

Strategic Sentinels: Investigating the Role and Distribution of Medieval Towers in Cyprus through Geospatial Analysis

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ABSTRACT

This study investigates the utilization and distribution of medieval towers in Cyprus during their original period (14th-15th Century) with a primary focus on the province of Larnaca. It explores the intended purposes of these constructions, including Pyla Tower, Kiti Tower (also known as Regina), Alaminos Tower (alternatively Koulas), and Xylofagou Tower. The research addresses questions regarding their original uses: Were they constructed as fortified structures with military purposes for the island's security, was their building purpose originally symbolic, serving as a "reminder" of the sovereignty of the Conqueror to the inhabitants of the island, or did they serve agricultural functions? A multifaceted approach is employed, integrating bibliographical and surveying documentation with geographical analysis to examine the interaction between these structures and their surrounding landscapes. This study aims to provide a comprehensive understanding of the purposes and significance of the medieval towers in the region using geoinformatics by examining both human-made and natural factors. A Geographic Information System (GIS) was utilized to establish data relationships and conduct spatial analyses, including cost-surface analyses, density analysis, and viewshed analysis. These analytical tools are crucial for elucidating the functional and spatial dynamics of medieval towers, enabling a deeper comprehension of the influences of these structures during their original construction period. Additionally, a photogrammetric survey was carried out to document the towers, enabling the examination of their architectural features and the determination of their original construction period or any later modifications.

Keywords: Geographic Information Systems, Medieval Towers, Landscape Archaeology, Photogrammetry, Cultural Heritage, Spatial Archaeology, Geospatial Analysis.

1. INTRODUCTION

The rich cultural heritage of Cyprus is vividly reflected in its historical landmarks, with medieval towers serving as silent testaments to the island's past. These towers were crucial in the island's defence strategy, frequently undergoing alterations to adapt to the needs of the era. Presently, the remnants of Cyprus's fortified heritage include four castles within the territories under occupation—Buffavento, Cantaras, Saint Hilarion, and Kyrenia—and other military edifices such as the Othello Tower in Famagusta and the bastions within Nicosia's city walls. In contrast, the non-occupied areas boast four castles—Paphos, Limassol, Kolossi, and Larnaca—and four medieval towers—Pyla, Kiti, Alaminos, and Xylofagou—alongside the ruins of two additional towers, La Cava and Troulli^{1,2}. These structures, ranging from feudal strongholds to administrative and judicial hubs, form a significant part of Cyprus's historical landscape.³

The term "landscape" is commonly associated with "countryside," including features such as mountains, trees, and crops. Nonetheless, contemporary usage of the term encompasses both natural elements and human-made structures.⁴ This expanded definition provides a valuable framework for understanding the "human environment" and its historical development. Using geoinformatics, this project seeks to determine the original purpose of the medieval towers in Cyprus during the time of their construction, as well as to map them out and investigate how the landscape has shaped their use over the ages.

Geographic Information Systems (GIS) are now widely employed across many fields as the primary tool for spatial data processing. New technologies facilitate the recording, evaluation, and protection of monuments and historical ensembles. Consequently, GIS has become a crucial tool for cultural heritage management, and its use for research in regional or "broad-field" contexts is closely related to Landscape Archaeology. This relationship introduces new technological methods to meet the theoretical needs of the field, encouraging new approaches.

This study investigates the use and distribution of medieval towers in Cyprus, specifically during the 14th and 15th centuries, with particular emphasis on the Larnaca province. By focusing on key towers such as those in Pyla, Kiti, Alaminos, and Xylofagou, the research explores several critical questions: Were these towers mainly built for military purposes, or did they also serve other functions, such as agricultural roles or symbols of authority? Additionally, how did these towers interact with their surrounding landscapes, and what factors influenced their strategic placement?

The structure of the paper begins with a review of existing literature on the use of GIS in studying medieval towers, followed by a detailed explanation of the research design and the data analysis techniques employed. The results from the GIS analysis, which include visibility, density, and cost-surface analyses, are then presented and discussed. The paper concludes by reflecting on the multiple roles these towers played and suggests directions for future research. This study aims to provide a deeper understanding of the strategic importance of these medieval towers in Cyprus by offering a fresh perspective through detailed spatial analysis. The findings contribute not only to the scholarly discussion on Cyprus's medieval fortifications but also offer practical insights for cultural heritage management and preservation efforts.

2. RELEVANT GIS APPLICATIONS FOR MEDIEVAL TOWER STUDIES

The incorporation of GIS into archaeological research has made significant advancements in the study of medieval towers, particularly in understanding their strategic distribution and functional purposes. Geospatial analysis in cultural heritage is essential for understanding the macro-scale, the "bigger picture." It uncovers hidden patterns, connections, and historical information, provides location-based insights, assists in conservation efforts by identifying vulnerable areas, and enhances understanding of cultural landscapes or settlements. It also facilitates inventoring and documentation, among other benefits.

