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The impact of urban sprawl on cultural heritage in Herat, Afghanistan: A GIS analysis

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ABSTRACT

Urbanization is a significant force affecting the preservation of archaeological sites across the globe. Even in war-torn countries such as Afghanistan, urbanization dramatically outpaces looting and other forms of site destruction that have been highly visible in the media. The study presents a method for analyzing how informal urban growth has and will affect heritage sites on the outskirts of the city in coming decades. The method draws on historical aerial and satellite imagery, historical maps and gazetteers, modern urban planning data, and predictive modeling within a GIS to trace recent urban growth, calculate potential areas of future urban growth, and investigate patterns in the impact of urbanization on Herat's cultural heritage. Because it employs simple GIS analyses and widely available input data, this approach should be useful for cultural heritage analysis in the vicinity of cities across Afghanistan and other areas experiencing informal urban growth.

1. Introduction

The destruction of archaeological sites in the Middle East has been the topic of headlines as a result of the Syrian war (Cohen, 2012; Curry, 2015; Lawler, 2012). Looting and performative destruction of archaeological sites is a major concern for both archaeologists and the public, and receives much attention in scholarship and the media. Looting and performative destruction have also been problems in Afghanistan, although the cultural heritage situation in that country makes fewer headlines (Thomas, 2004; Stein, 2015). However, there are other significant forces threating the cultural heritage in the region. Afghanistan has a rapidly rising urban population resulting in unregulated rapid urban expansion. Not only has the growing urban population led to a mass proliferation of squatter settlements and a lack of access to basic services, but it is significantly contributing to the destruction of Afghanistan's cultural heritage and poses a major challenge for conservation efforts (Government of the Republic of Afghanistan, 2015). Urbanization is defined in this paper as the unplanned urban sprawl radiating outwards from the edge of a city. The effects of urbanization on cultural heritage, particularly in Afghanistan, is little studied and is usually only within the context of a single site (Murdock and Hritz, 2013). This rapid and unplanned urban development is negatively impacting the rich urban heritage of many of Afghanistan's cities and surrounding hinterlands as heritage sites are absorbed into new urban fabrics. The absorption of a heritage site into a modern city can result in a variety of compromising outcomes, such as the looting of historic building materials for new construction, trash dumping or outright destruction (Rayne, et. al, 2017). The Afghanistan Heritage Mapping Partnership has found that in ten major urban centers of Afghanistan, approximately 166 sites have been absorbed by rapidly increasing urban fabrics within the last 50 years (Hammer, et. al, 2017).

The aim of this paper is to analyze the effects of unregulated urban expansion on heritage from a broader perspective, using the city of Herat in northwestern Afghanistan as a case study. Significant research has been done on the historic core of Herat, but heritage sites on the periphery of the city have been largely ignored (despite their historical significance) and are therefore the focus of this study. If Herat continues to expand outwardly at the rapid rate it currently is, how will heritage sites in its urban hinterland be impacted? Remotely sensed imagery was used to not only identify archaeological sites within Herat's hinterland, but also to systematically evaluate the effects of diachronic unregulated urban sprawl on identified sites.

1.1. Herat and its historical significance

Herat was chosen as a case study because of the availability of historical, archaeological and architectural literature, as well as the accessibility of data regarding urbanization (Allen, 1981, 1983; Bruno, 1981; Franke, 2008; Republic of Afghanistan, 2015; O'Kane, 1987; Potter, 1992; Universitá degli studi di Firenze, 2013;). The city has extensive historical roots and has experienced damaging rapid, unplanned urban development in recent years. It has been inhabited since at least the Achaemenid period (550–330 BCE), although earlier

