

# Monastic Architectural Reconstruction From a 1962 U-2 Aerial Photograph of Nartang in Central Tibet

KARL RYAVEC, University of California, Merced, CA, USA

TENZIN NYANDAK, Studio Nyandak, NYC, USA

YUMTSOKYI BHUM, Studio Nyandak, NYC, USA

---

In the mid-20th century, United States U-2 Spy Planes flew over Central Tibet and captured high-resolution aerial photographs of Tibetan Buddhist monasteries just before they were destroyed en masse during China's Cultural Revolution ca. 1966-76. This paper presents a cross-disciplinary study that uses Frame 2646R from U-2 Mission G3203 as the foundation for a 3D reconstruction of the Monastery. The methodology combines shadow analysis, satellite image orthorectification, and architectural rendering with extensive historical research drawn from Tibetan, Chinese, and Western sources. As a digital heritage initiative, it explores 3D modeling alternatives to photogrammetry, a method which requires numerous images to digitally reconstruct a single landmark. For now-destroyed historical sites with little existing visual documentation, shadow analysis presents a unique opportunity for 3D modeling. This paper culminates in two 3D reconstruction results, including: 1) a depiction of building masses on Nartang Monastery's campus based only on shadow analysis and 2) a model with detailed renderings of some of the Monastery's most notable spaces. To reconstruct the latter, sources such as early architectural field work drawings, a thangka painting, and accounts from travelogues contributed to incorporating speculative, stylized features into the shadow-analysis model. Our team of architects and researchers hopes this work informs future collaboration across fields to support cultural heritage preservation, especially in contexts where significant built manifestations of culture are lost.

---

## Keywords:

Built Heritage; Nartang (sNar thang) Monastery; Architectural 3D Reconstruction; Tibetan Monastic Architecture; Historical Aerial Photographs.

## SDH Reference:

Ryavec, Karl, Tenzin Nyandak, and Yumtsokyi Bhum. 2025. "Monastic Architectural Reconstruction From a 1962 U-2 Aerial Photograph of Nartang in Central Tibet." *Studies in Digital Heritage* 9 (1): 1–36.

<https://doi.org/10.14434/sdh.v9i1.39637>

## 1. INTRODUCTION

Throughout the early 12th to mid-20th centuries, Nartang Monastery served as a center for Tibetan Buddhist practice, a home for up to thousands of monks at a time, an educational campus, and a

---

Author's address: Karl Ryavec, Department of Anthropology and Heritage Studies, University of California Merced, 5200 Lake Rd., Merced, CA 95343, USA; email: kryavec@ucmerced.edu; Tenzin Nyandak, Studio Nyandak, 108 East 16th Street, 6th floor, New York, NY 10003, USA; email: tenzin@nyandak.com; Yumtsokyi Bhum, Studio Nyandak, 108 East 16th Street, 6th floor, New York, NY 10003, USA; email: yumtso@nyandak.com

© 2025 by the authors; licensee *Studies in Digital Heritage*, IU, Bloomington (IN), USA. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution License (CC BY-NC 4.0)

renowned printing press for sacred spiritual texts. The Monastery is located in central Tibet, near the city of Shigatse. Though Nartang Monastery's historical legacy as a key site of cultural and religious production endures, its original physical traces have been reduced to scattered outlines of its structural foundations. Having facilitated scripture production with over 100,000 woodblocks of the religious scriptures, Kangyur and Tengyur (Akester 2016), Nartang's original printing press was one of Tibet's largest, at one time producing more scriptures than even the Potala Palace press in the capital city of Lhasa. By 1967, the Cultural Revolution led to the complete destruction of Nartang and its press, one among thousands of other destroyed Tibetan Buddhist monasteries (Fig. 1). Today, Nartang's once tangible presence has been replaced by a few newly built structures that represent parts of the previous campus now retrospectively deemed most significant. One of these buildings is Nartang's new, 1990 printing hall, which currently houses a relatively modest collection of 100 actively used woodblocks (Henss 2014).

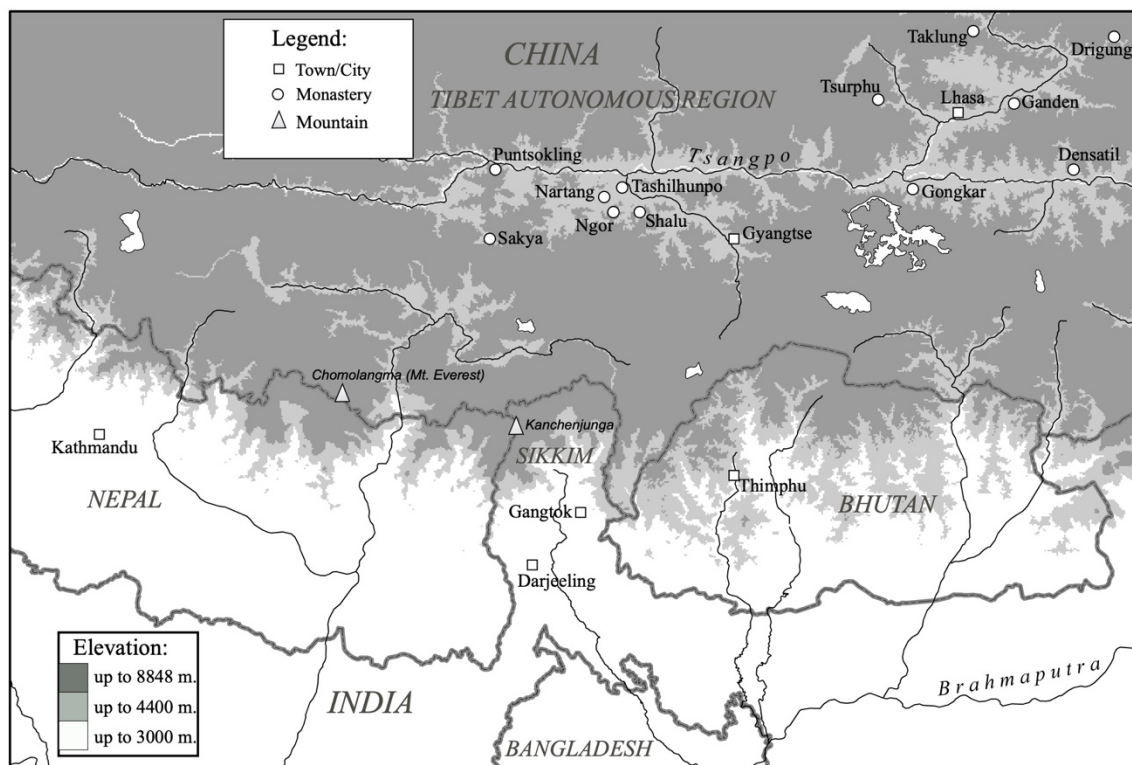


Figure 1. Tibetan Buddhist Monasteries, including Nartang, in Central Tibet (Authors 2025).

A review of studies, historical accounts, travelogues, and guidebooks reveals numerous inconsistencies between Nartang Monastery's architecture as it exists today and as it did in the past. Even the names of the temples at Nartang, such as "Holds 3,000" and "Hall of 10,000," reference holding far more monks than the Monastery's 21st-century population of 40 (Dorje 2004). Acquiring details about Nartang's historical structures and architecture requires searching through sources in numerous languages, formats, and periods to piece together what are often only brief mentions of the

Monastery. Aside from consolidating accounts from diverse sources, this project also introduces a new dataset into the fields of monastic historical studies, cultural heritage preservation, and Himalayan architecture: U-2 Spy Plane aerial photographs of Tibetan Buddhist monasteries prior to their mass destruction.

In 1962, a Lockheed U-2 plane nicknamed "Dragon Lady", took off from an airbase in India and, en route over Nartang, took the highest-resolution aerial image of the Monastery before its destruction only four years later. During the mid-20th century, United States U-2 planes flew at an elevation of 70,000 to 72,000 feet and captured ground, building, and geographical features with remarkable accuracy. With a resolution of approximately 1-meter, their photos over Shigatse and its surrounding regions in the Tibet Autonomous Region (TAR) are far more useful for close analysis than other aerial documentation of the original Nartang Monastery, as obtained from Corona KH-4A satellite imagery in 1965 (2.7 meter resolution) (USGS EROS Archive 2018a) and the Hexagon satellite in 1975 (6-9 meter resolution) (USGS EROS Archive 2018b) (Fig. 2). While these satellite images are useful on a landscape scale, their building-scale level details are nearly impossible to discern. These features make the declassified U-2 images particularly compelling as an evidentiary source to identify and analyze the built environment they captured.

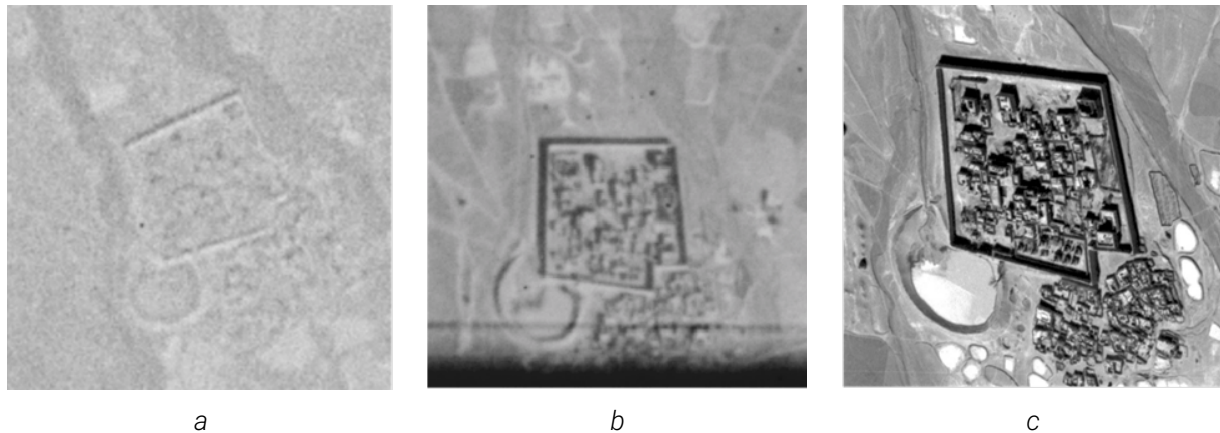


Figure 2. Aerial photographs of Nartang Monastery (north orientation): a) Hexagon Satellite KH-9(1975); b) Corona Satellite KH-4A (1965); c) U-2 Spy Plane (1962).

The previously unstudied frame of film, Frame 2646R from U-2 Mission G3203 (Fig. 3-4), was the basis for our 3D model of Nartang Monastery. The high resolution of the U-2 image allowed us to draw the shapes and masses of the model's buildings on a data-based shadow analysis. The visual depiction was substantiated by in-depth historical research into the design of Nartang's buildings and layout. Our paper thus serves as a cohesive written and visual guide to Nartang Monastery's major structures as they stood before their destruction in the late 1960s. Architectural rendering and historical research informed each other throughout this project, as described in this paper's methodology. The final architectural models are presented in our results.



Figure 3. 1962 U-2 Aerial image of Nartang before its destruction (west orientation) in Frame 2646R of Mission G3203.



Figure 4. Detail of figure 3, focusing on the built environment of Nartang.

Our comparison between modern-day Nartang and the Monastery before it was destroyed does not suggest that the current one lacks spiritual or cultural integrity. Rather, it points to the importance of referring to multimedia historical sources, rather than currently rebuilt structures, for accurate representations of once prominent and revered sacred spaces. Especially in the case of Nartang, along with many of Tibet's early monasteries, built environments arise from community needs, values, and resources. Therefore, analyzing their historical forms has the potential to indicate past societal and cultural patterns. As our analysis will clarify, understanding and documenting historical architecture is pertinent to analyzing and preserving Tibet's cultural heritage.

## 2. LITERATURE REVIEW

Indigenous Tibetan sources on Nartang's pre-1960 layout include a Guide to Central Tibet (Tib. dBus gtsang gnas yig) by Jamyang Khyentse Wangpo (Tib. (1820-1892) ('jam byangs mkhyen brtse'i dbang

po 2020) first translated into English by Alfonsa Ferrari (Ferrari 1958). Recently, there have been sources that provide even greater detail, including: (Akester 2016); Situ Rinpoche's *An Account of a Pilgrimage to Central Tibet during the Years 1918-1920* (Kah thog si tu Chos kyi rgya mtsho 1972) translated by Everding (Everding 2019); and the *History of Nartang Monastery* (Tib. dPal sNar Thang Chos Sde'i Lo Rgyus) (Bstan 1985). Jamyang Khyentse's descriptions reference past accounts of Nartang and provide an overview of the internal spaces in some of its major structures. His text is substantiated by both Situ Rinpoche's guide and the *History of Nartang Monastery*, the former being a first-hand description of Situ Rinpoche's visit to the monastery in the early 1900s, while the latter work is a chronological history of Nartang's abbots. Though these sources are frequently cited throughout the research literature on Nartang and they provide integral details on individual buildings, they do not cohesively or spatially relate these buildings to each other or to the Monastery's wider campus. Of the Tibetan texts that survey historic cultural sites across the region more broadly, *The Blue Annals* (Tib. Bu ston chos 'byung) is especially widely referenced (van der Kuijp 2016).

Western research on traditional Tibetan architectural monuments mainly started with the work of the noted Italian Tibetologist Giuseppe Tucci (1894-1984) who led a number of expeditions to Tibet during the 1920s to 1940s. His resulting *Indo-Tibetica* series in 4 volumes (1932-1941) focuses on iconographic studies tracing the development of Tibetan Buddhist art from its origins in South Asia and includes some plans of key temples where murals and statuary were studied in situ. Tucci was noteworthy as one of the rare western scholars who was able to obtain permission to conduct fieldwork by the Tibetan government in Lhasa before Tibet's annexation by China during the 1950s. It was not until the partial reopening of Tibet to the West during the 1980s that western field-based research on Tibetan heritage sites resumed. More common among early, western accounts of Nartang Monastery are travelogues written by passing visitors. In *Trans-Himalaya Unveiled*, David Fraser recalls the New Year festival rituals he witnessed during his visit to Nartang Monastery in the early 1900s (Fraser 1907), providing an account of the Monastery's spaces in use before its destruction. Sarat Chandra Das's *Narrative of a Journey to Tashilhunpo in 1879* describes similar activity (Das 1881).

