

A satellite's view of Nalanda's past

Nalanda is believed to have been the world's oldest residential monastic university, and a continually active Buddhist centre of learning from the 5th to the 12th centuries AD. This report describes how modern satellite technology can augment traditional archaeological efforts to shed light on Nalanda's past. It is an outcome of a multidisciplinary research project entitled *A study of Nalanda using GIS and remote-sensing*, conducted by the author under a Fellowship awarded by Nalanda University in 2013-2014. A detailed essay is under revision and review for *Archives of Asian Art*.

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How large was Nalanda?

Xuan Zang, who resided at Nalanda between 635 AD and 641 AD, has made by far the most detailed record of the spatial layout of various structures within the complex. Translations of his description list structures such as monasteries, temples, images, stupas, a gate, walls, tanks, etc.¹ The Archaeological Survey of India (ASI) has conducted excavations in several phases. The excavated remains comprise sixteen large structures: a row of four temples or *Chaityas* on the west (numbered 3, 12, 13 and 14), a row of eight west-facing monasteries or *Viharas* (numbered 1, 4, 6, 7, 8, 9, 10 and 11) parallel to the temples, two smaller north-facing monasteries (numbered 1A and 1B), and to the east of Monastery 7 are Temple 2 and the Sarai temple (Fig.1).

Human enterprises on such spatiotemporal scales often leave impressions on the environment, which may be detectable when the region is studied holistically using space-based remote sensing technology (although they may be invisible to the naked eye or from the ground). This study has analysed images from the Landsat series of satellites, and also from the Indian Remote Sensing satellites Resourcesat1 and Cartosat1, and has found evidence for several buried features around the presently excavated site of Nalanda. This provides firm support for the hypothesis put forward by other investigators that the site was much larger than the currently exposed archaeological remains.²

Footprints on the environment

A long-lasting residential establishment must draw resources from the local environment for its sustenance, with water being perhaps the most essential. A synoptic view from a satellite allows one to survey large swathes of land and identify present and, more interestingly, past sources of water. Careful examinations of coarse resolution satellite images (from Landsat) have shown an unusual cluster of such water bodies surrounding Nalanda in a pattern not seen elsewhere in the vicinity. This, together with their proximity, suggests that they may be associated with the site, and may therefore help trace its extent.

Fig.2 shows these water bodies surrounding the excavated site and neighbouring villages, and suggests an approximate boundary. Tanks in the vicinity of the site have been noticed and explicitly mentioned by Chinese travellers and, later, by British explorers. It is believed that these tanks were not primarily intended as reservoirs, but were dug for earth needed to make the enormous quantity of bricks required for building the monasteries and temple structures.³ However, satellite image analysis show that the shapes, location and layout of the tanks display careful planning; they are mostly geometrical (squares or rectangles), with sides roughly parallel to the four cardinal directions. Such precision may have been unnecessary if these tanks were excavated solely for mining earth for brick making. The largest tank, Dighi Pokhar, has a conspicuous eastward spread unlike the other large tanks (Indra Pokhar and Pansokar Pokhar), which snugly bound the area containing the remains (see Fig.2). Analysis of a Cartosat1 image reveals a 10 km long palaeochannel terminating at Dighi Pokhar's eastern end. At some time in the past, this palaeochannel would have been fed by water curving off from the nearby river Panchana. Further ground observations and archaeological explorations are necessary to establish whether the diversion was man-made or natural.

The cluster of water bodies around Nalanda suggests that the area within may have had a higher elevation. The present study analyses a Digital Elevation Model (DEM) –generated using a pair of stereo-images from Cartosat1–demonstrating that the topography within the proposed extent is not a single long ridge, but is comprised of two distinct clusters of mounds. The southern cluster is larger and comprises of the entire excavated area and adjacent regions, including the villages of Muzaffarpur, Kapatia, Surajpur and Baragaon. The northern cluster is smaller, covering Begumpur and her environs. For brevity, these clusters will be referred to as the southern and northern mounds. Both harbour several interesting details that are virtually impossible to discern at ground-level.