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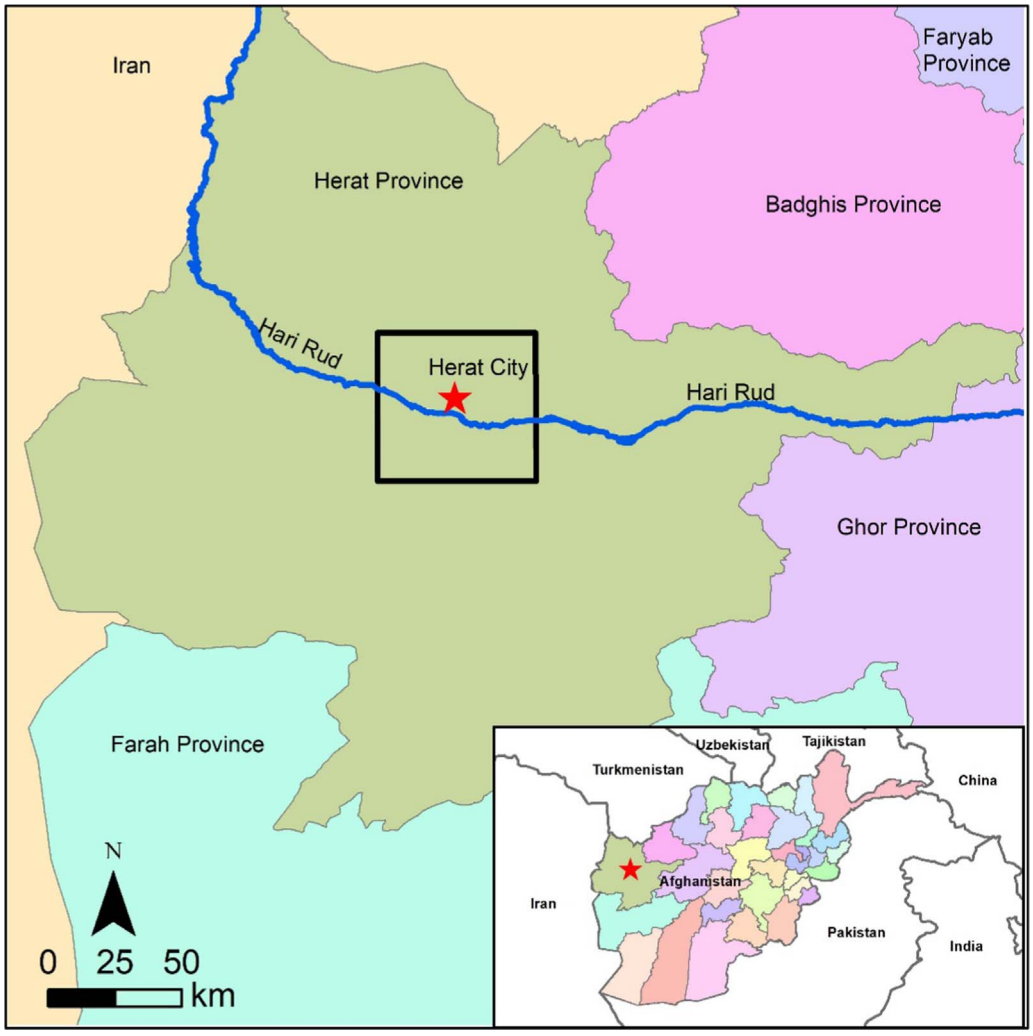

Fig. 1.1. Overview map of Herat province, showing the extent of the study area within the black square and the location of the city of Herat indicated by a red star.

periods of Herat are not well understood (Barthold, 1984). During the Islamic period, Herat was under the control of several different dynasties, such as the Tahirids, Samanids, Ghurids, Kartids, Ghaznavids and was often a provincial capital (Bosworth, 1998; Franke, 2008; Le Strange, 1966; Negmatov, 1998). At the time of the Mongol invasions, historical sources vary concerning estimates of the city's size. Muhammad Khwandamir, the famous Persian scholar, estimates the death toll at 1.6 million, while al-Juzjani comes to the figure of 2.4 million (Omrani and Leeming, 2005). Lawrence Potter suggests a much smaller population: 50,00 within the city and 150,00 living in the hinterland (Potter, 1992). Despite variances in population estimates, even the most conservative figure provides a context for the extent of the city during the early to mid-Islamic periods.

The historical period for which the most information is available is the Timurid period (Franke, 2008). The Timurid dynasty was in power from 1381 until 1506 CE and many of the Timurid rulers were known for their sponsorship of architectural works (Potter, 1992). The most famous Timurid historical site in Herat is known as the Musalla complex and was commissioned by Shah Rukh's wife in 1417 CE. It includes a madrasa, mausoleum and a masjid and is located just north of the Old City today (Hatch-Wolfe, 1966). Many of the medieval monuments in Herat suffered intensely as a result of heavy bombardment by the British in 1885 and then nearly a century later by the Soviets in 1984 (Barry, 1998). Some of the Timurid monuments are still visible, ranging from masjids to extravagant gardens, and have been the focus of this study.

The reign of the Timurids in Herat is characterized by expansive urbanization, and an understanding of Herat's Timurid growth helps explain recent patterns of cultural heritage destruction. As noted by Khwandamir, fifty-eight buildings of importance were located outside of the Old City's walls, predominantly north of the Old City following an historic roadway (Gaube, 1979). This is of particular importance as the Timurid sites along that historic roadway lie outside of the current urban fabric and are those which are at the greatest risk of being overtaken by future unregulated urban sprawl, particularly as much of the previously completed work has focused on the historic core of the city. The seriousness of this is further compounded by the fact that the majority of heritage work in the city has focused on the urban core (Fig. 1.1).

2. Methods and data sources for identification of sites and tracking urban expansion

In order to begin evaluating the effects of rapid urbanization on the cultural heritage of Herat in remotely sensed imagery, a study area of 60 km by 60 km grid was created, with Herat in the center.[1] Archaeological and historic sites were systematically identified in satellite imagery and historical maps in order to create a catalogue. This remote site discovery process was completed by overlaying

[1] The size of the study was chosen in order to create a large enough data-set so that it could be used for future research endeavors.

modern satellite imagery with a 1 × 1 km grid and systematically inspecting satellite imagery and historical maps within each grid square for possible sites. Other cultural heritage and landscape archaeological projects have used a similar version of this "remote survey" method (Thomas and Kidd, 2017).

