Urban Planning (ISSN: 2183–7635)
2023, Volume 8, Issue 3, Pages 406–424
https://doi.org/10.17645/up.v8i3.6866

Article

A Catalyst Approach for Smart Ecological Urban Corridors at Disused Waterways

Sara Biscaya [1,*] and Hisham Elkadi [2]

[1] Department of Design and the Built Environment, University of Huddersfield, UK
[2] School of Science Engineering and the Environment, University of Salford, UK

* Corresponding author (s.biscaya@hud.ac.uk)

Submitted: 21 February 2023 | Accepted: 28 April 2023 | Published: 26 September 2023

Abstract
Green and blue infrastructures have always played a key role in shaping European cities, acting as drivers for urban and rural development and regeneration. There is a reawakening of consciousness by European cities towards their waterways following long periods of estrangement relating to (de)industrialisation and, consequently, the decline in industrial riverfronts. This article reviews the precedents relating to the regeneration of disused waterways in European cities, depicts the common threads that distinguish those locales, traces similarities with the Manchester Ship Canal, and develops a catalyst-based approach for future development. The catalyst-based approach is a well-established methodology in other disciplines but has not been tested in urban design. The article investigates the Deux-Rives in Strasbourg and similarities to, and possible scenarios for, future development of the Manchester Ship Canal. The catalyst-based approach focuses on connectedness, employment, health and well-being, affordable housing, and the challenge of governance in managing cross-border areas around waterways. The article explores the potential of a catalyst-based approach in developing a smart ecological urban corridor, applying possible scenarios alongside the Manchester Ship Canal. Through an investigation of the possible application of the distinctive innovative methodology, combining the catalyst-based approach with a community engagement process, the article examines possible scenarios of urban development with green and blue infrastructure linked by a linear mobility spine for a smart and sustainable urban corridor between Manchester and Liverpool alongside the Manchester Ship Canal.

Keywords
catalyst-based approach; disused waterways; European cities; Manchester Ship Canal; SPL Deux-Rives; urban ecology; urban waterways regeneration

Issue
This article is part of the issue “Shipping Canals in Transition: Rethinking Spatial, Economic, and Environmental Dimensions From Sea to Hinterland” edited by Carola Hein (Delft University of Technology), Sabine Luning (Leiden University), Han Meyer (Delft University of Technology), Stephen J. Ramos (University of Georgia), and Paul van de Laar (Erasmus University Rotterdam).

1. Introduction

Waterways are critically important for the health and well-being of their surrounding communities as well as the environment. They have been a foundation of material economic wealth worldwide. Waterways, in many European locales, have gone through different stages of development over the last two centuries. Many sites have seen the rise of industrialisation and, more recently, a decline in their banks. Such disused landscapes provide opportunities to develop smart urban corridors that could heal the rural–urban fabrics around waterways and provide an innovative model for future urban living, with access to the natural environment, innovative mobility modes, and the provision of contemporary economic activities.

Green and blue infrastructures have always played a key role in European cities. The overlaying patches of different rural and urban areas around waterways are complex and require different approaches and ways of thinking. The current ecological and societal challenges can no longer be overcome via current planning practices. The trends in cities' development are now established around economics, nature, the search for a new healthy urban lifestyle, and new approaches to governance that will serve the multitude of variables and everyday occurrences/disruptions that cities face.

This article investigates the possible adoption of a catalysts-based approach for the development of disused waterways. Through an extensive literature review on existing waterways' development, projects (Section 2), and a case study analysis of the Deux-Rives project in Strasburg (Section 3), key strands for development were identified and applied in a number of scenarios for the development of the Manchester Ship Canal (MSC) in the UK. The catalysts-based approach (Section 4) was applied using the identified strands in a similar development to the MSC (Section 5) to develop six scenarios for a smart ecological urban corridor between Liverpool and Manchester (Section 6). The article explores six scenarios of urban development with green and blue infrastructure linked by a linear mobility spine.

The concept of ecological urban corridors first appeared in the field of biology. With the increase in human demands and scarcity of resources, the concept has become central in rapid urbanisation and in regional integration in connecting green corridors in cities and intercities. The speed at which cities grow and the need to take over existing rural areas is increasing at a fast pace due to population growth and exodus to the urban areas (Seto et al., 2013; United Nations Department of Economic and Social Affairs, 2018; United Nations Economic and Social Council, 2018).

The rapid development of urban expansion leads to biodiversity loss and landscape fragmentation. Some argue that it is necessary to focus large scale on ecological corridors both within urban and rural areas and concern has begun to be raised on their ecological, social, cultural and other features (Che, 2001; Han et al., 2022; Peng et al., 2017; Rouget et al., 2006; Savard et al., 2000). An urban ecological corridor will meet the needs of residents in terms of creating an ecological green living open space. The term "urban ecological corridor" is usually defined by a linear or ribbon ecological landscape that provides the functions of an isolated natural habitat, green open space, or human habitat in the context of an artificial eco-environment of a city or urban area (Biscaya & Elkadi, 2021; Noss & Harris, 1986). With the paradigms of economic development and ecological protection, with the expansion of urban environmental problems and increasing human ecological demands, the efficient construction and management of urban ecological corridors are seen as a possible way to resolve the contradictions in the process of rapid urbanisation.

There are several classifications of urban ecological corridors which vary according to the structure or function of an urban ecological corridor. In terms of structural function, they can be identified as a river corridor (Han et al., 2022; Peng et al., 2017; Yan et al., 2021), a green transportation corridor (Yueguang et al., 2003), a biodiversity conservation corridor (Li et al., 2009), a heritage corridor (Yu et al., 2005), and, more recently, a recreation corridor (which is a response to urban residents' need for green open space and recreational space, i.e., walking and cycling). In terms of functional classification ecological urban corridors can be defined as a barrier corridor, impeding materials, energy, and information from flowing and, by doing so, protecting special species from external interference thus conserving biodiversity (Noss & Harris, 1986; Peng et al., 2017). These can cause natural habitat fragmentation, reduce landscape connectivity, and increase local species' extinction. Conversely, they can create ecological constraints to urban expansion and prevent urban sprawl such as London, Seoul, and Beijing greenbelt constructions (Gant et al., 2011; Munton, 2016; Yang & Jinxing, 2007). Additionally, there are communication corridors. These promote the flow of important channels for water, nutrients, energy, plants, and animals thus increasing the connectivity possibilities between important patches (Zhang et al., 2005). The two functions are not exclusive and can occur simultaneously in ecological urban corridors.

The idea behind urban development is interlinked with the way technology is shaping our present and dramatically impacting our future. The ubiquitous infrastructure is considered an enabler of smart urban development (Anthopoulos & Fitsilis, 2010; Anttiroiko, 2013; Kitchin, 2014). Technology has an impact on developing urban infrastructure, planning, water supplies, public transportation, and environmental protection (Anttiroiko, 2013; Kitchin, 2014). Complex information systems require an innovative approach to urban development (Anthopoulos & Fitsilis, 2010; Anttiroiko, 2013; Kitchin, 2014). Blue and green corridors are urban corridors developed around watercourses, flow paths, and surface water ponding along with the green infrastructure that typically accompanies urban blue corridors (Gaston et al., 2013; Kazmierczak & Carter, 2010; Li et al., 2017; Scott Wilson, 2011). The dynamic linkages and ecological relationships of both with the urban environment create areas of multifunctional use (Gaston et al., 2013; Li et al., 2017; Scott Wilson, 2011).

2. The Rise and Decline of Inland Waterways in Europe

2.1. European Waterways' Role and Relevance: Historical Catalysts for Development

At the beginning of the 21st century, European cities witnessed the phenomenon of shrinkage. The main factors attributed to causing shrinking cities include an increasingly ageing population and internal migration from underdeveloped to more competitive sustainable and healthy locations (Wolff & Wiechmann, 2018). These trends are associated with cities in North America and Europe (UN-Habitat, 2008, p. 40) that have experienced changing demographic and economic conditions that have led to spatial configurations (Haase et al., 2014; Wiechmann & Bontje, 2015). Cities in Central Europe have experienced a severe demographic shift relating to infertility, economic decline, and to selective out-migration (Haase et al., 2014). Urban shrinkage is now an issue within policies and planning strategies yet research on the cross-national comparative perspective is limited (Großmann et al., 2013). The changes in the spatial configuration of European cities present an opportunity for re-imagining their future in more environmentally sustainable and healthy contexts.

Cities are not studied as "isolated islands" but little research on urban histories has examined urban-rural links with environmental underpinnings (Castonguay & Evenden, 2012; McDonnell & Pickett, 1990). The rural landscape has been artificially shaped to meet social and economic needs, as have urban settlements. These are both shaped by the geographical, topographical, and spatial conditions of the landscapes they occupy. Spatial analysis of waterways has overlooked the varying patches of the rural and urban landscapes. Urban waterways' inter-relationships highlight the need for a spatial analysis of urban growth within a city including beyond its official boundaries (Pupier, 2020).

In many European locales, waterways have gone through different stages of development in the last two centuries. Many sites have seen the rise of industrialisation and, more recently, have seen a decline in their banks (Castonguay & Evenden, 2012). Many have witnessed the decline and disuse of their waters in parallel with the impoverishment of the communities alongside their banks (e.g., the River Mersey in the UK, Trancao in Portugal, and Alzette in Luxemburg). Ecologically, waterways have paid a high price for serving the needs of industries and their densely populated regions during the 1800s (Gollin et al., 2016). Urban growth as well as industrial wastes have contributed to a decline in the health of the waterways (Castonguay & Evenden, 2012; Knoll et al., 2017).

