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Integrating GIS and Landscape Index for Sustainable Development Planning: Analyzing the Cultural, Historical, and Ecological Landscape Patterns of Ancient Towns-A Case Study of Guilin, China

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Abstract

This study aims to analyze the ecological landscape patterns of Guilin's ancient towns by integrating Geographic Information Systems (GIS) and the Landscape Index. It examines how urban growth, tourism, and modernization affect the ecological and cultural sustainability of heritage areas. Additionally, the study provides insights into sustainable heritage management by assessing spatial metrics related to landscape fragmentation and ecological connectivity. A quantitative research design was applied, and the analysis of landscape patterns and fragmentation was conducted with the help of GIS mapping and the Landscape Index. Data on spatial change were gathered and analyzed to determine variations in land use, patch density, edge contrast, and ecological connectivity over time. The paper used spatial measures to identify areas at high risk of fragmentation and assess how urbanization affected the historic landscape. The findings reveal considerable landscape discontinuity caused by urbanization, which leads to a reduction in green areas and ecological deterioration. Areas with high fragmentation were also identified. The results indicate that cultural and ecological sustainability in the historic towns of Guilin is threatened and that landscape change and heritage degradation are largely caused by urbanization and development related to the tourism industry. This research integrates GIS-based spatial analysis to propose data-driven conservation strategies. It contributes to sustainable urban planning and offers a replicable framework for heritage preservation in historically significant towns facing urbanization challenges.

Keywords: GIS, landscape index, fragstats, heritage conservation, sustainable development

1. INTRODUCTION

Preservation of cultural and historical heritage in old towns is very critical and requires a holistic approach involving urban planning, landscape conservation, sustainable design, and development. Old settlements are unique cultural identities of a nation, tourism architectures, and local historical documents, which contribute to national identity and local communal identity throughout the world [1]. However, the emerging demands of modernization, urbanization, and environmental degradation jeopardize the character of such heritage zones, and new planning and conservation rationales that balance economic and cultural needs alongside ecological sustainability must be executed [2]. The most significant city in the history of China, Guilin, is known as a city that harbors ancient towns and offers a much-needed mix of ancient Chinese architecture, natural beauty, and culture [3]. In this way, the towns, being ecologically vulnerable places, are prone to increasing urbanization, pressure from infrastructure development, and the overcrowding of tourism, which demand strategic intervention that will regulate cultural conservation and ecological sustainability [4].

Further, the issues of historical integrity in many ancient towns must face the demands of modern city building. The situation requires measures to be taken to promote awareness of heritage conservation [5]. The rapid growth of urban centres in previous years has also resulted in the fragmentation of the landscape, the decrease of green areas, and the transformation of overall land-use patterns, which have caused adverse effects on both the historical components and the ecological values of these towns [6]. Uncontrolled urbanization has led to unregulated infrastructural developments, which encroach on historic architecture and destroy ecological characteristics, thereby exposing heritage sites to hazards including soil erosion, floods, and decline of the biosphere [7]. Moreover, the increased tourist flow in town areas with a high concentration of heritage locations has also resulted in increased environmental pressure, over-commercialization, loss of habitats, and an increased tourism carbon footprint [9]. Development policy, encompassing effective spatial analysis, conservation, and development without the participation of the local community, will in many ways fail to implement sustainable interventions in order to address the two problems of urban expansion and environmental protection.

FragStats and Geographic Information System (GIS) are computer applications that provide an effective means of spatial pattern analysis, ecological connectivity, and the influence of urban sprawl on cultural landscapes [10]. GIS provides quality mapping and allows scientists to observe changes in land use, historic change, and measure spatial associations between the natural environment and built-up territories [11]. In the same way, the Landscape Index can be used to offer measurable information regarding fragmentation, patch connectivity, and the ecological integrity of the landscape through the FragStats computer program, which contributes to the identification of high-risk locations that need to be conserved [12]. By introducing such analytical metrics, scientists can develop evidence-based conservation policies that can coexist with the model of sustainable city planning to ensure adaptive and effective practice of heritage conservation and prevent environmental degradation [13].

The research requirement that will be met by this study is the necessary addition of the ecological sustainability aspect in heritage conservation by using the QGIS package and FragStats software as mapping tools to analyze the landscape dynamics of and surrounding the ancient towns of Guilin.

1.1. RESEARCH PROBLEM

The ancient towns of Guilin have remained highly affected by urban sprawl and tourism despite the attempts made by the government to preserve the history of these towns through policies. Moyano et al. [6] attribute the problem to uncontrolled transformations of land use that promote landscape fragmentation and architectural discontinuity, but the existing conservation policies have not attempted to consider ecological connectedness, focusing instead on physical reconstruction. Equally, Qiu et al. [9] stress that tourism has increased environmental pressure and the commodification of heritage, but there is little public involvement in conservation planning activities. The lack of connection between spatial planning and socio-ecological reality exposes the inability of isolated strategies to deal with the global threat. The fragmentation of green land, the loss of biodiversity, and the diminishing cultural identity are indicative of the urgency of integrative, data-oriented models. The purpose of the study is to create an interdisciplinary approach, which will consist of GIS, landscape metrics, and stakeholder involvement to stimulate ecologically friendly and culturally resistant planning in Guilin.

1.2. RESEARCH OBJECTIVES

This study aims to develop a comprehensive approach to managing heritage conservation, combining qualitative spatial analysis based on GIS, landscape measures, and the involvement of local people in the matter. To be more precise, the study utilizes software such as QGIS and FragStats, with the help of which shifts in the landscape structure are mapped and measured, along with local views collected via qualitative fieldwork. The final objective is to contribute to adaptive planning models, maximization of ecological sustainability, and cultural resilience in heritage towns in Guilin.

The research was informed by three general objectives. First, it measured patterns of ecological landscapes in the historic urban settlements of Guilin, and the focus was on settlement patterns, green cover, and urban development patterns of the places with reference to age. Using GIS-based spatial analysis, this study investigated the impact of modernization on land use. Second, it estimated the perceptions and attitudes of residents toward individuals who live near conservation areas, recognizing civic participation as an important tool in defining sustainable policies. The methods through which the stakeholders perceived the preservation and development balance and conservation roles involved interviews and surveys. Third, the study assessed how much spatial analysis can be utilized to inform sustainable preservation of heritage and urban planning. By utilizing FragStats landscape measures along with GIS maps, the analysis mapped high-risk areas of fragmentation and those with conservation potential and provided urban planners and policymakers with useful data based on which they could develop adaptive sustainability-oriented solutions.

In line with these goals, the study was informed by two guiding questions: (1) How do Guilin's ecological landscape patterns represent cultural and historical changes? (2) What are the attitudes and responses of the local community toward ecological sustainability?

To address the critical problems of old towns amid rapid urbanization, this study needs an interdisciplinary methodology that involves spatial study, cultural heritage preservation, and environmental sustainability. By employing GIS and Landscape Index, the study has added to the existing literature on preserving heritage by providing a formal and evidence-based approach to the evaluation of landscape transformation and ecological danger [14]. The study will provide objective data on how the process of urbanization and tourism growth affects historic landscapes. The evidence-based findings will aid policymakers in basing their policies on evidence of reversing environmental deterioration while simultaneously preserving cultural heritage. Moreover, participation of the community in heritage conservation efforts is also emphasized in the research. The current literature indicates that conservation policies that are more suitable are those that resonate with the local voice and incorporate community actors into the decision-making process [15].

This study will give good recommendations on empowering a participatory style of governance, which will empower local communities in the management of heritage based on the results of public opinion and the level of participation [16]. In particular, in Guilin, where economic development caused by tourism is the key factor, the issue of cultural sustainability is the most critical [17]. In addition, the study has far-reaching implications for the planning of urban sustainability, and the lessons apply by extension to other ancient towns facing similar conservation problems [18]. This research methodology paradigm can be adjusted into a functional model to comprehend landscape change in various diverse geographic landscapes for cross-comparison in most landscapes rich in heritage [19]. The paper gives a broad methodological technique in accordance with the international goals of sustainable development, namely in creating resilient urban areas, cultural sustainability, and ecological safety through the incorporation of the principles of GIS-based conservation planning and landscape ecology.

