CARTOSAT-1 views the Nalanda Buddhist ruins

Nalanda, Nala, Nalaka and NalakaGrama are all variants of the same place as reported in various Buddhist and Tibetan texts of the 17th century. It is an ancient Buddhist ruin located close to the village of Bargaon, 90 km southeast of Patna and 11 km north of Rajgir (ancient Rajagriha), Bihar, between 25°6′–25°10′N lat. and 85°24′–85°30′E long. Nalanda has an ancient history of being established as a Buddhist centre of learning, going back to the days of Mahavira and Buddha during the 6 and 5th centuries BC. The Pali Buddhist literature also contains several references to Nalanda. It is said that Buddha visited Nalanda and mentioned it to be a prosperous seat of learning under a mango grove named 'Pavarika'. Hiuen Tsang, the famous Chinese scholar of the 7th century BC described Nalanda as 'charity without intermission'[1]. The Gupta period (4–5th century AD) and the Pala period (8–12th century AD) also described Nalanda[2]. Based on the findings of Nalanda by Buchanan–Hamilton in 1838, General Alexander Cunningham identified the site for the first time in the year 1861–62, which was followed by A. M. Broadley, who carried out some excavations[3]. Later, for about twenty years, beginning with 1915–16 up to 1937, the Archaeological Survey of India (ASI) excavated the site, besides its preservation and collection of antiquities. Excavations conducted during 1974–82 and recently in 2004–05 have revealed the existence of ruins of a temple close to the Nalanda. Further, it is stated[1] that the 2500-yr-old Nalanda University was spread over an area of 16 sq. km. However, till now only 1.5 sq. km of the ruins has been reported to be excavated by the ASI.

The present study aims at determining the geographical location, spatial extent and geometric patterns of the archaeological structures and to examine the possible potential sites using the Indian Remote Sensing Satellite data. The study has been carried out over an area of 16 sq. km in and around Nalanda, including the 1.5 sq. km area of the present excavated site. The datasets used for the study include high resolution CARTOSAT-1 PAN (Aft) data at 2.5 m resolution of February 2006 and IRS P6 LISS-IV (MX) data at 5.8 m resolution of November 2005. Further, the study has been substantiated using ASI maps (ground-surveyed), topomaps and by limited field-work.

The CARTOSAT-1 image clearly shows the location, extent, pattern and layout of Nalanda. On comparing with the ASI map, it is observed that nine out of the ten monasteries and four out of the five temples/stupas, with their geometric shape and pattern, are distinctly visible on the imagery. The remaining monastery (no. 10) and temple (no. 4) were noticed in ruins during the ground-truth visit. Monasteries 1–3 show the presence of a paved surface over the others (unpaved surface). Other details identified on the image include the compound wall, pathways, entrance to the monasteries, vegetation/trees, tanks, lakes, settlements, approach roads, besides cultivated lands with field bunds. The compound wall as observed on the ground was built by ASI during 1970s (pers. commun.). Traces of the wall are also seen on the CARTOSAT-1

