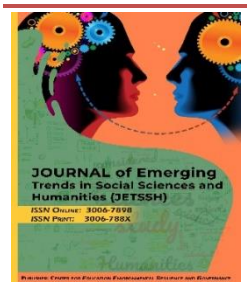

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Evolution of Tape to Electronic Mapping in Pakistan's Archaeology: A Case Study of Buddhist and Late Medieval Periods Sites in District Mansehra

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ABSTRACT

The mapping of archaeological sites and artifacts within excavation units is essential for proper documentation in exploration and excavation. Many traditional techniques for mapping archaeological sites have been used during the colonial period and still are being practiced in different field activities by archaeologists of Pakistan. The use of digital mapping using a total station for creating digital maps of archaeological sites is gradually being adopted in modern excavations. This paper will present a comparison of maps made by earlier techniques and newer digital maps using examples from the Buddhist sites of Zar Dheri, Bado Dhari site, and Guli Bagh, as well as some of the late Muslim medieval period sites from District Mansehra, Pakistan. All these sites have been recently excavated and documented by the Department of Archaeology Hazara University, Mansehra with the financial support of Higher Education Commission Pakistan and administrative support of the Directorate of Archaeology and Museum Government of Khyber Pakhtunkhwa.

Introduction

The mapping of archaeological sites and artifacts within excavation units is essential for proper documentation in exploration and excavation. Many traditional techniques for mapping archaeological sites have been used during the colonial period and are still being practiced in different field activities by archaeologists of Pakistan. Since 1947, a great number of archaeological field research programmes involving extensive surveys and systematic excavations at selected sites have been carried out in Pakistan covering a wide chronological range dating from prehistory to the Islamic and later

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historical times (Mughal, 1990).

Archaeological sites are always found in eroded conditions with natural and human encroachments during archaeological explorations. It is difficult to get actual measurements with both vertical and horizontal angles of any site to locate the area of archaeological excavations. Mostly, the plane-tabling procedure, which involves generating a drawing of the topographical features both natural and man-made with accurate ground measurements is being used to obtain photographic input in Pakistan. Theodolites, chains, and tapes were used to measure lengths and angles on the ground in order to locate or provide control points that would regulate the map's geometrical attributes and scale. The mapping process was delayed by the need for considerable fieldwork, which required a lot of men, money, effort, and time. The practice of involving professionals from national surveying departments or hiring several private surveyors is still ongoing in Pakistan Archaeology using these traditional techniques (Chadha, 2002).

Problem Statement

In Pakistan, the contribution and ideas of Sir Mortimer Wheeler about site mapping stratigraphy, scientific excavation, and other archaeological techniques served as the foundation for knowledge creation in the field of Archaeology. The mapping activities in Pakistan's archaeology, the placement of points on the archaeological site's surface for the goal of mapping are extremely difficult, time-consuming, and complex procedures. Both the base map of the area to be mapped and the accurate location of a few notable features or survey sites in the area were necessary for determining geometric qualities like the scale of the map, which required comprehensive ground survey. Mostly, the plane-tabling procedure, which involved generating a drawing of the topographical features both natural and man-made with accurate ground measurements is being used to obtain photographic input. Theodolites, chains, and tapes were used to measure lengths and angles on the ground in order to locate or provide control points that would regulate the map's geometrical attributes and scale. The mapping process becomes delayed by the need for considerable field work, which required a lot of men, money, effort, and time. The use of digital mapping using a total station for creating digital maps of archaeological sites is rarely being adopted in modern excavations. This paper presents newly adopted digital maps using examples from the Buddhist sites of Zar Dheri, Bado Dhari site, and Guli Bagh, as well as some of the late Muslim medieval period sites from District Mansehra, Pakistan.

