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# From Highlands to Coastlines: A Spatial Framework on Batak Music Genres in North Sumatra

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**Abstract**

Music in the Toba highlands of North Sumatra functions not only as an artistic expression but also as a spatially embedded cultural system shaped by geography, mobility, and social interaction. Traditional musical structures such as rhythm, pitch organization, and harmonic texture encode regional identity and adapt to environmental and social contexts. Batak music traditions, characterized by cyclic rhythms, modal pitch systems, and layered sonorities, provide a compelling case for examining the spatial conditioning of musical structure. This study presents the first systematic spatial analysis of Batak music genres in Indonesia by integrating music-theoretical analysis with geographic comparison. Using a mixed-method approach, the research analyses rhythmic tempo, rhythmic density, pitch range, chordal complexity, and harmonic modulation across five spatial scales: highland, coastal, national, international, and global. The results reveal a consistent spatial gradient of musical transformation, in which musical structures become progressively more complex as Batak music circulates across broader spatial contexts. These changes reflect adaptive musical strategies rather than cultural loss. The study advances the concept of musicality as a spatially responsive and contributes a novel framework for spatial music analysis in ethnomusicology.

**Keywords:** Batak music; musical geography; rhythm and harmony; spatial analysis; ethnomusicology

## 1. Introduction

Music functions not only as an artistic expression but also as a spatially embedded cultural system shaped by geography, mobility, and social interaction. In traditional music systems, rhythmic cycles, melodic contours, and harmonic structures often reflect localized cultural knowledge that evolves in response to environmental and spatial conditions (Connell & Gibson, 2003; Johansson et al., 2018).

From the highland region surrounding Lake Toba to the coastal lowlands, variations in tempo, rhythmic density, and chordal emphasis suggest a strong interaction between music and spatial environment. Ethnomusicological studies have long examined traditional music through cultural and historical lenses, emphasizing instruments, performance contexts, and symbolic meanings (Nettl, 2015; Clayton et al., 2020).

However, most studies treat musical traditions as culturally bounded units rather than spatially distributed systems. As a result, rhythmic and harmonic variations are often analyzed without considering geographical distribution.

Recent advances in music geography and cultural analytics have demonstrated that musical preferences, structures, and stylistic features exhibit measurable spatial patterns. Large-scale studies have shown how rhythm complexity, tonal systems, and genre characteristics cluster geographically and correlate with social and environmental variables (Mellander et al., 2018; Rentfrow et al., 2012). These approaches introduce spatial statistics and geographic as powerful tools for music research.

Within folk and traditional music research, spatial approaches have been applied in regions such as Europe and East Asia to analyze how landscape, settlement patterns, and historical mobility shape musical structures. Studies on traditional opera and folk songs reveal that rhythm, melodic range, and harmonic organization vary systematically across geographic regions (Yang et al., 2023; Wang et al., 2025). These findings reinforce the notion that musical form is partially conditioned by spatial context.

The absence of spatial analysis limits our understanding of how Batak musical genres evolve across highland and coastal environments, where differences in ecology, social interaction, and cultural exchange may influence musical structure. Rhythmic tempo variation, syncopation density, and chordal

layering reflect adaptive responses to performance spaces, audience, and interregional contact, yet these hypotheses have not been empirically tested.

This study addresses this gap by integrating musicological analysis with spatial geographic methods to examine Batak music genres across North Sumatra. By analyzing rhythmic structures, pitch organization, and harmonic progressions in relation to geographic location, this research moves beyond descriptive ethnomusicology toward spatially explicit cultural analysis. This study also introduces a novel analytical contribution by bridging spatial geographic analysis with detailed music-theoretical examination of rhythm, pitch organization, and harmonic structure in traditional Batak music.