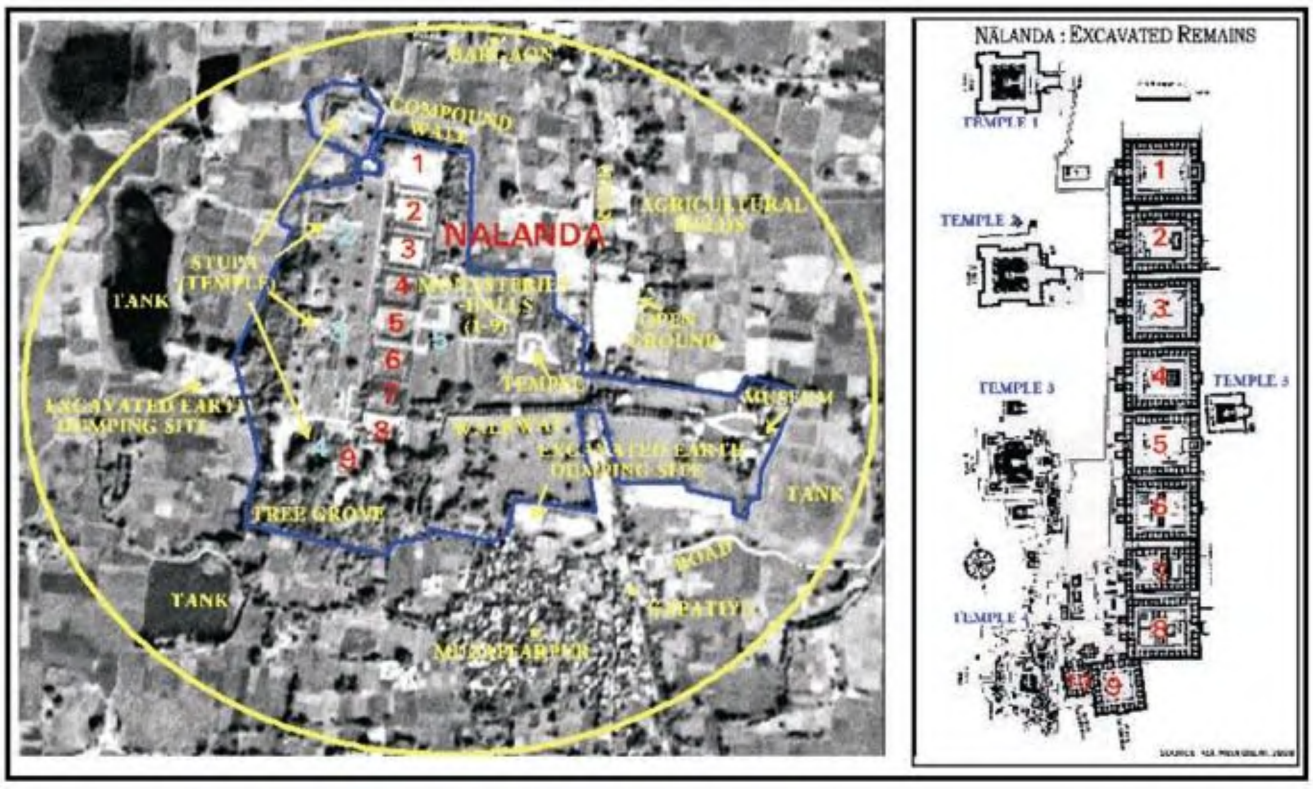

Figure 1. CARTOSAT-1 image (3 February 2006) and ASI map (2006) showing the Nalanda site.