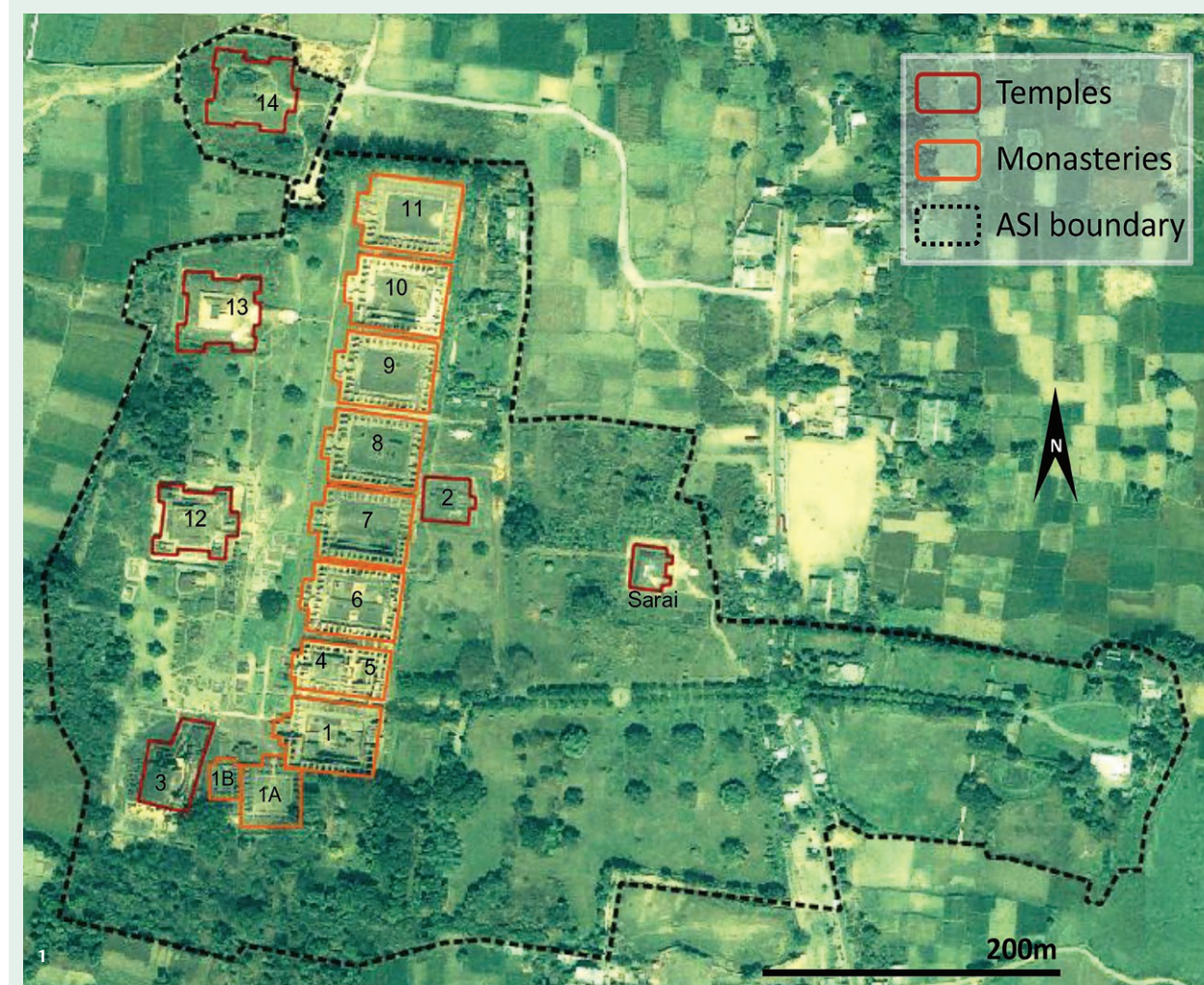


Fig.1 (left): Temples, Monasteries and ASI property boundary as seen on satellite image of 21 November 2006, Google Earth.