An example of GIS application is provided by Kirk's (2017) research in Sicily, which focuses on the changes in the use of defensive fortifications primarily during the 15th-17th centuries using geospatial methods. The results showed that although defensive towers did not have more authority than feudal castles at that time, due to their location (coastal, elevation, etc.), they represented a defense system across the island with a more centralized power structure.⁵

Ferreira-Lopes P.W. and Molina Rolazem J.F. in 2018 studied medieval watchtowers using GIS for the documentation and understanding of medieval architectural heritage in the ancient Kingdom of Seville. Their goal was to create a historical and spatial database to contribute to the management and preservation of cultural heritage. Some analyses they conducted included a thematic map of building materials, spatiotemporal analysis, density analysis of tower distribution in the territory, visibility simulation from the towers, visibility analysis between towers, and more.⁶

Heslop M. (2020), in his book "Medieval Greece: Encounters Between Latins, Greeks, and Others in the Dodecanese and Mani," studied medieval watchtowers and castles in the Dodecanese and Mani to understand their functionality and usability, as well as the connection between them. This study focused on the archaeological-historical aspect of the towers, and the application of GIS using thematic maps and locations provided answers regarding construction dates, communication between towers, and reasons for settlement movements.⁷

Kantner J. and Hobgood R. (2016) studied two watchtowers, Kin Ya'a and Haystack, located in the Southwest of America in New Mexico. They conducted a viewshed analysis to interpret the use of the towers. The authors concluded that the towers were not merely watchtowers but were central places that monitored the surrounding area and their settlements. They argued that in modern archaeology, the use of GIS is now an alternative method for interpreting and understanding archaeological spatial locations.⁸

In general, GIS is increasingly used for a broader interpretation and understanding of contemporary issues. The above applications focused on medieval watchtowers in different regions using GIS, attempting to interpret their use and functionality by cross-referencing mainly bibliographic and historical sources. However, GIS analyses that cross-reference the architectural and spatial aspects of towers by performing topographical surveys and photogrammetric documentation along with historical, geographical information are very few bibliographically. Therefore, this study was conducted, focusing on the use of research data and interdisciplinarity in GIS, to achieve a more holistic and comprehensive analysis of the watchtowers of Cyprus from architectural, historical, and geospatial perspectives, providing more accurate and targeted answers to our study's questions.

3. METHODOLOGY

This paper endeavors to thoroughly document and analyze the geographical, architectural, and historical aspects of the medieval towers from their original construction to the present day, with a particular focus on those within the Larnaca District. The selection of these towers—Pyla, Kiti (Regina), Alaminos (Koulas), and Xylofagou—was based on their structural integrity, abundance, and accessibility, making them ideal candidates for in-depth analysis.

The research methodology was structured in several phases, beginning with the establishment of the historical context for each tower through an extensive review of bibliographical data. This phase also included the examination of the towers' geographical positioning and architectural features, utilizing in-situ measurements and observations. Tools such as the Leica GS07 antenna and Leica Viva CS10 controller were used to capture precise measurements, while photogrammetric models were created using Agisoft software to provide detailed architectural documentation. To enhance the historical accuracy and contextual relevance, medieval pathways were digitized based on historical maps, such as Alexander Drummond's 1754 map, which was geo-referenced to WGS84 coordinates despite its hand-drawn inaccuracies. Additionally, the study incorporated the digitization of surrounding medieval structures—mansions, castles, and water features—to explore the interactions between these towers and their environments. The geographical analysis extended beyond the Larnaca District to include all medieval towers in Cyprus with existing ruins. This broader analysis allowed for a more comprehensive understanding of the towers' locational attributes and their roles within the medieval landscape. GIS were employed to perform various spatial analyses, including viewshed/visibility analysis, cost surface analysis, density analysis, centroid analysis, and nearest linear distance calculations. These analyses were crucial in deciphering the strategic positioning of the towers and their interrelationships.

The methodology was designed to address key research questions regarding the multifunctionality of the towers—whether they were exclusively military or also served other purposes, such as agricultural or symbolic roles. It also sought to determine if the towers functioned as part of an organized network or as independent structures and to understand their relationship with surrounding natural and human-made features, such as cities, coastlines, and royal houses. Finally, the study aimed to uncover the factors that contributed to the dense distribution of towers in Larnaca and how these towers interacted with each other and the broader landscape of medieval Cyprus.

