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Research Article

Strategies of GIS-Based Urban Country Park Planning and Ecological Restoration

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Purpose. This study centers around the Wangzhanghe Country Park located in Jiaozuo City as the research object. Through analysis of the site's evolution by GPS and its status-quo by GIS, the map of spatial distribution suitability has been illustrated. *Design*. Based on the major principle of achieving sustainable development of the ecosystem and the derived concept of building a diversified landscape, we have developed the overall scheme of planning and landscape layout of the country park. Specifically, the area of ecological restoration is further divided into the areas of quarry restoration, bare land restoration, slope protection, vegetation, and dam maintenance, and restorative measures are put forward accordingly. *Findings*. Our research findings indicate that thanks to the vegetation restoration of the side slope, the area of bare land in mountain farmland has been evidently reduced, whereas the severely damaged ash pits and green spots have also been restored. Originality: in the meantime, we have leveraged the flat space at the foot of the mountain to foster a viewing experience and provide recreational activities for citizens, so that they are able to effectively increase their access to outdoor events and improve their sense of engagement and experience in the events, thereby providing a reference for building a green, diverse, and sustainable system of ecological services for the urban country park.

1. Introduction

The country park serves as the link between the city and the countryside and plays a protective role in preserving the ecosystem and enhancing the environmental quality of surrounding areas. Due to the impact imposed by natural conditions and human activities, urban country parks are still encountered with such issues as improper spatial layout, severe soil pollution, and local soil erosion, thus hindering the advancement of ecological civilization and sustainable development in cities [1–5]. Therefore, it has become the current research focus of numerous scholars at home and abroad to elaborate on the question of how to build urban country parks in a healthy, ecofriendly, balanced, and diverse manner from the ecological perspective.

Ecological restoration serves the goal of enhancing the stability and sustainability of ecosystems through the integrated use of chemical restoration, physical restoration, and engineering technical measures. It involves the process of facilitating the restoration, reconstruction, and improvement of the ecosystems subject to degradation, damage, or even complete destruction [6–9]. The technologies commonly used at present include but are not limited to the technologies for soil remediation, phytoremediation, landscape remediation, and rewilding [10–14]. Numerous scholars tend to focus on the impact imposed by ecological restoration on the resilience of biological resources and biodiversity from the macro perspective while analyzing the effects of ecological restoration based on the assessment of the maintenance function of biodiversity. In China, efforts of ecological restoration mainly focus on the farmlands, grasslands, rivers, forests, and mining wasteland, which are subject to the intervention and impact of human beings. Moreover, the studies on the effect of ecological restoration

tend to focus on the assessment of the extent of environmental quality improvement, but the reports on such studies merely account for a small proportion [15–17].

This study centers around the Wangzhanghe Country Park located in the northern mountainous area of Jiaozuo City as the research object. Based on the field survey and analysis of the evolution of the site and environmental conditions of the ecosystem, we have analyzed such factors as the elevation, slope gradient, and slope aspect with GIS to further verify the core construction space of the country park. In addition, judging from the perspective of ecological restoration, we have put forward a green, diversified, and sustainable strategy for ecological planning to meet the needs of citizens for the natural experience of the ecosystem, as well as cultural activities, thereby providing a reference for the planning and positioning of the country park in Jiaozuo City [18–21].

2. Digital Analysis of the Status-Quo and Evolution of the Site

2.1. Overview of the Site. The research site is located to the northwest of the boundary of the major urban area of Jiaozuo City in Henan Province, which is part of the Northern Mountain of Jiaozuo City and covers an area of 15 hectares. The highways adjacent to the research site are well developed, but there is no green space in the park, and the site is linked together with the Jiaozuo Film Studio and the scenic area of Fengshan Park on the same line. In the northern parts of the site, there are pits and dams in need of maintenance. Moreover, in areas adjacent to the mountain, there are vast stretches of woodland and bare land that are required to be restored. At the foot of the mountain, there are also small factories, buildings, and farmland (as illustrated in Figure 1). Subsequent to numerous years of development, the mining industry in the Wangzhanghe area of Northern Mountain has become the major growth engine of Jiaozuo City. However, the local mountains are riddled with holes due to years of private digging and mining, as well as illegal operations and processing by individual market entities. Therefore, it has become the primary task for Jiaozuo City to develop a proper system of ecological conservation in the northern mountainous area so as to restore the local destroyed environment, which is also consistent with the need of achieving sustainable development in the city.

2.2. GPS Analysis of the Evolution of the Site. Judging from the analysis with GPS, the area of bare land of the current land in 2010 was rather extensive (26.15%), and the mountain was severely damaged. In addition, the flat land at the foot of the mountain was basically occupied by farmlands and buildings, whereas the local residents suffered from the impact of suboptimal ecological conditions and overcrowded life. In 2014, the area of bare land was diminished to a significant extent in the mountain, 11.86% less than in 2010. However, large-scale factories were found at the foot of the mountain. In 2017, the scale of the factory was further expanded, the farmland area was reduced by 1.92%, and many farmlands were gradually turned into forests. In 2020, more evident effects were shown in terms of the environmental governance in the mountain. The area of bare land decreased by 17.51% compared with 2010, as evidenced by the significant reduction of the area of bare land and gradual relocation of factories, as well as the transition of the majority of farmlands into woodlands (Figure 2).

