Journal of Multimedia Processing and Technologies

DLINE JOURNALS

Print ISSN: 0976-4127
Online ISSN: 0976-4135

JMPT 2025: 16 (3)
https://doi.org/10.6025/jmpt/2025/16/3/155-163

# Multimedia Design of an Eco-Friendly Plan for the Landscape Environment in the Rural Region

Shuo Wang
Henan Kaifeng College of Science Technology and Communication
Kaifeng, Henan, 475001. China
wsasd880911@126.com

## ABSTRACT

*This work centers on the optimization design of the green architectural landscape environment in traditional villages, utilizing the niche genetic algorithm. The aim is to investigate how optimization design techniques can enhance the green architectural landscape environment in these villages. By examining the cultural traits and environmental challenges faced by traditional villages and integrating both domestic and international research advancements, a method grounded in the niche genetic algorithm is introduced. The results from experiments indicate that this approach significantly improves the green architectural landscape environment in traditional villages, thus elevating the quality of life for residents and their adaptability to the environment. This study offers a novel method and strategy for the sustainable development of traditional villages.*

**Keywords**: GA Application, Conventional Rural Settings, Eco friendly Designs, Space Environment

**Received:** 3 March 2025, Revised 27 May 2025, Accepted 9 June 2025



## 1. Introduction

As urban growth continues to progress, traditional villages, which represent unique human settlements with historical and architectural significance, are encountering significant challenges and predicaments. The swift pace of urbanization has resulted in the gradual deterioration of the original green spaces and architectural attributes of these villages, leading to environmental contamination, ecological degradation, and cultural erosion [1]. Traditional villages serve as vital vessels of national culture, treasured cultural heritage, and spaces for individuals to reconnect with nature and seek spiritual nourishment. Consequently, enhancing the design of the green architectural landscape environment in traditional villages has emerged as a critical issue that needs to be tackled [2].Conventional design approaches frequently overlook the cultural traits and environmental requirements of traditional villages, creating a gap between design solutions and real world situations. To remedy this issue, researchers have recently concentrated on the optimization of the green architectural landscape environment in traditional villages, intending to better the ecological setting and improve the quality of life for

residents through scientific design techniques. Nevertheless, studies on optimizing the green architectural landscape environment in these villages remain relatively sparse and lack a systematic and thorough research methodology [3].

Traditional design techniques are often constrained by manual experience and subjective assessments, failing to fully account for the combined effects of various factors, which limits the effectiveness of design solutions. Therefore, it is essential to integrate innovative design concepts and techniques to enhance the optimization of the green architectural landscape environment in traditional villages. The genetic algorithm, recognized as an intelligent optimization technique, can conduct global searches and adapt, which allows it to tackle complex optimization challenges effectively. It mimics the process of biological evolution, progressively refining design solutions through ongoing evolution and natural selection to arrive at the optimal outcome [4].

Genetic algorithms have found extensive application in fields such as urban planning, landscape architecture, and architectural optimization, achieving noteworthy results. In the context of optimizing the green architectural landscape environment in traditional villages, the application of genetic algorithms is anticipated to offer a novel approach and methodology. The niche genetic algorithm is an enhanced version that incorporates the concept of a niche, improving the algorithm's convergence and search efficiency by regulating the population size and intensifying competition among individuals. The niche genetic algorithm has demonstrated effective optimization outcomes across various domains, outperforming traditional genetic algorithms. This paper aims to investigate how to enhance the green architectural landscape environment in traditional villages through optimization design strategies. Specifically, we will examine the cultural attributes and environmental challenges of conventional villages, integrate both domestic and international research advancements, and propose an optimization design strategy based on the niche genetic algorithm. By experimentally validating the effectiveness and practicality of this approach, we aspire to contribute new techniques and methodologies for the sustainable development of traditional villages.

