The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLVIII-M-9-2025
30th CIPA Symposium "Heritage Conservation from Bits:
From Digital Documentation to Data-driven Heritage Conservation", 25–29 August 2025, Seoul, Republic of Korea

Digital Restoration of the Heritage Landscape through a GIS-Based Approach: Case Study of the Gochang Dolmen Site in South Korea

Minjae Zoh [1], Woojin Shim [1, 2, *], Ilhong Ko [1]

[1] Asia Center, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, Republic of Korea
– (mz369, tlasang1, mahari95)@snu.ac.kr (*corresponding author)
[2] Department of Geography, College of Social Science, Chonnam National University, 77, Yongbong-ro, Buk-gu, Gwangju, Republic of Korea

Keywords: GIS Data, Heritage Landscape, World Heritage Designated and Non-designated Sites, Gochang, Dolmens, Public Awareness

Abstract
This study explores how the global emphasis on World Heritage designation often privileges visibly intact and monumental sites, marginalizing heritage that has been destroyed, undocumented, or exists outside official recognition. Focusing on the Gochang Dolmen Site in South Korea—a UNESCO World Heritage Site since 2000—the research highlights the discrepancy between designated dolmens and numerous non-designated or non-extant megalithic features in the region. Utilizing Geographic Information Systems (GIS) and archival data, the study reconstructs the broader dolmen landscape, including sites that have been displaced, damaged, or erased due to development and environmental change. By converting national heritage data into point-based spatial representations and producing 3D visualizations, the research offers new insights into the relationship between extant and lost sites, encouraging a more integrated interpretation of prehistoric cultural landscapes. This approach aligns with South Korea's 2022 National Basic Framework Act on Cultural Heritage, which promotes digital technologies for inclusive heritage management. The findings demonstrate the potential of GIS not only to support technical conservation efforts, but also to democratize heritage narratives by reintroducing marginalized or absent features into public memory and discourse. Ultimately, the study argues for a shift from monument-centric heritage frameworks toward landscape-based and digitally-informed strategies that embrace both presence and absence as vital components of cultural heritage.

1. Introduction

The establishment of the World Heritage List has led to the global valorization of inscribed sites, reinforcing the importance of tangible evidence, integrity, authenticity, and conservation in international heritage discourse. However, this emphasis on designated physical heritage inherently privileges what is highly visible or materially intact, often neglecting sites that have been destroyed, damaged, or insufficiently documented. This study focuses on South Korea, where such dynamics have created a marked distinction between World Heritage properties and those protected at the national or local level. This disparity has significant implications for heritage governance, particularly regarding funding allocation, public visibility, and preservation priorities. While World Heritage designations confer international prestige and enhanced state support, they represent only a small fraction of the world's—and South Korea's—rich and diverse cultural landscape. As a result, many historically and culturally significant sites, especially those that no longer exist in their original form, fall outside the scope of the World Heritage Convention and must rely instead on domestic legal and institutional mechanisms for protection. This distinction highlights broader challenges in heritage recognition and management, particularly in contexts where destruction, urban development, or a lack of documentation has obscured or erased physical traces. By addressing these gaps, this study contributes to the growing discourse on digital heritage and proposes a GIS-based approach to restoring and interpreting non-extant and non-designated heritage landscapes, extending beyond the limitations of conventional conservation frameworks.

This study takes as its central case the Gochang Dolmen Site in South Korea, part of the *Gochang, Hwasun, and Ganghwa Dolmen Sites* inscribed on the UNESCO World Heritage List in 2000. While the World Heritage designation emphasizes the conservation of the officially recognized dolmen clusters, historical and archival data reveals the existence of hundreds of non-designated dolmens in Gochang, many of which have been damaged or displaced. Additionally, several contemporaneous Bronze Age settlements in the region have been excavated and are no longer extant. These undesignated dolmens and lost settlements remain largely absent from contemporary conservation narratives, reflecting a broader challenge in heritage management—particularly in contexts where preservation practices continue to prioritize physically extant and visually prominent monuments.

