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The Representation and Limits of Sustainable Architecture in the Urban Regeneration: A Reading Through Düsseldorf / Kö-Bogen II Project

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A b s t r a c t

Sustainable architecture has become a powerful formal and symbolic tool for urban regeneration. This study examines transformation of urban regeneration process as a remedial intervention addressing adverse conditions created by Düsseldorf's 19th-century industrialisation. Kö-Bogen II building, a product of this transformation from Düsseldorf's automobile-oriented planning paradigm to a nature-centred one, is case study for this research. Adopting qualitative research methodologies, study was conducted through literature review and analysis of Kö-Bogen II's sustainable design parameters. Findings indicate that it possesses quality of a 'living organism' that meets sustainable design paradigms and actively participates in environmental cycles. However, study highlights that, despite the building's strong representation of sustainable architecture, it also possesses potential for 'Green Gentrification' triggered by the value appreciation it generates. This situation opens a discussion on the critical point where the representational power of sustainable architecture encounters urban boundaries such as social accessibility and socio-spatial stratification. Consequently, true success lies beyond technical excellence and requires inclusive urban policies as well.

K e y w o r d s : Urban Renewal, Sustainable Architecture, Architectural Symbol, Green Facade, Kö- Bogen II

1. Introduction

With the increasing prevalence of environmental issues, the concept of "sustainability" began to gain prominence in the 1980s and was brought to the forefront of the global agenda with the Brundtland Report (1987) (WCED, 1987). In the years that followed, approaches developed to protect natural resources initiated a significant transformation within the discipline of architecture, and the concept of "sustainable architecture" took its place in the literature. Today, sustainable architectural products shape the identities of cities not only through their technical and environmental approaches but also through their roles in urban renewal processes.

The primary objective of this study is to examine the replication of sustainable buildings, as well as their impacts and limitations, through Kö-Bogen II building- a powerful physical representation of urban renewal and transformation- within the context of urban center transformation processes.

This study examines the evolution of the concept of urban renewal-from its emergence as a response to the unhealthy conditions of the 19th-century Industrial Revolution to the present day through Düsseldorf and Kö-Bogen II building. In this context, the morphological development of the city from its origins to the present is summarized, with particular emphasis on the transition from the automobile-oriented rationalist planning model of the post-World War II era to the 21st-century paradigm of nature-oriented, pedestrian-friendly, and climate-sensitive sustainable planning.

Based on a literature review and on-site observations, the building's architectural composition and design features within the urban context are analyzed. Finally, Kö-Bogen-II, which stands out for its building envelope and green facade systems, is evaluated in terms of sustainable architectural criteria; this evaluation highlights not only the building's advantages but also its long-term maintenance requirements, applicability at the urban scale, replicability, and inclusivity.

1.1. Urban Regeneration Concept

The concept of urban regeneration first emerged in the 19th century with the aim of improving cities that were in poor sanitary conditions. It emerged as a form of social reform, born as a response to the overcrowded and unsanitary conditions in British cities brought about by the Industrial Revolution. It developed in the advanced nations of the era based on the belief that providing better housing conditions for people would have a beneficial effect on the public's economic situation. The first example of its implementation as a nationwide urban reform took place in the mid-19th century with Haussmann's renovation of Paris under the orders of Napoleon III. In the United States, the movement began in the late

19th and early 20th centuries with the aim of beautifying cities; a new urban strategy was introduced that sought to provide people with better living environments through the design of wide boulevards and open streets (Urban renewal, 2026).
Xia et al. define urban regeneration as a complex process aimed at revitalizing urban areas by improving their social, economic, physical, and environmental aspects. The concept of sustainable urban regeneration has evolved and come to the forefront (Xia et al., 2024).
Although the term "urban regeneration" initially emerged in connection with policies aimed at eliminating slums, it evolved into a concept emphasizing the rehabilitation of below-standard buildings with the implementation of housing legislation and building codes in the mid-20th century (Hoffman, 2008). Said and Dindar also note that while urban renewal initially focused primarily on physical transformation, its scope has expanded over time to incorporate physical, social, environmental, and economic factors. This development has laid the groundwork for sustainable urban regeneration methodologies.
Carra et al. defines urban regeneration as a series of systematic and comprehensive actions aimed at addressing evolving urban challenges and improving degraded urban areas from physical, environmental, social, and economic perspectives. Urban regeneration aims to solve urban problems and draws upon relevant criteria, methodologies, and techniques. Careful urban planning refers to a meticulous process that involves defining the boundaries, surroundings, size, degree of transformability, scale of intervention, and urban planning parameters related to the redevelopment of the area to be renewed. Urban regeneration processes that encompass the transformation of city sections that are still functional and in use and thus do not require regeneration simply because they have been abandoned, are particularly challenging. (Carra et al., 2023).
At the heart of urban renewal lies an understanding of the value of existing socio-cultural and material resources in the urban environment and their careful utilization (Neugebauer, 2021). Its importance is also growing in the context of climate change, driven by the goal of creating sustainable cities.

1.2. Urban Regeneration in Germany

The destruction caused by the war in Germany, coupled with insufficient investment in the maintenance, redevelopment, and restoration of buildings, left many towns/ cities in poor condition by the 1950s and 1960s. "Flächensanierung"—a term referring to the redevelopment of areas—emerged as a prominent approach to urban development, particularly in West Germany. This process also led to the demolition of old structures and the emergence of a car-friendly urban model (Mueller, 2020).