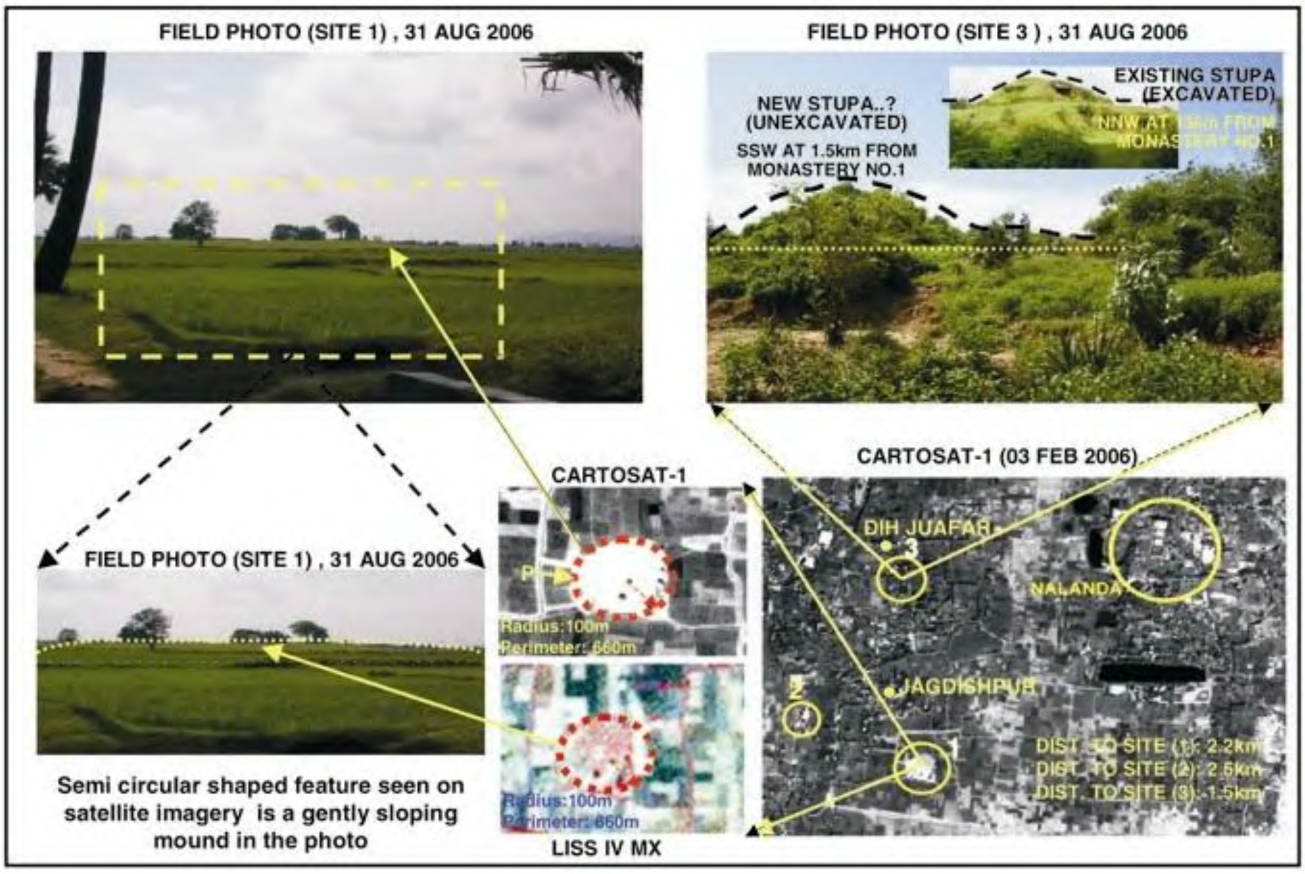

Figure 2. Three mounds identified on CARTOSAT-1 and their ground photographs.

Figure 3. Location and alignment of the four tanks as seen on IRS P6 LISS IV MX (29 November 2005).

imagery. The perimeter of the wall is 3.38 km and the area enclosed is 0.5 sq. km. The newly developed settlement, Muzaffarpur, is seen 200 m to the south of the site. The older settlement, Bargaon, is located 350 m to the north of the site (Figure 1).

A conspicuous, semi-circular-shaped feature is seen on the CARTOSAT-1 image. It is gently sloping, having a perimeter of 660 m, is 4 m in height from the ground and covers an area of 0.034 sq. km (3.4 ha), which is under consideration by ASI for excavation. It is located at a distance of 2.2 km from the Nalanda site and 350 m south of Jagdishpur settlement. It has been mentioned in the literature[1,3] as having a lot of archaeological relevance. Two other mounds are also seen on the CARTOSAT-1 image, which were also identified at a distance of 2.5 and 1.5 km respectively, from the Nalanda site. They are at a height of 5 and 7 m respectively, from the ground, having a perimeter of 490 and 535 m and an area of 0.01 (1.0) and 0.02 sq. km (2.0 ha) respectively. It can also be seen that the silhoutte, height and extent of the unexcavated mound no. 3, is similar to the existing excavated stupa, located around 136 m in the NNW direction from monastery no. 1 (Figure 2).

Another major observation on the imagery is the location of four tanks on the four cardinal corners of the Nalanda site. Each is aligned and oriented with respect to the other (Figure 3), which suggests a virtual boundary to the site. Tank no. 1 is referred[3] to have been in existence since the 7th century AD.

Thakker's[4] study on Nalanda using IRS 1D LISS III of 1999, showed the existence of a cross seal structure (horizontal and vertical lines of ancient town-planning). The IRS P6 LISS IV (MX) image of November 2005 shows the existence of such a cross structure. During ground truth, it matched with the existing stream/field channels filled with flowing water. However, the relevance of this cross structure to the site and its extension needs to be explored further.

The study using high resolution CARTOSAT-1 satellite data offered a valuable insight in assessing the Nalanda

site towards establishing baseline information to serve as a repository for further monitoring and archaeological investigations.

