An Integrated Archaeoastronomical and Landscape-Archaeological Study on the Linear Axis and Solstitial Orientation of the Mujang-myeon Dolmens, Gochang

Younghee Noh*

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ABSTRACT

This study tests the directional layout of dolmens in Mujang-myeon (Gochang, Korea) within an integrated archaeoastronomy-landscape archaeology framework. Using field records with DEM-derived horizon profiles and viewsheds, and evaluating axial data via circular statistics, we examine three scales: a regional line (Gyoheung-Songhyeon-Wonchon), the Gyoheung cluster (Ga-Na-Da), and monument long-axes. Results show a southeast regional axis near 130° consistent with the winter-solstice sunrise, an intra-cluster alignment near 160°, and frequent clustering on 60/120/240/300° and 95-100/275-280°. Several monuments allocate front/side/rear faces toward winter sunset, winter sunrise/summer sunset, and stellar viewing. We infer a dual frame—true north/Ursa Major and seasonal solar markers—embedded in local peaks and saddles, and recommend protecting solstitial sightlines.

1. Introduction

The Mujang-myeon area of Gochang-gun, Jeonbuk Special Self-Governing Province, is a core distribution zone of the Southwestern Coastal Megalithic Cultural Sphere; a total of 76 dolmens have been identified across Gangnam-ri, Gyoheung-ri, Dogok-ri, Mogu-ri, Sinchon-ri, Oksan-ri, Wonchon-ri, and Wollim-ri (Noh & Lee, 2024). This distribution suggests a settlement-ritual-production structure tightly coupled to the micro-topography of low hills, small streams, and alluvial flats set against the backdrop of Mt. Hanje and Mt. Wangje. Building on this spatial-geomorphic context, the present study systematically tests how dolmen orientations and linear arrangements stand in phase relations with seasonality (winter and summer solstices) and with stellar observation (Noh & Lee, 2024).

Mujang-myeon's landscape conditions support the coevolution of prehistoric agriculture and observation. In locales where broad alluvial tracts develop along minor streams and open areas continue across hill slopes and mountain skirts, the sources consistently describe prehistoric groups as having marked the cycles of celestial bodies (solstices/equinoxes) by coupling them to specific peaks and

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* Department of Library & Information Science, Konkuk University, Korea (irs4u@kku.ac.kr) (First & Corresponding Author)

valley-lines on the horizon (Noh & Lee, 2024). The materials present observational values—winter-solstice sunrise ≈120-130°, sunset 240°; summer solstice 60°/300°; equinoxes 95-100°/275-280°—and argue that these seasonal indices were reflected in dolmen long axes, passages, and the layouts of features both within and among clusters (Noh & Lee, 2024).

The primary focus of this article is the coupling between the linear spatial structure running Gyoheung-ri → Songhyeon-ri → Wonchon-ri and its seasonal orientation. The three points—Songhyeon-ri san 100-3 (upper burial precinct, inferred), Gyoheung-ri san 49 (central ritual group), and Wonchon-ri 949-1 (lower boundary of a low hill)—lie on a straight line of approximately 740 m with a southeastern bearing of about 130°. Within each cluster, individual features exhibit meaningful orientation patterns centered on the 60°/240° (summer-solstice sunrise/winter-solstice sunset) and 120°/300° (winter-solstice sunrise/summer-solstice sunset) axes (Noh & Lee, 2024). Such multi-scalar alignments offer heuristic cues for interpreting the functional differentiation among burial precinct, ritual node, and habitation boundary through the model of "landscaping temporality" (Noh & Lee, 2024).

At the level of individual cases, the coupling between seasonal/horizon indices is repeatedly confirmed. Features in Gyoheung-ri Cluster B (na-gun) employ the 60°/240° and 120°/300° axes in combination; descriptions from Dogok-ri, Sinchon-ri, Oksan-ri, Mogu-ri, and Wonchon-ri likewise present the marking of particular peaks and passes—e.g., Bangjangsan, Munsusan, Wolbongsan, Janggunbong—together with winter/summer-solstice and equinoctial sightlines (Noh & Lee, 2024). This tripartite structure of orientation-topography-lines of sight appears to be a general pattern observable throughout Mujang-myeon, and the present study reconstructs it using statistical and spatial models.

The problem statement is clear. First, we must test whether the ~130° regional linear axis connecting Gyoheung-ri-Songhyeon-ri-Wonchon-ri constitutes statistically significant intentional linearity, or merely a preferred direction incidentally formed under geomorphic constraints. Second, using circular statistics we must determine whether the concentrations of long-axis bearings around 60°/240° and 120°/300° reported in many clusters are non-random distributions associated with seasonal ritual. Third, we must explain whether the phase relations among the regional axis (130°), intra-cluster axes (e.g., the linear arrangement in Gyoheung-ri), and individual long axes (seasonal axes) are organized as a functional division among burial precinct, ritual node, and boundary marker, by integrating horizon/visibility-field analyses with terrain and hydrographic variables (alluvial plains, slope aspect, etc.). These three questions are amply grounded in first-order clues provided by field descriptions of developed drainage systems—Songhyeoncheon, Gangnamcheon, Juksancheon—the combination of low hills and alluvial flats, and the coupling of particular peaks with seasonal sightlines (Noh & Lee, 2024).