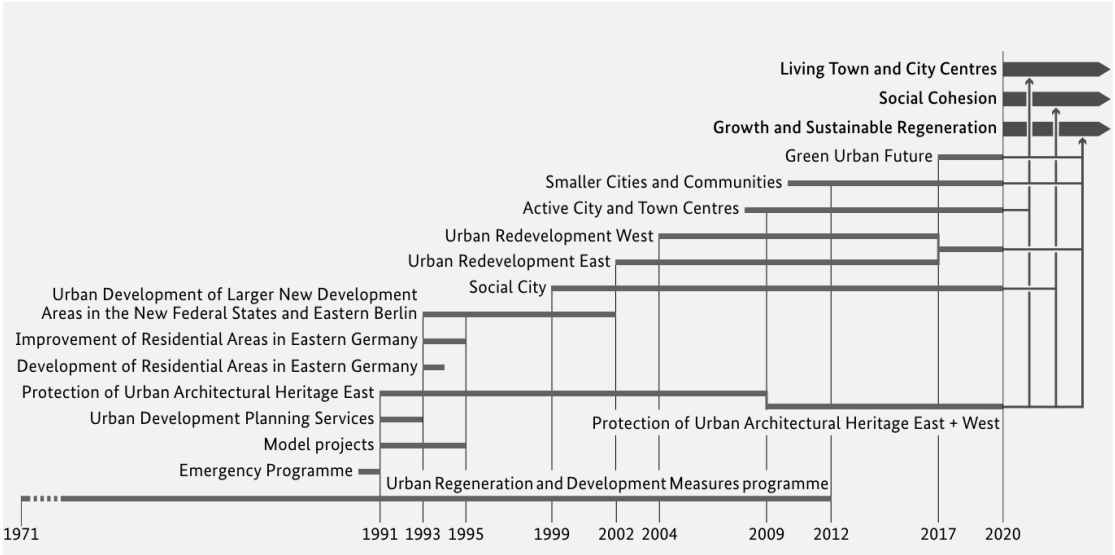


Figure 1. Development of the Concept of Urban Regeneration in Germany (Mueller, 2020).

In Germany, the regulation of urban renewal involves numerous mechanisms at the local level. The German Planning Act (Baugesetzbuch, BauGB) contains many provisions on this subject. Neugebauer (2021); explained the urban renewal process in detail, and the most important milestones of the process can be listed as follows since the 1970s:
1970s: A shift from growth-oriented projects toward urban renewal, heritage preservation, and citizen participation; the introduction in 1976 of participatory processes (§ BauGB) and tools for preserving the urban fabric (Erhaltungssatzung, Milieuschutz),
Late 1980s–1990s: Strengthening of entrepreneurship and public-private partnerships in planning amid an economic crisis; the introduction of the project-based zoning plan (Vorhabenbezogener Bebauungsplan) in 1990; and the development of contract-based planning tools (Städtebauliche Verträge) in 1993,
2000s: The introduction of the accelerated planning process (Vereinfachtes Bebauungsplanverfahren §13a) in 2006 to balance the complexity created by increasing environmental assessments and participatory processes, and the strengthening of direct democracy at the local level; the direct election of mayors, the spread of referendums and open lists, and with this transformation, "local citizen democracy" has become effective in place of "local party democracy" (Neugebauer, 2021).

2. Material and Method

Kö-Bogen II, a contemporary reflection of the transformation in Düsseldorf's urban form and the case study building of this research, is analyzed as a tool for urban repair and regeneration—a process in which the historical fabric is reimagined through ecological innovation.

Based on qualitative research, the study was conducted in two phases. In the first phase, a detailed study was conducted using academic databases as the primary source among internet resources. Following the general research, a textual analysis was performed using scientific studies related to the subject, architecture and urban design journals, websites of institutional firms (Düsseldorf City Council, relevant newspaper articles), and the views of various authors. In this section, Düsseldorf's urban development from its founding to the present day and its sustainable urban renewal are first presented within the context of "socio-political and economic dynamics." The concept of sustainability, sustainable architecture, and sustainability parameters are defined. Based on the content of these parameters, the design criteria to be analyzed in the second phase regarding Kö-Bogen II building were identified.

In the second phase, the architecture of Kö-Bogen II building was first introduced through both a review of current literature and on-site examination and observation (documentation). Subsequently, Kö Bogen II was analyzed using the design criteria encompassed by the parameters of sustainable architecture.

3. History of Düsseldorf's Urban Development and Regeneration in the Context of Socio-Political and Economic Dynamics

Shaped by its strategic location after gaining city status in 1288 along the banks of the Düssel River (Looz-Corswarem, 2021), Düsseldorf grew rapidly with industrialization and was rebuilt following the severe destruction of World War II through planned urban regeneration and modern architecture. As the capital of the state of North Rhine-Westphalia (since 1946), Düsseldorf is Germany's sixth-largest city, boasting an international airport and transportation links (Mauer et al., 2012; RWTH Aachen, 2015). It is a culturally leading city with its opera, theaters, and museums (Düsseldorf City Administration, n.d.) (Figure 2). In its urban development process, the city has evolved from a defense-focused center into a service-oriented metropolis driven by the post-war "economic miracle" (Wirtschaftswunder), establishing a unique character based on the balance between its historic urban fabric and modernization.

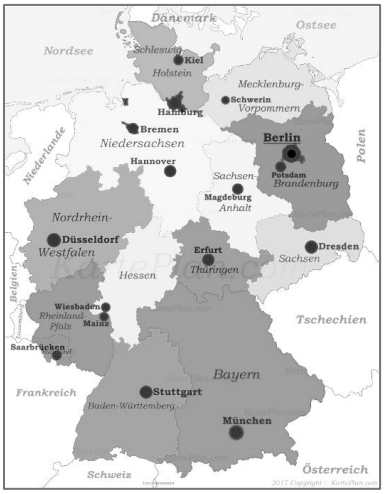


Figure 2. Düsseldorf's Location within the Rhine-Ruhr Region and the Borders of the Federal Republic of Germany (Karteplan (n.d.)).

3.1. Stages of Urban Development and Planning Approaches in Düsseldorf from Its Founding to the 21st Century (1130–2000)

Foundation and the Middle Ages: From Defense-Oriented Structure to Administrative Center (1130–1550): Düsseldorf was founded around 1130 at the mouth of the Düssel River under the name "Thusseldorp" and attained city status in 1288, thereby gaining autonomy (Mauer et al., 2012). By 1350, the city had defined its early morphological boundaries with a fortification system (a ring of walls) covering approximately four hectares; its designation as the capital of the Duchy of Berg accelerated urban development, leading to the formation of a commercial and administrative structure centered on the Altstadt (Old Town) (Table 1).