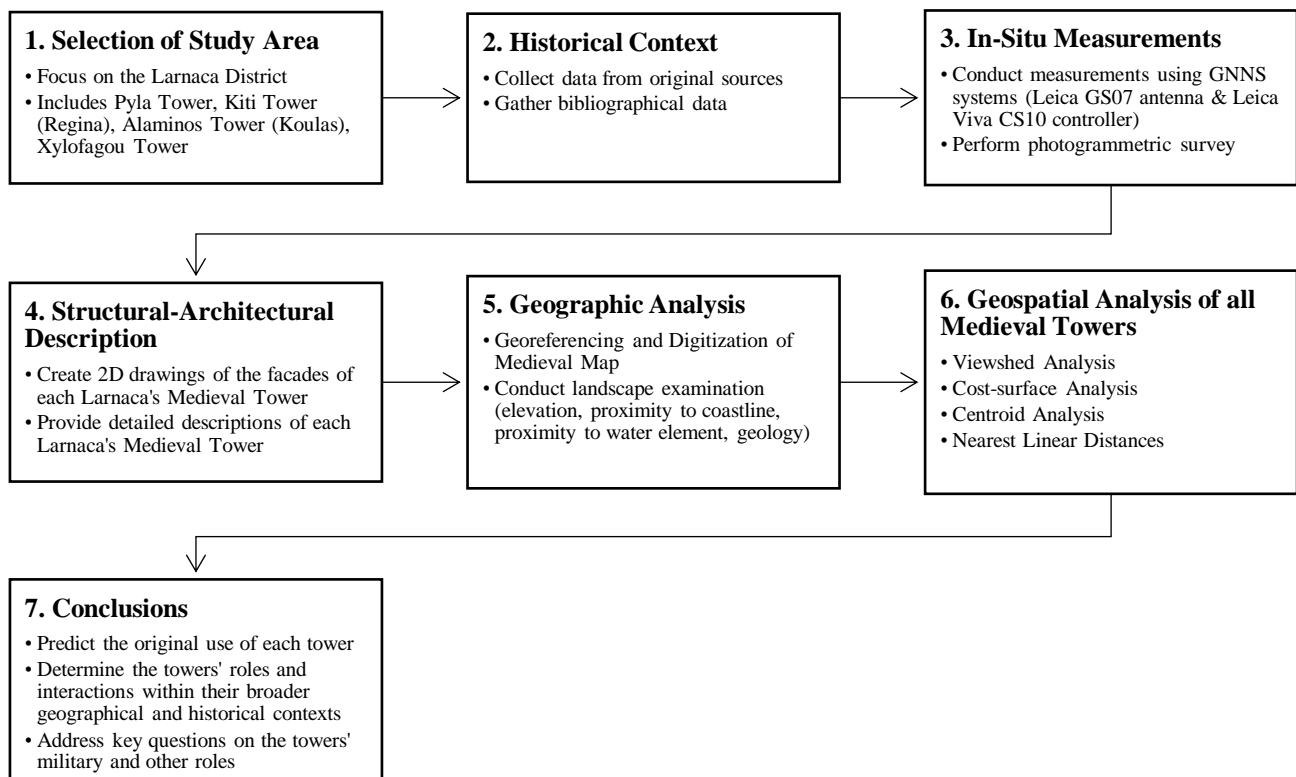


Figure 1: Methodology flow progress chart

4. RESULTS AND DISCUSSION

4.1 Kiti (Regina's Tower)

3.1.1 Historical Background

The Tower of Kiti, also known as the Tower of Regina, is located in the village of Pervolia near Kiti in the Larnaca District. This tower is deeply intertwined with the history of Kiti. Throughout the medieval period, Kiti became a valuable fief, changing hands among several prominent noble families. By the early 16th century, the fiefdom was under the control of Hercules Podocataro, the last feudal lord of Cyprus. It was during this time that the Tower of Kiti was constructed (1489-1570).^{2,9,10} Despite falling into disrepair by the early 20th century, the tower was restored in 1911 by the Department of Antiquities and again in 1977-1978.³

3.1.2 Architectural Features

The Tower of Kiti (figure 2 a & b) is a square structure with two floors, each side measuring approximately six meters. The only opening is an elevated entrance located on the northern face, about four meters above the ground, corresponding to the first interior floor level. This entrance was likely accessible by a retractable ladder, enhancing the tower's defensive capabilities. The tower's construction includes robust stone walls, with no additional openings other than the entrance, emphasizing its role as a defensive observation point. Internally, the tower features simple wooden elements for doors, windows, and floors, reflecting a utilitarian design that prioritizes functionality. This simplicity in construction suggests an emphasis on defense and practicality, typical of similar structures from the same period.

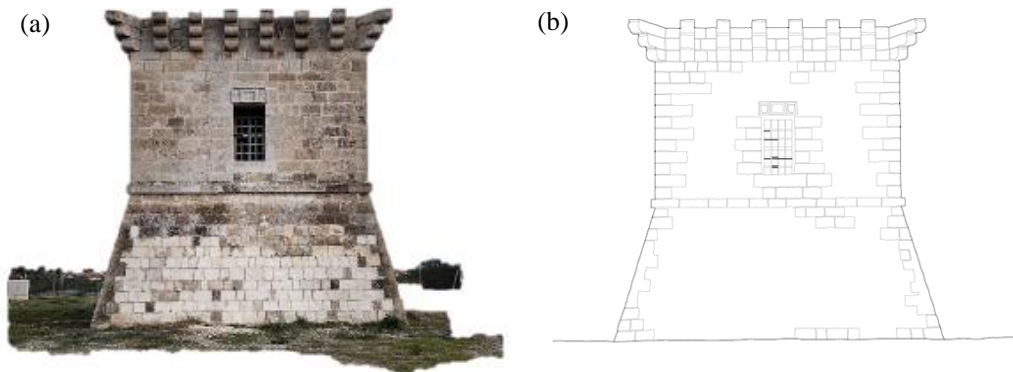


Figure 2 (a & b): 3D Documentation of Tower of Kiti and 2D drawing of the North façade

3.1.3 Geographic Analysis

The geographic analysis of the Tower of Kiti revealed its significant strategic value due to its elevated position (figure 3) on a hill 20 meters above sea level, providing an extensive viewshed. The tower's location allowed it to oversee the southern coastline and the surrounding inland areas, making it an ideal point for monitoring both maritime and terrestrial activities. The analysis indicated that the Tower of Kiti had a panoramic view of the medieval fiefs, the Larnaca Castle, and visibility extending as far as the Tower of Alaminos (figure 4). This wide range of visibility was essential for defense and communication.