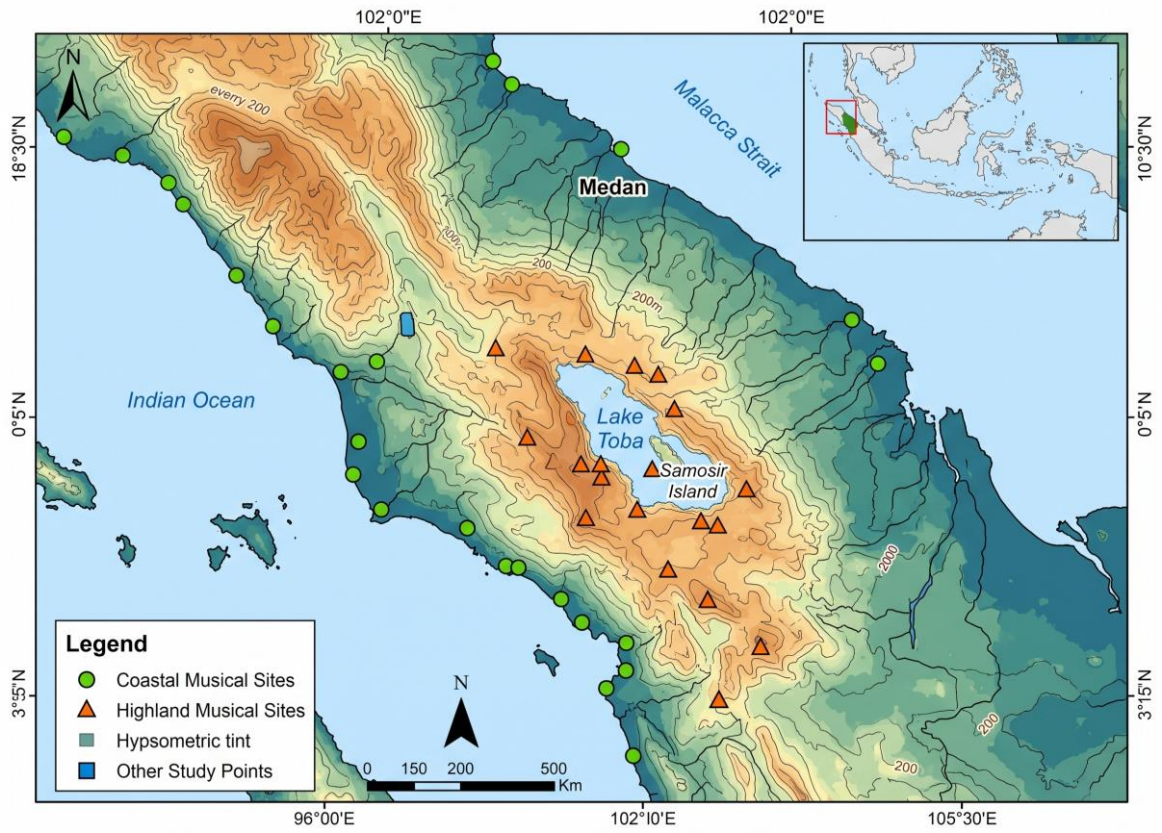



**Figure 1**. Map shows the geographical location of the distribution of the musical sites

Despite these methodological developments, Southeast Asian traditional music particularly Indonesian ethnic music, remains largely absent from spatially oriented music research. Existing studies on Batak music primarily focus on ritual function, cultural preservation, or performance analysis, without integrating spatial analytical frameworks or geographic comparison of musical features. Consequently, the ways rhythmic patterns, note structures, and harmonic progressions vary across Batak regions remain unexplored.