During China's closed-door policy of the 1950s to 1960s, teams of official Chinese scholars studied traditional Tibetan architectural monuments among other topics. Most of their findings, including many hand-drawn maps and plans of important monasteries, were not easily accessible in the West and mainly filled volumes of internal-use cultural relics (Ch. Wenwu) inventories conducted by county, provincial, and national-level work teams. Starting in the 1980s, some of these earlier Chinese studies were published along with new research. In the case of Nartang Monastery, hand-drawn floor plans and photographs from 1959 fieldwork conducted by the Chinese archaeologist Su Bai (Su 1996), were included in the Chinese text *Archeological Studies on Monasteries of Tibetan Buddhism* (Ch. Zangchuan Fojiao Siyuan Kaogu) in 1996. This invaluable primary source documents the structures of key spaces within the Monastery campus less than a decade before destruction. Post-1980s Western surveys of historically notable central Tibetan temples and monasteries include Henss' 2-volume *The Cultural Monuments of Tibet*, which features a section on Nartang Monastery (Henss 2014). Also important to mention is Schuman's 2016 dissertation on Nartang monastery during the 12th through 15th centuries (Schuman 2016), which focuses on an earlier part of the Monastery's

history before the creation of the Parkhang Chenmo ("Great Printing Hall") in the 1700s. His in-depth historical review centers religious uses of Nartang's buildings and the abbots who commissioned their constructions and renovations, rather than the architecture or locations of the structures themselves. Space does not permit detailing similar major survey works covering Tibetan Buddhist religious sites in regions beyond the Tibetan Plateau in China, mainly in Mongolian, Indian, Nepalese, and Bhutanese lands.

Digital models of Tibetan cultural and religious monuments are relatively new. Initial work started in the 1990s by the Tibetan and Himalayan Digital Library (now The Tibetan & Himalayan Library) project based at the University of Virginia. Techniques and models derived from video game software were employed to construct virtual renderings of the Meru Nyingpa Monastery in Lhasa (Tibetan and Himalayan Library 2025). Though no peer-reviewed publications have resulted from this project, users can access the architectural plans and, with the right software installed, engage in an online virtual tour of the complex (thlib.org).

The largest collection of published 3D digital architectural models of Tibetan religious monuments is presented in the three-volume series *Buddhist Architecture in the Western Himalayas* edited by Auer and Neuwirth (Auer and Neuwirth 2015). Most of the sites studied are in India. However, the important Tibetan Buddhist monastery of Tholing, included in Vol. 3, is in China because the part of western Tibet where it is located was directly administered by the former Lhasa-based Kingdom of the Dalai Lamas ca. 1642-1950. Tibetologist Roberto Vitali also used Tholing as the subject of a monastic reconstruction model, as detailed in his 1999 book, *Records of Tho Ling: A Literary and Visual Reconstruction of the 'Mother' Monastery in Gu Ge* (Vitali 1999). Vitali's book inspired our study's use of historical texts to inform an estimated identification of and location of individual sacred temples and notable spaces within a monastic campus. Detailed, stylized, and thoroughly researched, his reconstruction in 1999 nevertheless lacked the capacity to utilize more advanced software for digital modeling.

The growth of Digital Heritage research and its applications coincided with the general ban on foreign fieldwork in Tibet after 2008, leading most non-Chinese efforts to study and document Tibetan Buddhist heritage sites to take place in India, Nepal, and Bhutan. An example of contemporary Chinese fieldwork concerned with the 3D modeling of Tibetan Buddhist monuments is presented in (Sun and Zhang 2018). In this study, the authors use drone mapping to derive a 3D exterior model of the famous fifteenth-century multi-storied Gyantse Kumbum (i.e. 'Chorten' or 'Stupa'). The Tibet Heritage Fund, co-founded by Andre Alexander, pairs the study and documentation of ancient Himalayan architecture with hands-on architectural preservation work, focusing especially on Tibetan architecture in Lhasa, Kham, Sikkim, and Ladakh. Their documentation of historical Tibetan monastic and vernacular architecture is featured in a range of publications, including *The Temples of Lhasa: Tibetan Buddhist Architecture 7th to 21st Centuries* (Alexander 2005), *Jokhang: Tibet's Most Sacred Buddhist Temple* (Dorje et al. 2010), *The Lhasa House: Typology of an Endangered Species* (Alexander 2019), and *Lhasa Old City: A Clear Lamp Illuminating the Significance and Origin of Historic Buildings* (Alexander 1999).

Our technical methodology is additionally inspired by the work of interdisciplinary researchers who study and document changes in the built landscapes of other cultural contexts. Digitally reconstructing sites from early aerial photography is an increasingly relevant tool for people in regions that have endured a significant loss of built heritage. Two organizations at the forefront of furthering this scholarship are Forensic Architecture and Bellingcat (Forensic Architecture 2025; Bellingcat 2025). Forensic Architecture Founder Eyal Weizman's book, *Forensic Architecture: Violence at the Threshold of Detectability* (Weizman 2017), includes in-depth descriptions of methods for modeling historically accurate 3D models of built heritage, such as pairing software-driven shadow analyses with references to multimedia verifiable sources. Bellingcat produces similar investigative work, with special emphasis on increasing public access to technologically complex data collection and analysis methods.

Until now, digital reconstructions of Tibetan heritage sites have focused on extant and largely undamaged sites of historical importance. Architectural renderings of now-destroyed sites in other regions are currently pioneered by investigative, data-drive research organizations. Our work with archived U-2 aerial photographs of Tibet presents an unconventional approach to integrating 3D architectural reconstructions with retrospective efforts to recover the material conditions of now-destroyed Tibetan monasteries in their most recent historical states. Based on frequent references in modern scholarship to past material inventories, this glimpse into historical, built heritage is necessary for understanding what these religiously significant structures once held and represented. Our research further argues that tangible monastic influence remains culturally relevant and dynamic in the contemporary landscape, not only during the Medieval and Early Modern periods.

### 3. METHODOLOGY

Initial data collection entailed the high-resolution scanning of U-2 aerial imagery of Nartang Monastery at the National Archives and Records Administration (NARA) in College Park, Maryland. Members of our research team at the architecture firm Studio Nyandak retouched, georeferenced, and scaled these high-resolution images to reconstruct the volume of the monastery complex using Rhino 8, a 3D modeling software. This reconstruction was based on an in-depth shadow analysis that utilized and cross-validated data from existing scholarly research, geographic coordinate data, sun simulating software, and declassified CIA mission reports. Our team prioritized limiting the margin of error for the preliminary shadow-analysis model by utilizing a purely data-based methodology. The goal of the subsequent, speculative model was to architecturally stylize parts of the Monastery by referencing scholarly research and artistic depictions of Nartang.

#### 3.1 Aerial Film Georeferencing

##### 3.1.1 Locating Nartang in U-2 aerial film frames

The U-2 photograph of the Nartang Monastery campus and its surrounding village is part of a series of images captured across the length of a single U-2 mission, G3203, which took place on December 10, 1962. The declassified report for Mission G3203 includes a series of maps of the U-2 plane's flight

path over Central Tibet. The original Nartang Monastery existed until 1967, and therefore still stood in Central Tibet when mission G3203 surveyed the region. Plotting Nartang on the flight path map (Fig. 5), confirms that the historical monastery would have specifically been captured by Frames 2646R of U-2 Mission G3203's film rolls (Fig. 6).

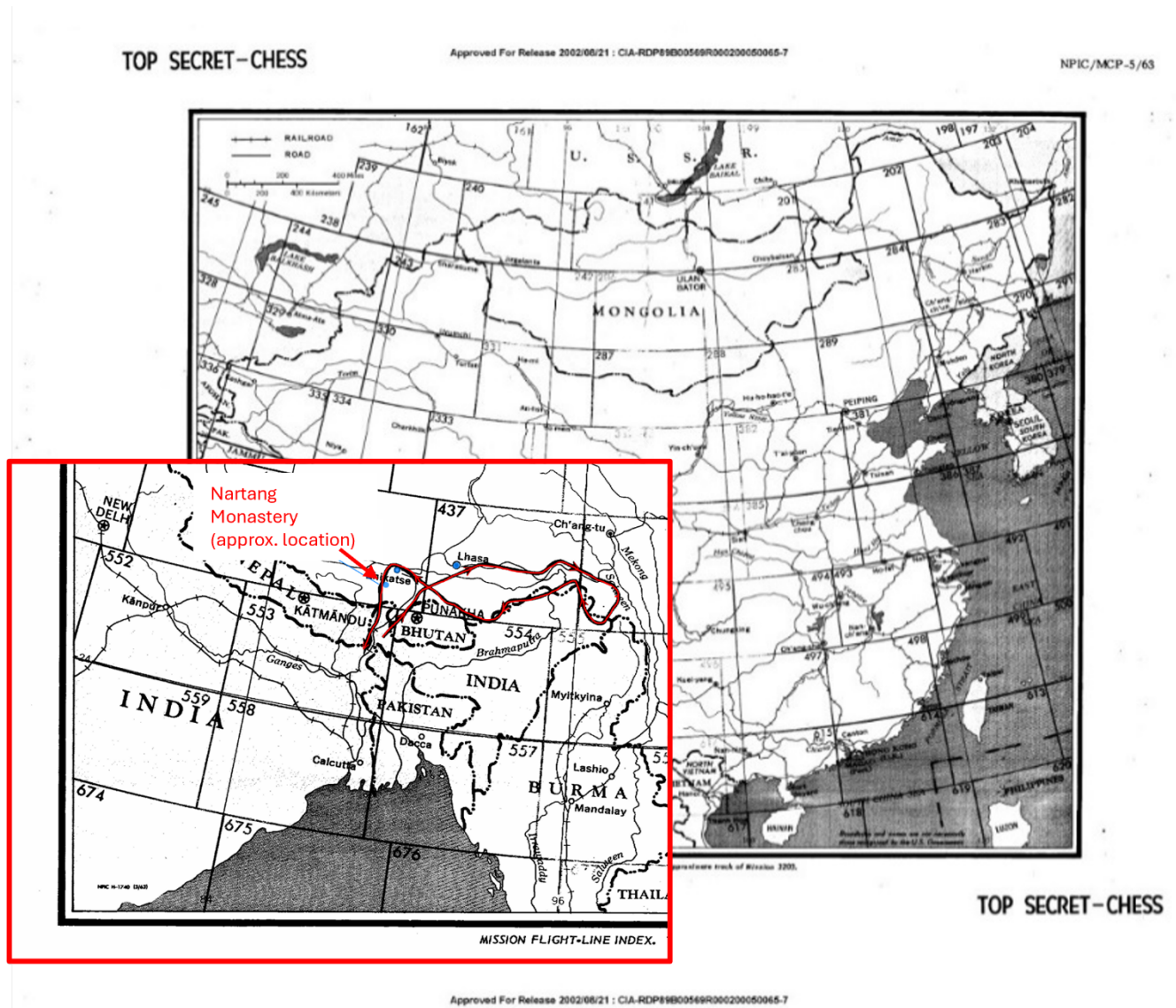


Figure 5. Map of Mission G3203 (National Photographic Interpretation Center 1963) with indicated location of Nartang Monastery.

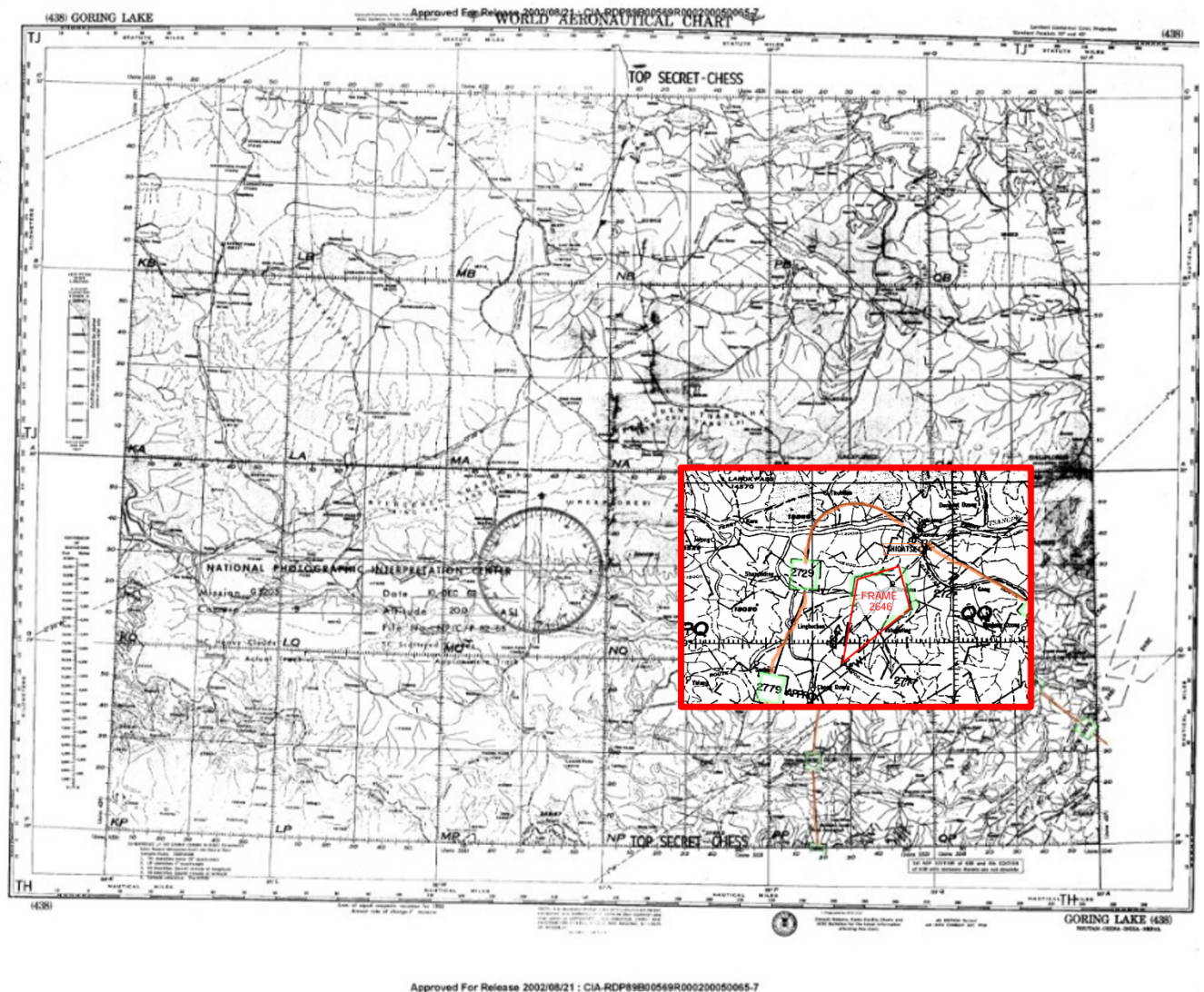


Figure 6. Film Frame 2646R mapped on Mission G3203's flight path (National Photographic Interpretation Center 1963).