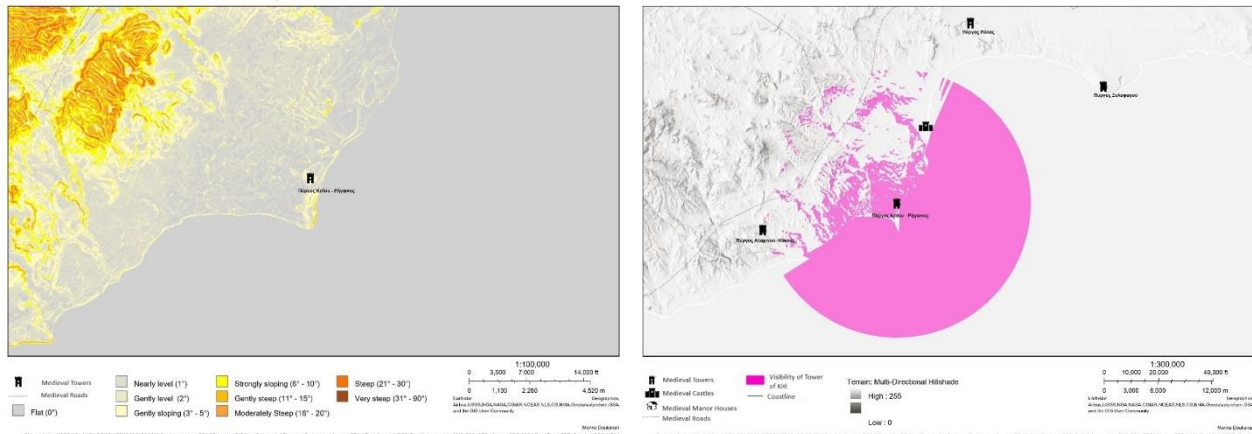


Figure 3 & 4: Terrain Slope and Viewshed Analysis - Tower of Kiti (Basemap 2: ESRI Terrain Slope Map, Basemap 3: ESRI Multi-Directional Hillshade, Medieval Observatories, Medieval Paths, Medieval Castles, Medieval Mansions, Georeferenced to the World Geodetic System "WGS 1984")

3.2 Alaminos Tower

3.2.1 Historical Background

The Tower of Alaminos, located in the village of Alaminos in the Larnaca District, is closely tied to the region's medieval history. Commonly known as "Koulas," from the Turkish word "kule," meaning tower, it was constructed during the late Venetian period (late 15th to early 16th century). Serving as an observatory, the tower was manned by a small permanent garrison during the Frankish and Venetian periods, often communicating through light signals to warn of dangers.^{2,9,11}

3.2.2 Architectural Features

The Tower of Alaminos (figure 5 a-e) is a modest rectangular structure built from unrefined stones, which is a notable contrast to the more refined architectural styles of other regional towers. The tower comprises three floors, with the entrance located on the northern face at an elevated height, originally accessible by a removable ladder. This feature provided enhanced security to the structure.³ The lower floor has no openings, while the upper floors have several narrow, rectangular loopholes and windows, designed for both surveillance and defense¹⁰. The simplicity of the Tower of Alaminos, with its functional design and minimal decorative elements, reflects a utilitarian approach that prioritizes practicality and defense.

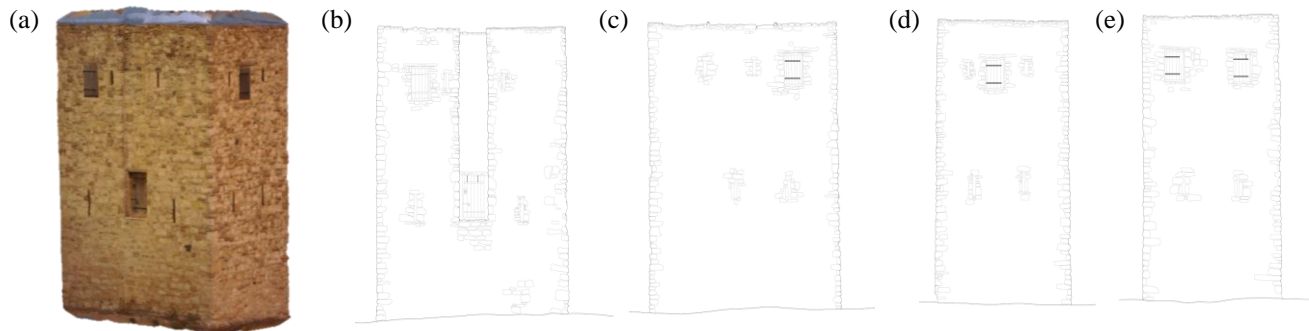


Figure 5 (a-e): 3D Documentation of Tower Alaminos and Tower facades

3.2.3 Geographic Analysis

The tower is about 4 kilometers from the southeastern coast of Larnaca and at an elevation of approximately 83.6 meters above sea level. From its position, it oversees Cape Petounta (Figure 7). It is situated near the core of the village, at the corner formed by the intersection of the road leading to the village of Mazotos and the road heading south towards the coastal part of the village. Unlike the previous towers, the Alaminos tower is not located at the highest point of the area nor among natural hill fortifications, which makes it conspicuous.

