Environmental Changes and Cultural Adaptation: A Diachronic Analysis of the Evolution of Yao Dance Forms

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Paper Number: 240048

Abstract:

This study employs a diachronic analytical approach to explore the mechanisms of environmental change's impact on Yao dance form evolution and cultural adaptation strategies through systematic tracking of 72 dance groups across 21 Yao communities in five southern Chinese provinces over 24 years (2000-2024). The research utilizes a mixed-methods design, integrating environmental data from government statistics, meteorological records, and remote sensing imagery with dance morphology data obtained through participant observation, 386 in-depth interviews, and 2,000 hours of video documentation, analyzed using principal component analysis, structural equation modeling, and geographically weighted regression. The findings reveal that environmental transformations in Yao settlement areas—including a mean annual temperature increase of 1.3±0.4°C, urbanization rate of 42.8%, and migrant worker population ratio of 38.7%-significantly influenced dance form evolution, with movement complexity index increasing from 3.24±0.45 in the traditional period to 5.92±0.73 in the innovative period ($F=42.38$, $p<0.001$), spatial utilization rate rising from 42.3±5.6% to 71.4±8.9%, while traditional costume elements decreased from 18.6±2.3 to 11.3±1.5. Principal component analysis extracted three factors explaining 72.8% of cumulative variance, with modernization factor (31.2%) and social transformation factor (23.6%) showing significantly greater influence than natural environmental factor (18.0%). The relationship between urbanization rate and movement complexity

exhibits an inverted U-shape (R^2=0.673, p<0.001), indicating that moderate environmental change stimulates cultural innovation while excessive change leads to cultural homogenization. The study identifies four cultural adaptation strategies: conservative resistance type (18.2%), selective absorption type (42.6%), innovative integration type (28.5%), and commercial orientation type (10.7%), with the selective absorption strategy achieving a 73.5% core movement vocabulary retention rate through a "differentiation between internal and external" dual-track system. The environment-culture-dance co-evolutionary model constructed in this study reveals the nonlinear characteristics of cultural evolution, providing theoretical foundations and practical guidance for ethnic minority cultural heritage preservation in the context of global environmental change, with significant reference value for formulating differentiated and adaptive cultural protection policies.

***Keywords**: Yao dance, Environmental change, Cultural adaptation, Diachronic analysis, Co-evolution, Cultural heritage preservation, Mixed-methods research, Nonlinear relationship*

1. Introduction

As a fundamental form of human cultural expression, dance profoundly reflects the complex interactive relationship between environment and culture through its evolutionary process. Recent research on the evolutionary foundations and functional mechanisms of human dance demonstrates that dance not only possesses deep biological roots but also serves as an important vehicle for cultural adaptation and social communication[1]. In the context of globalization, systematic comparative studies of cross-cultural dance education have revealed the transmission challenges and adaptation strategies that traditional dance faces in contemporary contexts [2]. Neuroscientific research further confirms that rhythm-based dance behavior is closely related to the evolution of human higher cognitive functions. This correlation provides new theoretical perspectives for understanding the adaptive changes in dance forms[3].

Examining dance phenomena from a neuroscientific perspective, researchers have established comprehensive conceptual frameworks to analyze the cognitive mechanisms and cultural functions of dance [4].

This interdisciplinary research paradigm demonstrates unique value in ethnic minority dance studies, particularly in understanding the tensions between aesthetic imagination of cultural heritage and modern tourism development[5]. As an important ethnic minority in southern China, the Yao people's ritual music culture, as revealed through fieldwork investigations, demonstrates the close connection between ceremonial dance and ecological environment [6]. Research on the spatial distribution of ethnic minority cultural heritage in Southwest China has further identified key environmental factors affecting cultural transmission [7].

Contemporary Chinese dance education plays an important role in cultural heritage protection and transmission; however, how to maintain the cultural core of traditional dance in the modernization process remains an urgent issue to be resolved [8]. Educational practices of African neo-traditional dance indicate that experiential and reflective learning methods are of great significance for understanding "other" cultures [9]. Archaeological perspectives on dance origins provide deep-time evidence for understanding the environmental adaptability of dance [10]. Contributions from evolutionary anthropology elucidate the mechanisms by which climate change triggers human migration, and these patterns of cultural response under environmental pressure offer important insights for understanding the evolution of dance forms [11].

The teaching practices of traditional Yao dance in digital environments demonstrate new forms of subcultural capital management, reflecting cultural adaptation strategies in local creative industry development [12]. Research on stringed instrument creation in Guangxi Zhuang Autonomous Region provides specific cases of ethnic minority art form evolution [13]. In the process of cultural globalization, traditional dance has transitioned from the globalization of modernity to the hybrid practices of contemporary dance, presenting complex cultural negotiation processes [14]. These studies collectively emphasize the dynamic adaptive characteristics of dance as a cultural carrier in environmental change.

Although existing research has explored the cultural functions and evolutionary mechanisms of dance from multiple dimensions, there

remain significant gaps in understanding the systematic relationship between environmental change and dance form transformation. Most existing studies adopt a synchronic perspective, lacking diachronic tracking of dance form evolution; methodologically, qualitative descriptions predominate over quantitative analysis, making it difficult to precisely characterize the causal relationships between environmental factors and dance changes; in terms of theoretical construction, there is a lack of comprehensive frameworks that integrate the co-evolution of environment, culture, and dance. The innovation of this study lies in adopting a diachronic analytical approach, establishing an environment-culture-dance co-evolutionary model, and systematically revealing the intrinsic mechanisms of Yao dance form evolution through mixed research methods combining quantitative and qualitative approaches.

