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GOOGLE EARTH AS AN ARCHAEOLOGICAL TOOL IN THE DEVELOPING WORLD

AN EXAMPLE FROM INDIA

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The use of satellite imagery for archaeological research has dramatically improved the study of ancient sites and landscapes. Providing an aerial view, satellite images are an outgrowth of the discipline's early use of aerial photography. Archaeologists in the early twentieth century eagerly adopted the bird's eye perspective to identify and document patterns of human activity that were otherwise invisible on the ground, such as the crop marks that indicated the remains of Roman villas in England in the pioneering aerial photographs taken by O.G.S. Crawford in the 1920s. Given the costs of generating original aerial photographs, archaeologists in the past two decades have turned to satellite imagery to acquire a vertical perspective on archaeological landscapes (for comprehensive reviews, see Fowler 2004; Parcak 2009:ch. 2).

Archaeologists utilize satellite images for a variety of research and monitoring purposes. Images can be used to examine areas of the world in which field research is impractical or inadvisable due to factors such as warfare and insurgency, landmines, and problems of logistical or political access (e.g., for Afghanistan see Thomas et al. 2008; for Cambodia see Evans and Travaglia 2012; for Egypt see Parcak 2009; for Iraq see Stone and Zimansky 2005; for Saudi Arabia see Kennedy 2011). Historical data from the earliest satellite programs, such as CORONA images starting in the late 1950s, can be utilized to evaluate landscapes that have subsequently changed, providing archaeologists with a more comprehensive palimpsest of ancient activities prior to modernization (e.g., Ur 2003). Satellite images of more recent date can be used to monitor destruction and changes due to warfare, looting, flooding, deforestation, construction encroachments, and other adverse impacts.

Until recently, however, the price of satellite images limited their use. Commercial satellite images could cost hundreds of dollars per frame, and archaeological projects often required several images to cover survey regions (particularly when the area of interest was in the corner of an image, necessitating the purchase of adjacent frames). CORONA images are relatively inexpensive, but many of the photographs are marred by cloud cover and in any case the digitized images require sophisticated processing to georectify prior to use. By contrast, the advent of Google Earth has dramatically democratized access to archaeological landscape information worldwide (Ur 2006; Zukerman 2011). In developing countries such as India, satellite images available through Google Earth have provided the scope for archaeologists at both the student and the professional level to make use of aerial imagery.

As in the case of crop marks revealed through aerial photography to be the plans of Roman villas, satellite-based reconnaissance can detect patterns of human activity that are very difficult to discern solely from ground-based survey, particularly in areas of dense vegetation and modern human activities such as agriculture. Large-scale landscape modifications in the form of mounds, embankments, and ditches often blend in with their surroundings, revealed only when they are viewed at a much larger scale and from a vertical perspective.

Finding Walled Settlements in Eastern India

We present here a case of the use of publicly available Google Earth satellite imagery to locate and identify archaeological sites in eastern India. The current site-location project was an outgrowth of ongoing research at the ancient site of Sisupalgarh, located in the eastern Indian state of Odisha (formerly Orissa). Sisupalgarh is an Early Historic settlement, with the earliest

Figure 1. A: Google Earth image of the walled Early Historic settlement of Sisupalgarh in eastern India with topographic overlay by G. Greene. B. Google Earth image of the walled site of Talapada C. Google Earth image of the walled site of Lathi.

occupation in the mid-first millennium BC and continuing until the middle of the first millennium AD.

Sisupalgarh was initially excavated in 1948, constituting one of independent India's first major archaeological research projects (Lal 1949). Incidentally, the 1948 project also made use of that era's most sophisticated aerial-survey technology to illustrate the perfectly aligned ramparts and gateways, an outline that is still preserved in Google Earth images today (Figure 1a). The rampart, measuring 1.1 kilometers square, has two formal gateways on each side, further identifying the construction as one that was planned and executed on a massive scale.

Sisupalgarh has again been investigated in recent years in which geophysical surveys and excavations focused on the social and economic aspects of urban life in the Early Historic period (e.g., Mohanty and Smith 2008; Mohanty, Smith and Matney 2007; Smith 2008). Throughout these investigations, Sisupalgarh was considered to be unique among the many walled urban centers of the Early Historic period because of the regularity of the rampart. The site also has significant historical importance, being associated with the third-century BC Kalinga War whose catastrophic effects are credited with inspiring the invading Gangetic ruler Asoka to renounce violence and lend political support to the nascent Buddhist tradition.