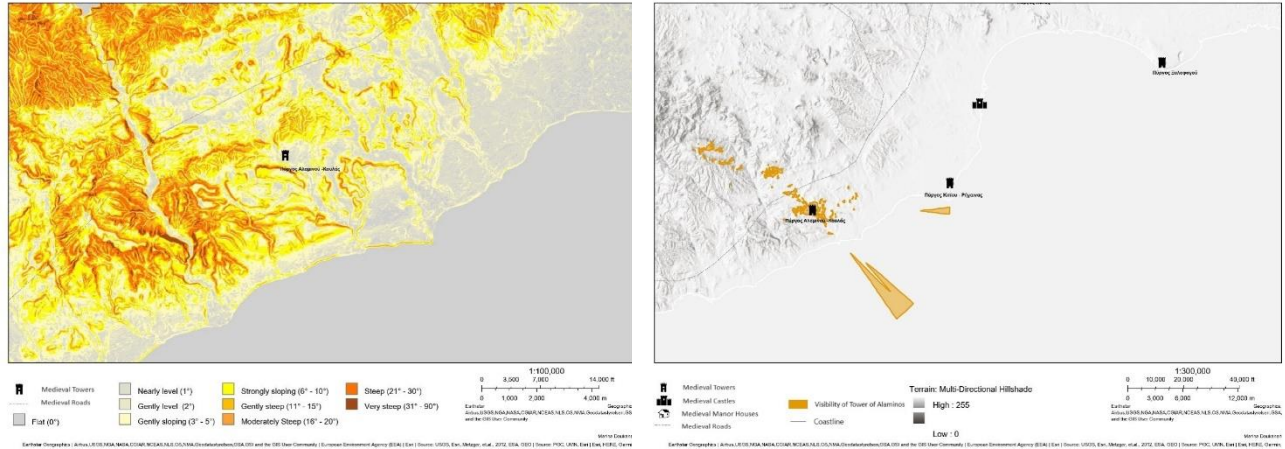


Figure 6 & 7 Terrain Slope and Viewshed Analysis - Tower of Alaminos (Basemap 9: ESRI Terrain Slope Map, Basemap 10: ESRI Multi-Directional Hillshade, Medieval Observatories, Medieval Paths, Medieval Castles, Medieval Mansions, Georeferenced to the World Geodetic System 'WGS 1984')

4.3 Pyla Tower

3.3.1 Historical Background

The Tower of Pyla, a medieval structure located in the village of Pyla in the Larnaca District [12], dates back to the 15th century and has been well-preserved due to recent restoration efforts. Historically, it served as a feudal stronghold for the Gibelet family^{2,9,12}. Its preservation and continued maintenance highlight its importance within the local historical and cultural heritage.

3.3.2 Architectural Features

The Tower of Pyla (figure 8-10) exhibits distinctive architectural features that reflect its strategic defensive role. The tower is a square, stone-built structure with a fortified appearance. It consists of three floors, each with specific features that enhance its defensive capabilities. The lower floor has thicker walls, providing robust support and protection, while the upper floors have narrow, rectangular openings, known as loopholes, designed for archers to defend against attackers. The entrance to the tower is elevated and accessible by a removable ladder, which could be withdrawn to prevent enemy access. The interior includes simple wooden elements such as floors and beams, reflecting a utilitarian design focused on functionality. The tower's roof is flat and accessible, allowing guards to survey the surrounding area. Additionally, there is a water cistern within the tower, essential for sustaining its occupants during sieges.



Figure 8-10 Camille Enlart, 1987; 3D Documentation and 2D drawing of Tower of Pyla

3.3.3 Geographic Analysis

The Tower of Pyla stands at an elevation of approximately 91.6 meters above sea level, providing a natural defensive advantage, and is about 4 kilometers from the coast (figure 11). This positioning provides the tower with natural defensive advantages due to the steep terrain and high hills to the north, which enhance its ability to oversee the surrounding landscape. The tower's visibility (figure 12) extends over a wide area, enabling it to monitor both the coastal and inland regions, which was crucial for defense and communication during the medieval period. Despite being situated within a densely populated area, the surrounding fertile agricultural lands and the proximity to significant medieval pathways highlight the tower's dual role in both military defense and agricultural oversight. The GIS analysis further underscores the tower's panoramic visibility, crucial for spotting potential threats from a distance and ensuring effective communication with other regional fortifications.

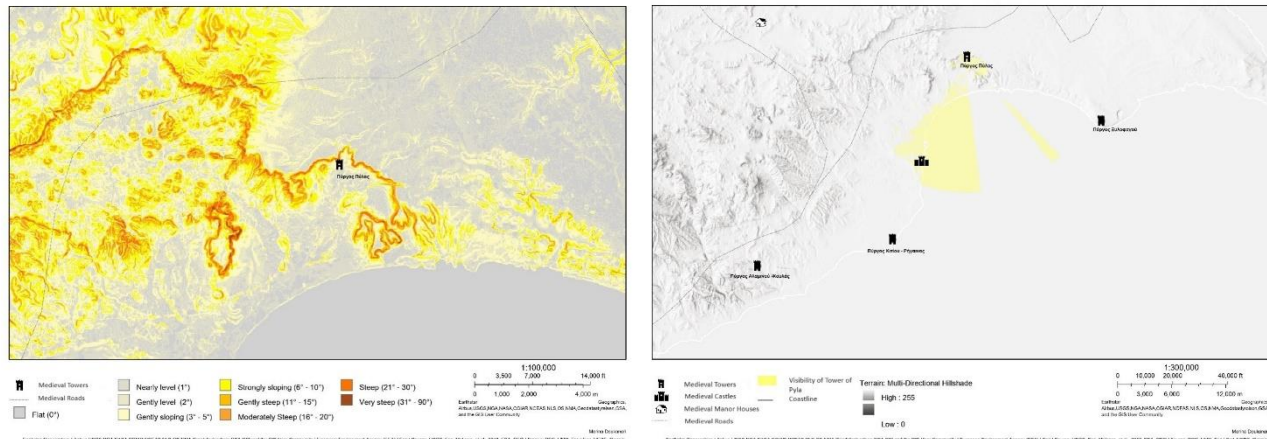


Figure 11 & 12 Terrain Slope and Viewshed Analysis - Tower of Pyla, (Basemap 12: ESRI Terrain Slope Map, Basemap 13: ESRI Multi-Directional Hillshade, Medieval Observatories, Medieval Paths, Medieval Castles, Medieval Mansions, Georeferenced to the World Geodetic System 'WGS 1984')

3.4 Xylofagou Tower

3.4.1 Historical Background

The Tower of Xylofagou, located in the village of Xylofagou, has a rich historical background tied to the medieval period of Cyprus.^{9,10} For the Tower, Censola (2015)¹³ provides the following information: "At the highest point of the elevation, there is a large tower which Pococke describes as an ancient ruin, but it is actually a simple observation post built before the reign of the Lusignans. The circumference at the base is 86 feet (approximately 26.21 meters) and the height is 18 feet (approximately 5.49 meters). At this height, no entrance can be seen, but it is likely that there was one at a higher point, accessed by a movable ladder."