The public can request U-2 film rolls from NARA for viewing and scanning. After acquiring a high-resolution scan of Frame 2646R (Fig. 3), our research team had a base from which to build a 3D model.

### 3.1.2 Correcting the angle of the Nartang aerial photo

To accurately detect and render the masses of the structures in the U-2 image, we orthorectified the image's topographic distortion. This required georeferencing the image by plotting corresponding

Ground Control Points (GCP) along the campus and surrounding village of the 1962 U-2 image of Nartang Monastery and a 2021 satellite image of the rebuilt Nartang Monastery (Fig. 7-10).

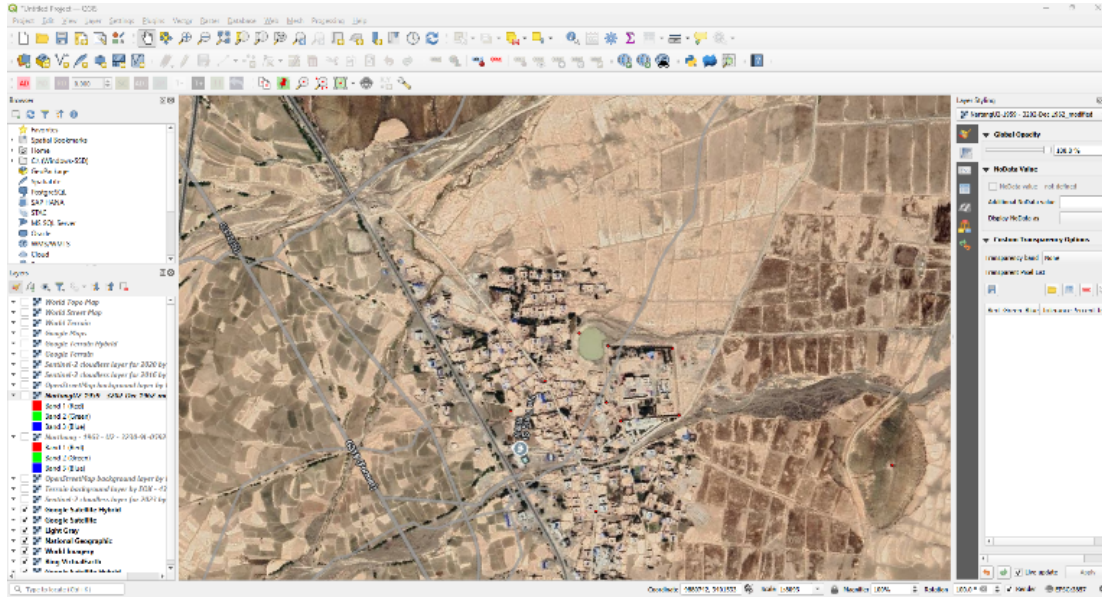


Figure 7. GCP were plotted along the 2021 Google Earth Satellite image of Nartang Monastery.

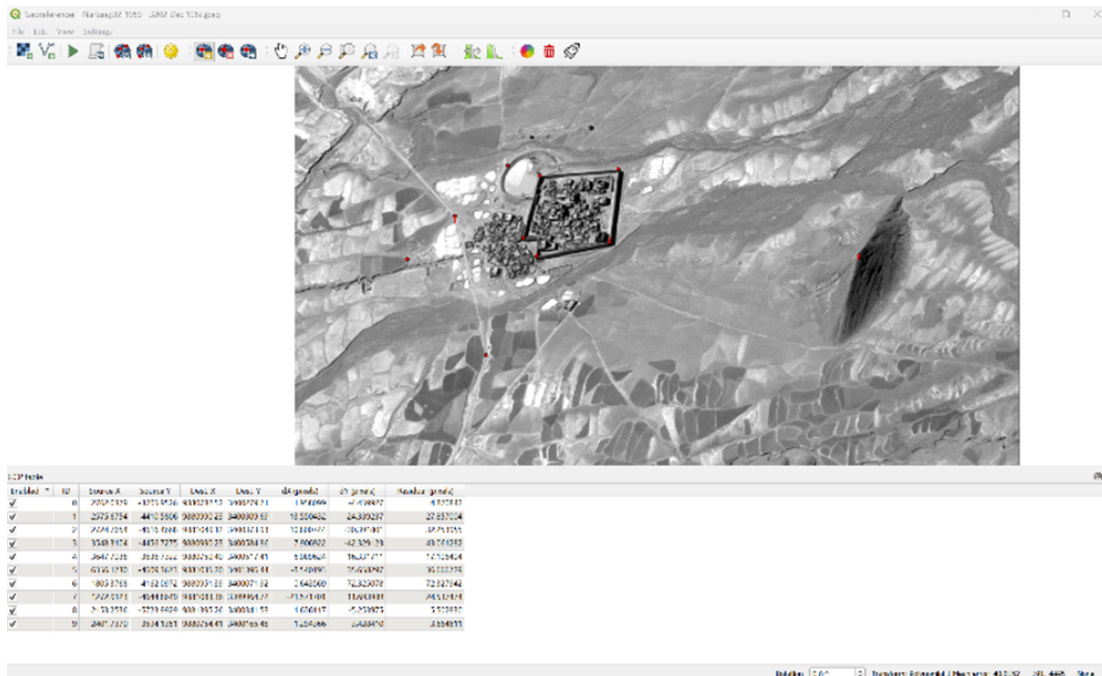


Figure 8. The corresponding GCP plotted on the 1962 U-2 image of Nartang Monastery.

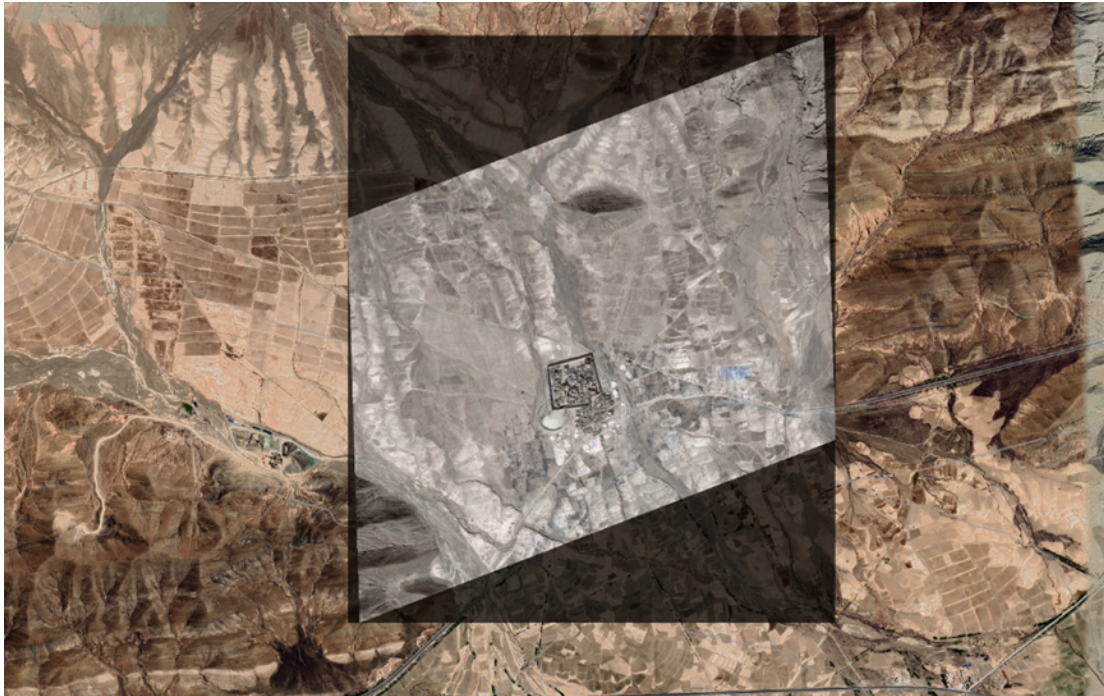


Figure 9. The U-2 image was overlaid on the 2021 satellite basemap by aligning the GCP.

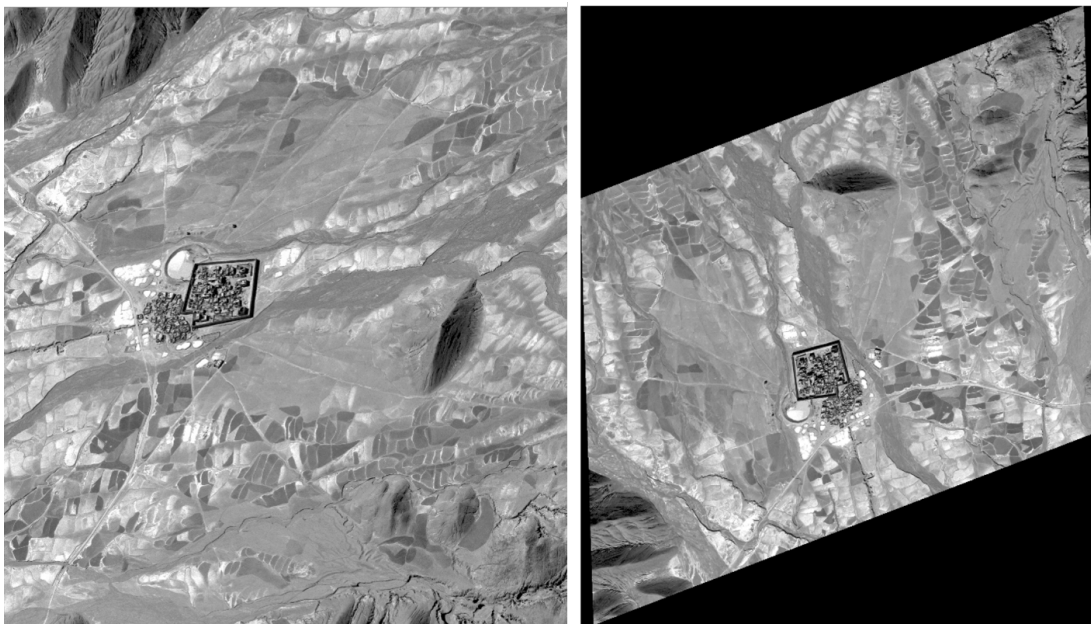


Figure 10. Before (left) and after (right) adjusting the distortion of the angled image. The corrected image (right) is oriented true North.

### 3.1.3 Image analysis and scaling

With the film frame image georeferenced (tied to a Pseudo-Mercator Coordinate Reference System), we could use the 2D aerial image as a base for a 3D model. Our team chose shadow analysis as a method for 3D modeling due to the high resolution of the U-2 image and this method's increasingly common use in the field of architectural studies for creating 3D models from aerial images (Weizman 2017; Bellingcat 2025).

To render the masses of the structures proportionally in size to each other, we needed to find a structure-to-shadow ratio that we could apply across Nartang's campus. This required knowing the height of at least one structure and the angle at which the sun hit it in the photo. For the former, we referenced previous research that estimated the height of the Monastery's original enclosure wall to have been 5 meters high (Akester 2016). To find the latter data point, we first verified the time that the U-2 photograph was taken. Generally, each U-2 film frame includes a snapshot of a UTC-time clock frozen at the moment of the photo, but the clock face pictured on Frame 2646R is unclear (Fig. 11). Although the timestamp for our reference image is not decipherable, the nearby Frame 9L 2639 captures the nearby town of Shigatse, according to the Mission Flight-Line Index, and shows a timestamped clock marked 06:30:24 UTC. Based on the known speed of travel of the U-2 plane, Frame 2646R would have then been captured at approximately 06:30:45 UTC. This converts to a local Peking Time of 14:30.

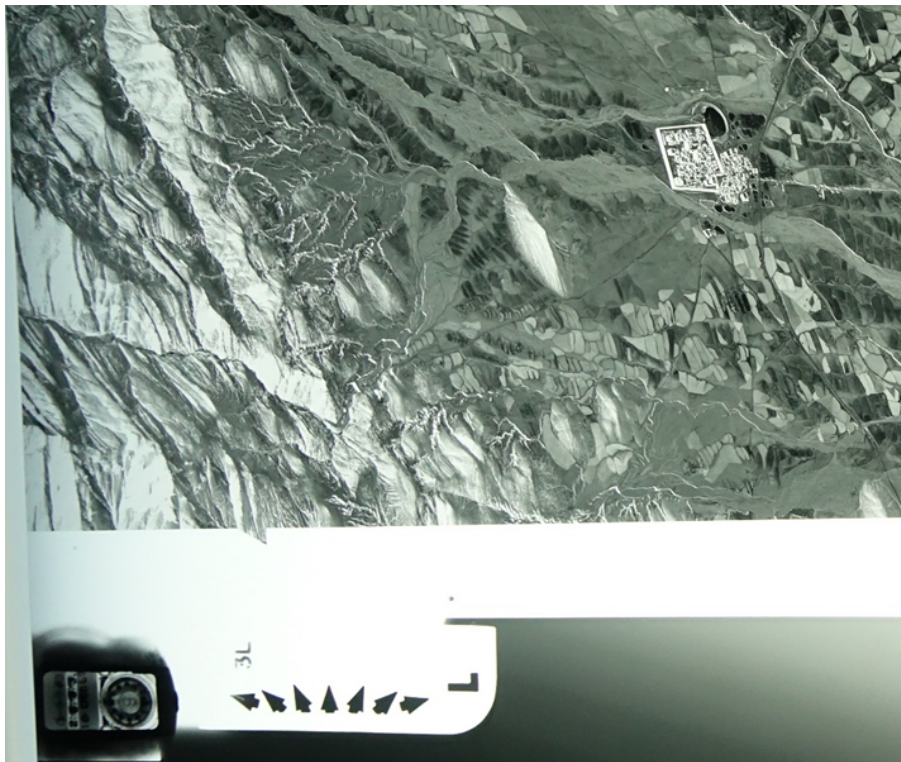


Figure 11. Illegible clock face at the bottom left corner of the low-resolution film frame scan.