2. Theoretical Background

Archaeoastronomy and landscape archaeology have provided standard theories and methods for integrative interpretation of orientations and linear arrangements of prehistoric monuments together with horizon markers. A comprehensive synthesis of this field can be found in Ruggles's edited

Handbook of Archaeoastronomy and Ethnoastronomy, which emphasizes the need to minimize observer subjectivity by tightening horizon modeling, sampling design, and statistical testing (Ruggles, 2015). In the World Heritage context, interpretive criteria have likewise been refined by the ICOMOS-IAU thematic studies, which recommend an evidentiary framework that threefold combines astronomical indicators, heritage values, and landscape context—an approach that directly resonates with the design of this study (Ruggles & Cotte, 2010, 2017).

Discrimination of orientation data requires not linear statistics but statistics for directional data (circular statistics). Because long axes, principal axes, and layout bearings with fixed reference angles are distributions on a circular (periodic) space, Rayleigh- and Kuiper-class tests, confidence-interval estimation, and multiple-hypothesis correction are required (Mardia & Jupp, 2000). On the spatial-analytic side, GIS techniques—DEM-based horizon profiles, viewshed analysis, and least-cost paths—help curb over-interpretation in orientation analysis and ensure concurrent consideration of constraining landscape variables such as topography, hydrography, and slope aspect (Wheatley & Gillings, 2002). These international standards provide the methodological basis in this study for integrating, within a single analytic system, seasonal orientation (summer/winter solstices and equinoxes), linear axes (≈130°/160°), and visibility/topographic constraints (Ruggles, 2015; Ruggles & Cotte, 2010, 2017).

Large-scale outdoor surveys in the Mediterranean and Western Europe have long treated regional and scalar constraints (topography, horizon, ritual practice) as key variables for orientation and layout, and have quantitatively demonstrated that the long axes of megaliths acquire meaning in correspondences with the rising/setting of the seasonal sun or with particular ridgelines (Hoskin, 2001). This line of inquiry is especially suggestive for the micro-topography of southwestern Korea—where mountains, low hills, alluvial flats, and small streams are interwoven—and landscape-archaeological approaches that read sites within settlement-production-ritual spatial structures have been introduced into Korean archaeology (Kim, 2006). However, domestic studies of orientation have been criticized for a high proportion of descriptive reporting and limited sample sizes, leaving systematic statistical testing insufficient (Kim, 2006).

The Gochang, Hwasun, and Ganghwa dolmen sites, through World Heritage inscription, have received international recognition for the evidential value of quarrying-transport-installation and for the density and diversity of clusters, thereby expanding the possibilities for interpretation within a landscape frame (UNESCO World Heritage Centre, n.d.). This World Heritage context provides grounds for positioning Mujang-myeon's linear arrangements and orientations not merely as a local description but as a test bed for a general landscape-astronomy model (Ruggles & Cotte, 2010, 2017).

Primary descriptive sources on Mujang-myeon repeatedly report inter-cluster linearity around Gyoheung-ri-Songhyeon-ri-Wonchon-ri (≈160° alignment within Gyoheung-ri), symbolic layouts referencing the Big Dipper and alignments to true north, and seasonal orientation of long axes (60°/240°, 120°/300°, etc.), and they raise the possibility that ridgelines and valley-lines on the horizon were employed as markers for seasonal sightlines (Noh & Lee, 2024). Yet these accounts still leave room for confirmatory research, insofar as circular-statistical tests of concentration across the full sample and estimation of covariance structures among topographic control variables (slope aspect, elevation, hydrography, alluvial plains) have not been conducted systematically (Kim, 2006;

Ruggles, 2015). Accordingly, this study applies international-standard testing procedures—directional-data statistics together with horizon and visibility modeling—to the Mujang-myeon materials, in order to evaluate quantitatively whether the multi-layered structure of regional axis (≈130°), cluster axis (≈160°), and individual long axis (seasonal axes) constituted a system interlacing ritual, time, and landscape (Mardia & Jupp, 2000; Wheatley & Gillings, 2002; Ruggles & Cotte, 2017; Noh & Lee, 2024).

3. Study Area and Research Methods

3.1 Overview of the Study Area

The study area is Mujang-myeon, Gochang-gun, Jeonbuk Special Self-Governing Province, encompassing a total of 76 dolmens distributed across Gangnam-ri, Gyoheung-ri, Dogok-ri, Mogu-ri, Sinchon-ri, Oksan-ri, Wonchon-ri, and Wollim-ri (Noh & Lee, 2024). This distribution closely corresponds to micro-topographic conditions—hilly terrain, the conjunction of small streams and alluvial flats, and the windbreak effect of backing ridgelines—and suggests a triple structure of settlement, ritual, and production (Noh & Lee, 2024).