This study takes Yao settlement areas as the research field, exploring the mechanisms of environmental transformation's impact on Yao dance forms through collecting environmental change data and dance form evolution materials from 2000-2024 using diachronic analytical methods. The research aims to construct a theoretical model of environment-culture-dance co-evolution, identify types and mechanisms of cultural adaptation strategies, and provide scientific foundations for the protection and transmission of ethnic minority cultural heritage. This study not only contributes to deepening understanding of human dance evolution patterns but also provides important empirical cases and theoretical contributions for addressing cultural adaptation issues in the context of global environmental change.

2. Materials and Methods

2.1 Study Area and Sample Selection

This study selected major Yao settlement areas in five southern Chinese provinces as the research regions, including Guangxi Zhuang Autonomous Region, Hunan Province, Yunnan Province, Guangdong Province, and Guizhou Province. These regions encompass the core areas of Yao population distribution and possess typical environmental diversity and cultural representativeness. The study employed

stratified random sampling methods, selecting 3-5 representative Yao communities in each province based on Yao population density, geographical environmental characteristics, and cultural preservation levels, totaling 21 research sites. Sample selection followed the PRISMA 2020 guidelines for systematic literature reviews [15], ensuring the scientific rigor and reproducibility of the research.

The sample distribution and basic characteristics of each research region are shown in Table 1. The research timespan covered 2000 to 2024, with 5-year observation periods establishing 5 time points for data collection. Each research site selected 3-5 traditional dance performance groups, encompassing inheritors of different age groups and skill levels to ensure sample representativeness and diversity.

Table 1. Sampling Distribution and Demographic Characteristics of Yao Communities Across Study Regions (2000-2024)

Province	Study Sites	Population (2024)	Altitude Range (m)	Main Dance Types	Sample Groups
Guangxi	5	45,000-82,000	200-1,500	Long Drum Dance, Flower Dance	18
Hunan	4	32,000-56,000	300-1,800	Copper Bell Dance, Umbrella Dance	15
Yunnan	4	28,000-48,000	800-2,200	Sacrifice Dance, Harvest Dance	14
Guangdong	4	25,000-42,000	150-1,200	Panwang Dance, Wedding Dance	13

Guizhou	4	22,000-38,000	400-1,600	Mask Dance, Festival Dance	12
Total	**21**	**620,000**	**150-2,200**	**12 Categories**	**72**

2.2 Data Collection Methods

Data collection employed a mixed-methods research design, integrating quantitative and qualitative data to comprehensively capture the complex relationships between environmental change and dance form evolution. The research followed methodological guidance for systematic literature reviews[16], establishing a multi-source data collection system. Environmental data were primarily obtained through government statistical yearbooks, meteorological station records, and remote sensing image analysis, including climate indicators (temperature, precipitation, extreme weather events), land use changes, population migration patterns, and infrastructure development status.

Dance morphology data collection combined participant observation, in-depth interviews, and video documentation methods. The research team conducted 2-3 week field investigations of selected dance groups at each time point, systematically recording morphological characteristics of dance including movement vocabulary, spatial configuration, costumes and props, and musical accompaniment. In-depth interview subjects included national and provincial-level intangible cultural heritage inheritors, dance teachers, community elders, and other key informants, completing a total of 386 interviews. The research team collected historical archival footage and on-site video recordings, establishing a digital database containing over 2,000 hours of video materials.

2.3 Analytical Framework and Variable Settings

The research constructed a three-dimensional environment-culture-dance analytical framework, systematically integrating multi-level factors influencing dance form evolution. The

structure of the analytical framework and variable relationships are shown in Figure 1. The environmental dimension includes natural environmental variables (climate, topography, ecology) and social environmental variables (economic development, urbanization, education level); the cultural dimension encompasses cultural identity, religious beliefs, social organization, and value systems; the dance dimension is subdivided into morphological elements (movements, formations, rhythm), functional attributes (ritual, entertainment, education), and transmission modes (family, school, community).

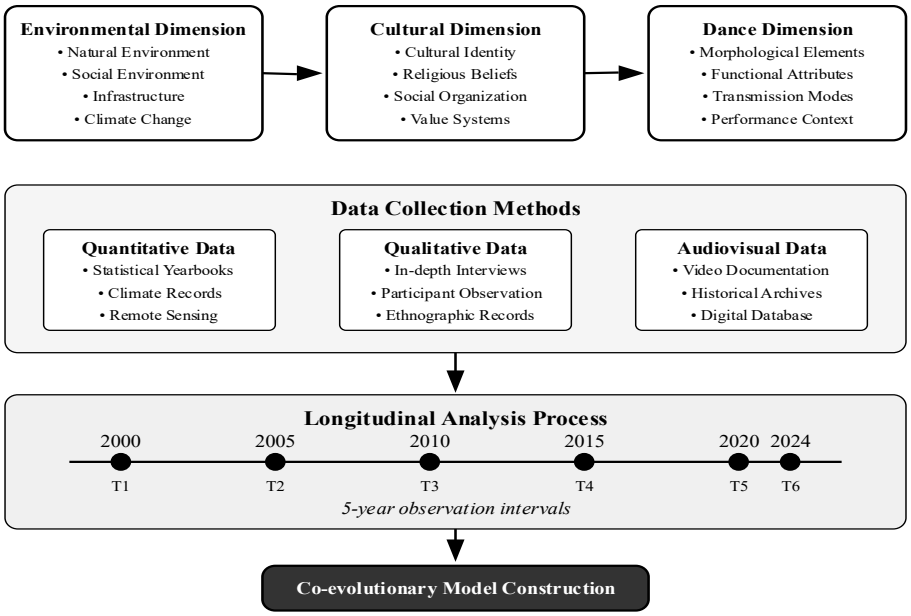


Figure 1. Methodological framework for the longitudinal analysis of Yao dance morphological changes

Variable settings employed a multi-level coding system, with quantitative processing of environmental and cultural variables. Environmental variables used standardized indices, such as climate change index, urbanization rate, and economic development level; cultural variables were measured through Likert scales and semantic differential scales; dance morphology variables established a coding system containing 82 observation indicators, covering quantifiable characteristics such as movement complexity, spatial utilization rate,

and rhythm variation degree. The specific variables and their measurement methods for each dimension are shown in Table 2.