16th Century: The Construction of an Administrative Center Identity (1550–1600): As Düsseldorf transitioned from a defensive focus to an administrative and logistical center following its designation as the administrative capital of the Duchy of Berg, the first port facilities (1570s) strengthened the city's commercial networks along the Rhine River, thereby enhancing its logistical capacity (Mauer et al., 2012). The Rathaus (City Hall), built in 1573, and the expanded palace complex integrated riverfront trade into the physical infrastructure and triggered densification in the Altstadt district (Düsseldorf City Administration, n.d.) (Table 1).

17th and 18th Centuries: Early Industrialisation and Planned Development (1600–1800): A culture-focused approach was reflected in the urban fabric; during the reign of Jan Wellem (after 1690), the first opera house was built, a comprehensive art collection was established, and opulent residences and monumental public buildings were constructed (Mauer et al., 2012). In 1787, under the rule of Carl Theodor (1724–1799), urban expansion increased and Carlstadt was established as a planned settlement area to the south of the old town (Fischer, 2011). Planned developments, such as

Baroque and Rococo-style buildings like Benrath Palace and its gardens, transformed the city into a European city of high aesthetic and spatial quality (Table 1).

19th Century: Demolition of the City Walls (defortification), the 'Garden City' Identity and the Stübben Plan (1800–1900): At the beginning of the 19th century, reforms under Napoleon and the city's transition to the Kingdom of Prussia led to the demolition of the city walls and fortifications (1801), facilitating the city's expansion (Gruber, 2001). Court architect Huschberger and landscape architect Weyhe designed Königsallee and Heinrich-Heine-Allee—a grand commercial axis—and the Hofgarten, known as the city's "green lung", on these vacated sites. As Germany's first public park, the Hofgarten is the fundamental spatial element underpinning the city's title as the "City of Art and Gardens" (Gartenkunst, 2019; Fischer, 2011).

From the mid-19th century onwards, urban expansion developed as a response to the need for space created by industrialization (Albers, 2006), and rapid growth in the sector led to uncontrolled population growth and the need for new planning. With the establishment of the German Empire (1871), the city became a hub for trade, banking, insurance and corporate management, and experienced significant physical growth (Looz-Corswarem, n.d.; Mauer et al., 2012). The "Stübben Plan", which played the greatest role in this development, ensured the integration of the historic fabric with new settlements and proposed wide boulevards and systematic building blocks (Stübben, 1890/1907). The construction of the railway lines (1885) and the Oberkassel Bridge (1898) transformed Düsseldorf into a strategic hub of the national transport network and established the city as a modern metropolis with a population exceeding 100,000.

The 20th Century: The Devastation of War and the Construction of Modernity (1900–2000): During the 20th century, Düsseldorf acquired the character of a multi-layered metropolis through its international trade fairs, corporate headquarters and public administration bodies (Looz-Corswarem, 2021). This new status of the city was also reflected in its physical structure; with Europe's first office skyscrapers such as the Stahlhof (1908) and the Wilhelm-Marx-Haus (1924), the city transformed into a modern administrative centre and pioneered a monumental form that paved the way for later vertical development approaches, such as the Dreischeibenhaus (1960). In particular, the urban developments along the riverbank, prestigious public buildings and cultural structures have served as architectural symbols of the city's economic power (Stadtverwaltung Düsseldorf, n.d.).

However, the heavy air raids during the Second World War destroyed 85 per cent of the building stock in the city centre (Mauer & Trudewind, 2020). The urban reconstruction process led by city planner Tamms was shaped by a rationalist approach that prioritized motorized traffic (RWTH Aachen, 2015). Modernization was pursued by opening up wide avenues such as Berliner Allee; however, some historic buildings were demolished during these interventions (Mauer et al., 2012). Düsseldorf's post-war modern urban morphology (1945–2000) has been examined in three sections.

- **The Period of Restructuring through Planning and Radical Implementation (1950–1960):** Düsseldorf, which remained in the British occupation zone in 1945, became the administrative and financial heart of 'Rhine Capitalism' when it was designated the state capital of North Rhine-Westphalia in 1946 (Mauer & Trudewind, 2020) . The 'economic miracle' (Wirtschaftswunder) of the 1950s transformed Düsseldorf into a major economic hub for the industrial and banking sectors. This laid the groundwork for the city's functional zoning and the redefinition of its identity as a 'metropolis of services and administration'. Under the 1952 Reconstruction Act, wide boulevards were opened up at the expense of the historic fabric (such as the demolition of buildings like the Düsselschlößchen). The most characteristic intervention of the period was the Berliner Allee, built parallel to Königsallee and serving as the main artery along the north-south axis (Fischer, 2011).

The most radical traffic-focused symbol is the elevated road (viaduct) project known as the 'Tausendfüßler' (Millipede) (Brockerhoff & Richters, 2013). The Tausendfüßler (1961–1962) was constructed to ensure the uninterrupted flow of the increasing number of vehicles through the city centre and to connect the main transport arteries (Onkelbach, 2013). The reinforced concrete structure entering the city from the north and rising above Jan-Wellem-Platz in the city centre has transformed the city's claim to be a 'fast and modern' metropolis into a physical monument by separating pedestrian and vehicular traffic on a vertical plane. However, this intervention also marked the beginning of an era that exerted pressure on the historic fabric and prioritized vehicles in the urban landscape.

- **Infrastructure Consolidation and Mega Projects (1960–1990):** Urban development in the 1960s was characterised by the relocation of transport infrastructure underground and the construction of mega-structures. During this phase, the Thyssen-Dreischeibenhaus (1960) and the Schauspielhaus (1969) theatre building—symbols of economic prosperity and architectural modernism—radically transformed the city's skyline. As an extension of urban regeneration and in line with transport strategies, from the late 1980s onwards, tram lines in the city center were gradually relocated to underground tunnels. With the planning of the Wehrhahn Line in the early 2000s, the square largely lost its function as a ground-level transport hub, creating a strategic opportunity to reinterpret the abandoned spaces (Looz-Corswarem, 2020). The MedienHafen (Media Harbour) project, launched in the 1980s, transformed port areas that had lost their function due to structural changes in maritime transport into a dynamic business and design hub through designs by international architects such as Frank Gehry and William Alsop (Mauer et al., 2012). The Rhine Riverside Tunnel (Rheinufertunnel), opened in 1993, diverted surface vehicle traffic underground, re-establishing the city's visual and physical connection with the river and transforming the riverside into a public recreational area.