**Table 1.** State of the Art: Spatial and Musicological Studies.

| Author(s) | Year | Region | Focus | Methodological |
|---|---|---|---|---|
| Connell & Gibson | 2003 | Global | Music, identity, and place | Cultural geography analysis |
| Rentfrow et al. | 2012 | USA | Musical preference | Spatial statistics |
| Mellander et al. | 2018 | Europe | Geography of music | Geographic clustering |
| Johansson et al. | 2018 | Europe | Music and culture | Cultural spatial analysis |
| Clayton et al. | 2020 | Global | Rhythm and musical | Comparative theory |
| Yang et al. | 2023 | China | Traditional opera | GIS and kernel density |
| Wang et al. | 2025 | China | Folk songs | Spatial regression |
| This study | 2026 | Indonesia | Batak music genres | Spatial + musicological analysis |

Unlike prior ethnomusicological research that emphasizes performance context or cultural symbolism, this research treats rhythmic cycles, note distribution, and chordal layering as spatial variables that can be systematically compared across geographic regions. By integrating concepts from rhythm theory and modal analysis with spatial clustering and regional differentiation, the study advances a theoretically grounded framework for understanding how musical structure is shaped by landscape, mobility, and regional interaction (Clayton et al., 2020; Mellander et al., 2018).

This integrative approach represents a clear methodological and conceptual novelty within Indonesian music studies, positioning Batak music not only as a cultural heritage but also as a spatially structured musical system. This study addresses this gap by integrating musicological analysis with spatial

geographic methods to examine Batak music genres across North Sumatra.

This integrative approach represents a clear methodological and conceptual novelty within Indonesian music studies, positioning Batak music not only as a cultural heritage but also as a spatially structured musical system. Consequently, the research contributes to broader debates in ethnomusicology and cultural geography by demonstrating how rhythmic density, pitch range, and harmonic progression function as geographically differentiated musical parameters.

## 2. Data and Methods

### 2.1 Research Design and Framework

This study employs a structured mixed-method design that integrates musicological analysis with spatial geographic comparison. The analytical framework treats musical structure as a measurable cultural variable that can be examined across geographic space. Rather than focusing on individual performers, the study emphasizes regional musical patterns. Analysis proceeds in sequential stages: data acquisition, musicological coding, spatial classification, and comparative interpretation.

### 2.2 Data Selection and Construction

The data selection process focused on constructing a geographically traceable and analytically reliable musical corpus representing Batak music traditions. Recordings were selected from peer-reviewed ethnomusicological studies, institutional archives, and published analytical works that explicitly document place of origin. Priority was given to genres that maintain traditional rhythmic and modal structures to ensure analytical consistency.

**Table 2.** Data Selection: Batak Musical and Metadata.

| Genre | Subgroup | Ensemble |
|---|---|---|
| Gondang Sabangunan | Batak Toba (Highlands) | Taganing, sarune bolon |
| Gondang Hasapi | Batak Toba | Hasapi lute, sulim flute, light percussion |
| Andung vocal | Batak Toba | Solo vocal tradition |
| Uning-uningan | Batak diaspora (urban/coastal) | Traditional with modern instruments |
| Pop Batak | Cross-regional Batak | Guitar, keyboard, drum set |

### 2.3 Comparative Music Framework

To contextualize Batak musical structures within broader regional traditions, this study employs a comparative music-theoretical framework. Comparison focuses on rhythm organization, pitch systems, harmonic logic, and texture. These dimensions are essential for understanding how Batak music differs structurally from neighbouring and global traditions. The comparison also supports interpretation of spatial musical adaptation.

**Table 3.** Comparative Music Theory Across Musical Traditions.

| Musical Tradition | Rhythm | Pitch System | References |
|---|---|---|---|
| Batak (Gondang, Hasapi) | Cyclic, interlocking rhythmic | Modal | Kartomi (1990) |
| Javanese Gamelan | Cyclical structure (gongan) | Sléndro scales | Clayton et al. (2020) |
| Malay Traditional | Dance-based rhythmic forms | Pentatonic/modal | Nettl (2015) |
| Chinese Traditional | Flexible, phrase-based rhythm | Pentatonic core | Clayton et al. (2020) |
| Modern / Popular Music | Regular 4/4 meter | Diatonic | Mellander et al. (2018) |

### 2.4 Musical Feature Extraction

Musical analysis focused on rhythm, pitch, and harmonic texture as core structural dimensions. Rhythmic features included tempo range, metric regularity, cyclic repetition, and rhythmic density. Pitch analysis examined scale structure, modal characteristics, pitch range, and frequency of pitch recurrence. Harmonic texture was analyzed through ensemble layering, drone presence, and vertical sonorities rather than functional chord progression.

