



# Landscape Regeneration of Urban Industrial Heritage Sites Towards the Human Factors Perspective: Perception and Assessment

**Mengyixin Li**

The School of Architecture and Urban Planning, Faculty of Landscape Architecture, Beijing University of Civil Engineering and Architecture, Beijing, China

**Email address:**

limengyixin@bucea.edu.cn

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**Abstract:** Urban industrial heritage sites activated through conservation and reuse have been considered to play a vital role in urban landscape, and they can be effectively transformed into public spaces extensively exploited by urban residents. The regeneration of urban industrial heritage has been increasingly discussed from the perspective of landscape worldwide, thus laying a solid basis for this paper. In general, by reviewing the evolving understanding of industrial heritage, this paper analyzes post-industrial landscape and urban industrial heritage as historic urban landscape. On this basis, three crucial aspects are proposed in order to conclude the essence of urban industrial heritage and existing problem of research on the landscape regeneration of post-industrial sites. Most importantly, the study relating to human-environment interaction on renewed sites based on the quantitative method has aroused less attention of professionals. Accordingly, the new interdisciplinary exploration of landscape architecture and human factors has been triggered, thus shifting the views from professionals' subjective planning and design to individuals' objective perception and assessment with the use of bio-sensory techniques. Lastly, through the quantitative and qualitative analysis, the whole process and tendency of landscape regeneration of urban industrial heritage sites with recommendations for the future relevant research are creatively indicated to provide valuable reference for the further exploration of post-industrial landscape.

**Keywords:** Urban Industrial Heritage, Post-industrial Landscape, Landscape Regeneration, Environmental Perception and Assessment, Bio-sensory Techniques

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## 1. Introduction

The existing sustainable urban regeneration and redevelopment are entering a novel stage with inventory planning and design as the leading paradigm. At this above stage, from the perspective of landscape, the regeneration of urban industrial heritage sites evolving around the conservation and reuse has created an enormous opportunity to stimulate the shape of emerging public spaces. According to the professional discourse of landscape architecture and architecture, the urban industrial heritage that has developed over the recent decades has been considered an instrument for the sustainable development of all societies [1], as well as a catalyst in urban regeneration [2].

As demonstrated by several relevant studies, the discussion relating to the landscape regeneration of urban industrial heritage sites has been conducted in architecture, landscape architecture and urban design. However, it is difficult to develop an interdisciplinary perspective to expand novel research contents. In this respect, this paper in the landscape architecture is conducted based on the human factors to creatively investigate the objective perception and assessment of renewed urban industrial heritage sites in a bottom-up manner. As a result, the quantitative analysis and scientific findings of the landscape regeneration of urban industrial heritage sites will be promoted to a certain extent.

## 2. The Review and Analysis of Urban Industrial Heritage

### 2.1. Industrial Heritage: The Perspective of Landscape

In the 1960s, the concept of industrial heritage was proposed in Western nations. With the increasing number of industrial heritage in the world's cultural heritage, a wide variety of relevant studies have aroused extensive international attention, thus promoting the evolution of industrial heritage concept conceived from the perspective of architecture to urban landscape. On that basis, the conceptual transformation creates more possibilities for the regeneration of urban industrial heritage sites.

#### 2.1.1. The Renewed Concept of Industrial Heritage

In 2011, TICCIH readjusted the concept of industrial heritage and declared that industrial heritage comprises sites, structures, complexes, areas and landscapes as well as the related machinery, objects or documents evidencing past or ongoing industrial processes of production, their transformation into goods, as well as the relevant energy and transport infrastructures. Industrial heritage indicates the profound connection between the cultural and natural environment [3].

It is therefore indicated that the renewed understanding of industrial heritage highlights the multi-layered site information including architecture and landscapes, which could be recorded, analyzed and conceived by architects and landscape architects.

#### 2.1.2. The Exploration of Post-industrial Landscape

Since the renewed concept has been grasped by a growing number of scholars, the former president of TICCIH Louis Bergen developed the value of the study of industrial heritage. It promoted professions to recognize the real value of industrial heritage which can be measured within a holistic landscape framework [4]. The perspective of landscape is essentially to fully comprehend the industrial heritage and its conservation and adaptive reuse as shown in Figure 1 [5].



**Figure 1.** Stefano Boeri Associati's Milan 'green river' plan for the landscape regeneration of a series of urban industrial heritage.