## 2. Space Environment Optimization in Traditional Villages

In recent times, the enhancement of green architectural landscape environments in traditional villages has emerged as a prominent subject within the academic sphere. Researchers from both domestic and international backgrounds have engaged in extensive studies in this area, introducing numerous valuable theories and methodologies. In China, scholars have delved deeply into the preservation and advancement of traditional villages. They stress the importance of maintaining the historical culture and architectural features of these villages and have proposed specific conservation strategies along with design principles. For instance, they have utilized approaches such as the restoration of historic buildings and the safeguarding of traditional production techniques to uphold the historical context and cultural values. Concurrently, some researchers have acknowledged the significance of the green architectural landscape environment in conventional villages, putting forward theories and methodologies for green architecture and landscape design. These investigations are rooted in the cultural traits and environmental needs of conventional villages, aiming to improve the quality of green spaces and enhance the residents' quality of life through design strategies.

In other countries, particularly in developed nations, there has been an active pursuit of optimizing the green architectural landscape environments in traditional villages. These nations concentrate on sustainable development and environmental conservation for traditional villages, proposing innovative design concepts and

practices. They highlight the integration of traditional villages with the surrounding natural landscapes, advocating for a harmonious relationship between architecture and nature. Additionally, they aim to minimize energy consumption and environmental impact through the use of sustainable materials and technologies. These international research efforts provide significant experience and insights for optimizing the green architectural landscape environments in traditional villages. Despite the advancements made by researchers both locally and internationally, the optimization of green architectural landscape environments in traditional villages still encounters several challenges and issues. The preservation and development of these villages frequently face conflicts with modernization and economic interests, necessitating a balance of various interests and demands during the design process. Furthermore, the optimization of green architectural landscape environments in traditional villages requires interdisciplinary knowledge and technology. It necessitates collaboration across various sectors, encompassing architectural design, landscape planning, ecological conservation, and cultural heritage. Moreover, technological limitations also pose challenges to the optimization of these environments. While methods such as genetic algorithms have found success in other domains, their application in traditional village design remains limited. The diversity and intricacy of traditional village design present hurdles for conventional optimization algorithms when evaluating the comprehensive effects of multiple factors. Consequently, there is a need for further investigation and exploration of appropriate optimization techniques and tools for enhancing the green architectural landscape environments in traditional villages.

The optimization of the green architectural landscape environment in traditional villages represents a multifaceted and demanding area of study. When tackling the challenges associated with the preservation and advancement of traditional villages, it is vital to amalgamate knowledge and resources from diverse fields and investigate models for interdisciplinary collaboration. Concurrently, it is crucial to leverage research findings from both domestic and international sources, align them with the specific realities of traditional villages, and develop appropriate design strategies and instruments. By thoroughly considering cultural, environmental, and social requirements and embracing a human focused design approach, it is anticipated that the enhancement and sustainable advancement of the green architectural landscape environment in traditional villages can be realized.

## 3. Niche Genetic Algorithm and Model Construction

### 3.1 Introduction to Niche Genetic Algorithm

The niche genetic algorithm is a refined version of the genetic algorithm aimed at improving the search efficiency and optimization performance of the algorithm. It incorporates the idea of a niche, which entails capping the population size and heightening individual competition, thereby bolstering the algorithm's convergence and search abilities. The conventional genetic algorithm is an optimization method rooted in biological evolution theory, mimicking genetic processes to seek the best solution to a problem. However, traditional genetic algorithms encounter certain drawbacks, including premature convergence and the risk of becoming trapped in local optima within the search space. The niche genetic algorithm enhances the capabilities of the standard genetic algorithm by introducing a niche, which is a small cluster of individuals within a localized environment. Within this niche, individuals compete intensely, and only the most fit individuals can survive and reproduce.