Three sources of geospatial data were compiled to facilitate identification of sites, spanning a period of time from 1965 to 2009 (Comer and Harrower, 2013). The earliest image is a 27 May 1965 CORONA satellite image from the Corona KH4A satellite's mission 1021. This image is particularly useful as it precedes the 1979 Soviet invasion of Afghanistan, allowing for an identification of features on the landscape which may no longer be visible as a result of agricultural expansion, industrial development, warfare or urban growth (Tirard-Collet, 1998). The second source of data employed for the remote site discovery is a series of 1:50,000 Soviet era survey maps that date to the mid-1980s and draw from Soviet aerial photos. Through comparison to CORONA, this set of maps helps visualize change to the landscape since 1965. The maps mark the locations of archaeological and ruined architectural features (United States Department of the Army, 1958). A similar set of Soviet topography maps has been used to catalogue archaeological sites in Uzbekistan ([30]). The final source of data for the remote survey was the ESRI Basemap, which is a series of mosaicked satellite images, usually of submeter resolution, from a variety of DigitalGlobe Corporation satellites. The dates of the images range between 2001 and 2009, and therefore represent a third longitudinal indicator of the condition of archaeological sites near Herat.

After compiling a catalogue of sites during the remote survey, it was necessary to determine the historical patterns of Herat's urban expansion in order to determine the characteristics of the city's growth over the last 50 years. Seven "urban footprints" were created by tracing the extent of modern building in Herat on seven satellite images from a range of years and sources: 1965 KH-4A Corona imagery, 1972 KH-9 Hexagon imagery, 1985 Landsat X imagery, 1994 Landsat X imagery, and 2002, 2012, and 2017 DigitalGlobe imagery. Comparing these footprints to archaeological site locations, the rate at which sites have been absorbed by the urban fabric is quantifiable. Sites within the old city of Herat are excluded from the following analysis, as they have always been within the existing urban area (Fig. 2.1).