It is relevant to note that South Korea's heritage governance underwent a significant transformation with the enactment of the *National Basic Framework Act on Cultural Heritage* (Act No. 18448), which came into effect in 2022. Replacing earlier legislation such as the *Cultural Heritage Protection Act* (1962), this Framework Act established an integrated policy system for the identification, preservation, utilization, and research of cultural heritage at both national and local levels. Notably, the Act broadens the legal definition of cultural heritage to include non-designated, intangible, and spatially diffuse elements, and explicitly encourages the adoption of digital technologies for documentation and restoration (Articles 3 and 22). Despite this progressive legal framework, heritage conservation in practice continues to privilege visible, extant structures, resulting in the relative neglect of heritage that has been lost, removed, or remains undocumented in the physical landscape.

This study addresses this gap by proposing a GIS-based digital restoration of the Gochang dolmen landscape beyond the boundaries and buffer zone of the World Heritage site. By harnessing spatial and archival data, it enables the World Heritage-designated dolmens to be understood as material witnesses to the historical transformations of Gochang's landscapes and communities. In doing so, the study seeks to move beyond the constraints of designated heritage and promote

a more inclusive approach to Korea's prehistoric past—one that acknowledges and reintegrates dispersed, fragmented, or erased heritage into national memory. By leveraging digital mapping technologies, this research contributes to ongoing debates in heritage studies about the potential of geospatial tools to enhance conservation strategies, recover overlooked histories, and expand the scope of heritage discourse beyond formally designated and physically extant sites.

2. GIS and Its Contributions to Heritage Conservation and Management

Geographic Information Systems (GIS) have become indispensable tools in the conservation and management of cultural heritage, offering spatially explicit methods for integrating, analyzing, and visualizing complex datasets across temporal and spatial dimensions (Gregory and Ell, 2007). By enabling multi-layered representations of cultural landscapes, GIS allows heritage professionals to assess historical changes, identify vulnerable areas, and make informed decisions grounded in empirical spatial analysis. One of GIS's key contributions to heritage conservation is its ability to define and manage buffer zones and protected areas around heritage sites—a practice strongly endorsed by the UNESCO *Operational Guidelines for the Implementation of the World Heritage Convention* (UNESCO, 2021, paras. 104–107). In this regard, GIS supports compliance with international protection standards by providing technical tools for zoning regulations, impact assessments, and environmental monitoring.

In practical terms, GIS supports a range of critical heritage management functions, including inventory and documentation, condition assessment, spatial analysis, predictive modeling, and long-term monitoring. These capabilities have enabled the systematic integration of heterogeneous datasets—such as archaeological records, historical maps, aerial imagery, LIDAR scans, and field survey data—into a cohesive geospatial framework (Parcero-Oubiña et al., 2013). This integration not only enhances the accuracy of site documentation but also provides a robust foundation for comparative and diachronic studies, which are essential for understanding the evolution of cultural landscapes.

Importantly, GIS has expanded its utility beyond expert-driven heritage management to encompass public engagement and participatory governance. Increasingly, web-based GIS platforms and mobile mapping tools allow communities to contribute local knowledge and spatial narratives. This democratizing potential is central to the concept of Participatory GIS (PGIS), which McCall and Minang (2005) describe as a vital bridge between local communities and formal heritage institutions. PGIS not only enhances data inclusivity but also fosters community stewardship, empowering stakeholders to participate actively in the interpretation, documentation, and management of heritage.

The integration of GIS into heritage practices reflects a broader paradigm shift from a monument-centric to a landscape-based approach. This shift acknowledges cultural heritage as spatially distributed, relational, and often embedded within dynamic, living environments. As Campana and Remondino (2014) observe, GIS-based documentation enables the identification and representation of both visible and invisible heritage elements, including sites that have been destroyed, damaged, or remain undocumented. In this way, GIS serves as a powerful tool for safeguarding cultural memory and informing forward-looking conservation policies.

In the South Korean context, this shift has been institutionally reinforced by the *National Basic Framework Act on Cultural Heritage* (Act No. 18448), which mandates the development and application of digital information systems as part of the national heritage management strategy. Article 22 of the Act explicitly promotes the use of digital technologies—including GIS—for documentation, monitoring, and restoration, extending their application to both designated cultural properties and non-designated heritage resources. This legal foundation creates opportunities to apply spatial technologies in more inclusive and innovative ways, addressing previously overlooked or marginalized heritage landscapes.