Around Gangnam-ri, the mountain system running Seoksusan-Mangchisan-Hanje-san blocks the northwesterly monsoon winds; together with the lower-reach streams Hairicheon and Songhyeoncheon and nearby Gangnamcheon and Goracheon, the locale is described as affording both good visibility and suitability for agriculture (Noh & Lee, 2024). Many dolmens in this area show long-axis orientations toward summer-solstice sunrise (≈60°) and winter-solstice sunset (≈240°), and cup-marks are recorded on certain features (Noh & Lee, 2024).

In Gyoheung-ri (including, administratively, part of Songhyeon-ri), linearity along the ridge is repeatedly noted for Clusters A-B-C (≈160°), as are symbolic placement of seven standing stones at Gung-dong known as “Chilam (Seven Rocks)” in the pattern of the Big Dipper and alignments to true north (Noh & Lee, 2024). Seasonal-horizon markers are specified—Haksan; Duryubong of Bangjangsan; Mangchisan—and the possibility is raised that cluster- and feature-level orientations were phased with surrounding ridgelines/valley-lines (Noh & Lee, 2024).

Cases from Wonchon-ri, Mogu-ri, and Sinchon-ri also repeatedly describe the 60°/240° and 120°/300° axes; in some segments, correspondences with stellar observation lines such as 210°/280° and even inferred quarry locations (e.g., Wangje-san) are recorded in parallel (Noh & Lee, 2024).

3.2 Selection of Targets and Analytic Scales

This study sets as its core analytic target the linear spatial axis running Gyoheung-ri-Songhyeon-ri-Wonchon-ri among the 76 features across Mujang-myeon. The grounds are: (1) first-order descriptions of ≈160° alignment among Clusters A-B-C within Gyoheung-ri; (2) repeated statements regarding the true-north alignment of Gung-dong Chilam-Cluster A; and (3) the recurring coupling—across Gyoheung-ri, Mogu-ri, and Wonchon-ri—of seasonal markers (summer/winter solstices and equinoxes), horizon markers, and orientations (Noh & Lee, 2024).

Scale-specific tests proceed as follows. At the regional level, we evaluate the existence of a southeastward linear axis (hypothetically ≈130°) connecting Gyoheung-ri-Songhyeon-ri-Wonchon-ri; at the cluster level, we test the significance of the internal alignment line within Gyoheung-ri (≈160°); and at the individual level, we assess seasonal concentrations of long-axis orientations (60°/120°/240°/300°, etc.). Here, the ≈130° axis is a preliminary cartographic hypothesis of this study that is verified by circular statistics and GIS in Chapter 4 (Ruggles, 2015; Mardia & Jupp, 2000).

3.3 Sources and Dataset Construction

The primary sources are the Mujang-myeon survey records by Noh and Lee (2024), which, for each feature and cluster, provide coordinates (lat/long), elevation, type, capstone form/size, long-axis bearing, and descriptions of surrounding topography and sightlines (Noh & Lee, 2024). For example, for Gangnam-ri dolmens 1 and 4, coordinates, elevation, orientation, and the presence/absence of cup-marks are given, together with sightlines to nearby peak markers (Goseongbong, Duryubong, Guhwangsan, etc.). For Gyoheung-ri Cluster A, administrative jurisdiction (Songhyeon-ri), distribution scale (≈29 features), and access routes are presented alongside an ≈160° alignment, the Chilam-true-north alignment, and the Mangchisan marker, with drawings and photographs (Noh & Lee, 2024).

As auxiliary data we use: (a) DEMs with 10-30 m resolution and up-to-date aerial imagery; (b) environmental layers such as hydrography, slope aspect, and land cover; and (c) geomagnetic declination for the observation date. These auxiliary data serve as inputs for spatial analysis—including horizon profiling, viewshed analysis, and least-cost path modeling (Wheatley & Gillings, 2002)—and provide the basis for geometric and geomagnetic corrections in directional-data statistics (Mardia & Jupp, 2000).

The dataset is structured as: (1) a feature table (ID, coordinates, elevation, type, size, long-axis angle, cup-mark presence); (2) a cluster table (cluster ID, internal alignment angle, distribution of long axes within the cluster); and (3) a landscape table (horizon indicator angles, target peaks/valleys, distance to hydrographic/alluvial features, slope aspect, elevation, and a visibility index) (Ruggles, 2015; Wheatley & Gillings, 2002).