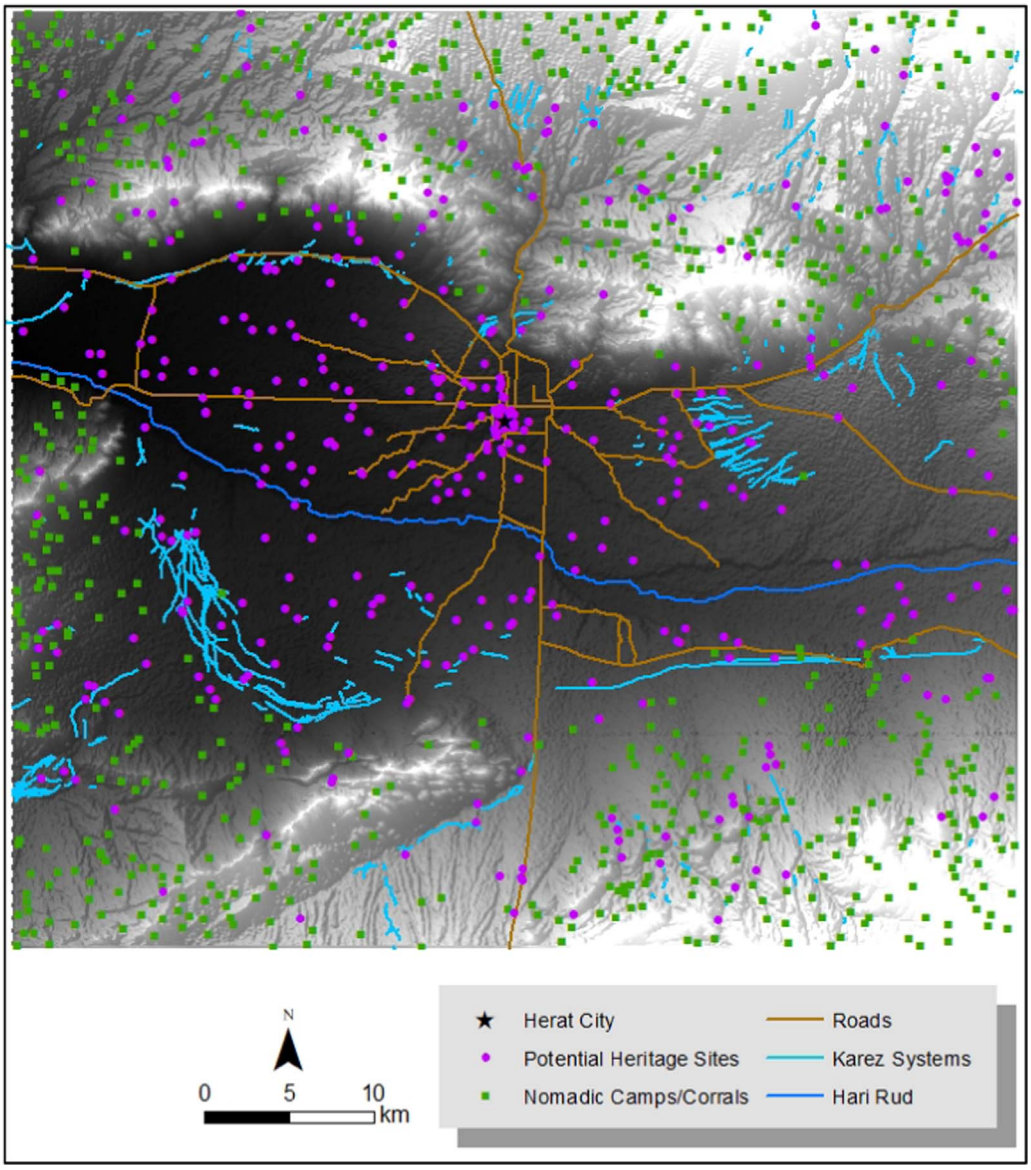

Fig. 2.1. Overview map of the results of the remote site discovery process.

3. Results

3.1. General patterns

The "remote survey" resulted in the identification of 442 points of potential archaeological or historic interest, including forts, caravanserais, mosques, shrines, and archaeological mounds, all of which can be seen in the image above. Of these sites, 7 were originally identified in the *Archaeological Gazetteer of Afghanistan* and 1 was identified from the Soviet-era maps. The site discovery process also mapped 532 nomadic encampments, 191 animal corrals, and 284 *karez* systems (underground irrigation systems).

The urban footprints show that from 1965 until 2017 Herat has grown by 646%. Between 1965 and 1972, Herat grew from 15 km^2 to 27 km^2, nearly doubling in size. The general trend of growth during this period was a relatively even outward growth in all directions. There was not significant growth between 1972 and 1985, but by 1994 Herat had grown to be 45 km^2. Growth was particularly significant along the east-west running highway, and the landscape north of the old city became densely populated. There was very little urban development and growth between 1994 and 2002, probably due to the civil war in Afghanistan. After the fall of the Taliban in 2001 and the American invasion in 2002, Herat grew dramatically. Between 2002 and 2012, the city expanded by just over 110% (from 47 km^2 to 99 km^2). The major areas of growth were to the northwest and east of the Old City, but significant expansion took place in all directions. Urban development north of the old city was least sprawling, due to mountainous geography. Most recently, between 2012 and 2017, Herat has expanded mostly eastward, increasing from 99 km^2 to 112 km^2. The spatial pattern of urban growth in the last several decades provides important data for predicting potential future growth.

Analysis focused on changes in the spatial relationship of the city with the surrounding archaeological and historical sites between 1965 and 2009 in order to evaluate consequences such as site destruction. By combining the data from both the remote site discovery and urban footprints, it was possible to determine the rate at which points of potential interest were absorbed by the urban fabric. By 1972, 19 identified sites were absorbed by the growing city. This number did not increase in 1985, but by 1994, the unplanned urban sprawl of Herat had absorbed 24 total sites. There was not an increase in the number of sites absorbed by the urban footprint by 2002. This is not surprising, as Herat did not significantly expand during this time period. In 2012, though, the urban footprint encompassed 38 sites, a 58% increase in the number of sites now within the urban fabric. This number did not increase between 2012 and 2017, but it is important to note that 18 sites are within 0.5 km of the current extent of the city (Fig. 3.1).

3.2. Significant sites

The remote site discovery process enabled the identification of several important historical sites in Herat that have been negatively impacted by urban development. Since 1985, 18 identified sites have been absorbed into the current urban fabric of the city, although not all of these sites have been entirely destroyed. The following paragraphs discuss three sites whose integrity has been compromised as a result of urban expansion and can be dated with certainty.

The famous Gawharshad Musalla Complex, one of the largest historic sites in western Afghanistan, is located just northwest of the Old City of Herat (Ball and Gardin, 1982). The complex has been irreparably damaged by informal urban development. The complex consists of a former *madrassa* with two minarets, a mausoleum, and a *masjid,* all built around 1417 CE (Allen, 1982; Hatch-Wolfe, 1966; O'Kane, 1987). Unfortunately, this once magnificent site now has an informal, user-created road running north to south directly through its center. Despite barricades and funds set aside by the government to create a bypass road, the user-created road continues to be used (Cassar and Noshadi, 2015). Additionally, the site is surrounded on all sides by dense urban settlement, whereas in the 1965 CORONA, the Musalla complex was more or less surrounded by agricultural fields and a few dispersed residences.

The historic Timurid garden called the Bagh-e Jahanara (*world-adorning garden*) has also suffered a great deal due to uncontrolled urban development. The construction of the garden is attributed to the reign of the Sultan Husayn Bayqara, and dates to the second half of the 15th century (Ball, 1981; O'Kane, 1987). Using the location description given by Warwick Ball in his 1981 publication, the remains of the garden were identified on the 1965 CORONA satellite image, and then on a later 2017 DigitalGlobe Satellite image (Ball, 1981). Unfortunately, now the Bagh-e Jahanara is in poor condition, as can be seen in the imagery below. The entire southern portion of the garden is being used as a modern cemetery and some modern house enclosures are also on the site. Additionally, the western portion of the site has been obliterated by modern industrial development.

