

# **A geoinformatics based approach for the study of archaeological site: preliminary investigations for Kaushambi (India)**

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## **Abstract**

The paper presents preliminary work related to creation of geospatial database for archaeological investigations at Kaushambi (India), a historic town dating back to 6<sup>th</sup> century BC, presently located at about 52 km to the west-south-west of Allahabad at the northern bank of River Yamuna in Allahabad district. The excavation work was taken up by Archaeological Survey of India (ASI) in 1937-38 and later by University of Allahabad from 1949 to 1965, revealed the remains of a large Buddhist monastery (Ghoshitaram) and residential area near Asokan Pillar. Recently an attempt has been made to conduct archaeological survey within the fortified area, with the help of modern Geoinformatics techniques, in order to understand settlement pattern. These techniques which have facilitated sensing the surface and sub-surface features, a reinvestigation and fresh interpretation of the site has been initiated.

**Keywords:** GPS, Survey, Geospatial database, GIS.

## **Introduction**

Conventional data collection techniques used in archaeology are time-consuming and have limitations in terms of visualization, accessibility, speed, storage and dissemination. However, advancements in data collection and interpretation techniques in the form of electronic surveying, remote sensing, Global Positioning System (GPS), airborne and terrestrial LiDAR, digital photogrammetry and sub-surface sensing with Ground Penetrating Radar (GPR) can be used for archaeological data collection and interpretation. The analysis of collected data can be easily carried out in a Geographical Information System (GIS) environment. Geoinformatics, the technology for collection, processing, and dissemination of geoinformation for managing and monitoring of objects and phenomena, has been used for creation of geospatial database of Kushambi (India).

## Overview of the study site

During Buddha's time Kaushambi was one of the six most important and prosperous towns of India. It was a nerve centre of ancient Indian communications as the principal routes from north to south and east to west met at the city. It was a terminus of river traffic and an important emporium of Madhyadesha. The city retained its importance at least up to the sixth century A.D., it was visited by the Chinese pilgrims Fa-Hien and Yuan-Chwang.

Kaushambi was the capital of Chedi-vatsa *janapada*, one of the prominent *janapadas*. As some of these *janapadas* figure prominently in the Brahmanas and Upanishads, it is not unlikely that the antiquity of Kaushambi goes back to the period of the Brahmanas. The *Shatapatha Brahmana* mentions a person called Proti Kaushambeya, a native of Kaushambi. This hoary antiquity of the city is confirmed by the *Mahabharata* and the *Ramayana*, the former ascribing its foundation to Kushamba, the third son of the Cedi King Uparicara Vasu and the latter to Kushamba, the son of Kusha.

***Sir Leonard Wooley in his famous report had suggested two sites, Kaushambi and Ahichatra as the most important sites in the Ganga valley, the excavation of which, according to him, would unravel the early history of the Indian people.***

The Archaeological investigations by the University of Allahabad at Kausambi (1949- 1965) are remarkable for many reasons: they begin at a time, soon after Independence, when no other university was able to mount such an exercise. They were prolonged and detailed projects and continued for a length of time far beyond that invested in perhaps any other site in post-Independence India by any agency. The Excavations at Kausambi are notable also for having produced two monographs based reports, which are the basic and foundational texts for the study of the site and the region. In 1949–50 the University of Allahabad began the excavation near the area of Asokan pillar.

In 1952 the Kausambi expedition of the University of Allahabad returned to the site and instituted a long series of excavations which would continue for the next thirteen years. The first site they chose was in the south-eastern corner of the fortified area and to the general acclaim of the community of Indian archaeology led to the discovery and excavation of a major Buddhist complex. The Ghoshitarama came to be securely identified with the discovery of monastic seals, votive inscriptions and an incense lamp all of which contained what was known to have been the name of a monastery built by a merchant at the site from legends in early Pali texts. The Ghoshitarama was excavated over four or five years ranging from 1954 through till 1958 and revealed an extensive complex where the configuration of the sacred space changed a number of times. Unfortunately the details of this entire excavated complex were never published. The first major epigraphic discovery was edited by A. Ghosh. The summary of the excavations and the major discoveries each year appeared in the respective issues of the IAR. The subsequent epigraphs found were edited and published by J.S. Negi and then also considered by G.R. Sharma in a subsequent essay on the Kusana adopted the Kausambi.