To verify the reconstructed timestamp of 14:30 local time, we first measured the length of the shadow on the U-2 image and then calculated its length based on its proportion to the wall itself, known to be 5 meters tall. The precision of our shadow measure depended on the resolution of the image, and we assumed a range of possible shadow heights, rather than one precise measure. We then ran Nartang's geographic coordinates and the height of the enclosure wall through SunCalc, an online shadow analysis tool, to generate the changing length of a shadow cast by a 5-meter-high object throughout the course of one day (December 10, 1962). Fig. 12 shows the SunCalc output table. The range of possible shadow heights, as detected at the resolution of the U-2 image, led us to assume a reasonable window of time that the image could have been taken at to be between 13:00-14:45 hours. The assumption of 14:30 using the speed/distance/time calculation method fell within this window.

daily data for: Qumig, Samzhubzê District, Shigatse, Tibet Autonomous Region, CHN  
lat: 29.19454°, lon: 88.76165°, on 10.Dec.1962

Time	Azimuth	Altitude	Shadow length (object height: 5m)
08:45	115.58°	+0.66°	n/a
09:00	117.41°	1.88°	152.04m
09:15	119.32°	4.63°	61.80m
09:30	121.32°	7.39°	38.53m
09:45	123.42°	10.13°	27.99m
10:00	125.62°	12.81°	22.00m
10:15	127.94°	15.41°	18.13m
10:30	130.39°	17.94°	15.44m
10:45	132.98°	20.38°	13.46m
11:00	135.71°	22.72°	11.94m
11:15	138.59°	24.94°	10.75m
11:30	141.65°	27.03°	9.80m
11:45	144.87°	28.99°	9.03m
12:00	148.27°	30.79°	8.39m
12:15	151.84°	32.42°	7.87m
12:30	155.59°	33.87°	7.45m
12:45	159.49°	35.11°	7.11m
13:00	163.54°	36.15°	6.84m
13:15	167.72°	36.96°	6.64m
13:30	172.00°	37.54°	6.51m
13:45	176.35°	37.87°	6.43m
14:00	180.72°	37.95°	6.41m
14:15	185.09°	37.78°	6.45m
14:30	189.42°	37.37°	6.55m
14:45	193.66°	36.71°	6.70m
15:00	197.80°	35.83°	6.93m
15:15	201.81°	34.72°	7.22m
15:30	205.66°	33.40°	7.58m
15:45	209.35°	31.89°	8.04m
16:00	212.86°	30.20°	8.59m
16:15	216.20°	28.34°	9.27m
16:30	219.36°	26.34°	10.10m
16:45	222.36°	24.20°	11.13m
17:00	225.19°	21.94°	12.41m
17:15	227.87°	19.57°	14.07m
17:30	230.41°	17.10°	16.25m
17:45	232.81°	14.54°	19.27m
18:00	235.09°	11.91°	23.71m
18:15	237.26°	9.21°	30.83m
18:30	239.32°	6.46°	44.14m
18:45	241.28°	3.69°	77.46m
19:00	243.17°	1.00°	287.61m
19:15	244.97°	-1.65°	n/a

Figure 12. Table displaying varying shadow heights over time for a 5-meter structure at Nartang Monastery's geographic coordinates on 12/10/1962 (SunCalc.org 2025).

This use of multiple data points allowed us to scale the image of Nartang Monastery's campus, find the shadow length of the enclosure wall, and subsequently the structure-to-shadow height ratio in

the U-2 image (Fig. 13). Repeating this process using other methods and data points simultaneously cross-checked each data point and allowed for a more precise measure, with a lesser degree of uncertainty, from which to build the model.



Figure 13. Orthorectified and scaled U-2 image of Nartang Monastery.

### 3.2 Shadow Analysis 3D Model

The following Results section displays a series of 3D models that resulted from our shadow analysis methodology. The orthorectified 2D aerial U-2 image of the campus outlines the campus's structures, and the subsequent 3D model builds up the heights of the structures according to the found shadow-to-structure height ratio. We began by building the mass of the enclosure wall according to the length of the shadow pictured on the U-2 image. We used this same ratio in Rhino 8 to build the masses of other structures within Nartang's campus, so that the heights of the structures in our final shadow-analysis 3D rendering are in correct proportion to each other.

### 3.3 Identifying and Stylizing the Campus Rendering

Simultaneously to the shadow analysis, written and visual records of Nartang also informed our 3D rendering. Using primary source floor plans and visual documentation of Nartang's structures allowed us to add material and ornamental details to the 3D model that were not distinguishable from the U-2 image alone. These primary sources include Su Bai's floor plans of Nartang in the 1950s (Su

1996), and Guissepe Tucci's photograph of Nartang's most prominent Stupa. Further research of existing scholarly literature on Nartang and artistic depictions of Nartang contributed to our mapping of the layout of the Monastery's major buildings, along with descriptions of their architecture and internal chapels. In the final stage of our project, we consolidated our technical modeling and historical research by creating speculative and stylized models of the Monastery campus. Below, we review evidence from existing literature on and artwork of Nartang that informed our identification and stylization of notable structures depicted on the 3D model.

### 3.3.1 Enclosure Walls

Nartang Monastery's historical borders, fractions of which remain today, were outer enclosure walls built from packed mud bricks during the 14th century by the Monastery's 13th abbot, Kunga Gyeltsen (Akester 2016). He built these walls around an existing ring of enclosure walls that the Monastery's 8th abbot constructed in the 13th century (Schuman 2016). Two sources point to the location of the Monastery's entrance. Akester's translation of Jamyang Khyentse's first-hand account of Nartang notes that the original entrance to Nartang Monastery was located on the south wall, a claim supported by an 18th-century painted thangka that includes a depiction of Nartang (Fig. 14). In this section of a thangka depicting various Tibetan monasteries, the entrance is on the south wall, toward the western side of the complex. This was corroborated from the shadow analysis.



Figure 14. Entrance toward the western side of the south enclosure wall (Himalayan Art Resources 2025).

Additionally, low village houses situated in the foreground of the painting just outside Nartang's south wall in the Thangka painting are only present on the south side of the Monastery in the U-2

image. The tops of the reliquary chorten depicted in Fig. 14 also only border the south wall of Nartang in the U-2 image.

### 3.3.2 Chorten

The chorten at Nartang were arranged in rows running east to west along the inside of the south enclosure wall (Akester 2016). Some were funerary tombs for mummified remains of Nartang's past abbots—the third through eleventh. From the U-2 photo, at least 11 chorten are clearly visible. Existing literature on Nartang also estimates there to have been 10-13 chorten in total. The tallest among them was called Tashigomang, dedicated to the 7th abbot, Chim Losang Drak (Akester 2016; Henss 2014).

### 3.3.3 Tashigomang ('Kumbum Chorten/Stupa')

Tashigomang Chorten, also referred to as "Kumbum Chorten" (Henss 2014, 688), was the largest and most intricate at Nartang Monastery, standing out among the two rows of reliquary chorten (Akester 2016). Tashigomang was also the first stupa to be reconstructed, in 2006, and its inner chapels' paintings were restored by 2007 (Henss 2014). Fig. 15 shows that the location of this first restored chorten at Nartang Monastery was the westernmost spot in the northernmost row of the two rows of chorten. The U-2 image shows the chorten in this location to be especially large indicating this is most likely the original location.



Figure 15. Nartang Monastery's first rebuilt chorten, Tashigomang (Google Earth 2011).

### 3.3.4 Sumtong-Ding ('Temple of Three Thousand')

Sumtong-Ding was a massive central temple on Nartang Monastery's campus, its name translating to "holds three thousand." Revisiting the thangka image of Nartang (Fig. 14), one especially tall building is visible, red, and located towards the center of the monastery. Inside it a large golden Sakyamuni Buddha is depicted. This temple is likely the Sumtong-Ding, famous for holding a "larger than life bronze statue of the Buddha" (Schuman 2016, 127). Fig. 14 also illustrates the impressive height of the temple, which was, before the Parkhang was constructed, "the tallest of Nartang's buildings" (Akester 2016, 567). Our shadow analysis detected this building as the second tallest building at Nartang Monastery, years after Parkhang Chenmo's construction.

Another factor that influenced our situating of Sumtong-Ding is that the temple was built to the east of the Temple of Three Realms (Akester 2016). The Temple of Three Realms was Nartang Monastery's first assembly hall, later incorporated in Parkhang Chenmo during the Printing Hall's early-1700s expansion.

### 3.3.5 Parkhang Chenmo ('Printing Hall')

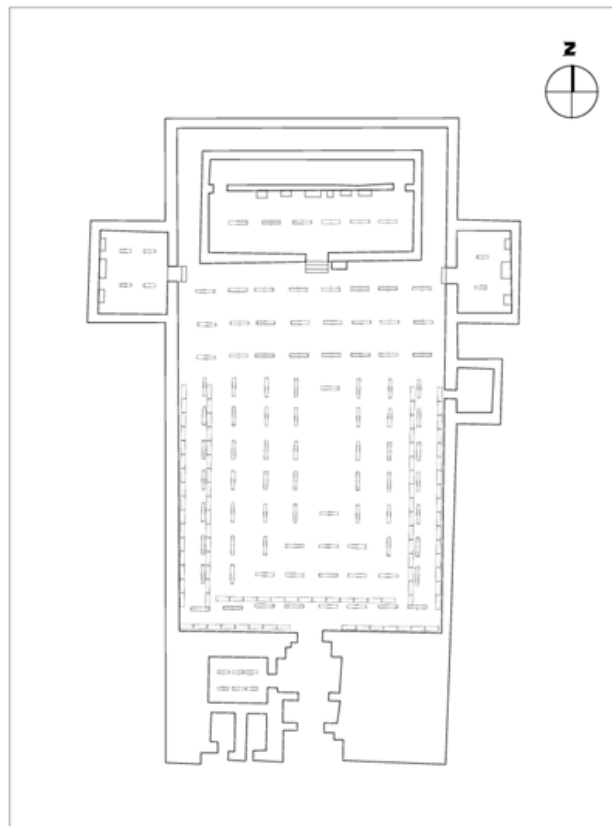


Figure 16. Floor plan of Parkhang Chenmo, redrawn by the authors from (Su 1996).

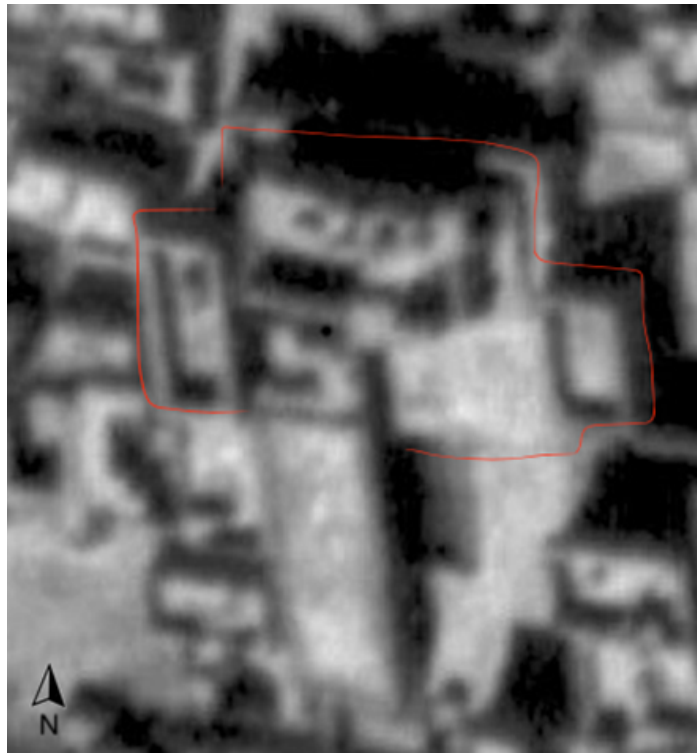


Figure 17. U-2 Image of Parkhang Chenmo with Temple of Three Realms portion traced.

The process of identifying Sumtong-Ding, alongside multiple scholarly sources, suggests that the largest building just west of Sumtong-Ding (Akester 2016) would have been Nartang Monastery's Parkhang Chenmo. Parkhang Chenmo was built as an extension of the Temple of Three Realms, once the main assembly hall. Su Bai documents this renovation history extensively, accompanying his floor plan (recreated by this paper's Authors in Fig. 16) of the conversion with written descriptions in his field notes. The northern half of his floor plan depicts what was previously the Temple of Three Realms, and the southern half what was once its courtyard. The courtyard was later merged with the Temple's front hall to serve as an 88-pillared assembly hall. This hall, called 'Khri Khang,' was extended in the mid-to-late 1700s to become the 108-pillared main printing hall of Parkhang Chenmo (Henss 2014). Fig. 17 shows the U-2 aerial view of Parkhang Chenmo. The outline of Su Bai's floor plan of Parkhang Chenmo, and especially of the two rooms connected to either side of the old Temple of Three Realms, matches the shape of the building pictured in Fig. 17.

Dorje states that the remains of the original Parkhang Chenmo lie to the rear of the 1990s rebuilt one and that this new Parkhang is part of a newly built courtyard (Dorje 2004). Fig. 18 shows to the west of Nartang's new courtyard a wide-open space with raised patches of earth that slowly disappear over time in Google Earth imagery in proceeding years. Given that every other building in the courtyard has either new construction or chorten situated directly to their rear, this site of demolition helped point to the location of the original Parkhang Chenmo.