2. LITERATURE REVIEW

2.1. SPATIAL LANDSCAPE CHANGE AND LANDSCAPE INDEX IN ECOLOGICAL AND LANDSCAPE ANALYSIS

Historical alteration of land use and land cover has contributed immensely to the structure, function, and sustainability of regional landscapes. To enhance the decision-making process in the future, temporal changes and consequences ought to be quantified properly. Geographic Information Systems (GIS) have been an essential part of urban and environmental planning, facilitating the collection of systematic data, storage, analysis, and visualization of spatial data to support the decision-making process [11]. GIS is crucial to ecological and historical landscape research, as it can analyze how land use transforms, urban sprawl, and environmental change, and give policymakers important spatial information to guide sound and sustainable use of resources [21]. The use of GIS in heritage conservation has served successfully to monitor landscape changes, identify culturally threatened sites, and ensure proper land use in a manner that prevents environmental degradation [22].

The effectiveness of GIS-based spatial modelling has been identified as improving conservation by pointing out critical locations for intervention, allowing a balanced approach to conserving heritage and current urban demands [23]. In addition, GIS is especially appropriate when it comes to exploring the spatial-temporal dynamics of the ecological system and provides a stable framework for the overall integration of data, including remote sensing images, topography, and socio-economic indicators, to assess the sustainability of ancient cities [24]. Despite GIS-based conservation planning having significant strengths, it has some limitations, including a lack of data, the need for expert technical expertise, and coordination issues between disciplines, which should be resolved to fully exploit its potential in sustainable heritage management [26].

In addition to GIS, FragStats is a specific computer application that is used to quantify the indices of the landscape to describe the pattern and fragmentation of ecological spaces as a complex of spatial measures indicating the installation of

land in terms of its composition, structure, and connectivity [27]. Alongside GIS and FragStats, more recent developments in spatial analysis methods have immensely contributed to landscape and ecological studies by giving more sophisticated analysis of both temporal and spatial processes. Gradient surface models and graph-based metrics can be considered an extension of the conventional patch-mosaic framework; they provide additional information regarding the connectivity of the landscape and ecological functional pathways.

The scale effects using multi-resolution analyses and sensitivity to the modifiable areal unit problem (MAUP), ecological inference has been made robust by eliminating biases associated with spatial and thematic resolution differences. Kitchen et al. [28] observe that time-series satellite imagery has been combined with remote sensing and machine learning to enhance the accuracy of land-use change detection and ecological trend analysis with random forests and long short-term memory (LSTM) neural networks. Besides, fractal dimension analysis and landscape connectivity measures serve as invaluable measures of spatial complexity and habitat permeability.

Land-use simulation models like CLUE-S (Conversion of Land Use and its Effects) can also be used to conduct predictive scenario planning. This combination provides GIS-based landscape analysis with active, scale-sensitive, data-based, and open opportunities for sustainable conservation planning. This type of review is particularly essential to establish how landscapes have evolved over a time frame and which man-made forces affected ecological integrity [13].

The changes in land use are sufficient to measure spatial heterogeneity based on the analysis of landscape indices, and no more action is required to delimit the land in danger because of habitat fragmentation or the loss of cultural continuity [12]. The planners will be able to work out the mitigation schemes that will reverse the negative effects of urbanization and guarantee the sustainability of ecological and cultural systems thanks to the assistance of such landscape indicators as patch density, edge contrast, and connectivity [29]. The combination of GIS and FragStats will enable planners to embrace the power of spatial analysis and conservation planning and thus promote the adoption of data to derive plans on how to maintain a cultural landscape [24].

Nonetheless, institutional support, interdisciplinary practice, and the involvement of the population, in turn, are needed to help close the gap between conservation strategies and scientific evidence and local socio-cultural settings [25]. An innovative use of GIS and Landscape Index will help improve the perception of the process related to spatial processes and eventually enable correct decision-making that will avoid the situation in which the historical and ecological integrity of the ancient towns of Guilin is lost amid contemporary urban development problems.

Ecological and landscape studies have benefited greatly as a result of recent technological changes in spatial analysis procedures, especially owing to the incorporation of GIS and landscape measures. Indicatively, Wang [30] uses GIS to study the urban tourism landscape, which indicates that spatial sprawl transforms ecological structures and landscape connectivity, which is essential in the planning of sustainable urbanism. To supplement this, Milovanovic et al. [31] critically discuss the development of landscape ecology, with a focus on the maturity of spatial planning instruments to address intensive land-use problems and ecological fragmentation. Such investigations highlight the need to consider the application of spatial analytical models in the analysis of landscape patterns and ecological sustainability.

2.2. PUBLIC PERCEPTION AND COMMUNITY ENGAGEMENT IN ECOLOGICAL CONSERVATION

The success of nature and heritage conservation processes is supported by public opinion and activity, as the members of the population are also the custodians and owners of the natural and cultural resources (Ahmad et al., 2024). According to experts, sustainable conservation can only be possible when the local community actively participates, as impressions and on-site documentation are critical to performing successful and effective management of heritage [26]. In the case of the classic Guilin towns, the way out of the adverse effects of mass tourism and urbanization and the promotion of ownership and responsibility in relation to environmental and cultural resources is stakeholder involvement [32]. The measures that have been targeted at participation have been observed to earn high levels of public support and sustainability, since the participation of people enables the implementation of policy to address the concerns of the people.

There are also issues such as a lack of sufficient awareness among people, a lack of motivation to participate, and a knowledge gap regarding how people can participate in the decision-making process, among others, but these issues exist [33]. Policies that create a balance between the conservation of the ecosystem and local community living conditions often suffer opposition because of unplanned conservation initiatives that fail to consider local socioeconomic conditions (Blanton et al., 2024). The case studies performed in other culturally diverse places have proven to be successful when local people are involved in planning and executing conservation initiatives, as not only is environmental sustainability improved, but so are cultural identity and the generational transfer of knowledge [19].

The attitude of the populace toward environmental protection depends on various variables, including education, economic gain, and religion, and hence the need to create interest and concern among a group of stakeholders [7]. Previous research has shown that though individuals are pro-conservation, their following is inconsistent in relation to perceived

costs and benefits, and economic security is often chosen in preference to environmental conservation rather than the other way around. The process of urbanization of the tourism economy in Guilin has introduced both opportunities and issues to the indigenous inhabitants who have gained economic interest and people with interest in environmental degradation, disappearance, and erosion of native traditions [8].

Research has also demonstrated that research on attitudinal improvement due to awareness campaigns, environmental education, democratic participation, and governance has shown significant improvement in conservation [19]. The continued use of digital technology, including GIS-based participatory mapping, has allowed residents to map changing surroundings and aid in conservation planning [20]. Interdisciplinary methods of policy, economic incentive, and choice facilitation with the participation of the community should be used, but to verify that community preference does not contradict ecological conservation, such measures are required [3]. Cultivating a system of environmental protection through joint infrastructure and the involvement of all stakeholders might create greater social devotion to conservation work and the sustainable development of the ancient towns in Guilin in the long run.

The combination of spatial analysis and public perception ensures good ecological conservation by the community. Codemo et al. [34] show that live action in planning instruments, which employs visual Q-based methodology, of changing the spatially measured local consent or dissent indicates that the conservation landscape is forming, especially in energy changes. On the same note, Pingarroni et al. [35] use participatory mapping to reveal spatial patterns of ecosystem services grounded on community preferences, demonstrating that localized perception data improve biodiversity planning and spatial equity. These analyses demonstrate that the concept of community engagement in terms of spatial visualization makes conservation more accurate and provides legality and long-term custodianship of the local stakeholders.

2.3. HISTORICAL AND CULTURAL SIGNIFICANCE OF GUILIN'S ANCIENT TOWNS (THIS STUDY AREA CAN DISCUSS IT LATER)

The history of the old towns in Guilin is deeply rooted in the rich history of Chinese culture, and their architectural characteristics have been rich with traditional planning of cities as well as ancient cultural tradition. Towns such as Xingping and Daxu are heritage to the history of development of this place, which was shaped by imperial China, the Silk Road, and local cultures [36]. The spatial form recalls the interaction of harmony between nature and human activity, which owes something to ancient Chinese geomancy (feng shui) and Confucian urban planning theories [4]. Over the years, these towns have undergone the pressures of modernization, urbanization, and a sudden increase in tourist development, which has compelled them to change their land use, demographics, and architecture [37]. Most of these towns are unable to maintain their nature even after economic developments and poor conservation policy have taken their toll despite the historical and cultural significance attached to them.

