【課程博士】

博 士 論 文 の 要 約

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学 位 論 文 題 名

Validation of landscape planning framework based on an assessment of ecological resistance and ecological risk

（生態学的抵抗力と生態学的リスクの評価に基づく景観計画手法の検証）

■ Backgrounds and objectives

Natural disasters and human activities have significant negative impacts on ecosystem stability, leading to the destruction of ecological structures and making habit fragmented. Furthermore, potential risks and threats (human aggregation, heavy rainfall, etc.) are still present and have a continuous impact. Ecological analysis is important for landscape planning sustainable development, biodiversity conservation, long-term resilience (Makhzoumi and Pungetti, 2003; Huang *et al*., 2022; Eikaas *et al*., 2023;). Ecological connectivity analysis can identify areas and corridors for maintaining connectivity between habitats (CMS, 2019), and ecological risk analysis can measure and predict the possible impact or harm on the ecosystem (Gao and Song, 2022). However, both are not sufficient in landscape planning. In this case, two main landscape types were selected for ecological assessment: mountainous areas and coastal areas. The aim of the study was to assess, analyze and predict the ecological status of landscape types through ecological connectivity analysis and ecological risk analysis, and to consider the necessity and applicability of ecological analysis for landscape sustainable planning and development. In more details, this paper focused on the Tianmeng Scenic Spot in China and the eastern coastal areas of Japan as the study areas, its main aims were to assess the ecological connectivity and ecological risk in response to human activities and natural disasters, explore the main driving indicators and vulnerable areas affecting ecological stability, and then predicted the future development trends.

Chapter 2 Establishing Landscape networks Based on Visual Quality and Ecological Resistance: A case study in Tianmeng Scenic Spot

■ Materials and methods

Scenic spot has received widespread attention for its landscape aesthetics and ecological values, but the rapid growth of tourism paths and activities led to habitat fragmentation. It increased travelers' convenience to diverse destinations (Jangra *et al*., 2023), but with the negative impact on wildlife movement for connectivity (Shi *et al*., 2018). Human recreation needs rely on visual impact and aesthetic quality (Gobster *et al*., 2007; Lafortezza *et al*., 2008; Botzat *et al*., 2016), however, visual evaluation often solely relies on subjective perceptions (Kang & liu, 2022). The first Chapter analyzed and evaluated ecological connectivity and visual quality of Tianmeng mountain, and combined them to build the sustainable landscape networks. In this study, the landscape visual assessment of Tianmeng Scenic Spot is based on both landscape visual sensitivity (LVS) from the objective aspect and landscape aesthetic evaluation (LAE) from the subjective aspect. The construction of ecological-resistance surfaces depends on the selection of resistance factors can reflect the status of ecological connectivity, and then the Minimum Cumulative Resistance (MCR) model was applied to select the ecological corridors.

■ **Results and discussion**

The results showed that the landscape quality of Tianmeng Scenic Spot still needed to be improved as landscape viewpoints with both high landscape aesthetics and visual sensitivity only accounted for 32.4%. The subjective landscape aesthetics and objective landscape visual sensitivity in Tianmeng Scenic Spot had a strong correlation in the evaluation of landscape quality, and improvement of landscape aesthetics could improve the quality of Tianmeng Scenic Spot to a certain extent. The comprehensive visual analysis of 34 viewpoints revealed the shortcomings of the landscape, such as the lack of landscape aesthetics but these locations were easily seen. Lack of accessibility despite the high landscape quality meant that three categories were formed according to the results of evaluation: landscape core viewpoints, landscape enhancement viewpoints, and follow-up supplementary-development viewpoints, so that the landscape status could be targeted to improve. In the analysis of ecological resistance surfaces, the very-high resistance areas, and high resistance areas (low ecological connectivity) were mostly distributed in the main tourism roads and their buffer areas around the northwest of Tianmeng Scenic Spot. 27 short cost and resistance paths were identified respectively using the MCR model to connect high-quality landscape points, respectively. The paths distributed in low resistance areas served as ecological corridors for wildlife migration and eco-friendly transportation routes, and cannot be developed or constructed as paved roads, others distributed in high resistance areas can be used as convenient transportation options for tourists.

