A Smart Ecological Urban Corridor for the Manchester Ship Canal

ABSTRACT

The paper examines the possibilities of developing a smart ecological urban corridor straddling the 36 miles long Manchester Ship Canal (MSC). Set within the historic counties of Cheshire and Lancashire (where the first planned industrial estate exists), the area is characterized by river and Canal settlements and centuries-old agricultural patterns that persist today. The MSC played a significant role during the industrial revolution. More recently the development of Media City UK at one end provides a smart typology that could expand along the length of the Canal to provide a contemporary new smart urban corridor.

This paper examines a number of ecological scenarios that could create smart networks in different parts of the Canal with its overlapping industrial estates, farms, villages, business parks, and ports.

Utilising a Delphi Technique, a series of cross-boundary multi-disciplinary meetings and workshops with key experts, partners from City Councils, key developers, industry partners and landowners were designed to identify consensus on potential future scenarios for the MSC.

The research utilized a new multi-disciplinary participatory workshop approach to develop a number of ecologically based scenarios**;** a blue-sky approach was used in the workshops underpinned by data analysis of a number of pre-determined catalysts for the MSC.

Keywords— Manchester Ship Canal, rural/urban regeneration, smart networks, smart ecological urban corridor

1. INTRODUCTION

The Manchester Ship Canal (MSC) is set within the dramatic environs of the historic counties of Cheshire and Lancashire that inspired the mystical landscapes and inception of the first planned industrial estate. This paper examines different scenarios for the development of a smart urban corridor straddling the MSC.

Fig. 1 Location of the Manchester Ship Canal in the UK.

The MSC played a significant role during the industrial revolution. The region's low-lying areas are characterized by river settlements and early ages' agricultural patterns that persist up until today.

Fig. 2 Map identifying the corridor area. (Source: https://digimap.edina.ac.uk/roam/os)

The development of MediaCity UK at one end of the site provides a smart typology that could expand along the Canal. The proposed metropole scenarios provide possibilities for developing smart networks between the distinct, but overlapping, geographies of the river (which incorporate farms, villages, business parks, and ports) allowing these areas to retain their present uses while becoming part of a larger coordinated smart system of sites, services and ecologies.

Previous regeneration scenarios for the region have been based on either qualitative and/or quantitative spatial analyses of the current situation. In the light of the pace of intervention of disruptive and new technologies, this paper argues that there is a need for a different more agile and contemporary approach.

The paper presents a new multi cross-disciplinary participatory workshops methodology combined with data analysis of a number of pre-determined catalysts for MSC to develop a set of ecologically based scenarios. Through a blue-sky approach, the workshops utilised partnership engagement with academics, local authorities, planners, local stakeholders, and industry partners to establish the environmental, liveability and economic drivers of the region. The workshops also set out a number of principles to guide the development of a smart ecological urban corridor for the MSC.

The ambition is to design architecture and infrastructure that will support the evolving programmatic typologies of the region while mediating the borders between the different industries, cultures, and avocations that are vying to co-exist in the region. The rural landscape of the region, similar to its urban settlements, is artificially shaped to meet social and economic needs. The proposed interwoven smart and networked metropole will reflect the expected complexity of future human habitation and society around the Manchester Ship Canal.

Developing a smart urban corridor linking Liverpool to Manchester responds to a number of future ecological and societal challenges, grounded in the local geographical conditions which are impacted upon by the increasing pace of climate change.