This competitive framework fosters greater diversity within the algorithm, allowing the population to more effectively explore and exploit the search space while avoiding premature convergence to local optima. Despite its numerous advantages in optimization tasks, the niche genetic algorithm also confronts various challenges and limitations. For instance, determining the ideal niche size and criteria for fitness evaluation is a critical issue

that necessitates adjustment and refinement based on specific challenges. Moreover, the computational complexity associated with the niche genetic algorithm is relatively high, requiring substantial computational resources, which must be carefully evaluated for practical implementation viability.

### 3.2 Establishment of Related Models Based on the Niche Genetic Algorithm

Algorithm To create an optimization model for the traditional green village environment grounded in the niche genetic algorithm, several steps should be followed. Initially, it is essential to articulate the design objectives and optimization benchmarks for the traditional green village environment. This may involve considerations such as green coverage, building configurations, landscape characteristics, environmental quality, and additional factors. Establishing clear goals and criteria will direct the formulation and assessment of the optimization model. Subsequently, the variables involved in the design of the green architectural landscape environment in traditional villages must be encoded to assist the genetic algorithm in its search and optimization efforts. For instance, building configurations can be depicted using coordinates or binary codes, while green coverage can be expressed through ratios or numerical values.

Then, construct the fitness function, which is an evaluation metric used to assess the quality of each individual in the population. The fitness function should be defined based on the design goals and optimization criteria. For example, the fitness function can be calculated based on factors such as green coverage, landscape diversity, and environmental quality. The fitness function should be able to quantify the superiority or inferiority of each individual regarding the optimization objectives.

Combining the fitness function with the genetic operators of the niche genetic algorithm (such as selection, crossover, and mutation), the model will undergo iterations and optimizations to converge towards better solutions. The optimization model based on the niche genetic algorithm can effectively address the complexity and multi-objective nature of optimizing the green architecture landscape space environment in traditional villages, leading to improved results in achieving sustainable development and enhancing the overall living quality in traditional villages.

$$x'_{ij} = \frac{x_{ij}}{x_{j\max}} \tag{1}$$

Greening rate fitness function:

$$x'_{ij} = \frac{x_{j\min}}{x_{ij}} \tag{2}$$

Among them, the green area refers to the green area within the village, and the total area is the total area of the village.Landscape diversity fitness function:

$$D_T = \begin{bmatrix} d(x_1, x_1) & \cdots & d(x_1, x_T) \\ \cdots & \cdots & \cdots \\ d(x_T, x_1) & \cdots & d(x_T, x_T) \end{bmatrix} \tag{3}$$

Among them, the number of landscape types refers to the number of different landscape types present in the village, and the total number of landscapes is the total number of landscapes within the rural region.Building layout fitness function:

$$y_{ij} = \frac{x_{ij} - x_{\min j}}{x_{maxj} - x_{\min j}} \qquad (4)$$

The mean building distance refers to the average distance between buildings within the village, while the maximum building distance represents the maximum distance between buildings within the rural region.The core of the genetic algorithm lies in the selection, crossover, and mutation operations. In the niche genetic algorithm, genetic operations need to be designed to fit the optimization of the green architecture landscape space environment in traditional villages. For example, the selection operation can retain excellent individuals based on the values of the fitness function. In contrast, the crossover and mutation operations can generate new individuals by changing the design variables. These operations should maintain the diversity and evolutionary dynamics of the population.

According to the above steps, the encoding method, fitness function, and genetic operations are integrated into an optimization model. The optimization model searches through iterations, gradually improving the design solutions to achieve the optimization objectives. In each iteration, individuals are selected, crossed, and mutated based on the fitness function to generate a new population. Throughout the iterative process of the model, the optimization results need to be evaluated and adjusted. Evaluation can be achieved by calculating the fitness function value for each individual to determine the quality of the current optimization results. If the optimization results are unsatisfactory, the parameters of the encoding method, fitness function, or genetic operations can be adjusted to improve the performance of the optimization model.

