on the earth's surface.
Railway	A track or network of tracks along which a train runs. Usually composed of a series of steel rails running along the ground.
Reconstruction	The act of rebuilding an archaeological site or a place to its known and earlier state that was damaged or destroyed. In reconstruction a mixture or additional "modern" and new materials and techniques are used and it is distinguished from Restoration by this use of new materials.
Road/Track	A path or route leading from one place to another, often including a built or anthropogenically modified/altered surface
Seismic Activity	Sudden movement/vibrations of the earth's crust e.g. earthquakes
Stationary Vehicle	Presence of non-moving objects used in transport e.g. cars, tanks etc., at a site. For example, the presence of stationary tanks may indicate that the site is under military control.
Structural Robbing	The act of removing material (e.g. stone/mudbrick) from an archaeological site.
Temperature/Humidity Change	Shifts in the environmental conditions at a site/of a feature. This definition would include changes in moisture content at both a local and regional level, as well as shifts in the comparative scales of hot and cold.
Tunnelling	The act of creating/digging a usually narrow passage or channel through earth/rock. This process can be connected with mining activities and the construction of hydrological features.
Vegetation/Crops/Trees	Cultivated or natural plant cover
Volcanic Eruption	The violent discharge of steam/volcanic material from an active vent in the earth's crust
Water Action	This term covers a series of *effects (e.g. erosion/weathering)* which are caused by the flow and movement of bodies of water (i.e. sea, lake, river, 'wadi'). It does not include flooding and precipitation which are listed as separate causes.
Wind Action	This term covers a series of *effects (e.g. erosion/weathering)* which are caused by the flow and movement of the wind. It does not include temperature and humidity changes which are listed as a separate cause.
Unknown	Unknown

Annex 4: Definitions of Disturbance Effect

Disturbance Effect	Definitions
Access Restriction	The limiting of movement into and around an archaeological site. This can be due to activities such as inundation, as well as occupation/use of the site for military purposes.
Alteration of Terrain	Changes in the shape/form of landforms or the topography of a site as the result of activities, such as the bulldozing/dumping of non-local material.
Artefact Displacement	The dispersal/spread of archaeological material/objects across the surface or subsurface of an archaeological site. This is often the result of ploughing.
Burning	The damage caused to archaeological sites/features via fire. This can include both damage caused by the flames of the fire, as well as smoke damage.
Chemical Leaching	The drainage/percolation of harmful chemicals/waste materials into the soils of an archaeological site.
Collapse/Structural Damage	Damage causing archaeological sites or features to fall in/subside or to become structurally unsound, or the structural integrity of the site or feature to be compromised. This may include the partial or full demolition/destruction of a site or feature. This category includes structural deformation, inclination and swelling.
Compacting	The pressing or packing down of archaeological sites/artefacts/soils and so the material becomes flattened and/or compressed.
Covered	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. It also covers sites that are only partially covered. This could also be caused by vegetation/tree cover.
Earth Displacement	The movement of earth/soil, not necessarily leading to the alteration of landforms and/or the burial of archaeological sites.
Erosion	The process of archaeological material being worn away/weathered, often due to natural causes. (e.g. exposure to wind, rain, sunlight, as well as salt crystallization, insects and pests damage, and growth of micro-organisms)
Loss/Removal of Archaeological Material	The removal of archaeological material from a site, often resulting from activities such as looting.
Relocation of Archaeological Features	The deliberate removal and relocation of archaeological features from one site to another. This may be done to protect archaeological features (e.g. prevent its destruction via inundation etc.) or for other reasons.
Structural Alteration	Damage or alteration to an archaeological site/feature where the result does not cause the feature to become structurally unsound/compromised.
Water Damage	The effects of water on archaeological features and sites, this includes rising damp, structural decay, rotting, rusting etc.
Not Applicable	Only to use when the cause is "No Visible/Known".
Unknown	Unknown

Annex 5: Definitions of Disturbance Cause/Effect Certainty

Disturbance Effect Certainty	Definitions
Not Applicable	The investigator has entered 'unknown' and certainty does not apply
Negligible	The investigator has considerable reason to doubt their identifications/interpretations. The evidence may also be contradicted by published sources/other imagery specialists or multiple imagery sources.

Low	The investigator has considerable reason to doubt their identifications/interpretations. It is It is not confirmed by published sources/other imagery specialists or multiple imagery sources.
Medium	The investigator has some reason to doubt their identifications/interpretations. It is not confirmed by published sources/other imagery specialists or multiple imagery sources.
High	The investigator has little reason to doubt their identification, it may or may not be confirmed by published sources/other imagery specialists or multiple imagery sources.
Definite	The investigator has no reason to doubt their identification and it is either confirmed by published sources/other imagery specialists or multiple imagery sources.