2. SMART ECOLOGICAL URBAN CORRIDORS IN PERSPECTIVE: PRINCIPLES, STUDIES AND UK CONTEXT

The concept of ecological urban corridors first appeared in the field of biology. With the increase in human demands and the growing scarcity of resources, the concept has gained a preeminent role in the rapid urbanisation and regional integration in connectivity green corridors in cities and between cities (Seto et al., 2013: U.N., 2018). The rapid development of urban expansion has led to biodiversity loss and landscape fragmentation. Some argue that it is necessary to focus on urban ecological corridors within the larger scale of urban and rural spaces. There is widespread concern in respect of such spaces regarding their ecological, social, cultural and other features (Savard et al., 2000: Peng et al., 2017). The term ecological urban corridor is usually defined by a linear or a ribbon ecological landscape that provides the functions of natural habitats, green open spaces or human habitat isolation in the context of an artificial eco-environment within a city or urban area (Noss and Harris, 1986: Zhou et al., 2006). With the paradigms of economic development and ecological protection alongside urban environmental problems and increasing human ecological demands, the efficient construction and management of an urban ecological corridor is seen as a possible way of resolving the contradictions in the process of rapid urbanization. There are several classifications of urban ecological corridors which vary according to their structure or functions. In terms of structural function, they can be identified as: a river corridor (Peng et al., 2017: Jiang et al., 2009), a green transportation corridor (Zong et al., 2013), a biodiversity conservation corridor (Zhou and Fu, 1998: Li et al., 2009), a heritage corridor (Kong-jian et al., 2005) and, more recently, a recreation corridor (which is a result of urban residents' needs for green open spaces and recreational spaces (e.g. for walking and cycling)). In terms of functional classification, ecological urban corridors can be described as barrier corridors, impeding materials, energy and information from flowing and, by doing so, protecting special species from external interference, thus conserving biodiversity (Peng et al., 2017, Noss and Harris, 1986). Ecological urban corridors can cause natural habitat fragmentation, reduce landscape connectivity and increase local species' extinction (Li, 1999). Conversely, they can create ecological constraints to urban expansion and can prevent urban sprawl such as in the case of greenbelts in London, Seoul and Beijing (Munton, 2006: Yang and Jinxing, 2007). Another typology is that communication corridors can promote the flow of important channels for water, nutrients, energy, plants and animals, thus increasing the connectivity possibilities between vital patches of ecological landscapes (Zhang et al., 2005). The two functions described above, are not finite and can ensue simultaneously in ecological urban corridors. Blue and green corridors are urban corridors developed around watercourses, flow paths and surface ponding water alongside the green infrastructure that typically accompanies such urban blue and green corridors (URS, 2011: Li et al. 2017). The dynamic linkages and ecological relationships of both with the urban environment create an area of multifunctional use (URS, 2011: Gaston et al., 2013: Li et al., 2017).

Urban development is interlinked with the way technology is shaping our present and is dramatically impacting upon our future. The ubiquitous infrastructure is considered as an enabler of smart urban development (Anthopoulos and Fitsilis, 2010, Albino et al., 2005). Technology has an impact on developing urban infrastructure, on planning, water supply, public transportation and environmental protection (Anttiroiko, 2013: Kitchin, 2014). Complex information systems require an innovative approach to urban development (Anthopoulos and Fitsilis, 2010: Kitchin, 2014).

The development of a Liverpool to Manchester smart ecological urban corridor presents a case study for the northwest region in the UK but its conditions/characteristics could be extrapolated to other parts of the globe. The increase of urbanisation across the Liverpool - Manchester region has negatively impacted on its habitat. The buffer area along the Manchester Ship Canal presents the possibility of developing a smart ecological urban corridor that promotes the connection between human needs, environmental infrastructure and scientific and economic development in the area while nurturing biodiversity and providing quality urban spaces for the increasing number of residents. The focus is to maintain the integration of human and natural systems.

The methodology developed in this paper aims at reading, integrating and making the most of different regeneration corridors' principles and smart urban development through the engagement of multi-disciplinary experts whilst also making the most of existing identified data sets' analyses.

The key drivers in regenerating urban corridors can be the economy, connection with nature and resilience, a healthier population, and culture and lifestyle. These drivers are global and have different facets and relevance in different urban areas and contexts.

Recent examples of redevelopments of river/canal sites include the Bradford-Shipley canal road corridor in the U.K. (Bradford Council, 2017), the Hafen City project, Hamburg in Germany (Ministry of Urban Development and the Environment, 2017: Sepe, 2013: Couch et al., 2011) and the Cheonggyecheon Stream project as part of Seoul's urban regeneration plans (Cho, 2010, Lah, 2011, Temperton et al., 2014). All these projects are to be completed by 2030 with Hamburg and Seoul being at the forefront of environmentally conscious urban regeneration.

The smart ecological urban corridor between Liverpool and Manchester presents a different vision as to how urban/rural patterns can provide differing contemporary ecological conditions for living and working. This research reads and analyzes the urban/rural settlement structures along the MSC corridor providing an insight into the patterns of living and working that have shaped them. The paper then proceeds to investigate possible scenarios for a smart networked metropole that integrates the urban and rural socio-economic and physical infrastructures along the corridor.

3. THE MANCHESTER SHIP CANAL

The Manchester Ship Canal links two of the major centres within the UK government Northern Power House initiative aimed at regenerating the economy of the North of England (H.M. Treasury, 2016). At the end of the 16th century Manchester was a local centre for the spinning and weaving of wool and linen. The wool was gathered locally but the linen was imported from Ireland (Grant, 1978: Owen, 1983). The city grew mainly due to its factories which caused an increase in the population. In the 17th century there were reports of 750 families living in Manchester and up to 2,535 persons were enumerated. In 1700, this number increased to 5,000 persons making Manchester a metropolitan centre of culture and trade (Owen, 1983). The city became a centre of manufactured wool and, increasingly, the marketplace for cotton goods.