Research Methodology

1. Sites Selection

The two Buddhist period sites; Bado Dheri, and Zar Dheri Buddhist Complex, and one Medieval period site were selected for mapping. Bādo Dheri, one of the newly explored Buddhist sites is located on the left bank of the Gandhian stream between the Karakoram Highway and the newly constructed CPEC road in district Mānsehra (Fig. 1-2). It lies between 34°23'13.24" north latitude and 73°12'57.50" east longitude (Shakir & Hameed, 2019). Zar Dheri, a well-known Buddhist complex is located in Tambah, a small village on the right side of Shinkiari-Dadar road in District Mansehra. The site lies between 73.27108° E Longitude and 34.4989° N Latitude (Shakir et al., 2021). The Medieval period site called Fort Feroza is located in the modern village of Guli Bāgh (ancient Pakhal) which is naturally protected by the high mountains of Tanglai, located on its east and north, while from the south and west, it is protected by the river Siran. It lies between N 34.44420288, and E 73.1635779 34.273 in the middle of modern town. All three sites have recently been selected for Archaeological excavations by the Department of Archaeology Hazara University Mansehra under the National Research Projects for Universities funded by the Higher Education Commission Pakistan.

2. Total Station (TS)

A total station is an electronic instrument used in modern surveying and building construction that uses electronic transit theodolite in conjunction with an electronic distance meter (EDM). There are varieties of Total stations being used in engineering and survey departments. In archaeology too, no special specification of total station is required. In the present study, we have used the Sokkia manufacturing company

instrument. The Sokkia has recently unveiled its latest total station, the iM-100, incorporating advanced integrated communications technology along with a robust Electronic Distance Measurement (EDM) system. According to Ray Kerwin, the Director of Global Surveying Products, this instrument is particularly well-suited for tasks such as site layout or as-built surveys, delivering high-performance capabilities within a user-friendly manual package. Key highlights of the iM-100 include its outstanding accuracy, reaching up to 5,000 meters with a prism and up to 800 meters in reflectorless mode. The instrument is equipped with dual-axis compensation, a feature designed to ensure the stability of measurements even in challenging terrains.

Furthermore, the iM-100 boasts integrated Bluetooth technology, eliminating the need for an external antenna for seamless connectivity with the controller. This advancement enhances the instrument's overall efficiency and ease of use in the field. Overall, the Sokkia iM-100 stands out as a cutting-edge total station that combines precision, adaptability to rough terrain, and modern communication features additional features include 50,000 points of internal memory and up to 32GB USB flash drive support, as well as up to 28 hours of battery life and IP66 certification.

3. Adjustment of total station

Two base points were selected at the top of the main stupa of Zar Dheri for the adjustment of the total station. One of them was selected for benchmark (BM) and by using GPS coordinates were taken as 34.1225.00 UTM at easting and 3818831.00 UTM at northing with 1090m elevation above the sea level. We used a UTM unit for the measurement in meters instead of degrees or angles. The UTM (the Universal Transverse Mercator) is a map projection system for assigning coordinates to locations on the surface of the Earth. The total station was adjusted on benchmark point (BMA) then three steps took place;

1. Centring
2. Leveling
3. Focusing

Figure 1: *Leveling and centering of Total Station*

The total station has been kept in the center of the benchmark with the help of the leveling head of the total station. The second point was to hold the total station within a proper level both horizontally and vertically. The third step was to focus on the target point or backside point (BMB) while holding a prism on it to confirm the reading of our benchmark (BMA).

4. Data Collection using Total Station

After creating a separate folder for the Zar Dheri project in the Total Station (TS), coordinates were

added in TS. Our major focus was the stupa area for topographic mapping only because the monastery area is almost totally covered by modern houses and it was difficult to have a clear map of the monastery area but it is included in the topographic map. The Zar Dheri main stupa was roughly in square shape 54x54m measured by the Japanese in 1995.