Thus, the concept of post-industrial landscape derived

from industrial heritage has aroused worldwide attention. In accordance with European Landscape Convention, landscape is recognized as the object, policy and strategy of industrial heritage conservation, while strongly supporting for the regeneration and redevelopment of post-industrial sites [6].

In the above context, there are considerable studies on the landscape vision of industrial heritage conservation and adaptive reuse in the field of landscape architecture, landscape ecology and land art.

Since the 1980s, a few representatives with diverse ideas have promoted the progress of this field worldwide, for example, Richard Haag, who used ecological technology to realize the transformation of industrial derelicts guided by the interdisciplinary practice (Haag, 1982); Bernard Lassus, who presented two scaled designs based on landscape design methods (Lass, 1998); Neil Kirkwood, exploring the means of green regeneration of abandoned sites through ecological restoration (Kirkwood, 2001); James Corner, practicing the innovation of industrial cultural landscape on the basis of the theoretical framework of 'landscape urbanism' (Corner, 1999); Peter Latz, who took 'landscape structuralism' as his method (Latz, 2017) as shown in Figure 2 [7].



**Figure 2.** Duisburg-Nord landscape park as the renewed urban industrial heritage Site planned through Peter Latz's landscape structuralism.

### 2.2. Urban Industrial Heritage as Historic Urban Landscape

Furthermore, the urban industrial heritage requires a historic and landscape perspective, thus indicating that interpreting the transformative post-industrial landscape as a historic object pertains to a diachronic research and explanatory analysis [8].

Above all, history refers to a way of thinking [5]. As proposed by German landscape architect Peter Latz, the landscape regenerated on urban industrial heritage sites is essentially a history accumulated by multiple layers of 'information', and the 'information density' evolves into the thickness of history in the flow of time [9]. When discussing urban industrial heritage, people require to cross the time dimension and analyze the superimposed forms of buildings, structures and landscapes hierarchically to investigate the correlations of changes in cities. It aims to reveal the evolving

process, and gain fully insights into the reasons for the constant that is often essential, reasonable, high-quality and inherited and the change that is certainly in response to the social, natural and living environment and technological choice.

Moreover, the Historic Urban Landscape (HUL) Recommendation adopted by UNESCO advocates the use of 'landscape method' to re-comprehend and evaluate urban heritage and build crucial bridges between heritage conservation and sustainable reuse as well as urban regeneration [10]. Furthermore, the Recommendation also advocates better integration of urban heritage conservation strategies based on the wider goals of overall sustainable development, to support public and private actions aimed at preserving and improving the quality of the human environment [11].

### ***2.3. Three Crucial Aspects of Urban Industrial Heritage and Landscape Regeneration on Sites***

According to the above argument, three significant aspects can be summarized to indicate the essence of urban industrial heritage and the existing problem of research on the landscape regeneration of post-industrial sites.

According to the vision of landscape, the urban industrial heritage is no longer limited to industrial buildings and remains themselves. Instead, it is more integrated with the natural resources and urban environment elements, human intervention and effects coexisting with industrial heritage in the development of time and space.

The urban industrial heritage acted as historic urban landscape implying highly complex structures, which are an crucial part of the social, spatial, cultural, and technological past [12]. It refers to a crucial link between the past of cities and their sustainable re-development in the future. It leads us to build a dynamic, full-circle thinking from aspect of landscape regeneration.

For landscape and ecology, the existing creative thoughts and methods have always revolved around the place-making of post-industrial sites via landscape planning and design in the process of urban regeneration. In the literature review, it is reported that most scholars are inclined to interpret planning strategies and implementation of post-industrial landscape. However, they seem to pay less attention to the spatial quality assessment of urban industrial heritage sites based on residents' subjective feelings and emotions, as well as the cognization of the emerging public space after the site is reactivated.

In brief, the perspective for future research should be shifted from the scholars' thoughts of planning and construction to the environmental perception and assessment of post-occupancy in real time. The novel exploration of urban industrial heritage sites is expected to be developed.

## **3. The Perception and Assessment of Renewed Urban Industrial Heritage Sites**

### ***3.1. The New Perspective: Human Factors***

Based on the lack of research on the perception and

assessment of renewed urban industrial heritage sites, the perspective of human factors is introduced to follow closely users' feedback of emerging public space in cities, and to discover new scientific methods of quantitative analysis of diverse feelings and judgement of individuals, groups and even communities. Moreover, the perspective of human factors stressing public participation may expedite the change from professionals' subjective ideas to users' real and objective views on renewed sites.