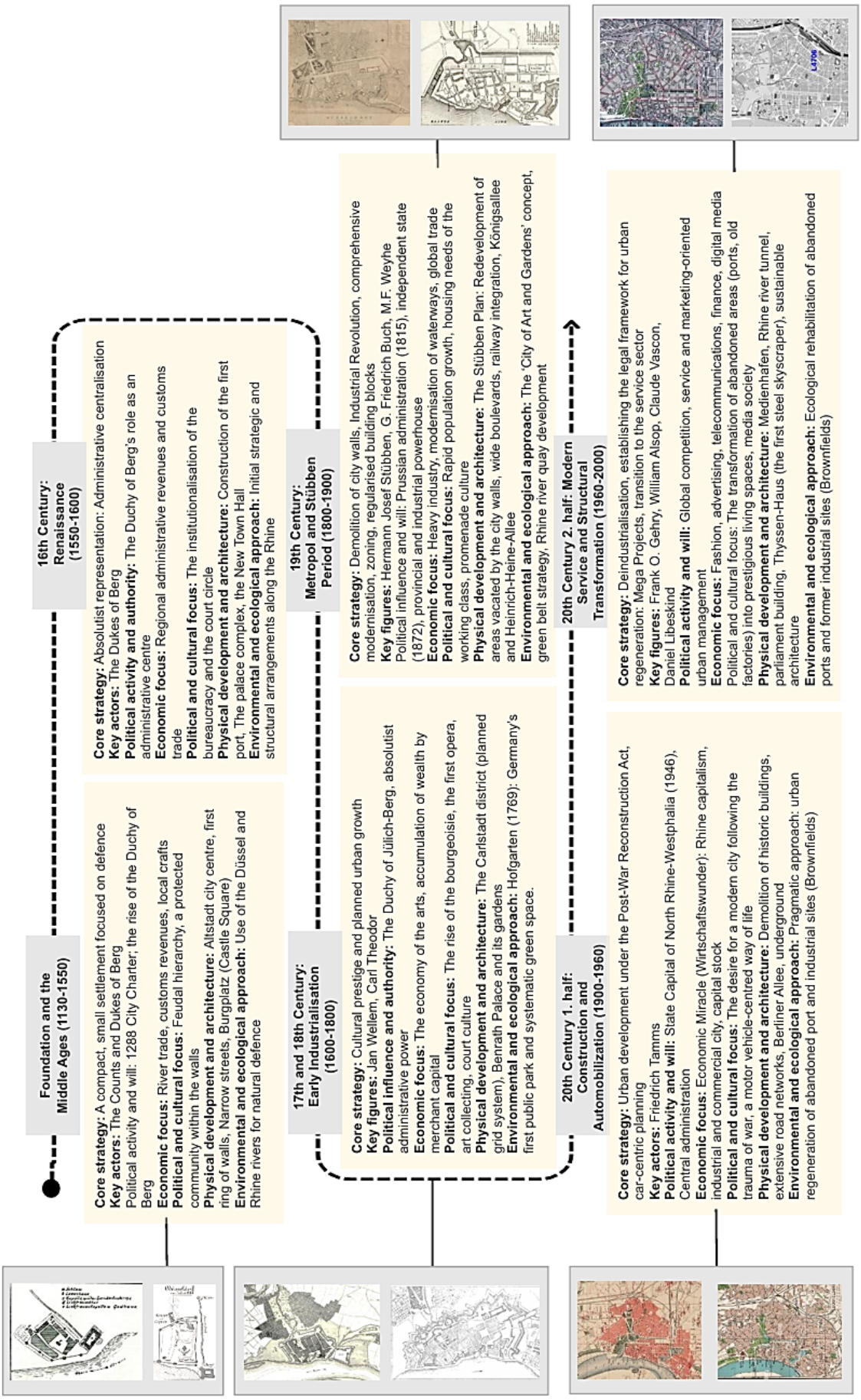
- **Deindustrialisation and the Shift Towards a Service-Oriented Economy (1990s–2000s):** This period is defined as Düsseldorf's transition from an industrial society to a service-based structure. The city has consolidated its position in the global economy by focusing on creative sectors such as telecommunications, advertising and fashion. The most radical manifestation of this was the creation of new public spaces resulting from the relocation of transport infrastructure underground. The planning of the Wehrhahn-Linie (Wehrhahn Line) metro project triggered a revolutionary transformation in urban morphology. With Jan-Wellem-Platz losing its ground-level interchange function (Fischer, 2011), the city moved away from the 'car-centric city' model. This spatial void paved the way for mega-projects such as Kö-

Bogen-I and Kö-Bogen-II. The functional transformation of railway and commercial areas freed up by deindustrialization was achieved through collaborative planning processes between the local authority and landowners (Mauer et al., 2012). According to Table 1, urban development in the 19th and 20th centuries can be summarized by the interaction of three dynamics:

- Geographical Location (River Rhine): The river is central to planning, serving both as a logistics route and a recreational area.
- Political Status (Capital City): Having been the state capital since 1946 has made the city the focal point for investment decisions, enabling massive infrastructure projects and urban regeneration schemes.
- Economic Flexibility: When industry declined (in the 1980s), the city's ability to repurpose its old port and factory areas for new sectors such as 'media' and 'fashion' rather than abandon them.

The foundation of this visionary reality lies in the success of rational planning during the city's post-World War II reconstruction: transforming its industrial heritage into a modern identity centered on services, finance and design, whilst integrating the 'green city' ideal with ecological sustainability through a hierarchical network of transport axes.

Table 1. Stages of Düsseldorf's Urban Development Approaches (1.130–2000). (Compiled by the authors using data from the literature).