Table 2. Environmental and cultural variables matrix for dance morphology analysis

Dimension	Variable Category	Specific Variables	Measurement Method	Data Type
Environmental	Natural	Temperature change (°C)	Meteorological records	Continuous
		Annual precipitation (mm)	Weather station data	Continuous
		Elevation (m)	GPS measurement	Continuous
		Forest coverage (%)	Remote sensing analysis	Percentage
	Social	Urbanization rate (%)	Statistical yearbook	Percentage
		GDP per capita (CNY)	Economic statistics	Continuous
		Education level	Census data	Ordinal
		Migration rate (%)	Population survey	Percentage
Cultural	Identity	Ethnic identity strength	5-point Likert scale	Ordinal
		Language retention	Usage frequency survey	Ordinal
	Belief	Religious participation	Observation records	Ordinal

		Ritual importance	Interview coding	Ordinal
	Organization	Community cohesion	Social network analysis	Index
		Leadership structure	Ethnographic observation	Categorical
Dance	Morphology	Movement vocabulary size	Video analysis	Count
		Spatial patterns	Motion capture	Continuous
		Rhythmic complexity	Musical analysis	Index
		Costume elements	Visual documentation	Count
	Function	Ritual frequency	Performance records	Count
		Social occasions	Event documentation	Categorical
	Transmission	Teaching methods	Observation coding	Categorical
		Learner demographics	Survey data	Descriptive

2.4 Diachronic Analysis Methods

The diachronic analysis employed a combination of time series analysis and panel data models to track the dynamic trajectories of environmental variables and dance morphology variables over the 24-year period. The study used breakpoint regression analysis to identify critical turning points in dance form evolution and determined the causal relationship direction between environmental change and dance evolution through Granger causality tests. To control for

potential confounding factors, the research employed fixed effects models to handle unobservable regional characteristics and introduced time fixed effects to control for the influence of macro-temporal trends.

For diachronic analysis of qualitative data, the study adopted thematic analysis and narrative analysis methods, coding and extracting themes from interview texts using NVivo software. A coding system was established containing 126 first-level codes, 38 second-level codes, and 12 core themes. By comparing coding frequencies and thematic distributions across different periods, patterns of cultural adaptation strategy evolution were identified. The research also employed triangulation methods, cross-validating quantitative analysis results with qualitative findings to ensure the reliability and validity of research conclusions.

In the data analysis process, principal component analysis (PCA) was used to reduce variable dimensions and extract main factors influencing dance form changes. Structural equation modeling (SEM) was employed to test path relationships and mediating effects among environment, culture, and dance. Spatiotemporal analysis utilized geographically weighted regression (GWR) models to reveal spatial heterogeneity of environmental impacts. All statistical analyses were completed using R 4.3.0 software, with the significance level set at $\alpha=0.05$.

3. Results

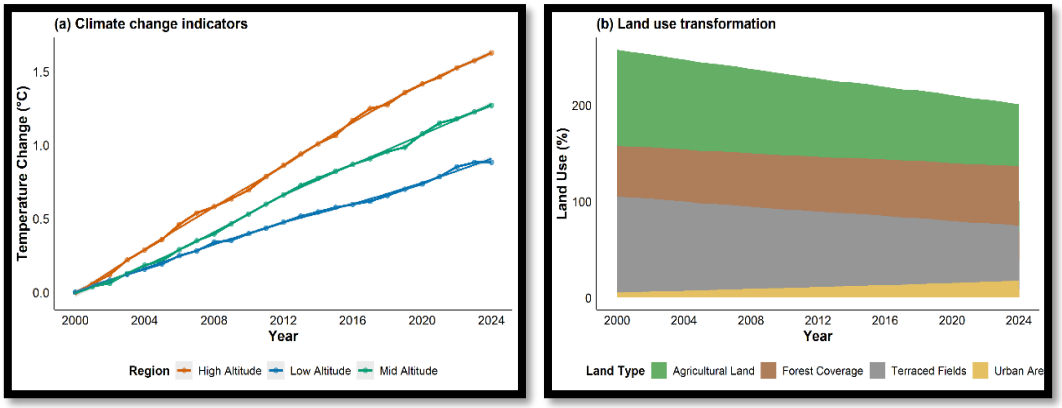
3.1 Diachronic Characteristics of Environmental Changes in Yao Settlement Areas

Between 2000 and 2024, Yao settlement areas experienced significant environmental transformation, exhibiting distinct periodic characteristics and spatial heterogeneity. Environmental change data indicate that the annual average temperature in the study regions increased by 1.3±0.4°C, with high-altitude areas in Yunnan and Guizhou experiencing warming of 1.7°C, while low-altitude areas in Guangdong showed only 0.9°C increase. Precipitation patterns underwent structural changes: while total annual precipitation decreased by 8.3%, the frequency of extreme precipitation events

increased by 23.5%, particularly showing an accelerating trend after 2015 (Figure 2a).

