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A Preliminary Study on Industrial Landscape Planning and Spatial Layout in Belgium

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Abstract: As the material carrier of industrial heritage, industrial landscape planning integrates industrial heritage, post-industrial, and industrial tourism landscapes. In this study, we define the concept of industrial landscape planning. As a subsystem of urban planning, we study industrial landscape planning by using the theories and methods of urban planning. As an example, we consider Belgium and identify the main categories of industrial landscape planning as industrial heritage landscape and industrial tourism landscape. We use an ArcGIS spatial analysis tool and kernel density calculations and reveal the characteristics of four clusters of industrial heritage spatial layout in Belgium, which match its located industrial development route. Each cluster has unique regional characteristics that were spontaneously formed according to existing social and natural resources. At the level of urban planning, there is a lack of unified re-creation. Urban planning is relatively separated from the protection of industrial heritage in Belgium.

Keywords: cultural heritage; industrial landscape planning; industrial landscape; urban planning; post-industrial landscape; industrial tourism; industrial heritage; spatial layout; spatial distribution; spatial structure

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1. Introduction

Throughout the history of urban development, a large number of industrial heritages have been left. As an important material carrier in the era of industrial civilization, industrial heritage represents the evolution of human civilization and cultural development. It is an important historical witness of humans entering industrial civilization from agricultural civilization. Industrial heritages are valued throughout the world due to their historical and cultural significance, as well as the knowledge, scientific and technological, economic, and artistic values they possess [1]. Among them, industrial heritage landscape is a special kind of cultural heritage in urban planning [2] as a concept that has been influential in the field of urban planning. With urbanism, the landscape of industrial heritage, which carries the industrial memory, is gradually disappearing and being destroyed. However, there are limited studies that have focused on industrial heritage landscape, especially its intrinsically logical relationship with the specific meaning of industrial landscape planning. To date, studies on industrial heritage in urban planning and cultural heritage have mainly focused on architecture [3], tourism management [4], sociology [5], cultural heritage [6], and other specific cases of transformation analysis and application [7–9]. Most studies on industrial heritage landscape have individually aimed at investigating regeneration [10], design [11], strategy [12], analysis [13], and other relevant fields [14,15]. Studies on industrial heritage in the field of urban planning and cultural heritage protection are relatively rich, and the scope of research is also deepening, however, there are no studies on the concept of industrial landscape planning. Additionally, there is a lack of specific application of the concept of industrial landscape planning in urban planning, and therefore, this needs to be further explored.

Before mid-19th century, the industrial revolution began in Britain, followed by Belgium as a traditional industrial country in Europe [16]. The industrial revolution promoted Belgian cities into the era of the modern industrial period. Along with an industrial upgrade, the development of industries in Belgium flourished, making Belgium the most developed industrial country, with abundant industrial category structures, a huge market, and a large number of industrial facilities distributed on the European continent [17]. In addition, the industrial revolution promoted expansion of Belgian cities and brought about reforms in urban morphology and scale. After an extraordinary expansion in industrial redevelopment and urbanism, extensive industrial heritages now exist in Belgium. These industrial heritages create challenges for urban development and carry the cultural context of a city, which is of great research value. However, limited studies have focused on industrial heritage conservation and renewal in Belgium [18,19], especially from the perspective of industrial landscape planning. As one of the material carriers of industrial heritage in Belgium, it is of great practical significance to strengthen the study of industrial landscape planning and to therefore strengthen the protection of the industrial heritage. In view of this, and based on the theory of industrial landscape planning, in this study we use quantitative geography and ArcGIS spatial analysis technology to analyze the spatial geography of the Belgian industrial heritage projects in the list of the European Route of Industrial Heritage, from the perspective of landscape architecture to reveal the distribution characteristics of its industrial landscape and types of industrial heritage manifestations, and then to describe in detail the formation background to provide a relevant reference for the protection and reuse of Belgium's industrial heritage.

2. Research Aim

In this study, first, we review the literature and analyze the topic of industrial landscape. Then, we describe the formation of industrial landscape planning; the internal and external connections between urban planning; and the range of industrial landscape planning in industrial heritage, post-industrial, and industrial tourism landscapes. We conduct a vertical and horizontal analysis of the relationships among the three. After this, we analyze and evaluate our findings in industrial landscape planning in Belgium.