The fluvial power of waterways represents the collective product of not only geology, ecology, and climate but also economics, technology, politics, and human conceptions. They provide habitats, food, water, hydropower, and mobility and can also guarantee connectedness, the flow of commerce, as well as water. Their geological value is matched by their economic role; politics complement this role: Waterways connect and divide nations and regions. A source of identity, they have often become the symbol of the communities they cross and "flow over" instead, but they also present dangers.

Damming, channelisation, canalisation, water extraction, and contamination have ruined urban waterways. These factors have resulted in different levels of impoverishment: biological, loss of free-flowing waters, loss of wildness, and repercussions for adjacent floodplains and riparian lands. Flooding hazards have become more frequent and intense, impacting the urban environments surrounding the waterways. Many waterways are currently undergoing ecological rehabilitation and are cleaner at present than at any time since the late 18th century (e.g., MSC, UK; Iton River, France; Odderbæk in Jutland, Denmark).

2.2. Urbanisation and Waterways: Current Trends

UN-Habitat (2008, 2016) identified the global trends which are shaping urbanisation. Firstly, there is the merging of cities into mega-regions, corridors, and city regions. These new formations have increased interconnectivity, but have also increased imbalances. The second global trend is suburbanisation. This can take multiple forms, from informal settlements spreading to the urban periphery or more formal suburban and satellite development causing urban sprawl and suburbanisation. However, in both cases, city expansion needs to be carefully considered as it can create social, economic, environmental, and governance challenges. Nevertheless, cities are considered central to achieving the UN Sustainable Development Goals, recognised particularly by Sustainable Development Goal 11, regarding sustainable cities and communities. Hence, inclusive, safe, resilient, and sustainable approaches to city design are essential for sustainable infrastructure, urban mobility, and energy systems (UN-Habitat, 2016). The inherent complexity of urban challenges has been recognised by the EU with the Pact of Amsterdam feeding into policy initiatives such as the EU Cohesion Policy which intends to integrate urban policy initiatives and go beyond individual sector working (European Commission, 2019).

Flooding is one of the principal environmental hazards faced in Europe (European Environment Agency, 2010). The urbanisation of rivers which run through many of our cities has undermined the ecosystem services which riverine ecosystems can provide, leading some to call for restoration and regeneration schemes in order to restore the ecosystem services provided by rivers (Everard & Moggridge, 2012). As Spits et al. (2010) noted, many European cities and towns are located along rivers in former flood plains. Their analysis of national and municipal policies in cities in the Netherlands, France, and Germany showed a trend towards policies to maintain river discharge capacity and, specifically in the Netherlands, a further change in policy to allow space for rivers. Furthermore, each country is found to approach the issue of building on flood plains differently. With development pressures for urban expansion likely to maintain an interest in riverfront and floodplain development, finding ways to combine both, i.e., room for the river and urban expansion, requires creativity (Spits et al., 2010). Others have observed a shift in European policies on flooding away from traditional policies on protection towards risk management and adaptation (Hayes et al., 2014; Mostert & Junier, 2009; Roslan et al., 2021).

Deprived communities around (dis)used waterways in Europe present a real challenge to cities' expansion. Studies have pointed out the need for creativity in addressing them (Spits et al., 2010) and the priority is to establish a baseline through a cross-national database that can provide a thorough assessment of these blue-ways' current conditions. From the Oresund Lagoon (Copenhagen) to the salt marshes of Aveiro (Portugal), from the industrialised banks of the Meuse in Liège (Belgium) to the Teressa River in the Catalan Valles (Barcelona), existing case studies allow for the identification of urban development catalysts, relying on a partly forgotten hydrographic network, which can be absent from the imaginary and the metropolitan narrative.

Cities are rediscovering their neglected waterways after decades of industrialisation and economic growth (Biscaya & Elkadi, 2021; European Environment Agency, 2016; Knoll et al., 2017). Berlin and Liverpool have been cleaning their rivers and rethinking urban planning around them. While the relevance of water and waste in the industrialising city has long been a focus of urban environmental research, waterways have not received the same attention (Kaika, 2004; Koop & Van Leeuwen, 2017). The reintegration of blue ways into urban life has been mainly conducted through decreasing pollution, parks development, and pathway construction based on ecological restoration (Castonguay & Evenden, 2012; Coates, 2013).

Recent projects around waterways in Europe are country- or locale-specific, focusing on different facets of development. Some projects focus on assessing and promoting heritage and tourism around blue ways such as the project "European Waterways Heritage: Re-Evaluating European Minor Rivers and Canals as Cultural Landscapes," aiming at promoting the cultural heritage of minor waterways and historic canals in Europe, or the NIWE, a network of canal, river, and lake waterway operators and promoters of the economic, social, and environmental benefits of Europe's inland waterways (ongoing). With an emphasis on transportation, the European Commission funded the Waterways Forward project under the EU TRIMIS—Transport Research and Innovation Monitoring and Information System (2010–2012).

Projects focusing on specific locales or countries include: Waterways for Growth focused on the North Sea Region (2007–2013) under Keep.EU (European Commission), London Waterways (social enterprise, ongoing) aiming to support communities that live on London waterways with emphasis on small urban mooring sites, Galway 2020 (ongoing) focusing on promoting and on the development of waterways in Galway, and, more recently, EMMA, funded by the Interreg Baltic Sea Region Programme (2014–2020) supporting integrated territorial development and cooperation for a more innovative, accessible, and sustainable Baltic Sea region. Additionally, there is the Danube STREAM—Smart, Integrated and Harmonized Waterway Management, focusing on the clean growth of transport management around the Danube.

RiverWiki, funded through the Environment Agency and managed by the River Restoration Centre (UK), provides an interactive source of information on river restoration schemes from around Europe. The focus is on the environmental restoration (i.e., water and biodiversity) in European rivers.

The World Bank supported a few projects in the 1990s and early 2000s around ports and inland waterways but none since then. Examples of the redevelopment of river/canal sites include the Bradford-Shipley canal road corridor in the UK (Bradford Council, 2017), the Hafen City Hamburg project in Germany (Ministry of Urban Development and the Environment, 2014), and Cheonggyecheon stream as part of Seoul's urban regeneration plans (Cho, 2010; Lee & Anderson, 2013; Temperton et al., 2014). All projects are due to be completed by 2030 with the projects in Hamburg and Seoul being at the forefront of urban regeneration awareness.

The Bradford Metropolitan District Council has developed the Bradford corridor which stretches over 3.10 miles in length and looks at housing, job creation, and ideas to deal with the rapid population growth in the area (Bradford Council, 2017). The Hafen City has been in development since 2000 with the aim of integrating the inner city with the existing port and industrial area. Since 2010, a new proposal has been under development to deal with the increasing growth in population and consequent growth of Hamburg city, due to its status as a city-state, as a highly successful port, and also due to its strategic position at the crossroads of Eastern and Western Europe. The principles of the project are based on its relationship with the river, existing urban qualities, and the quality of its open spaces. The project focuses on inclusiveness, affordable homes, education, and improving the quality of life through public spaces and green and environmentally-friendly city development which intends to result in an improvement in the quality of life of its citizens, improved mobility, and integrating natural space in the city (which is facing the current and future climate changes' challenges through energy turnaround; Couch et al., 2011; Ministry of Urban Development and the Environment, 2014; Sepe, 2013).

More recent waterways-funded projects include Waterborne and MERLIN (Horizon Europe 2022). The first focuses on clean maritime transportation and the second on the ecological restoration of freshwater-related ecosystems. The projects include a workstream focusing on inland European waterways.

3. Urban Development of Waterways: The Deux-Rives Project, Strasbourg

The literature review on inland waterways in Europe enabled the identification of historical catalysts for urban development around waterways as well as current trends. The case of the Deux-Rives project in

Strasbourg captures many successful urban catalysts for the redevelopment of neglected European waterways and supports the catalysts-based approach applied to the MSC. The Rhine is a major European river, stretching from Switzerland, through France, Germany, and the Netherlands to the North Sea. Its length is over 1,320 km, of which 880 km are navigable. Its catchment area covers Italy, Austria, Liechtenstein, Luxembourg, and Belgium (Frijters & Leentvaar, 2003). Ecologically, the Rhine Valley is an alluvial reservoir containing the largest European groundwater resource (Longuevergne et al., 2007).

The river's geographical position has been considered as a conflictual border between France and Germany for decades (Febvre & Schöttler, 1997). Conversely, it has also been a strong symbol of international cooperation, for example when it was part of the Vienna Treaty (1815) and was opened to international traffic (Reitel, 2006). Strasbourg is part of this narrative; it has been claimed in different periods of history over the last five centuries by both France and Germany. It has been part of France since the end of the Second World War.