Figure 2: *Collecting data at different target points*

For the confirmation of the previous measurement, first, we started collecting different points to cover the total area of the main stupa enclosed inside the boundary wall which was followed by the points for a counter map of the main stupa. The area selected for ongoing excavation is also included and marked separately in the topographic map. The excavation is being conducted by the Department of Archaeology, Hazara University Mansehra collaboration with the Directorate of Archaeology and Museum Government of Khyber Pakhtunkhwa.

5. Mapping Software

All the points were saved automatically in TS which can easily be transferred into a desktop computer or laptop. We used AutoCAD for mapping and drawing which is a commercial computer-aided design (CAD) and drafting software application widely used in industry, by architects, project managers, engineers, graphic designers, city planners, and other professionals.

Results and Discussion

Prior starting to digging on the three sites, a grid plan of each site was prepared by following Wheeler's techniques. For the Bado Dheri, excavated in 2019 a counter map was prepared using tape mapping due to the unavailability of the Total station but later on, it was re-mapped with the help of the Total station. To establish a reference point, a datum was set on a stone atop the primary stupa, situated at an elevation of 949 meters above sea level. The site was then systematically organized with a total of 1008 trenches, each measuring 5x5 meters. Among these, 36 trenches were arranged in an east-west direction, while 28 were laid out north-south. The grid plan was meticulously prepared, and each trench received a unique identification number. The numbering process commenced from the northwestern corner, ensuring a methodical allocation to all trenches on the site. Horizontally, the numbers start with the digit 1; while vertically they start with A in alphabetical order as shown in Figure 3.