Figure 18. New Parkhang and nearby demolition remains (Google Earth 2011).

#### 4. RESULTS

Displayed in Fig. 19 is the 3D model of Nartang Monastery, using as its base a scaled 1962 U-2 aerial photograph. The buildings on the campus and their volumes, locations, courtyards, and parapets, were all reconstructed using shadow-detection and 3D modeling software. Fig. 20 identifies five of the Monastery's primary built structures, Parkhang Chenmo, Sumtong-Ding, Chorten, Tashigomang, and the Outer Enclosure Walls. Subjects of more historical texts, floor plans, and images, we were able to render these specific structures with greater design detail. The following section consolidates and reviews existing sources which have informed this model's production and stylization of the Monastery's foremost components.

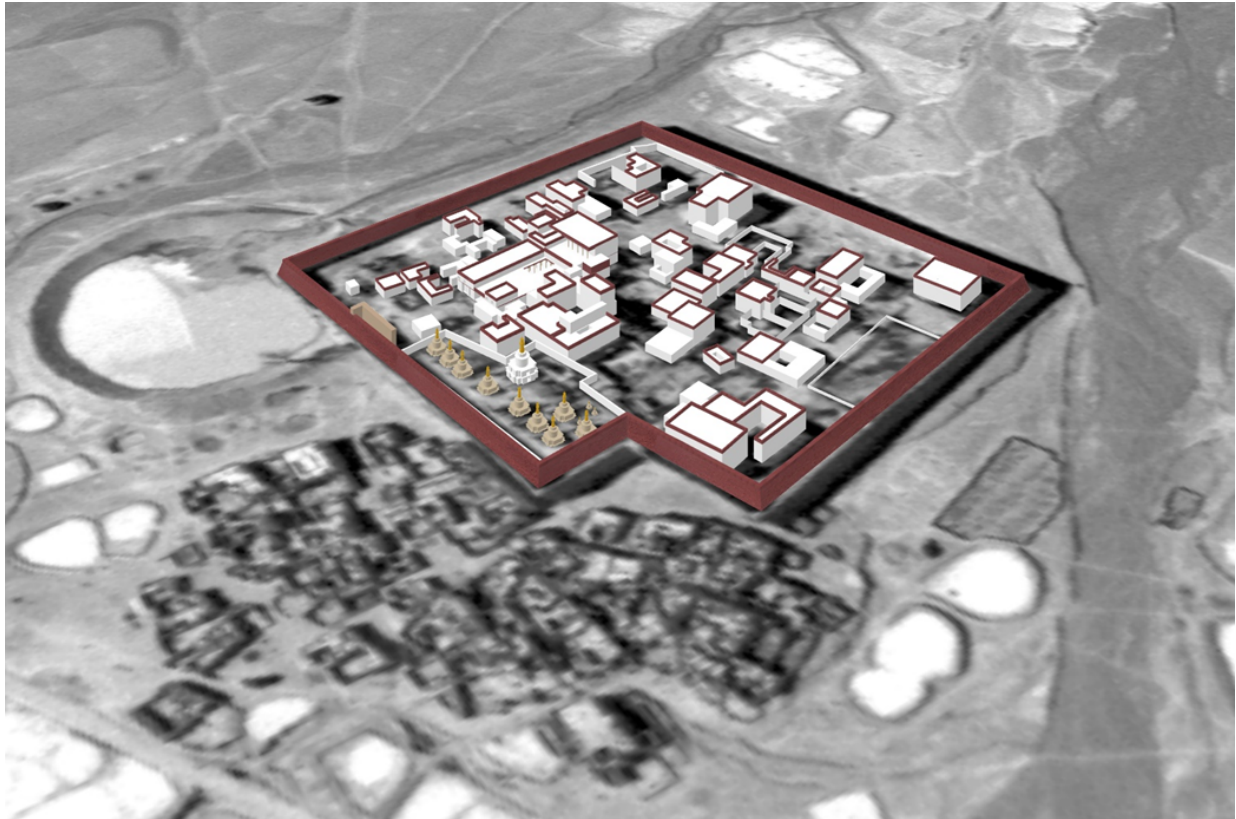


Figure 19. 3D model of Nartang Monastery (Studio Nyandak 2025).

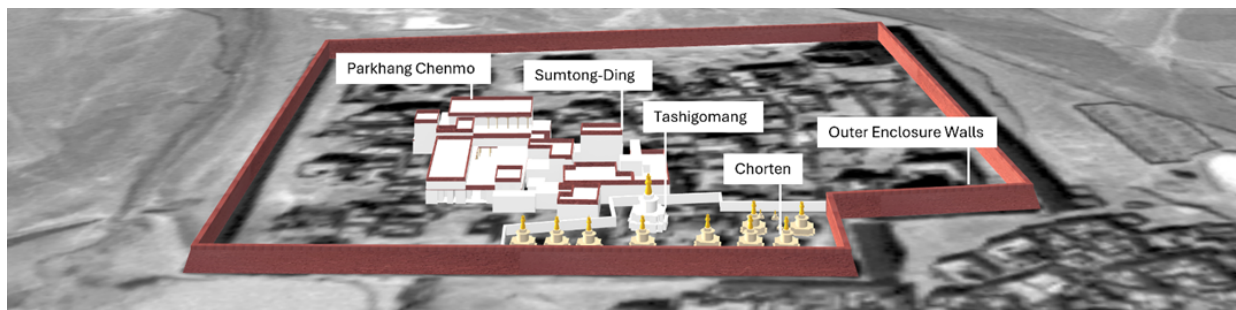


Figure 20. Nartang Monastery detailed rendering with identified structures labeled (Studio Nyandak 2025).

#### 4.1 Enclosure Walls

By the 18th century, multiple rings of enclosure walls encircled the monastery. Abbot Kyoton Tsultrim's inner walls of the 1200s were square and served in part as a defensive, fortress-like protection for the monastery. This early design was practical given the tension created by a contemporaneous civil war between the Drikung Kagyu and Sakya sects near the Monastery at the

time. The later outer walls had a perimeter of about 800 meters (Schuman 2016) and were made of about 14 layers of packed mud bricks (Akester 2016; Schuman 2016). While some historians reference the outer enclosure walls to have been white, our model bases its speculative dark red wall finish on the Thangka depiction of Nartang (Fig. 14) and the traditional earthen material composition. The buildings within the walls were mostly whitewashed (Das 1881; Lange 2020), and generally tightly packed together to shield inhabitants from heavy, dusty winds common in the arid region (Akester 2016).

## 4.2 Parkhang Chenmo

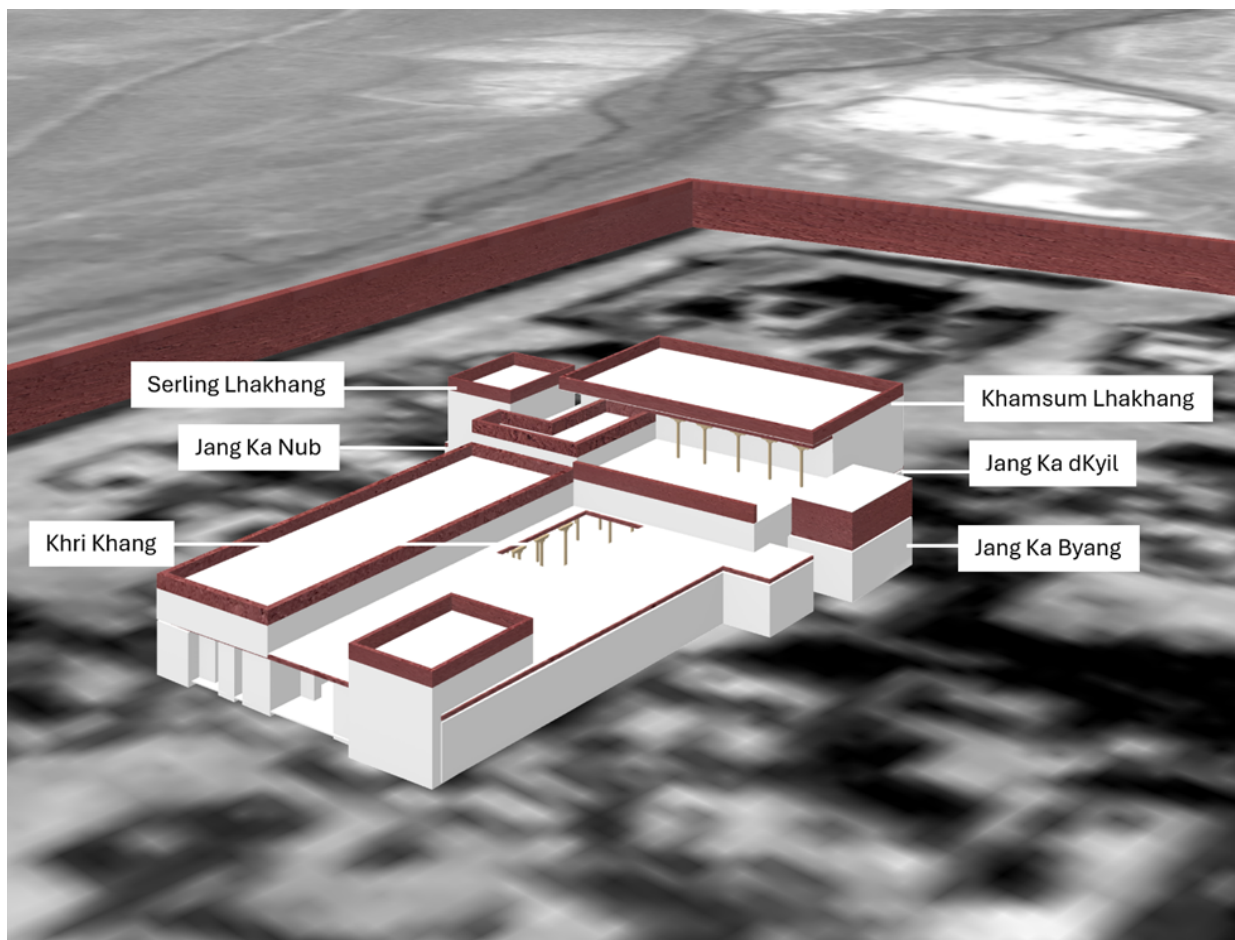


Figure 21. Parkhang Chenmo rendering with labeled chapels (Studio Nyandak 2025).

The printing hall was supported by 108 pillars made from various tree species, including Juniper and Sandalwood (Akester 2016). Barely processed, their bases resembled natural tree trunks. This 108-pillared Printing Hall was converted from a previously 88-pillared (Henss 2014) “Khri Khang,” or ‘Room of 10,000,’ once an assembly hall for 10,000 monks (Everding 2019). Though this conversion occurred

in the 18th century (Schuman 2016), it incorporated old structures so that parts of Parkhang Chenmo reflected 13th-century architecture that “at least partly existed around 1960” (Henss 2014, 683).

The converted Khri Khang held sacred objects from its original use and printing materials for its new products, the Buddhist Kangyur and Tengyur texts (Schuman 2016). Over 100,000 woodblocks were estimated to have been stored in the Khri Khang and used to print these texts (Su 1996; Akester 2016). Additionally, some larger carved blocks were used to print sacred drawings on paper, such as a set depicting the live stories of the Panchen lamas Nartang was also famous for. Many thangka painters copied these drawings for patrons across the Tibetan Buddhist world. During his visit to Khri Khang, Situ recalls that “on the head side,” there was one bronze Buddha statue surrounded by several other statues and thousands of scripture prints (Everding 2019, 263). Here, Situ likely describes what other scholars refer to as Khri Khang’s main sanctum, or “Jang Ka dKyil” (Akester 2016; Bstan 1985). Jang Ka dKyil was previously part of the Three Realms Temple before its incorporation into the Parkhang Chenmo complex (Fig. 21). Therefore, when Situ visited Parkhang Chenmo, Jang Ka dKyil must have been in a separate, but connected, room to the Khri Khang.

In the center of Jang Ka dKyil was a large, bronze Sakyamuni. Smaller statues surrounded it, including one depicting Vajra Bodhisattva and other Buddhist figures (Su 1996; Akester 2016; Everding 2019). To the rear of the sanctum, behind the Sakyamuni, was what Su Bai describes as a “fan door” that led to two chapels that flanked Jang Ka dKyil, Jang Ka nub and Jang Ka Byang (Su 1996). These chapel names indicate their respective locations, “nub”, Tibetan for ‘west,’ “dKyil,” Tibetan for ‘center,’ and “byang,” for ‘north.’

“Jang Ka Nub” was also once part of Three Realms Temple (Akester 2016; Bstan 1985). It was a four-pillar chapel with a medicinal, “fire-resistant” clay Buddha (Akester 2016) and a massive iron pot or tea cauldron. (Everding 2019) describes this vessel as having eighteen handles and (Akester 2016, 263 and 568) as “supposed to have been a treasure revealed from the earth”. Everding, the translator of Situ Rinpoche’s guide, states that the pot was once used by many monks in an assembly hall when the Monastery had its peak enrollment and later went unused and stored in the chapel due to a sharp decrease in monastery population (Everding 2019, 265n1).

To the other side of Jang Ka dKyil was the two-pillared “Jang Ka Byang” (Akester 2016). Multiple sources confirm that it was located across from Jang Ka Nub (Su 1996; Akester 2016), but because “byang” means ‘north,’ it may have also been positioned more northward. This chapel too held a clay Buddha, this one called “water-resistant” (Akester 2016, 568). Jang Ka Byang was a protector chapel that held an image of Tara, “the implements and substances for the fulfillment ritual” (Bstan 1985, 7), and was also once part of the Temple of Three Realms.

With Jang Ka dKyil, Jang Ka Nub, and Jang Ka Byang on the ground floor of the Temple of Three Realms section of the 1700s Parkhang Chenmo complex, the floor above held the 6-pillared Khamsum Lhakhang (Bstan 1985), positioned above the main sanctum (Fig. 21). The first floor also held the 4-pillared Serling Khang, positioned above Jang Ka Nub (Akester 2016). Khamsum Lhakhang held a life-size bronze Buddha in the form of Aksobhya (Akester 2016; Su 1996) and one in the form of Khasarpani, surrounded by bronze statues of Maitreya and the Bodhisattva Padmapani (Everding 2019).