3. Industrial Landscape Planning

Industrial landscape planning is included in the concept of landscape; therefore, in this study, we discuss it under this premise. Before the beginning of the industrial revolution, landscape was mainly regarded as an aesthetic object, which was the research object of landscape poetry, landscape painting, and landscape architecture, etc. [20,21]. After the beginning of the industrial revolution, with a significant increase in social material wealth, a unique cultural temperament, namely industrial culture, was formed. Under this premise, urban landscape that represents industrial culture became an industrial landscape [22,23]. The industrial landscape as a human activity traces the material bearing of the architectural heritage, this study mainly involves the semantic of landscape architecture contained in the term landscape.

The term planning refers to the development vision of integrating multiple elements in a specific field. The elements of the industrial landscape do not exist in isolation. The combination of these two terms constitutes the industrial landscape planning, which shows that from the perspective of time scale, it focuses on the long-term, from the perspective of content, it focuses on the strategic level, and the guidance of principle.

3.1. The Features of Industrial Landscape

Industrial landscape refers to the external environment of an industrial plant including a single building, which has more advantages than the indoor space of industrial buildings, such as broad vision, sufficient light, fresh air, as well as a continuous and changing natural landscape. The external spaces of industrial buildings can be regarded as second spaces for production and life, which are interdependent with the internal spaces and complementary

to each other [24]. With the advent of the post-industrial era, the ecological concept of urban construction has been strengthened. The design of industrial landscape has remained at the enterprise plant beautification, environmental greening level, but it has also gradually become a type of landscape [25]. The quality of an industrial landscape environment is an aesthetic problem and is also related to the cultivation of sentiment, improvement of health, improvement of efficiency, improvement of product quality, and measurement of scientific management level [26]. In view of the destructiveness of industrial activities to nature, designers and researchers of industrial landscape reasonably plan and use landscape ecological design principles to design according to the production process of sustainable development and industrial building standards and to therefore reduce industrial production destruction of nature. This requires more in-depth design and research in industrial landscape in order to create a better urban living environment.

3.2. The Categories of Industrial Landscape Planning

3.2.1. Industrial Heritage Landscape

Initially, when landscape first appeared in the field of industrial heritage, it was a technical word [27], and industrial heritage landscape was understood to be the spatial practice activities related to industrial production as well as its process and results [28]. Similar to cultural landscape, an industrial heritage landscape reflects the relationships among industrial production facilities, such as machines, architecture, and nature. This triangular relationship that industrial heritage landscape has with industrial culture and civilization includes industrial production information and facilities and the entire industrial memory [29]. In this study, it mainly refers to the new functions, contents, and meanings that designers give to industrial cultural relics with historical, technical, socially significant, architectural, or scientific research value, and the characteristics of the transformed landscape are closely related to the times and social development [30].

3.2.2. Post-Industrial Landscape

Following the development of an industry, a post-industrial landscape appears when old industrial facilities are transformed or upgraded [31]. In this study, a post-industrial landscape generally refers to the a new landscape that is designed and constructed as the main elements of the landscape after the industrial production activities stop, and all kinds of industrial facilities, surface traces, and waste left on the industrial wasteland are retained, renewed, or artistically processed [32]. These industrial facilities cover all kinds of facilities related to industrial production, mainly including production facilities; storage facilities; transportation facilities; and other infrastructure, management, and public service facilities, including all kinds of workshops, warehouses, power transformation and distribution stations, boiler rooms, etc. [33].

3.2.3. Industrial Tourism Landscape

Industrial tourism landscape mainly refers to tourism facilities landscape with industrial facilities as the material carrier. At the end of the 19th century, American industrial enterprises took factory visits to appreciate the charm of modern industrial production as a means of publicity and it gradually became the rudiment of industrial tourism [34].

In the middle of the 20th century, with European countries stepping into the post-industrial era, industrial tourism, as a kind of "nostalgic landscape", transformed many industrial heritages of "rust belt" into Renaissance assets with tourism value [35,36], which has become an important way for European industrial cities to realize economic transformation and an urban renaissance. At the end of the 20th century, with increased interest in sustainable development, industrial tourism has been interpreted as a new green ecotourism [37].