Another Timurid garden, the Baghchi Ali Shir, has also been destroyed by modern development. This garden is just west of the

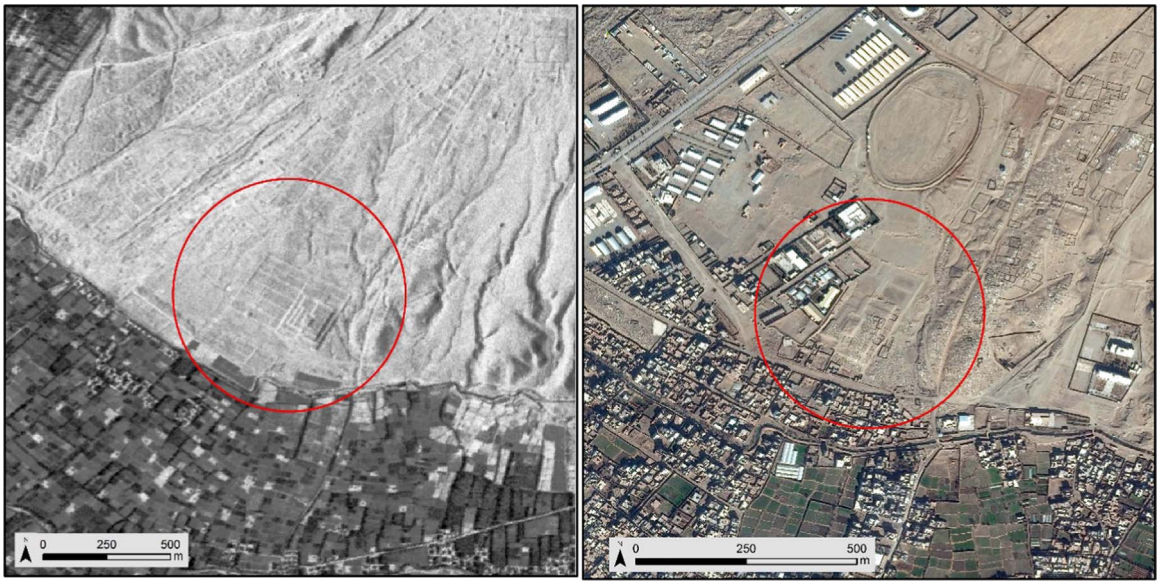

Fig. 3.1. (left) Within the red circle are the visible remains of the Bagh-e Jahanar in the 1965 CORONA. (right) Modern urban development has severely encroached on the western and southern parts of the garden.

Islamic shrine complex known as Gazurgah, and is described by Bernard O'Kane and Terry Allen (Allen, 1982; O'Kane, 1987). Both authors date the garden to the second half of the 15th century, and describe its location, aiding in remote identification of the site. In the 1965 CORONA image, faint traces of the garden's terraces are visible, and the remains of it appear to be in relatively good condition. By 2017, though, the southern half of the garden has been entirely devastated by the construction of a modern garden complex, probably associated with Gazurgah.

4. Predicting urban growth

It is clear that rapid, uncontrolled urban growth is compromising Herat's heritage, and urbanization data also suggest that unregulated urban sprawl will continue unabated (Republic of Afghanistan, 2015). Therefore, many sites will be at risk in the near future, especially in the absence of formal urban planning (Najimi, 1988). Sites which lie in a zone of future uncontrolled urbanization should be the subject of future management strategies. In order to identify which sites are at risk, an urbanization model was created in order to identify where Herat is most likely to expand. This model takes into account four variables, each of which are differentially weighted: access to major roadways, access to water, degree of slope, and distance from the current extent of the city. Slope is weighted as being the most important variable, Euclidean distance from the current extent is weighted as being 75% as important as degree of slope, and access to water and roadways was weighted as being 50% as influential as degree of slope. These variables were determined suitable for the model based on the following information.

As seen throughout the imagery of Herat, roadways have clearly influenced the direction that the city has expanded. The University of Florence's Strategic Masterplan in 2013 reports that 51.2% of Heratis owned a car. However, alternatives to driving are part of daily life in Herat, and therefore access to roadways is weighted less within the model, at 0.18. For example, one study indicates the primary mode of transportation for 60% of people in Herat is walking (Najimi, 1988). In spite of this claim, data on roadways in Herat comes from a combination of data from the University of Florence's Masterplan and the manual tracing of roads visible in satellite imagery. Distance intervals were calculated using Euclidean distance.

Distance from access to water is the second variable included in the urbanization model. According to the official sources, 54% of people in Herat have access to piped water, and therefore 48% of the residents must acquire water by some other means, more often than not, by walking to a manually operated well (Republic of Afghanistan, 2015). This study elaborates further: 21% of people in Afghanistan take 15 min or less to walk to a well and 10% walked 15–30 min to reach a well. The Herat Strategic Masterplan provides data about access to water, although it is not clear how these data were obtained and interpreted by the researchers. Two maps in the masterplan represented access to piped water and well water. Maps were scanned and digitized, then layered over one another, resulting in a map representing areas with access to either water source, or both. Piped water only reaches certain parts of the city, and portions of the urban area that piped water does not reach are reliant on wells (Universitá degli studi di Firenze, 2013). The distance from access to water has been calculated using Euclidean distance from both access to piped water and well water. This variable has been weighted the same as access to roadways (0.18) because the data available concerning access to water in Herat have limitations.