For human factors, engineering psychology based on the theory of human cognitive information processing provides its theoretical foundation [13]. In fact, the human factors advocate the idea of 'user-center design' refers to a cross-combination at the level of 'human relevance' in several fields (i.e., sociology, psychology, physiology, engineering, cognitive science, interaction and visual design, as well as users' experience design) [14]. From the perspective of purpose and methodology, human factors substitute a series of laws of physiology and psychology into the morphological and engineering designs of products, processes or systems, as an attempt to seek more efficient, safer, healthier and better human-centered interface of working and life.

The application of the human factors to human-oriented landscape architecture is becoming a novel type of exploration, facilitating the critical thinking about the weakness of cognition based on subjective experience induction in the planning and design. On the renewed industrial heritage sites, the interplay between people and the environment is concerned. Users' perception, awareness and assessment bottom-up reflecting their demands and preferences will further become important criteria for diagnosing and analyzing the conservation and reuse of urban industrial heritage.

### ***3.2. The Perception of Renewed Urban Industrial Heritage Sites with Bio-sensory Techniques***

The development of cognitive sciences and human factors generates the new understanding of how to measure individuals' experience of urban environment [15]. From the viewpoint of evolution, positive affective responses induced by external information may stem from human's intuitive experiences for survival [16]. By instinct, complex environmental perceptions can be simplified into two dimensions of affective valence and affective arousal, which can be measured by physiological affective indicators [17]. The above two dimensions and related measurement indicators are capable of interpreting people's obscure feelings with knowledge of neural science, cognitive processing.

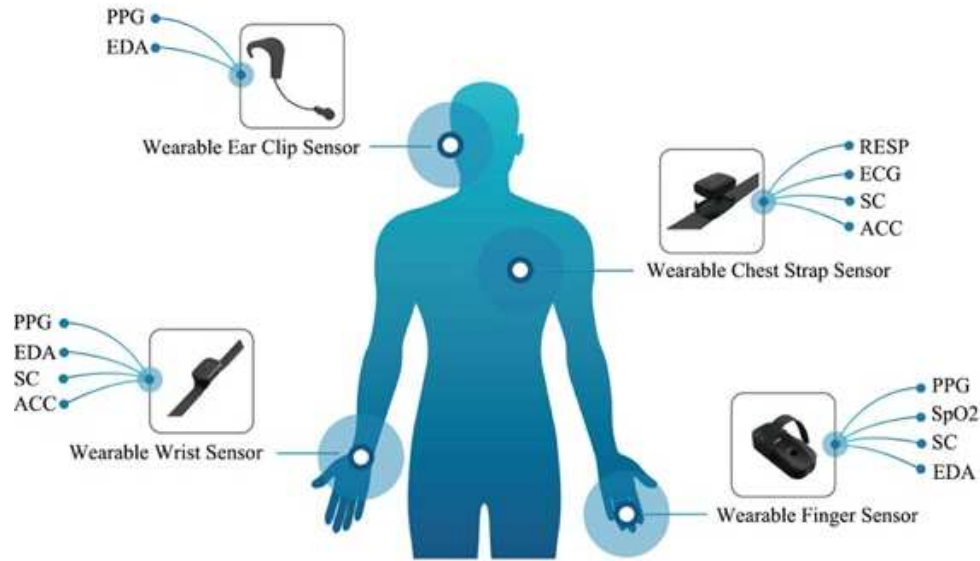
Given the human cognitive mechanism of physical environment, a novel method of assessing real-time in-situ environmental affective experience through wearable bio-sensory techniques has been proposed recently in landscape architecture and urban design as shown in Figure 3 [18]. With the synergistic progress of virtual reality and physiological sensor technology, the techniques by

experiments can present the personal physiological data to reflect the degree of landscape perception via electrocardiogram (EKG/ECG), electroencephalogram (EEG), skin conductance (SC), respiration (RESP).