3.2. Düsseldorf's 21st-Century Urban Development: Post-Industrial Transformation and the Vision of a Global Metropolis (Post-2000)

Düsseldorf's urban morphology has been shaped by strategic interventions that began as targeted initiatives within the urban fabric, as the city embarked on its transformation into a 'global center for services, finance and creative culture'. The symbolic starting point of this transformation is the MedienHafen project, in which the disused old customs port has been transformed into a multi-functional media and design hub. The deconstructivist Neuer Zollhof buildings (1999/2000), designed by Frank Gehry, serve as an architectural testament that bridges the city's industrial heritage with the digital and creative age. This success in the harbor provided the necessary impetus for extending urban regeneration practices to the city center (Central Business District).

The most radical spatial transformation of the early 2000s was Kö-Bogen-I project, realized through an architectural design competition as part of the rehabilitation of the city's 'Central Business District' (CBD). The project's most critical move was the demolition in 2013 of the "Tausendfüßler" viaduct—a legacy of the car-centric urban planning of the 1950s that physically divided the city center (Middeldorf, 2012). The north-south vehicle traffic previously carried by the Tausendfüßler has been diverted to the newly constructed underground tunnels. Designed by Daniel Libeskind, this mega-structure diverts vehicular traffic into underground tunnels, creating a continuous, pedestrian-focused public space between Schadowstraße and Königsallee. This intervention serves as a monumental reference to Düsseldorf's 19th-century 'Garden City' (Gartenstadt) ideal, realized through the high-tech architectural language of the 21st century (RWTH Aachen, 2015).

Today, Düsseldorf is defined not merely as an administrative center, but as a global hub where international capital flows intersect with high-quality living standards (Looz-Corswarem, 2021). The final stage of this vision is Kö-Bogen-II project, where urban regeneration strategies have been integrated with the sustainability paradigm. The building, which embodies the city's post-industrial identity through an ecological mega-structure, stands out for its 'living façade' design, which pushes the boundaries of architectural representation.

4. An Analysis of Kö-Bogen-II Building in the Context of Sustainable Architecture Parameters

4.1. Kö-Bogen-II Architectural Project Competition and Spatial Strategies

Designed by Tamms after the Second World War with a focus on motor vehicles, Düsseldorf's most important square, "Jan Wellem Platz", had been transformed into a concrete island by this development. Built in 1962 to alleviate heavy traffic, the "Tausendfüßler" severed the link between the city's major green space, Hofgarten Park, and Königsallee (Figure 3).

Following the Düsseldorf City Council's decision to move the rail system underground, the Tausendfüßler was demolished in 2013 despite initiatives by the German Architects' Association (BDA) and the public (Dahms, 2011; Brockerhoff & Richters, 2013; Westhoff, 2025) (Figure 3). Jan-Wellem Square was relieved of its burden as a ground-level 'traffic junction', and this created the necessary spatial void for its redesign as a public space in conjunction with its surroundings. This space has enabled the redevelopment of the northern section of Königsallee and the entire area connecting to Hofgarten, Jan-Wellem-Platz, Schadowplatz and Gustaf-Gründgens-Platz (City of Düsseldorf, 2009) (Figure 3).

A call was made in a declaration published by the German Association of Cities (Deutscher Städtetag, 2002), and a paradigm shift has taken place (Fischer, 2011) in favor of a planning approach centered on nature, prioritizing pedestrians and climate-sensitivity. The 'Blue-Green Ring' (Blau-Grüner Ring) strategy, which integrates existing park fabric and waterways (the Düssel River and the Rhine axis) surrounding the city into a unified ecological network, has been implemented (City of Düsseldorf, 2013). Accordingly, the new mega-structures built in the city center are now defined not merely as architectural objects, but as active components of the urban ecosystem. It has become mandatory for the structures being built to incorporate underground cisterns for rainwater management and to include 'sedum'-based extensive green roof systems that minimize the urban heat island effect and support biodiversity (Ingenhoven, 2020; City of Düsseldorf, 2021).

Figure 3. Aerial views of the Tausendfüßler elevated road between the Hofgarten and Jan-Wellem-Platz before its demolition, and Jan-Wellem-Platz (a. Stöfer (2006), b. Linksfraktion Düsseldorf (2008), c. HPP Architekten (n.d.)).

In this context, the City Council organised an international urban design competition (2008) (Figure 4) to transform the area starting from the northern end of Königsallee, encompassing Corneliusplatz, Hofgarten, the former Jan-Wellem-Platz, Schadowplatz, and Schadowstraße. Competition aimed to realise the following fundamental principles (City of Düsseldorf, 2009; City of Düsseldorf, 2004; Schüßler-Plan, 2017; Ingenhoven, 2020);

- *Spatial Integration:* Redesign of the physical and functional connection between Königsallee and Schadowstraße- which had been disrupted by past infrastructure-focused planning decisions- as a pedestrian-priority continuity,
- *Global Competitiveness and Economic Vitality:* Repositioning of the city center as an attraction hub on an international scale,
- *Ecological Restoration and Climate-Sensitive Design:* In line with the 'Blue-Green Ring' (Blau-Grüner Ring) strategy, ensuring environmental rehabilitation that supports biodiversity, optimizes air quality and mitigates the urban 'heat island' effect,
- *Governance and Implementation Model:* Working within a partnership model that combines public and private sector dynamics.

In line with these objectives, Kö-Bogen-I building, designed by architect Libeskind, was constructed following a competition launched (2009) for the first phase of the site's design. Subsequently, in 2014, a second competition was launched to fill the 'urban void' at Gustaf-Gründgens-Platz and its surroundings; Christoph Ingenhoven's Kö-Bogen-II design was selected as the winner and implemented (Westhoff, 2025; City of Düsseldorf, 2014).

4.2. Architectural Composition of Kö-Bogen II: The Developer's Vision, Geometry and Landscape Integration

4.2.1. Investment Strategy, Urban Location and Morphological Layout

Kö-Bogen-II, integrated into the urban fabric in 2020, is the result of a multi-stakeholder urban governance model implemented by the City of Düsseldorf. The stakeholders involved in this governance model (Stiftung Deutscher Nachhaltigkeitspreis, 2021) are:

- City of Düsseldorf (Stadt Düsseldorf): Framework for urban regeneration, management of the competition process, oversight in the public interest, infrastructure investments.
- Investor and Developer (Capital Side): CENTRUM Group & B&L Group: Project financing, management of construction and operational processes within the framework of a Public-Private Partnership (PPP) agreement.
- Architecture and Engineering (Technical and Design Side): Architect Christoph Ingenhoven (Ingenhoven Architects)/ Werner Sobek (Structural design).
- Scientific and Technical Consultants (Supporting Side): Berlin Beuth University of Applied Sciences: Academic consultancy on microclimate simulations and plant health.