2.3. GIS Analysis of the Status-Quo of the Site. This study involves the use of such factors as elevation, slope gradient, and slope aspect with the tentative use of weighted stacking to illustrate a map of distribution suitability [22–24], thereby verifying the core construction space of the country park and providing a reference for its positioning in Jiaozuo City. Judging from the GIS analysis of elevation, slope gradient, and slope aspect, it is found that there is a huge height difference in the site at present. The gap between the maximum altitude and the minimum altitude amounts to 216 m, whereas the overall slope is rather small. About 39% of the areas of the site have a slope of less than 9°, whereas roughly 25% of the areas of the site have a slope ranging between 9° and 15°. Moreover, the areas of the site that have a slope of over 15° account for about 36%. In the majority of the areas of the site, there are sunny slopes and woodland, whereas only a small proportion of the site consists of shady slopes, which are located in the valleys and the northern slopes. In addition, there are certain buildings and stretches of bare land in the southern part of the site, whereas the ash pits account for a large proportion of the mountains, which is huge. Through GIS analysis, we have recorded the damage incurred to mountains, waters, woodlands, fields, lakes, and grasslands in the ecological fracture space located in the Wangzhanghe in the Northern Mountain, thereby providing a reference for the ecological restoration in the next step (Figure 3).

3. Planning Strategies Based on Ecological Conservation

For humankind, health and survival are closely linked to the varying elements of mountains, water, woodland, fields, lakes, and grassland, and they are coexistent with each other in symbiosis. The research is guided by the concept of ecological restoration of mountains, waters, woodland, fields, lakes, and grasslands life community [25–29] and centers on the major thinking of "one belt (Ecological Civilization Corridor), two rings (main roads + main water systems), and two points ("ash pit" + "dam") so as to elaborate on and extend the overall planning and landscape layout (Figure 4).

First, based on the map on the distribution of ecological sensitivity and the holistic analytical results of the status-quo of the site, the ecological restoration area is further divided into the areas of quarry restoration, bare land restoration, slope protection, vegetation restoration, and dam maintenance. In this way, ecological restoration is carried out in partitions to better restore the overall ecological balance. Second, through varying means of landscape construction,

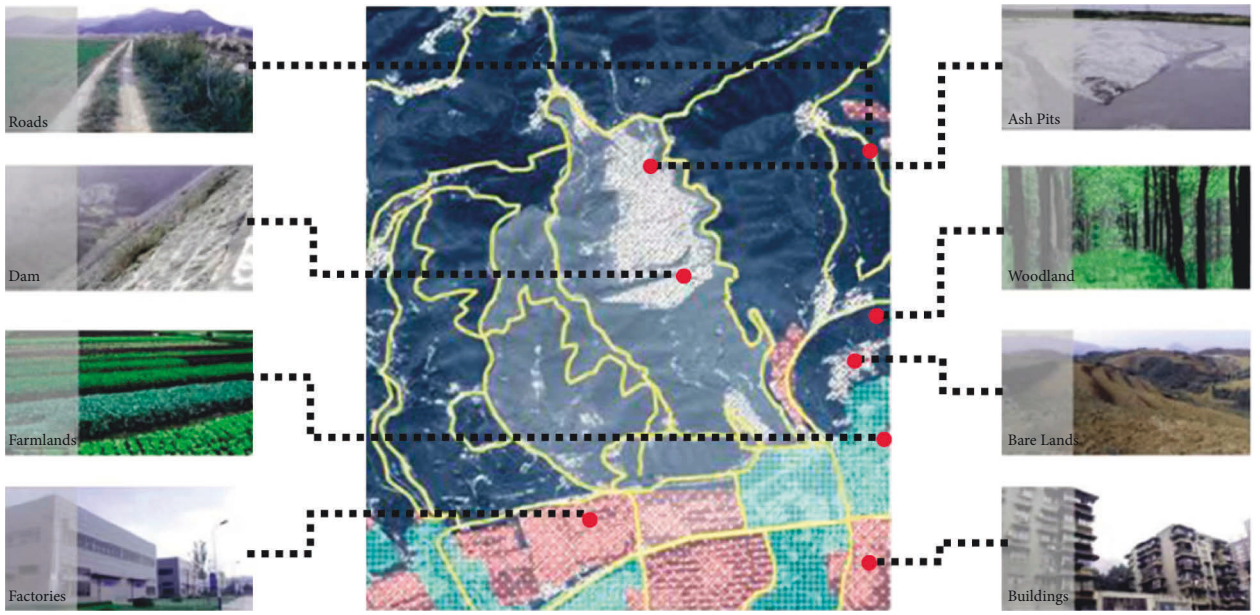


Figure 1: The status-quo of the site (illustrated by the author).