The Rhine river basin is made of four distinctive river ecosystems; the High Rhine (above Basel and mostly located within Switzerland's boundaries), the Upper Rhine (situated between Basel and Bingen), the Middle Rhine (in between Bingen and Cologne), and the Lower Rhine (the lower stretch of the river between Cologne and the German-Dutch border and the arms of the Netherlands delta; Frijters & Leentvaar, 2003; Mellor, 2021). The lower stream was subjected to major flood controls in the 20th century. The river historically has played a significant role as a safe border between antagonistic neighbouring states as well as being a major shipping route (Frijters & Leentvaar, 2003; Mellor, 2021). The more recent border change in the Rhine has been the one between France and Germany following the chemical disaster of 1986 (Van Dijk et al., 1995).

Due to its geographical position and cross-border cover, the Rhine has suffered from rapid industrialisation since 1850 (Reitel, 2006) causing water quality deterioration (i.e., wastewater discharges by industries, agriculture, etc.) with consequent high levels of pollution rates causing severe damage to its ecosystems. This was exacerbated by the fire at the Sandoz chemical factory near Basel for which the river water was used to extinguish the fire, and this used water then flowed back into the Rhine causing the extinguishing of nearly all the aquatic life downstream (Schiff, 2017). The Sandoz incident was the driver for the transboundary collaboration through the Rhine Action Programme of 1987 or the "Salmon 2000 Goal" (Frijters & Leentvaar, 2003) and the inception of the eco-city, Deux-Rives project in Strasbourg.

3.1. Strasbourg, Upper Rhine

A major port city with the second largest inland port in France, Strasbourg is situated in the traffic junction connecting the Atlantic to a wider Europe and Germany to Italy; it has always benefited from its transborder location (Bik, 2006; Pupier, 2020). As with the MSC, it has witnessed a decline in its use and its preeminent economic role and geographical position following the decline in shipping and the environmental crisis; this has caused a significant impact on the communities based around the two rivers.

The city sits between two rivers, the Ill and the Rhine, both contributing to its significance in the 19th century but also to its downfall due to three main factors: (a) increasing floods in the alter Rhine which affected Strasbourg's citadel, consequently being the focus of various projects for river regulations around the bridge between the Strasbourg and Kehl; (b) these and the rapid population growth and absence of appropriate sewage systems which have lowered the water table resulting in the ending of shipping and the decline of the rivers' water quality (Knoll et al., 2017; Reitel, 2006); and (c) issues with urban governance and water management changing its hydrological profile have also played a key role in its decline (Koop & Van Leeuwen, 2017). Another factor which has contributed to the rivers–city relationship and its consequences is due to the municipality of Strasburg being subject to the national water strategies of the foreign policy of France and Germany throughout its history (Knoll et al., 2017; Koop & Van Leeuwen, 2017).

Despite being located 3 km from the river, during the 17th and the 19th centuries Upper Rhine water management changes, both Strasbourg and Kehl became border cities giving way for a cross-border urban space to grow, with the main functions of a city and including the majority of the population (Reitel, 2006; Sohn, 2014). This area gave way to several new projects following the Sandoz ecological accident in 1986 with new cross-border cooperation initiated and developed by the European Union (Pupier, 2020; Schulte-Wülwer-Leidig et al., 2018).

3.2. EcoCités, "Deux-Rives/Zwei-Ufer"

Strasbourg's historical role and geographical position as a key border city and, subsequently, its development during the 20th century with its expansion to the north, south, and west at the cost of its border with Germany posed a number of challenges. The Grande Île of Strasbourg has had World Heritage status since 1988, the first urban area of France inscribed in UNESCO's World Heritage List (UNESCO, 2023). With the growing need for housing, and using the wastelands so as to avoid urban sprawl, the city turned to its neighbour across both the waterways, the Ill and the Rhine, from Strasbourg to Kehl in Germany (Mazzoni, et al., 2016). The aim was to be internationally recognised for its Franco-German identity through a vision of people-centred transboundary cooperation across states while retaining its human dimension and its connectedness with nature and green areas while preserving and respecting its heritage. With a vision to establish an economic and cultural centre in Strasbourg, the project focused on developing four districts: Citadelle, Starlette, Coop, Rives, and Port du Rhin (City and Eurometropolis of Strasbourg, 2009, 2010). The vision was pursued through car-free arteries and organically connected neighbourhoods with vegetation through to a high-quality environmental strategy that encompasses the transformation of 250 ha of port wasteland from the Ill to the Rhine (City and Eurometropolis of Strasbourg, 2010).

In response to the Ministry of Ecology's EcoCités initiative, both cities collaborated to promote several large-scale sustainable city projects in the urban, social, and energy areas based on the challenge of the expected demographic growth of 50,000 new inhabitants by 2030 (Almassy et al., 2018; City and Eurometropolis of Strasbourg, 2010). The project's rationale was based on the region's competitiveness, its exponential demographic growth, the increasing numbers of younger and most-deprived sectors of the population in the territory, an economy centred on creativity and innovation, and considerable land resources. The project is anchored on three interlinked layers: the blue, the green, and the public transport framework (Figure 1).

The blue layer preserves the visible and invisible (underground) water to secure the quality of the environment. The area's historical context made it the structuring element of the design. The green layer is made up of parks, forests, and valleys that run along the watercourses and agricultural land linking the territory. Its fundamental role is in establishing the spatial relationship of the city with the wider region, as with the water framework, but also to guarantee ecological continuity and biodiversity protection. A dedicated corridor of public transport, consisting mainly of tram and rail networks, links the two cities and the different areas (i.e., living, working, and leisure). It is also linked with the wider transport network outside Strasbourg. The aim is to remove car traffic from the area. The layers serve as

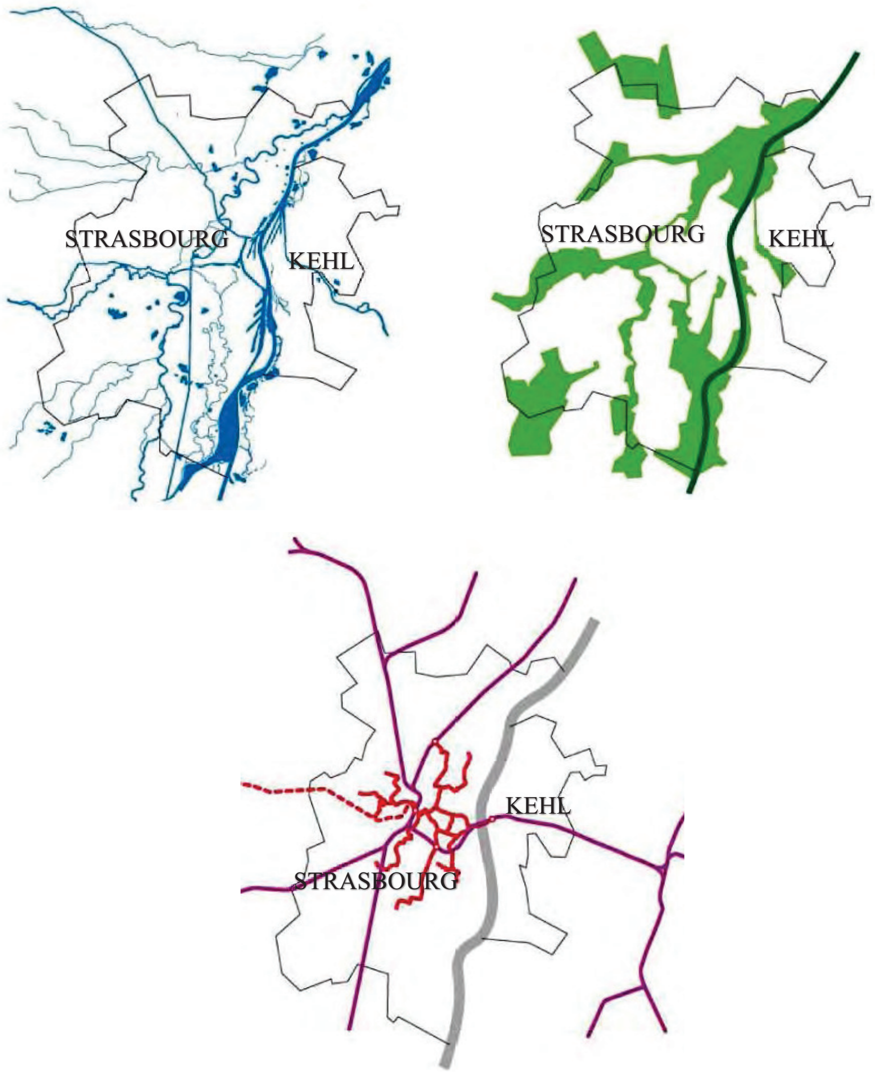

Figure 1. Strasbourg blue, green and public transport framework. Source: Authors' work based on City and Eurometropolis of Strasbourg (2009, p. 5).

an urban development framework and are to be read and interpreted in juxtaposition (City and Eurometropolis of Strasbourg, 2009, 2010, SPL Deux-Rives, 2023).

3.3. Identified Key Development Principles

Connectedness, a key principle of the project, is the continuous linkage with Germany through the tram line estalished in 2012, supporting the city's future urban development. The transport line plays a significant structuring role in lessening the effects of demographic growth in the Port du Rhin area. The tram network was complemented by an increase in transport bike infrastructure. Ecological connectivity is, therefore, one of the key project drivers.