In these industrial enterprises, industrial facilities have become landscapes and progressively evolved into tourism products, factories have begun to have dual economic benefits as secondary and tertiary industries and have therefore optimized the industrial

structure of the city. In this study, the industrial tourism landscape mainly refers to the market demand for industrial resources to attract industrial resources into tourism landscape resources and the development of comprehensive tourism landscape products, most of which involves modern planning and design for the construction of new industrial facilities [35,37,38].

3.3. The System of Industrial Landscape Planning

Industrial landscape planning is a new concept, and currently, in academia, there is no clear consensus on its definition. In this study, based on a review and analysis of the relevant literature, we defined industrial landscape planning as a system that includes industrial heritage, post-industrial, and industrial tourism landscapes (Table 1) [39,40], which are elements that are not isolated from each other. For industrial landscape planning to function effectively, it should have the characteristics of systematicness, integrity, continuity, dynamic stability, versatility, and regionality. Systematic planning and orderly development and construction are necessary in order to achieve the function of industrial landscape planning to the greatest extent, and therefore, the natural landscape of an industrial landscape and social civilization simultaneously integrate the resources and space of a city. They are described as a whole planning system.

Table 1. The internal relationship of the industrial landscape planning.

Item	**Industrial Landscape Planning**		
	Industrial Heritage	**Post-industrial**	**Industrial Tourism**
Cause for emergence	Industrial production	Urban regeneration	Economic transition
Character	Conserve the appearance of the building, renew the internal	Conserve the essence part, rebuild the rest in the modern landscape	New cases are the main ones and renewal is the second
Core	Memory retention	Landscape priority	Market orientation
Foothold	Museums, exhibitions, art galleries, memorials, etc.	Children's Park, creative park, office building, Science Park, etc.	Factory visit, enterprise introduction, production process science popularization, etc.
State	Stopped production	No production function	Maintain production

3.4. The Relationship between Industrial Landscape Planning and Urban Planning

The methods and disciplines in urban planning are continuously changing. Beginning with the industrial revolution, urban industrial structures have been considered to be important elements in urban spatial structure planning. Following the disordered development of industries, natural and urban environments were rapidly damaged. Society has gradually realized the importance of eco-friendly space and landscape [41], and therefore, sustainable development in urban planning has become a trend. Sustainable development aims to reuse urban areas and to more effectively use building sites [42]. Industrial landscape planning is a form of sustainable development that has a set of overlapping goals, for instance, energy consumption, pollution reduction, protection of natural areas, etc. From environmental protection to the cross-disciplinary aspects of sustainable development, in the mainstream, each element in urban planning does not exist in isolation, including industrial landscape planning (Figure 1) [18,43,44]. Industrial heritage protection is related to urban context, and its development focuses on urban function and space. By studying the industrial landscape in overall urban planning and discussing protection and development from the perspective of industrial landscape planning, it is possible to achieve a sustainable industrial landscape and urban industrial context resources can be formed. To protect industrial heritage, we need to consider industrial landscape planning in the context of urban planning, and at the same time, urban planning must be taken into consideration; the

two complement and can benefit each other. They need to function together systematically with integrity and continuity. Architects practicing industrial landscape planning should consider urban planning and vice versa. The two should be integrated through planning for orderly construction to create an industrial landscape in natural and human landscapes with organic unity.

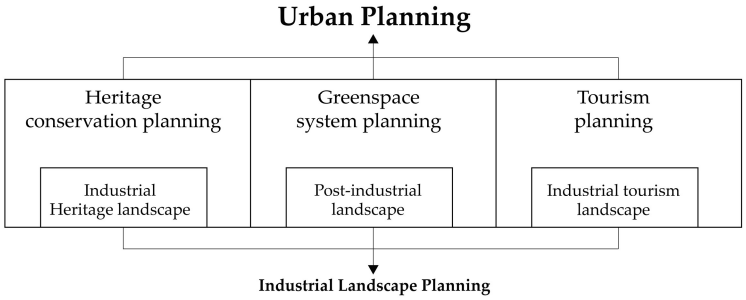

Figure 1. The internal logical relationship between industrial landscape planning and urban planning.

3.5. Exploring the Path of Industrial Landscape Planning

The purpose of industrial landscape planning is to conserve and rejuvenate the culture of industrial heritage; then, the concrete elements of industrial landscape can develop with harmony and sustainability. More specifically, first, existing industrial heritages are conserved. Second, the relationship between abandoned industrial facilities and present industrial facilities is coordinated to complete the integration of industrial heritage conservation and modern urban space demand. Third, effective industrial landscape planning with urban spatial planning results in an industrial landscape that inherits the culture of the industry and urban growth development at the same time (Figure 2).