3. Sources and Methods for Case Study Analysis

The Korea Heritage Service (KHS) operates the *National Heritage Geographic Information Service* (https://gis-heritage.go.kr/main.do), a digital platform that integrates spatial data with comprehensive information on Korea's cultural heritage. For the general public, it provides accessible content such as photographs, architectural drawings, video documentation, and descriptive metadata for heritage sites. Equally important, however, is the platform's function in supporting informed decision-making related to the management, conservation, and policy development of national heritage resources. Central to this function is the platform's GIS Combined Intranet System, which supplies real-time data on both designated and non-designated heritage properties. Although not publicly accessible, the intranet system can be made available for research purposes upon approval by the KHS.

Among the datasets provided by the GIS Combined Intranet System, the *Buried Cultural Heritage Spatial Data Set*—a comprehensive digital archive of excavation reports, field surveys, and archaeological interventions across South Korea—is of particular significance. Although the dataset offers extensive national coverage, it is primarily presented as polygonal data, delineating entire areas of investigation rather than indicating the precise locations of archaeological features or finds. This format has limited its utility for traditional spatial archaeological analyses, which rely on fine-grained locational precision.

In response, recent scholarship has begun to reinterpret this dataset as a form of archaeological 'Big Data,' applying broader analytical frameworks to extract historical and spatial insights. For example, by converting polygon data into point-based representations, researchers have traced diachronic patterns of human settlement and modeled ancient pathways and mobility systems (Ko, 2022; Ko et al., 2023). These developments underscore the latent potential of national GIS archives not only for advancing academic research but also for fostering public engagement with heritage landscapes.

In this study, we utilized the *Buried Cultural Heritage Spatial Data Set* (BCHS Data Set) provided by the Korea Heritage Service (KHS). As noted above, the original dataset consists of polygon features, each containing multiple attributes related to chronological classification and site typology (categorized as major, intermediate, and minor). To enhance analytical clarity, we conducted a preprocessing step in which the individual polygons of all investigated heritage sites in Gochang—numbering 1,382 in total (Figure 1)—were disaggregated based on unique combinations of chronological and typological attributes. Chronological classification followed the six-period

framework commonly adopted in Korean archaeological scholarship. For site typology, we categorized the heritage sites into two groups: (1) those *physically extant within the landscape* (including sites originally categorized in the BCHS Data Set as "dolmen site," "fortress site," etc.), and (2) those *no longer physically extant within the landscape* (including "settlement site," "shell midden site," "road site," "mining site," "farm site," "ironworking site," etc.). For mounded tombs, we referred to recent visual survey data (Naju National Research Institute of Cultural Heritage, 2011) to determine whether each tomb should be classified as extant or non-extant within the current landscape.

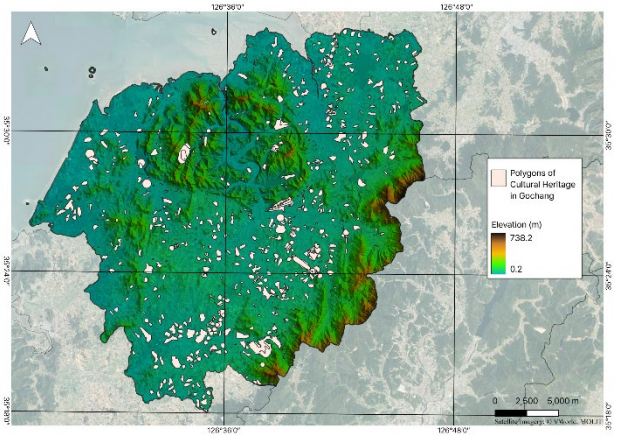

Figure 1. Map of Gochang, South Korea, with spatial data from the “Cultural Buried Cultural Heritage Spatial Data Set” provided by the Korea Heritage Service’s “GIS Combined Intranet System” expressed in its original polygon form.

The heritage site polygons were subsequently converted into point features by calculating the centroid of each polygon (Figure 2). All GIS processing was conducted using QGIS 3.34, with the coordinate reference system set to the Korea 2000 Unified Coordinate System (EPSG:5179) to ensure compatibility with national geospatial datasets. For terrain analysis and visualization, we employed the NASA Shuttle Radar Topography Mission (SRTM) Version 3.0 Global 1 arc-second Digital Elevation Model (DEM), which was downloaded from the USGS Earth Explorer platform.