3.4.2 Architectural Features

The Tower of Xylofagou (figure 13 a&b) is a simple yet imposing medieval structure with distinctive architectural features. It has a cylindrical shape with a slight taper towards the top, and it is constructed from roughly cut limestone blocks of nearly uniform height and width. It has relatively low height is due to the removal of building materials over time, as noted by historian Antoniadēs⁹. Unlike other towers in the Larnaca District, the Tower of Xylofagou lacks any openings, including an entrance in its present form, which is a unique characteristic. The tower's straightforward construction emphasizes its primary function as an observation post. The simplicity and robustness of its design highlight its role as a vital component of the medieval defensive network in the region.

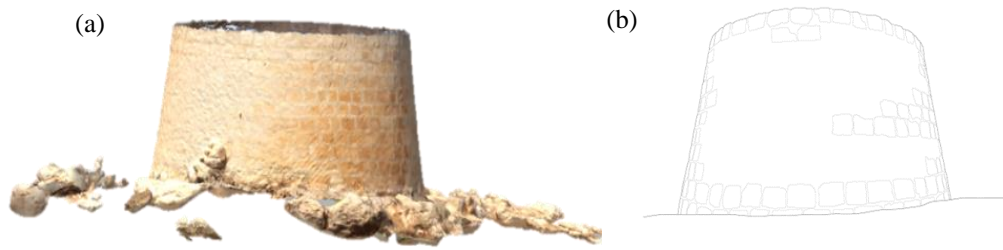


Figure 13 (a & b): 3D Documentation of Tower of Xylofagou and 2D drawing of the North façade

3.4.3 Geographic Analysis

The Tower of Xylofagou, situated at the highest point of the Pyla cape at approximately 111.6 meters above sea level and about 600 meters from the coast (figure 14). This elevated position allows the tower to oversee a significant portion of the Larnaca coastline and towns. The surrounding area is rocky with dense shrub vegetation, which adds to the tower's natural defensive advantages. The steep cliffs descending towards the sea further enhance its defensibility by restricting access from the coastline. The viewshed analysis (figure 15) underscores the tower's strategic location, providing panoramic visibility essential for early warning and surveillance during its operational period.

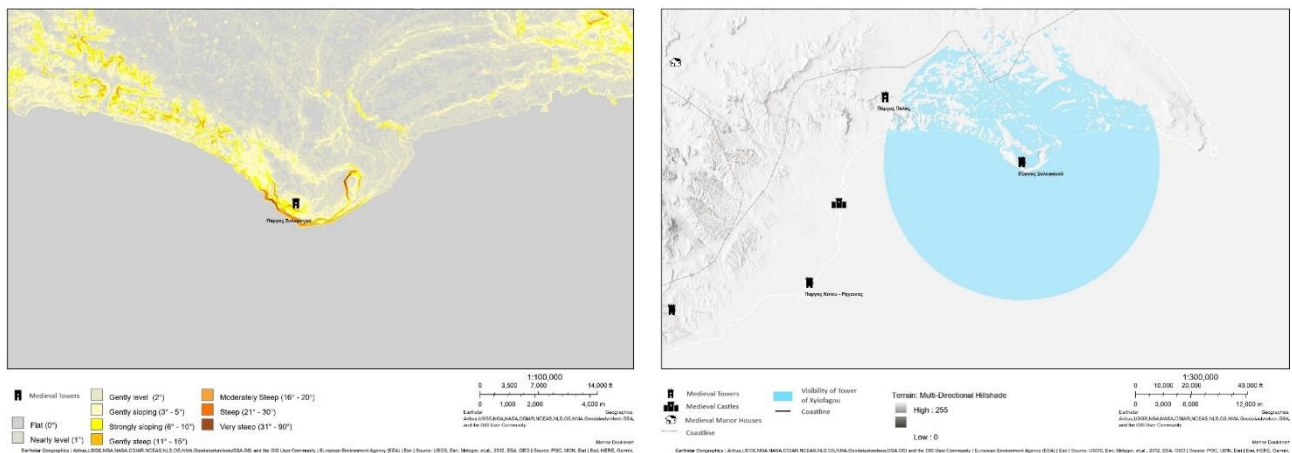


Figure 14 & 15: Terrain Slope and Viewshed Analysis - Tower of Xylofagou, (Basemap 16: ESRI Terrain Slope Map, Basemap 17: ESRI Multi-Directional Hillshade, Medieval Observatories, Medieval Paths, Medieval Castles, Medieval Mansions, Georeferenced to the World Geodetic System 'WGS 1984')

4.5 Geospatial Analysis of Cyprus Medieval Towers

Most of the towers, specifically five (Pyrgos, Kiti, Xylofagou, Alaminos, and Kato Pyrgos), out of the seven mentioned above, are located near the coastline, while the other two are in semi-mountainous areas in the center of the island (Figure 16). This may be due to the fact that the towers located centrally in Cyprus, which historians date back to the 14th century, were probably erected inland to serve a specific and possibly completely different purpose from the towers built a century later (15th century) along the coastline.

It has been observed that although the towers are not primarily located at the highest points of the island, they are situated at the highest elevation points in the surrounding area, thus visually covering the nearest bays and promontories. However, this specific condition does not apply in all cases, such as in the Alaminos Tower, which is located at approximately the same elevation level as the wider area.