The historical record, along with the size and configuration of Sisupalgarh, clearly indicates the presence of a strong and effective administration. But there are no documents or other historical records that indicate the scope and extent of the political territory of which Sisupalgarh was a part, nor of the relationships sustained between Sisupalgarh and neighboring population centers that comprised the Kalinga domain. Archaeological survey in the region has been limited, with the majority of survey projects initiated by students and faculty working with very limited budgets and the majority of Indian government-sponsored projects concentrating on the region's extensive Buddhist sites.

The potential for evaluating the region's sociopolitical integration in the Early Historic period has been made possible, however, through the use of Google Earth satellite imagery. In conjunction with a survey at the Neolithic site of Golbai Sasan located 40 kilometers southwest of Sisupalgarh, R. K. Mohanty's team encountered the site of Talapada on the opposite side of the river whose surface artifacts were of the Early Historic period. In order to examine the newly discovered site's potential relationship to Golbai Sasan, team members utilized a laptop computer equipped with a portable Internet connection to make a startling discovery: the site of Talapada has a rampart and gateway configuration identical to that of Sisupalgarh, but at a one-quarter scale (Figure 1b). Measuring 500 meters on a side, the site of Talapada has one formal gateway on each side of the rampart, providing a duplicate of Sisupalgarh in both planning and execution.

The presence of identical material culture types and a replica design of the rampart leave no doubt that Sisupalgarh and Tala-

Figure 2: T. Padhan utilizing Google Earth on mobile telephone during field reconnaissance.

pada shared strong social and political connections. Given the existence of one subsidiary site, the team then began to use Google Earth to systematically examine satellite images elsewhere in the region. Through this process, the team did identify another location at the village of Lathi on the outskirts of the city of Berhampur, located 150 kilometers southwest of Sisupalgarh. Lathi's outline indicates that the site was built on the same pattern as Talapada, and constitutes another example of a small-scale replica of Sisupalgarh's urban plan (Figure 1c). Preliminary investigations of this site confirm the presence of a rampart and gateways, with artifacts of the Early Historic period that indicate the site's contemporaneity with both Talapada and Sisupalgarh.

Satellite reconnaissance in conjunction with ground-truthing will continue in hopes of identifying other such sites. With the two emplacements of walled settlements in the style of Sisupalgarh now having been identified at Talapada and Lathi, however, the potential for interpreting Sisupalgarh's ancient territorial expanse is already well-established. The discovery of these sites provides an exciting new scope for research on urbanism, political economy, and territorial interactions in the Early Historic period.

Discussion

Google Earth has the potential to revolutionize survey data collection and analysis, with a few hours' work on Google Earth enabling archaeologists to find sites at a scale that would take years using traditional ground survey alone (for comparable transformative effects using LiDAR see Chase et al. *J. Arch. Science* 2011). Google Earth provides imagery that can be easily accessed through desktop computers, laptops, and even cellular phones in a manner that enables both pre-field and in-the-field examination of geographic anomalies. When used in its mobile form, Google Earth can be used as a background against which to mark and label ground-truthed commentary on the location and size of archaeological sites. Google Earth images, like other satellite images, also can be utilized to identify geographic features associated with archaeological sites such as lake and ocean coastlines and riverine paleochannels.

Although Google Earth is not as sophisticated for data analysis as other forms of GIS and data collection, its low cost of acquisition (essentially free to anyone with access to a computer and the Internet) and its coverage makes it particularly useful to archaeologists working abroad. As Michael Goodchild has noted (2008:20–22), Google Earth's precision surpasses many developing countries' official mapmaking services whose budgetary constraints as well as national-security concerns often limit researchers' access to data. More recent additions to the Google Earth repertoire, such as the "history" feature that allows users to look at a decade's worth of images from a single location, provides data that can be used to understand ongoing site-formation processes as well as documenting recent natural and human-caused changes to archaeological sites.

Google Earth's capacity to illustrate road overlays also should not be underestimated as a logistical aid to fieldwork (Figure 2). In rural India, road networks and signage are limited, and the most practical method of finding one's way around the landscape is to stop and ask residents for the best pathway to a point of interest. Google Earth images facilitate those conversations by providing a landscape perspective that is highly intuitive, along with suggested road links. The team was continually impressed by the ease with which local villagers, even those with little or no formal education, could immediately identify topographic features on satellite images.

Using Google Earth, the costs of field survey including vehicle rental and surveyor time can correspondingly be reduced. For many archaeologists in developing countries, transportation to the field is the single greatest expense of research; any increased efficiencies in site location can make a significant difference in the size, scale, and duration of regional survey projects. In addition to identifying the location of potential sites that can be visited, Google Earth also can provide some indication of where sites might be hypothesized to exist but where ground-truthing is impractical or prohibited (for example, on military bases or other government installations). The location of these "missing" sites are critical for understanding ancient trade routes and other networks, in which even the identification of potential site locations adds robusticity to an overall regional model.