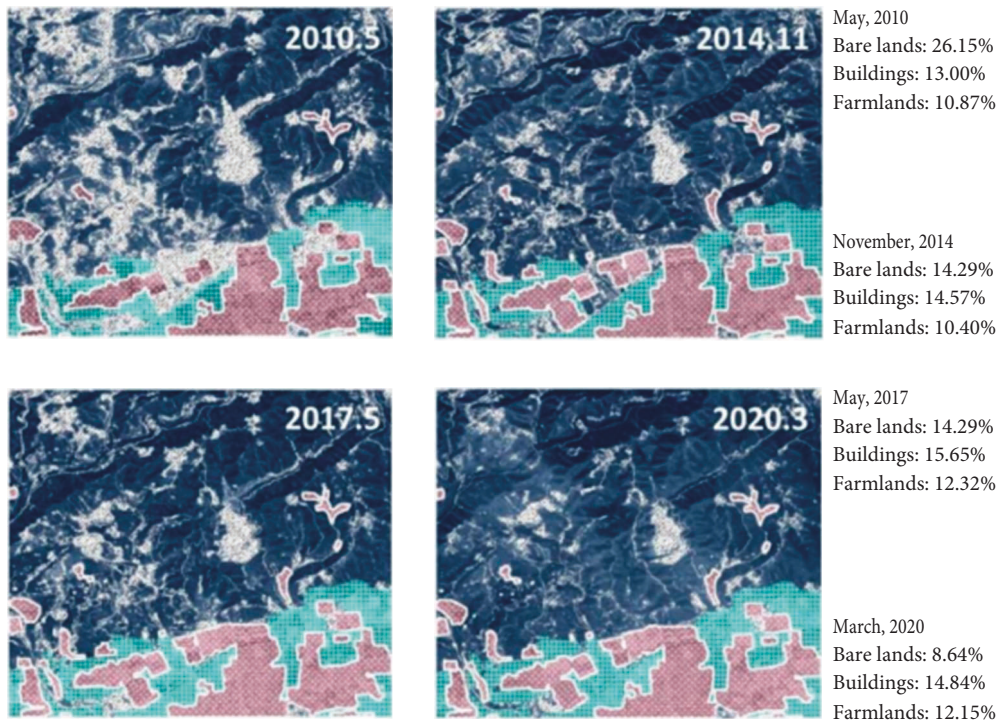


Figure 2: Analytical diagram on the evolution of the site (extracted from Google Earth).

efforts are made to enhance the structuring of space for resting, exchanges, and fitness activities. In the meantime, we attach importance to the public nature and diversified functions of the site and intend to enhance the sense of engagement and experience of tourists. For instance, we have established classrooms for quarry culture and ecological education, mini-programs for experience activities, and cultural exhibition boards, among other forms of presentation, so as to enrich the cultural ambiance of the site. In addition, we have established such facilities as a campsite, an area of agricultural experience, a platform for sightseeing, a bird observatory, and fitness climbing walls, so as to enhance the intelligent experience and to integrate the three elements of the ecosystem, human settlement, and culture for the maximum efficacy of country parks.

During the development and design of the roads in the park, we attach importance to the ways of connecting relevant road systems of the town while strengthening its links