Over a period of thirty long years the Department of Ancient History, Culture & Archaeology, University of Allahabad carried out prolonged and detailed investigations into the archaeology of Kausambi. They were confronted with material cultures which were completely new to archaeologists and were presented with testing challenges of interpretation. The excavation records and the curation of the excavated materials have been of an almost unparalleled order and continue to allow us to revisit the material cultures upon which the foundations of their interpretations were built. The attempts made to place Kausambi in its context continue to have a deep and binding relevance and while placed within the theories and paradigms of their time they continue to be important milestones in the manner in which the archaeology of the Ganga plains was comprehended. To conclude this consideration of the cumulative work at the site it is perhaps apposite to quote from their statement of 1980:

"In the light of the archaeological evidence which points to the development of urbanization in the Gangetic valley in a chalcolithic context which was rooted in the Neolithic cultures of the region, a fresh appraisal of the total body of evidence, taking into consideration the archaeological, Puranic and Vedic material, has become a desideratum."

The ruins of the well-known site of Kaushambi (25°20'30"N, 81°23'12"E) are situated on the left bank of the river Yamuna (Figure 3) at a distance of nearly 50 km from Allahabad in a south-westerly direction (Bala Bhaskar, 2004). The remains of the ancient city viewed from a distance give the impression of an imposing hillock, which, when approached nearer, reveals itself as a chain of rolling mounds, standing high above the surrounding plains, girdled on the south by the Yamuna. The chain of mounds has a peripheral circuit of about 6.45 km. The rampart proper has an average height of 9 to 10 meters from the surrounding from the field level. The towers or the bastions, however, are considerably higher, those in the north-western corners being as high as 21.33m. The fortified city forms an irregular oblong on the plan. The city was provided with gates on three sides east, north and west. The location of the southern gate cannot be determined on account of the erosion caused by the Yamuna. Besides the bastions, Gates and sub-gates, the city was encircled on three sides by a moat, which, though filled up at places, is still discernible on the northern side. At some points, however, there is evidence of more than one moat. The defenses at Kaushambi betray an advanced knowledge of fortification (Rai *et al.*, 1988). At places the gates are provided with curtain-walls on the outside, the same being best illustrated near the eastern gate.

The entire city, thus encircled by the rampart wall and moat, is littered with a huge mass of brickbats indicating the density of structures in the city. With the passage of time, the habitation levels inside the city went on rising and an approximate thickness of 17m of habitation deposit furnishes the vertical record of city's life and antiquity. It was a memorable event in the history of Indian Archaeology when on the first of March, 1948, Sir Mortimer, who was convinced of the potentialities of the site and the prospects of its excavation, authorized the University of Allahabad to excavate Kaushambi with Dr. G. R. Sharma as Director.

The excavations have been conducted in the following areas:

1. Near the Ashokan pillar which laid bare a part of the residential area of the city
2. The Ghoshitarama monastery (Figure 1 & 2).
3. The Defense area, the Eastern Gateway and the tower at the north-eastern corner
4. The Stone Fortress Palace.

The University of Allahabad and Indian Institute of Technology Kanpur initiated a joint project on "Application of Modern Technologies to the Study of Past". In 2008–09 a team of archaeologists and technologists initiated reinvestigation of selected areas of the ancient of Kausambi.

### **Methodology**

The excavation carried out in the past is under reinvestigation with the help of modern Geoinformatics tools. The methodology for the revised work is divided into the five components (a) Processing of preliminary data using Google earth, IRS and Resources at and SRTM data (b) Field work using electronic total stations and GPS (c) Post-processing of field data (d) Preparation of geospatial database (e) Analysis and interpretation of geospatial database.