In 2016, the project was extended to public-owned developers and the adopted strategy was based on urban development programming in a "non-static" manner which will allow the project to evolve and adapt according to the feedback received (Strasbourg, 2023). The key principle in the applied methodology is "iteration," the project unfolds and develops with time and through the different add-ons and their assessment. The stakeholders involved from both sides of the waterway include: the project owner and manager, elected representatives, current and future inhabitants and workers, local residents, and associations (Strasbourg, 2023), thus increasing the region's resilience through cross-cooperation in urban planning development. The project's other principles include *inclusivity and cultural diversity*, increasing *employment and high-grade technical job* opportunities, connectedness with nature to promote a *healthy living environment*, preservation of historical and cultural heritage, securing quality for the environment through an ecological balance, *social justice* and local democracy. These principles are translated into three project axes that aim to build the metropolis on the two banks of the river.

The first axis is to recycle urban spaces and open the metropolis to the river by highlighting the Grande-Ile, a World Heritage site, in urban policy and creating a metropolitan belt linking the historic city centre with the suburbs and different municipalities (Figure 2). The second aims at structuring the metropolitan district's poles and centres to encourage a social and functional mix, supporting the tram network's constant urban renewal (Figure 2) and the third axis focuses on nature in the city and the quality of the public spaces and also on preserving large areas for agriculture to supply the metropolis.

The strategy is driven by 24 projects with different timeframes and is spread across 23 municipalities with a vision for almost 17, 000 housing units thus increasing affordable housing in France by 40% with 80% situated near public transport, for the expected increase of 50,000 inhabitants by 2030 (Almassy et al., 2018).

4. Catalyst-Based Approach for Waterways' Urban Development

A catalyst-based approach is used in this article as a method that incorporates many urban designs' best practices—granularity, incrementalism, and the mixing of uses, scales, and people. The catalyst design approach has been used in both chemistry and biology to improve activity, selectivity, and the scope of a catalyst application (Abbasi et al., 2022). Initial catalyst identification is based on published literature with the goal of utilising already-existing catalysts as opposed to developing new ones (Abbasi et al., 2022; Imhof & Van der Waal, 2013). Catalysis-based research can be complex. Regardless of the catalyst development tools used, involving key stakeholders from the beginning and taking into account the overall impact of a catalyst on the process is the key to success (Imhof & Van der Waal, 2013; Moulijn et al., 2000). This approach/method might not be appropriate for all regeneration schemes. The application of a catalyst-based approach in this article focuses on areas abandoned because of deindustrialisation, in some

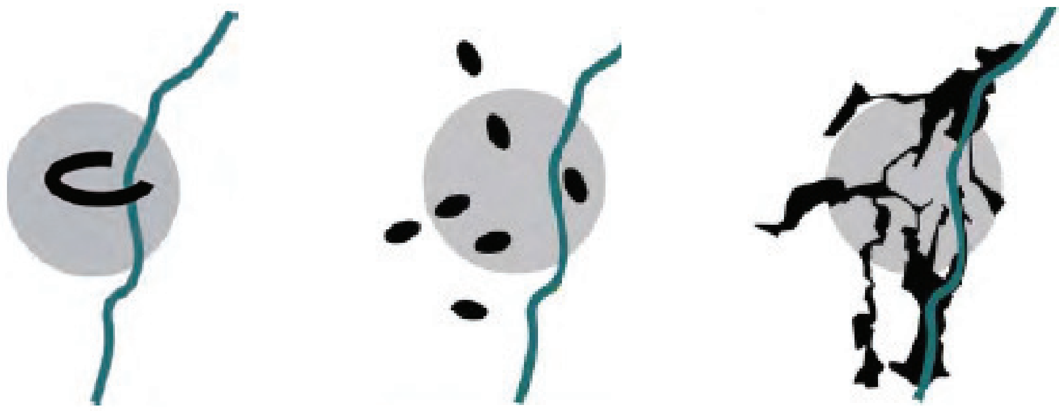

Figure 2. Deux-Rives project's axes. Source: City and Eurometropolis of Strasbourg (2009, p. 2).

cases recycling the properties of waterways cleared or left vacant by mid-20th century urban "renewal" programmes in neighbouring cities. The article presents a number of ecologically based scenarios for the MSC based on the identified catalysts from the literature review and Deux-Rives case study.

Identification of the initial catalysts was obtained based on Gough et al. (2017) guided literature review and thematic analysis of European disused waterways' catalysts for urban development (Vaismoradi et al., 2016). Springer, Science Direct, Google Scholar, IEEE Xplore, and ACM Library were extensively used. Articles, reviews, case studies reports, conference proceedings, and book chapters were reviewed. Significant research publications published between 1999 and 2019 were obtained on: (a) green and blue urban corridors' historic development and methodologies; (b) European cities' growth and the societal and ecological challenges it presents as well as applied catalysts; (c) European urban growth in relation to climate change, urban population, pollution, and depleted infrastructure; (d) new trends such as disruptive technologies, digital cities, and urban data analytics; and (e) contemporary catalysts for urban development and innovative ways to support ecological urban growth through blue infrastructures that consider natural risks as part of the urban systems' stability. This review and the Strasbourg case study analysis also identified general themes and catalysts to be applied to the MSC case study. The literature review and the waterway urban development precedents revealed five common threads: (a) connectedness, (b) employability, (c) health and wellbeing, (d) housing, and (e) governance.

4.1. Connectedness

Waterways could be, if not well integrated, a divided natural element as much as a connector feature. Maintaining and/or enhancing connectedness between the different rural and urban patches around waterways is, therefore, a key catalyst in the development of waterways' regions. Plans should aim for continuous linkage via sustainable mobility networks to deal with future urban development whilst preserving biodiversity corridors to lessen the effects of increased demographics. Sensitive ecological planning would ensure connectedness with nature to promote a healthy living environment.

4.2. Employability/Jobs

Communities around disused waterways are usually among the lowest-income groups in a region. Lack of infrastructure, a spread-out, usually isolated, population, and low education levels lead to high unemployment rates in these regions. The provision of meaningful jobs and high-grade technical/paid job opportunities is, therefore, a must in redevelopment efforts. Plans should aim to particularly support younger generations and the most deprived sectors of the population to establish a thriving economy based on creativity and innovation respectful of natural resources in order to increase the competitiveness of the region.

4.3. Health and Wellbeing

Waterways provide fantastic opportunities to promote a healthy living environment, preserve historical and cultural natural cultural heritage, and secure quality for the environment through an ecological balance. Successfully implemented projects would ensure accessibility to nature and blue and green infrastructure in order to promote wellbeing and health for work and leisure. Successful development, however, could lead to highly attractive propositions for urban developers with projects that could severely damage the ecosystem. Efforts should be made to maintain the natural ecosystem with clean fresh water and clean air in order to preserve and enhance a region's agricultural economy.

4.4. Housing

Land values are intrinsically linked to upgrades in its available infrastructure. This is particularly noticeable in waterfront locations. While this could be seen as a positive outcome of any development, a balance should be struck to ensure affordability and to avoid segregation of deprived local communities. Planning policies should aim at establishing a level of diversity through affordable housing with good living conditions supported by a good/accessible transport network.

4.5. Governance

It would be difficult to draw strict boundaries around development areas along waterways. Such regions are by nature fluid and seamlessly connected. Any development or regeneration efforts should, therefore, consider agile cross-borders or/and cross regions plans across various combined authorities or official groups which include different stakeholders, inhabitants (current and future), workers, local residents, and other actors in the areas that can support waterways' resilience (across areas/regions) by cross-cooperation in urban planning development.

The study of the Deux-Rives project traced the identified catalysts for waterways' projects in the literature, in what is believed to be a successful regeneration project across the Rhine in Strasbourg. The aim is to support the development of a catalyst-based approach that could be applied to develop smart blue and green urban corridors in the MSC region in the UK which could potentially be extrapolated to other inland European waterways' contexts. The catalysts-based approach presents an evolving methodology in urban development as well as an approach to transboundary collaboration in support of communities and urban ecologies. Through this approach, a number of ecological-based scenarios for the MSC were developed by applying an iterative process invention grounded on the development and application of the identified catalysts.

5. The Development of the Manchester Ship Canal

The literature review and the analysis of the existing EcoCité project linking Strasbourg (France) and Kehl (Germany) led to the foundation of the potential catalysts for the urban development of disused waterways. Efforts have been made below to apply those catalysts to the development of the MSC in the UK. The aim is to integrate the rural and urban landscapes in support of smart urban futures in the region. There are strong similarities between the two waterways' contexts of Strasbourg and Manchester. The two inland waterways have historic and ecological significance in their respective regions, both have been impacted by the industrial revolution with the increase of pollution and the subsequent decline in shipping and navigation in different ways. Both projects aim to interlink two cities in a more sustainable and ecological way. The identified catalysts in Strasbourg could, therefore, be used and applied to unlock the potential of the inland waterways in Manchester.

Based on the potential environmental, liveability, and economic catalysts and enablers identified, the MSC project enlisted academics, local governments, and industry partners to establish a set of principles that would guide the development of a smart urban corridor for the MSC. With a focus on creating potential scenarios (Pill, 1971) of what the smart ecological urban corridor along the MSC could be, the Delphi Technique was used in the iterative process to achieve consensus on real-world knowledge from experts in the fields of the identified catalysts on what to apply (Dalkey & Helmer, 1963; Hsu & Sandford, 2007). To determine the potential of the MSC corridor, to consider potential catalyst projects, and important drivers and enablers, a series of multidisciplinary meetings and iterative workshops with key experts from various fields (including urban design, ecology, engineering, environmental studies, transportation, health, and social science) were held (Dalkey & Helmer, 1963). As Pill (1971) and Oh (1974) suggested, participants were chosen based on their background and expertise rather than their familiarity with the topic.