The Buddha was also the main image of Serling Lhakhang, the other first-floor chapel. The statue was the length of a yard (Everding 2019), covered first in gold and then by an outer layer of clay (Akester 2016). Serling Lhakang also held numerous bronze statues, three clay statues of Atisa and his two main disciples, and a scripture written in gold ink (Everding 2019; Akester 2016).

Fig. 22 is a labeled floor plan of Parkhang Chenmo, based on Su Bai's 1959 drawing (Su 1996). It includes the Temple of Three Realms and its patio, after being incorporated into the later built Khri Khang. This labeled image interprets Su Bai's drawing from an aerial perspective, showing the upper, first-floor chapels—Khamsum Lhakhang and Serling Khang—obstructing the view of the chapels below them, Jang Ka dKyil and Jang ka Nub, respectively. Su Bai's floor plan depicts an assembly hall of 88 pillars, which he estimates to be nine rooms wide and eleven rooms deep in size (Fig. 23). Therefore, the Khri Khang depicted here likely does not show the part of the extension that made Parkhang Chenmo 108-pillared.

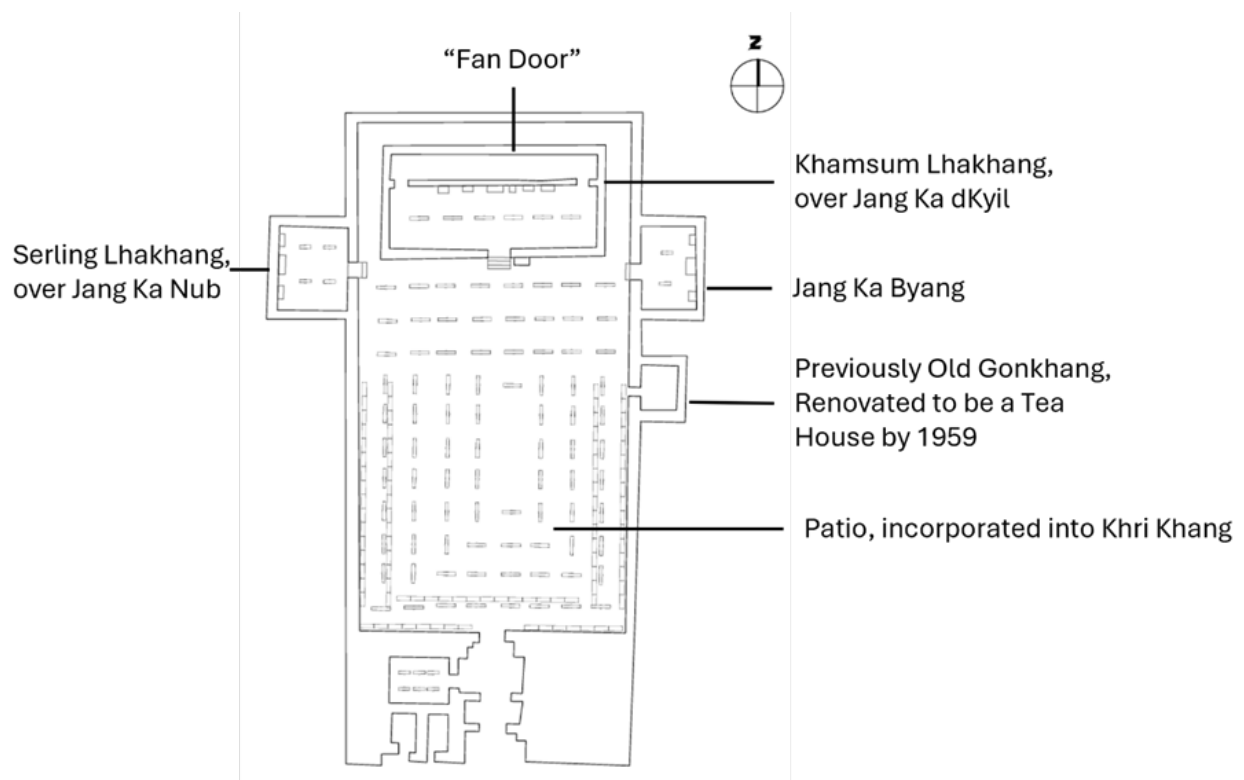


Figure 22. Floor plan of Parkhang Chenmo redrawn from (Su 1996) and labeled by Authors.

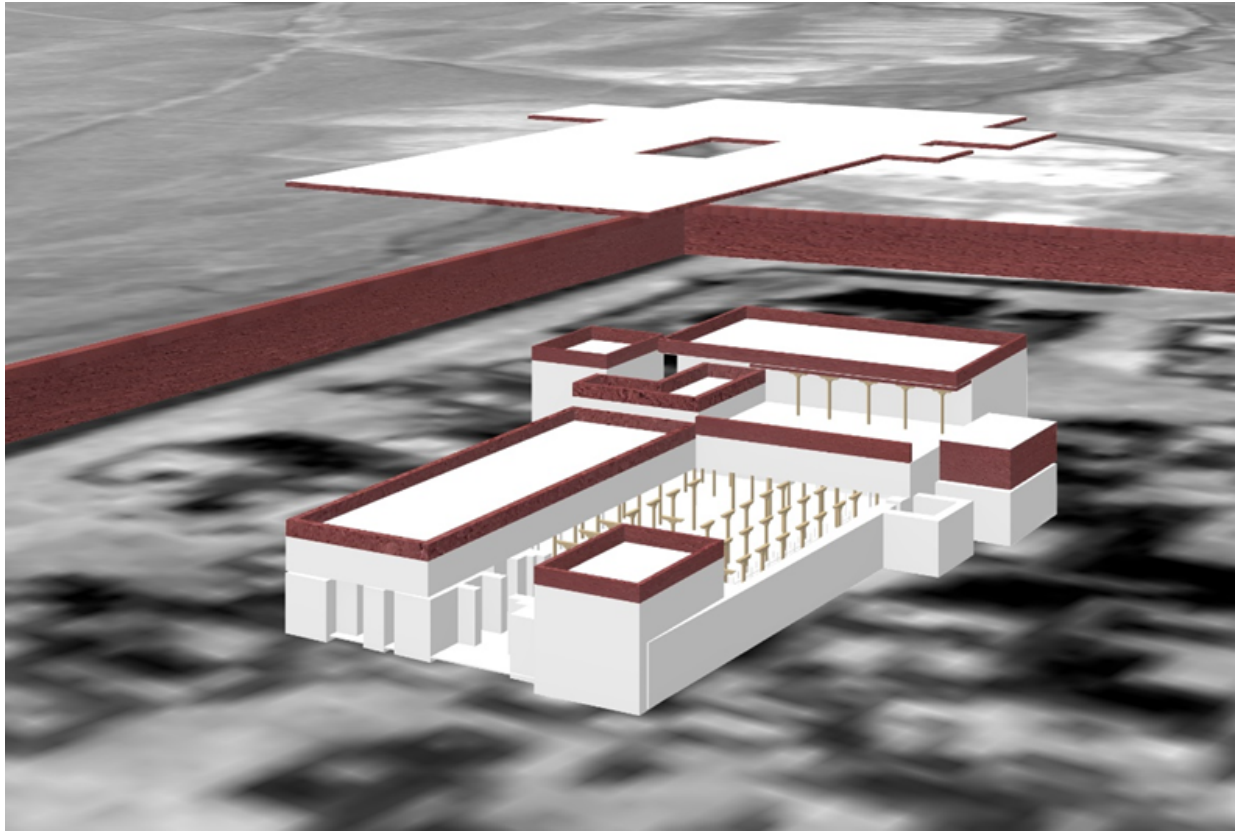


Figure 23. Parkhang Chenmo rendering with Khri Khang roof removed to exhibit floor plan and pillars (Studio Nyandak 2025).

### 4.3 Sumtong-Ding

Before the construction of Parkhang Chenmo in the 1700s, Sumtong-Ding was the “tallest of Nartang’s buildings,” consisting of multiple stories of chapels (Fig. 24) and incarnate lamas’ apartments (Akester 2016, 567). After Parkhang Chenmo was erected, 35 chapels are estimated to have existed between the two expansive buildings (Akester 2016). Sumtong-Ding was commissioned and designed by Nartang Monastery’s 7th abbot, Chim Namkha Drak, in the 13th century (Schuman 2016). The records of Su Bai and Situ Rinpoche, who both visited the Temple before its destruction, provide integral insight into the layouts of Sumtong-Ding’s chapels (Su 1996). While Su Bai describes Sumtong-Ding in one cohesive section of his text, Situ Rinpoche intersperses his descriptions of its chapels with that of the Parkhang. One can infer that his path was not random, as the succession of chapels within buildings he visits—Tara Hall and Lama Lhakang, Khamsum Lhakang and Serling Khang, Maitreya Hall, and Sumtong-Ding’s main assembly hall—are located next to or directly above and below each other. So, while the following description and visualization of Sumtong-Ding takes his route into account when estimating the locations of Sumtong-Ding’s chapels, it primarily uses Su Bai’s account, focused specifically on Sumtong-Ding.

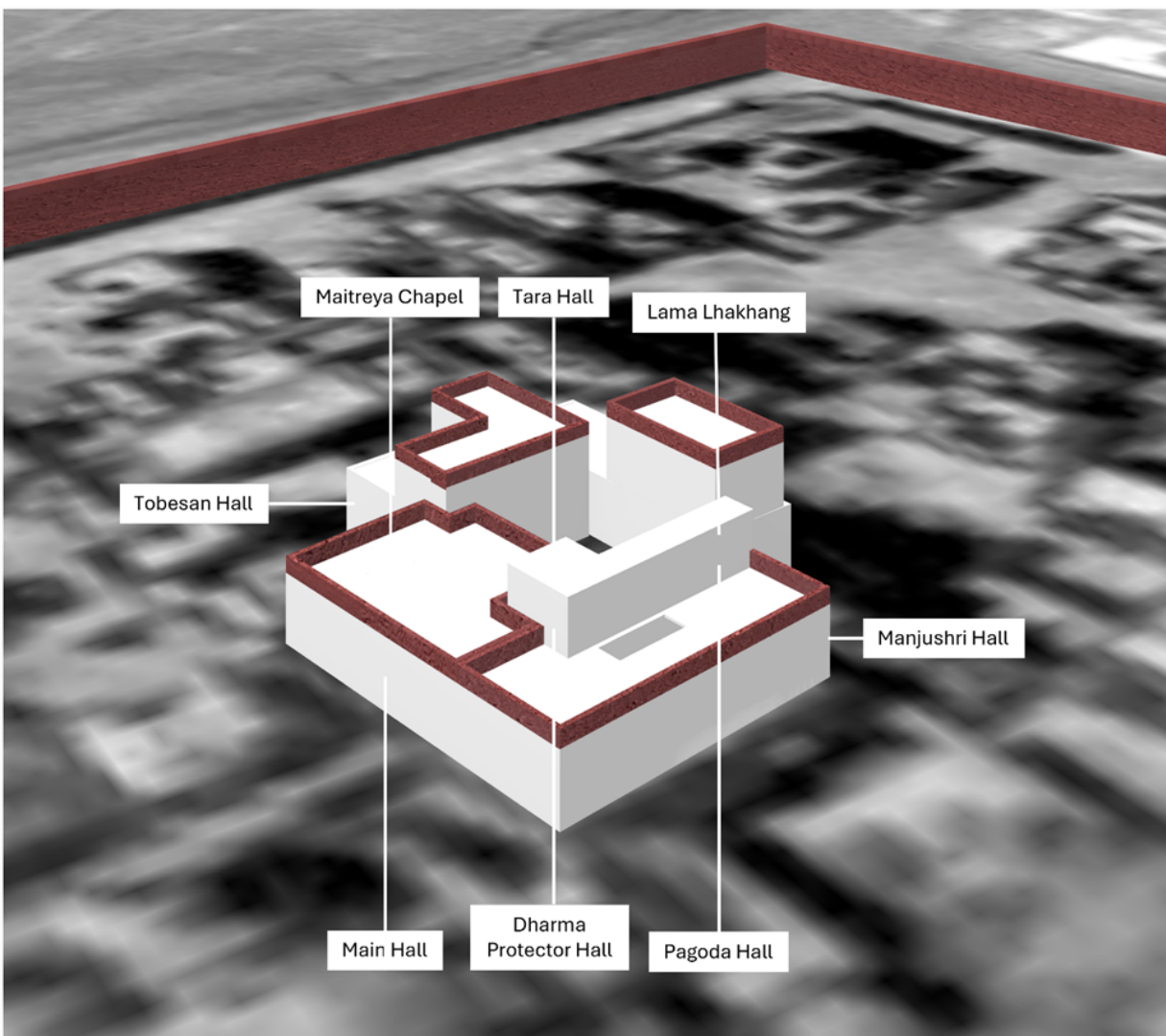


Figure 24. Sumtong-Ding rendering with labeled chapels (Studio Nyandak 2025).

The first space within Sumtong-Ding that Su Bai mentions is its Main Prayer Hall. Sumtong-Ding's main sanctum was along the eastern wall of this prayer hall, which was located on the ground floor of the Temple (Su 1996; Akester 2016). The main image in this sanctum was a bronze Sakyamuni, noted by historians as "towering" and "life-size" (Schuman 2016; Akester 2016). Situ Rinpoche and Su Bai do not mention one large Sakyamuni, pointing to the possibility that the figure did not last until the 1900s. Instead, Su Bai notes multiple statues of the Buddha centered along the back wall of the sanctum. Along the sanctum's side walls, to the right and left of the back wall, were statues situated within a curated, rocky landscape, referred to as "mountain rocks" (Su 1996, 122) and "stucco niches" (Akester 2016, 567). Enshrined by this scenery along the left wall were statues of the 16 Arhats,

Tshongkhapa, and a small Buddha. The rocky scape of the right-hand wall included statues of lotus flowers and monks (Su 1996). There was also a bronze Bhaisajyaguru in the main sanctum that held the relics of Nartang Monastery's 7th abbot (Akester 2016). On the wall opposite the Sakyamuni, framing the entrance to the sanctum, were shelves of scriptures including a golden-scripted copy of the Kangyur (Su 1996; Akester 2016). On either side of the sanctum were long, small rooms with entrances that led to the main prayer hall. Su Bai notes that these small worship halls were said, as of 1959, to have been in their original forms, never having been renovated (Su 1996). Besides this chapel's ground floor, Su Bai additionally states that numerous renovations to the Temple made inferring its original layout impossible in 1959. This comment offers an important reminder that the evolution of Nartang's built structure, spanning hundreds of years, cannot be understood from any singular first-hand account.