Tourism development, particularly in recent times, presents opportunities and threats, where the development of tourism results in an economic payoff at the expense of historic buildings and streetscapes [3]. The concept of sustainable development has been observed to conflict with the concept of conservation, whereby existing literature has focused on harmonizing the two concepts to ensure that cultural heritage is conserved in accordance with the needs of contemporary cities, but there is a gap in the implementation of systematic schemes that could maintain long-term conservation without compromising economic sustainability [38].

The historic town conservation of Guilin has been conducted according to various government and nongovernment frameworks, and fragmentation of the policies and other enforcement mechanisms has become a significant issue [32]. Project conservation has also been inclined toward material restoration of historic buildings to the detriment of general landscape processes, including ecological sustainability and cultural continuity [36]. It has been identified as an effective instrument, and leveraging geospatial technologies like GIS and landscape metrics analysis as a FragStats tool has been identified to help assess the spatial and ecological health of such towns with evidence-based data forming the basis of sustainable development planning [39].

However, according to research, even where this type of technology exists, practical implementation is limited due to economic factors, inefficient use of technical skills, and even opposition from neighbourhoods [12]. All these must be addressed under an interdisciplinary response that addresses gaps between heritage preservation, ecological landscape study, and urban sustainability planning processes. GIS and FragStats analysis enable planners and policymakers to see the spatial dynamics in Guilin's historic towns from a different perspective so as to make more rational decisions with an environmentally sustainable approach and preservation of cultural history. Thus, the application of technological innovation to community-based conservation is an opportunity through which such old landscapes can retain their cultural identity and adjust to the changing requirements of modern society [40].

3. METHODOLOGY

The study employs an integrative research style that entails the synthesis of geospatial and landscape metrics to estimate the cultural, historical, and ecological landscape patterns of the ancient Guilin cities in China. The research employed Geographic Information Systems (GIS) and the Landscape Index with FragStats, which can accomplish an integrated spatial analysis of landscape fragmentation and historical conservation patterns. The methodology aims at providing systematic data collection, processing, and interpretation in support of sustainable development planning.

Guilin, a city in the Guangxi Zhuang Autonomous Region of China, was the research site of choice, as it is highly concentrated in terms of historical and cultural heritage, scenic karst scenery, and the issue of heritage against urban development that has already become rampant. The distribution of the old towns around the site is basic, and these towns have been centers of trade in the past, as well as cultural hubs initially, such as Xingping and Daxu. These cities possess unique architectural designs, traditional town structures, and historical cultural practices that reflect the history of developments in China. However, urbanization and modernization due to tourism have brought a shift in the landscape, and the issue of the strict study of spatial tendencies and environmental management is necessary.

The study area map (Figure 1) shows the geographic position of Guilin in Guangxi, China, and gives a specific administrative division of the districts and counties of Guilin. The left side also displays the location of Guilin within the province of Guangxi, while the right side gives a magnified image of Guilin and the different counties it comprises, including urban and rural areas. The changes in color reveal the administrative boundaries, which are highlighted by the fact that the study was conducted in the space of historical, cultural, and ecological landscapes. Such major sites as Xiufeng, Qixing, and Xiangshan are identified, which are major points of historical and urban development of significance in the study.

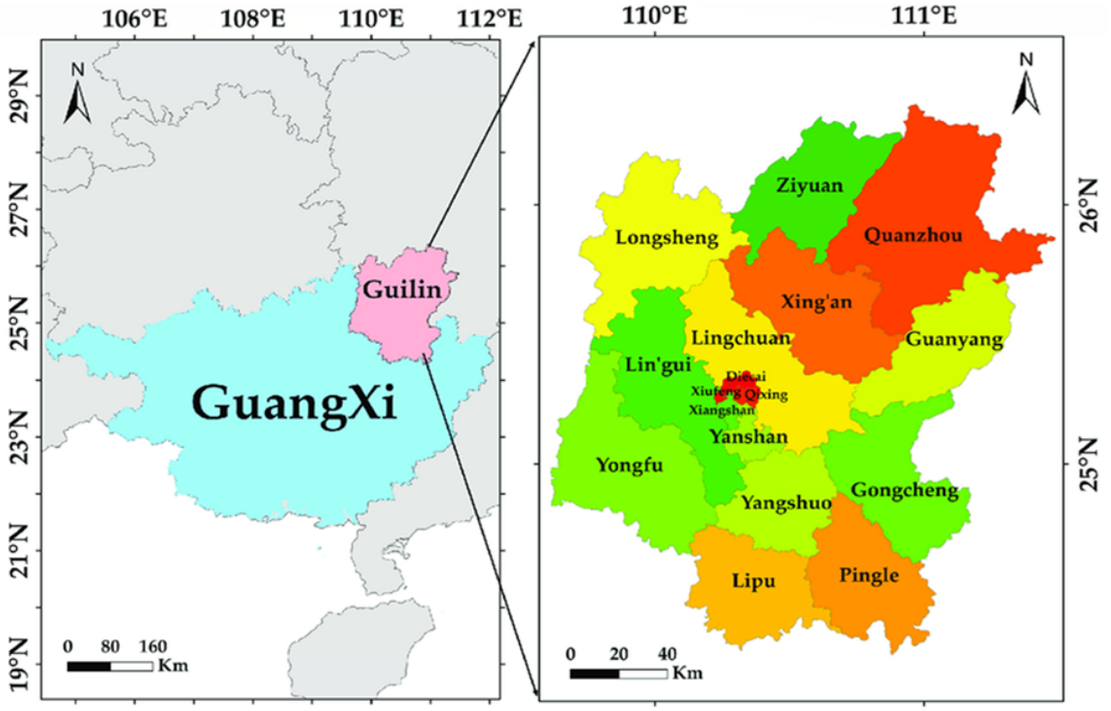

Figure 1. *Study area map: Guilin, China*

To encompass the urbanized as well as the natural environment, the research area was delimited by demarcating it according to the administrative boundaries and key geographical features included in the research area. To record the change in settlement pattern and land use over time, historical maps and high-resolution satellite images were employed. The reductions have also been a slight decrease in cropland (brown), probably as a result of urban and industrial conversion of the land. The stability of the water bodies (blue) has not changed sharply, meaning that there have not been any significant changes to the entire water sources. Figure 2 demonstrates the effect of urbanization on the natural environment, which should be considered with sustainable planning strategies to maintain the balance between development and ecological conservation.

The multi-source approach to data collection was followed, which involved remote sensing images, past cartographic data, and field surveys to obtain both spatial and qualitative characteristics of the ancient towns in Guilin. The high-

resolution satellite images were obtained through open-access remote sensing archives and government archives to investigate changes in the landscape during the past 20 years. The historical maps were scanned so as to track the changes that have taken place in settlement patterns and the development of the urban centre over a long period, and historical changes are noticed. In order to cross-establish GIS-based findings and any changes in land use and conservation measures, field surveys were conducted to document architectural features.