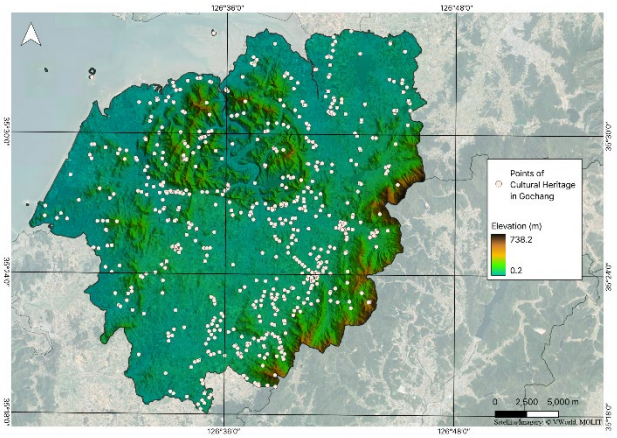

Figure 2. Map of Gochang, South Korea, with spatial data from the “Cultural Buried Cultural Heritage Spatial Data Set” provided by the Korea Heritage Service’s “GIS Combined Intranet System” transformed into points.

Additionally, a 3D rendering of the terrain was produced using the ArcMap 3D Scene environment, based on the SRTM DEM data. This rendering was created for visualization purposes only and did not involve any form of quantitative spatial analysis. Although formal metadata standards such as ISO 19115 were not applied in this project, the data structure and coordinate reference system were deliberately maintained to support potential future integration with national heritage management systems. The GIS dataset developed through this study not only enhances public awareness of heritage landscapes but also provides a valuable foundation for identifying candidate sites for future conservation efforts.

4. Case Study: Contextualizing Gochang’s World Heritage Dolmens using GIS Data

This study builds upon recent innovations by proposing a GIS-based digital restoration methodology applied to the Gochang Dolmen Sites. Rather than simply mapping existing dolmen locations, this research integrates transformed spatial data with historical records to reconstruct the distribution of now-absent megalithic features. In doing so, it contributes to heritage conservation in two key ways. First, it produces spatially accurate historical layers that can inform preventative protection strategies for areas at risk, particularly those threatened by development or natural erosion. Second, it provides heritage authorities with a tool to visualize relationships between extant and vanished features, thereby improving the management of both designated and non-designated heritage zones.

In line with Article 12 of the *National Basic Framework Act on Cultural Heritage* (2022), which mandates the use of digital technologies for cultural heritage information and conservation planning, this approach supports a more inclusive and data-driven heritage management system. The study also incorporates comparative spatial analyses, contrasting current and historical dolmen distributions to assess patterns of preservation, loss, and landscape transformation over time. In doing so, it offers both theoretical insight and practical tools for advancing integrated and forward-looking heritage governance.

The World Heritage-designated dolmens of Gochang have been afforded a status that appears to transcend both time and place. They are often presented as timeless symbols of human ingenuity rather than as cultural phenomena rooted in the specific historical and geographical context of Gochang. Framed primarily through comparisons with other global examples of megalithic architecture, they are frequently detached from the local narratives and landscapes in which they are embedded.

To spatially and temporally contextualize the dolmens within the broader landscape of Gochang, GIS data from all investigated heritage sites in the region were used to produce a series of analytical maps. The dataset consisted of: (1) point data converted from the polygon features of the “Buried Cultural Heritage Spatial (BCHS) Data Set,” acquired by the authors in 2018, and (2) point data for heritage sites identified between 2019 and 2025. The compiled dataset was first visualized using a six-period chronological framework commonly employed in Korean archaeology (Figure 3). In addition, the sites were categorized and visualized based on their physical extant status in the present-day landscape—distinguishing between those that are still visible and those that are no longer extant (Figure 4). Following this classification, 3D maps were produced to further support the spatial and temporal contextualization of the World Heritage dolmen sites within the broader heritage landscape of Gochang.