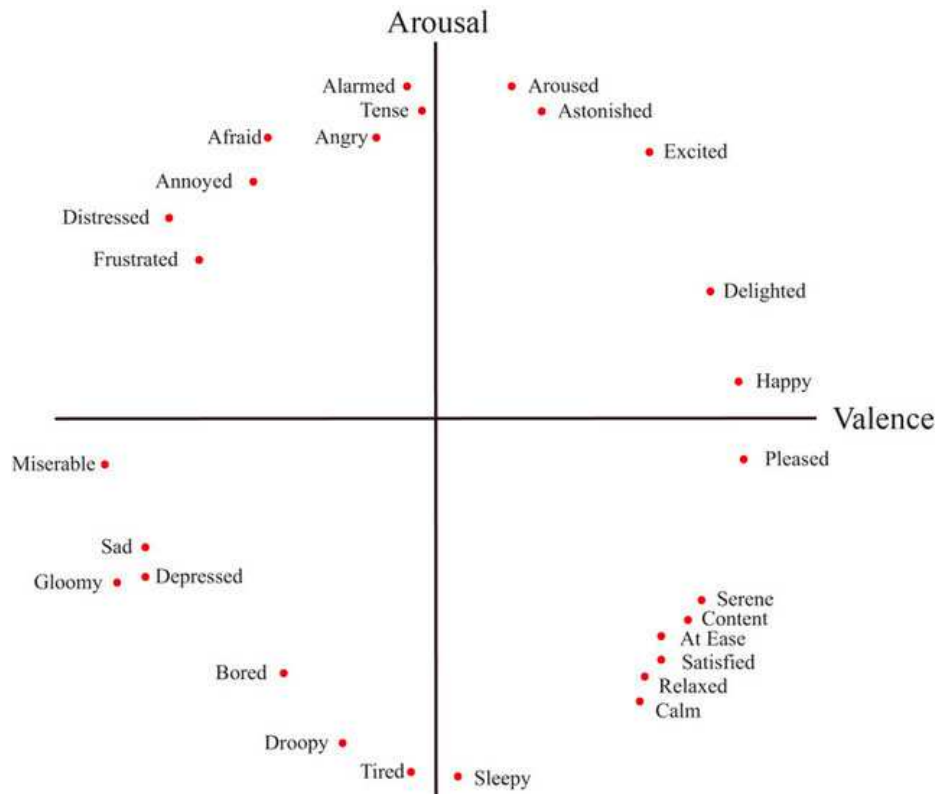
Besides, eye trackers are capable of acquiring visual behavior data, accurately capturing people's rapid cognitive processing of the environment, and exploring the types of landscape elements playing the major role. As a result, the data of area of interest (AOI) with independent variables (e.g., proportions of industrial heritage and pavement, the height and richness of vegetation, the height of terrain, as well as

newly added buildings) can be presented in different pre-defined landscape scenes though fixation count and duration, time to first fixation, visible heatmaps and trajectory maps.

On the basis of the scientific and effective equipment, the human-environment interaction is formed, which consists of the environmental information acquisition of post-industrial sites through scene images as stimuli, cognitive processing, as well as emotional responses [19]. Thus, a series of data can be objectively acquired and recorded for further analyzing different perceptions and assessments.



**Figure 3.** The wearable bio-sensory techniques with characteristics of high monitoring accuracy and strong portability.



**Figure 4.** The arousal-valence two dimensional model by James Russell.

### 3.3. The Assessment of Renewed Urban Industrial Heritage Sites

On the basis of experiments, the acquired physiological and eye tracking data are ready to be coped with using the platform of Matlab to analyze the individuals' environmental experience at that time. In accordance with the dimensions of affective valence in x-axis and affective arousal in y-axis indicating the positive and negative degree of emotion and the intensity of emotion in the arousal-valence model, respectively in Figure 4 [20], there are different emotional assessments from satisfied, neutral to unsatisfied to reveal various perceptions of landscape elements in the scenes of renewed industrial sites.

Furthermore, the assessment indicators of perceptions can be deduced based on the two-dimensional model, according to the analytical physiological data of the above independent variables on site. The positive indicators in the first and fourth quadrants primarily consist of calm, relaxed, interested in natural atmosphere exhibiting high biodiversity, delighted about the artistry and history of industrial heritage, excited about the whole industrial scenes with large scales and varied terrain. The negative indicators in the second and third quadrants primarily embrace nervous, tired because of poor spatial accessibility, frustrated about regenerated effect, afraid of site environmental contamination.

In brief, from the novel perspective of human factors integrated with the landscape architecture, urban residents' perception and cognition can be observed, recorded and analyzed in the public participation. It will generate more scientific findings by applying bio-sensory techniques, which will help rethink shortcomings of planning and design, and lay a design basis for the constant renovation as well as

design guidelines for the improvement of spatial quality in the future.

## 4. Conclusion

### 4.1. The Whole Process of Landscape Regeneration of Urban Industrial Heritage Sites

For the landscape regeneration of urban industrial heritage sites, a conceptual framework is proposed in this paper to analyze its constant process, which covers the in-depth comprehension of urban industrial heritage conservation and reuse as a foundation, the place-making achieved based on landscape planning and design and ecological restoration, and environmental perception and assessment of renewed sites as shown in Figure 5. In fact, this system is developed to foster a circle of interaction among the components in terms of the landscape regeneration, public participation and cognitive feedback, and diagnosis and optimization of space quality.