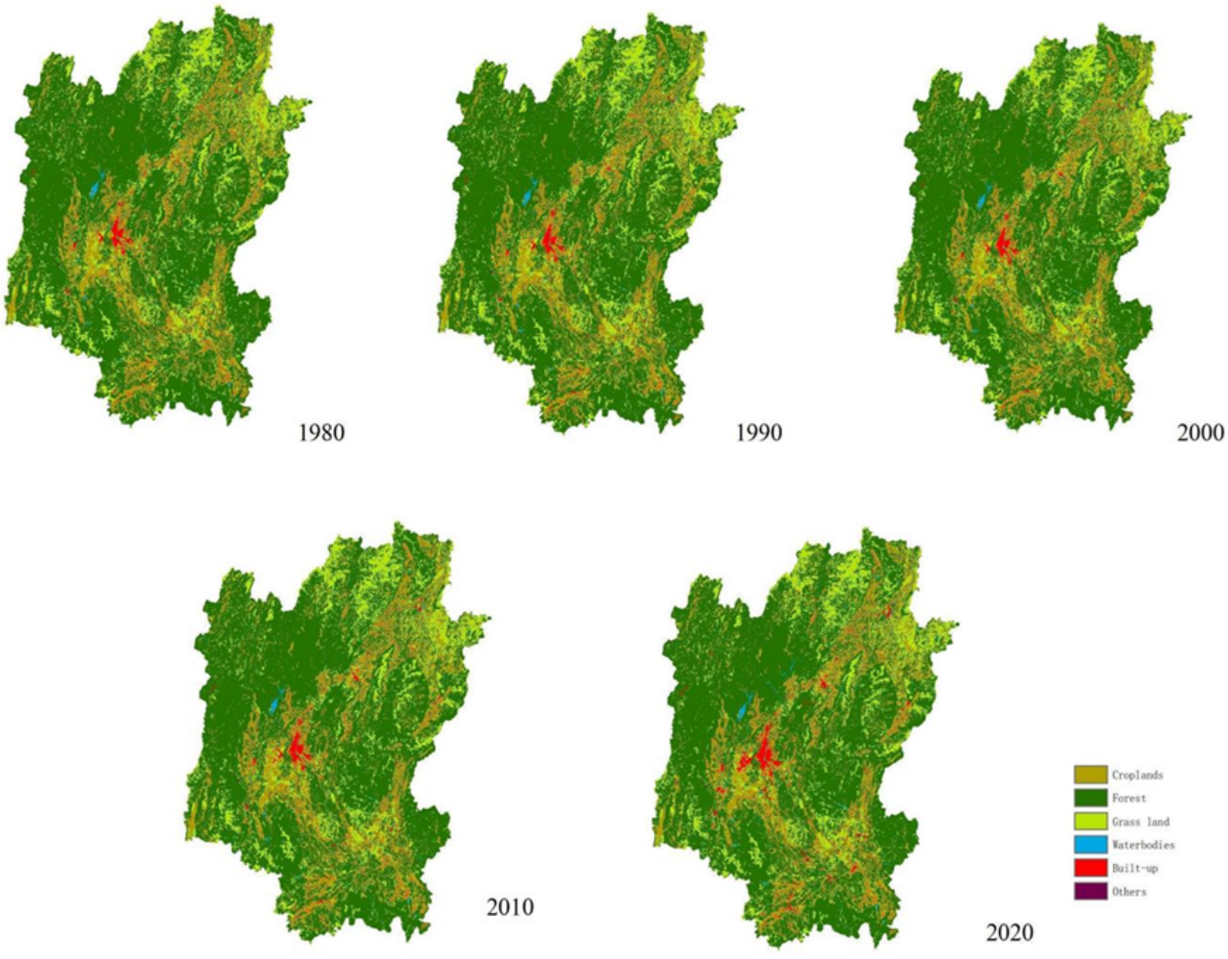

Figure 2. *Historical land use changes in Guilin*

The sampling procedures adopted in this study were restrictive, thus establishing a clear methodological objective, which is to use stratified random sampling in choosing residents of various age groups and settlement areas. The survey was carried out on a cohort of 150 participants with measured perceptions through structured questionnaires, which were created to address the level of ecological degradation, conservation practices, and change in the landscape. The responses were thematically coded and analyzed in NVivo to identify patterns. This not only provided findings in a quantifiable and localized form, which enhanced the reliability and representativeness of the community feedback to the conservation planning process.

The study considered a validation procedure for the land use/land cover classifications to guarantee the accuracy of the land use/land cover classifications based on high-resolution Google Earth images and ground truthing at 50 control points. A confusion matrix was used to determine the accuracy of the classification, and the Kappa statistics were used to determine the agreement between the observed and classified data. This step in validation was essential to ensure that the spatial outputs were reliable, minimize the errors of classification, and justify evidence-based decisions in the conservation of heritage landscapes.

Data preprocessing included georeferencing, image classification, and map vectorization to enable accurate spatial comparison.

The analysis strategy was designed to integrate fragmentation modes, interconnectedness, and land-use allocation through GIS-based spatial analysis and FragStats landscape metrics. Geographic data analysis, land cover formations, and change detection simulations were performed with the assistance of GIS. The social survey attributes of the study entailed semi-structured interviews and questionnaires, which were carried out among locals who resided around the historical cities of Guilin. The sampling procedure implemented to make sure that different age groups, professional and working

backgrounds, and lengths of stay in town were reflected in the sample set was a stratified sampling method. This was an attempt to unify the opinions held on heritage protection, land-use change, and the perceived effects of urbanization. The local administrative records were used to determine potential respondents. The administration of the questionnaires was done through face-to-face interviews and community meetings.

The qualitative analysis of the responses was carried out with the help of content analysis and codification, and the analyzed results offered common themes and issues, which were later used to combine the spatial results to impact conservation strategies. Such a plan was intended to enable greater understanding of the perception and utilization of the new landscape of heritage towns by the local communities. The study used supervised classification methods to categorize the land cover types, which included built-up areas, green areas, and water areas, to make a temporal contrast on how urbanization was taking place.

Quantitative measures of spatial heterogeneity and fragmentation were determined by calculating landscape metrics within products such as patch density, edge contrast, and connectivity indices, with FragStats. These statistics have been used in identifying areas where there are high ecological disturbance and urban encroachment. Spatial autocorrelation statistics, e.g., Moran's I and Getis-Ord Gi*, were also used to establish cluster patterns of the features of the landscape, and they had a spatial dependence on the growth of the settlements. The results were interpreted through the lens of sustainable development planning and emphasized the interventions to restore consistency between heritage preservation and environmental sustainability. Combining GIS with FragStats was an effective spatial analysis tool, and the results of the study will be used to guide decision-making towards the preservation of Guilin's old towns. The largest patch index (LPI) did decrease a bit, and it means that the dominance of one land cover type decreased. The density of edges (ED) and total edge (TE) increased, which means the increased complexity of landscape boundaries with urbanization and increase of land use.

4. RESULT

Table 1 presents the changes in land cover composition in Guilin between 1980 and 2020, and the city has undergone dramatic changes in composition due to urbanization and land-use changes. Constantly rising, the built-up area is growing from 43,352.34 ha (1.57%) in 1980 to 62,715.44 ha (2.27%) in 2020, as evidenced by the continuous development of urban infrastructure and communities. This growth has been associated with a slow decrease in cropland, which dropped to 527,209.07 ha (19.07%) in the year 2020, corresponding to 538,910.42 ha (19.52%), which was obtained in 1980, and this is due to the conversion of agricultural land to urban development. Nevertheless, forest cover has been the most dominant category of land, even though it has experienced some slight decline during the research period, from 1,781,422.59 ha (64.53%) to 1,771,766.93 ha (64.09%). On the same note, the area of the grasslands has not been constant, as it was at its highest of 379,093.23 ha (13.70%) in 2000, which slipped to 373,084.56 ha (13.49%) in 2020. Simultaneously, the water bodies have grown from areas of 25,791.85 ha (0.93%) to 29,522.58 ha (1.07%), which may imply conservation activities or changes in hydrology. The Other category, which is minimal, has experienced slight increases, suggesting small-scale land modifications.