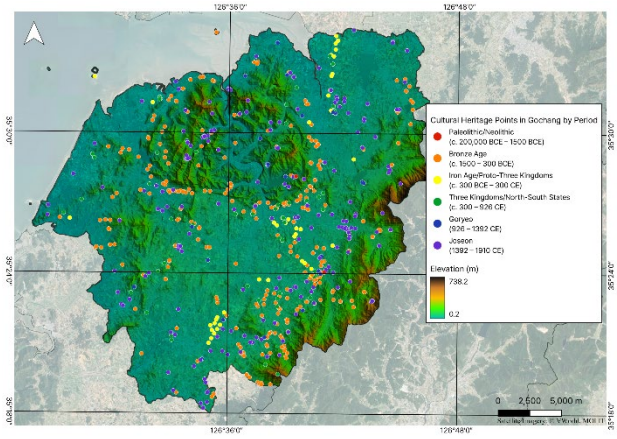

Figure 3. Map of Gochang, South Korea, with cultural heritage sites (expressed as point data) classified into six periods.

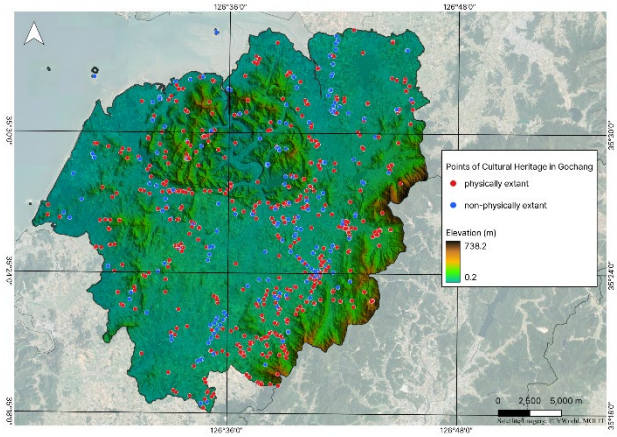

Figure 4. Map of Gochang, South Korea, with cultural heritage sites (expressed as point data) classified into those that are physically extant in the present-day landscape and those that are not.

Gochang is a basin bordered by mountain ranges along its northwestern and southeastern edges. The highest concentration of dolmens is found along these mountainous zones, while contemporaneous settlements are situated in the central part of the basin, where rivers flow and converge (Figure 5).

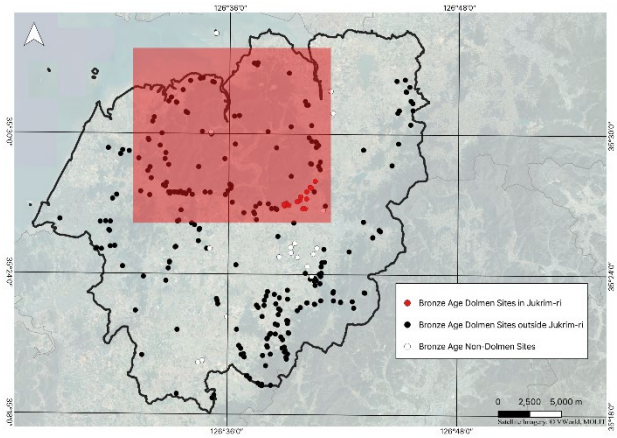

Figure 5. Map of Gochang, South Korea, illustrating the distribution of all Bronze Age sites, with the red box denoting the area visualized as a 3D landscape in Figures 6 and 7.

A 3D map was created to visualize the distribution of dolmens and settlements in the northwestern zone of Gochang, where the Jukrim-ri World Heritage-designated dolmens are located (Figure 6). This visualization includes not only the World Heritage-designated dolmens in present-day Jukrim-ri, but also non-designated yet extant dolmens, as well as Bronze Age settlement sites that were contemporaneous with the dolmens but are no longer visible in the present-day landscape. By integrating these elements within a single 3D map, the analysis illustrates that the Jukrim-ri dolmens were part of a broader cultural pattern—one in which dolmens were constructed along the foot slopes of mountainous areas by communities residing in nearby villages established on the surrounding alluvial plains.