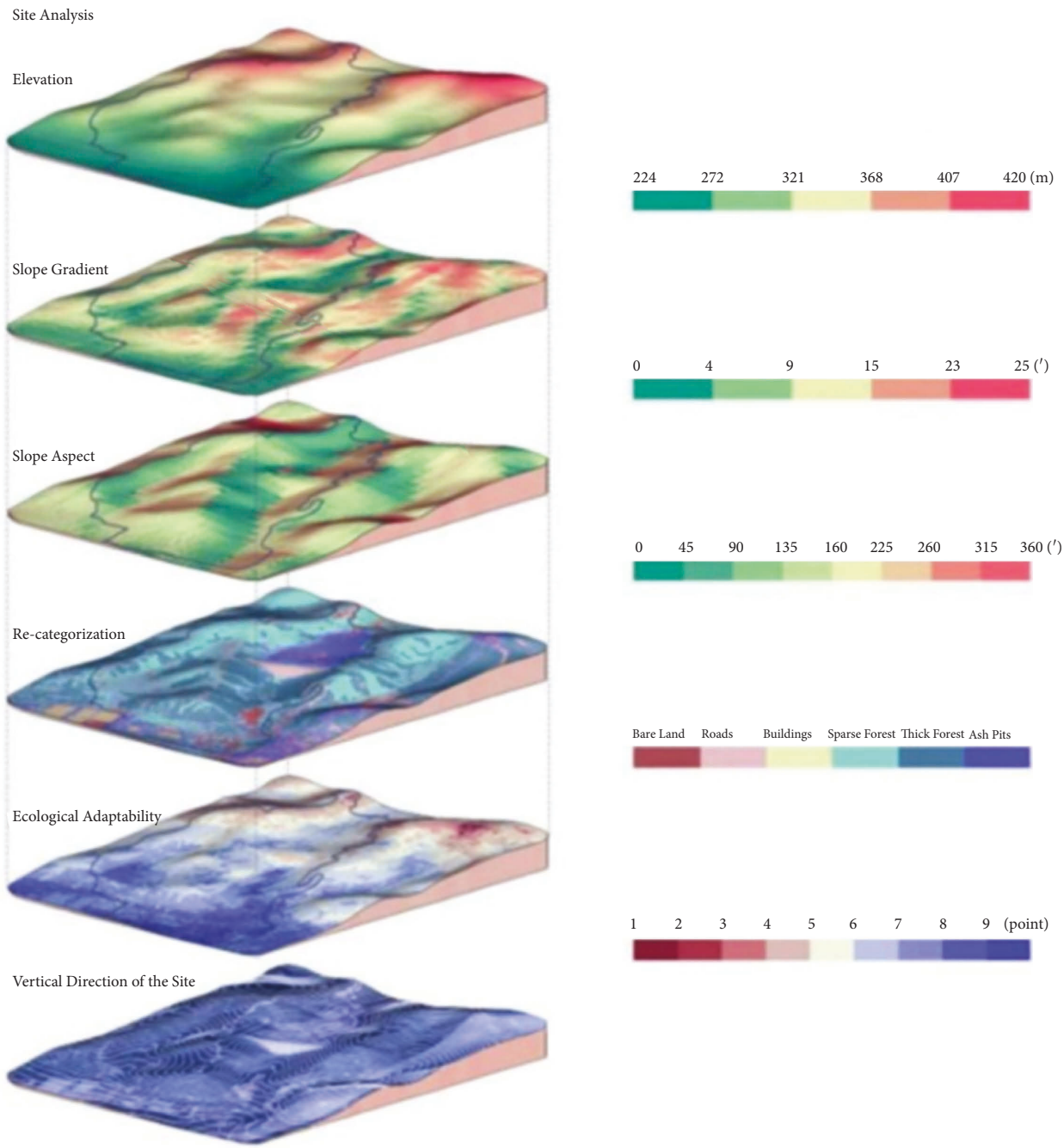


Figure 3: Diagram on the GIS analysis of the site status (extracted from ArcGIS).

with external transportation and enhancing its integration with the urban atmosphere [30–34]. The road systems are designed based on the positioning of the park in the city as well as the traffic carrying capacity subsequent to comprehensive development. In addition, the public infrastructure is established in light of the functional areas of the site as well as the internal road systems. There are four parking lots set up at the south entrance, east entrance, and west entrance, respectively. In particular, the south entrance serves as the main entrance with a large flow of traffic. Next to each of the parking lots, a tourist service center is established to improve the overall experience of services for visitors. Apart from the nodes of sightseeing, we have set up 9 additional nodes of engagement to enrich the tourist experience, which are located in the experience area of the mountain, and the three entrances located in the south, west, and east (Figure 5). Participatory activities set up include farmland planting experience, vegetable and fruit picking, interaction with pets, ancient temple worship, fishing, barbecue cooking, photography sketching, and other participatory activities, which