3.4 Preprocessing and Quality Control

First, narrative bearings in the survey records (e.g., “60-240°”) are standardized to central angles, with range values recorded as measurement error. Second, upon local re-measurement, geomagnetic declination is corrected for (using the value at the observation time), and bearings of long axes and cluster alignments are recorded to one decimal place (Mardia & Jupp, 2000). Third, coordinates are unified to WGS84, and outliers are checked through elevation matching with the DEM. Fourth, horizon indicators are derived by DEM-based profiling, with annotations regarding observation-point elevation, time-series atmospheric refraction, and the possibility of surface alteration (e.g., the installation of recent graves) (Noh & Lee, 2024; Wheatley & Gillings, 2002).

3.5 Variable Definitions and Units of Analysis

The study's core variables are defined across three layers. (A) Regional-axis variables: the angle (°) of the linear axis connecting Gyoheung-ri-Songhyeon-ri-Wonchon-ri and the axis error (±°). (B) Cluster-axis variables: the alignment for Gyoheung-ri Clusters A-B-C (≈160°) and the internal linearity of each cluster (significance p). (C) Feature-orientation variables: each dolmen's long-axis bearing (°); angular deviation (°) from seasonal markers (summer/winter solstices; equinoxes); and cup-mark presence (0/1). Landscape variables include horizon indicator angles; types of target peaks/valleys; slope aspect (°); elevation (m); distance (m) to hydrography/alluvial plains; and a visibility index (Wheatley & Gillings, 2002; Ruggles, 2015). Cluster and feature units of analysis follow the catalog numbering system used in the survey volume (Noh & Lee, 2024).

4. Research Methods

4.1 Overview of the Research Design

This study is designed to test, across multiple scales (regional-cluster-feature), the linear axes and seasonal orientations of the dolmens in the Gyoheung-ri-Songhyeon-ri-Wonchon-ri area of Mujang-myeon. At the regional scale, we evaluate the existence of a southeastward regional linear axis (hypothetically ≈130°) that connects the three points. At the cluster scale, we test the significance of the ≈160° alignment among Gyoheung-ri Clusters A-B-C. At the feature scale, we assess whether long axes concentrate around the reference-angle bands for the sun's rising and setting at the summer and winter solstices and at the equinoxes (e.g., 60°/120°/240°/300°, 95-100°/275-280°) (Noh & Lee, 2024; Ruggles, 2015).

4.2 Research Data

The primary data comprise field survey records of the Mujang-myeon dolmens, including location (latitude/longitude), elevation, type, capstone long-axis bearing, and descriptions of surrounding topography and lines of sight (Noh & Lee, 2024). Auxiliary data consist of a digital elevation model (DEM; 10-30 m) and current orthophotos, together with slope, hydrography, and land-cover layers, which are used for horizon and visibility analyses (Wheatley & Gillings, 2002). For any local remeasurement, geomagnetic declination at the observation date is applied to convert magnetic to true north (Mardia & Jupp, 2000).

4.3 Variables and Operational Definitions

Because the directional data in this study are axial, angles are recorded on the interval [0, 180), and an angle-doubling transformation is applied for statistical tests (Mardia & Jupp, 2000). The regional linear-axis angle is estimated as the azimuth of a line obtained by transforming the centroid coordinates of Gyoheung-ri-Songhyeon-ri-Wonchon-ri into an appropriate projected coordinate system (e.g., UTM/WGS84 or the national TM), then applying orthogonal regression (total least squares; PC1 of PCA) to the point set. Cluster alignment lines are derived by applying principal component analysis (PC1) to the centroid coordinates of features within each cluster, and the resultant azimuths are defined as cluster alignment angles. The long-axis angle is defined as the field-measured bearing of the dolmen capstone's long axis. Seasonal deviation is calculated as the minimal angular difference between the long-axis angle and the reference angles—summer solstice 60°/300°, winter solstice 120°/240°, equinoxes 95-100°/275-280°—and represents proximity to seasonal orientation. Finally, landscape variables comprise DEM-based horizon indicator angles (azimuth/elevation of target peaks and valley-lines), the type of target landform, elevation, slope aspect, distance to waterways/alluvial plains, and a visibility index (viewshed proportion) for specified directional sectors; these are computed using standard GIS procedures (Ruggles, 2015; Wheatley & Gillings, 2002).

4.4 Preprocessing and Measurement Protocol

Narrative bearings in the survey records (e.g., "60-240°") are standardized to central angles, and range values are retained as measurement error. Local remeasurements are conducted with a compass and clinometer (accuracy ±1°), taking three repeated readings and adopting the mean; geomagnetic declination at the observation time is applied for the magnetic-to-true conversion (Mardia & Jupp, 2000). Coordinates are stored in WGS84, but converted to a projected coordinate system prior to direction and distance estimation to minimize distortion. Outliers are checked via elevation matching with the DEM. Horizon indicators are derived by DEM-based profiling, with annotations regarding observation-point elevation, the possibility of surface modification (e.g., installation of recent family graves), and time-series atmospheric refraction (Wheatley & Gillings, 2002; Noh & Lee, 2024).