### **Data resources used for investigation**

Data resources used for the purpose are topographic sheet, satellite images (PAN, LISS-III and LISS-4 sensor images from Indian remote sensing satellites available from National Remote Sensing Center, NRSC, Hyderabad, India), Shuttle radar topographic mission (SRTM) data C band, and Google Earth images. The detailed site survey for two sites near Asokan pillar and Ghoshitarama monastery was carried out with the help of Trimble total stations, Leica differential GPS (DGPS) and GPR.

As the extent of the site was known from the archaeological records, the site location was searched with the help of Google Earth. Snap shots of the same were taken which helped in planning the preliminary survey of the site. Also, the SRTM data for the same location was searched and analyzed. The field work involved surveying using instruments like total station and GPS. Survey work was initiated by setting up the base station and a large number of control (or reference) stations. These control stations were used as starting points for the total station and GPS survey. The coordinates in total station were recorded in Universal Transverse Mercator (UTM) zone 44 map projection with WGS-84 as the reference ellipsoid. Creation of database work comprised processing all the data gathered by total station and GPS during field surveying and satellite images using an image processing system to convert all data to a common coordinate system (UTM Zone 44 with WGS-84 as the reference ellipsoid). The digital image processing of satellite imagery and arrangement of creation of geospatial database was facilitated by using ERDAS and ArcGIS software.

The GIS based database created consists of data both in raster and vector formats. The raster data is in the form of maps and plans of the area. The various layers used in the present work include:

- (i) Topographic maps 63G at 1:250,000 scale and 63G/7 at 1:50,000 scale

- (ii) LISS-III, LISS-IV and PAN satellite imagery (23.5 m, 5.6 m resolution respectively)
- (iii) Aerial photograph of Kaushambi.
- (iv) Plan of defense area, Ghoshitarama monastery and Fort area
- (v) Data from GPS and Total station survey for Asokan pillar and Ghoshitarama monastery area

### **Field work or survey work**

The various surveys carried out on the study site involved (a) GPS survey and (b) Total station survey. The GPS survey was started by setting up a base station at the site and establishing multiple control points. These reference points were processed with respect to the base coordinates to eliminate various errors. The GPS survey at Kaushambi was done using GPS instrument SR530 from Leica Geosystems. The total station survey was carried out using the Trimble 5600 DR200+ equipment which has the capability to work in direct reflex mode also.

### **Post-processing of field data**

All data generated from the survey was processed in the laboratory and was used for the generation of DEM. The laboratory work for the same comprised processing and manipulating all the data. It involved usage of different software like SkiPro, Geodimeter, ERDAS IMAGINE 8.7 and ArcGIS 9.1. The Total station data was used to prepare TIN model from which contour map or a DEM was generated.

### **Preparation of geospatial database**

For the preparation of geospatial database, major steps carried out were generation of DEM (using survey data, contour lines and benchmarks), georeferencing of topographic sheets, satellite images and digitization of different features (boundary, mounds, etc.). Figures 4 and 5 show GIS maps of Asokan pillar and Ghoshitarama monastery area and DEMs of these areas prepared with field data.

### **Concluding Remarks**

The Archaeological GIS for Kaushambi is under development which can be used for the management of archaeological data and would facilitate rapid, precise and accurate data storage and retrieval under GIS environment.

