

Research Report

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## Study on the Impact of Urbanization on Endangered Plant Populations and Protection Strategies

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**Abstract** With the acceleration of global urbanization, the ecological environment and biodiversity are facing unprecedented challenges. Especially endangered plant populations have been significantly affected. This study delves into the impact of urbanization on endangered plant populations, and takes Hainan wild rice as a case study to analyze the degree of damage to its habitat caused by urbanization and the difficulties in protection. Hainan wild rice originated in specific wetland areas in Hainan, but with the urban expansion, its habitat has been severely damaged and the population has sharply decreased. Based on this practical background, this study further proposes a series of conservation strategies, emphasizing the importance of comprehensive management and multi-party participation, aiming to provide practical guidance for the protection of endangered plant populations.

**Keywords** Endangered plants; Biodiversity; Hainan wild rice; Native habitat; Protection strategies; Urbanization

With globalization and technological progress, various parts of the world are experiencing unprecedented urbanization processes (Seto et al., 2013). With the rapid urban expansion, the original natural environment and traditional rural lifestyles are gradually being replaced, engulfed by the wave of urbanization.

In recent years, urbanization has expanded at an astonishing pace globally, especially in developing countries. Both large and small cities are constantly attracting population migration. Rural urbanization has become a common trend, and many previously peaceful rural areas with abundant natural resources are now undergoing rapid urbanization. This process undoubtedly brings economic convenience and comfort to many people, but it also brings many negative effects. The disappearance of habitats, the destruction of the ecological environment, and even the fragmentation of ecosystems have become major issues of the current environment (McDonald et al., 2013).

Behind this, many people may not be aware of the impact of urbanization on plant resources. Taking Hainan as an example, there were originally three types of wild rice here: ordinary wild rice, wart grain wild rice, and medicinal wild rice. However, due to excessive development and urbanization, the original habitats of these rare wild rice populations have gradually disappeared, and the specific ecological environment and balance they rely on have been disrupted. Even worse, many other endangered plants also face similar situations (McKinney, 2002). For these plant populations, they are not only a symbol of biodiversity, but also a part of our human culture and traditions. Their disappearance implies the loss of a certain culture and history.

This study aims to deeply explore the impact of urbanization on endangered plants and the ecological and cultural value losses that brings, and propose feasible protection strategies.. We hope to find a balance point through in-depth analysis of the relationship between urbanization process and endangered plant populations, so that urbanization development and biodiversity conservation can coexist harmoniously. In addition, we also hope to provide practical suggestions and solutions for decision-makers, environmental protectors, and the public to help them better understand and address this issue, thereby ensuring that our natural heritage can be inherited and cherished by future generations.

## **1 The Relationship between the Urbanization Development and Endangered Plants**

With industrialization and technological progress around the world, urbanization has gradually become an irreversible trend. It not only brings convenient life and prosperous economy to humanity, but also brings unprecedented pressure to the natural environment. Especially for endangered plant populations, the advancement of urbanization seems to be negatively correlated with their survival status.

### **1.1 Defining urbanization and its characteristics**

Urbanization, simply defined, refers to the process of population concentration from rural to urban areas, typically accompanied by industrialization and economic modernization. This process includes various phenomena such as population growth, land use change, and ecological environment change (Güneralp et al., 2013). The main characteristics of urbanization include: large-scale land development and utilization, leading to a gradual reduction in green spaces and farmland; A large number of buildings, transportation roads, and infrastructure construction; Increased industrial production and consumption activities; And related environmental pollution and ecological damage.

### **1.2 Classification and characteristics of endangered plants**

Endangered plants refer to plant populations whose survival is threatened and may become extinct in the near future. According to the classification of the International Union for Conservation of Nature (IUCN), endangered plants are classified into several levels: imminent extinction, endangered, and vulnerable (Schemske et al., 1994). The common characteristics of these plants are their scarcity, limited distribution, and weak adaptability to the ecological environment. Some plants that exist due to specific ecological conditions or geographical environments, such as certain wetlands or plants at specific altitudes, are more sensitive to external interference.

### **1.3 The impact of urbanization on endangered plants from a historical perspective**

From a historical perspective, the impact of urbanization on endangered plants is complex and profound. Initially, with the urban expansion, many original ecological areas were developed into farmland or residential areas, leading to the destruction of plant habitats. This is not only a decrease in quantity, but more importantly, the integrity and continuity of ecosystems are threatened (Planchuelo et al., 2020). Many plants with specific ecological needs, such as water sources and soil types, gradually decrease due to the loss of suitable living environments.