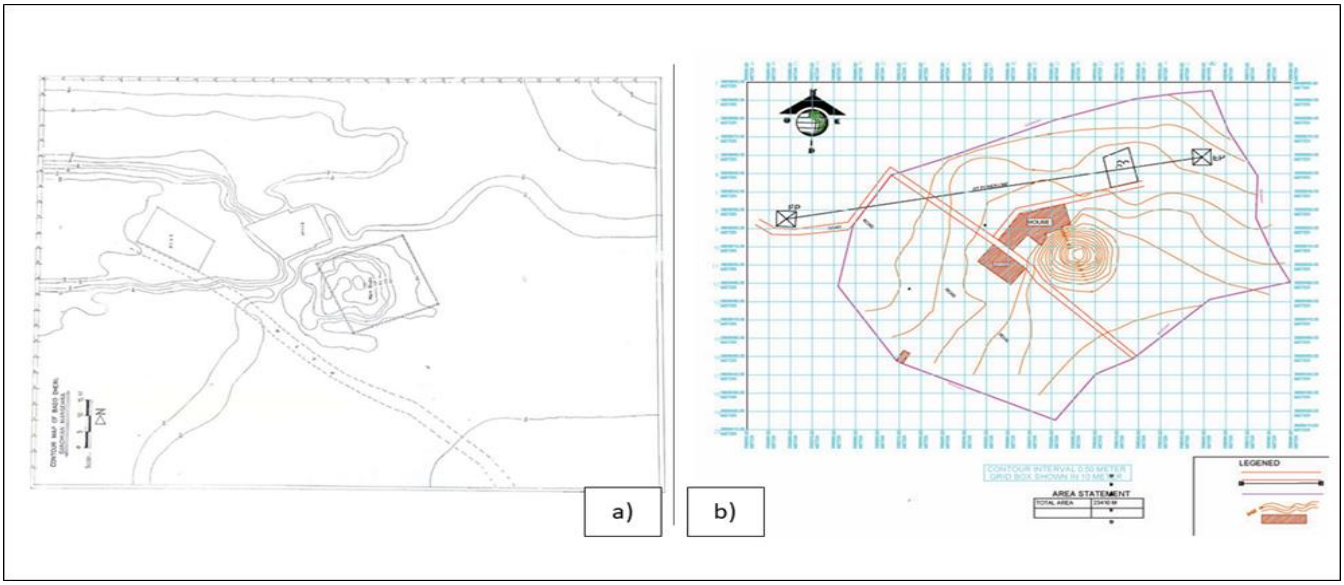
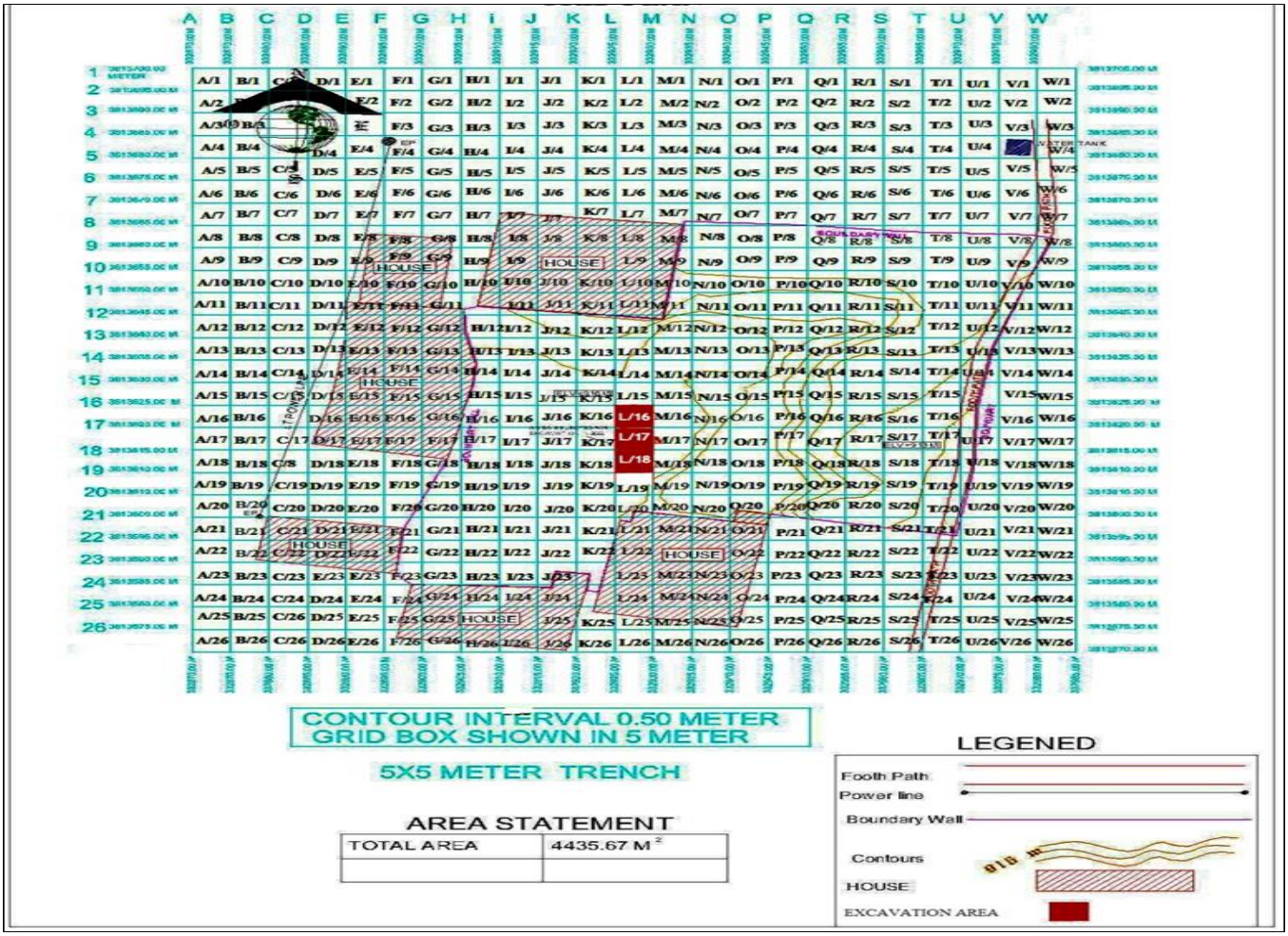