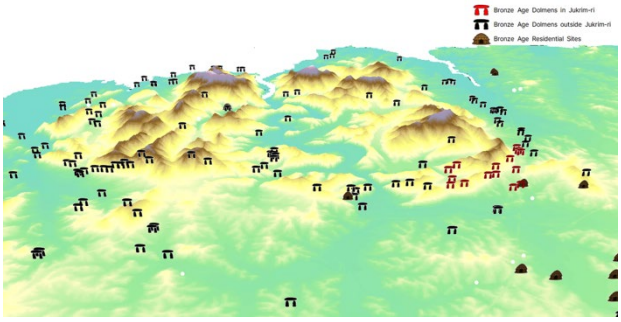

Figure 6. 3D map visualizing the distribution of dolmens and settlements in the northwestern zone of Gochang, where the Jukrim-ri World Heritage-designated dolmens are located.

From a public archaeology perspective, this 3D map serves as more than a visualization tool – it becomes a medium for storytelling and public engagement. By situating Bronze Age settlements alongside the dolmens within a reconstructed landscape, the map allows viewers to move beyond the dolmen’s monumentality and symbolic permanence. Instead of seeing the dolmens in isolation, the public is invited to consider the lived experiences of the people who built them – their communities, spatial relationships, and interactions with the landscape. This shift in focus humanizes the past and democratizes heritage interpretations, making it more relatable and inclusive. The map encourages audiences to imagine the social, labor, and environmental contexts in which these megalithic structures were created.

From a heritage point of view, this 3D aids in lessening the distinction between dolmens that are designated as ‘World Heritage’ and those that are not, allowing for a more inclusive and holistic understanding of the dolmen landscape. By presenting both designated and non-designated dolmens within the same spatial and temporal frame, the map challenges hierarchical perceptions of value that often privilege officially recognized sites over others of equal historical and cultural significance. This approach encourages the recognition of overlooked or marginalized heritage and promotes a more equitable conservation ethic- one that values the broader cultural landscape and not just its most monumental elements. It also invites the decision-makers or governing bodies of heritage to reconsider preservation priorities, potentially leading to a more integrated protection strategies that extend beyond the boundaries of World Heritage.

Building on this more integrated understanding of the dolmen landscape, the 3D visualization was further developed to include traces of human activity in Gochang from periods following the construction of the dolmens (Figure 7). Notably, the spatial distribution of later-period heritage sites rarely overlaps with that of the dolmens, raising intriguing questions about the “path-dependency” of heritage sites—that is, how the presence of

monumental features like dolmens may have influenced spatial decision-making in subsequent eras, just as they continue to shape cultural and administrative actions today.

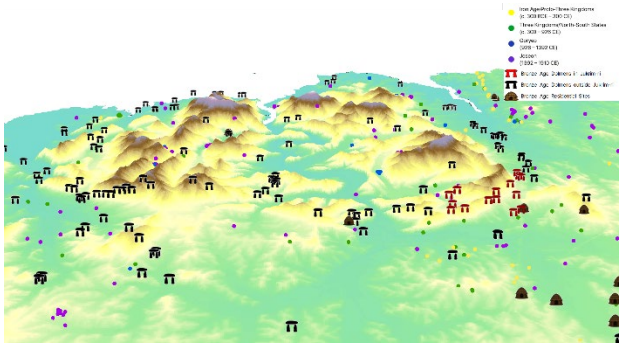

Figure 7. 3D map visualizing human activity from periods following the construction of the dolmens in the northwestern zone of Gochang, where the Jukrim-ri World Heritage-designated dolmens are located.

This is particularly evident in the case of Iron Age and Proto–Three Kingdoms Period tombs, which are generally situated at considerable distances from the dolmens. While this pattern may be attributable to a variety of environmental, cultural, or political factors, it is also worth considering historical perceptions. In a Goryeo-period account by Yi Gyu-bo (1160–1241), writing about his travels to the southern lands in *Namhaegwolilgi* (featured in his collected works, *Tongguk Yi Sang-guk chib*), he recounts how he encountered dolmens and was told that the populace regarded them as the work of ancient saints (Yu, 2023). This suggests that a sense of reverence—or even deliberate avoidance—may have contributed to their spatial separation. Such patterns offer valuable insight into how the meanings attributed to heritage features can evolve over time and influence long-term landscape use.

This study has demonstrated the value and potential of GIS-based visualization in reinterpreting the dolmen landscape of Gochang. Accordingly, heritage must be understood not only in terms of presence and monumentality, but also through spatial memory and absence. Rather than prioritizing World Heritage designated sites, the findings encourage a more landscape-based approach to heritage – one that accounts for how past structures shape future human actions. In sum, these two maps effectively demonstrate how the World Heritage dolmens are not an isolated phenomenon, but are embedded within a wider network of megalithic construction and human activity across the Gochang region.