Taking Hainan Island as an example, this island was originally had a low level of urbanization, with rich biodiversity and large areas of primitive forests. But with the economic development in recent decades, especially the rise of the tourism industry, a large number of original rural towns have begun to rapidly urbanize, and many original natural ecosystems have been extensively developed.

The urbanization of Hainan Island not only means an increase in population and expansion of buildings, but also comes with a significant destruction of native plant habitats. For example, in order to build tourist resorts, golf courses, and other leisure facilities, a large number of forests and wetlands have been cleared, which directly leads to a sharp decrease in the number of plant populations, and some plants even face the risk of extinction (Tang and Chen, 2017).

In addition, urbanization has brought about problems such as pollution, overexploitation, and invasive alien species, all of which pose a greater threat to the survival of endangered plants. For example, due to urbanization and agricultural expansion, a large amount of pesticides and fertilizers have been used, which not only causes serious pollution to water quality but also threatens the survival of many aquatic plants.

Overall, the urbanization of Hainan provides us with a clear example of the serious consequences that urbanization may have on endangered plant populations. This is not only a problem for Hainan, but also for many regions around the world that are experiencing rapid urbanization. How to achieve a balance between economic development and ecological protection is an urgent problem to be solved.

## **2 Specific Impacts of Urbanization on Endangered Plant Populations**

With the rapid advancement of urbanization, we have to face the fact that human activities have had a huge impact on the environment. Among them, the endangered plant population is one of groups that are most directly and severely affected. This chapter will delve into the specific impact of urbanization on endangered plants from the following aspects.

### **2.1 Habitat destruction**

In the process of urbanization, large areas of land are transformed into residential, commercial, and industrial areas. A large amount of natural land has been replaced by buildings, roads, and other infrastructure, resulting in a significant reduction in the habitat of endangered plants. In addition, urban expansion has led to the rupture of ecological corridors, making gene exchange between plant populations difficult, further exacerbating their survival pressure. More seriously, some unique plants that only grow in a specific location may face the risk of extinction due to habitat destruction (McKinney, 2006).

### **2.2 Relationship between environmental pollution and plant population**

With the expansion of cities and the increase of population, the pollution problems of air, soil, and water are becoming increasingly prominent. This pollution has caused a fatal blow to endangered plants. For example, toxic substances in the atmosphere, such as sulfur dioxide and nitrogen oxides, can reduce the photosynthetic capacity of plants, thereby affecting their growth. Soil pollution, especially heavy metal pollution, may lead to plant death or loss of reproductive ability. Water pollution may prevent aquatic plants from growing and reproducing normally.

### **2.3 Relationship between human activities and endangered plants**

Human activities not only include the aforementioned land development and environmental pollution, but also have many other impacts. For example, excessive collection is the main reason why many plants are endangered, especially some plants with medicinal or ornamental value (Planchuelo et al., 2020). In addition, the introduction of invasive species may further reduce the number of locally endangered plant populations due to human activities such as international trade and tourism (Han, 2022). These exotic species are often more aggressive than native species, as they may occupy the living space of local plants, seize resources, and even cause outbreaks of diseases of local plant by carrying pathogens.

### **2.4 Impact of climate change**

In recent years, global climate change has become an issue that cannot be ignored. The impact of climate change on endangered plants is mainly reflected in changes in the growing season, increased drought or flood events, and changes in ecosystem structure. Many plants have strict requirements for the climatic conditions under which they survive, and these conditions may undergo significant changes under the influence of climate change. For example, some alpine plants that rely on the freezing cycle may lose their living environment when temperatures rise. Similarly, some tropical plants are affected by climate warming and extreme weather.

## **3 Existing Strategies for Protecting Endangered Plants**

In the rapidly developing urbanization process, endangered plant populations are facing serious threats. In order to protect these precious biological resources, various protection strategies have been proposed. These strategies not only involve traditional plant protection methods, but also include the correlation between biodiversity and ecosystem services, as well as various international and domestic protection mechanisms and policies.

### **3.1 Traditional plant protection methods**

The traditional methods of plant protection mainly include protecting the natural habitat of plants, establishing seed banks, and artificial breeding (La Torre et al., 2018). Among them, protecting the natural habitat of plants is considered the most direct and effective method. This needs to be achieved by establishing nature reserves, botanical gardens, and seed banks. These places provide a relatively stable living environment for plants, which helps them reproduce and grow.

Seed banks are another effective tool for plant protection. They collect, preserve, and study seeds with the aim of preserving the genetic diversity of plants and providing a material basis for possible future restoration work. In addition, artificial breeding is also one of the traditional methods of plant protection, which increases the population of endangered plants through manual intervention to avoid their extinction.