Su Bai's descriptions and floor plans provide insight into the design and layout of the main prayer hall itself, including column counts, arrangements, and orientations of a central patio and lectern. To the right of its lectern was one statue of Tsongkhapa and one of the Monastery's 5th abbots. The sides of the front wall were lined with cabinets of religious texts, framing a more central painting of the Gods of the Four Directions. On the right wall was a painting of the 16 Arhats. On the left wall of the prayer hall was a small, dharma protector hall with protector deity statues.

The next room that Su Bai visited was the Stupa Hall. According to his floor plans, this hall was above the Main Prayer Hall, directly to its south side, and supported by 4 pillars. It was primarily filled with stupas, among them a 4-level tall bronze stupa with statues of the Buddha. Akester also mentions a hall with "numerous bronze stupas (chorten)," stating that it was next to the prayer hall containing the main sanctum (Akester 2016, 568). While their descriptions of relics within the chapel align, Su Bai's and Akester's positionings of the chapel do not. One explanation for this discrepancy may be that Akester's description of the chapel location relied on historical sources predating Su Bai's 1959 trip to the temple. Su Bai explicitly states that much renovation was done to the upper floors of Sumtong-Ding by the time he sketched and took records of it. Since he both pinpoints a more precise location in his text and visited the Temple in the same year as the U-2 plane mission from which we obtained aerial imagery, the positioning of Stupa Hall in our 3D model is based on Su Bai's floor plans.

On the east side of the main hall, on the same floor as the Stupa Hall, was another Dharma Protector Hall. This room was 2-pillared, and there are no descriptions of it other than Su Bai's, which is limited to describing that the left-hand wall held a cabinet with gods and a statue of a protector deity.

On the second floor, directly above the Stupa Hall was the 4-pillared Lama Lhakhang (Akester 2016), a chapel dedicated to the succession of past abbots. In this chapel, many abbots of Nartang Monastery were represented by clay statues. On the back wall, Sakyamuni was enshrined in the middle of an altar. A thangka portrait of Nartang's 4th abbot was hung to the left of this altar. Additionally, Situ Rinpoche noted 30 volumes of written text (Everding 2019), and Schuman a complete, golden edition of the Kangyur (Schuman 2016).

On the same floor as the Lama Lhakhang, was the 2-pillared Tara Hall directly above the first floor Dharma Protector Hall. Though unmentioned in Su Bai's review of the room's contents, multiple other scholars mention that the main image in this hall was a silver-cast statue of Tara. A life-sized

Sakyamuni was enshrined in the middle of the hall. To the left and right of the Sakyamuni were rows of altars for statues of various deities, including the Gods of the Four Directions and the Buddha (Su 1996; Everding 2019). A statue of Sakyamuni was also present along the eastern wall of the Hall, and to its left were two models of the Vajrasana temple in Bodh Gaya. One of these models was carved from stone, and the other from wood. These models were of high cultural value and are mentioned throughout the literature on Nartang (Su 1996; Akester 2016; Everding 2019).

The Maitreya Chapel was located below the level of the Lama Lhakhang and above that of the main sanctum (Everding 2019). Su Bai states that this first-floor chapel had undergone an almost complete renovation by 1959, explaining some discrepancies between his text and other historical accounts of its structural layout. There is a rich literature on the Maitreya Chapel and its relics, with many sources stating that it was one of the most frequently and prominently visited chapels at Nartang Monastery (Akester 2016). Situ states that the chapel was especially famous for its grand, standing sculpture of the Bodhisattva Maitreya (Everding 2019). This bronze statue was said to have originated from India and had abilities to speak. The Maitreya Chapel also contained a stone footprint of the Kyoton Tsultrim and numerous other bronze statues (Akester 2016; Everding 2019). Traveler Sarat Das also references the impressiveness of this “immense collection of gilt images” surrounding a Maitreya in Sumtong-Ding (Das 1881, 45–46). The Maitreya Chapel also held a reliquary of “sealed treasures” that required special authorization to see, such as shoes of past spiritual leaders, thangkas, and other relics that were made of precious materials or had spiritually significant origins (Akester 2016).

Su Bai follows his discussion of the Maitreya Hall with that of the Manjushri Hall. The Manjushri Hall contained a smaller room, covered by paintings of protector deities and heavenly kings. Akester also describes a chapel in Sumtong-Ding with an “outer hall and inner shrine,” that he calls “Protector Hall” (Akester 2016, 568). Because Su Bai does not depict an inner room in any of Sumtong-Ding’s other spaces, our model bases its placement of Manjushri Hall on the ground floor next to the Main Prayer Hall on Akester’s description of ‘Protector Hall’s’ location. Su Bai describes the back wall of this hall as having three levels of altars behind three statues of Maitreya. The hall also contained cabinets of religious texts, a mural of a waterscape, a statue of the Dalai Lama, and depictions of Atisa, his two attendants, and Tara.

The last chapel that Su Bai describes is what he calls “Tobesan Hall.” He depicts this hall as having a patio and an eastern entrance, the largest entrance shown in any of his Sumtong-Ding floor plans. Along the middle of the back wall was an enshrined Sakyamuni, surrounded by statues of Avalokitesvara, Milarepa, Atisha, Rinchen Zangpo, Drungdunpa, and bronze statues of Buddhas. A standing Sakyamuni was placed on the hall’s left (northern) wall, and on the hall’s right wall a seated “Medicine Buddha” (Su 1996, 125). Su Bai also notes that these statues were painted in the 1300s and Nepali in style. Also on the right wall was a wooden mandala. The front wall of the hall displayed multiple murals, one of the Thousand Buddhas and to its right one of two lamas sitting across from each other.

Out of all the spaces they surveyed at Nartang Monastery, both Situ Rinpoche and Su Bai first record entering Sumtong-Ding’s main hall. Akester states that the building faced south, and had a long, south-leading corridor entrance to its main hall indicating a southern entrance to Sumtong-Ding.

Additionally, U-2 imagery shows paths that lead directly from the yard of chorten to Sumtong-Ding's southern wall, identified as part of its Main Prayer Hall in our model (Fig. 24). The entrance to Tobesan Hall also appears to be a main entrance to the temple that would have led to where our model situates the Temple's inner courtyard. The Manjushri Hall's (or 'Protector Hall's') entrance also faced east according to Su Bai (Su 1996). Both Tobesan and the Manjushri Hall had east-facing entrances, so we based our locating of the chapels within Sumtong-Ding on the room width and length approximations provided by Su Bai's records, paired with the shape of the Temple as detected by our shadow analysis.

#### 4.4 Tashigomang

Tashigomang (Fig. 25-26) was the largest stupa in the rows of chorten built along the southern enclosure wall of Nartang Monastery. It was 10 meters tall, 12 meters wide, and contained seven chapels in total. Henss describes it as Kadam-style, with a stepped base (Henss 2014).

On the second level in the northernmost chapel were the relics of Chim Losang Druk, and in the easternmost chapel were the 16 Arhats in rocky niches and a statue of Munindra. In the southernmost chapel were the Buddhas of the Ten Directions and an eleven-faced Avalokiteshvara, and in the westernmost chapel were many Satra-style statues of deities (Everding 2019). On the lower level, three chapels were arranged around a lion throne, which in Su Bai's floor plan of Tashigomang, redrawn by our research team in Fig. 26 appears to have been along the southernmost wall. The northernmost chapel held a statue of Bhagavan and another set of Arhats in rocky niches. Murals were painted on the walls of all the lower-level Lhakhang, depicting a thousand images of the Buddha (Everding 2019).

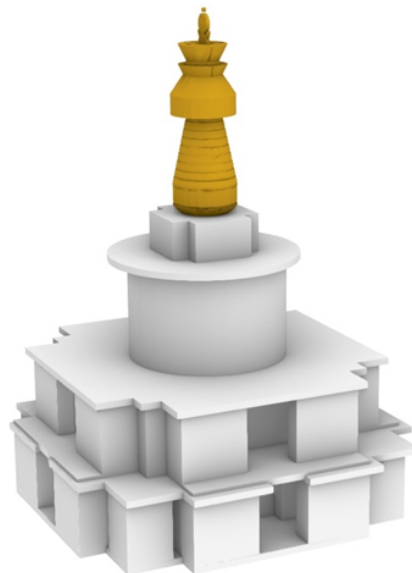


Figure 25. 3D rendering of Tashigomang Stupa (Studio Nyandak 2025).

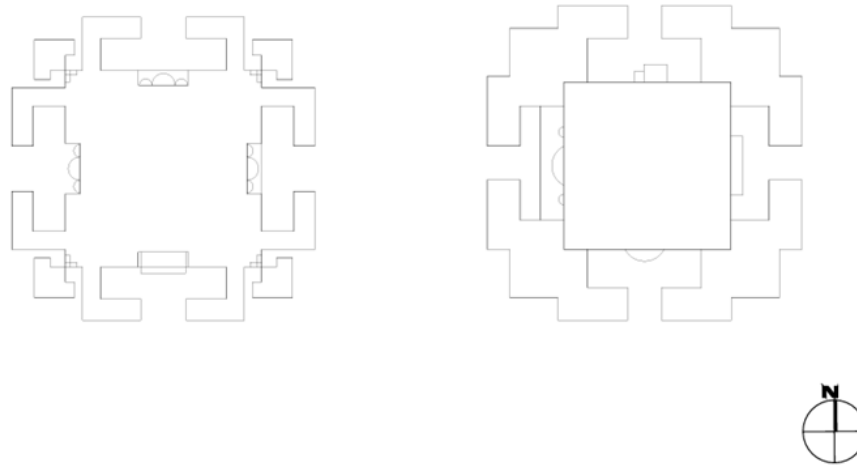


Figure 26. Floor plan of Tashigomang's second (left) and first (right) levels, redrawn by Authors (Su 1996).

#### 4.5 Other Chorten

The other chorten (Fig. 27) in the enclosed chorten yard were smaller and less ornate than Tashigomang and did not hold thrones. They may not even have permitted internal access for worshippers. Rounded and made of packed earth, Situ Rinpoche described them as looking like lumps of brown sugar (Everding 2019).

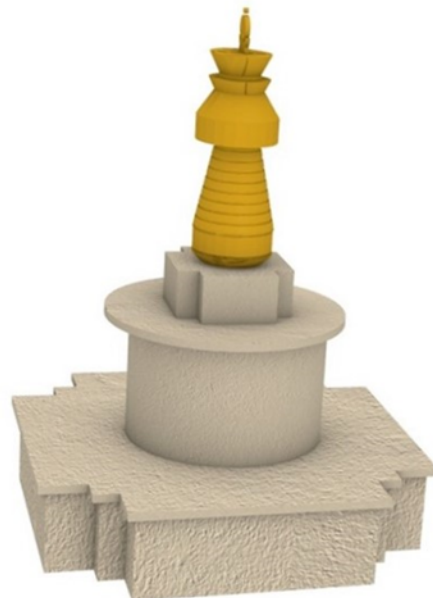


Figure 27. 3D rendering of Nartang chorten (Studio Nyandak 2025).

## 5. DISCUSSION

A few elements appear immediately alike between the most current (2021) aerial image of Nartang Monastery and that of the 1962 U-2 image (Fig. 28-29); the enclosure walls cover an almost identical perimeter, the rebuilt chorten and their surrounding mounds occupy similar locations, and the village houses surrounding Nartang are all located near the southern enclosure wall. However, the two images are otherwise disparate—the recent containing a small fraction of structures compared to the 1962 Monastery. Among the few recent structures are the new Parkhang, Nechung Chapel, Tashigomang, and Assembly Hall. Within these halls are stored some original relics, such as 8,000 woodblocks from the original Nartang Kangyur and Tengyur cannon, as well as new murals and altars displaying images once common in Nartang (Sakyamuni, the 16 Arhats, the Gods of the Four Directions, etc.) (Dorje 2004). The new works emulate revered treasures, especially those related to the Kangyur and Tengyur, that once adorned the Monastery's chapels. Nevertheless, our investigation reveals a deeply layered material history in the former Nartang that is absent now in the latter.

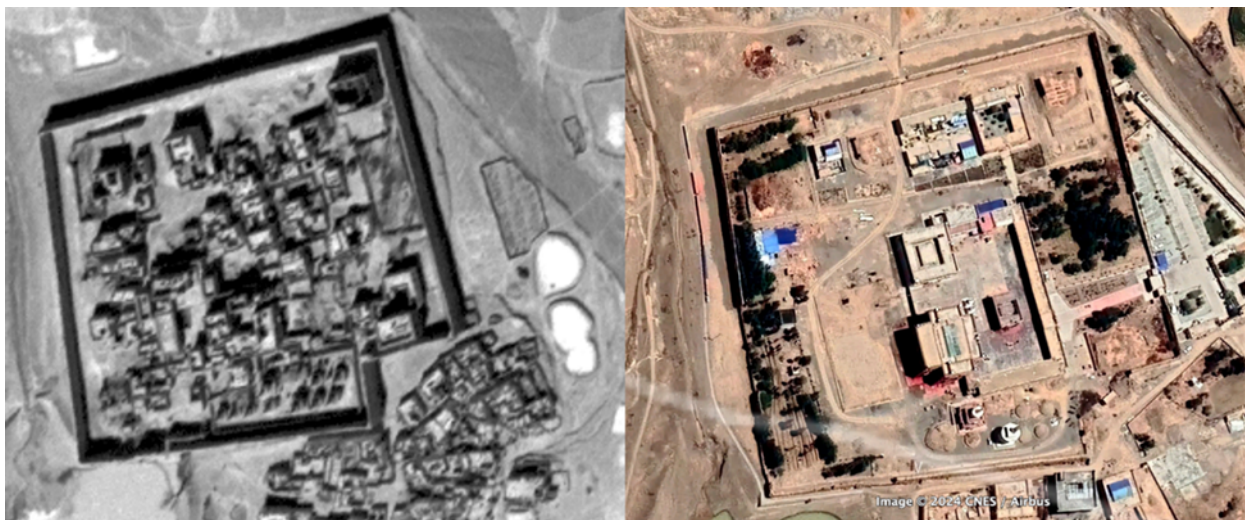


Figure 28. Orthorectified U-2 image of Nartang Monastery in 1962 (left) and Google Earth imagery of Nartang in 2021 Nartang Monastery (right).