Chapter 3 Multi-dimensional and multi-temporal landscape ecological risk assessment in the eastern coastal areas of Japan

- **Materials and methods**

The eastern coast areas of Japan are threatened by multiple ecological risks due to frequent natural disasters, climate changes, human activities, etc. Taking the eastern coastal areas of Japan as the research object, this study performed the analysis of the spatio-temporal patterns and driving mechanisms of ecological risk from 2009 to 2021 by establishing the ecological risk assessment framework of "Nature - Landscape Pattern - Human Society" (NA-LP-HS) based on ArcGIS. It was important to determine the scale of the study area before conducting the ecological risk analysis, we performed optimal performance tests using multiples of the resolution of the analyzed data. After conducting an ecological risk analysis, the principal component analysis (PCA) model was used to rank the main driving factors of the ecological risk.

- **Results and discussion**

The ecological risk in the research area had a trend of gradually decreasing from the southwest to the northeast. From 2009 to 2015, the reason for the sudden increase of ecological risk lies in the natural disasters, with the 2011 Great East Japan Earthquake and Tsunami Disaster as the typical representative. The regions with the greatest risk increase were radiated by Sendai, including Sendai Bay, Fukushima, Sanriku-minami, and Sanriku-kita; from 2015 to 2021, areas of the greatest risk increase come from the urban cluster centered around Tokyo, comprising Tokyo Bay, Sagami Bay, Chiba, and Ibaraki. The aggravation of rainfall erosion, and landslide and mudslide disasters were the main causes of ecological instability. The results of PCA showed that the main risk driving aspects from the southwest to the northeast were greatly influenced by human activities, landscape features, and natural aspects, respectively. This study demonstrated the ability of multidimensional ecological risk assessment to identify high-risk areas and driving factors, and provide a visual analysis and decision-making basis for sustainable development.

Chapter 4 Predictions of vegetation changes in coastal areas with sea level rise in Sendai, Japan

- **Materials and methods**

Based on the ecological risk analysis of the Eastern Japanese coastal zone in the previous chapter, the results showed that the driving factor of ecological risk in the Sendai area were vegetation coverage and land use and land cover. As vegetation coverage was important for the Sendai region as a major driver of risk affecting, Chapter 4 aimed to explore the relationship between the survivable space of coastal vegetation and coastal width, and to predict the coastal inundation area and plant growth space based on sea level rise. Four study sites in Sendai region (Gamou, Arahama, Yuriage, and Ido) were selected to analyze the relationship between coastal vegetation, coastal width, and sea level rise in the context of climate change. In this study, field survey on vegetation at the above four sites were conducted, and then the relationship between vegetation distribution and coastal width was investigated. Subsequently, based on projections of future sea level rise from the 6th Intergovernmental Panel on Climate Change (IPCC 6), the inundation of the coastal zone inundation of the coastal zone was projected based on the ArcGIS. Future vegetation coverage varied according to the inundated coastal zone.

- **Results and discussion**

The results revealed that when the coastal zone width was less than 61.5m, vegetation was almost nonexistent. Among the five scenarios (SSP119, SSP126, SSP245, SSP370, and SSP585) considered for sea level rise, SSP585 exhibited the fastest rate of rise, followed by SSP370, SSP245, SSP126, SSP119 which had the slowest sea level growth rate, representing a greener and more sustainable path. In predicting the vegetation distribution from 2030 to 2150, it was observed that Ido started to experience no plants existing in the SSP585 scenario by 2090. By 2150, except for the Yuriage, all the study areas were in the poor ecological state, no plants survived in the study area under the SSP585 scenario. Most of the coastal spaces of this study were insufficient to cope with future sea-level rise.

Through the ecological connectivity analysis and ecological risk analysis of the two landscape types, it could provide a reference for policy makers to protect vulnerable areas and sustainable development.