Table 1. *Land cover composition in Guilin between 1980–2020*

Year	1980	1980	1990	1990	2000		2010		2020	
Land Cover	Area (hm2)	%	Area (hm2)	%	Area (hm2)	%	Area (hm2)	%	Area (hm2)	%
Other	212.67	0.01	212.67	0.01	212.67	0.01	319.37	0.01	393.80	0.01
Built-up	43352.34	1.57	44604.93	1.62	44982.09	1.63	46981.85	1.70	62715.44	2.27
Water-body	25791.85	0.93	25920.80	0.94	26100.27	0.94	27349.73	0.99	29522.58	1.07
Grass land	371127.42	13.44	377252.13	13.66	379093.23	13.70	374545.38	13.56	373084.56	13.49
Forest	1781422.59	64.53	1775260.75	64.30	1778703.39	64.29	1776205.38	64.33	1771766.93	64.09
Cropland	538910.42	19.52	537566.00	19.47	537578.28	19.43	535821.92	19.41	527209.07	19.07
Total area	2760817.28	100.00	2760817.28	100.00	2766669.93	100.00	2761223.63	100.00	2764692.38	100.00

Figure 3 shows how the use and appearance of land in Guilin changed between 1980 and 2020. The constructed areas have also increased significantly (red) over time, especially in urban centers, which is a sign of urban sprawl. Meanwhile, green areas (forested) have been predominant, although with slight fragmentation in the development of infrastructures. In Table 2, the spatial measures are introduced to analyze the change in landscape pattern in Guilin between the years 1980 and 2020. Patch density (PD) and patch number (NP) increased, resulting in greater fragmentation. Table 3 also shows that the Shannon Diversity Index (SHDI) increased with time, and this represents an increase in landscape diversity, whereas the Shannon Evenness Index (SHEI) declined but slightly, which represents a more skewed balance of the land cover types. These tendencies show how urban growth and the fragmentation of the landscape of Guilin occurred in the last forty years.

The landscape measures provided in Tables 2 and 3 are very technical, which might be clarified to non-specialist readers with an explanatory note. A short glossary of the significant indices preceding Table 2 would be useful. As an example, patch density (PD) and number of patches (NP) characterize how fragmented and dispersed a landscape is; the greater the

values, the more fragmented and dispersed the land cover characteristics of the land mass are. The Largest Patch Index (LPI) can be used to describe the prominence of the largest land cover type, but the diversity of the landscape can be measured by indices such as the Shannon Diversity Index (SHDI).

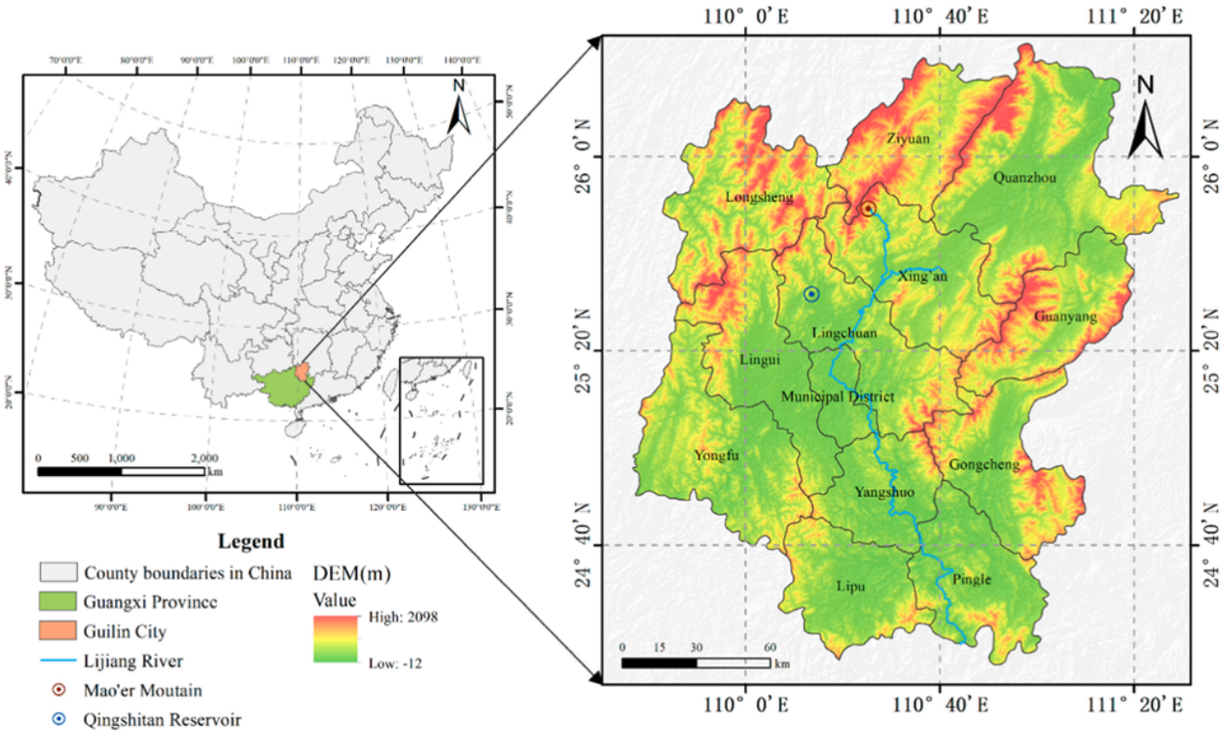

Figure 3. *Spatial distribution of landscape patches*

Table 2. *Results of spatial metrics calculation on landscape pattern in the Guilin region between 1980 and 2020*

Year	Metrics	Metrics	Metrics	Metrics	Metrics	Metrics	Metrics	Metrics	Metrics	Metrics	Metrics
Year	CA	NP	PD	LPI	TE (m)	ED (hm2)	AREA- MN	GYRATE-MN (m)	SHAPE- MN	PARA_MN	IJI (%)
1980	2766669.93	23662.00	0.86	30.10	163210680	58.99	2546.75	6606.86	34.92	4677.83	983.66
1990	2766669.93	23662.00	0.86	30.10	163210680	58.99	2546.75	6606.86	34.92	4677.83	983.66
2000	2766671.28	23669.00	0.86	30.07	163237200	59.00	2561.94	6624.92	34.86	4632.99	990.73
2010	2766261.33	23412.00	0.85	28.43	165853920	59.95	2400.74	7021.92	37.15	5406.45	1035.05
2020	2766031.47	24150.00	0.87	28.26	168314100	60.85	2400.05	7009.28	38.06	5937.94	1028.29

Similarly, the Shannon Evenness Index (SHEI) represents the measure of evenness in the distribution of the types of land cover. Table 3 is presented, followed by the ability to interpret the results in terms of an overall tendency of overall land use diversity, with an increasing SHDI, yet a decline in evenness, with a decreasing SHEI, which proves that specific land uses, especially built-up areas, have become more dominant. This type of interpretation will enhance understanding on the part of the readers and connect numerical trends to real-life implications of land cover change.

Table 3. *Changes in landscape diversity and evenness metrics in Guilin (1980–2020)*

Metrics	Year	Year	Year	Year	Year
Metrics	1980	1990	2000	2010	2020
SHDI	1.6994	1.6994	1.6998	1.7145	1.7379
SHEI	0.5880	0.5880	0.5881	0.5823	0.5801

4.1. SPATIAL ANALYSIS OF LANDSCAPE TRANSFORMATION

In the last twenty years, urban development in Guilin's old towns has been changing drastically, with the major cause being rapid urbanism and rising tourist progression. The data from historical imagery through satellite images and GIS-grounded geospatial studies provide insight into how the land use currently observed in residential and agricultural areas has changed over time to commercial and infrastructural development. Urbanization, especially around some of the main locations of heritage sites such as Xingping and Daxu, has caused massive destruction of vegetation cover and water bodies, thus causing a change in the original natural landscape of the area.

The issue of urban sprawl changed the space utilization pattern of ancient settlements, since new structures replaced

the ancient architectural designs. In addition to this, there are improved road networks and transport infrastructure, which have made access to these heritage towns easier; however, conversely, land-use conversions have also increased. More and more extensive landscape changes, at times to the detriment of ecological balance and historical integrity, have also been aided by the construction of hotels, shopping malls, and recreational amenities to counter the tourism boom. The need to have sustainable urban planning programs that balance heritage conservation and environmental sustainability is emphasized by such a change.

The effects of tourism and urbanization on landscape heritage are witnessed in terms of the growing commercialization of heritage sites and the forgetting of the original cultural features. Although no one can refute the economic payoff as a result of tourism, unforeseen commercialization has fostered problems such as overpopulation, pollution, and infrastructural amenity requirements at the expense of conservation. Besides, the assembly of high-density commercial structures at the expense of native settlements erases the historic townscapes and cultural heritage hitherto carried by such historic towns. GIS analysis also shows a lowered diversity of the landscape, whereby monologue urban covers take over the formerly distributed land use.