Figure 2. The principle of industrial landscape planning.

The historical context of industrial heritage and its planning and protection is one of the important branches of cultural heritage protection. However, in specific planning, there are contradictions between protection and development. Therefore, a specific path in industrial landscape planning cannot be generalized and predefined but should be classified according to a specific situation. Planners need to evaluate current industrial heritage landscapes; to establish a comprehensive evaluation system of the historical, cultural, social, scientific and technological, artistic, aesthetic, location, and tourism values that they possess; and to therefore determine the value level of these industrial heritage landscapes. By combining spatial layout and the functional aspect of industrial landscape planning, an industrial heritage landscape with a higher value level can be protected and reused, whereas one with a lower value level can be appropriately transformed or demolished to provide spare construction land for a city.

4. Spatial Analysis for Industrial Landscape Planning in Belgium

The purpose of industrial landscape planning is to protect and revive the landscape culture of urban parks, so that the elements of industrial landscape can coexist harmoniously and develop sustainably in a city. The principles of industrial landscape planning are as follows: (1) to protect the present industrial heritage of a city; (2) to consider the relationships among industrial heritage, post-industrial, and industrial tourism landscapes; (3) and to complete the integration of industrial heritage protection and modern urban

planning needs. Implementing industrial landscape planning with urban space planning involves continuous development of the industrial landscape, revitalized in the context of an urban park and, at the same time, carried out reasonably and orderly with the development and construction of a city.

Surveying and analyzing the details of an industrial landscape is the foundation for further studies on industrial landscape planning. Specific guidance for illustrating the layout of industrial landscape planning could include the following:

1. Surveys that follow relevant surveying methods, such as field exploration, basic data collection, and analysis.
2. An analysis that includes the development path of an industry, the variety of elements of an industrial landscape, etc.
3. According to background material collection, a summary of the features and challenges of the industrial landscape and an illustration in the industrial landscape status atlas.

4.1. Research on the Present Situation of Industrial Landscape Status in Belgium

Starting in 1802, the first industrial revolution process began in Belgium and resulted in an extraordinary growth of industry in Belgium during this period, which followed a fluctuating path of development with periods of acceleration, peak points, slowdowns, and the ending, demonstrating that the law of development is dynamic [45]. This feature has determined that the industrial abandoned sites in Belgium are separated broadly with a variety of conditions and categories. With the economic transformation and the prevalence of the concept of sustainable development, because of society's limited knowledge about the value of industrial heritage, a large number of industrial facilities have disappeared completely in the process of relocation and industrial upgrading [46]. Therefore, in Belgium, only a few sites remain and have been conserved and renewed properly based on the sites of the European Route of Industrial Heritage. In this study, we conducted a statistical analysis and classified the existing industrial heritages in Belgium for industrial landscape planning.

The survey results show that heavy industry holds the main position in the current situation of industrial landscape planning, which matches the industrial history in Belgium. Heavy industrial heritage facilities have been featured in the occupation of huge territories, closed spatial structures, etc. They are an independent functional part of a city zone, comparatively. After the sustainable concept was raised, these sites have become one of the main targets that should be improved and regenerated in cities [47]. According to the survey results, a limited number of heritages belonged to the range of the post-industrial landscape. Instead, most of the sites belonged to the modern industrial tourism landscape, and they were all built from industrial heritages. With the help of Google geographic coordinate picker and Google Earth, the industrial heritage of Belgium was calibrated, and we established a spatial database of Belgian's industrial heritage landscape. Combined with the relevant theory of industrial landscape planning, the spatial distribution map of industrial heritage in Belgium was generated (Figure 3). In this map, the site distribution of Wallonia is more than that of Flanders and that of Brussels (Table 2). The industrial heritage landscape is mainly distributed in Wallonia, which is also more than that in Flanders.