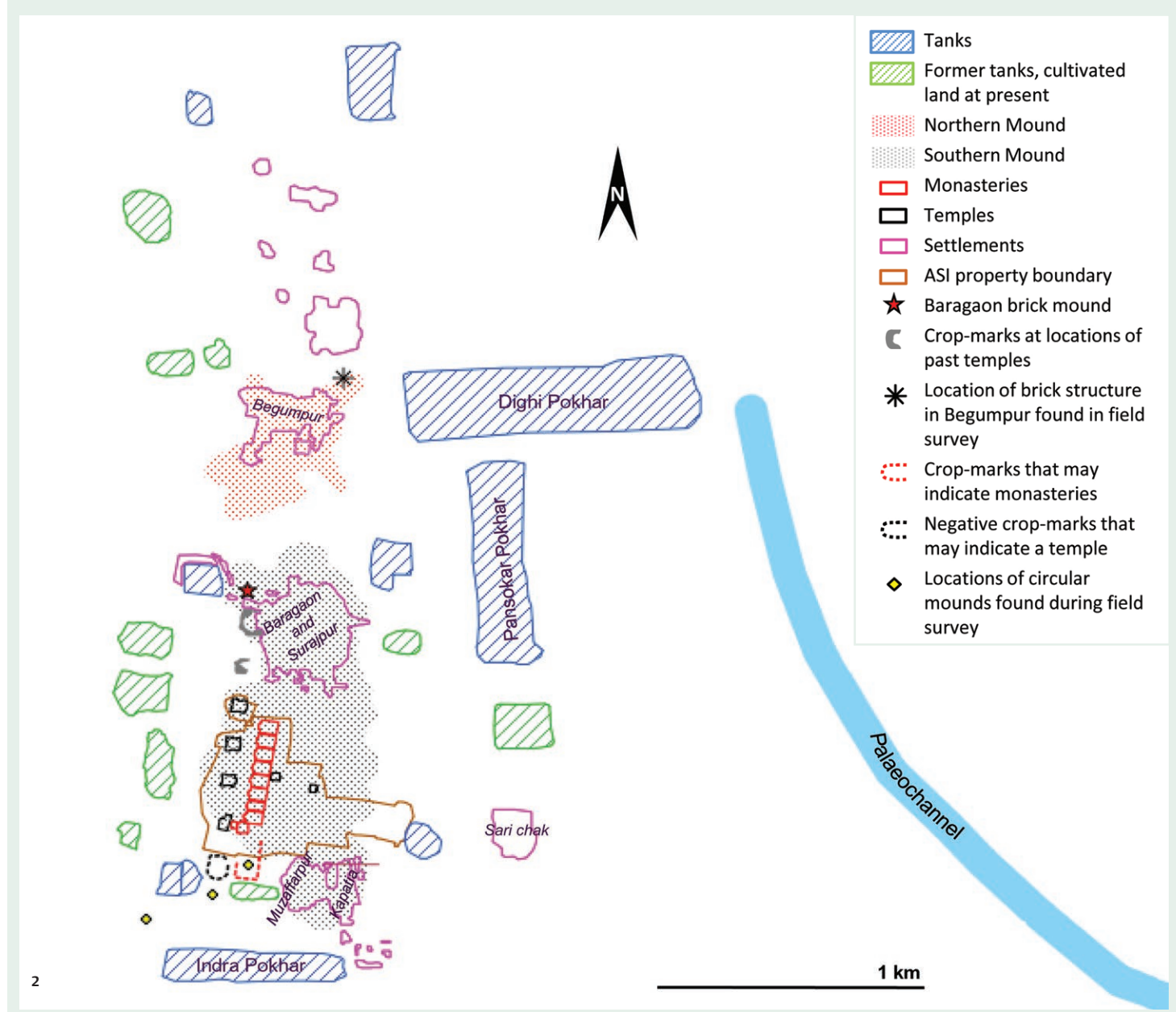


Fig.2 (below): Map showing Nalanda and environs with tanks, settlements excavated ruins of Nalanda together with features detected in satellite imagery.

The southern mound

This is a long mound stretching 1.6 km in a north-south direction. The northern end is as wide as the settlement of Baragaon and Surajpur combined; the widest band is where Temples 2, 3, 12 and Sarai are located, and the southern end narrows, covering Kapatia and Muzaffarpur. Buried archaeological remains often affect the health of surface vegetation and create positive or negative 'crop-marks',⁴ which reveal themselves as distinctive patterns when viewed from above. Vegetation patterns indicating subsurface archaeological remains may be seen only under certain weather/moisture conditions. Therefore, multispectral images (from Resourcesat1) from three dates, with seasonal variations, were analysed. These revealed two successive crop-marks north of Temple 14. It is interesting to note that when a line joining the centres of Temples 12, 13 and 14 is extended northwards, these two patches lie neatly along this axis. Two additional points of interest relate to this axis-line. First, a brick mound in Baragaon lies within a few metres of this axis-line. Misra has observed that this brick mound "...appears to have been a Chaitya in the row of the excavated Chaityas 3, 12, 13 and 14 of the Nalanda site".⁵ The second noteworthy point is that the two crop-marks together with the brick mound lie at regular intervals along this axis-line, and the gaps between them are comparable to the gaps between Temples 12, 13 and 14. These observations suggest that the two crop-marks were locations of past temples. It is likely that these structures were subsequently quarried for bricks because they lie closest to the largest settlements in the region (Baragaon and Surajpur). The brick mound in Baragaon would have been the third victim to brick mining as noted by Cunningham: "From its close proximity to the village, this ruin has supplied materials for all the existing houses, and is consequently of much smaller dimensions...".⁶ At present, the brick mound of Baragaon is used as a multi-tier terrace for grazing cattle, and for drying hay and grains. At ground-level it is not possible to identify these crop-marks as the location of past temples, as the land is now used for agriculture.