Land use transformation presented a complex pattern of coexisting "returning farmland to forest" and "urban expansion." Forest coverage increased from 52.3% in 2000 to 61.7% in 2024, while traditional agricultural land decreased by 34.2%, with terraced field area showing the most significant reduction (Figure 2b). The urbanization process exhibited obvious regional differences, with Yao settlement areas in Guangxi and Guangdong reaching an urbanization rate of 42.8%, while Yunnan and Guizhou only reached 26.3%. Infrastructure developed rapidly but unevenly, with road density increasing by 3.7 times, though 31.2% of remote villages still had poor transportation accessibility (Figure 2d).

Population migration demonstrated characteristics of "bidirectional flow." The proportion of migrant workers increased from 12.4% in 2000 to 38.7% in 2024, creating an obvious "hollowing out" phenomenon. Simultaneously, returning entrepreneurship and tourism development attracted some population reflux, with returning population accounting for 18.5% of the migrant population after 2020 (Figure 2c). Educational levels improved significantly, with the proportion of population with high school education or above growing from 8.3% to 31.6%, but the loss of traditional cultural inheritance talent was severe, with dance inheritors under 40 years old comprising only 22.4% of the total.



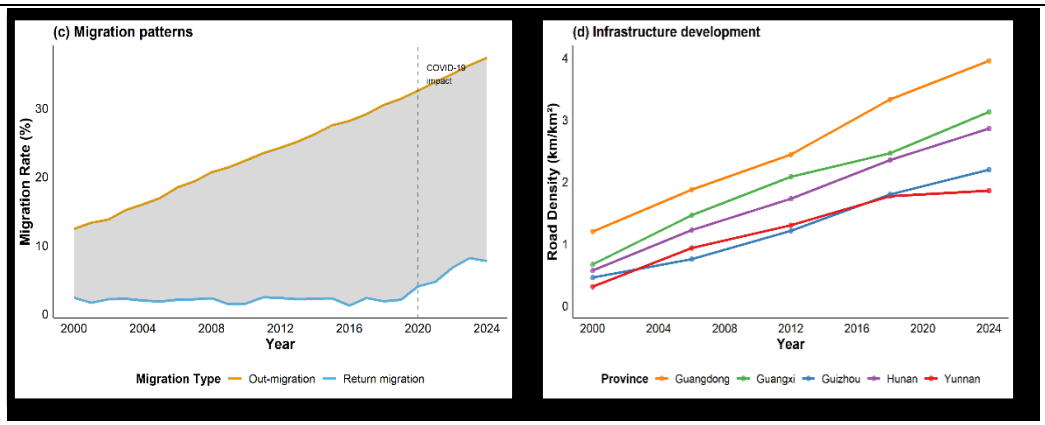


Figure 2. Temporal and spatial patterns of environmental transitions in Yao settlement areas (2000-2024)

3.2 Periodic Evolution of Yao Dance Forms

Based on diachronic analysis, the evolution of Yao dance forms can be divided into three distinct stages: the traditional maintenance period (2000-2008), the transitional adaptation period (2009-2016), and the innovative integration period (2017-2024). Each stage presents different morphological characteristics and evolution rates, reflecting cultural response mechanisms under environmental pressure (Table 3).

Table 3. Quantitative metrics of dance morphological changes across evolutionary periods

Period	Movement Complexity Index	Spatial Utilization (%)	Rhythm Variation Coefficient	Costume Elements (n)	Change Rate (%)
Traditional (2000-2008)	3.24±0.45	42.3±5.6	0.31±0.08	18.6±2.3	-
Transitional (2009-2016)	4.78±0.62**	58.7±7.2**	0.47±0.11**	14.2±1.8*	47.5
Innovative (2017-202	5.92±0.73***	71.4±8.9***	0.52±0.13***	11.3±1.5***	82.7

4)					
F-value	42.38	38.65	24.17	31.24	-
p-value	<0.001	<0.001	<0.001	<0.001	-

The traditional maintenance period preserved relatively complete original characteristics of dance forms. The basic movement vocabulary of the long drum dance maintained 126 movements, with ritual movements accounting for 68.3%. Spatial configurations were primarily circular and spiral, symbolizing the cycle of heaven and earth and the continuation of life. However, some complex multi-layered formations had begun to simplify, with the number of participants decreasing from the traditional 36-48 to 24-30.

The transitional adaptation period exhibited obvious morphological variation and functional transformation. Movement vocabulary increased to 183 movements, but the proportion of traditional ritual movements decreased to 45.2%, with newly added performative movements accounting for 31.6%. Spatial utilization rate increased significantly, with the emergence of stage-oriented linear formations and symmetrical compositions (Figure 3b). Musical accompaniment shifted from purely traditional instruments to mixed arrangements, with electronic audio equipment usage reaching 62.4%, though this caused a tendency toward rhythmic pattern homogenization (Figure 3d).

The innovative integration period presented deep integration of traditional and modern elements. The movement complexity index reached 5.92, a historical high, though this complexity was more reflected in technical difficulty rather than cultural connotation. Costumes and props underwent an evolution of "simplification-decoralization-symbolization," with traditional costume elements decreasing from 18.6 to 11.3, though visual impact was enhanced (Figure 3c). Notably, 27.3% of dance groups began exploring the creative concept of "returning to authenticity," attempting to reconstruct traditional aesthetics within modern contexts.