## 4. Application of the Model in Optimizing Village Space Environment

The green architecture landscape space of traditional villages is primarily located in the outskirts of cities, closely related to the city without affecting its administrative, commercial, and service functions. Its emergence is a result of urban expansion and rural urbanization, characterized by bridging the transition between cities and rural areas. The normal ratio of its location is shown in Figure 1, which indicates that only when the city and adjacent green villages are in this normal ratio range can they harmoniously and healthily develop together.

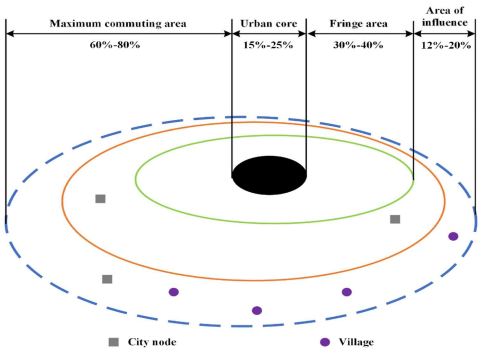


Figure 1. Relationship between the Distribution of Green Villages and the City

The optimization design of the green village environment focuses on the development of the urban fringe area and the enhancement of rural green spaces. The essence of the urban fringe area is the zone where the city and the countryside blend, with economic, activities, and functions intertwining and gradually blurring the boundaries. This provides green spaces for the city while bringing economic benefits to the countryside.

In the optimization design of the green village environment, it is crucial to plan and design the proportion of green spaces in the urban fringe area reasonably. When the proportion of green spaces is less than 30%, it fails to meet the citizens' demand for green leisure and relaxation spaces. The lack of green spaces can impact the physical and mental health of citizens, depriving them of the restoration and joy that natural environments can bring. Simultaneously, farmers cannot gain additional income and job opportunities from green spaces. The lack of economic activities and employment opportunities limits rural development, preventing farmers from enjoying the benefits of urban development.

However, when the proportion of green spaces exceeds 40%, it may imply that the urban development is not well-rounded and the economic level is relatively low. An excessively high proportion of green spaces may reflect problems in urban planning and development, requiring more economic activities and infrastructure construction to elevate the development level of the fringe area.

Therefore, the optimization design of the green village environment needs to consider the proportion of green spaces in the urban fringe area comprehensively, aiming to achieve coordinated development between the city and the countryside and harmonious coexistence between humans and nature. Through scientific planning and design, a green village environment can be created, enhancing the quality of life for residents and promoting a virtuous cycle of urban-rural interaction.

The optimization design of the green village environment introduces carbon emissions as a crucial environmental impact indicator used to evaluate the extent of negative ecological impact in a specific region or factory. Effectively measuring carbon emissions can reveal the actual situation of ecological issues. Taking five villages surrounding a particular city as an example, industrial production accounts for 35% of the total, construction accounts for 43%, and transportation accounts for 22%. In the context of the optimization design of the green village environment, carbon emissions account for 43% of the total, showing a 2% increase compared to 2019. The main reasons for this growth include policy adjustments in industrial structure, upgrading of energy consumption structure, and an increase in GDP. This indicates that the economic development of the five villages has led to a rise in carbon emissions. Therefore, this study conducted an investigation and analysis of the GDP data and carbon emissions of the five green villages in recent years, and the summarized data is presented in a line chart in Figure 2.