Participants representing different stakeholders were presented with the most recent qualitative and quantitative data which were used to examine the socio-spatial traits of the MSC region. Participants in the workshop were also shown the analysis of key catalysts to help guide their discussion. To aid in the analysis and discussion at the workshops, data on the various existing layers of the MSC corridor were gathered and processed concurrently. Various institutions and local governments provided key data sets that the participants used to further define and identify the catalyst projects.

6. Manchester Ship Canal

The MSC, a symbol of the industrial revolution, could inspire a new smart ecological urban corridor that connects diverse communities, industries, and government agencies.

The 56-mile Liverpool to Manchester smart ecological urban corridor is a case study within the northwest region in the UK, but its conditions and characteristics can be extrapolated to other parts of the globe: Fast-paced population growth in both Liverpool and Manchester has increased human urban habitat demands. The buffer area along the MSC has the potential to develop into a smart ecological urban corridor that connects human needs, environmental infrastructure and scientific and economic development, biodiversity, and quality urban space for a growing population. Human-natural system integration is key.

The first major urban regeneration project along the MSC was MediaCity (2006) in Salford Quays, formerly Manchester Docks (Nevell & George, 2017). According to Biscaya and Elkadi's (2021) research, innovative technologies sparked Manchester's industrial revolution.

An iterative process was applied through two workshops that enabled the formation of a high level of consensus among various experts and interested parties in various sectors and activities (Hsu & Sandford, 2007; Pill, 1971). The workshops were supported by basic data analysis and the evaluation of the opinions gathered during the workshops in the catalyst-based iteration process. The themes and concepts were mapped based on the level of agreement reached, and the findings are presented here.

6.1. Catalysts and Scenarios

The scenarios were developed based on a number of iterations and on the different amalgamations of the key five catalysts previously explained.

6.1.1. Create a Digital Highway and Infrastructure to Support Business, Working, and Living Connectivity

The MSC is currently mainly used for freight transport and there are logistics hubs along its margins with some key industry infrastructures (Figure 3).

The canal can be transformed into a digital highway infrastructure, potentially with drones to attract innovative business investors and subsequent technological jobs for high-qualified professionals. The area can be developed along the digital infrastructure through the design of a connected working and living environment (Figure 4).

6.1.2. Green Space Creation and Natural Capital

The canal's environment and landscape are its key assets. Green areas promote healthy, collaborative living.

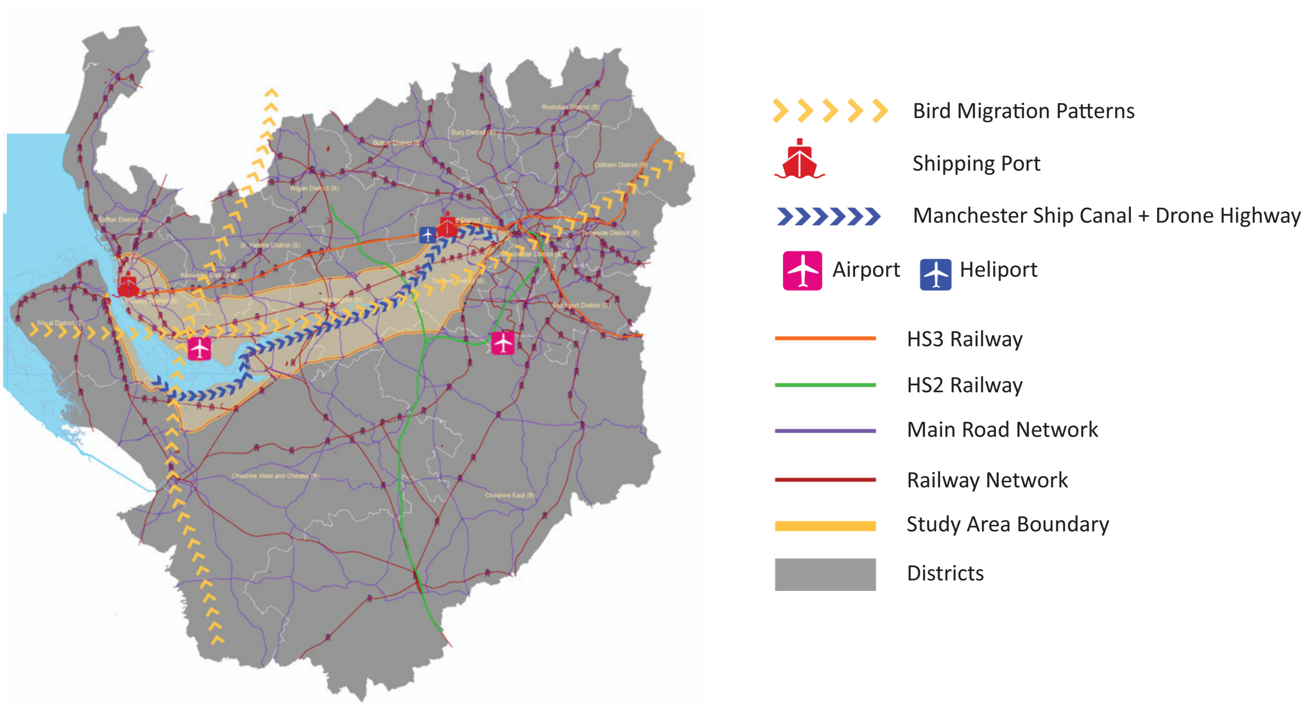

Figure 3. Transport networks, high-speed railways, airports and airfields, digital highways, and birds' migration paths. Source: Authors based on Digimap.

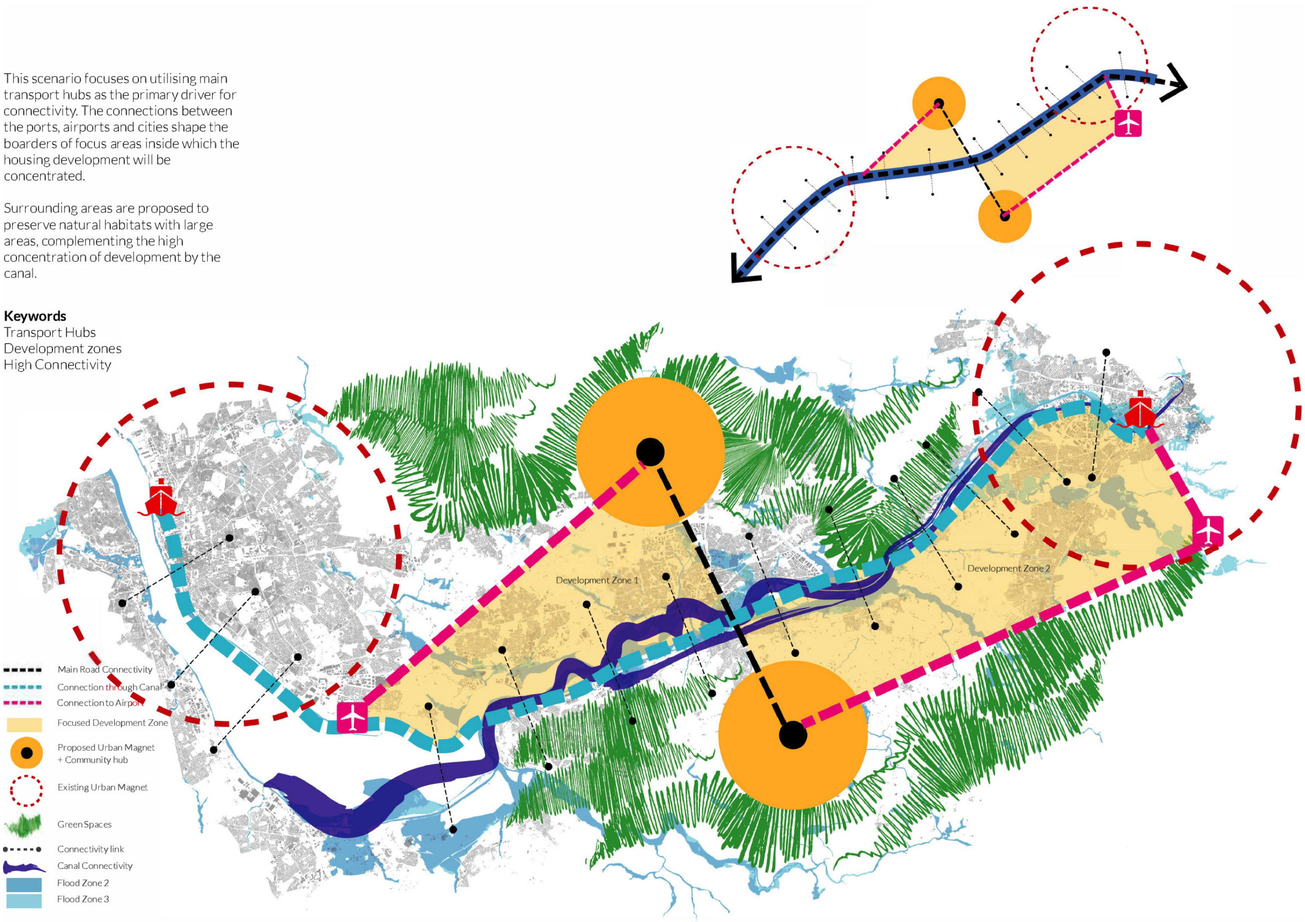

Figure 4. Scenario 1.