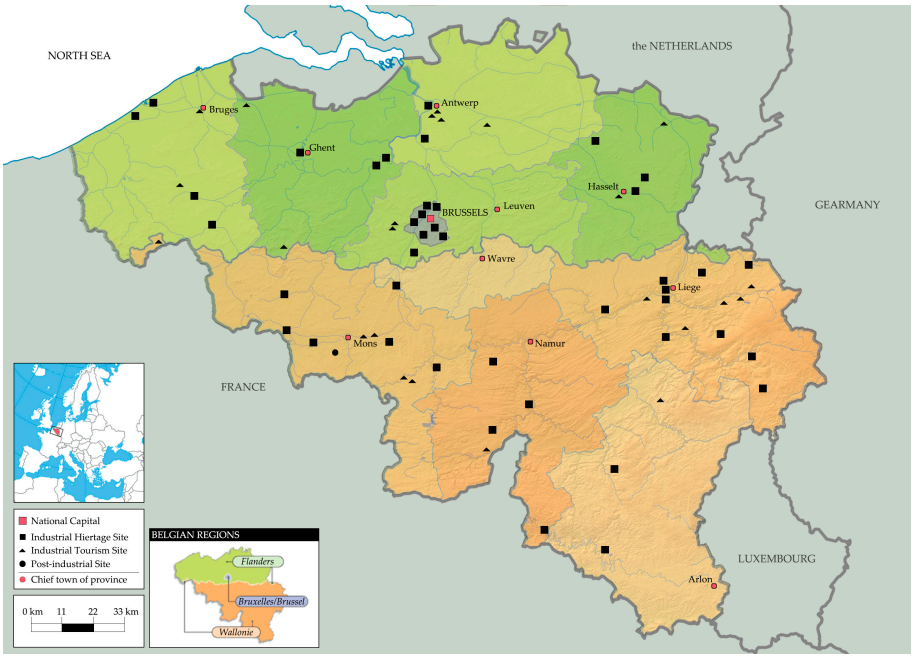

Figure 3. The industrial landscape distribution map of Belgium.

Table 2. The industrial landscape distribution in each region in Belgium.

Region	Number in Total	Industrial Heritage	Post-Industrial	Industrial Tourism
Flanders	24	13	-	11
Wallonia	35	21	1	12
Brussels	7	7	-	-
Total	66	41	1	23

4.2. Functional Planning of Industrial Landscape Planning in Belgium

Functional planning is a method of function transfer and industrial upgrade for industrial landscape [48]. It mainly focuses on the elements of industrial heritage in the categories, existing status, land territory, location, community status, etc. Specific industrial heritage landscape functional planning needs to be based on its actual situation, in line with the requirements of an urban master plan, green space system planning, and other upper planning [49,50]. The main paths are as follows:

- For the industrial heritage landscape, industrial heritages with large land occupation, abundant existing relics, and superior natural and community resources have a high class of possibility for transferring function. In this situation, a synthetic construction model is adopted, combining industrial heritage conservation and territory spatial planning.
- For the industrial tourism landscape, if the existing remains of the industrial heritage landscape resources are abundant and running well, the main types of remains are industrial buildings or facilities, which can transform their functions into indoor architectural landscapes such as cultural exhibitions and museums, tourism activities and production are running together harmoniously.
- For the post-industrial heritage landscape, industrial heritages of municipal public facilities such as stations, with special commemorative significance and quarries, which are mainly open-air industrial equipment heritages, can be transformed into parks and squares with a post-industrial landscape architecture form.

4.3. Case Studies of Industrial Landscape Planning in Belgium

In order to combine the principle of industrial landscape planning with the case study, this study selected three representative cases to verify the theoretical research according to the existing Belgian industrial landscape sites, aiming at the different characteristics of industrial heritage landscape, industrial tourism landscape, and post-industrial landscape and applies the results of theoretical research to provide guidance for the case study.