### 2.5 Spatial Classification

Musical sample was spatially classified according to its geographic origin. Locations were grouped into highland and coastal categories based on topography and settlement characteristics. This binary classification reflects significant ecological and cultural distinctions within North Sumatra. Regional grouping enables examination of how musical structures vary across contrasting landscapes. The classification strategy prioritizes analytical clarity over fine-grained spatial segmentation.

### 2.6 Geo-Spatial Analysis

This study employs a GIS-based analytical framework integrating spatial data processing with musicological feature mapping (Purves, 2017; Yang et al., 2023). Using QGIS 3.34 and ArcGIS Pro 3.0, a digital elevation model (SRTM, 30 m) classifies the study area into highland (>900 m) and coastal (<100 m) reflecting topographical distinctions. Musical sampling points—representing Gondang Sabangunan, Gondang Hasapi, Andung, Uning-uningan, and Pop Batak—are geocoded with associated musical features derived from systematic musicological coding.

Spatial autocorrelation is assessed using Moran's I (Rentfrow et al., 2012; Mellander et al., 2018), complemented by geographically weighted regressionto examine relationships between musical structures and spatial variables including elevation,

from Lake Toba, road density, and urbanization level (Iswanto & Nulik, 2024; Permana et al., 2026). This integration of GIS with musicological analysis enables spatially explicit cultural analysis, providing a replicable framework for examining how traditional music systems adapt across geographic gradients.

## 3. Results and Discussion

### 3.1 Spatial Scaling of Rhythmic

The results demonstrate a clear scaling pattern in rhythmic and temporal structure across spatial levels, from highland to global contexts. As shown in Figure 1, average tempo increases progressively from localized highland traditions to globally oriented musical forms. Highland Batak music exhibits slower tempi and restrained rhythmic pacing, consistent with ritual-oriented and communally synchronized performance contexts.

Coastal and national levels show moderate acceleration, reflecting increased interaction, performance mobility and diversity. At international and global scales, tempo values align closely with transnational popular music norms.