When the axis line is extended further south of Temple 3, there is a conspicuous gap in the tree canopy identifiable on the Cartosat1 image. Once again, this lies at a distance comparable to the intervals observed earlier between temples further north. On the ground, this area is flat and is used for agriculture. The subsurface here may have a tightly packed foundation – again suggestive of a buried structure – because of which large trees find it difficult to take root. To the south of Monastery 1, the vegetation pattern resembles three sides of a rectangle whose eastern and western edges align respectively with the eastern and western walls of Monasteries 1, 4, 6-11. This suggests that there may be additional similarly shaped

structures south of Monastery 1. A ground study showed undulations along this feature, as though the surface cover was hiding some structure underneath. Three circular mounds were found while exploring this area on the ground, one of which lies along the axis-line referenced above.

The northern mound

The northern mound is much smaller than the southern one, but it has a very interesting shape. The northwest, northeast and southeast extremes of the mound form three corners of a four-pointed feature. This feature measures 450m (northeast-southeast corners) by 400m (northwest-northeast corners), but its elevation is only around 4-5m higher than the surrounding area. This mound lies to the west of Dighi Pokhar, and may correspond to Buchanan's observation when he approached this area from Bihar Sherif on 8 January 1812. He crossed the river Panchana and "About four miles from thence I came to a tank called merely Dighi, which is the commencement of the ruins... Immediately west from this tank is a very considerable space elevated with the fragments of brick".⁷

A field exploration was undertaken to seek evidence (undulated surfaces or exposed old walls, for instance) along the periphery of this feature. The residents of the village were inquisitive and perhaps apprehensive about the purpose of our visit. However, they were forthcoming with information, especially once they were invited to examine the 3D satellite image of their village and environs (Fig.3). As we probed them for information about any exposed old structures in the vicinity, one resident reported that a small trench had recently been dug on his land and offered to lead us there. As the team followed him, our GPS track traced northward, then eastward, and ended by the trench located almost precisely at the north-eastern corner of the northern mound. The asterisk in Fig.2 indicates this location, where a brick structure – perhaps only the pro-verbial tip of the iceberg – has been discovered. The massive structure one suspects lies hidden beneath the northern mound is comparable in size and shape to the Vihara quadrangles of Vikramasila (in Bihar) and Somapura (in Bangladesh).

Conclusions

This study, using satellite images, has identified several features that are of archaeological interest in the environs of Nalanda. They are:

- The pattern of water bodies surrounding Nalanda, possibly indicating the site's extent and spread in south to north direction.
- A palaeochannel that drew water towards the site from the river Panchana, which intersects the site at the eastern end of Dighi Pokhar, and could explain why this tank extends significantly further east than other tanks.

Fig.3: Residents of Begumpur examining the 3D satellite image of their village and environs.

Fig.4: Monks worshipping on the north side of Temple 3.

Fig.5: Xuan Zang memorial at Nalanda.

- Within the proposed extent there are two separate (northern and southern) clusters of mounds.
- Vegetation patterns indicate that along the line of Temples 3, 12, 13 and 14, there may have been two additional temples to the north and one additional temple to the south. Similarly, an extension of the main row of monasteries to the south is hypothesized.
- The northern cluster of mounds includes Begumpur, and reveals a shape suggesting that the mound might be hiding remains of a large four-pointed structure. A field expedition has revealed that the location of the brick structure excavated recently in Begumpur coincides with the northeast corner of the four pointed subsurface structure.

These findings were presented at the international conference held in Rajgir (January, 2014), jointly organised by Nalanda University and IAS: "Cultural Heritage: Environment, Ecology and Inter-Asian Interactions".⁸ The satellite data analysis was conducted in the laboratory facilities of Karnataka State Remote Sensing Applications Centre (KRSRAC) Bangalore.

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