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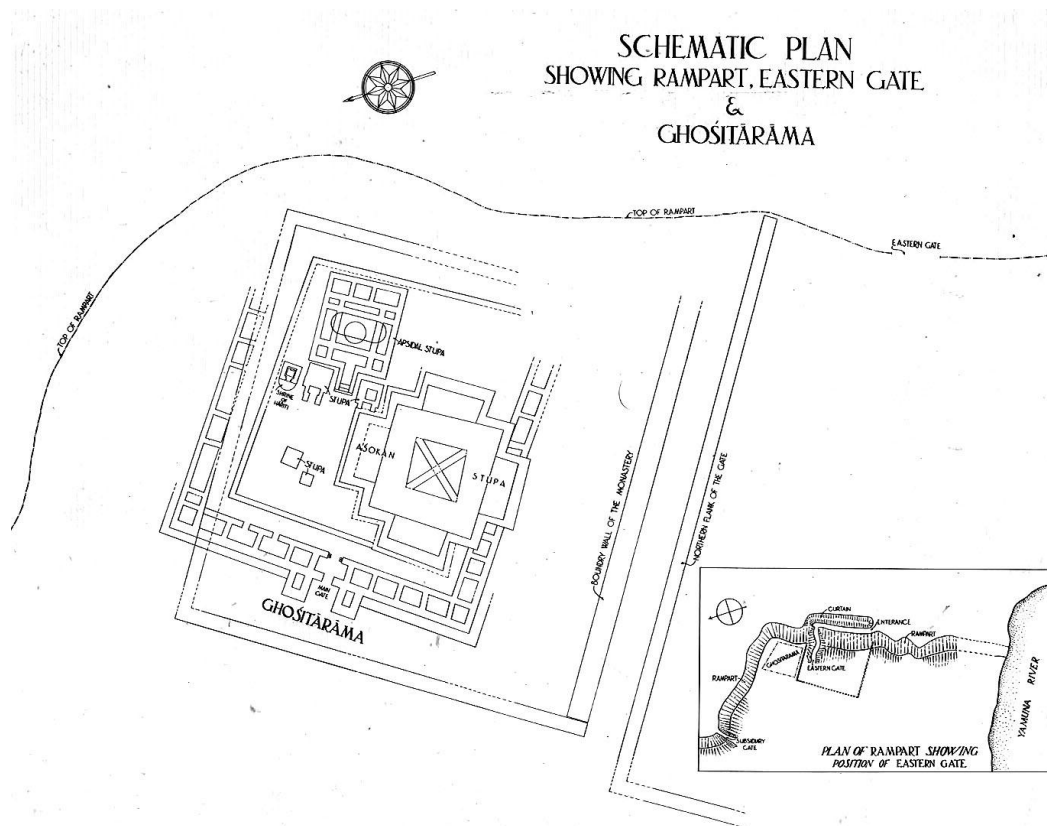