The analysis of the density of tower locations (Figure 16b) strongly indicates that the majority of towers are located in the Larnaca province. The defense of the island could not be fully ensured solely by the existing towers, leading to the conclusion that either their primary function was not primarily about protecting the island but rather overseeing and safeguarding other significant structures of the era with which they were adjacent, or there are ruins which are not yet documented and require further research.

Regarding the function of the towers, it was found in Figure 16c that almost all the towers are located near rivers (the maximum distance from a water element is 5 km for the Xylofagou Tower), leading to the conclusion that the agricultural use of the towers, given the structural provision of the storage space they all contained without exception, was, if not the primary, an alternative/complementary use for these buildings.

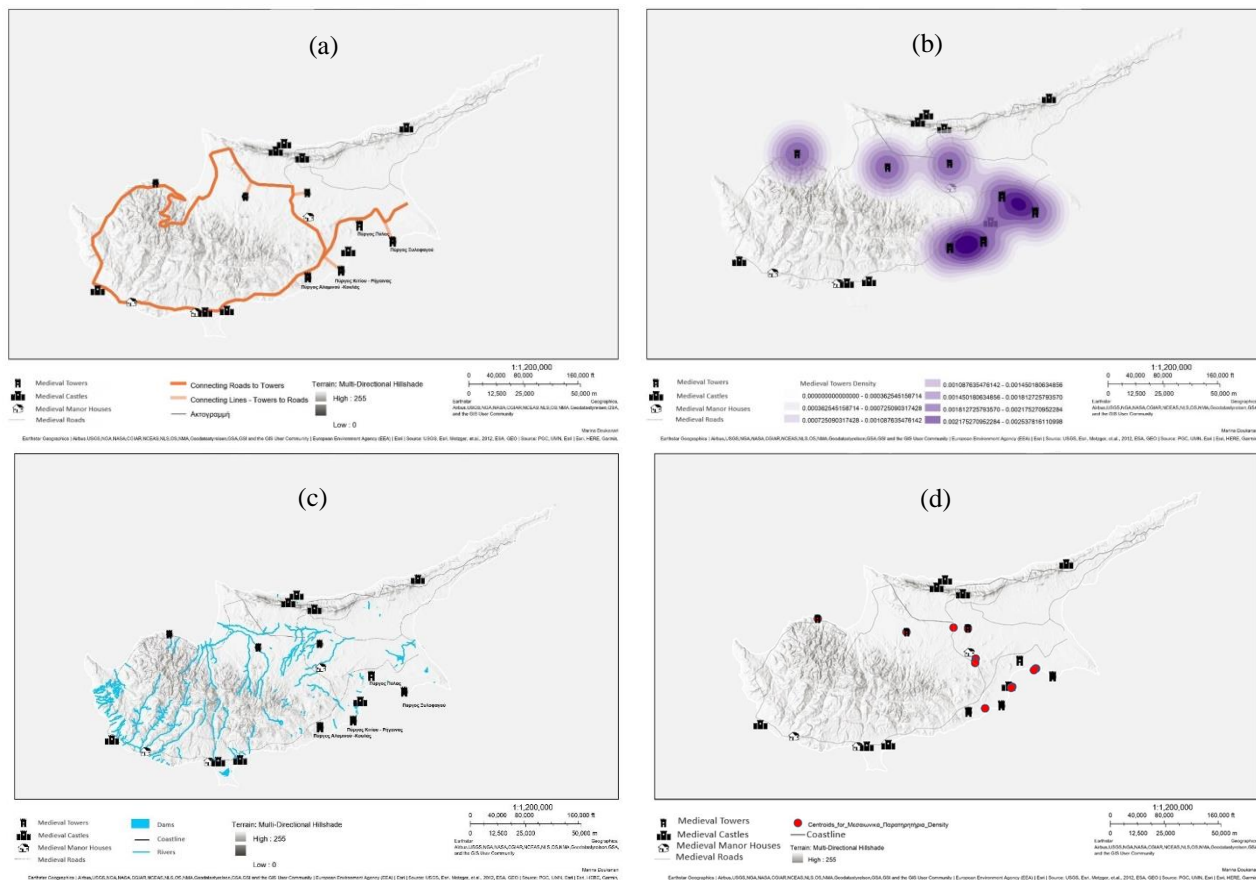


Figure 16 (a-d): a-Nearest Connecting Lines, b- Density of the Medieval Towers, c- Proximity to water elements, d- Centroids of Medieval Towers (Basemap: ESRI Multi-Directional Hillshade, Medieval Observatories, Medieval Paths, Medieval Castles, Medieval Mansions, Georeferenced to the World Geodetic System 'WGS 1984')