Urban/rural interconnections, urban agriculture on the urban fringe, and living and working hubs can support the flood-prone MSC margins (Figure 5). Green spaces and natural capital preservation improve air quality and residents' and tourists' livelihoods (Figure 6).

6.1.3. Creative and Innovative Jobs

Innovative jobs drive population fixation. Given that young people tend to settle in major cities despite data showing that housing and the quality of life are

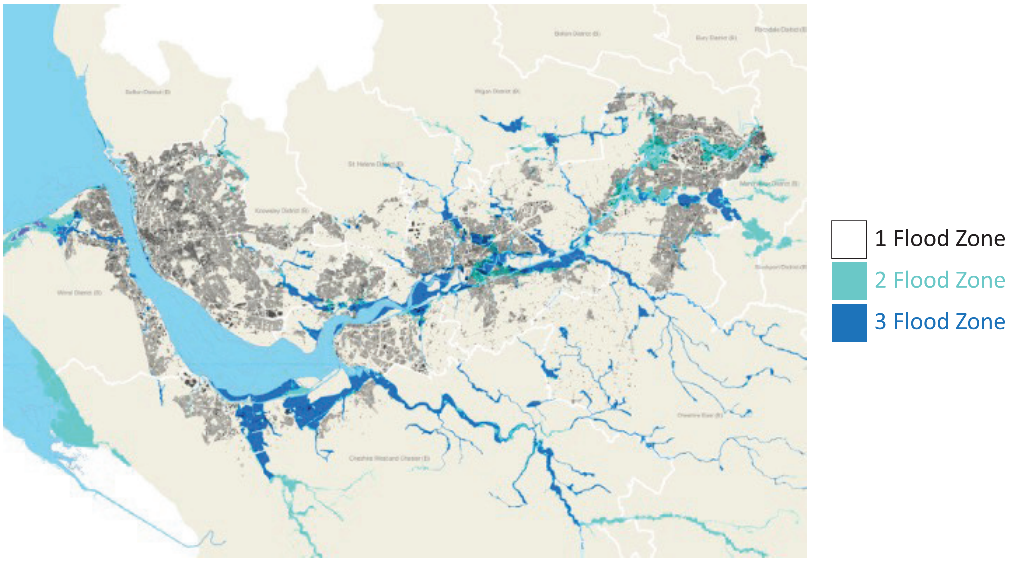

Figure 5. Flooding map. Source: Environment Agency (2016).

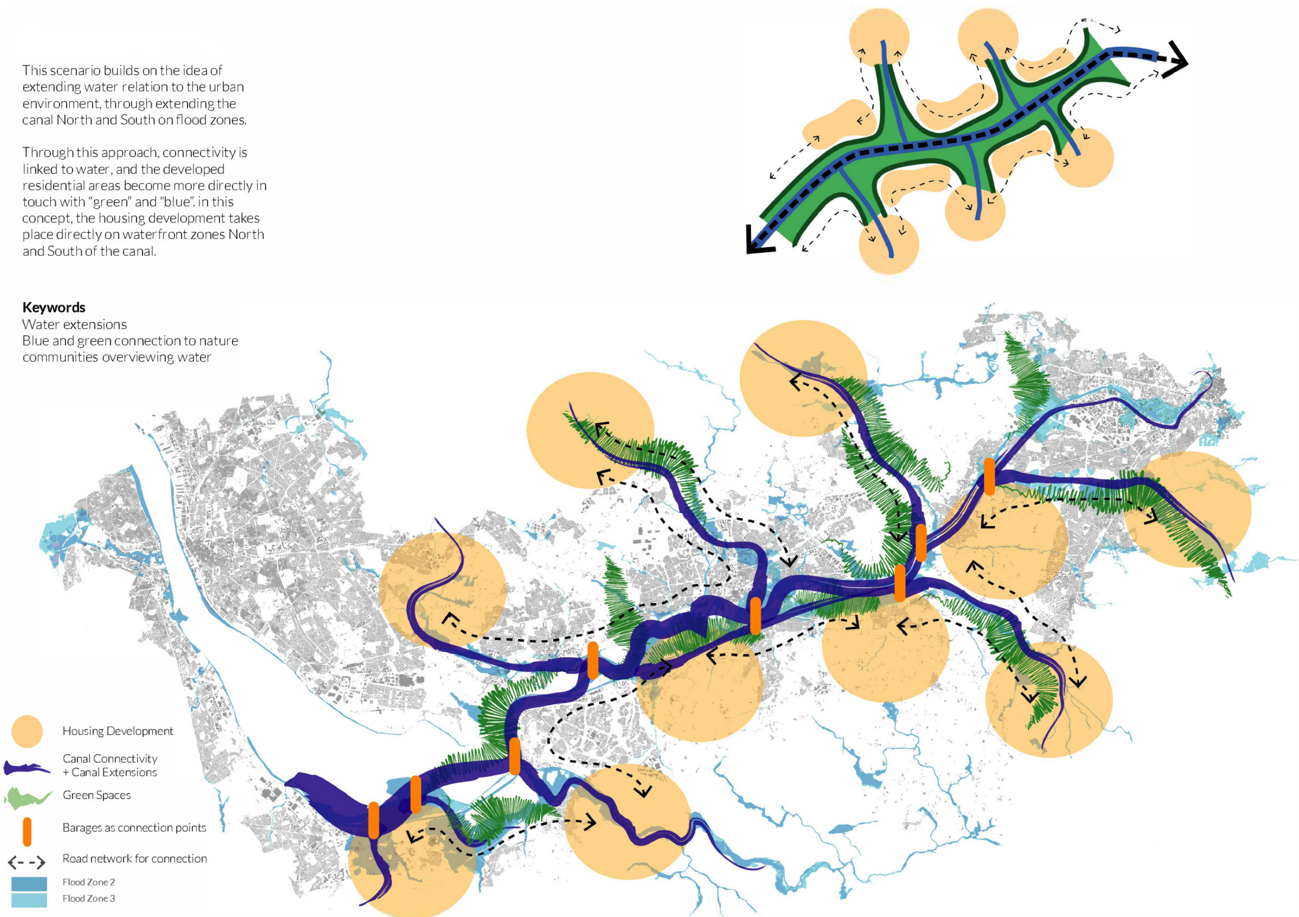

Figure 6. Scenario 2.

unsuitable, population growth trends along the corridor require special attention. The creation of innovative jobs along the corridor may attract highly skilled young people to work and live (Figure 7).

6.1.4. Linking the North With the South: Mobility and Active Transport Along the Corridor

Changing corridor use and mobility is necessary. Development depends on the canal's north–south connection. Local and government initiatives to improve the transport network and increase mobility can form the basis for a connected active transportation network along and through the MSC. This will support creative and innovative businesses to grow and create jobs. More bridges, cableways, or boats along the corridor in strategic locations near working/housing hubs and green spaces can enhance this (Figure 8).

6.1.5. Create High-Density Affordable Housing Integrated With the Natural Environment and Easy Access to Greenspaces

Creating innovative jobs is inextricably linked to this theme. Population and housing must be altered. Affordable housing is essential to attract youth. High-density housing that connects housing hubs, work hubs, and green spaces is considered the most effective way of creating liveable areas along the corridor (Figure 9).

6.1.6. Re-Designing the City Centres and the Urban Corridor to Improve Collaborative Living

With population growth, city centres will become more expensive places in which to live (Figure 10). The design of the corridor and the re-designing of the cities' centres can enhance connectivity along the urban corridor while providing a sustainable environment in which to live, work, and visit that is close to the city centres and provides easy access to them, as well as access to green spaces and outdoor spaces that can be enjoyed by all.

6.1.7. Education for the Future

Digital and disruptive technologies affect future education. Today's generation expects adaptability, not lifelong employment. Given education's strong presence in the Salford Quays area (the former Manchester Docks), more can be envisioned, including the establishment of relations between education and innovative business. Technology will play a major role in education in the future. Digital, media, creative industries, professional services, and new distribution and logistics business models can explore these relations.