Figure 1 : Schematic plan showing rampart, eastern gate & Ghositarama



Figure 2 : General view of the remains of Ghositarama Monastery at Kausambi

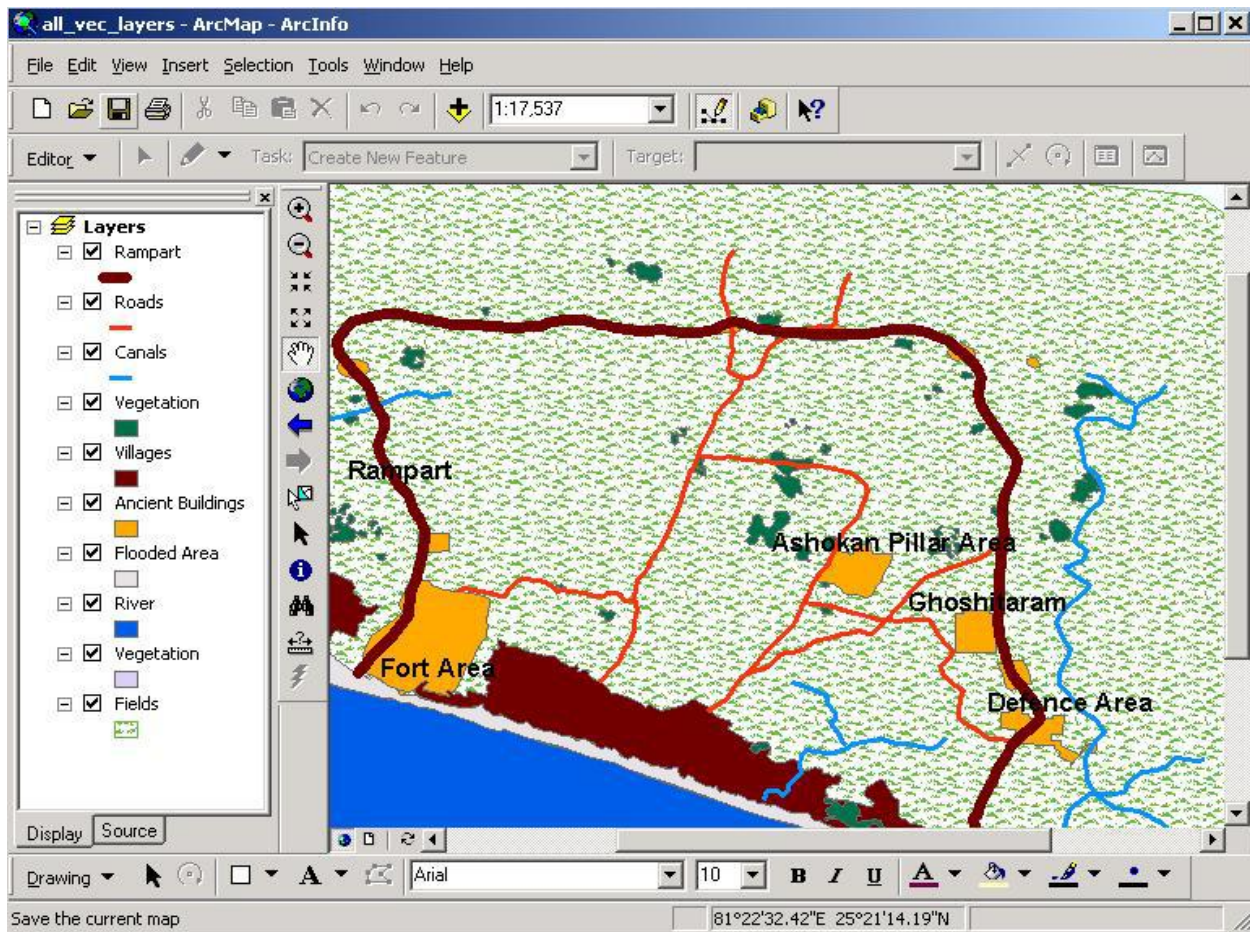


Figure 3: Thematic layers in geospatial database of Kaushambi (Bala Bhaskar C, 2004)