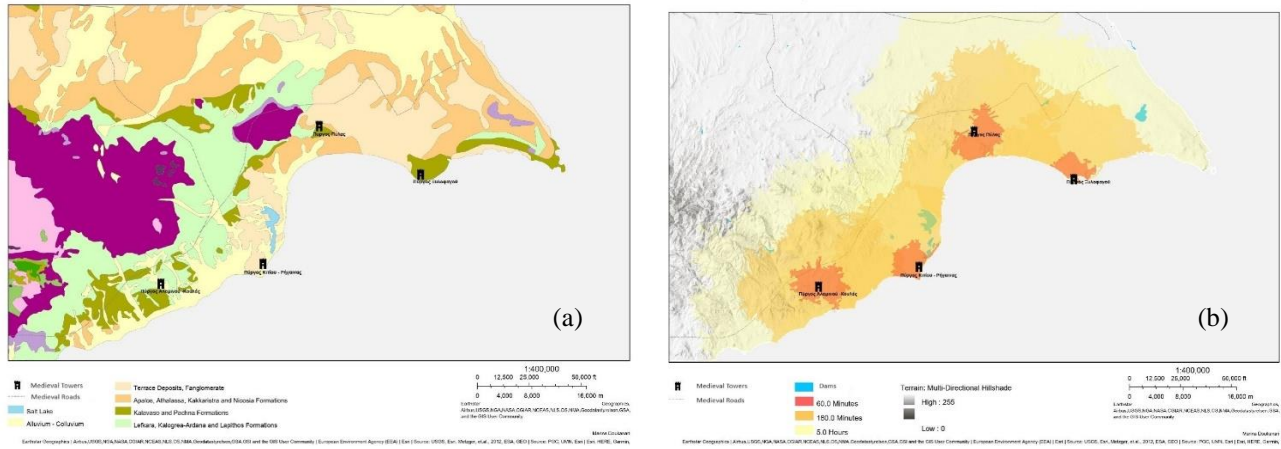


Figure 18 (a&b): a- Geology of the area, b- Cost Surface Analysis (Basemap a: Geological Map- data from the Department of Geological Survey, Basemap b: ESRI Multi-Directional Hillshade, Medieval Observatories, Medieval Paths)

4. CONCLUSIONS AND FUTURE WORKS

Based on this study, several comparative conclusions have been drawn regarding the medieval towers of Larnaca. These findings address the initial questions and raise new considerations about the siting and functions of similar fortifications that may have existed during the medieval period.

4.1 Conclusions

The GIS analysis, combined with historical and architectural studies, revealed that the primary reasons for the selection of the tower sites were:

- Proximity to Water Elements: All towers are located near rivers, dams, or salt lakes, with the maximum distance being 5 km (Xylofagou Tower).
- Proximity to the Coastline: Towers constructed in the 15th century are located close to the coastline.
- Accessibility to the Road Network: All towers have easy access to medieval paths, except for the Xylofagou Tower.
- Adjacency to Areas with Irrigated Soil and Crops: The towers were strategically placed near fertile agricultural lands.
- Geology of the Area: Towers were constructed in areas where the Pachna-Kalavaso formation is present, facilitating the use of locally available construction materials.
- Visibility and Area Control: The towers were situated to provide complementary visibility, ensuring control over critical areas.
- Proximity to Significant Medieval Structures: Towers were often located near royal mansions and castles to enhance control and protection.

The towers served multiple purposes, debunking the belief that they were solely military fortifications. Their strategic locations indicate:

- Defensive Network: The towers were part of an organized defensive system, communicating via beacons and providing mutual support.
- Checkpoints: They monitored coastlines and navigation routes.
- Administrative Centers: Proximity to agricultural lands and settlements suggests they oversaw local production and served as symbols of feudal authority.

- Agricultural Warehouses: Their storage spaces and landscape location indicate they were used for agricultural purposes at some point.
- Feudal System Support: The towers symbolized feudal authority and served various administrative and fiscal functions.
- Geospatial analysis revealed that the Alaminos Tower differs from the others, being located on a plain with limited visibility, suggesting a role other than primary observation. Similarly, the Xylofagou Tower, with its unique circular shape and lack of openings, functioned mainly as a border checkpoint.

Geographical analyses indicate the necessity of fortifications in areas where existing structures have been destroyed. Regions such as Rizokarpaso-Lythragkomi, Akama, Upper Panagia, and Trikomo need further investigation to confirm the presence of historical fortifications.

4.2 Future Works

This study demonstrates the effectiveness of GIS in uncovering the original uses of medieval towers in Larnaca. The integration of spatial analysis with historical and architectural-structural documentation provided a comprehensive understanding of these structures. While the towers were primarily built for defense, their roles evolved to include administrative and other multifunctional purposes, reflecting the dynamic history of the region. A more explicit comparison with similar structures in other Mediterranean regions, such as the medieval towers of Euboea, highlights both the unique and common aspects of the Cypriot towers¹⁴. The article on Euboea's towers suggests that, like the towers in Cyprus, these structures also served as domestic and landscape phenomena, which supports the idea that the evolution of tower functions was a broader regional trend rather than a localized development.

Future work will expand the analysis to other fortified structures in Nicosia Province, such as the Tower of Kato Pyrgos (Troulli), Tower La Cava, and Tower of Akaki. Additionally, Earth Observation, Remote Sensing, and AI techniques will be integrated to semi-automatically identify previously undocumented remains where geographical analysis suggests their presence. These advanced methods, combined with a comparative approach that includes studies like those of the Euboea towers, will further enhance our understanding of Cyprus's medieval fortifications within the broader context of Mediterranean defensive architecture.

The use of GIS in cultural heritage studies is invaluable, providing insights that enhance our understanding of historical landscapes and their development over time. Future research will continue to leverage these technologies to explore and document the rich history of Cyprus's medieval fortifications, while also drawing comparisons with similar structures across the Mediterranean to contextualize the findings more effectively.

ACKNOWLEDGEMENTS

This paper was initially conducted as part of the Independent Study phase in the Interdepartmental Master of Science Program in Conservation and Restoration of Historical Buildings and Monuments at the University of Cyprus.

The authors acknowledge the 'EXCELSIOR': ERATOSTHENES: EXcellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment H2020 Widespread Teaming project (www.excelsior2020.eu). The 'EXCELSIOR' project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 857510, from the Government of the Republic of Cyprus through the Directorate General for the European Programmes, Coordination and Development and the Cyprus University of Technology.

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