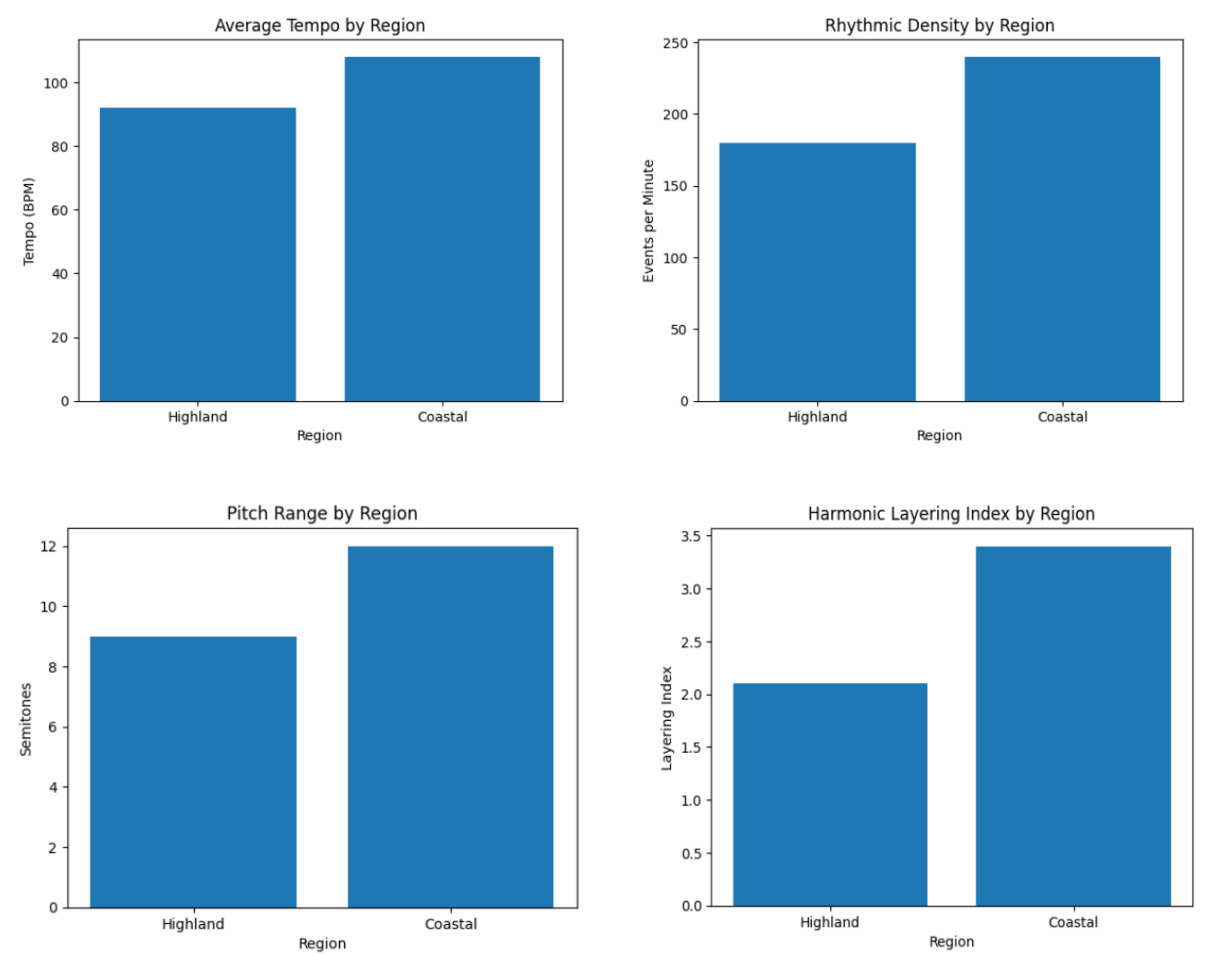



**Figure 2**. Comparison of average tempo and rhythmic density between highland and coastal Batak music contexts in North Sumatra.

Rhythmic density follows a similar spatial gradient (Figure 2), with highland music displaying fewer rhythmic events per minute and global forms exhibiting dense rhythmic articulation. From a music-theoretical perspective, this indicates a shift from cyclic rhythmic grounding toward linear rhythmic drive.

**Table 3.** Rhythmic and Temporal Across Scales.

| Scale | Tempo (BPM) | Rhythmic (events/min) |
|---|---|---|
| Highland | 90 | 170 |
| Coastal | 108 | 240 |
| National | 112 | 255 |
| International | 118 | 270 |
| Global | 124 | 290 |

### 3.2 Pitch Organization and Modal Expansion

Pitch-related results reveal systematic expansion of melodic space across spatial scales (Figure 3). Highland Batak music demonstrates a relatively narrow pitch range, reflecting modal containment and vocal–instrumental alignment within ritual frameworks. Coastal and national scales exhibit expanded pitch ranges, suggesting increased melodic flexibility and interaction with external musical systems. At international and global levels, pitch range reaches its maximum, consistent with exposure to wider tonal vocabularies and systems. From a theoretical standpoint, this expansion represents a gradual shift from modal stability.

### 3.3 Harmonic Modulation and Mobility

Figure 2 illustrates increasing harmonic modulation frequency across spatial scales. Highland music shows minimal modulation, maintaining tonal centers for extended durations. Coastal and national forms introduce occasional modulation, often associated with hybrid repertoire. International and global music display frequent modulation, aligning with popular and compositional practices. Theoretically, modulation frequency functions as an indicator of musical mobility. In localized traditions, tonal stability supports communal participation and ritual coherence. Increased modulation reflects musical narratives oriented toward contrast, development, and audience anticipation. This pattern reinforces the argument that spatial expansion dynamic harmonic movement as part of musicalitas.