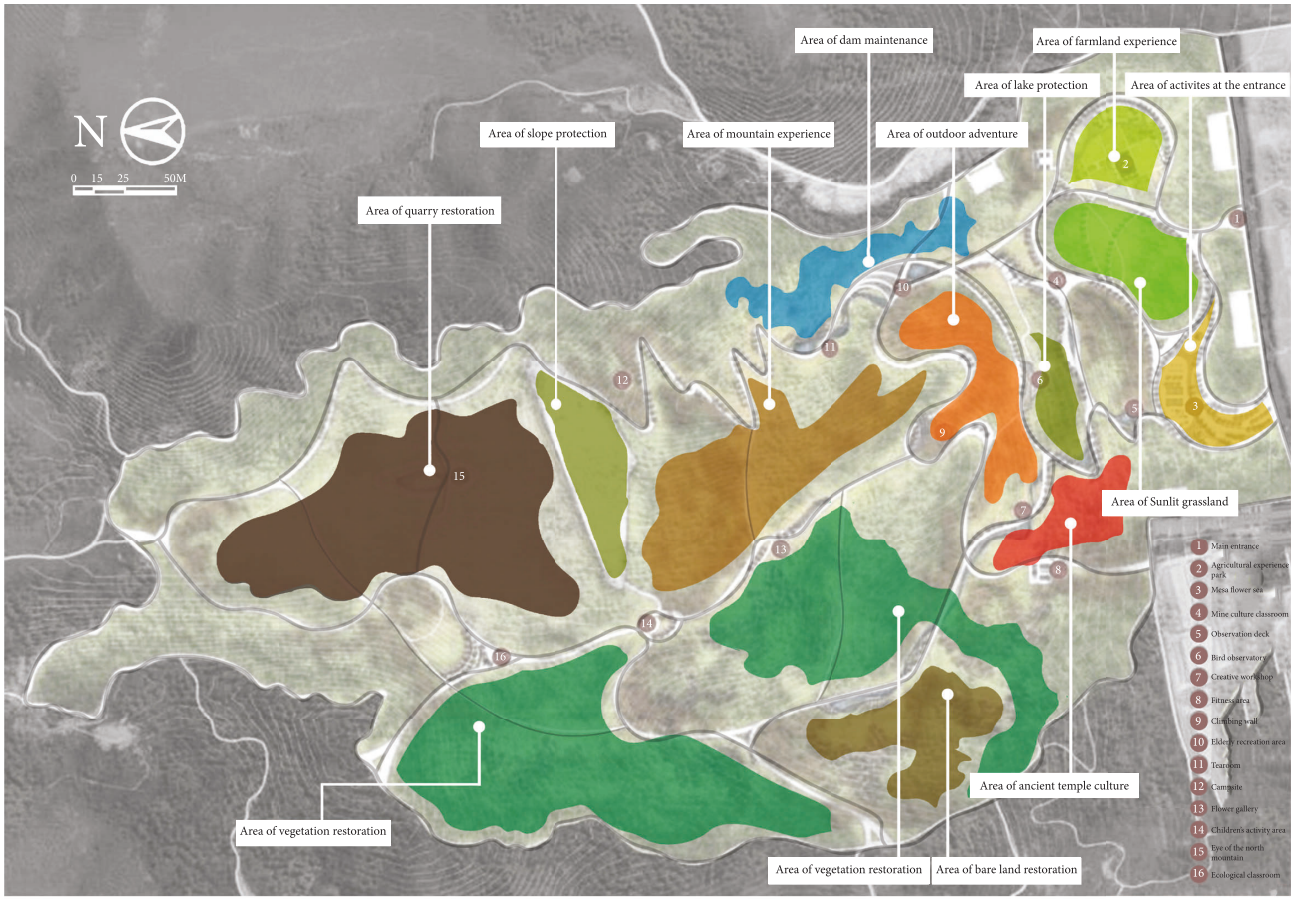


Figure 4: Overall planning and landscape layout (illustrated by the author).

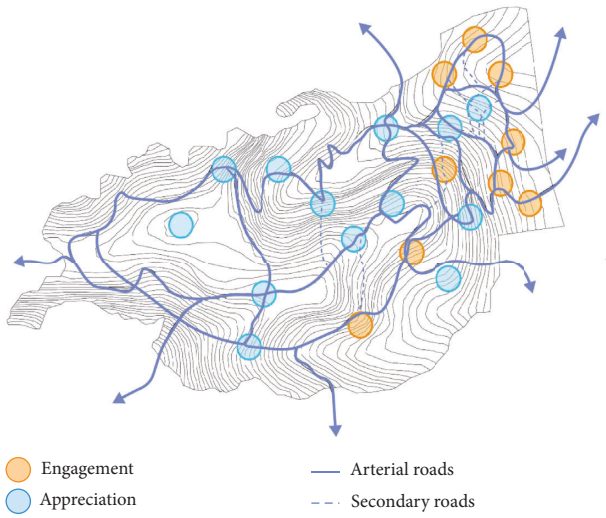


Figure 5: Map on the distribution of road systems and landscape nodes (illustrated by the author).

not only create diversified landscape nodes and sightseeing characteristics but also sort out the relationship between woodland, mountains, farmland, and water. While sorting out the four relationships of woodland, mountains, farmland, and water, we will restore the ecology and create diversified landscape nodes to create rich experiences and sightseeing characteristics.

4. Specific Strategies for Ecological Restoration

4.1. Steps of Implementing the Ecological Restoration. First, from the three aspects of ecological pressure, status, and response, assessment measures are taken to evaluate the ecological pattern or the spots, corridors, and substrates of the site of Wangzhanghe in Northern Mountain. Second, based on the current conditions of the elevation, slope gradient, slope aspect, categorization, and vertical direction of the site, evaluation and analysis are carried out on the sensitivity, adaptability, and risks of the ecological environment, whereas the primary environmental issues faced by the area are clarified to further identify the features and distribution of sensitive areas of the ecological environment. Third, based on the varying levels of sensitivity, the ecological environment is categorized with comprehensive zoning in light of the ecological sensitivity in varying areas. Fourth, numerous regulations are imposed and early warning infrastructure is built to curb pollution and alleviate damage incurred to the ecological environment. Last, starting from such aspects as the vegetation, microorganism, and chemistry, compound measures of restoration and design are taken to cope with the damaged ecological

environment so as to meet the needs of varying groups of people and to enrich the activity of the site as well as the experience of sightseeing and tourism.

4.2. Strategy for Ecological Restoration from Varying Angles. From the angle of ecological conservation, measures are taken to link the multitiered and diversified landscape environment with ecological restoration that combines natural and artificial means. We closely focus on the combination of ecology, human settlements, and culture, according to the main purpose of "green diversity, sustainable," supplemented by the function of "fitness and leisure, new experience" and the theme of "memory inheritance and new humanities," create a diversified landscape experience country park based on ecological restoration. From the angle of human settlement, the diverse tourism experience with minimal environmental intervention is integrated with the site design in consistence with the needs of varying groups of people. For example, the combination of parking lots and tourist service centers meets the needs of different groups of people. From the angle of cultural promotion, the environment for learning and disseminating ecological knowledge is established, through mine cultural propaganda, ecological education exhibitions, and other activities, enabling citizens to understand and publicize the quarry culture while sparking a new sense of pride for the culture of Jiaozuo City. From the angle of ecological restoration, the strategy for designing diversified urban country parks is put forward in combination with such theories as landscape ecology, art aesthetics, and social psychology. We realize the ecological restoration concept of "mountain, water, forest, field, lake, and grass" life community.