These developments have not only endangered the ecological soundness of the historic towns in Guilin but have also reduced their authenticity as cultural heritage destinations. Unchecked urban sprawl and unchecked increases in tourist activities can permanently change the natural and historical composition of such ancient towns, and therefore, policy reforms are needed in order to incorporate conservation in the development strategies.

According to Table 4, the updated version of the land use and land cover of the land of the ancient town of Guilin demonstrates the main changes that occurred in the city between 1980 and 2020. The first trend is the long-term growth of urban and built-up areas that are today over 62,715.44 ha (2.27%), which is characterized by rapid urbanization and infrastructure development. On the other hand, the agricultural area has been decreasing slowly to 527,209.07 ha (19.07%), which is being transformed into urban and commercial estates. Although the most prominent land category is forest cover (1,771,766.93 ha or 64.09%), a minor decline indicates that there is deforestation or alteration of the landscape. Several fluctuations of grassland and shrubland areas have been witnessed, reaching 373,084.56 ha (13.49 percent), which depict the variations in vegetation dynamics with land-use pressures. The 29,522.58 ha of water has been stable at 29,522.58 ha (1.07%), indicating either conservation successes or minimal changes in the hydrological conditions. Also, there is the category of other land use, which is not much (393.80 ha or 0.01%), but has slightly grown, implying minor landscape changes.

Table 4. *Land use and land cover classification in Guilin's Ancient Town*

Land Use/Land Cover Type	Description	Area Coverage (ha)	Percentage of Total Area (%)	Trend (1980–2020)
Urban/Built-Up Areas	Residential, commercial, and industrial zones	62,715.44	2.27%	Increasing
Agricultural Land	Farmland, orchards, and cultivated fields	527,209.07	19.07%	Decreasing
Forest Cover	Natural and managed forested regions	1,771,766.93	64.09%	Slightly declining
Water Bodies	Rivers, lakes, and reservoirs	29,522.58	1.07%	Stable
Grassland/Shrubland	Open green spaces, meadows, and small vegetation patches	373,084.56	13.49%	Fluctuating
Other	Miscellaneous land uses, including barren land and non-classified areas	393.80	0.01%	Slight increase

Although the paper tells a compelling story of how urbanization and tourism have impacted cultural identity in the old towns of Guilin, it could use a lot more reinforcement by adding the real results of the community survey. Indicatively, 73 percent of the sampled inhabitants reported that they are strongly interested in the preservation of historical houses and cultural heritage, which has depicted a general concern over cultural diminishing. Moreover, 67 percent of them believed that current conservation activities were insufficient and too tourism-agenda-oriented. These figures point to the growing lack of alignment between the urban development agenda and the hopes of the community in the preservation of heritage sites. Such information adds credibility to the claims about cultural change and provides a more precise picture of the sentiments in society. Accordingly, in this case, when issues of identity loss and commercialization are discussed in Sections 4.1 and 4.4, there is a need to include this evidence to support the claims under discussion.

4.2. LANDSCAPE FRAGMENTATION AND ECOLOGICAL CONNECTIVITY

The analysis of fragmentation of the landscape, which was achieved with landscape metrics, shows an upward tendency in the concepts of spatial isolation and ecological disruption in the old towns of Guilin. The focus of the calculation of the patch density index shows that the amounts of small and dispersed land patches are sharply increasing, indicating the fact that urbanization has resulted in the discontinuity of green areas and natural corridors. This fragmentation is especially observable in the surrounding buffer zones of heritage properties, where new urban developments have brought about artificial nature and culture frontiers.

The strong effects of boundaries are identified by the edge contrast analysis, and urban sprawls with their pressure on the limited areas of green space and historical sites are widespread. These results confirm the spatial analysis of autocorrelation, which reveals patches of high-fragmentation areas in peri-urban centres that are being superseded with intensive residential and commercial sites. The gradual loss of green space and historic areas of land use will not only

negatively impact the resilience of the biosphere and the maintenance of ecological integrity but also burden the historical landscape in terms of long-term conservation.

The following Figure 4 illustrates green space connectivity in the city of Guilin in the years 1990 to 2020, which reveals ecological corridors, barriers, and sources. Through the years, the primary and secondary sources of ecology (green areas) have improved in size, whereas the ecological corridors have improved in terms of interconnection (yellow and red lines). The presence of ecological pinch points and barriers suggests that the relationship between landscapes can be impaired by the fragmentation of the environment. This analysis indicates a rise in the ecological network resilience, which promotes the conservation of biodiversity and sustainable land-use planning.

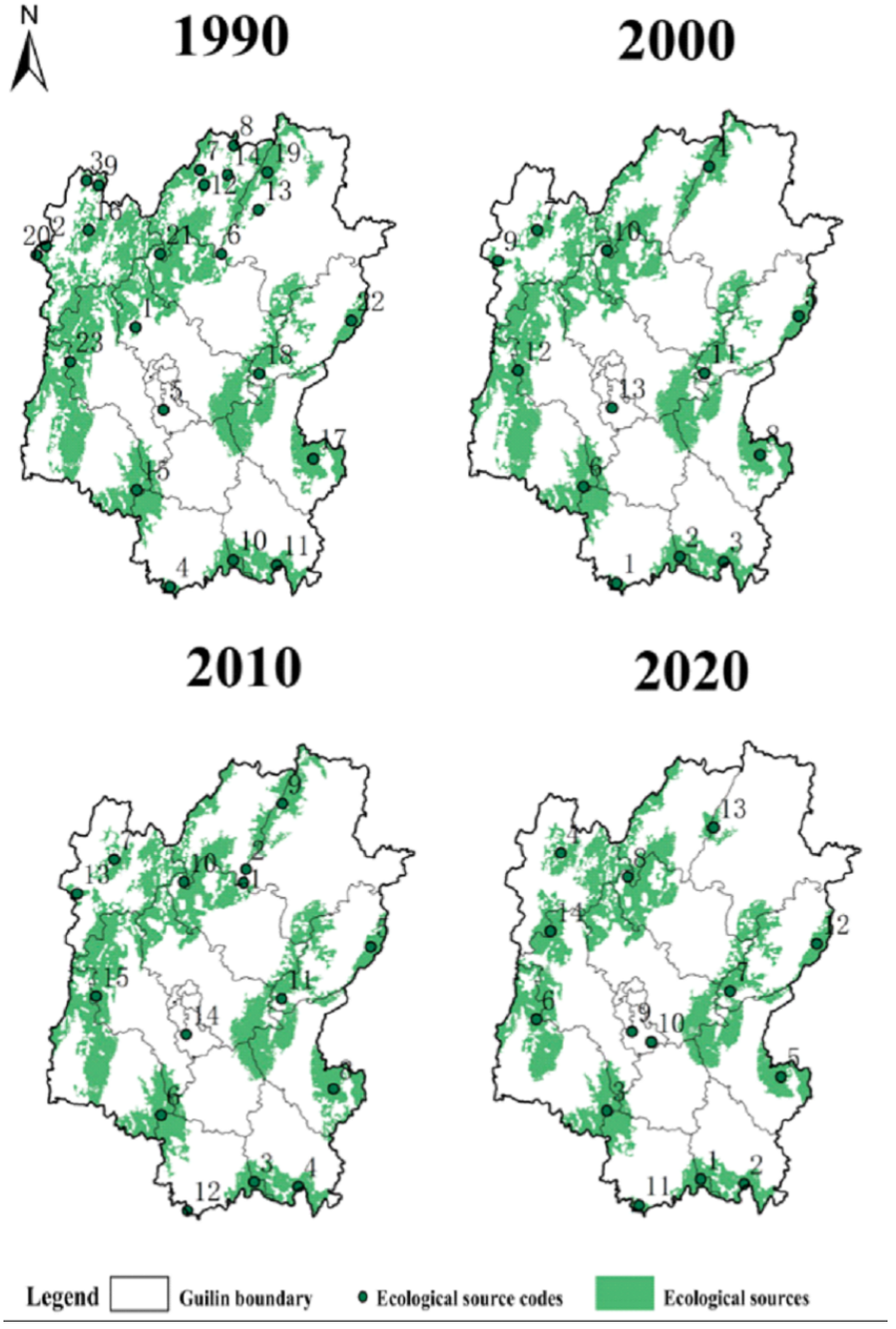

Figure 4. *Connectivity analysis of green spaces*

The trend, along with urban development and urban loss, is further based on spatial connectivity indices, which recorded declines in the degrees of landscape cohesion over time. The destruction of necessary green belts and wet networks interrupted the hydrologic regimes of nature, putting the natural regions into environmental risks such as land erosion as well as water flooding. Besides this, observations in the field also indicate that the destruction of ecological areas has led to the loss of native vegetation, affecting not only the biodiversity of the area but also the aesthetic value of the heritage towns.