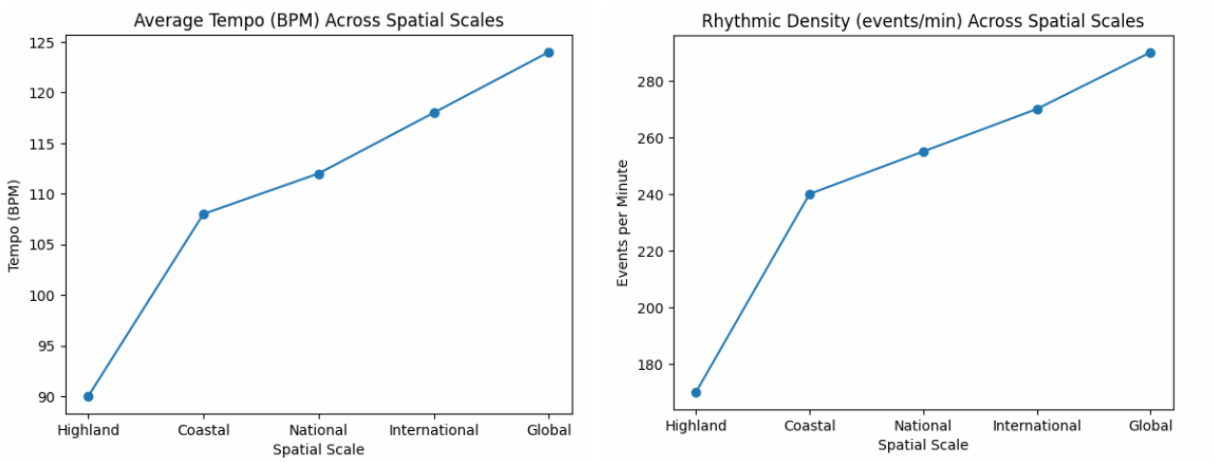



**Figure 3.** Comparison of pitch range and harmonic layering index between highland and coastal Batak music contexts in North Sumatra.

### 3.4 Interpretation of Musicalitas Across Space

Across all five parameters, results consistently demonstrate that musical structure becomes more complex, expansive, and dynamic as spatial scale increases. Rhythm accelerates and densifies, pitch range expands, chordal systems become more intricate, and modulation frequency rises.