Figure 3 a) Contour map of Bado Dheri by tab mapping, b) Contour map of Bado Dheri by total station

Similarly, before excavation at the Fort Feroza Guli Bagh, a topographic map of the site was prepared with the help of Total Station where 598 trenches ranging from A/1 to W/26 were marked. The map covers the possible area including houses and agricultural fields. Three tranches (L/16, L/17, L/18) were selected for the excavation process from a total of 598. All these trenches measuring 5x5 and 29900 lot numbers were provided ranging from 1-50 to each of the trench (see figure 4).

Figure 4: *Grid plan of Fort Feroza using Total Station*



The Zar Dheri site received limited documentation from Japanese archaeologists in 1992, primarily due to modern constructions and other encroachments. In the current excavation, the Tokyo National Mission's excavation map from 1992 was used as a foundation (Figure 5), with some additions incorporated. Additionally, a detailed topographic map was created using a Total Station (Figure 6).

Following the Wheeler Technique, the site was divided into grids, each measuring 20x20 meters. These larger grids were further subdivided into 4 trenches of 5x5 meters each. In total, 2916 trenches were strategically laid out to cover the entire site. Once the grid plan was established, each trench received a specific identification number, commencing from the northwestern corner. The horizontal numbering started with a digit (1), while the vertical sequence began with letters in alphabetical order (A). For instance, the initial grid in the north-western corner featured trenches labeled as AI/1, AI/2, AI/3, and AI/4, while the final grid in the south-eastern corner concluded with L VIII/1 and LVIII/2 (Figure 7).

Figure 5: *Grid Plan of Zar Dheri Shinkairi, Mānsehra (Courtesy: Tokyo Mission Pākistān 1992)*