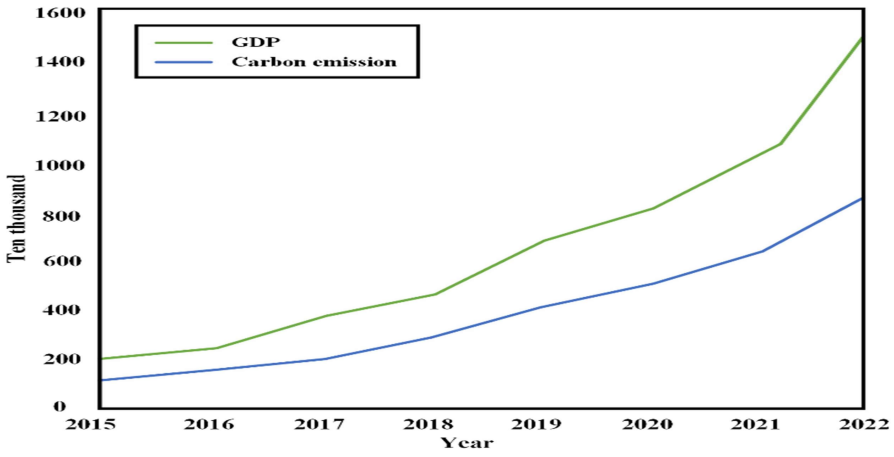


Figure 2. Relationship between EcoRural GDP and Carbon Emissions in Recent Years

The green village environment optimization design based on the niche genetic algorithm can address the challenge of increasing carbon emissions and achieve coordinated development between the environment and the economy. This algorithm can effectively reduce carbon emissions and enhance the environmental quality of green villages through optimization design methods and mechanisms. In the design process, carbon emissions can be introduced as one of the optimization objectives. Through encoding and selection operations, the optimization algorithm can explore building and landscape solutions with lower carbon emissions, thus reducing carbon emission sources. Meanwhile, by adjusting the industrial structure, optimizing energy consumption, and improving resource utilization efficiency, the carbon emissions of green villages can be effectively controlled.

The design of the green architecture landscape space environment in traditional villages has multidimensional attributes and a complex structure. Therefore, it is not just a simple land use design but instead relies on the comprehensive integration and optimization of the economic, natural, and social aspects constructed through village construction planning. Within this integrated system, the emphasis should be on ecological limitations, promoting green production, and ultimately establishing a pleasant and livable new healthy environment. By using the model established based on the niche genetic algorithm, the structure and function of green spaces can be reasonably optimized and controlled, achieving goals of moderate development, sustainable utilization, and environmentally friendly practices. Ultimately, this approach promotes the harmonious development of the entire green village in terms of economy, society, and the environment, yielding optimal benefits.

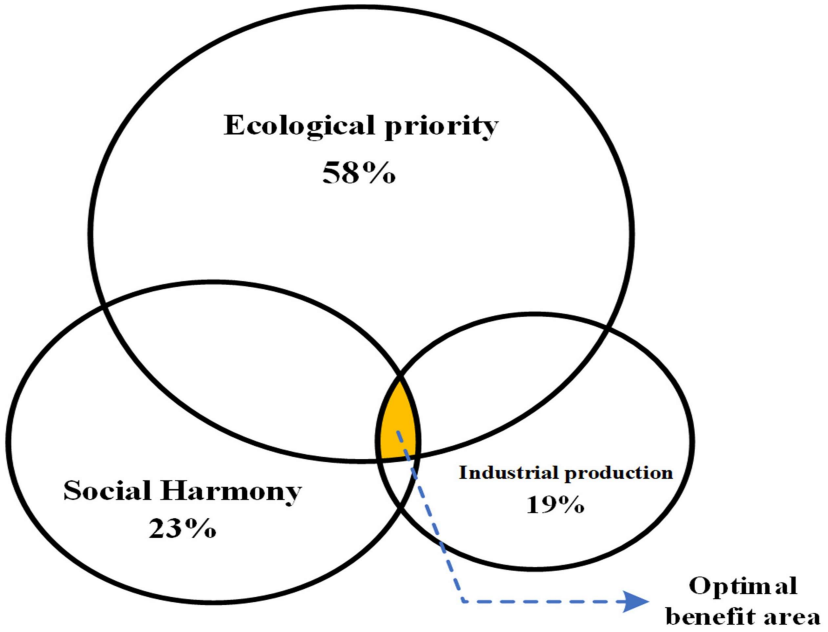


Figure 3. Econ rural region Environment Design and Final Goal Scale

The planning and criteria are depicted in Fig. 3. Due to its ecological priority, it represents the largest share at 58%, followed by community harmony at 23%, while industrial production accounts for 19%, ensuring the village's development and meeting the daily needs of the villagers. The three primary objectives overlap rather than exist independently, necessitating a balance among them, illustrated by the yellow area in the figure. In this space, a comprehensive and harmonious advancement of the environment, economy, and society is achieved, bolstered by cutting-edge technological innovations, established policies, regulations, and efficient monitoring systems.