5. Conclusion

The results of this study demonstrate that heritage management GIS data can be effectively leveraged to produce maps that enhance public understanding and engagement with cultural heritage. GIS-based approaches, such as the one employed here, provide critical insights that reach beyond the boundaries of officially designated World Heritage sites. Through spatial analysis and digital mapping, previously undocumented, fragmented, or destroyed heritage elements can be reconstructed and reintegrated into broader cultural landscapes.

This aligns with calls for holistic heritage management, which emphasizes the interconnectivity between designated and non-designated sites (Taylor and Lennon, 2011), as well as with UNESCO's evolving recognition of cultural landscapes and the importance of managing buffer zones beyond core inscribed areas (UNESCO, 2019). GIS enables the modeling of such extended zones and the simulation of potential development pressures or environmental threats, contributing to more proactive and informed conservation strategies.

Importantly, digital mapping also holds considerable potential for heritage education and public outreach. The general public is typically exposed only to heritage that is formally designated, visibly intact, and physically preserved. Digital tools, however, allow for the visualization of erased or overlooked heritage, expanding access to histories and landscapes that have long remained invisible.

In the case of the Gochang Dolmen Sites, the use of GIS facilitated the reconstruction of dolmen distributions that have been altered or erased due to agricultural development, infrastructure expansion, or natural erosion. This spatial reconstitution not only provides a more comprehensive understanding of the dolmen landscape but also prompts new questions about site selection, cultural practice, and long-term landscape change—questions that may remain inaccessible through conventional archaeological or textual approaches alone.

Ultimately, the use of GIS in heritage management is not merely a technical enhancement. It represents a conceptual and epistemological shift in how we understand, protect, and engage with heritage—particularly in contexts where physical traces have vanished but cultural significance endures. This study affirms the potential of geospatial technologies to contribute to more inclusive, forward-looking, and community-oriented approaches to heritage in South Korea and beyond.

Acknowledgements

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea [NRF-2020S1A6A3A02065553].

References

Campana, S., Remondino, F., 2014: *3D Recording and Modeling in Archaeology and Cultural Heritage: Theory and Best Practices.* Archaeopress, Oxfordshire.

Gregory, I. N., Ell, P.S. 2007. *Historical GIS: Technologies, Methodologies, and Scholarship.* Cambridge University Press, Cambridge.

Ko, I., 2022: Asia in Data: Exploring Innovative Methods of Data Collection and Analysis for Asian Studies, ICAS12 Conference.

Ko, I., Shim, W., Jung, H., 2023: Multiplicity and Path Dependency in the Modeling of Historical Routes: A Case Study of the Wonju Basin in the Central Region of the Korean Peninsula, *The Professional Geographer*, 76(1), 1-12.

McCall, M.K., Minang, P.A., 2005: Assessing participatory GIS for community-based natural resource management: Claiming community forests in Cameroon. *The Geographical Journal*, 171(4), 340-356.

Naju National Research Institute of Cultural Heritage. 2011. Ancient Tombs in the Youngsan River Basin Detailed Survey Report. Naju, Korea.

Parceo-Oubina, C., White, P.V., Guimil-Farina, A., Blanco-Rotea, R., Lopez, M.F.P., Herrero, A.S., Caballero, A.H., Garcia, C.G., 2013: GIS-Based Tools for the Management and Dissemination of Heritage Information in Historical Towns: The case of Santiago De Compostela (Spain). *International Journal of Heritage in the Digital Era*, 2(4), 566-672.

Republic of Korea. 2022. National Basic Framework Act on Cultural Heritage, Act. No. 18448.

Taylor, K., Lennon, J., 2011: Cultural Landscapes: A Bridge Between Culture and Nature? *International Journal of Heritage Studies*, 17(6), 537-554.

UNESCO, 2019: *Operational Guidelines for the Implementation of the World Heritage Convention.* UNESCO, Paris.

Yu, J., 2023. A Study of the Geographical Characteristics of “Namhaengwolilgi” by Lee, Kyu-bo. *The Journal of Jeonbuk Studies*, 10, 119-141.