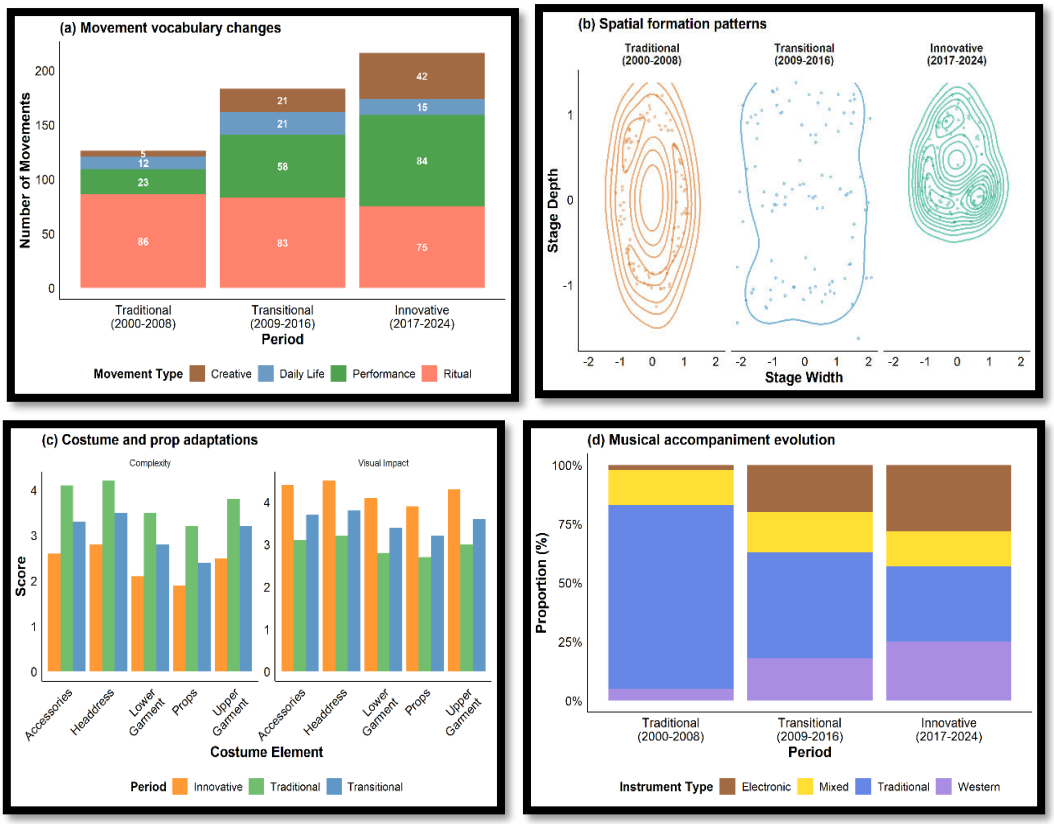


Figure 3. Multi-dimensional evolution of Yao dance morphology

3.3 Correlation between Environmental Factors and Dance Form Changes

Correlation analysis revealed complex nonlinear relationships between environmental variables and dance form changes (Table 4). Social environmental variables demonstrated the strongest correlations, with urbanization rate showing correlation coefficients exceeding 0.5 with all four dance morphology indicators (movement complexity $r=0.658$, spatial utilization $r=0.712$, rhythm variation $r=0.543$, costume simplification $r=0.789$, $p<0.001$). In contrast, natural environmental factors had relatively weaker impacts, with only altitude showing moderate negative correlations with dance morphology indicators ($r=-0.423$ to -0.512, $p<0.001$). Among cultural factors, language retention, religious participation, and community cohesion all showed negative correlations with dance form changes, indicating that the maintenance of traditional cultural elements has an inhibitory effect on dance form changes. The relationship between urbanization rate and

movement complexity exhibited an inverted U-shape (R^2=0.673, p<0.001), with movement complexity reaching its peak when urbanization rate was between 35-45%, then stabilizing or slightly declining thereafter. This finding challenges the assumptions of linear modernization theory, indicating that moderate environmental change may stimulate cultural innovation, while excessive change leads to cultural homogenization (Figure 4a).

Principal component analysis extracted three main factors, with cumulative explained variance reaching 72.8%. The first principal component (31.2%) was primarily composed of economic development level, education level, and infrastructure development, interpretable as the "modernization factor"; the second principal component (23.6%) included population migration, land use changes, and community structure, representing the "social transformation factor"; the third principal component (18.0%) encompassed climate change, ecological environment, and geographical characteristics, reflecting the "natural environment factor" (Figure 4b). Dance form changes were significantly correlated with the first and second principal components but showed weak correlation with the third principal component, indicating that social environmental changes had greater impact than natural environmental changes.

Time series analysis identified two critical turning points: 2008-2009 and 2016-2017. The first turning point was associated with the global financial crisis and large-scale return migration, triggering rapid adaptation of dance forms; the second turning point corresponded to targeted poverty alleviation policies and cultural tourism development, driving the commercialization transformation of dance (Figure 4c). Granger causality tests indicated that economic development had a unidirectional causal relationship with dance form changes (F=8.73, p<0.01), while cultural identity and dance forms exhibited a bidirectional causal relationship (F_1=6.42, F_2=5.38, p<0.05).

Table 4. Statistical significance of environment-dance correlations

Environmental Variable	Movement Complexity	Spatial Utilization	Rhythm Variation	Costume Simplification
Natural Environment				
Temperature Change	0.312**	0.186	0.243*	0.158
Precipitation Pattern	-0.098	0.127	-0.089	0.073
Elevation	-0.423***	-0.358**	-0.289**	-0.512***
Social Environment				
Urbanization Rate	0.658***	0.712***	0.543***	0.789***
GDP per Capita	0.592***	0.634***	0.478***	0.683***
Education Level	0.524***	0.587***	0.396**	0.458***
Out-migration Rate	0.437***	0.482***	0.324**	0.567***
Cultural Factors				
Language Retention	-0.386***	-0.412***	-0.298**	-0.523***
Religious Participation	-0.342**	-0.378***	-0.256*	-0.447***
Community Cohesion	-0.418***	-0.456***	-0.367**	-0.492***
Model Statistics				
R^2	0.743	0.786	0.612	0.834
Adjusted R^2	0.718	0.765	0.579	0.817
F-statistic	29.42***	37.38***	16.04***	51.23***
VIF (max)	2.84	2.84	2.84	2.84