## 5. Conclusion

This research emphasizes the optimization design of the green architectural landscape environment in traditional villages, founded on the niche genetic algorithm. By analyzing cultural characteristics and environmental challenges within conventional villages and merging domestic and international research findings, a design method based on the niche genetic algorithm is presented. Experimental findings reveal that this approach effectively enhances the green architectural landscape environment in traditional villages, improving both the quality of life and environmental adaptability for residents. This research introduces a new method and strategy for the sustainable development of traditional villages, possessing both theoretical and practical importance. Future studies may further refine and expand this approach to facilitate better optimization of the green architectural landscape environment in traditional villages.

**Acknowledgements**

The study was supported by the Project of Hunan Social Science Achievement Appraisal Committee: Urban cultural ecological renewal strategy ofDongting Lake District under the background of"Three High and four New" strategy(No. XSP22YBC588); Key Laboratory of Key Technologies of Digital Urban-Rural Spatial Planning of Hunan Province(No. 2018TP1042).

## Reference

[1] Chen, G., Sharma, A. (2022). Green Landscape Design Based on Niche Genetic Algorithm for E-Business Solutions. International Journal of e-Collaboration (IJeC), *18*(2), 1–11.

[2] Ma, H., Zhou, X. (2019). A GPS location data clustering approach based on a niche genetic algorithm and hybrid K-means. *Intelligent Data Analysis, 23*(S1), 175–198.

[3] Yang, H., Liu, X. (2019). Solving approach of inverse kinematics for manipulators based on improved adaptive niche genetic algorithm. *Journal of Northwestern Polytechnical University, 37*(3), 488–495.

[4] Chou, F. I., Ho, W. H., Chen, C. H. (2020). Niche genetic algorithm for solving multiplicity problems in genetic association studies. *Intelligent Automation & Soft Computing, 26*(3).

[5] Zhang, W., He, H., Zhang, S. (2019). A novel multi-stage hybrid model with enhanced multi-population niche genetic algorithm: An application in credit scoring. *Expert Systems with Applications, 121*, 221–232.

[6] Sulistiyani, A. T., Setyono, P., Wahyunengseh, R. D. (2021). The local elites' perception of "Hamemayu Hayuning Bawana" philosophies in the Green Village Program in Yogyakarta Province. *IOP Conference Series: Earth and Environmental Science, 724*(1), 012099.

[7] Sulistiyani, A. T., Setyono, P., Wahyuningsih, R. D. (2020). Bureaucratic role in green village innovation model at Yogyakarta, Indonesia. *IOP Conference Series: Earth and Environmental Science, 423*(1), 012035.

[8] Kawagishi, U., Kitano, K. (2000). Study on the living space planning viewing from community activities by

collective living and leisure activity. Part 2: Case study on residents of cooperative town “Verde Akibadai”. *AIJ Journal of Technology and Design, 6*(11), 239–244.

[9] Bicksler, A. J., Center, E. A. I., Bates, R., et al. (2014). *The current and future roles of small farm resource centers in extension and advisory services: Synthesis report from seven case studies in Southeast Asia*. MEAS.

[10] Supriatna, S., Niyartama, T. F., Kuswidi, I. (2016). Determination of leisure levels of village patronage UIN Sunan Kalijaga Yogyakarta: Improving governance patronage towards rural green village and environmentally friendly. *Biology, Medicine, & Natural Product Chemistry, 5*(1), 15–18.