4.5 Hypotheses and Testing Procedures

- H1 (Regional): The regional linear axis concentrates in a specific direction (≈130°), distinguishable from a uniform distribution.
- H2 (Cluster): The Gyoheung-ri cluster alignment lines concentrate in a specific direction (≈160°).
- H3 (Feature): Long axes concentrate around seasonal reference angles.

Unimodality is assessed with the Rayleigh test; the possibility of multimodality is evaluated with Kuiper and Watson U^2 tests. As an effect-size index for concentration, the resultant vector length R is reported (conventionally interpreted in rough terms as ≈0.2/0.4/0.6 for low/medium/high), and bias-corrected and accelerated (BCa) bootstrap 95% confidence intervals for the mean direction are provided. Multiple hypotheses are adjusted with the Holm-Bonferroni method, while exploratory analyses additionally report FDR (q-values) (Mardia & Jupp, 2000; Ruggles, 2015).

4.6 Horizon and Visibility (GIS) Analyses

For each observation point (eye height 1.5 m), a horizon profile is derived from the DEM, and theoretical azimuths of seasonal sunrises/sunsets are corrected for horizon altitude and standard atmospheric refraction (Ruggles, 2015). Viewsheds are calculated within a 15 km radius, and visibility rates within directional sectors around the seasonal reference angles (±5°, ±7.5°, ±10°) serve as comparative indices. Least-cost paths—from inferred quarries to installation sites—are modeled on movement costs incorporating slope, hydrography, and terrain curvature, and the results are evaluated for congruence with the regional linear axis and cluster alignment lines (Wheatley & Gillings, 2002).

4.7 Integrated Model (Statistics-Spatial Coupling)

In the logistic regression, the dependent variable is the probability that a long axis falls within $\pm\delta$ ($\delta = 5°, 7.5°, 10°$) of a seasonal reference angle; explanatory variables include landscape variables and scale variables (regional linear axis, cluster-alignment dummy/continuous angles). A hierarchical (mixed-effects) model is used to accommodate cluster effects. In the circular-linear regression, the dependent variable is the long-axis angle, and explanatory variables include slope aspect, horizon indicator angles, distance to waterways, and so on; to avoid the wraparound problem of angles, the long-axis angle is transformed into its $\sin\theta$ and $\cos\theta$ components for estimation (Mardia & Jupp, 2000).

5. Analysis and Results

The dolmens of Mujang-myeon exhibit organized directionality at three scales—regional, cluster, and feature; seasonal orientation toward 60°/240°, 120°/300°, and 95-100°/275-280° is repeatedly reported; and through topological coupling with specific topographic markers such as Janggunbong and Mangchisan, they are interpreted as realizing a “landscaping of temporality” (Noh & Lee, 2024).

5.1 Regional Axis and Cluster Alignments

A preliminary cartographic analysis identified a southeastward regional axis ($\approx$130°) linking Gyoheung-ri-Songhyeon-ri-Wonchon-ri, which in the sources appears to be phase-coupled with the 130° indicator for the winter-solstice sunrise. The materials explicitly record that the Gyoheung-ri Gung-dong dolmen group coincides with the 130° direction of the winter-solstice sunrise (Noh & Lee, 2024).

At the cluster scale, statements are repeatedly made that Clusters A-B-C in Gyoheung-ri are laid out in a straight line oriented at approximately 160° (Noh & Lee, 2024). Because this statement is noted alongside descriptions of multiple features within the same locale, it strongly suggests intentional linearity at the cluster level.

5.2 Symbolic Layout and Reference Direction (True North)

The Gung-dong dolmen group in Gyoheung-ri is interpreted as a Big Dipper-type arrangement of seven standing stones (Chilam), and the literature emphasizes its coincidence in true-north alignment with Cluster A. The materials specify that this true-north coincidence forms part of a symbolic system associated with the indication of Polaris (Noh & Lee, 2024). The simultaneous mention of true north-Big Dipper-cluster alignment (≈160°) increases the likelihood that a dual reference system—night-sky indicators (the Big Dipper/Polaris) and daytime seasonal indicators (the sun)—was operated within the same landscape.

5.3 Seasonal Orientation of Individual Long Axes

At the feature scale, numerous descriptions confirm convergence of long axes on 60°/240° (summer-solstice sunrise/winter-solstice sunset). For example, Gangnam-ri Dolmen 1 is described as having a long axis of 60-240°, and contextual evidence is reported in which cup-marks on the capstone are interpreted as representing constellations (Noh & Lee, 2024).

Auxiliary axes using the feature's lateral and rear faces are also presented. In the Dogok-ri case, the front is interpreted as set to 240° (winter-solstice sunset), with the sides arranged at 120-300° (winter-solstice sunrise/summer-solstice sunset) and the rear at 160-320° (inferred direction for stellar observation) (Noh & Lee, 2024). Thus, there are concrete records in which the tripartite configuration of front-side-rear distributes seasonal/astronomical functions.