4.3. Strategy for Sponge City. The development of the sponge city serves the purpose of restoring and rebuilding the structures and functions of the water ecosystem, including but not limited to the absorption, storage, seepage, and purification of water when it rains and the release of the stored water when necessary, so as to improve the natural ecological balance of the city [35–39]. This study elaborates on the use of the strategy for sponge cities in dams and slope protection areas while focusing on the six aspects of seepage, retention, storage, purification, utilization, and drainage. Judging from the study, it is recommended to use the recycling system to recycle rainwater for irrigation with the collected rainwater; to adopt the design of vertical landscape and emergency discharge for alleviating the issue of urban waterlogging, to carry out the design of high-performance green space for sewage interception so as to facilitate decentralized governance and popularize scientific education; to conduct the planning of sunken green land and the design of permeable pavement for soil protection and modification; and to set up the multifunctional space for activities with seasonal landscapes and flood detention gardens. In addition, special measures of purification are taken to transform the original slope terrain prone to dispersion in water flowing with an utterly low ratio of rainwater into a terrace, thus facilitating the absorption and purification of rainwater. On the terrace, solar radiation helps to promote the light-driven conversion of pollutants, whereas sand facilitates physical adsorption and purification. Moreover, the roots of plants are used to further absorb and convert the pollutants (Figure 6).

4.4. Strategy for Plant Growing and Restoration. Phytoremediation refers to the method of plant extraction and phytostabilization to enhance the capabilities of plants in absorbing heavy metals, or the utilization of plant roots and their secretions to accumulate, precipitate, and convert heavy metal pollutants for minimizing the activity and toxicity of such pollutants [14, 40, 41]. At present, this approach is regarded as the most widely used technology with the lowest cost and no secondary pollution. Moreover, measures are taken to enhance the effect of phytoremediation, including but not limited to the agronomy, chemical induction, and inoculation of rhizosphere microorganisms, so as to impose an impact on the biomass of enriched plants and to improve the absorption capacity of heavy metals. In terms of the selection of hyperaccumulator plants, it is recommended to opt for plants with efficacy in such areas as the resistance to water and humidity, capacity of absorbing heavy metals, release of fungicides, prevention of noise and dust, fixing of carbon, and reduction of soil salinity. The main tree species used are *Platanus acerifolia*, *Cedrus deodara*, *Platycladus oricentalis*, *Tamarix chinensis*, *Albizia julibrissin*, and *Ulmus pumila*. The main use of herbal enrichment plants is Bidens pilosa, palm grass, Sedum Alfredia Hance, leaf bud rat ear mustard, and Pteris Nervosa.

4.5. Strategy for Ecological Restoration of the Ash Pit. As the core node of the whole planning and design, the damaged mining area will be repaired from the "scars" of the city to the "landscape" of the city. First, the survey is conducted and measurements are made of the ash pit as a whole, whereas the sketch of its overall shape is drafted accordingly. Based on the sketch, overall planning of layout is conducted on the establishment of water supply and drainage facilities as well as the planting of vegetation, whereas the partial excavation is carried out accordingly (Figure 7(a)). Next, the ash pit is filled with fly ash, which facilitates the management of open pit disasters and lowers the requirements for capital input at the same time (Figure 7(b)). Subsequent to the filling of fly ash, a layer of guest soil is laid on top to lower the concentration of pollutants in the soil while minimizing the contact of pollutants with plant roots. At present, this approach is widely adopted in numerous countries with evident effects (Figure 7(c)). Moreover, the site is leveraged to shape the terrain, collect rainwater, and set up the water supply and drainage facilities, thus guaranteeing the irrigation of plants in subsequent stages (Figure 7(d)). The compound treatment approach is adopted in plants and microorganisms for degrading and eliminating environmental pollutants. Given that this approach consumes less energy, has little environmental damage, and incurs lower costs, it is suitable for pollution treatment in a large area

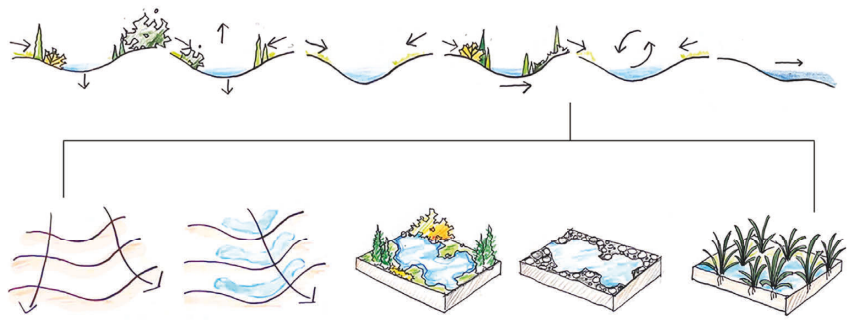


Figure 6: Strategy of sponge city (illustrated by the author).