Kö-Bogen-II is in a central area covering the north-eastern section of Königsallee, including the Hofgarten, Jan-Wellem-Platz, Schadowplatz. It is situated opposite Gustaf-Gründgens-Platz, home to the listed and iconic Schauspielhaus theatre and the Drei-Scheiben-Haus office building. These structures played a significant role in the building's location and architectural form. In implementing the building's sustainable architecture, legal responsibilities were secured between investor and municipality regarding its construction in accordance with the competition brief and the jury's decision (visual relationship with the Schauspielhaus and Dreischeibenhaus, mandatory green façade, maintenance periods, mixed-use, organization of the square, etc.) (Landeshauptstadt Düsseldorf, 2009; Stadt Düsseldorf, 2014; Ingenhoven, 2021). The building features a geometric layout comprising two volumes. The main building, a five-story trapezoidal structure, is designed with a sloping, green façade to provide a clear view of the theatre building. A valley-like environment has been created with the smaller, triangular building featuring a green roof (Ingenhoven Associates, 2020). The 'Supergreen' philosophy by the building's architect, Ingenhoven (A+U, 2015), forms the basis of Kö-Bogen II's architectural form and ecological strategies (Global Design News, 2021). Constructed to sustainability standards and utilizing high technology, the building features green façades facing the square and a sloping roof, and holds DGNB Platinum certification (Stiftung Deutscher Nachhaltigkeitspreis, 2021) (Figure 4).

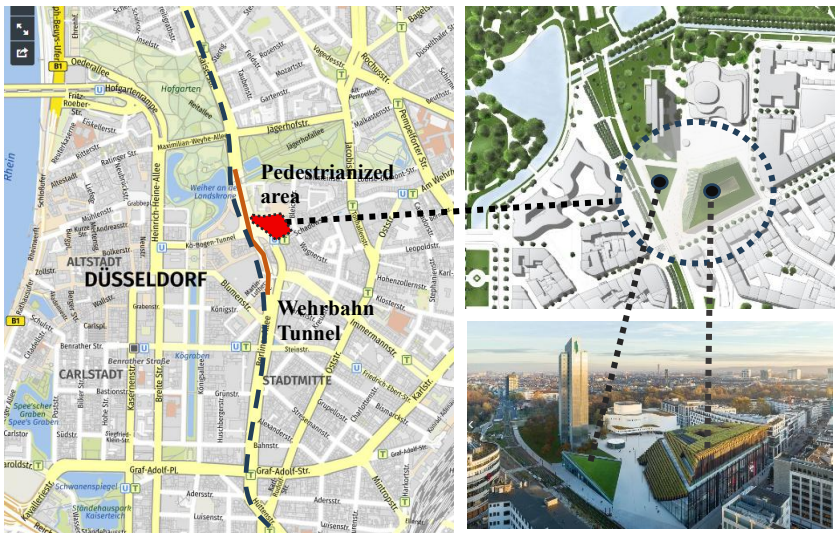


Figure 4. The location of Kö-Bogen II between Hofgarten-Jan-Wellem Platz and Gustaf-Gründgens Platz (a. Ingenhoven associates, n.d., b. Mapz, n.d., c. Landeshauptstadt Düsseldorf, n.d.).

4.2.2. Architectural Design Characteristics: Vertical and Horizontal Spatial Organization

Kö-Bogen-II, with its geometric composition comprising two volumes- a five-story trapezoidal main structure and a complementary smaller block- features a distinctive geometry designed to preserve the urban visibility of the other buildings on the site. This requirement for spatial hierarchy in the competition brief (height, green space ratio, visual axes) has endowed the urban void with a new identity by creating a 'public valley' concept in the square (City of Düsseldorf, 2009). The building, with a gross floor area of 42,000 square meters, houses office spaces on the upper floors and commercial units (shops and restaurants) on the ground floor. The basement level features a supermarket providing direct access to the Düsseldorf metro network (U-Bahn) and underground car park levels (Figure 5).

The main building's south façade, which stretches along Schadowstraße (pedestrian shopping axis) and measures 120 meters in length and 27 meters in height, and the adjoining west façade are entirely glazed; the façades facing Gustaf-Gründgens-Platz, however, are entirely clad in plants. The transparent shell enhances the visual permeability of the commercial units towards the street, whilst the green façade creates a visual layer that frames the building as an urban valley. The ground floor features trapezoidal recesses marking the entrances, the third floor has continuous glass strips allowing natural light into the offices, and the roof features two trapezoidal courtyards sloping towards Gustaf-Gründgens-Platz. The triangular canopy roof of the 10-metre-high small block has been designed as a walkable grass area. The triangular façades of the small building, which houses a gastronomic function, are also glazed to facilitate the relationship between interior and exterior spaces and social interaction. (Figure 5).

Figure 5. Kö-Bogen II floor plans and sloped geometry (a. b. c. d. e. (Schmidt, 2013), f. Sirel, 2025).

4.2.3. Shell and Structural Characteristics

Kö-Bogen II has been conceived as a high-performance ecological organism. The building's main structure consists of high-strength reinforced concrete columns and beams, extending from the underground car park levels up to the fifth floor. Its sloping surfaces, which form the building's 'valley' shape, are supported by a combination of angled steel and reinforced concrete elements, rather than conventional vertical load-bearing members (German-Architects, 2020) (Figure 6).