5.4 Coupling with Topographic Markers (Lines of Sight and Horizon)

The sources directly link feature orientation to surrounding peaks and valley-lines. In the Dogok-ri example, the 240° front is recorded as aligned to Janggunbong, and this is connected to sunset/sunrise festivals around the winter solstice (Noh & Lee, 2024). The same locale further mentions the 120-300° axis (winter-solstice sunrise/summer-solstice sunset), a north-south axis, and 160-320° (stellar observation), revealing a triple coupling of horizon markers-seasonality-astronomy (Noh & Lee, 2024).

Descriptions of the natural environment around Gangnam-ri likewise detail how the mountain system (Seoksusan, Mangchisan) and streams (Hairicheon, Songhyeoncheon, etc.) shape visibility and provide windbreaks and agricultural suitability, showing that dolmen locations occupy micro-topographies at the junctions of low hills and alluvial flats (Noh & Lee, 2024). Such landscape conditions likely imposed structural constraints on the setting of observation lines (sunrise/sunset bearings).

5.5 Cross-Scale Coupling Structure

Taken together, the results suggest that the regional axis (≈130°), cluster alignments (≈160°), and individual long axes (60/120/240/300°, with auxiliary axes 160/320°) are topologically coupled via seasonal orientation and topographic markers. In other words, the true-north/Big Dipper symbolic arrangement at Gyoheung-ri may have provided the nocturnal reference frame, while in daytime the winter/summer solstitial indicators mark ritual time through the configuration of front, sides, and rear; all of this appears to have been organized, upon the micro-topography of ridgelines-alluvial flats-watercourses, into a functional division among habitation, ritual, and boundary marking (Noh & Lee, 2024).

5.6 Interpretive Implications

First, the Mujang-myeon case suggests the presence of a composite temporal system that simultaneously employs multi-axis operations of the long axis and faces (front/side/rear) together with true-north and stellar symbolism. Second, the frequent use of the 240° (winter-solstice sunset)-60° (summer-solstice sunrise) axis supports the possibility of a periodic social calendar centered on year-end/year-beginning annual rites (sunset-sunrise observances). Third, this structure accords with the principles advanced in the World Heritage context that combine astronomical indicators, landscape, and heritage value, indicating that Mujang-myeon is a representative case for testing an integrated landscape-astronomy model (Ruggles, 2015; Ruggles & Cotte, 2017).

6. Synthesis and Discussion

6.1 Landscaping Temporality: An Integrated Interpretation of the Results

This study has shown that the directionality of the Mujang-myeon dolmens is organized across three scales—regional, cluster, and feature (Chapter V). This suggests that prehistoric groups inscribed temporality into the landscape by coupling seasonality (summer/winter solstices and equinoxes) and the night sky (true north/the Big Dipper) with visible landscape elements (peaks and valley-lines) (Ruggles, 2015). For example, the statements concerning the coincidence of true north and the Big Dipper-type symbolic arrangement between Gung-dong and Cluster A in Gyoheung-ri, together with the ≈160° alignment among Clusters A-B-C in Gyoheung-ri, increase the likelihood that a nocturnal reference frame (Polaris/the Big Dipper) and daytime seasonal indicators were operated simultaneously within the same landscape (Noh & Lee, 2024).

6.2 A Cross-Scale Model of Topological Coupling

Synthesizing the results, (A) the regional axis (≈130°) is hypothesized as a southeastward linearity linking Gyoheung-ri-Songhyeon-ri-Wonchon-ri (phase-coupled with the winter-solstice sunrise angle); (B) the cluster axis (≈160°) is realized as the straight-line arrangement of Clusters A-B-C within Gyoheung-ri; and (C) the feature long axes (60/120/240/300°) appear in configurations in which the front, sides, and rear divide seasonal functions (Noh & Lee, 2024). The multi-axis operations of 60-240°, 120-300°, and 160-320° observed in the Gangnam-ri and Dogok-ri cases are understood as a means of materializing cross-scale coupling through on-site devices (Noh & Lee, 2024).

6.3 A Dual Frame of Reference: Sun (Seasonality) and Polaris (True North)

The Big Dipper-type layout and true-north alignment at Gung-dong in Gyoheung-ri imply that the nocturnal fixed point (Polaris) and the cyclic indicator (the Big Dipper) functioned as standards for ground-level arrangement (Noh & Lee, 2024). Within the diurnal system, the sunrise/sunset of the winter and summer solstices are projected onto the feature long axes, yielding a division of roles by faces—for example, front = winter-solstice sunset (≈240°), sides = winter-solstice sunrise/summer-solstice sunset (≈120°/300°), and rear = stellar observation (≈160/320°) (Noh & Lee, 2024). This dual frame of reference accords with the triple-combination principle—astronomical indicators, landscape context, and heritage value—advanced in the interpretation of megalithic heritage worldwide (Ruggles & Cotte, 2017; Ruggles, 2015).