- The representative case of industrial heritage landscape is the Blegny-Mine museum in Liege (Figure 4) [51]. That is one of the four major mining sites of Wallonia recognized as UNESCO world heritage was transformed by the former Argenteau-Trembleur [52]. The feature of its industrial heritage landscape is this setting lies in the conversion into a leisure center and the preservation of the two pits from different periods, and one gives access for the visitors to the underground galleries on the levels −30 to −60 m [53]. These industrial heritage landscape facilities give visitors a special immersive experience.
- The representative case of industrial tourism landscape is the Tramway Lobbes in Thuin (Figure 5) [54]. That is a rural railway discovery center, with a locomotive exhibition and light railway system that served rural Belgium from the late 19 century. The rural railway system is still running not only for tourism but also for commuting, and tourists can take its tramcars through the picturesque wooded countryside, passing the notable church, gardens, and a belfry at Thuin [55].
- The representative case of industrial heritage landscape is the "PASS" Science Adventure Park in Mons (Figure 6). That is a modern science adventure park transformed by a colliery complex. Inside the park, all the industrial facilities were redesigned and renewed, the internal facilities were transformed into a science theme gallery for education, and external facilities were transformed into a landscape architecture park for leisure. Permanent and temporary exhibitions on scientific and artistic themes are located in ultra-modern buildings and grass plots, and special events are held on the site throughout the year. Compared with the Blegny-Mine, the post-industrial landscape of 'PASS' pays more attention to the creation of landscape architecture parks and theme parks for the purpose of leisure. The original industrial legacies are mainly material carriers for modern design, not for retaining.

Figure 4. The former mine passage is now an experienced facility in Blegny-Mine.

Figure 5. A railway system still in use for commuting and tourism in Thuin.

Figure 6. Open-air children's play facilities in 'PASS' Science Adventure Park.

4.4. Spatial Layout of the Industrial Landscape Planning in Belgium

An in-depth analysis of the spatial distribution characteristics and overall pattern of Belgium's industrial landscape provides a comprehensive understanding of the survival status of Belgium's industrial heritage and provides some reference for the protection and utilization of industrial heritage. In order to find out the mutual laws of industrial heritage in Belgium, this study obtained the spatial distribution characteristics of the industrial landscape in Belgium with the help of kernel density operation model in ArcGIS software (Geographic Information System Company, Environmental Systems Research Institute, West Redlands, CA, USA) (Figure 7).

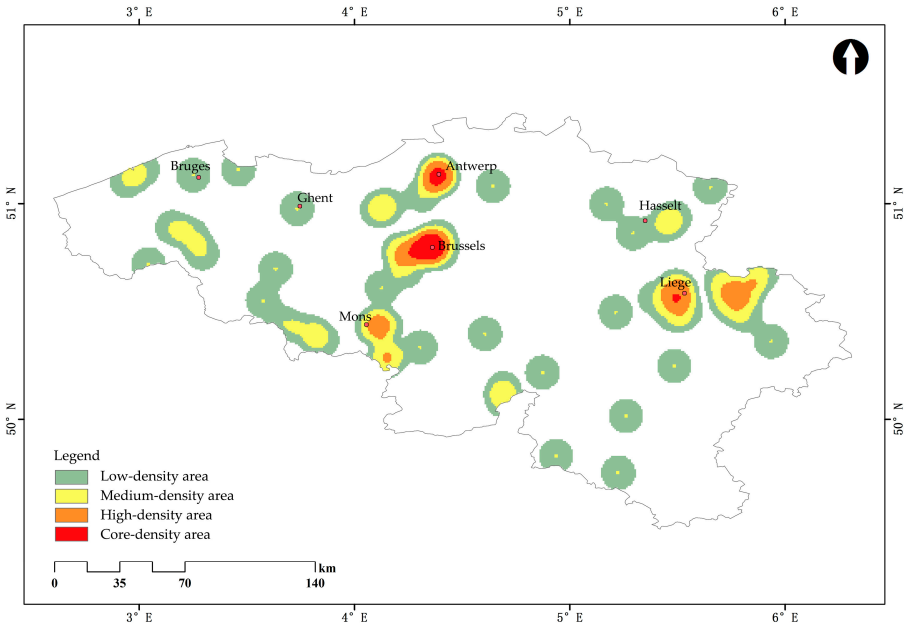

Figure 7. Spatial layout of industrial landscape in Belgium.

The spatial layout of industrial landscape planning should conform to the main direction of urban spatial development as well as the regional industrial spatial layout and should be considered in coordination with tourism planning and urban green space planning [56]. On the basis of the characteristics of the current industrial landscape distribution in Belgium, the spatial structure planning theory is applied to promote the development of surrounding areas and the overall upgrading of industrial communities [57].