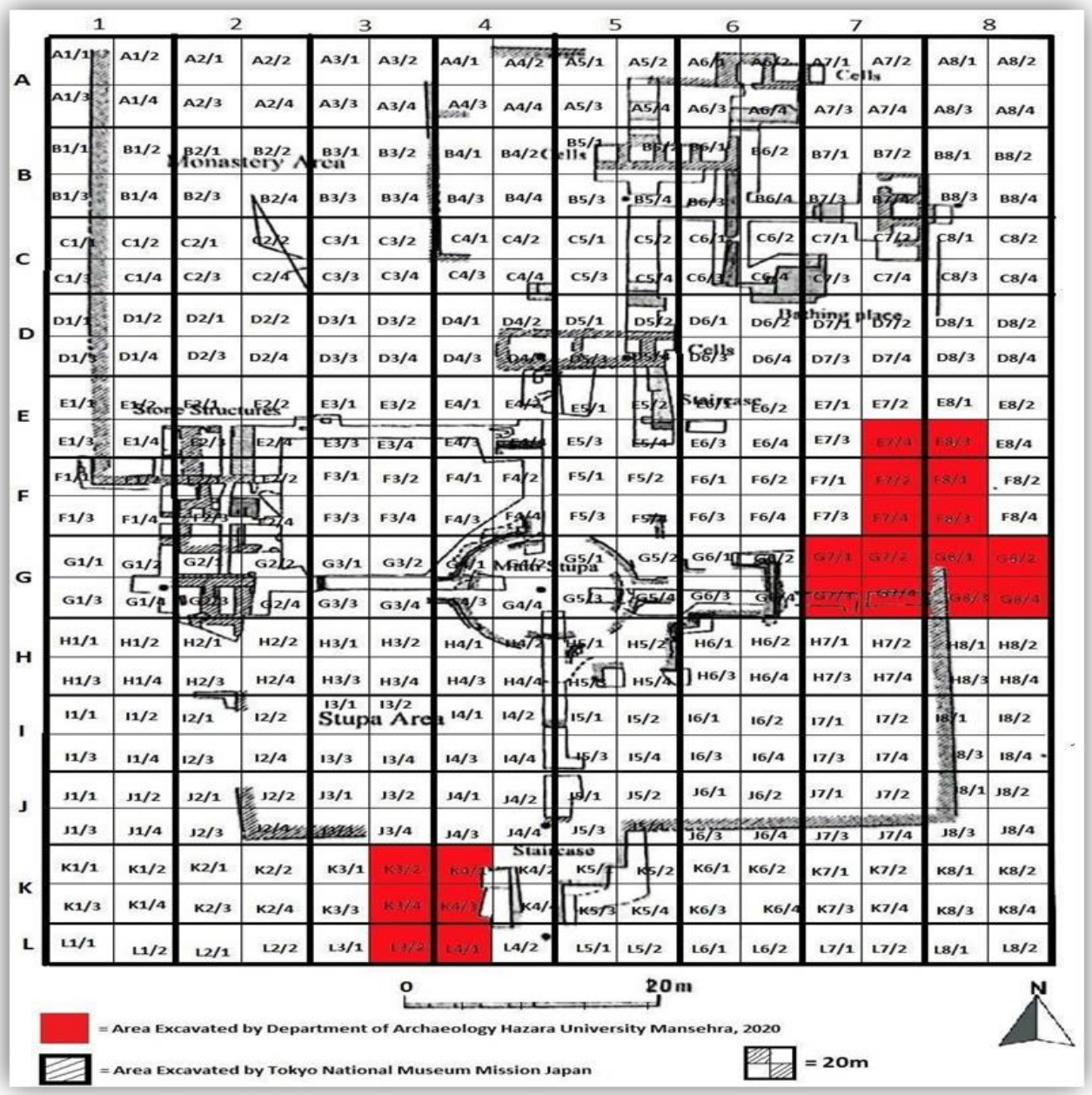
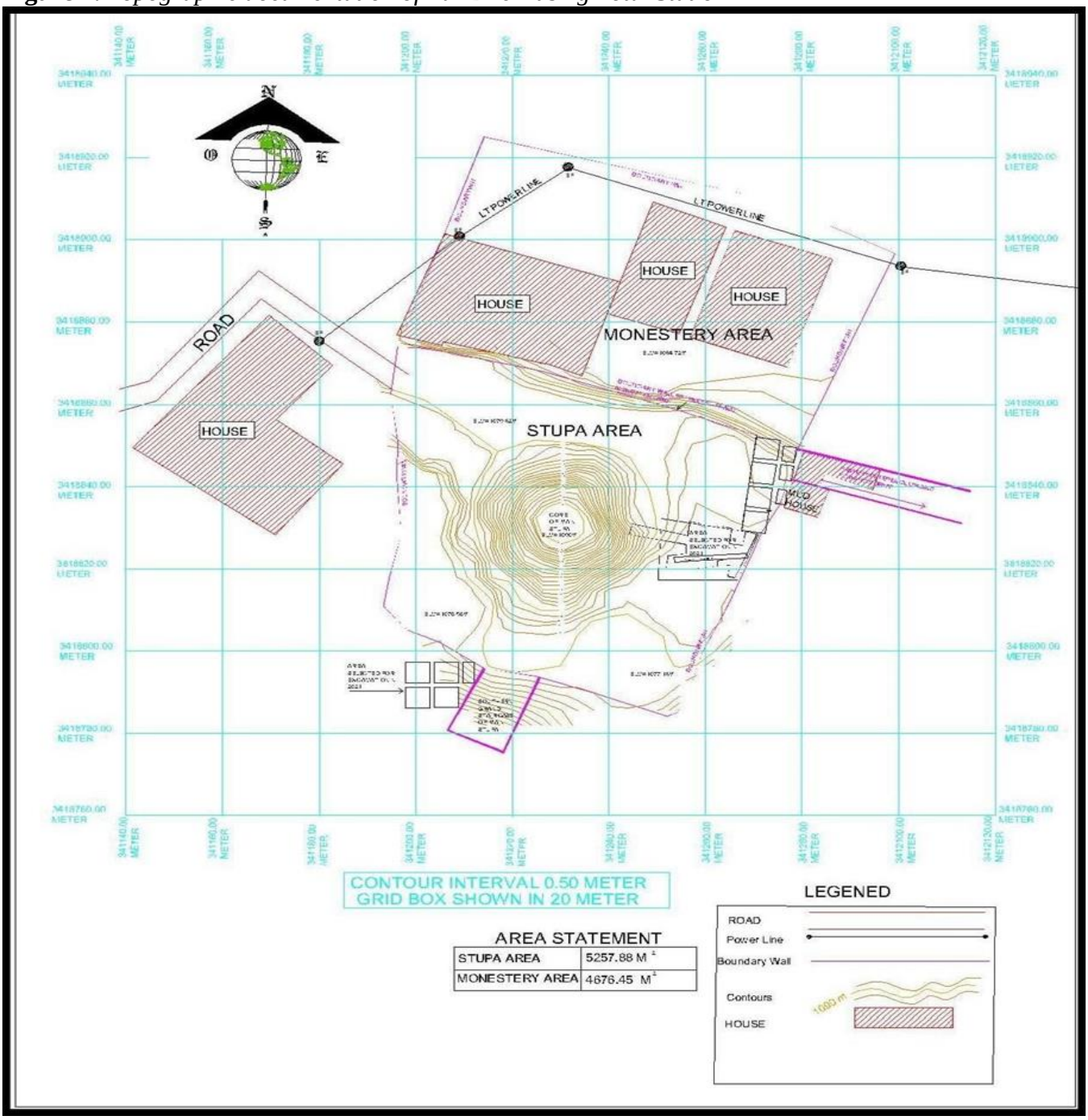