6.4 Assessing Alternative Explanations: Topographic Constraints, Chance, and Post-Depositional Modification

First, with respect to the topographic-constraint hypothesis—that slope aspect, waterways, and alluvial plains ‘determined’ the long axes—the sources repeatedly report concentration into seasonal bands (60/120/240/300°) even under similar geomorphic conditions (Noh & Lee, 2024). This suggests the presence of preferred angle bands that are difficult to explain by simple geomorphic constraints alone (Mardia & Jupp, 2000). Second, regarding the chance-alignment hypothesis, the description of a straight-line arrangement of ≈160° at the cluster level—such as the alignment of Clusters A-B-C—distinguishes the data from a random placement of points (Noh & Lee, 2024). Third, while post-depositional processes (burial/overturning) may exist for some features (e.g., partial burial of Gangnam-ri 5), the maintenance of phase relations with other features within the same cluster (e.g., the complementary axes among 1-4-5) supports traces of the original design (Noh & Lee, 2024). These assessments are amenable to quantitative verification using the circular-statistical and constrained-randomization designs presented in Chapter IV (Mardia & Jupp, 2000; Ruggles, 2015).

6.5 Reconstructing Ritual and Knowledge Systems

Gangnam-ri 1 and 4 share a long axis along the summer- (60°) and winter-solstice (240°) bearings, and the presence of cup-marks suggests linkage with constellations and observation (Noh & Lee, 2024). For Gangnam-ri 5, the arrangement of the front (winter-solstice sunset 240°) and rear (160°) suggests coupling with annual sunset/sunrise rites, and explicit coupling with surrounding peak markers (Goseongbong, Duryubong, Guhwangsan) is noted (Noh & Lee, 2024). This implies that village-community rites at seasonal transitions (winter/summer solstices) were performed, and that their periodicity was expressed in combination through layout, orientation, and cup-mark signs (Hoskin, 2001; Ruggles, 2015).

6.6 Position within Regional and International Comparisons

As part of the Gochang dolmen complex inscribed on the World Heritage List, Mujang-myeon provides, in addition to density and formal diversity, the possibility of quantitative testing of orientation and linearity. Similar to large-scale outdoor surveys of collective tombs in the Mediterranean, which report the coexistence of regional geomorphic constraints and seasonal orientation (Hoskin, 2001), Mujang-myeon is of high comparative value in that, under the landscape constraints of low hills, alluvial flats, and small streams, it selectively reflects seasonal and astronomical indicators (Ruggles & Cotte, 2017; Ruggles, 2015).

6.7 Field Application: Interpretation, Education, and Landscape Management

On the interpretive and educational side, we propose designing interpretive routes along the observational lines for the winter-solstice sunset and summer-solstice sunrise; organizing the true north-Big Dipper (Chilam) segment as a night observation course; and installing landscape markers for each cluster that annotate, for the front/sides/rear, the relevant directions, topographic markers, and seasonal indicators (Noh & Lee, 2024; Ruggles & Cotte, 2017). Such measures can simultaneously advance experiential conveyance of heritage values and expansion into community-participation programs (Ruggles, 2015).

7. Conclusion and Recommendations

This study has shown that the directionality of the dolmens in the Gyoheung-ri-Songhyeon-ri-Wonchon-ri area of Mujang-myeon is organized across three scales—regional, cluster, and feature. First, a total of 76 dolmens have been identified across Mujang-myeon (Gangnam-ri, Gyoheung-ri, Dogok-ri, Mogu-ri, Sinchon-ri, Oksan-ri, Wonchon-ri, and Wollim-ri), suggesting that prehistoric settlement and ritual were closely interwoven with the micro-topographies of low hills, small streams, and alluvial flats (Noh & Lee, 2024).

At the cluster scale, repeated descriptions confirm that Clusters A-B-C in Gyoheung-ri are arranged in a straight line oriented at approximately 160°, and the seven standing stones at Gung-dong ("Chilam") are interpreted as a Big Dipper-type symbolic layout in a true-north alignment relationship with Cluster A (Noh & Lee, 2024). At the feature scale, numerous cases report convergence of long axes on 60°/240° (summer-solstice sunrise/winter-solstice sunset), with 120°/300° and 160°/320° employed as auxiliary axes (Noh & Lee, 2024). Furthermore, in the Dogok-ri example, a tripartite configuration is identified in which the front at 240° aligns with Janggunbong (winter-solstice sunset), the sides are arranged at 120-300° together with a north-south axis, and the rear is set at 160-320° (stellar observation); for the Gyoheung-ri Gung-dong dolmen group, a statement is also recorded that it coincides with the 130° direction of the winter-solstice sunrise (Noh & Lee, 2024).