Belgium is located in the northwest of the European continent; it is a country with abundant mountain and river resources. Due to its abundance of natural resources, it has an excellent natural environment for a heavy industry foundation [58]. When the first modern factory was constructed in Searing, the industry in Belgian expanded rapidly, especially, machinery in Liege, coal in Mons, textiles in Ghent, the port in Antwerp, and service in Brussels. With the introduction of the machine textile industry, the industry started to develop in the Flanders region; then, due to the development of the mining industry, the industrial center began to shift towards the Wallonia region. Finally, with the rise in manufacturing and processing manufacturing industries, the focus of development began to return to the Flanders region. The regional characteristics of industrial heritage are very obvious. Overall, industrial heritage appears in clusters in Belgium [59] and is consistent with the spatial layout of industrial landscape in Belgium.

However, due to the lack of unified planning, these industrial landscape resources are not effectively integrated together. As a result, Belgium, which has excellent industrial culture, has not formed such a famous cultural card as the Ruhr district in Germany.

5. Discussion

Industrial heritage, industrial tourism, and post-industrial landscape constitute the theoretical framework of industrial landscape planning, based on theoretical exploration. The three categories of the industrial landscape are different forms of industrial heritage protection. They are in the same time and space sequence, but the forms of transformation and reuse are different. Combined with case studies, this study finds that the distribution of the industrial landscape in Belgium is extremely unbalanced, which limits the brand building of the industrial culture. The existing resources are mainly belonging to the industrial heritage and industrial tourism landscape, and the post-industrial landscape is extremely scarce, which also reflects the lack of vitality of current urban construction in Belgium to a certain extent. From the perspective of industrial landscape planning, we propose three points of guidance for its application:

- The post-industrial landscape projects can be added to the core area of the city, which not only increases the open-air space for the city but also provides citizens with modern public parks for leisure. It retained the industrial culture, also in line with the concept of sustainable development of green development.
- The development of industrial heritage landscape projects in the suburbs can protect and utilize the abandoned industrial heritage, meanwhile stimulates the economic vitality of the surrounding communities with lower costs but gain higher benefits.
- The industrial tourism landscape projects in the outer suburbs can bring tourists an industrial tourism experience, while also minimize the negative impact of industrial production on urban life.

In terms of specific projects, Belgium is the country with the densest railway lines in Europe, and its railway system can be a significant advantage of its industrial culture. Unfortunately, this advantage has not been fully utilized at present. Although Belgium has a large number of industrial landscape resources, but its spatial distribution is relatively scattered. In future regional planning, we can take the landscape resources of the location into consideration, combine with various regions and various types of industrial landscape resources, balance the allocation of resources from the regional planning level, and create a cultural card of industrial landscape belonging to Belgium through comprehensive protection.

6. Conclusions

Industrial landscape planning plays an important role in urban planning and heritage protection, but there is no general and comprehensive understanding of it. In this study, we defined the concept of industrial landscape planning, discussed its internal and external relations with urban planning, and explored its application. We analyzed industrial landscape planning from macroscopic, systematic, and comprehensive aspects to identify industrial heritage, post-industrial heritage, or industrial tourism landscapes. The core issue was to deal with the protection and development. The different stages of development and different forms of presentation are interrelated and interdependent.

In this study, we considered Belgium as an example and provided an overview of its industrial landscape planning and spatial distribution characteristics, then did case studies with theoretical principles. Industrial landscape planning in Belgium is highly matched with its industrial development route. Most of the landscape projects of industrial heritage, post-industrial heritage, and industrial tourism were built on its located industrial resources. The scatter plots show strong regional aggregation and spatial distribution characteristics of four clusters. The main industrial heritages of each region are consistent with Belgium's historical course; meanwhile, all of the natural and cultural resources are reflected in Belgium's regional characteristics. However, the scatter plots also highlight the lack of a unified layout at the urban planning level for the protection of the industrial landscape in Belgium. Each cluster and each landscape type are relatively independent. It is necessary to take industrial landscape as a special type of urban planning from the macro, systematic, and overall perspective. For specific promotions, to enhance the brand of Belgium's industrial culture and urban renewal and community building, we need to make a unified deployment of Belgium's industrial landscape projects from the urban planning level, promote the post-industrial landscape projects in the core area of the city, promote the industrial heritage projects in the suburbs, and promote the industrial tourism projects in the outer suburbs, meanwhile focusing on key areas such as railway industry. This study only starts from the current situation of industrial landscape planning and provides a general description of functional planning, spatial structure layout, and context protection planning. Industrial landscape planning still needs more detailed studying and practice.

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