The third variable of the model takes into account the fact that degree of ground slope affects urbanization processes. The model assumes uncontrolled development will not take place on terrain with high degrees of slope, although slopes which are often considered inappropriate for safe habitation are sometimes developed in Afghanistan (Republic of Afghanistan, 2015). Flood prone areas and normally uninhabitable hillsides are frequently irregularly developed into residential zones. Slope has been given the highest weight in the model at 0.36, because of the reliability of the dataset showing currently occupied slopes as well as due to the impossibility of developing land at very high degrees of slope. The predictive model assumes more future uncontrolled development will occur on slopes of less than or equal to 6°. This was determined by deriving the slope of currently urbanized land in Herat from a Shuttle Radar Topography Mission digital elevation model with a resolution of 30 m. 92% of the urbanized area within the current extent of the city is on slopes of 3° or less, 6% is on a slope between 3° and 6°, 1% is located on slopes of 6–12° and 1% of current development is on a slope above 12°. Therefore, the model predicts it is unlikely that this city will expand onto areas with degrees of slope higher than 6° SRTM DEM was used to identify areas of less than 6° of slope.

The final variable input into the urbanization model is Euclidean distance from current extent of the city and is weighted at 0.27. The model assumes the majority of development in Herat will radiate outwards from its current edge. This assumption is grounded in the historical patterns visible in the diachronic urban footprints of Herat.

Both distance from current extent and slope are considered to be more influential in the process of urbanization. Slope has been calibrated to be twice as influential as distance from available water and roadways, whereas distance from the current extent is weighted one and a half times as influential as the first two variables. The image below shows each of the variables individually (Fig. 4.1).

The model is organized into several "risk of urbanization" categories based on the combination of the proximity to the current extent of the city and occurrence of the four input variables. The model identifies which sites are most at-risk for being damaged by future uncontrolled development, and therefore these sites should be the focus of conservation. The categories of risk that are a product of the model are: very high risk, high risk, medium-high risk, medium risk, medium-low risk, low risk, very low risk and no risk. A total of 86 of the 442 identified sites lies within the highest three categories of risk and should be prioritized in conservation efforts: 9 cemeteries, 6 dwellings, 14 enclosures, 6 forts, 3 *qal'at* (traditional fortified dwellings), 10 archaeological mounds, 12 towers, 3 shrines, 16 instances of surface architecture, 3 ruins of towns, and 1 mounded wall feature. 22 of these sites lie within the area of very high risk. Several historic towers, architectural sites, square mounds, and even the ruins of a small village are the highest level of risk for future unregulated development, and without proper management strategies these sites are predicted to be at risk very soon. 15 more sites fall in the area designated as high risk, included the Islamic Tomb of Molana, several towers, mounds, a single *qal'a,* and a large fort (Fig. 4.2).

5. Discussion

The combination of the temporal imagery analysis and the urbanization model allow for some conclusions to be drawn about the scale of cultural heritage problems related to urbanization in Herat. In addition, this study quantifies and categorizes the future possibilities of damage to sites outside of the historic quarter of Herat that are normally disregarded in studies of the city.

This study has made clear that Herat's heritage has already been damaged as a result of urban growth, and assumes it is likely that urban expansion will continue to do so. Nevertheless, the urban expansion model used to determine the quantity of at-risk sites is subjective. The variables comprising the model could easily be weighted in a different manner or other variables could be introduced to the model. These alterations could possibly result in a different number of at-risk sites. Additionally, the remote site discovery process was also subjective as a different analyst may interpret the satellite images differently. However, the approach used in this study is useful not only because the process can be easily duplicated for other difficult to access regions of the world but also because it provides a starting point for identifying at-risk heritage in Herat. Furthermore, the approach used in this study is robust and transparent in its processes and assumptions.