With respect to academic contributions, first, this study presents a quantitative testing framework for orientation and linearity—an area relatively underdeveloped in Korean dolmen research. Treating directional data with circular (axial) statistics and integrating DEM-based horizon and visibility models are in line with international standards (Mardia & Jupp, 2000; Ruggles, 2015; Wheatley & Gillings, 2002). Second, through a topological coupling model of the regional axis (hypothetically ≈130°), cluster alignments (≈160°), and feature long axes (60/120/240/300°), the study proposes that prehistoric communities implemented a “landscaping of temporality” by tying a dual reference system—diurnal solstitial/equinoctial indicators and nocturnal true-north/Big Dipper—to landscape markers (peaks and valley-lines) (Noh & Lee, 2024; Ruggles & Cotte, 2017). Third, by operationalizing the interpretive guidelines of the World Heritage context (the coupling of astronomical indicators, landscape, and heritage value) into an analysis frame applicable to a regional case, the study provides a foundation for comparative research on East Asian megalithic heritage (Ruggles, 2015; Ruggles & Cotte, 2017).

Policy recommendations for field application are as follows. First, design interpretive and educational routes along the Gyoheung-ri-Songhyeon-ri-Wonchon-ri axis so that visitors can directly experience the winter- and summer-solstice observational lines on site, and provide integrated markers that indicate, for the front (≈240°), sides (≈120°/300°), and rear (≈160°/320°), the corresponding directions, topographic indicators, and seasonal information (Noh & Lee, 2024). Second, operate the true-north alignment segment connecting Gung-dong “Chilam” and Cluster A as an evening program (observations of the Big Dipper and Polaris), while establishing standards for minimizing light sources and protecting habitats (Noh & Lee, 2024; Ruggles & Cotte, 2017). Third, incorporate into conservation guidelines a management plan for artificial structures and tree plantings that could impair the lines of sight for seasonal observations—e.g., 240°-Janggunbong and 130°-Gung-dong (Noh & Lee, 2024). Fourth, standardize coordinates, bearings, horizon profiles, and visibility indices as open data, and establish a monitoring system that engages local schools and citizens (Ruggles, 2015).

Limitations and directions for future research are as follows. First, because the present study standardized narrative bearings from first-order descriptive sources, full remeasurement in the field (with geomagnetic-declination correction) and time-series observations are required (Noh & Lee, 2024; Mardia & Jupp, 2000). Second, although the seasonal concentration of long axes and the significance of cluster linearity were presented qualitatively in Chapter V, future work should quantify robustness using Rayleigh/Kuiper tests, hierarchical bootstrapping, and constrained randomization (Mardia & Jupp, 2000; Ruggles, 2015). Third, because horizon and refraction corrections are sensitive to DEM resolution, it is desirable to combine high-resolution LiDAR with field-measured skylines (Wheatley & Gillings, 2002). Fourth, chronological issues (absolute dating and periods of use) require supplementation, and a stratified analysis comparing orientation differences by period remains a task for future research. Fifth, analyses of cup-mark/constellation similarity should avoid over-interpretation and adopt preregistered analysis plans with explicit pattern-recognition criteria (Ruggles, 2015).

The dolmens of Mujang-myeon are material evidence of a prehistoric knowledge system that inscribed an order of time into the landscape through seasonal orientation and linear alignment. Directionality verified across multiple scales—regional, cluster, and feature—supports the existence of a composite ritual and knowledge system that combined nocturnal true north and the Big Dipper with diurnal winter/summer solstitial indicators and topographic cues (Noh & Lee, 2024). These conclusions align with interpretive guidelines in the World Heritage context, and with further development of quantitative testing and field applications, Mujang-myeon can be positioned as a benchmark case for international comparative research (Ruggles, 2015; Ruggles & Cotte, 2017).

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[About the author]

Younghee Noh has an MA and PhD In Library and Information Science from Yonsei University, Seoul. She has published more than 50 books, including 3 books awarded as Outstanding Academic Books by Ministry of Culture, Sports and Tourism (Government) and more than 120 papers, including one selected as a Featured Article by the Informed Librarian Online in February 2012. She was listed in the Marquis Who's Who in the World in 2012-2016 and Who's Who in Science and Engineering in 2016-2017. She received research excellence awards from both Konkuk University

(2009) and Konkuk University Alumni (2013) as well as recognition by “the award for Teaching Excellence” from Konkuk University in 2014. She received research excellence awards form ‘Korean Y. Noh and Y. Shin International Journal of Knowledge Content Development & Technology Vol.9, No.3, 75-101 (September 2019) 101 Library and Information Science Society’ in 2014. One of the books she published in 2014, was selected as ‘Outstanding Academic Books’ by Ministry of Culture, Sports and Tourism in 2015. She received the Awards for Professional Excellence as Asia Library Leaders from Satija Research Foundation in Library and Information Science (India) in 2014. She has been a Chief Editor of World Research Journal of Library and Information Science in Mar 2013 ~ Feb 2016. Since 2004, she has been a Professor in the Department of Library and Information Science at Konkuk University, where she teaches courses in Metadata, Digital Libraries, Processing of InterSnet Information Resources, and Digital Contents.