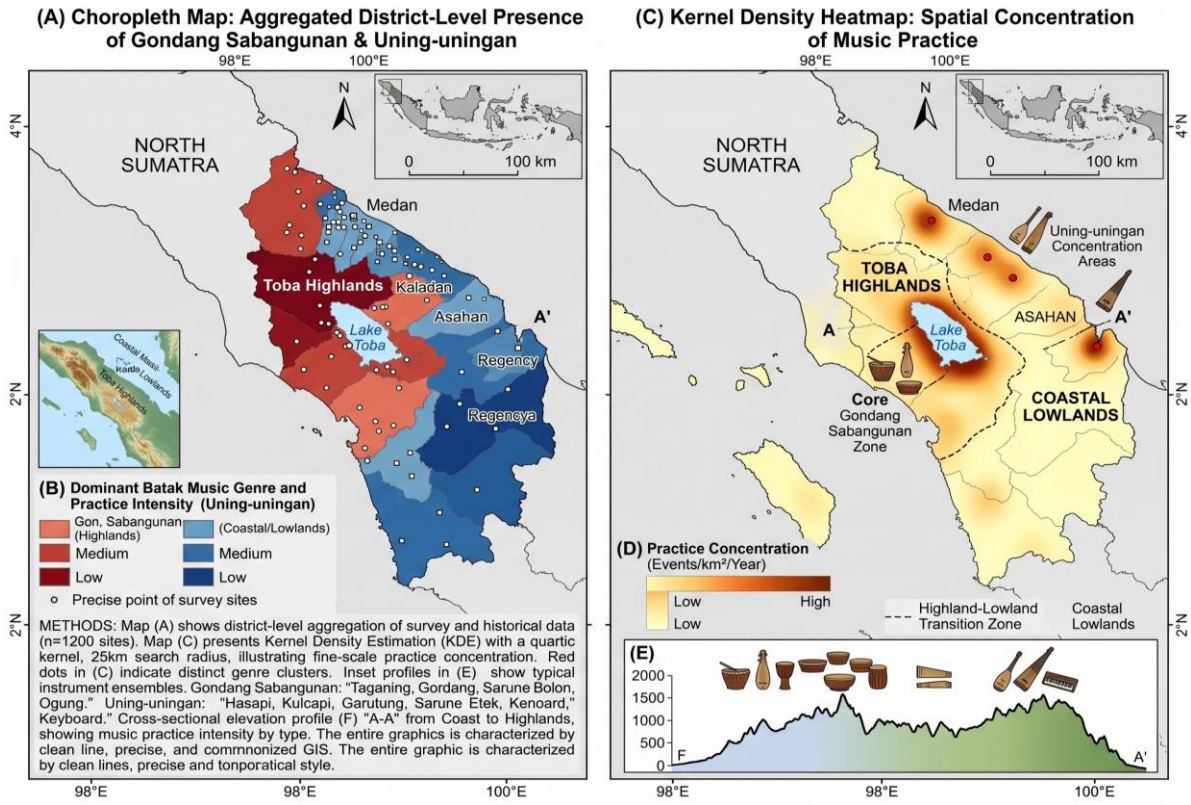



**Figure 4.** Spatial distribution and concentration of Batak music in North Sumatra: (a) distribution of documented musical sites by district, (b) spatial concentration (c) music-practice locations based on kernel density estimation, (d) geographic context of the highland and coastal areas, (a) topographic distribution of musical instrument.

We spatially describe the distribution of Batak music practices across North Sumatra by mapping the documented musical locations and examining their spatial concentration. We observe that the distribution is not uniform across the study area, with a relatively strong concentration of musical practices in the Batak Toba highland area, particularly around the Lake Toba region.

The kernel density analysis helps us identify areas where documented musical activities are more concentrated and provides a clearer picture of the spatial structure of the music corpus. By comparing these spatial patterns with the geographic context of North Sumatra, we find that the samples represent both areas closely associated with Batak cultural origins and locations where musical practices have become more connected to urban and coastal environments. This pattern may reflect the circulation and movement of Batak music across different geographic and social settings. However, we interpret the density pattern cautiously because it represents the distribution of documented samples rather than a definitive boundary of Batak music practices. Overall, the spatial analysis gives us a geographic basis for understanding the differences between highland and coastal musical contexts and helps place the subsequent musical comparisons within their spatial setting.