Although the urbanization model created here is specific to Herat,

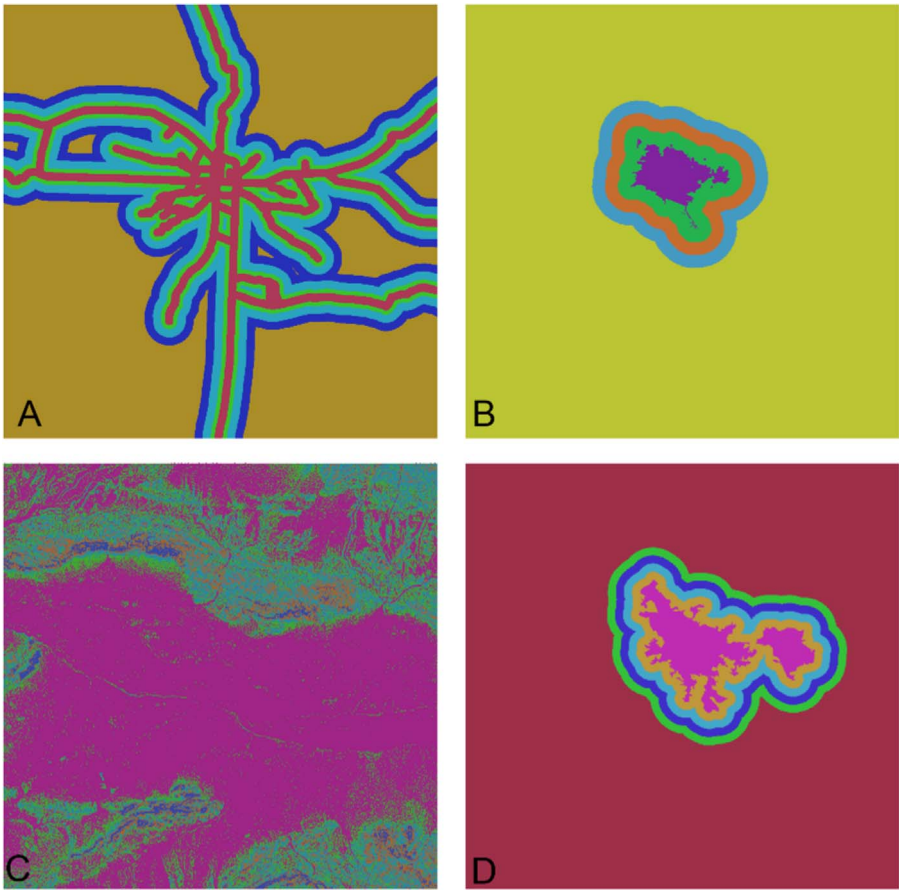

Fig. 4.1. Image "A" shows the Euclidean buffer for roadways, with the innermost buffer extending 500 m and all subsequent buffers extending 1 km. Image "B" shows Euclidean buffer of distance from available water, with each buffer ring being equivalent to 1 km. Image "C" displays the slope variable and image "D" shows Euclidean distance from the current extent, with each buffer ring extending outward 1 km.

the general approach to determining urban growth is generalizable. The types of data used in the approach here, such as information concerning urbanization patterns, including master plans, are widely available. This is of particular importance because there are many other informally growing cities within difficult to access conflict zones. Herat is an exception in this respect as it has been the subject of a substantial number of studies. The advantage of the urban expansion model created in this study lies not only in the use of widely available data, but that it utilizes relatively simple GIS techniques that are much less complicated than other predictive models, such as the well-known SLEUTH approach (Clarke, 1996). Applying a similar method to other rapidly growing cities in Afghanistan should be undertaken, as 134 sites have been identified as being within 1 km of the 10 major urban centers in the country (Hammer et. al, 2017).

6. Conclusions

Herat, the western-most provincial capital of Afghanistan, possesses an unparalleled historical trajectory, and a significant amount of the historical landscape of Herat can still be detected today using satellite imagery. The city is at least two millennia old, and has endured the ravages of time ranging from the conquests of Alexander of Macedon to the onslaught of the Mongol invasions. The city has survived tremendous destruction, and has cyclically flourished, as the monuments, shrines, mosques, administrative buildings and pleasure gardens of the Timurid period show. Unfortunately, the unique architectural and archaeological heritage of Herat is at great risk of destruction by rapid unregulated urban sprawl. In fact, as I have demonstrated, uncontrolled development has already taken its toll.

This study sought to identify many of the significant architectural and archaeological traces of Herat's past that have been negatively impacted by uncontrolled development. Areas of possible future urban expansion were identified using a geospatial model, in order to ascertain which heritage sites are at risk for being destroyed or compromised. Geospatial methods have a great potential for aiding in management strategies, although in Herat more drastic measures may need to be taken in light of recent moves by the municipal government. Unfortunately, due to a lack of resources, corruption and alternative priorities on the part of the Afghan government, cultural heritage management strategies may be difficult to be effectively implemented despite the fact that cultural resources are not renewable (Surovell, et. al, 2017). For example, in Herat, with the election of a new mayor, increasing municipal revenues takes precedence over the preservation of historic sites (Khamma Press, 2016). Surrounding the historic Friday mosque are over 160 traditional historic shops, all of which were recently destroyed (Pajhwok Afghan News Agency, 2016). In light of this, what can be done to preserve the cultural heritage of Herat?

Because of these specific obstacles, and the lack of adherence to recently developed urban planning strategies, such as *The Herat Strategic Masterplan* (Universitá degli studi di Firenze, 2013), it may not be possible to halt continued damage to the city's cultural heritage. Therefore, the most responsible and attainable goal is to implement an extensive project of recording before continued damaged makes this impossible. Traditional methods of archaeological and architectural recording are appropriate, although 3D modeling has of late become a popular way of documenting heritage, particularly architecture. Projects such as the one which is on-going in Bam, Iran could be used as a model for 3D recording in Herat (Vatandoust, et. al, 2008).