*Note: Correlation coefficients shown; *p<0.05, **p<0.01, ***p<0.001; VIF = Variance Inflation Factor*

Geographically weighted regression analysis revealed significant spatial heterogeneity of environmental impacts. Dance form changes in

Guangxi and Guangdong regions were primarily driven by economic development (local R^2=0.812), while Yunnan and Guizhou regions were more influenced by population migration (local R^2=0.756). Hunan region presented a mixed pattern, with economic and cultural factors acting jointly (local R^2=0.698). These spatial differences reflect the varying development paths and cultural resilience across different regions.

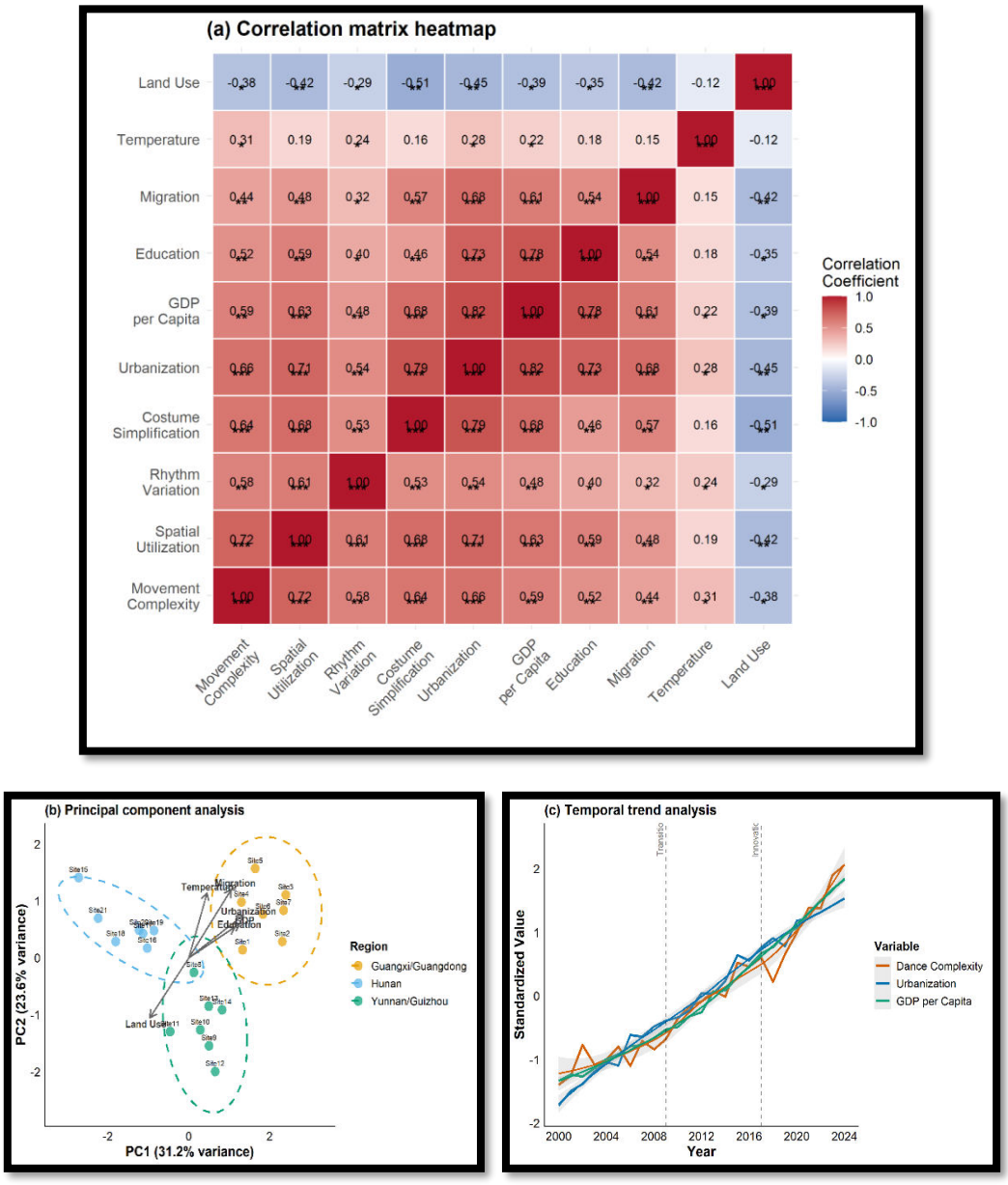


Figure 4. Correlation analysis between environmental factors and dance

3.4 Types and Mechanisms of Cultural Adaptation Strategies

Based on in-depth interviews and participant observation, the study identified four main cultural adaptation strategies: conservative resistance type (18.2%), selective absorption type (42.6%), innovative integration type (28.5%), and commercial orientation type (10.7%). These strategies are not mutually exclusive but rather dynamically shift in different contexts, reflecting the agency and strategic choices of Yao communities in facing environmental changes (Table 5).