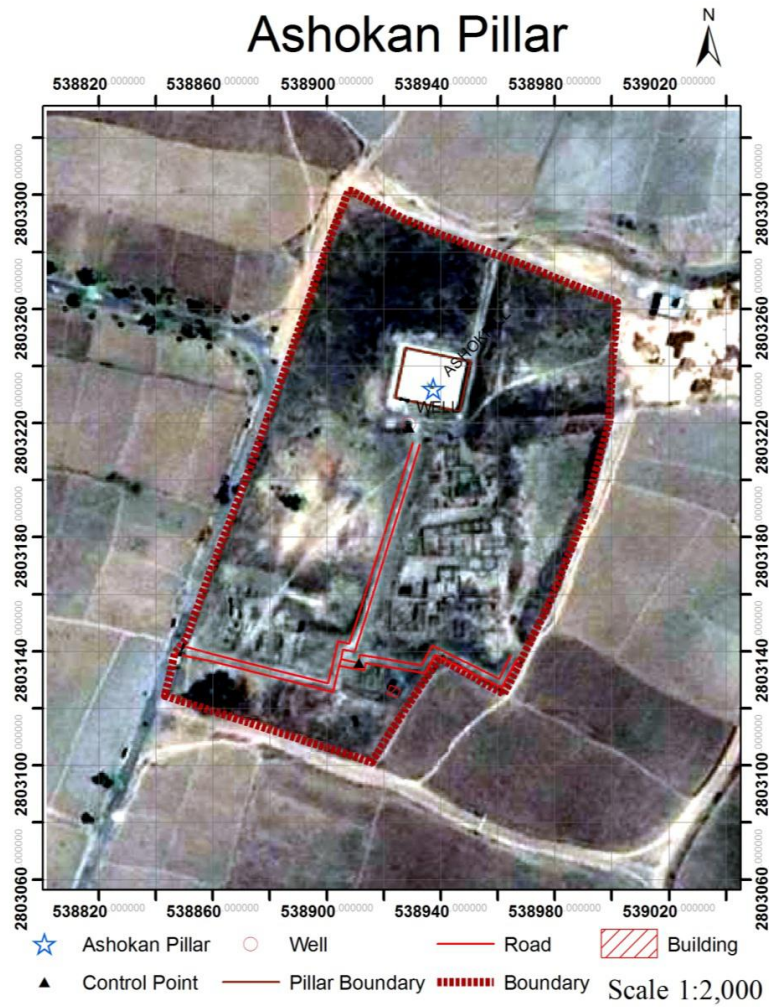


Figure 4 (a): GIS map for Asokan Pillar

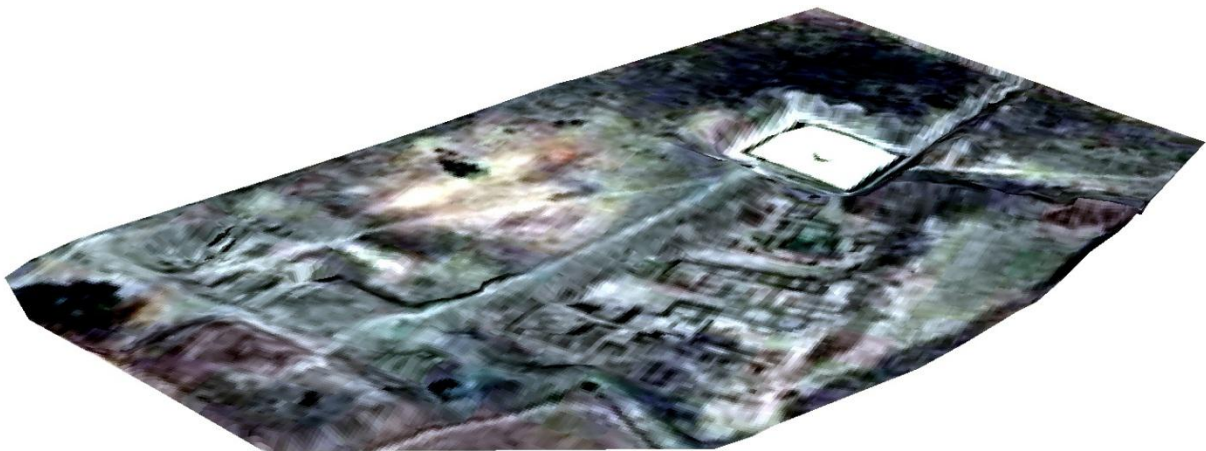


Figure 4 (b): Google image of Asokan Pillar draped over DEM generated from the TIN model