Apart from the historical significance of Herat's heritage, why is it

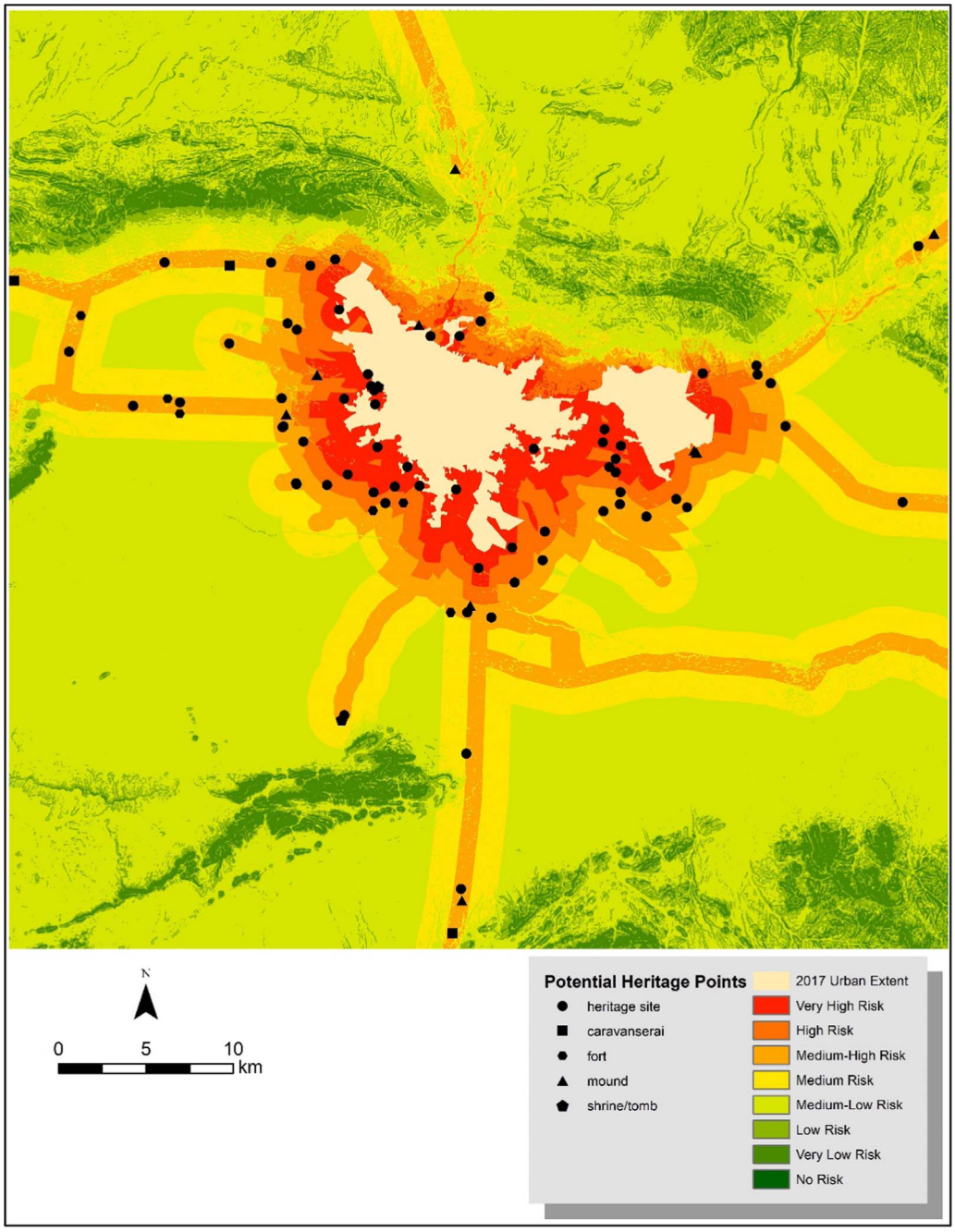

Fig. 4.2. This map shows the final product of the potential urbanization model, with all identified sites in areas of high risk shown.

worth saving? How will heritage benefit the local community? Heritage will not only benefit Heratis by helping to foster a local tourist industry, as was the goal of the German-Afghan team's work in opening a museum in the citadel of Herat (Universitá degli studi di Firenze, 2013), but an understanding of heritage can encourage cross-cultural interaction and appreciation, as well as a sense of a shared past that could encourage more open communication between groups which otherwise may feel disparate. In a country that has been occupied and at war for decades, there is a desperate need for uniting factors, conduits for conservation, and a sense of community. In the words of the president of Afghanistan, H.E. Mohammad Ashraf Ghani, "In Afghanistan, a monument can never be just a monument. It is the history of our people's encounters with other people's markets, states, technology, beliefs and knowledge. Afghan archaeology, history, folklore and ethnography reveal the extent to which we are all part of a long, lively conversation about what it means to be a citizen of Afghanistan," (Cassar and Noshadi, 2015). The preservation of Afghanistan's cultural heritage, then, is not just about preserving old relics, but about fostering a sense of community for the creation of a better future.

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