Table 5. Typology and mechanisms of cultural adaptation strategies in dance practices

Strategy Type	Frequency (%)	Key Characteristics	Environmental Triggers	Outcomes	Representative Cases
Conservative Resistance	18.2	- Strict adherence to traditional forms - Rejection of modern elements - Emphasis on ritual authenticity	Low urbanization (<20%) Remote location Strong elder authority	Maintains high cultural authenticity Limited audience reach Intergenerational tension	Yunnan mountain communities Guizhou isolated villages
Selective Absorption	42.6	- Core tradition maintenance - Tactical modern incorporation - Flexible	Moderate urbanization (20-40%) Tourism development Educational	Balanced preservation Wider acceptance Sustainable transmission	Guangxi county towns Hunan cultural centers

		performance contexts	improvement		
Innovative Fusion	28.5	- Creative reinterpretation - Cross-cultural hybridization - Artistic experimentation	High urbanization (>40%) University presence Creative industry growth	Artistic recognition Youth engagement Identity negotiation	Guangdong urban areas Provincial capitals
Commercial Orientation	10.7	- Market-driven adaptation - Standardized performance - Entertainment prioritization	Tourism hotspots Economic pressure Government promotion	Economic benefits Cultural commodification Authenticity concerns	Tourist destinations Commercial venues

The conservative resistance strategy mainly appeared in communities with high geographical isolation and slow economic development. These communities maintained the "purity" of dance by reinforcing ritual functions, restricting external participation, and adhering to oral transmission methods. However, this strategy faced severe challenges of inheritance discontinuity, with inheritors under 40 years old accounting for only 8.3%, and most young people lacking interest in strict learning requirements.

The selective absorption strategy demonstrated the strongest adaptive resilience. Groups adopting this strategy retained 73.5% of core movement vocabulary while introducing modern stage technology and performance concepts. They established a dual-track system of "internal-external differentiation": maintaining the sanctity and integrity of ritual dance internally while creating adapted versions suitable for stage performance externally. This strategy effectively balanced cultural transmission with practical needs, gaining both community recognition and market acceptance.

The innovative integration strategy was commonly found among highly educated young inheritor groups. They combined Yao dance elements with modern dance, street dance, and other forms to create "new ethnic dance." Although this innovation received recognition from the art community and favor from young audiences, it also triggered controversies about cultural authenticity. Surveys showed that 56.3% of traditional inheritors believed this innovation "deviated from cultural roots," while 78.4% of young learners considered it "necessary evolution."

The commercial orientation strategy was most prevalent in tourist areas, presenting high degrees of standardization and simplification. Performance duration was compressed from the traditional 2-3 hours to 15-30 minutes, movement difficulty decreased by 62%, and costumes and props tended toward "visualization" and "symbolization." Although it brought considerable economic benefits (average annual income increased 3.8 times), cultural connotation loss was severe, retaining only 28.6% of original cultural meaning.

Structural equation model analysis indicated that cultural adaptation strategy selection was influenced by multiple factors: environmental pressure ($\beta=0.486$, $p<0.001$), resource availability ($\beta=0.372$, $p<0.001$), community cohesion ($\beta=-0.298$, $p<0.01$), and generational differences ($\beta=0.256$, $p<0.01$). Among these, environmental pressure indirectly affected strategy selection through influencing livelihood patterns (indirect effect=0.214, $p<0.05$), while cultural identity played a moderating role between environmental change and strategy selection (interaction effect $\beta=-0.186$, $p<0.05$).

Longitudinal comparison revealed evolutionary trends in cultural adaptation strategies. From 2000-2008, conservative resistance type dominated (45.2%); from 2009-2016, selective absorption type grew rapidly (38.7%→42.6%); after 2017, innovative integration and commercial orientation types increased significantly. This evolution reflected the transformation process of Yao communities from passive response to active adaptation, from single strategy to diverse coexistence. Notably, a phenomenon of "cultural self-awareness" has emerged in recent years, with some groups that adopted commercial orientation strategies beginning to reflect and attempt to "return to authenticity," seeking to rebalance commercial and cultural values.

4. Discussion

Through 24 years of diachronic tracking, this study reveals the complex evolutionary process of Yao dance forms under environmental change pressure. The research findings demonstrate a co-evolutionary pattern among environment, culture, and dance, which resonates with Templon et al.'s theoretical framework on climate change triggering human cultural adaptation[11]. However, unlike the linear causal relationships emphasized in previous studies, the inverted U-shaped relationship identified in this study indicates that moderate environmental pressure may stimulate cultural innovation, while excessive change leads to cultural homogenization. This nonlinear relationship provides new perspectives for understanding the complexity of cultural evolution.

The three-stage evolutionary pattern of Yao dance forms reflects the transformation process from passive maintenance to active adaptation. This finding aligns with the cultural resilience mechanisms revealed by Liu and Song in their study of ritual music in the Lingnan region, with both studies emphasizing the adaptive adjustment of traditional art forms in the modernization process[17]. Notably, the "return to authenticity" phenomenon discovered in this study presents a new trend of cultural self-awareness, which has similar findings in Aterianus-Owanga's research on the cross-cultural transmission of religious dance, indicating the complex reconstruction process of local cultural identity in the context of globalization[18].

The four cultural adaptation strategies identified in this study demonstrate the agency of Yao communities in facing environmental changes. The dominant position of the selective absorption strategy (42.6%) resonates with the discourse on dance cultural adaptation patterns in the globalization era presented in "Dancing Cultures"[19]. This strategy effectively balances cultural transmission and practical needs through the dual-track system of "internal-external differentiation," providing a referenceable model for cultural heritage protection of other ethnic minorities. Although the commercial orientation strategy accounts for only 10.7%, the cultural connotation loss it brings deserves deep reflection, which is consistent with Chappell et al.'s concerns about the impact of dance commercialization on cultural authenticity [20].