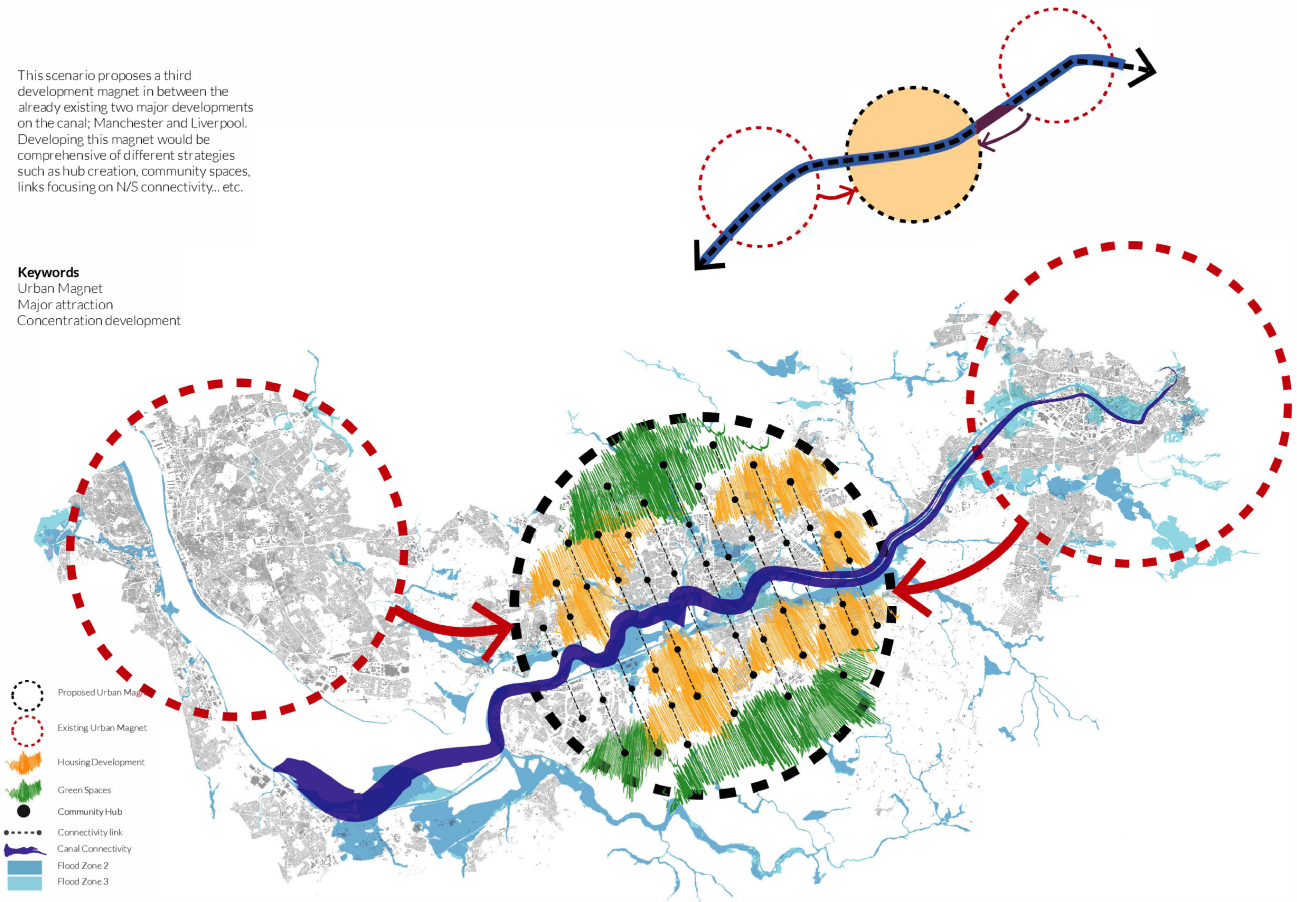

Figure 7. Scenario 3.

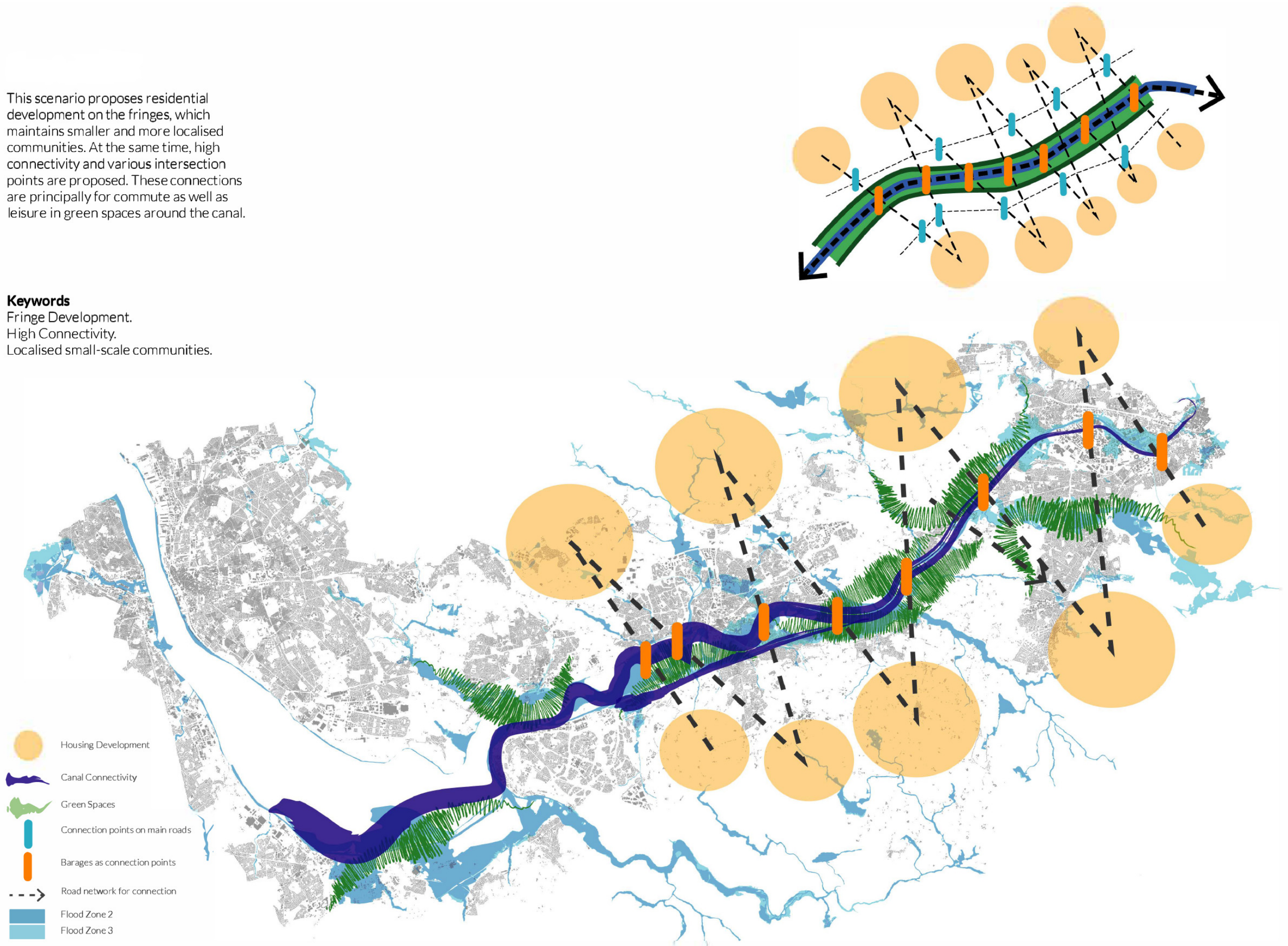

Figure 8. Scenario 4.

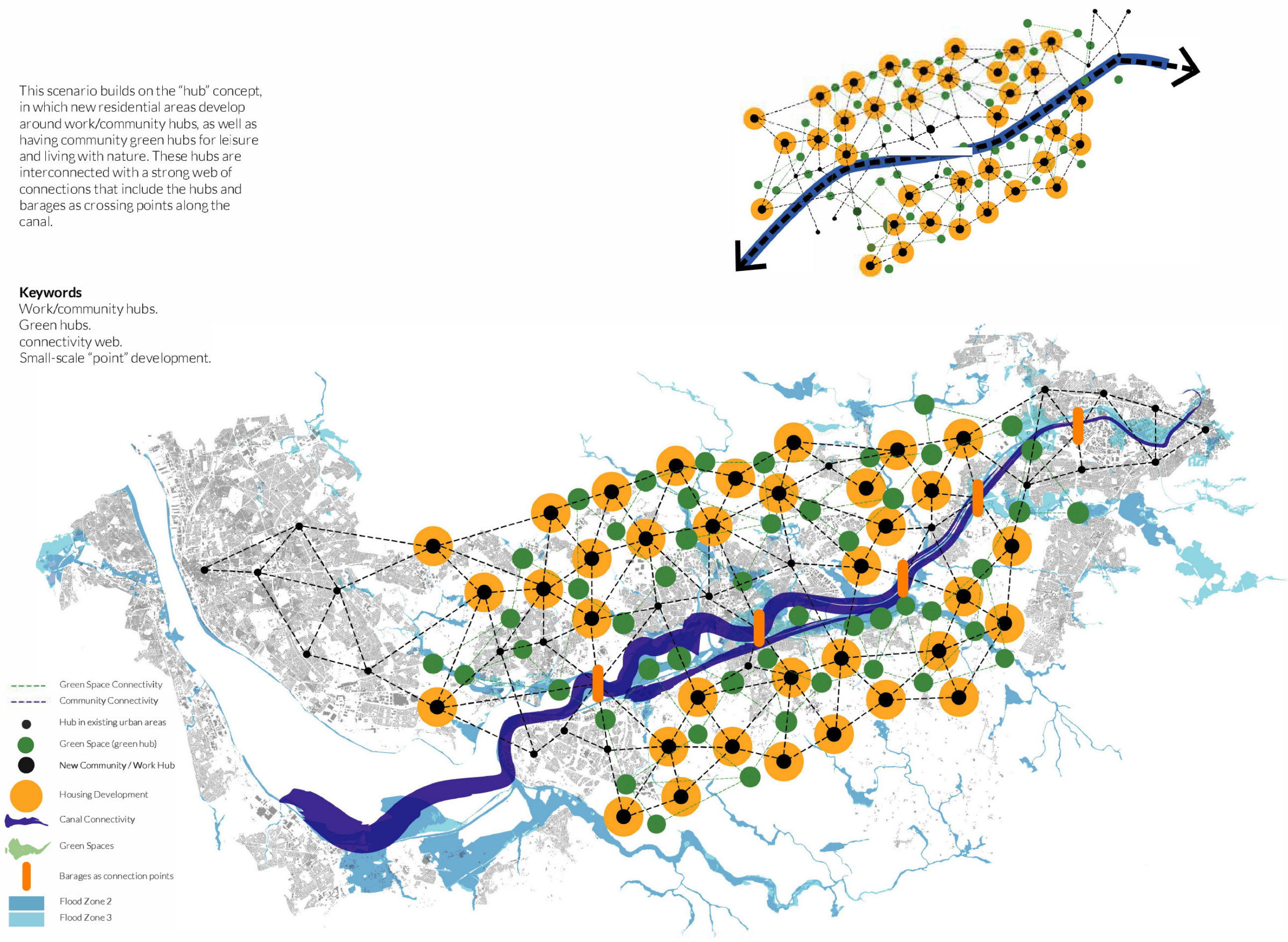

Figure 9. Scenario 5.