Liverpool has been a commercial centre since the 1700s and particularly so from the 1800s onwards due to its geographical position as the U.K. entrance of goods from Ireland and from the growing Americas via the Irish Sea (Owen, 1983: Clemens, 1976). This strategic position also allowed the city to control shipping and distribution prices, which had a hand in impeding Manchester's continuous growth up to the middle of the 18th century (Clemens, 1976). The roads through Lancashire were notoriously bad. Suggestions had been made, since 1660 onwards, that the Mersey and Irwell rivers should be made navigable from the estuary to Manchester to support the city's growth. The first Bill sent to parliament was rebutted and was only approved in 1720 after a number of attempts (Clemens, 1976: Leech, 2014). Several ideas were envisioned during this period including one from Thomas Steer (1792) of building eight veins each to be by passed by locks, a forerunner for the MSC project of 1882 (Clemens, 1976: Leech, 2014).

Between the 18th and the 19th century two major endeavours took place: the linking of the Bridgewater Canal with the Mersey Estuary at Runcorn in 1776 and the opening of Stephenson's Liverpool and Manchester railway in 1830 (Owen, 1983, Owen, 1983, Bagwell, 2002). Both developments were game changers in the corridor linking Liverpool to Manchester and contributed to the growth of Manchester as a metropolis. The Bridgewater canal became a friendly rival to the railway since there was enough traffic for both even though the railway represented only a two-hour trip from Liverpool to Manchester as opposed to the seven hours by water (resulting in the cutting of freights and tolls) and the actual quantities carried on both methods of transport continue to rise (Bagwell, 2002). In 1844 Lord Francis Egerton purchased the Mersey and Irwell Company and by-1882 the Bridgewater trustees had linked the Mersey and Irwell rivers and the Bridgewater canal to the Liverpool & Manchester railway (Grant, 1978: Owen 1983). Liverpool was benefiting from the dock and town dues imposed on all goods brought in by sea before they could be taken by barge or rail to Manchester and Manchester and its surrounding neighbourhoods were experiencing a commercial decline. In 1882 Manchester Mayor along with leaders of commerce and industry, bankers, financiers and engineers specialised in navigation of canals and rivers held a meeting that began the implementation of the Manchester Ship Canal (Owen, 1983: Leech, 2014). The idea was to convert the existing navigation into a deep-water ship canal. The first two Bills submitted to Parliament in 1882 and 1883 were not successful due to a number of technical issues but also mostly due to the resistance of its opponents/supporters of the Liverpool economical purview (Grant, 1978: Leech, 2014). A third Bill was prepared with the project's revisions and was submitted in 1884 to be accepted after heated discussions in 1885 (Grant, 1978: Leech, 2014).

The MSc was opened for traffic in 1894 allowing the Port of Manchester to become the third busiest port in Britain (Grant, 1978: McNeil and Nevell, 2000). The area around the MSC evolved from the factory-based cotton industry to hosting wider industrial and technological centres as the 19th and 20th centuries progressed. The area became a major engineering centre with the adoption of the power loom for weaving and in playing a lead in the development of machine-tool production and precision engineering, although it has experienced a significant decline in the last 20 years (McNeil and Nevell, 2000).

In 2006 the development and establishment of MediaCity in the remains of the Manchester docks (now known as Salford Quays) became the first significant urban regeneration project along the MSC (Nevell and George, 2017). The industrial revolution was

ignited in Manchester through the visions of innovative technologies, this paper explores potential visions for the future of a smart ecological urban corridor by applying a new methodology that builds on the history of the MCS without disregard for the increasing speed of disruptive technologies.

4. METHODOLOGY

4.1. METHODOLOGY

This paper applies a new multi-disciplinary participatory workshops approach to developing a number of ecologically based scenarios. Through working partnerships, the project engaged cross-disciplinary partners including academics, local authorities, planners and industry partners to find the potential environmental, liveability and economic drivers and enablers to establish a set of principles that can guide the development of a smart urban corridor for the MSC. A blue-sky approach was used in the workshops combined with data analysis of a number of pre-determined catalysts for the MSC.
The Delphi Technique was applied in this study aiming at a consensus of opinion concerning real-world knowledge from experts in the fields that the MSC urban ecological corridor would address (Dalkey and Helmer, 1963: Hsu and Sandford, 2017) with a focus on developing potential scenarios (Pill, 1971) of what this corridor along the MSC could incorporate.
Four iteration phases, as per the diagram in Fig. 3, were determined to achieve consensus (Dalkey and Helmer, 1963) within a series of multi-disciplinary meetings and three workshops with key experts from different fields, including urban design, ecology, engineering, environmental studies, transport, health, and social science, to identify the potential of the MSC corridor, prospective catalyst projects, and key drivers and enablers.

Participants were sampled based on their background and expertise and not simply on their knowledge of a subject, as recommended by Pill (1971) and Oh (1974). An initial literature review was conducted on ecological and urban green and blue corridors and on the Manchester Ship Canal's history followed by a number of meetings to identify the research questions, relevant stakeholders and data requirements.