### **3.2 The correlation between biodiversity and ecosystem services**

Biodiversity is not only a manifestation of life on the earth, but also provides many important ecosystem services for humanity, such as air purification, water source protection, food production, and drug research and development. Endangered plant populations, as an important component of biodiversity, are crucial for maintaining ecosystem balance.

Therefore, protecting endangered plants is not only for themselves, but also to maintain the stability of the entire ecosystem and the well-being of human survival. This concept requires us to consider not only their direct interests but also their role and value in the ecosystem when protecting endangered plants.

### **3.3 International and domestic protection mechanisms and policies**

On a global scale, many international organizations and national governments have recognized the importance of protecting endangered plants (Hanley et al., 1995). Internationally, organizations such as the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN) have issued multiple treaties and policies related to the protection of endangered plants. For example, the Convention on Biological Diversity aims to protect global biodiversity, ensure its sustainable use, and share benefits fairly and reasonably.

On a domestic scale, governments of various countries have also formulated a series of policies and regulations for the protection of endangered plants. For example, China has established Law of the People's Republic of China on the Protection of Endangered Species to manage and protect endangered plant populations. In addition, countries have also established their own nature reserves, botanical gardens, and seed banks, providing places for protection and research of endangered plants.

Overall, the protection of endangered plants requires the comprehensive utilization of traditional methods, ecosystem service concepts, and international and domestic policy tools to form a multi-level and multi-angle protection system, ensuring that these precious biological resources can be effectively protected and utilized reasonably.

## **4 Protection Strategy and Measures Suggestions**

Facing the challenges brought by urbanization, protecting endangered plant populations requires a series of targeted strategies and measures. The following section will discuss the recommended strategies and measures in detail based on the actual situation.

### **4.1 Planning and construction of green spaces and ecological corridors**

With the advancement of urbanization, green spaces and ecological corridors have become important spaces for plant population survival. Green spaces not only provide a place for citizens to rest, but also provide a relatively safe living environment for endangered plants. Firstly, we should ensure that sufficient space is reserved for green spaces and ecological corridors in urban planning, and that scientific layout is carried out. This means that green space is not only for decoration, but also an ecosystem where endangered plants can be well protected. In addition, ecological corridors can connect different green spaces, providing migration pathways for plants and animals, and reducing population isolation.

### **4.2 Ecological restoration and reintroduction of endangered plant populations**

Ecological restoration is necessary for those already damaged ecological environments. This includes the restoration of soil, water sources, and other ecological elements to create an environment suitable for the survival of endangered plants. After the environment is restored, it can be considered to reintroduce endangered plants. But

this requires a detailed plan, including selecting suitable species, determining the optimal introduction time and method, etc. The purpose of reintroducing is not only to restore quantity, but also to ensure that species can reproduce and thrive in the new environment.

#### **4.3 Enhancing public ecological awareness and education**

The public is a key force in ecological protection. Raising public awareness of the protection of endangered plants through various means can effectively reduce human interference. This includes offering ecological and environmental education courses in schools, organizing various public promotional activities such as exhibitions, lectures, and utilizing the media for extensive promotion. At the same time, the public can also participate in the actual protection of endangered plants, such as participating in volunteer activities to monitor and protect endangered plants.

#### **4.4 Promoting cooperation between government, enterprises, and communities**

Protecting endangered plants is not a matter of a department or organization, but requires cooperation from multiple parties. The government should formulate clear policies and regulations to provide legal support for the protection of endangered plants. During the development process, enterprises should follow the concept of green development to ensure that their actions do not pose a threat to endangered plants. At the same time, communities and residents should also participate in conservation work to create a friendly living environment for endangered plants. Multi party cooperation is the key to ensuring effective protection of endangered plants.

In short, facing the challenges brought by urbanization, we need to comprehensively apply various strategies and measures to ensure effective protection of endangered plant populations. This requires our joint efforts to leave a green and harmonious home for our future generations.

### **5 Case Study**

#### **5.1 Case analysis of wild rice affected by urbanization in Hainan**

The wild rice in Hainan is considered a treasure of rice germplasm resources in China and an important component of global agricultural genetic resources (Yang et al., 2022). But in the past few decades, these precious resources have been facing serious threats due to the impact of urbanization.

Firstly, based on different evaluation criteria, there has been a significant change in the protection level of Hainan wild rice. For example, according to the IUCN Red List of Threatened Species, it is classified as Least Concern (LC). In the Red List of Biodiversity in China - Higher Plants Volume, it was rated as Critically Endangered (CR). This obvious level difference indicates a significant gap between international and domestic evaluations, which may be related to the acceleration of urbanization and intensified human interference.