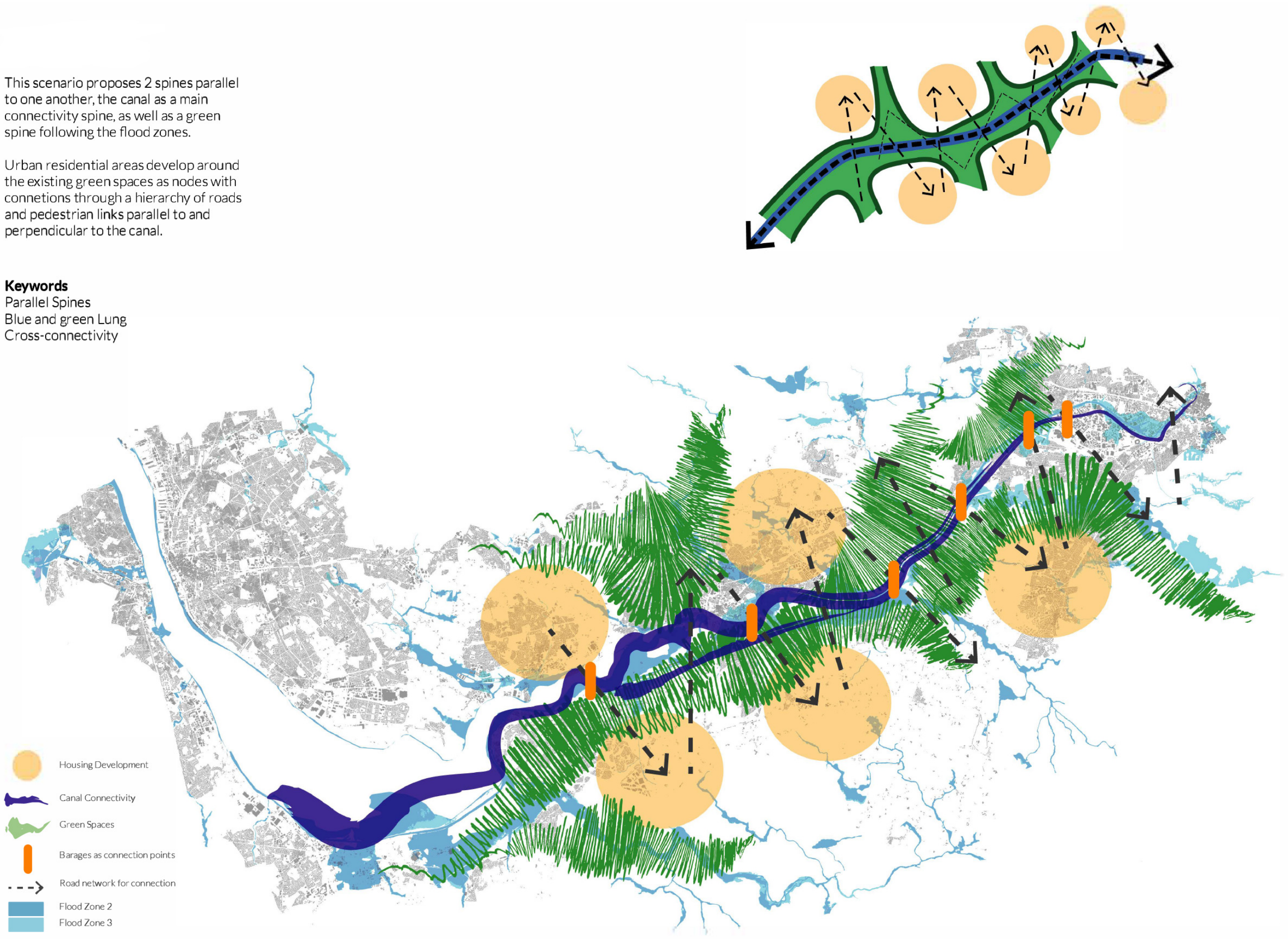

Figure 10. Scenario 6.

Agile policies are the key driver to the MSC urban corridor regeneration. Identifying key moves and catalyst projects allows for the development of multiple smart ecological urban corridor scenarios alongside the MSC.

7. Conclusions

European cities are going through a transformation phase due to several societal and ecological challenges. While some face a shrinking population, others are growing with an increasing demand to meet their environmental challenges. European disused waterways provide opportunities as well as challenges for those growing cities. They present possibilities to install green and blue infrastructure that would positively contribute to sustainable and healthy urban development across their linear configurations. Waterways could also reinvent their past with suitable and more contemporary and sustainable mobility measures. Re-imagining the possible future of disused waterways requires alternative strategic planning processes that would cater for blue-sky thinking and innovation models.

This article provides an alternative approach to strategic urban planning that could be used to develop sustainable and ecologically driven scenarios in a complex large-scale rural/urban setting such as waterways' domains. A catalyst-based approach for urban development around disused waterways is used in this study to develop six different scenarios for the transformation of the Manchester–Liverpool urban corridor alongside MSC. Building on a review of similar waterways' urban development in Europe and an in-depth analysis of the Deux-Rives project in Strasbourg, five common catalysts were identified: connectedness, employability, health and wellbeing, housing, and governance. Through an iterative process, using desk-based and stakeholders' workshops applied to the MSC case study based on synthesising, modifying, and testing to improve the activity, selectivity, and scope of the identified catalysts, a number of ecologically based scenarios were developed.

Through a thematic analysis of factors that are common in several case studies, six scenarios that could accelerate the development and implementation of smart ecological urban corridors were developed.

The MSC case explored the identified catalysts from the review and the Deux-Rives case study and allowed for the definition/exploration of the catalysts to develop an ecological blue and green urban corridor around the canal. The main challenges of the process were as highlighted in the literature: timeframes, length of the process, and resources. The MSC case study explores the methodology further by identifying future enablers through the imagining of the future of the canal.

The catalyst-based approach presents an evolving methodology in urban development as well as an approach to transboundary collaboration in support of communities and urban ecologies. Through this approach, a number of ecologically based scenarios for the MSC were developed by applying an iterative process invention grounded on the development and application of the identified catalysts.

Conflict of Interests

The authors declare no conflict of interests.

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About the Authors

Sara Biscaya (PhD) is the Head of Architecture the Built Environment at the University of Huddersfield, with 22 years of experience as an architect and urban designer (chartered architect, Architects Registration Board and Royal Institute of British Architects) specialised in production and coordination of information and spatial data visualisation. Her research focuses on data applications in developing smart urban futures that integrate the urban and rural socio-economic and physical infrastructures to support communities, stakeholders, and decision-makers. Current projects include Economic and Social Research Council, "Technology Enhanced Stakeholder Collaboration for Supporting Risk-Sensitive Sustainable Urban Development" (Global Challenges Research Fund, £970k), the Arts and Humanities Research Council's "Design Accelerators: Design the Green Transition 2023," "The Value of Design for Sustainable Housing—Towards a Smart Place Demonstrator" (£50k), and the Universities Research Foundation 2023 "Leading the way in Smart Home Research and Innovation" programme (£300k).

Hisham Elkadi (PhD) currently holds the position of dean of Architecture and the Built Environment at the University of Salford in the UK. In the time he has been at Salford, Professor Elkadi demonstrated a capacity for strong and strategic leadership, relationship building, and creating and implementing a model for smart urban futures. He works closely with the industry and local and national governments and has contributed to the regeneration of a number of cities including Geelong (Australia), Rome, Belfast, Salford, and Manchester. He has attracted a number of projects amounting to £20 M from European Regional Development Fund, the Arts and Humanities Research Council, EU FP6 NoE, EU UIA and Peace programme, Australia and UK Government funds, BC Newton programmes, and many others. Prior to his appointment at Salford, Professor Elkadi was the head of the School of Architecture and Building at Deakin University in Australia and the chair of its Academic Board. He was also head of the School of Architecture and Design in Belfast and the director of architecture at the University of Newcastle upon Tyne in the UK.