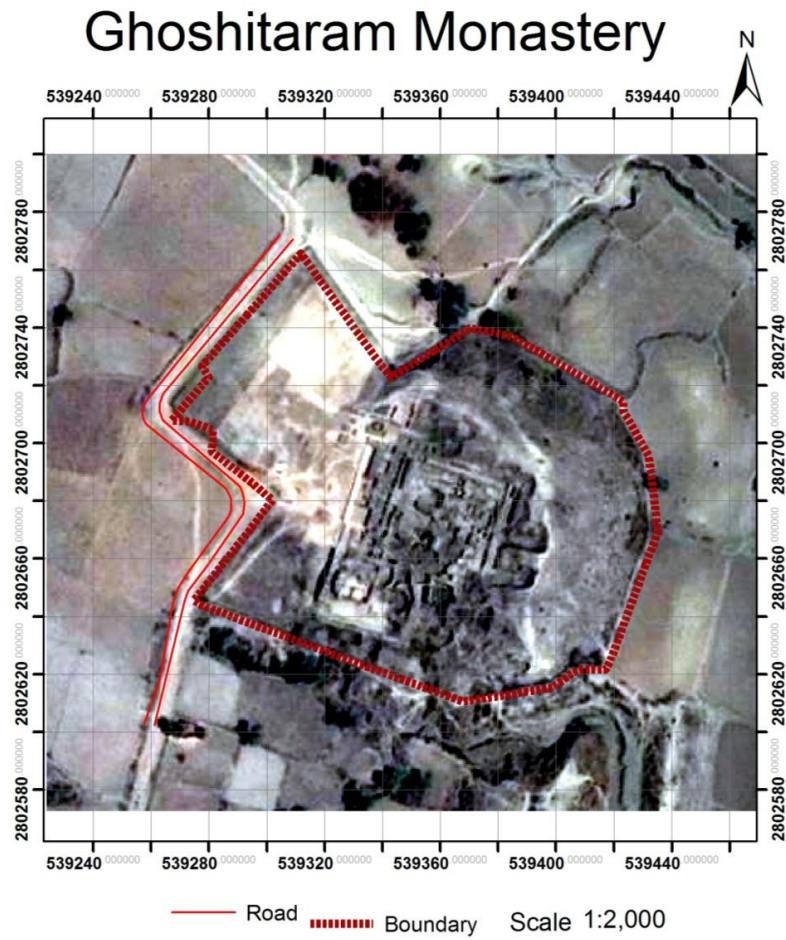


Figure 5 (a): GIS map for Ghoshitarama Monastery

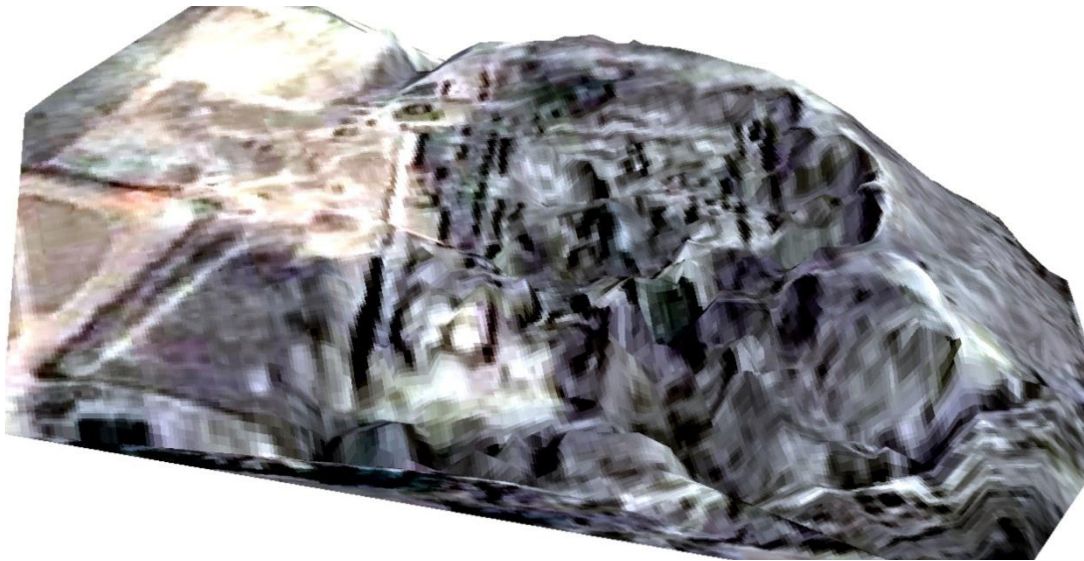


Figure 5 (b): Google image of Ghoshitarama monastery draped over DEM generated from the TIN model