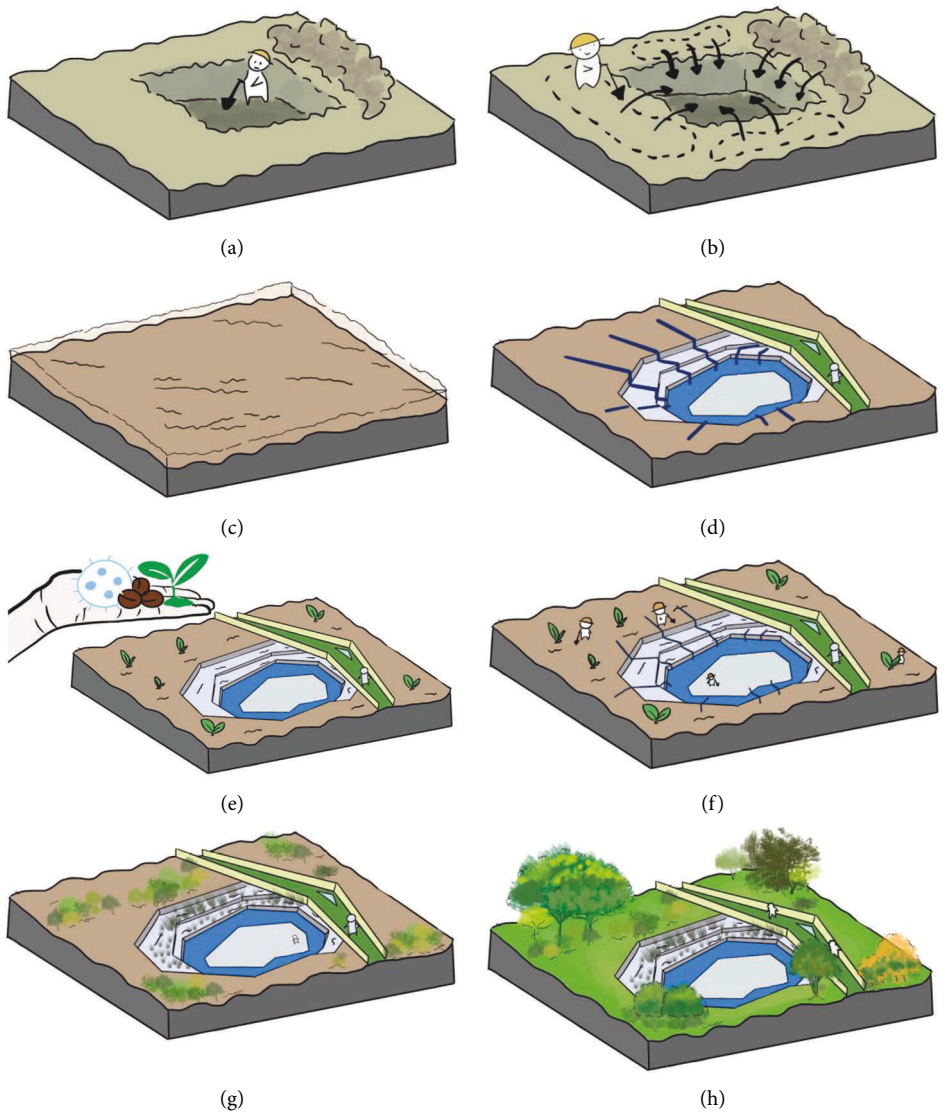
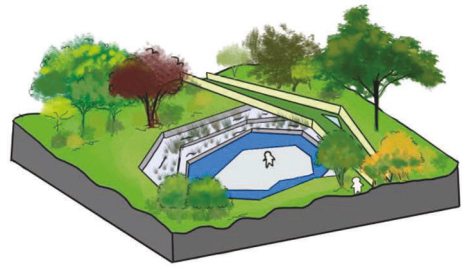


Figure 7: Continued.



(i)

Figure 7: Strategy for the ecological restoration of the ash pit from A to I (illustrated by the author).