Figure 7: *Topographic documentation of Zar Dheri using Total Station*



Conclusion

In the context of archaeological studies in places like Mansehra, where sites from the Buddhist and late medieval periods exist, using total stations for digital mapping offers a more precise and comprehensive understanding of these historical areas. The digital maps created through total station surveys assist archaeologists in preserving and analyzing these sites with a high degree of accuracy and detail. The utilization of Total Station technology for topographic documentation in archaeological endeavors is paramount for enhancing our understanding of past civilizations and cultural landscapes. The precision and versatility of Total Stations significantly contribute to the meticulous recording of archaeological sites, providing invaluable data for researchers, conservators, and historians. The establishment of survey control points and careful instrument orientation ensure the accuracy of measurements, laying a robust foundation for the subsequent creation of detailed topographic maps. By seamlessly integrating electronic theodolite and distance measuring

capabilities, Total Stations allow archaeologists to capture not only the horizontal and vertical dimensions of a site but also its intricate features and spatial relationships.

The three-dimensional mapping produced through Total Station surveys aids archaeologists in reconstructing ancient structures, delineating settlement patterns, and understanding the overall layout of historical sites. This technology proves particularly beneficial in documenting delicate artifacts, excavation trenches, and architectural remains with a high degree of accuracy. Furthermore, the processed data, including contour lines and digital elevation models, offers a comprehensive visualization of the archaeological landscape. This wealth of information not only aids in academic research but also informs conservation efforts, site management, and the development of interpretive materials for public engagement. As we continue to delve into the rich tapestry of our cultural heritage, the incorporation of Total Station technology in archaeological topographic documentation stands as a pivotal tool for unraveling the mysteries of the past. Its ability to provide precise, reliable, and detailed spatial data reinforces its significance in preserving and understanding the diverse historical narratives embedded in archaeological sites around the world.

Conflict of Interest

The authors showed no conflict of interest.

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