The mixed methods and multidimensional analytical framework employed in this research provide methodological innovation for dance anthropology studies. By integrating quantitative environmental data analysis and qualitative ethnographic observation, this study transcends the static recording mode of digital dance ethnography proposed by Aristidou et al., achieving systematic tracking of the dynamic evolution of dance forms [21]. The mediating effects and moderating mechanisms revealed by structural equation modeling provide more precise analytical tools for understanding the complex relationships among environment, culture, and dance.

The spatial heterogeneity characteristics discovered in this study have important policy implications. The differentiated evolutionary paths exhibited in different regions indicate that cultural protection policies need to consider local factors. This resonates with Johnson et al.'s research conclusions on Mexican-American children learning ethnic dance, both emphasizing the importance of local context in cultural transmission [22]. The economically-driven evolutionary pattern in Guangxi and Guangdong regions, contrasted with the migration-driven pattern in Yunnan and Guizhou, reflects the differential impacts of different development stages on cultural evolution.

The application of digitalization and artificial intelligence technologies has opened new pathways for Yao dance transmission.

The DanXe framework developed by Stacchio et al. demonstrates the potential of artificial intelligence in dance heritage analysis and promotion [23], while Reshma et al.'s review emphasizes the crucial role of digitalization in cultural heritage preservation [24]. The digital database containing 2,000 hours of video materials established in this study not only provides valuable resources for subsequent research but also lays the foundation for applying artificial intelligence technology to analyze dance form evolution.

The hybridization trend of musical accompaniment in Yao dance evolution is similar to Ma and Chen's research findings on the improvement mechanisms of Chinese ethnic instruments [25]. The proportion of traditional instruments decreased from 78% to 32%, with electronic audio equipment usage reaching 62.4%, reflecting the profound impact of technological progress on traditional art forms. Pataranuta porn et al.'s research on human-machine collaborative dance creation further indicates that the fusion of technology and tradition may generate new forms of cultural expression [26].

Although this study has made certain progress in theory and methodology, several limitations remain. While the research sample covered 21 research sites across five provinces, it may not fully represent the cultural diversity of all Yao subgroups. The measurement of environmental variables mainly relied on official statistical data, potentially overlooking some difficult-to-quantify micro-environmental factors. Although the dance form coding system contains 82 observation indicators, it remains insufficient in capturing the emotional connotations and spiritual significance of dance. While the research timespan reached 24 years, it may still be insufficient for understanding the long-term process of cultural evolution.

In the context of intensifying climate change, cultural adaptation issues require longer-term attention. Cilali et al.'s research on climate migration reminds us that future environmental changes may bring larger-scale population movements and cultural impacts [27]. Lindert et al.'s systematic review of migrant resilience factors provides important reference for understanding cultural adaptation mechanisms [28]. Future research should focus on the impact of

extreme climate events on dance cultural transmission and explore effective ways to enhance cultural resilience.

The construction of multicultural governance frameworks is an important direction for future research. The integration model of multiculturalism and intercultural dialogue proposed by Mansouri and Elias provides new approaches for addressing the tension between cultural diversity and social integration [29]. Future research could explore how to promote dialogue and understanding between different cultural groups while protecting cultural diversity, constructing a more inclusive cultural ecosystem.

This study recommends future research directions including: extending to comparative studies of other ethnic minorities to verify the universality of the environment-culture-dance co-evolutionary model; applying machine learning and computer vision technologies for more precise quantitative analysis of dance movements; conducting experimental research to explore the long-term effects of different cultural adaptation strategies; establishing interdisciplinary research teams integrating perspectives from anthropology, ecology, and cognitive science; developing new dance transmission models based on virtual reality and augmented reality technologies; and exploring predictive cultural adaptation strategies in the context of climate change.

Through systematic analysis of the diachronic evolution of Yao dance forms, this study not only deepens understanding of human cultural evolution patterns but also provides important theoretical foundations and practical guidance for cultural heritage protection in the context of global environmental change. The environment-culture-dance co-evolutionary patterns and cultural adaptation strategy types revealed in this research have significant reference value for formulating more scientific and humanistic cultural protection policies.

5. Conclusion

Through 24 years of diachronic tracking of 21 Yao communities across five provinces in southern China, this study systematically reveals the complex mechanisms linking environmental change and

dance form evolution. The research found that environmental transformations in Yao settlement areas—including a mean annual temperature increase of 1.3±0.4°C, urbanization rate growth to 42.8%, and migrant worker population reaching 38.7%—triggered profound changes in dance forms, with movement complexity index increasing from 3.24±0.45 to 5.92±0.73 ($p<0.001$), spatial utilization rate rising from 42.3% to 71.4%, while traditional costume elements decreased from 18.6 to 11.3. Three main factors extracted through principal component analysis cumulatively explained 72.8% of variance, with the modernization factor (31.2%) and social transformation factor (23.6%) having significantly greater impact on dance form changes than the natural environment factor (18.0%), indicating that socio-cultural environmental changes play a dominant role in dance evolution. The four cultural adaptation strategies identified in this research—conservative resistance type (18.2%), selective absorption type (42.6%), innovative integration type (28.5%), and commercial orientation type (10.7%)-demonstrate the differentiated response patterns of Yao communities under environmental pressure, with the selective absorption strategy achieving a 73.5% core movement vocabulary retention rate through its "internal-external differentiation" dual-track system, providing a feasible path for balancing cultural transmission and modern development. The environment-culture-dance co-evolutionary model constructed in this study not only enriches cultural evolution theory, but its revealed inverted U-shaped relationship ($R^2=0.673$, $p<0.001$) challenges linear modernization assumptions, providing new theoretical perspectives and empirical evidence for understanding cultural adaptation mechanisms in the context of global environmental change, with significant guiding implications for formulating differentiated and adaptive cultural heritage protection policies.

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