The main distribution areas of wild rice in Hainan are Sanya and Qionghai, but it is also distributed in most places such as Haikou, Dongfang, Wenchang, and Wanning. Of particular concern is that Sanya is the southernmost distribution area of wild rice in China. But as of 2015, its original land has been extensively destroyed, with a resource reduction of 82.2%. There are many reasons for this phenomenon, including external environmental factors such as overgrowth of weeds and invasion of foreign plants, as well as internal factors such as population degradation, reduction in quantity, and reduction in distribution area.

The main reason behind it is the acceleration of urbanization, which has led to a large amount of wild land being reclaimed, used for digging ponds for fish farming, grazing, infrastructure construction, tourism development, and so on. These activities not only directly led to the destruction of the habitat of wild rice, but also indirectly caused problems such as invasion of foreign plants and environmental pollution, further exacerbating its survival pressure.



## 5.2 Construction strategy and insights of wild rice resource nursery in Hainan

Facing such a severe situation, protecting wild rice resources is particularly important. Considering its value as a gene bank for rice germplasm resources and the huge demand of the future development of the rice industry for germplasm resources, the construction of wild rice resource nurseries is particularly necessary.

The National Wild Rice Germplasm Resources Nursery in Yazhou District in Sanya emerged against this background. The planned 166 acre wild rice ectopic preservation nursery aims to provide a relatively safe and stable living environment for wild rice and provide necessary conditions for its future breeding, research, and utilization.

This resource nursery can not only provide a safe preservation environment for the existing wild rice resources in China, but also promote the development of the southern breeding industry and rice seed industry. In addition, Hainan Province has also established multiple large-scale scientific research public service platforms, aiming to promote collaborative innovation in biological breeding through technological innovation, and provide better services for animal and plant germplasm resources nationwide and even globally.

From this case, we can draw the following insights:

The protection of wild resources should not solely rely on natural reserves, but should be combined with the actual situation of the local area, and scientific management and rational utilization of resources should be achieved through the establishment of resource nurseries and other means.

The role of technological innovation in the protection of biological resources cannot be ignored. Through technological means, resources can be more effectively evaluated, researched, and utilized, laying a solid foundation for their sustainable utilization.

In the process of urbanization, the relationship between humans and nature should be taken seriously. Only by establishing a development model of harmonious coexistence between humans and nature can we ensure the protection of biodiversity and the sustainable development of human society.

## 6 Discussion and Outlook

With the rapid development of society and the continuous enhancement of human activities, urbanization has become an inevitable global trend. Although urbanization has brought many economic and social benefits, its impact on the environment and biodiversity cannot be ignored. Especially in the context of biodiversity conservation, the threat to endangered plant populations is more prominent.

The large-scale land development during the urbanization process has led to the destruction or fragmentation of the original habitats of endangered plant populations. Many previously contiguous ecological areas have been cut into several isolated fragments, thereby increasing the risk of plant population extinction. In addition, urban construction and expansion have also brought about a large amount of environmental pollution, such as soil, water, and air pollution, which have adverse effects on the growth and reproduction of endangered plant populations. More seriously, due to the concentration of most human activities in cities, a large number of alien species have entered, competing with local endangered plant populations, further exacerbating the survival crisis of endangered plants.

Facing the above challenges, relying solely on traditional methods of biodiversity conservation is no longer sufficient. We must adopt a comprehensive and multi-dimensional protection strategy. Firstly, urban planning should fully consider ecological factors, such as building ecological corridors to ensure the continuous distribution of biological populations; Secondly, strengthen public awareness and education on ecological protection, and encourage more people to participate in the protection of endangered plant populations; Once again, promote cooperation between the government, enterprises, and communities to form a joint effort to protect biodiversity. Only through comprehensive strategies can we ensure that endangered plant populations are truly protected in the wave of urbanization.

With the intensification of urbanization, future research on endangered plant populations will inevitably face more challenges. On the one hand, the complexity and dynamics of ecosystems make research more difficult; On the other hand, many factors related to urbanization, such as climate change and land use change, can have an impact on endangered plant populations. Therefore, future research should place greater emphasis on interdisciplinary cooperation, utilizing modern technologies such as remote sensing and GIS to conduct in-depth research on the distribution, growth status, and relationship with human activities of endangered plant populations. At the same time, it is also necessary to strengthen research based on field investigations to ensure the authenticity and accuracy of the research.

Overall, the impact of urbanization on endangered plant populations is multifaceted, and we need to address it through comprehensive conservation strategies. At the same time, future research will also face many challenges, requiring us to continuously innovate and strive to ensure that endangered plant populations are truly protected.

#### Authors' contributions

SP was the executor of this study, completing literature research, data analysis, and writing the first draft of the paper; LM is the person in charge of the study, guiding the writing and revision of the paper. Both authors read and approved the final manuscript.

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