These are environmental transformations that are directly related to the unplanned developments in building works and land reclamation, which are not guided by the need to preserve the environment but by economic development. The increased density of urban impervious surfaces also contributes to the instability of ecology, as they decrease the amount of natural water uptake and augment surface runoff. In case the trends remain, the long-term environmental sustainability of the old towns of Guilin will be compromised, and thus, there is an urgent demand to seek an integrated conservation policy between heritage conservation and ecological sustainability.

Table 5 indicates an increase in ecological landscape fragmentation and low connectivity between the year 1980 and the planned 2020. Indicators that indicate crucial changes pertain to an increase in patch density, a decrease in edge contrast, and an increase in the complexity of urban sprawl, all of which reflect more fragmented and irregular geographical features. The drop in the Aggregation Index indicates the ecological connectivity drop, whereas the slight rise in the Shannon Diversity Index implies an increase in landscape heterogeneity. On the whole, these developments signify the continuing effect of urbanization on the natural habitat and the increased fragmentation along with diminished connectedness with time.

Table 5. *Landscape fragmentation and connectivity analysis results*

Metric	1980	2010	2020	Interpretation
Number of Patches (NP)	23,662	23,412	24,150	Overall increase in the number of patches, indicating growing spatial fragmentation
Patch Density (PD)	0.86	0.85	0.87	Indicates slight fragmentation due to urban sprawl
Mean Patch Size (MPS, ha)	116.7	102.5	98.5	Decreasing average patch size suggests increased fragmentation
Edge Contrast Index (ECI)	30.10	28.43	28.26	Slight reduction in ecological edge variation, likely due to homogenization
Landscape Shape Index (LSI)	3.5	4.2	5.1	Indicates more irregular, fragmented landscape forms over time
Mean Shape Index (MSI)	1.40	1.63	1.72	The complexity of patch shapes increasing with urban development
Aggregation Index (AI) (%)	75.8	68.9	62.4	Decreasing cohesion and clustering of similar land cover types
Shannon's Diversity Index (SHDI)	1.70	1.71	1.73	A slight increase shows a growing mix of land use types

4.3. LAND HISTORICAL LANDSCAPE ALTERATIONS

The ancient towns of Guilin have partly experienced enormous changes in the past decades; this is mainly because of the changes in the character of traditional towns and the increasing role of tourism-based development in this process. Traditionally, these towns were characterized by the classical Chinese architecture, construction out of wood, roofs of tiling, and small alleys, which created a complete cultural cityscape. Nevertheless, spatial studies and historical GIS mapping show that there is a slow disappearance of such characteristics, and they have been substituted by commercial buildings, including boutique hotels, souvenir shops and tourism hotels. Old houses and street scenes have been reused, and new materials such as steel and glass now feature in the skies and are disrupting the harmony in the traditional locations. These developments demonstrate how one tries to balance between holding onto culture and adapting to urbanization.

Several policies have tried to resolve this conflict. Early preparations towards the incorporation of heritage in urban planning were made by the 1998 Law on the Protection of Cultural Relics and the Urban and Rural Planning Law of 2002, which saw the creation of the urban zoning of key areas in Guilin. However, these efforts were usually compromised by lazy enforcement and the increased pressure of development. In 2011, the Guidelines on Protection and Use of traditional Villages were set up in an attempt to balance conservation and revitalisation, but regularly meant recreated or commercialised heritage sites. Most recently, the 2017 National Territorial Spatial Planning Outline incorporated sustainability and heritage into planning structures, but in reality, it gave modern developments the ability to infiltrate historic regions.

Such policy interventions have yielded mixed responses in the communities. Some of the resident's value economic aspects associated with tourism, and others mourn the disappearance of cultural authenticity. The tendency of "heritage imitation", in which the old-established aesthetics are superficially replicated, tends to induce the issue of cultural commodification. Despite zoning and revitalization efforts, fast city growth has resulted in visual and functional disintegration of the old and new areas. Low-level engagement of community in the planning activities makes long-term conservation goals even more challenging. This reality points to the desperate need of more stringent conservation regulation as well as a more balanced planning outlook that will ensure the continued existence of not only economic life but also cultural continuity in the ancient towns of Guilin.

4.4. COMMUNITY PERCEPTION AND ENGAGEMENT IN CONSERVATION

The small-town communities living in the ancient towns of Guilin are the locations of heritage preservation, and their opinion can be used to depict the subtle understanding of preservation amidst urbanization. A survey on 15 people showed that 60% were above 45, 27% between 30 and 45 years and 13% below 30 years, indicating that older residents were overrepresented in the sample. By occupation, the majority of them were residents, business owners (40%), retired residents (27%), cultural employees (20%), and an even smaller proportion of students and public servants (13%). It

is important to note that 73 percent of the people who were interviewed were very worried about conserving historical buildings and culture, with the seniors being more devoted to heritage conservation, as others would be inclined towards modernization, which leads to economic development. The survey also established that 67 percent of all respondents felt that the efforts to conserve were not adequate and were more affected by tourism development. Almost 8 out of 10 of them stated low or no involvement in making decisions in any of the urban planning process, and 6 out of 10 of them believed their views were not reflected in the policy-making process. Nonetheless, other community participants, especially the older generation and cultural workers, have indicated their participation in local heritage activities or informal conservation organizations. It was noted in interviews that there was a major paradox as the entrepreneurs in the region valued the respective nature of the economic gains of tourism, concerned over the fact that authenticity was being lost and growing commercialization. Respondents demanded inclusion in heritage planning, having recommended methods like education programs, support in terms of finances to locally led programs, and GIS-based participatory mapping to involve the locals in identifying and preserving sensitive heritage areas.

4.5. IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT PLANNING

The study then concludes that the sustainable development policy needs to strike a balance between conservation and the threats of imminent urbanization in the now historic towns of Guilin on an equal note. As the cultural and environmental landscapes continue to change through tourism-induced commercialization and sprawl, a growing interest arises to integrate conservation of heritage as part of the overall urban planning processes. The use of GIS-based technologies, predictive modeling, and spatial analysis as the primary feature of sustainable development planning in developing evidence-based decision-making is one of its key features.

The GIS and Landscape Index offers a significant clue to the landscape transformation process and processes of city fragmentation and information regarding the urbanization patterns that could help planners to design proactive conservation planning to comply with balanced ecological and cultural demands. Through GIS-based urban planning, the local government can observe the land-use dynamics in real time, be able to evaluate the effects of the development plans, and implement evidence-based decisions that are not only sustainable. In addition to this, the inter-disciplinary effort among urban planners, conservationists, ecologists, and the community must be sought to develop a multi-dimensional heritage management strategy.

To bridge the historical preservation and the modern infrastructure construction, it must have a multi-stakeholder dialogue where cultural historians, environmental scientists, policymakers, and community members unite and assist in decision-making. Additionally, the presence of foreign partnerships with organizations addressing cultural heritage conservation can provide valuable knowledge and financial resources to preserve it in the long run. Sustainable heritage management can eventually succeed in Guilin when there is synergy between policy structures, technologies, and community engagement in such a manner that the needs of development would be satisfied and at the same time, there would be no cost to history and environment. It is possible through a visionary approach that can combine conservation with urbanization that the historic towns of Guilin can be a model of sustainable management of heritage, preserving the rich culture and yet addressing the needs of the new coming generation of urbanization.

5. DISCUSSION

5.1. INTERPRETATION OF FINDINGS

The results of the study properly correspond to the main aims of the conducted research to evaluate the spatial landscape transformations and analyze the community attitude to ecological and heritage protection in the old towns of Guilin. GIS and remote sensing analysis showed that other green spaces continued to reduce, with increased landscape fragmentation, especially in regions characterized by rapid urbanization moving fast owing to tourism. These geocentric changes justify the fear of an even more ecologically degraded environment and the necessity of adopting an ecological approach to conservation.