Nartang's original planning was site-specific, being both socially strategic and environmentally defensive. The tall enclosure walls protected against both civil strife between the Sakya and Kagyu sects and the strong, dusty winds of Shigatse. Against this environmental concern, the 21st century Monastery's architecture no longer includes twisting alleyways to provide walkers protection. This architectural difference reflects the changed demographic, and subsequently needs, that the space now serves; whereas thousands of monks once relied on the protection Nartang provided with its high walls and packed buildings, the current Nartang houses far fewer monks and hosts far more tourists who only visit for short durations.



Figure 29. Nartang Monastery site plan reconstruction from U-2 image (Studio Nyandak 2025).

Another foundational facet of Nartang's structural planning was its inspiration from the Tibetan Buddhist cosmological model of the universe that was popularized from the late 11th to the early 12th century, preceding Nartang's founding in 1158 (Davidson 2004). This new cosmological model posited Tibet at the center of the Buddhist world by weaving Tibetan Buddhist deities into wider Buddhist origin stories (Schuman 2016). In this model, a four-sided mountain, Mount Meru, was said to have emerged from the ocean due to the converging force of winds from four directions (Davidson 2004; Beer 2014). Around Mount Meru arose concentric rings of "iron mountains," here represented by the 8th abbot Kyoton Tsultrim's building of towering enclosure walls around Nartang Monastery. Additionally, reflecting how the new cosmological blueprint prescribed spiritual importance as increasing spatially from geographic peripheries to a center, Nartang Monastery's main assembly halls and temples were all built towards the middle of the enclosed campus.

The Monastery's 7th abbot, an expert in the Abhidharma texts from which the Buddhist cosmological blueprint was derived, built Sumtong-Ding at the center of Nartang, with an east-facing entrance (Schuman 2016). In their studies on Tibetan Buddhist monastery layouts, Malhotra (Malhotra 1992, 39) and (Alexander 2005, 264) map Mandala-inspired monastic campus blueprints. Both blueprints feature a primary prayer hall with an east-facing entrance, central to a square-shaped and walled campus enclosure; Malhotra also depicts chorten lining the inside of the enclosure walls (Malhotra 1992). While Schuman states that Nartang did not follow the esoteric mandala blueprint exemplified by other monasteries, like Samye and Sakya, he and others specify that this formation and Nartang's were derived from the same cosmological model.

Comparing our 3D model of Nartang with mandala-style monastic campus layouts uncovers further similarities in planning styles. Nartang's boundaries were demarcated by square-shaped walls with clusters of chorten bordering them. Moreover, Parkhang Chenmo was also centrally located, next to Sumtong-Ding. Though the Parkhang was a printing press by 1959, rather than a temple, its prized location was likely a result of it being an extension of the already central Temple of the Three Realms, a prayer hall. The printing press' central location was nevertheless fitting after this renovation, as its scriptures define Nartang's religious legacy.

Nartang's primary religious structures were built at the center of its campus for over 800 years, and the ways that the use of their spaces evolved reflect wider changes; Sumtong-Ding replaced the Temple of the Three Realms which became too small for increasing enrollment numbers, and Parkhang Chenmo then became the Monastery's central focus as scripture production surpassed monk education in priority when the Monastery became a branch of Tashilhunpo in the 18th century (Schuman 2016). In the newly constructed Nartang, none of this history is architecturally visible. For example, few reconstructed buildings have limited elements to their peripheries, making the courtyard they surround the central feature, rather than a prayer hall. Nevertheless, the Monastery's square, "iron mountains," remain.

Before the 1960s, the Monastery's history manifested tangibly through its renovated structures and their ancient relics, elements that gave insight into the evolution of the Monastery's uses, social organization, and religious affiliations. The original Parkhang Chenmo is a prime example. Our 3D model depicts the building as it existed after its 1700s expansion, its final form before its late 1960s destruction. In this stage, it consisted of a variety of once-separate halls that were repeatedly repurposed, rather than demolished, as the needs of the monastery shifted. This preservationist form of renovation meant that the first prayer hall at Nartang Monastery, the Temple of the Three Realms, existed until the Monastery was destroyed. It was first enveloped by the 88-pillar Khri Khang extension, then by the 108-pillar Parkhang Chenmo, but remained intact throughout both. Su Bai mentions a similar dynamic in Sumtong-Ding renovation history; while many aspects were changed, its foundations and ground floor plan remained (Su 1996).

Rather than erasing history, the pre-1960s renovations of Nartang's principal structures revealed shifts in cultural and architectural styles by exposing the Monastery's well-preserved older sections. Since historical aspects of religious structures were incorporated into the Nartang Monastery renovations, there was a significant distinction between the buildings on its campus in 1962 and

those rebuilt today. These records of renovations also evidence a legacy of built heritage preservation in monasteries by Buddhist practitioners themselves.

Applying shadow analysis in conjunction with historical research allowed us to create a 3D reconstruction of a historical site from a photograph without the use of photogrammetry. Photogrammetry is a method for 3D reconstruction which requires the analysis of numerous photographs of a single site. In the case of Nartang Monastery and many other historical Tibetan Buddhist monasteries, there exists very few pictures of the campus before its destruction in the late 20th century. The ability to model its structures from just one image was made possible by our textual research; factors such as the time at which the U-2 photograph was taken and the height of Nartang's enclosure wall not only informed the shadow analysis, but in the technical process were themselves cross-validated through joint digital analysis.

The methodology this research presents can be applied in Tibet alone to over 6,000 Buddhist monasteries that were destroyed during the Cultural Revolution. Our research team continues to apply this study's methods to other monasteries photographed along flight paths of U-2 missions. More broadly, and especially for regions that have undergone mass destruction of cultural sites, historically informed 3D reconstruction allows interdisciplinary researchers the opportunity to document and analyze built heritage in a widely accessible format.

## 6. ACKNOWLEDGEMENTS

The authors sincerely thank Passang Tashi, Anoushka Mariwala, and Tsering Yangchen, architects at Studio Nyandak who invaluable contributed to the 3D reconstruction of Nartang Monastery.

## 7. REFERENCES

- Akester, Matthew. 2016. *Jamyang Khyentsé Wangpo's Guide to Central Tibet* (Dbus Gtsang Gnas Yig). Serindia Publications, Inc. <https://serindia.com/products/jamyang-khyentse-wangpos-guide-to-central-tibet-by-matthew-akester>.
- Alexander, André, ed. 1999. *Lhasa Old City: A Clear Lamp Illuminating the Significance and Origin of Historic Buildings*. VFKA / Tibet Heritage Fund. [https://www.tibetheritagefund.org/old\\_web\\_2002/4\\_publication/4\\_01/4\\_01\\_00\\_en.html](https://www.tibetheritagefund.org/old_web_2002/4_publication/4_01/4_01_00_en.html).
- Alexander, André. 2005. *The Temples of Lhasa: Tibetan Buddhist Architecture from the 7th to the 21st Centuries*. Serindia Publications. <https://books.google.com/books?id=MHHqAAAAMAAJ>.
- Alexander, André. 2019. *The Lhasa House: Typology of an Endangered Species*. Serindia Publications. <https://www.abebooks.com/9781932476842/Lhasa-House-Typology-Endangered-Species-1932476849/plp>.
- Auer, Carmen, and Holger Neuwirth, eds. 2015. *Buddhist Architecture in the Western Himalayas*. 1st, 2nd, and 3rd eds. Verlag der Technischen Universität Graz.
- Beer, Robert. 2014. *The Encyclopedia of Tibetan Symbols and Motifs*. Shambhala.
- Bellingcat. 2025. "Investigations." <https://www.bellingcat.com/category/news/>.
- Bstan, Blo, ed. 1985. *dPal sNar Thang Chos Sde'i Lo Rgyus*. Tibet People's Publishing House.

- <https://library.bdrc.io/show/bdr:W8LS43781?s=%2Fshow%2Fbdr%3AMW8LS43781>.
- Das, Sarat Chandra. 1881. Narrative of a Journey to Tashilhunpo in 1879. Bengal Secretariat Press.  
<https://tile.loc.gov/storage-services/service/rbc/rbc0001/2014/2014gen23029v3/2014gen23029v3.pdf>.
- Davidson, Ronald M. 2004. "The Kingly Cosmogonic Narrative and Tibetan Histories: Indic Origins, Tibetan Space, and the bKa' 'chems Ka Khol Ma Synthesis." In *Cosmogony and the Origins*, edited by Roberto Vitali. Amnye Machen Institute (Lungta).
- Dorje, Gyurme. 2004. *Footprint Tibet*. 3rd ed. Footprint Handbooks.
- Dorje, Gyurme, Tashi Tsering, Heather Stoddard, Andre Alexander, Ulrich van Schroeder, and His Holiness The Dalai Lama. 2010. *Jokhang: Tibet's Most Sacred Buddhist Temple*. Thames & Hudson.
- Everding, Karl Heinz. 2019. *Kaḥ Thog Si Tu's Pilgerreise Durch Zentraltibet in Den Jahren 1918–1920: Ein Beitrag Zur Kunst- Und Kulturgeschichte Tibets: Edition Und Übersetzung Des dBus Gtsang Gnas Bskor Lam Yig*. International Institute for Tibetan and Buddhist Studies (IITBS) GmbH.
- Ferrari, Alfonso. 1958. "mK'yen Brtse's Guide to the Holy Places of Central Tibet." In *Serie Orientale* Roma, vol. 16. IsMEO.
- Forensic Architecture. 2025. "Investigations." <https://forensic-architecture.org/>.
- Fraser, David. 1907. *The Marches of Hindustan: The Record of a Journey in Thibet, Trans-Himalayan India, Chinese Turkestan, Russian Turkestan, and Persia*. W. Blackwood and Sons.  
<https://archive.org/details/cu31924023218443>.
- Henss, Michael. 2014. *The Cultural Monuments of Tibet: The Central Regions*. Vol. 2. Prestel.
- Himalayan Art Resources. 2025. "Item No. 81872." <https://www.himalayanart.org/items/81872>.
- 'jam byangs mkhyen brtse'i dbang po. 2020. "Dbu Gtsang Gi Gnas Rten Gsar Rim Gyi Mtshan Byang Mdor Bsdus Dad Pa'i Sa Bon." In "Jam Dbyangs Mkhyen Brtse'i Dbang Po'i Bka" 'bum, vol. 24. *Khams sde dge rdzong sar dgon: Rdzong sar blo gros phun tshogs*. Scanned at: Tibetan Buddhist Resource Center, Cambridge, Massachusetts.
- Kaḥ thog si tu Chos kyi rgya mtsho. 1972. *An account of a pilgrimage to Central Tibet during the years 1918 to 1920 :being the text of Gangs ljongs dbus gtsang gnas bskor lam yig nor bu zla shel gyi se mo do by Kaḥ-thog Si-tu Chos-kyi-rgya-mtsho*. Sungrab nyamso gyunphel parkhang.
- Kuijpp, Leonard WJ van der. 2016. "The Lives of Bu Ston Rin Chen Grub and the Date and Sources of His Chos' Byung, a Chronicle of Buddhism in India and Tibet." *Revue d'études Tibétaines* 35: 203–308.
- Lange, Diana. 2020. *An Atlas of the Himalayas by a 19th Century Tibetan Lama: A Journey of Discovery*. Vol. 45. Brill's Tibetan Studies Library. Brill.
- Malhotra, Sanjeev. 1992. "The Architectural Manifestation of Tibetan Buddhist Religious Principles: A Case Study of the Monastery Complex at Dharamshala, India." Ph.D. dissertation, Kansas State University.
- National Photographic Interpretation Center. 1963. *Mission Coverage Plots: Mission 3203, 10 December 1962*. <https://www.cia.gov/readingroom/document/cia-rdp02t06408r000500010030-2>.
- Schuman, Michael D. 2016. "Building Place and Shaping Lives: Nartang Monastery from the Twelfth through Fifteenth Centuries." PhD Thesis, University of Virginia.  
[https://libraetd.lib.virginia.edu/public\\_view/2b88qc50s](https://libraetd.lib.virginia.edu/public_view/2b88qc50s).

- Su, Bai. 1996. *Archeological Studies on Monasteries of Tibetan Buddhism*. Cultural Relics Publishing House.
- Sun, Zheng, and Yingying Zhang. 2018. "Using Drones and 3D Modeling to Survey Tibetan Architectural Heritage: A Case Study with the Multi-Door Stupa." *Sustainability* 10 (7): 2259. <https://doi.org/10.3390/su10072259>.
- Tibetan and Himalayan Library. 2025. "Meru Nyingpa." The. <https://www.thlib.org/places/monasteries/meru-nyingpa/>.
- USGS EROS Archive. 2018a. "Declassified Satellite Imagery – CORONA, ARGON, and LANYARD (1960–1972)." <https://www.usgs.gov/centers/eros/science/usgs-eros-archive-declassified-data-declassified-satellite-imagery-1>.
- USGS EROS Archive. 2018b. "Declassified Satellite Imagery – KH-9 (Hexagon) (1971–1984)." <https://www.usgs.gov/centers/eros/science/usgs-eros-archive-declassified-data-declassified-satellite-imagery-3>.
- Vitali, Roberto. 1999. *Records of Tho Ling: A Literary and Visual Reconstruction of the 'Mother' Monastery in Gu Ge*. High Asia / Amnye Machen Institute.
- Weizman, Eyal. 2017. *Forensic Architecture: Violence at the Threshold of Detectability*. Zone Books.

Received March 2025; revised May 2025; accepted July 2025.