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Isolation of RNA from cell scrapings and blood samples from cervical cancer patients

Cervical cancer is the third most prevalent form of cancer worldwide among women, with greater burden of the disease in the developing countries. Collection of biological samples for analysis has constraints and warrants generating maximum information. Cervical scrapings have been collected from patients where biopsy is difficult or not feasible, for example, in patients undergoing radiotherapy or follow-up patients. Isolation of RNA for gene expression studies is a cumbersome and time-consuming process. It is difficult to isolate from cervical cell scrapings due to three reasons: (i) The amount of cells obtained from the scraping is less; (ii) High levels of endogenous RNAase, and (iii) Contamination with DNA and proteins.

To overcome these problems, we developed a simple and efficient RNA isolation procedure by modifying the original method described by Chomczynski and Sacchi[1], which improves recovery of total RNA from small quantities of cells suitable for gene expression studies (PCR). Basically this was done by collecting the scraped cells in guanidine thiocyanate to inhibit RNAase activity and subsequent cooling to –20°C, and reducing the incubation time to 20 min in the re-precipitation step.

Scraped cervical cells, approximately 50 mg, were collected in 10 ml saline in a Falcon tube and stored on ice. The cells were centrifuged at 2000 *g* for 5 min. The supernatant was discarded and cells were transferred into a 1.5 ml polypropylene tube. In case of cell scrapings with blood contamination, rewash with 5–10 ml saline was done. Buffy coat was separated from 5 ml of whole blood and used for RNA extraction. Next 500 µl of solution D (4 M guanidine thiocynate; 25 mM sodium citrate, pH 7; 0.5% sarcosyl; 0.1 M 2-mercaptoethanol) was added to the cells and vortexed until a viscous lysate was observed. To this, 100 µl of 2 M sodium acetate (pH 4) and 500 µl of phenol (water-saturated) were added with thorough mixing by inversion. Guanidinum thiocynate and phenol facilitate immediate and effective inhibition of RNAase activity. Then 100 µl of chloroform–isoamyl alcohol mixture (49 : 1) was added to the homogenate and the final suspension was shaken vigorously for 20–30 s, cooled to –20°C for 5 min and centrifuged at 12,000 *g* for 15 min at 4°C. The homogenate separates into aqueous and organic phases by addition of chloroform–isoamyl alcohol mixture. On centrifugation RNA remains exclusively in the aqueous phase, DNA in the interphase and proteins in the organic phase. RNA was precipitated from the aqueous phase by the addition of 1 ml isopropyl alcohol and maintained at –20°C for at least 1 h for precipitation. RNA pellet obtained after centrifugation at 12,000 *g* for 10 min at 4°C was dissolved in 200 µl of solution D and re-precipitated with 1 volume of isopropyl alcohol and incubated for 15 min in –20°C and centrifuged at 12,000 *g* for 15 min at 4°C. The pellet obtained was washed with 1 ml of chilled 75% ethanol, vortexed and centrifuged at 12,000 *g* for 10 min at 4°C. Ethanol was decanted and the pellet was dissolved in aliquot volume of sterile double distilled water for further analysis. For long-term storage we recommend storage in absolute ethanol at –70°C.

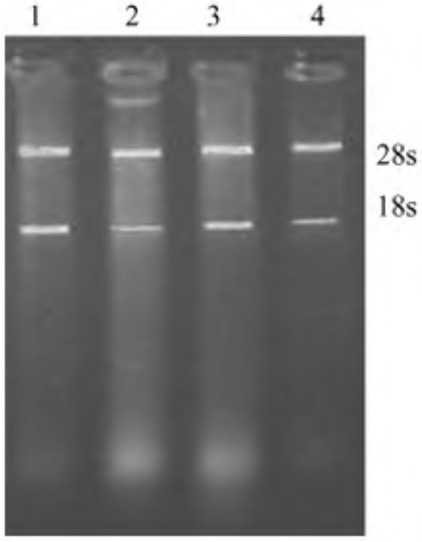

Figure 1. Agarose gel electrophoresis of RNA isolated from cervical cell scrapings (lanes 1 and 2) and blood samples (lanes 3 and 4).