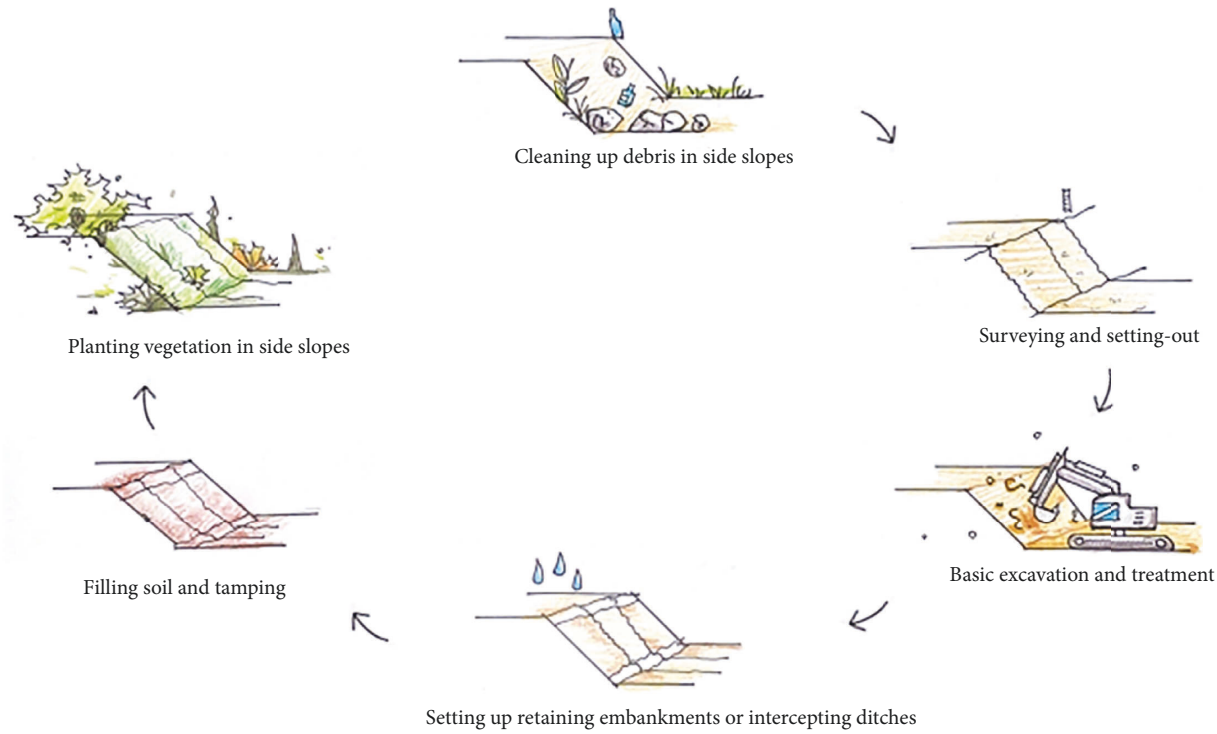


Figure 8: Mind map on the strategy for slope restoration (illustrated by the author).

(Figure 7(e)). Last but not least, we carry out local soil remediation and artificial intervention planting in the remediation area to make its natural resistance work, gradually expand the green spots, and build relevant prevention infrastructure to prevent repollution (Figure 7(f)). In terms of the effects shown in the restoration of the ash pit, the growth of herbaceous plants can be seen in the short-term; growth of shrubs can be seen in the mid-term, whereas the layers of arbors, shrubs, and grass can be gradually formed in the long term (Figures 7(g)–7(i)).

4.6. Strategy for Slope Restoration. In this study, the methods of soil engineering and vegetation planting are adopted to stabilize the slope. First, a detailed survey is conducted to figure out whether there are potential hazards undermining the stability of the slope, including but not limited to collapse, falling rocks, mudslides, landslides, water gushing, and caverns, and then the debris is cleaned up on the surface of the slope in advance so as to ensure that the slope is generally flat for vegetation restoration [42]. Second, efforts are made to review the measurement of the layout plan, to design a proper slope, and to excavate planting holes, whereas the retaining embankments or intercepting ditches are established outside the top slope to prevent surface water from scouring the slope. Last but not least, vegetation is planted on the soil-filled slopes, whereas those tree species with well-developed roots, vigorous growth, and strong resistance to disease are selected to facilitate soil and water conservation while improving the ecological landscape. The roots or stems of vegetation planted at varying positions on the slope are used to reinforce and stabilize the slope. Such vegetation is expected to help intercept rainfall, control soil erosion, promote water circulation in soil, facilitate the growth of plants, and maintain biodiversity (Figure 8).

5. Conclusion

Strategies related to ecological restoration are vital measures for speeding up the building of ecological civilization. During the construction of urban country parks, it is required to take into account the changes taking place in environmental factors and to properly formulate the schemes for ecological restoration while referring to the local ecosystem. Such measures will enable the restoration of the ecosystem from the structural to the functional aspects [43]. Compared with foreign countries, the ecological restoration of urban country parks in Chinese cities still lacks systematic and holistic guidance in terms of ecological theories, has limited practical experience in relevant fields, and is faced with numerous problems.

Judging from the perspective of ecological civilization built upon a sound ecosystem, this study centers on the overall layout and design of the ecological restoration of the site. Based on the spatial features and attributes as well as the shaping of the topography of the site, we intend to create such facilities as road systems, landscape nodes, and infrastructure to enrich the recreational entertainment of the site. In addition, we have adopted numerous strategies of ecological restoration to improve the ecological environment of the site, so as to enhance the mutual complementarity of ecological civilization and ecological restoration. Therefore, in light of the issues taking place in varying regions, we need to opt for corresponding technologies of restoration to build an urban ecological country park with green, diversified, leisurely, and health-promoting features. With these attributes, we aim to enhance the sense of engagement and experience and maintain the sustainability, stability, and continuity of ecosystems in the country park, so as to gain the benefits of ecological services at varying levels.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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