Even though the renewed industrial heritage sites are significantly diversified in terms of their purpose, design and evolution over time [3], three open questions should constantly be addressed to consider the involved key points in the whole process of landscape regeneration.

How urban industrial heritage sites with historic urban landscapes can be converted into public spaces for people to use through planning and design?

How can we gain insights into the public perception and assessment of post-industrial landscapes through more scientific, new methods?

How to analyze the information of user perception and assess which is objectively obtained, provide feedback and inspection for the landscape regeneration of urban industrial heritage, as well as relevant design guidelines?

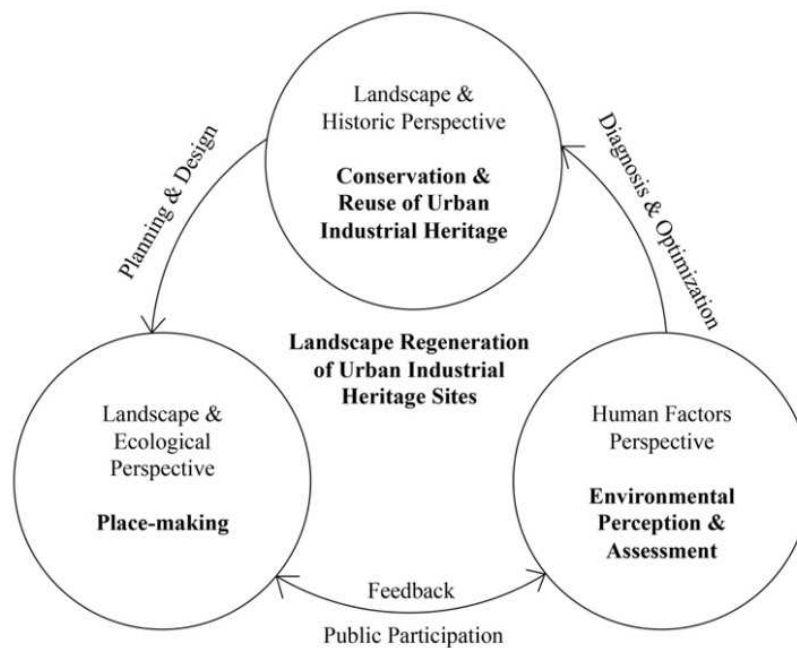


Figure 5. The whole process of landscape regeneration of urban industrial heritage sites.



#### 4.2. The Tendency of Landscape Regeneration of Urban Industrial Heritage Sites

When urban industrial heritage sites are transformed from the professionals' perspectives to the post-occupancy perception and assessment, an evidence-based paradigm of analysis-inspection-improvement will be a critical tendency in the future development. It is indicated that the professionals in practice should analyze the site status, inspect the effects of planning and design based on the individuals' perception and assessment, identify the questions and provide feedback on decisions and methods of the landscape regeneration.

The evidence-based paradigm should be considered in the landscape regeneration of urban industrial heritage sites, since it indicates the two-way interaction between design and practice. Even though the ambiguity of environmental experience itself, more complex information and assessment as evidence could demonstrate the various impact of urban industrial heritage on city dwellers through new scientific techniques.

In the future, the perception and assessment of renewed urban industrial heritage sites will be an essential factor in maintaining and shaping good urban spatial quality, and serve as an effective tool for predicting how people will interact with their surroundings in the spatial and temporal dimensions. Furthermore, the relevant research on post-industrial landscape has the potential to incorporate more novel technological approaches and data types in terms of mobile phone data for travel behavior tracking, social media data for the cognitive analysis of post-industrial sites, bio-sensory data combined with mobile GPS tracker for the accurate monitoring of spatial perception changes, as well as computer vision algorithms for image annotation and automatic classification.

In brief, this paper aims to present some novel research ideas and inspiration for the conservation and reuse of urban industrial heritage according to the vision of landscape from both quantitative and qualitative analysis. Significantly, the application of neurocognitive and wearable bio-sensory technologies will lay a basis for urban residents to participate in the landscape regeneration of post-industrial sites. Some technological measurement results will be part of future public decision-making and trade-off processes, providing a new type of validation for urban monitoring. These interdisciplinary exploration will have the valuable reference for more relevant research in the future.

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