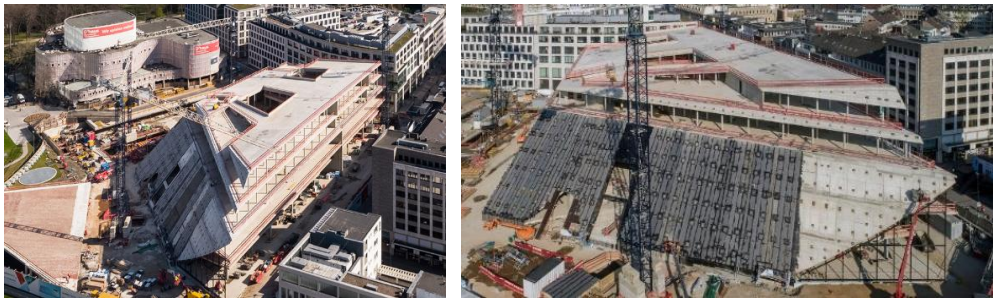


Figure 6. Structural characteristics of the outher shell a. b. (German architects, n.d.), c. Sirel (2025).

The sloping structure softens the massing effect on the façade facing Gustaf-Gründgens-Platz, whilst allowing the roof to blend into the landscape as a 'fifth façade' (City of Düsseldorf, 2009). The project's engineering achievement lies in its living outer shell- attached to this rigid structural system and recognized in the literature as Europe's largest green façade system (Ingenhoven Architects, 2020). The façade, designed as a response to climate change, consists of over 30,000 hornbeam (Carpinus betulus) hedges, integrated into a planting system spanning 8 kilometers in length (Bund Deutscher Architektinnen und Architekten [BDA], n.d.). The selection of native, hardy and low-maintenance species ensures the system's ecological sustainability. Measurements of the 30,000 hornbeam hedges have demonstrated that the cooling effect they provide is equivalent to approximately 80 mature trees and significantly reduces the urban heat island effect around the building (Bazzocchi et al., 2021). The continuity of the ecological cycle is supported by an integrated irrigation and drainage system fed by rainwater. In conditions where rainwater is insufficient, plant health is safeguarded via a sensor-controlled drip irrigation system. The longevity of the living fabric is guaranteed by a legal contract under which the investor has assumed responsibility for maintenance for 99 years (Stiftung Deutscher Nachhaltigkeitspreis e.V., 2021) (Figure 7).

This Phyto technological green façade system improves the urban microclimate by creating a 'thermal buffer zone' between the building envelope and the external environment (Bazzocchi et al., 2021). By blocking sunlight in summer to enhance indoor comfort and storing moisture through evapotranspiration, this system also reduces the urban heat island effect (Halbig, 2024; Bornett, 2020). In this respect, Kö-Bogen II offers a concrete architectural response to this problem with its dense vegetation.

Furthermore, the façade, which provides acoustic insulation and supports biodiversity, functions as a holistic, nature-based solution that extends beyond the building itself (Kaltenbach, 2023; Bazzocchi et al., 2021; German-Architects, 2020). Vegetation enhances biophilic comfort, creating a restorative effect on users.

Figure 7. Kö-Bogen II building structure and shell system (a. (Kaltenbach, 2020), b. Sirel (2025), c. d. Anderson (2023), e. (Schüßler-Plan, n.d.), f. (BauNetz Wissen, n.d.), g. ı. Sirel (2025), h. (Landeshauptstadt Düsseldorf, n.d.)

The building's sustainability is supported by technical systems designed in accordance with EnEV 2016 and the layout of equipment on the green roof. Thanks to this holistic approach, Kö-Bogen II has been awarded DGNB Platinum certification and has won various international awards.

4.3. Analysis of Kö-Bogen II Building Based on Sustainability Parameters

Within the scope of this study, the formal relationship between Kö-Bogen II and the built environment has been analysed within the context of its ecological and socio-economic impacts, using the theoretical framework provided by selected sustainability literature.

4.3.1. Sustainable Architecture: Conceptual Framework and Sustainability Parameters

Following the Industrial Revolution of the 19th century, urban growth based on a consumption-driven economy led to the rapid depletion of natural resources, and urban designs that prioritized motor vehicle traffic were often favored. In the final quarter of the 20th century, thanks to growing global awareness, the concept of 'sustainable development' was included in the Stockholm Declaration, adopted at the 'UN Conference on the Human Environment' (1972). The Declaration universally recognized that living in a healthy environment is a fundamental human right (Mengi and Algan, 2003; Sirel, 2017). In the Brundtland Report (1987), sustainable development was defined as a development model aimed at protecting natural resources and ecosystems whilst considering the needs of future generations (WCED, 1987). Kibert (1994), one of the pioneers of the transformations that subsequently influenced architecture, contributed to the introduction of the concept of 'sustainable architecture' into literature, systematized as building construction based on resource efficiency and ecological principles.

In current literature, sustainable architecture is described as architectural design and practice based on principles such as the conservation of natural resources, energy efficiency and the reduction of environmental impact. It is a long-term process encompassing the design, construction, maintenance, use and demolition phases of buildings (life cycle design – LCD). In the 21st century, sustainable architecture has been reimagined as a 'living organism' that generates its own energy, makes efficient use of water resources, utilizes local and recycled materials, and improves microclimate. Ingenhoven's (2021) "Supergreen" philosophy defines sustainable architecture as the integration of technology and nature as a means of spatial improvement. The literature on sustainable architecture emphasizes the necessity for a building to possess "ecological, economic and social" parameters. The simultaneous, balanced and effective management of these parameters underpins success. This holistic approach, encompassing all three parameters, demonstrates that sustainable architecture is not merely an environmental protection strategy, but also a matter of economic rationality and social justice. The design criteria that sustainable buildings must incorporate within the context of these three parameters are supported by a broad academic literature spanning various disciplines (Ruckelshaus, 1989; Gilman, 1992; Roodman and Lenssen, 1995; McDonough and Braungart, 2002; Kibert, 2004; Yeang, 2006; Kayıhan and Tönük, 2008; Kibert, 2016; Sirel, 2017; Sirel, 2021; Ingenhoven, 2021; Mickevičienė, 2021; Bazzocchi et al., 2021; Adın, Kaşlan and Sirel, 2025).

In light of the selected literature, the design criteria for sustainable architecture that are consistent with sustainability parameters are presented under the following main headings on Table 2;

Table 2. Parameters of Sustainable Architecture.