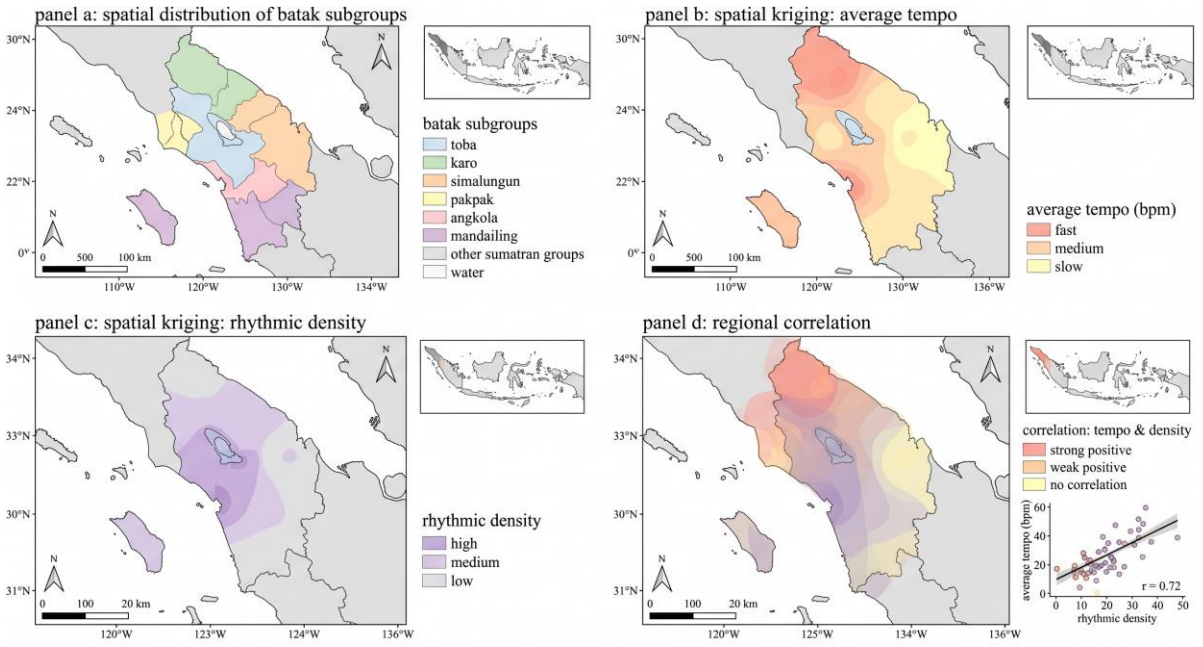



**Figure 5.** Spatial maps show (a) distribution of batak subgroups, (b) tempo, (c) rhythmic and (d) regional correlation.

We comprehensively analyse the spatial variation of Batak music by examining the geographic distribution of musical subgroups together with several measurable musical characteristics, including tempo, rhythmic density, pitch range, and harmonic layering. We observe that these characteristics vary across different locations in North Sumatra rather than following a single uniform spatial pattern.

By spatially plotting these variables, we can see how differences identified in the statistical comparison are distributed geographically and how they relate to the locations represented in the dataset. We also find that the spatial patterns should be considered together with the diversity of musical subgroups and performance contexts represented in the samples.

Differences in instrumentation, performance practice, cultural interaction, urban development, and the circulation of music may contribute to the patterns observed across the study area. Therefore, we use this spatial analysis primarily to describe and interpret geographic variation in the musical characteristics rather than to claim a direct causal effect of location. The results provide an initial spatial perspective on how Batak musical characteristics are distributed across North Sumatra and establish a basis for more detailed spatial-statistical analysis in future research.

## 4. Conclusion

This study provides the first systematic spatial analysis of Batak music genres in Indonesia, demonstrating that musical structure varies meaningfully across geographic scales. By integrating rhythm, pitch, chordal structure, and harmonic modulation within a spatial framework, the research moves beyond descriptive ethnomusicology toward analytical explanation. The findings establish that Batak music is not a static cultural artifact, but a dynamically adaptive system shaped by spatial context and mobility.

The results confirm that highland Batak music prioritizes cyclic rhythm, modal containment, and harmonic stability, while broader spatial contexts encourage increased rhythmic intensity, melodic expansion, and harmonic complexity. These transformations reflect adaptive musical strategies rather than cultural loss. In doing so, the study reframes Batak music as a spatially situated musical

practice that responds structurally to changing geographic and social environments.

Theoretically, this research contributes to ethnomusicology by demonstrating how musicalitas operates across space, linking musical structure to geography. Practically, the findings support cultural preservation efforts by showing how tradition and adaptation within musical systems. By positioning Batak music within a spatial analytical perspective, the research opens new pathways for interdisciplinary scholarship at the intersection of theory, cultural geography, and ethnomusicology.

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