These spatial understandings are further supported by the social survey. A large number of residents indicated that they understood the decline of the environment, but they believed they were not involved in any planning decisions. The absence of connection highlights the presence of participatory types of governance. In addition, the study points out that despite the presence of heritage renovation projects, they are often concerned with beauty, but not with nature and cultural sustainability.

The integration of spatial data with community input not only ascertains the inconsistencies between policy change and domestic issues, but also demonstrates the inconsistency between policy action and local issues. Altogether, the findings of the study help to legitimize its purpose of promoting a data-driven, community-informed conservation system that responds to physical landscape changes and sociocultural aspects of sustainability.

5.2. THE IMPACT OF LANDSCAPE CHANGE AT GUILIN

The change of the ancient towns of Guilin over the past decades is a reflection of broader conflicts between heritage protection, urbanization, and eco-friendly conditions. The intrusion of urbanization into places of historical integrity has disrupted the continuity of traditional landscapes and diminished continuity in the cultural and ecological boundaries. This is consistent with the existing data on the role of unregulated urbanization and over-tourism development in becoming fragmented and degraded heritage sites in heritage areas [41]. Evidence that urban growth is taking over natural habitats and fragmenting ecological corridors into pieces is also validated by the trend towards Patch Density (PD) and Edge Contrast Index (ECI) in response to the landscape index analysis.

The modernization currents and altered architectural tastes have also impacted the cultural and historical environment of Guilin. There is an increase in irregularity in the development of the landscape, as shown by the Landscape Shape Index (LSI), which implies uneven integration of modern infrastructure with traditional planning. Although there have been few efforts to conserve historic enclaves, the Aggregation Index (AI) reveals that people are still losing historic landscapes, meaning that they are losing cohesive cultural landscapes. This signifies the occurrence of urban growth in a way that breaks the spatial continuity of traditional neighbourhoods and a possible disappearance of a culture [33]. There are previous instances in the literature of other ancient cities where new development endangers the existence of old urban forms due to change by newcomers [42, 43].

The landscape index's applicability to fragmented landscape evaluation has provided valuable evidence on the ecological implications of urban growth. More significant indicators include patch density and contrast of edges, which prove that Guilin's old towns have been severely discontinuous, affecting ecological and historical integrity [29]. The findings are consistent with larger studies that support the beneficial role of spatial fragmentation in encouraging ecological degeneration, where unregulated urban growth causes habitats to be a limiting factor and habitats to be significantly diluted by meaningful ecosystem functions [44]. As an illustration, areas around the Lijiang River passage and the Daxu Ancient Town have been characterized by an enhanced built-up increment at the cost of previously adjacent arboreal areas as well as the integrity of the conventional terrain.

Moreover, alteration and halting of archaic water control infrastructures, such as canal paths and adjacent wetlands, have increased environmental stress in areas of heritage. Provide the actual location of the affected area at Guilin as an indication of the current situation at Guilin. This is an indicator of the necessity to initiate landscape-wide conservation schemes that consider ecological connectivity and the conservation of historic townscapes.

Cultural transformation has been high in Guilin at Daxu Ancient Town, Jiangtou Village, and the Mopanshan district. The historical streetscape has been turned into shopping malls and guesthouses in Daxu, where the traditional Ming and Qing courtyard houses have been transformed. Jiangtou Village has had the removal of old houses to construct roads and other tourist facilities, which have changed the layout of the village. In Mopanshan, commercial growth has quickly taken the place of rural settlements with more modern buildings, undermining the traditional space structure and culture.

Studies indicate that the devaluation of traditional architecture would make communities lose touch with their cultural legacy because the built environment is an important development in building a collective memory and maintaining heritage. This backs up the conclusions of Li et al. [24], which highlight the power that architectural heritage has had in keeping culture together. This generation gap suggests that more general societal value and attitude changes about heritage attributes, as an inclusive part of conservation programs, should be addressed and linked with cultural education and outreach activities to encourage a sense of ownership and respect for the preservation of the past.

To maintain the landscape of Guilin, it is necessary to combine ecological preservation with preservation of heritage. The development of cities and towns has divided major ecological areas, woodlands, rivers, and karst features, resulting in loss of biodiversity and destabilization of the natural systems. Spatial applications, such as GIS and FragStats, demonstrate the increasing amount of landscape fragmentation, which requires the use of ecological corridors, topography buffer areas, and green networks to improve connections. Ecological resilience can be enhanced by sustaining traditional water systems and indigenous plants, as well as low-impact architecture and solutions based on nature. Environmental assessment policies and sustainable land use should be encouraged.

One of the main factors of sustainable heritage management is interdisciplinary collaboration. The application of GIS and landscape index in this study brings out the utilization of technology in conforming to data-oriented planning for conservation. Technology, per se, however, cannot resolve the socio-cultural and economic aspects of heritage conservation, though [13]. Only the combination of spatial analysis with anthropological, ecological, and economic analysis, a harmonious balance of all that will ensure the creation of broad conservation strategies. The cooperation between urban planners, historians, environmentalists, and community stakeholders can yield more solutions with context specificity and elaborated to satisfy both the requirements of urban development and the preservation of heritage [45].

5.3. POLICY AND PLANNING RECOMMENDATIONS

The ecological sustainability of Guilin can only be integrated into its preservation of ancient towns through an interdisciplinary approach, where cultural and environmental sustainability are denominated. Urban sprawl may be curbed by adopting an ecosystem-based approach to conservation, stringent land-use measures, and ecological buffer zones that will conserve biodiversity. Risk mapping based on GIS does facilitate proactive conservation, whereas tourism capping and promoting low-impact practices minimize degradation. The design with environmentally friendly conservation should be sustainable, using local resources and traditional techniques. Moreover, water management through the restoration of historic canals and wetlands that are climate-resilient is strengthened to oversee cultural heritage and environmental integrity in Guilin's old sceneries to sustain good development over a long period.

Engagement of communities in the conservation of ancient towns is necessary in the city of Guilin. Even with high public awareness, there is a lack of engagement because they are not engaged in decision-making. Participatory heritage councils to be formed between residents, specialists, and authorities may create a sense of collective responsibility. Local people could be empowered with digital applications such as participatory GIS to monitor changes in heritage, and mobile mapping can also be used. Long-term stewardship can be strengthened with financial and technical assistance to the communities in terms of community-led initiatives and educational programs. By incorporating local knowledge, local traditions, and youth participation into conservation policy, there will be inclusive, sustainable heritage management that will balance cultural preservation, environmental sustainability, and economic development.

6. CONCLUSION

This paper was able to integrate spatial analysis, landscape measures, and community perception to determine the ecological and heritage issues confronting the ancient towns of Guilin. The study shows that through the revelation of trends of green space fragmentation and lack of community participation, the widespread conservation strategies require integration and evidence-backed approaches. The GIS approach was found to be useful in diagnosing spatial change and setting planning with local priorities. Other heritage areas that are facing the same pressures caused by urban growth and tourism can also be adapted to this methodology beyond Guilin. The research provides an ecological integrity/cultural preservation connection that can inspire stronger and more inclusive heritage management in varied geographic and socio-political contexts and settings.

7. LIMITATIONS OF THE STUDY

The study is limited by the fact that it relies on remotely sensed evidence, which does not always capture ecological fine-scale variations. Another limitation of the social survey sample was also the geographical perspective; it may not have seen the bigger picture of the community. Secondly, ground truthing and the quality of satellite imagery can be seasonal and, thus, influence the quality of classification. These restrictions may cause limitations to the extrapolation of the findings to other regions or conservation sites.

8. FUTURE WORK

Future studies to explore the same should focus on spatial analysis throughout several seasons and also use higher-resolution images to enhance ecological validity. Diverse and more extensive community engagement modalities like participatory mapping and focus groups can further expand the wisdom of the local insight. It would be beneficial to do comparative studies with other heritage locations and prove the flexibility and efficiency of the framework. Proactive conservation and landscape management work could also be improved when it is integrated with real-time monitoring systems.

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