Ecological Sustainability Parameters
○ *Passive Design Strategies:* Ensuring the optimization of natural lighting, passive heating and natural ventilation through environmentally sensitive site planning.
○ *Materials Management:* The preference for local and recyclable building materials (wood, steel, glass, etc.) with low embodied energy.
○ *Active Systems:* Integration of renewable energy and the use of energy-efficient climate control technologies.
○ *Resource Conservation:* Water management strategies such as rainwater harvesting and greywater recovery, alongside waste management processes during the construction and operational phases.
○ *Sustainable Mobility:* Site location prioritizing public transport and pedestrian accessibility to reduce the carbon footprint.
Economic Sustainability Parameters
○ *Operational Efficiency:* Minimization of operating costs through a high-performance building envelope and energy-efficient mechanical systems.
○ *Durability:* The selection of low-maintenance, durable products and the adaptability of the structure to changing needs.
○ *Spatial Comfort and Efficiency:* Enhancing user productivity and indoor air quality by ensuring acoustic, thermal and visual comfort.
Social Sustainability Parameters
○ *User Well-being:* Supporting social values and maximizing user well-being through comfortable, healthy and flexible spatial designs.
○ *Biophilic Design:* Improving users' psychological and physical health through a direct connection with nature.

- *Conflicting Outcomes of Social Parameters* (Sustainable architectural projects can sometimes lead to unexpected social consequences despite their ecological successes)
  - Property Values and Spatial Exclusion: Sudden increases in property values around 'green' labelled projects can lead to the displacement of low-income residents from the area.
  - Spatial Homogenization: The risk of the area becoming homogenized due to a decline in socio-economic diversity.
  - The Green Gentrification Paradox: A situation where ecological improvement conflicts with the 'social' dimension of sustainability by triggering social injustice.

Socio-economic Parameters

- *Risk of Green Gentrification:* The high level of comfort offered by the building and the prestige it brings to the area have the potential to trigger the phenomenon of 'green gentrification', as defined by Isabelle Anguelovski (2016; 2018). Rising property values in the project's vicinity may lead to the indirect exclusion of low-income groups from this high-quality urban environment.
- *Socio-Economic Homogenization:* The redefinition of the area as a hub for international luxury brands carries the risk of a decline in urban diversity and the emergence of a more socio-economically homogeneous structure. This situation raises questions regarding the delicate balance between the parameters of "social justice" and "economic value" within sustainability.

An analysis of the sustainable design features of Kö-Bogen II Project is summarized in Table 3;

Table 3. Analysis of sustainable design features of Kö-Bogen II Project.

Kö-Bogen II Analysis Matrix		
Sustainability Parameters	**Design Criteria and Outcomes**	**Literature Reference**
Ecological Sustainability Parameters	Microclimate improvement with 30,000 hornbeam hedges, rainwater harvesting, and a low carbon footprint thanks to its central location.	Ingenhoven (2021)
Economic Sustainability Parameters	Low operating costs thanks to thermal insulation, DGNB Platinum certification, and optimised maintenance costs through the selection of native plants.	Kibert (2005); Mickevičienė (2021)
Social Sustainability Parameters	Psychological well-being (restorative effect) through an 8 km green corridor, integration of vertical public spaces via a sloping roof form	Biophilic Design Principles
Socio-economic Parameters	Risk of gentrification, spatial exclusion and socio-economic homogenisation due to rising property values	Anguelovski (2016)

5. Results

This study analyses how the concept of urban regeneration—which emerged as a response to the unhealthy urban conditions of the 19th-century Industrial Revolution—has evolved in line with today's ecological imperatives and sustainability paradigms, focusing specifically on Kö-Bogen II project as an outcome of this evolution. Düsseldorf's urban development has undergone a radical transformation, shifting from the post-Second World War 'car-centric planning' paradigm towards the 21st century's nature-centered, pedestrian-priority and climate-sensitive 'Blue-Green Ring' (Blau-Grüner Ring) paradigm. As the most powerful embodiment of this transformation, Kö-Bogen II occupies the void created by the demolition of the massive concrete viaduct "Tausendfüßler", which once divided the urban fabric, serving as a testament to architecture's capacity for urban repair.

In the analysis of Kö-Bogen II building, the technological and aesthetic possibilities offered by sustainable architecture stand out as the project's key strengths. With its 'living shell' comprising 30,000 hornbeam hedges, the structure is not merely a building but is represented as an active component of the urban ecosystem—a 'super-green' mega-structure. In this context, the project's ecological performance demonstrates outstanding success through its minimization of the urban heat island effect, rainwater management and support for biodiversity. Its efficiency, certified by the DGNB Platinum certification in the economic dimension, and the restorative effect it offers through biophilic design in the social dimension, position Kö-Bogen II as a "successful model" in contemporary sustainability literature.

However, whilst the building demonstrates a successful capacity for representation, it also raises questions regarding the "socio-economic limits" of sustainable architecture. In terms of "Architectural Representation", the building showcases the aesthetic fusion of technological innovation with nature; yet, in terms of "Architectural Limits", it confronts the complex reality of urban justice. In particular, the phenomenon of "Green Gentrification", as highlighted by Anguelovski (2016), constitutes the building's critical limit. The high-quality and prestigious ecological environment created by Kö-Bogen II, by triggering an increase in property values in the area, carries the risk of leading to the 'indirect exclusion' of lower-income groups from these high-quality areas and the socio-economic homogenization of the urban fabric.

Consequently, an analysis of Kö-Bogen II demonstrates the power of sustainable architecture in the urban regeneration processes achieved in Düsseldorf. According to the literature on sustainability, it is clear that this power can only lead to true sustainability through the balancing of ecological benefits with social justice and inclusivity, rather than merely through technical and aesthetic achievements. The building's success in terms of sustainability depends not merely on it being an energy-efficient structure, but on its ability to serve as a fair urban policy tool that benefits all social strata of the city.

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CRediT Author Statement
Author 1: Conceptualisation; Methodology; Investigation; Writing – original draft (including project design and narrative structuring), Author 2: Writing – review & editing; Formal analysis; Language editing. All authors have read and approved the final manuscript.

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