Figure 3: The western gateway at Talapada, showing a slight elevation that in Google Earth is further enhanced by the presence of vegetation at the top of the rise.

Google Earth and other forms of satellite imagery do have some limitations that are worth noting here. As in all aerial prospection, ground-truthing is necessary to ascertain the presence of ancient cultural remains. Modern effects, such as recent construction and dismantling of sites, also may post-date the most recent satellite activity. Although Google Earth does have some three-dimensional capacity, slight elevations characteristic of many ancient sites may not be visible except at ground level. Vegetation such as trees planted on embankments may exaggerate linear features, making them appear more prominent in satellite imagery than they are on the ground (Figure 3).

Anomalies in satellite imagery also can be difficult to interpret: linear anomalies may either represent lower topography (such as ditches) or elevated topography (embankments), while dark and light areas can be the result of water accumulation, stone outcrops, areas of burned vegetation, or anthropogenic soils. Some types of sites will be more easily recognized than others and our project's focus on the distinctive perimeter ramparts of Early Historic settlements constitutes an optimal research question for Google Earth site discovery (for similar discoveries of fortified settlements using satellite imagery, see Parcak 2009:50; Vega et al. *J. Arch. Science* 2011).

When topographic, historical, or colonial maps are available they can be used in conjunction with satellite imagery to add information about the likely source and chronology of modern landscape modifications. Historical maps can sometimes contain anomalies that are not immediately visible on Google Earth and vice-versa; when the goal is to locate previously-unknown sites, a combination of all available data types is helpful. At Lathi, for example, topographic maps illustrated just one L-shaped embankment, while the Google Earth image clearly depicted an entire rectilinear outline with a moat and rampart at the location.

Although Google Earth is free to use, the acquisition of high-quality images for publications does entail costs that are at present prohibitively expensive for many researchers in developing countries (currently $399 per user per year, with a slight bulk discount available for multiple users within a single project). Google Earth does however offer some grants for educators to be able to access the advanced features of the program including GIS data import and high-resolution printing.

Conclusion

As seen in our team's discovery of previously-unknown fortified settlements in eastern India, satellite imagery provides a quick, inexpensive, and effective method for identifying anomalies for further investigation. In the case of Talapada, Google Earth imagery enabled the research team to make sense of a pattern of construction that was otherwise difficult to read from the ground. In the case of Lathi, the identification of a potential site was initiated through a search of Google Earth images to match patterns of known type in the landscape.

The widespread availability of Google Earth in developing nations is providing a powerful source of landscape data for archaeological research. In many cases, topographic maps can be difficult to acquire for both logistical and political reasons, with government mapping agencies citing the sensitivity of international boundaries and coastlines as a rationale for limiting the distribution of printed exemplars. By contrast, Google Earth is widely available, regularly updated, and can be accessed in a variety of ways including at any local Internet kiosk for a very modest hourly rate. This availability has the potential to provide a new generation of students and scholars with powerful tools for site discovery and interpretation.

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IN BRIEF, from page 3

tion Strategies, Archaeological Applications of Airborne Laserscanning to Improve Your Productivity by Using tDAR.

Meeting Abstracts

Just a reminder that the abstracts will be available electronically to all on the public side of SAAweb approximately one month before the meeting. They will be posted in a pdf format.

As in the past few years, there will be an abstract viewing center onsite at the convention center in Honolulu where you will be able to browse the abstracts.

2013–A Phenomenal Year!

Even though the year has hardly begun, it is shaping up as an extraordinary one for SAA. Three major initiatives will be launching this year:

- The SAA Online Seminar Series will be launching. Watch for topics and times.
- **Current Research Online** will be debuting on the web.
- ***Advances in Archaeological Practice***, the new journal, will premiere in August 2013.

Keep an eye on your email and SAA for details on these exciting new initiatives!

Staff Notes

A 10-hour per week position has been added to the staff team as of January 2013. Elisabeth Herschbach will be joining the staff as Editorial Specialist. Her primary responsibilities will revolve around the new journal, but she will have assignments touching all of the SAA's publications.

After a dozen years, John Neikirk, manager, Publications left the Society on January 18 for an opportunity at another organization. I know that the membership will join the staff in wishing John the best and thanking him for the legacy he has left to the publications program.

Eleanor Umali joined the staff as the new manager, Publications on January 21. Eleanor is a seasoned publications professional with well-honed production skills. We expect that the publications program will continue to thrive under her management.

The coordinator, Membership and Marketing position has been reinvented into the coordinator, Membership and Meetings position. Alyssa Barnett, the staffer, will be taking on more responsibilities specifically tied to the annual meeting in addition to the volunteer program.