During the first workshop data on the Canal were presented and discussed and initial catalyst themes were identified by the participating panels and mapped according to the level of consensus achieved.
The themes were selected to cover a range of objectives for the redevelopment of the region, including:

- **Rurban Fusion:** Human-wildlife interactions in an urban environment
- **Future Mobility and Interconnectivity:** Changing patterns of use and mobility in the proposed corridor
- **The Corridor Economy:** Directing regional development through channels, foci and amplifying the potential for regional economic growth
- **Inhabiting a Smart Urban Corridor:** Population trends and housing patterns
- **Manchester Ship Canal Rurban Living:** Urban / rural interconnections, exploring topics from urban agriculture to the urban fringe
- **Smart Manchester Ship Canal Futures:** How the design of particular configurations afford possibilities for co-existence

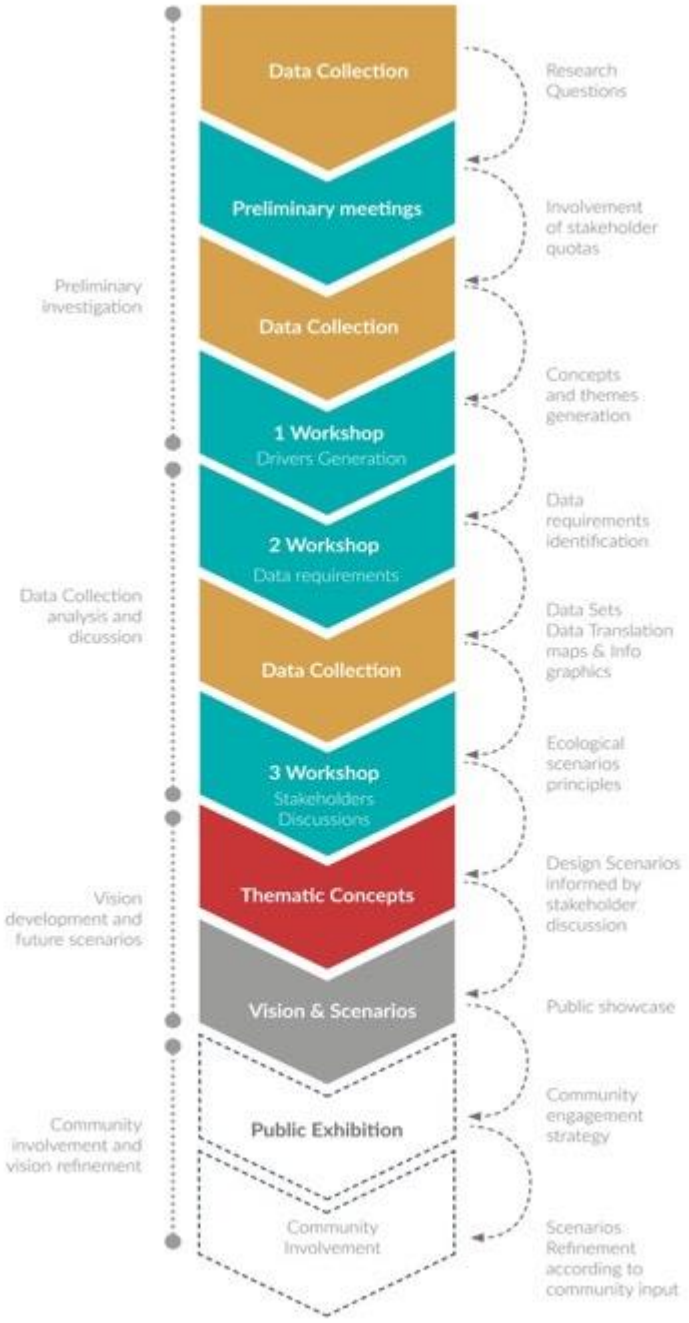


Fig. 3 Methodology Diagram

Based on the initial catalysts' identification a second workshop was conducted to assess the data gathered for each theme.
The socio-spatial characteristics of the MSC region were identified and analysed using current available qualitative and quantitative data from several sources such as but not limited to: the Office of National Statistics, Public Health England, The Department of Communities and Local Government, the Copernicus Land Monitoring Service, Digimap – Ordinance

Survey and GMOpenDataForum in the form of GIS Datasets and excel sheets.
The basic analysis was introduced to participants of the workshop to inform their discussions.
Participants were asked to respond on three areas of development; Environment, Living and Co-existence, and Economy. A number of key points were identified. These key points in the three areas of development were reviewed and collated in between the workshops. A series of 12 meetings in total took place to discuss the data sets, the main themes/drivers and to develop the catalysts' projects.
Parallel to the workshops, more detailed data on the different existing layers of the MSC corridor were collected and processed to support the workshops' analysis and debate. An in-depth analysis of all the existing and future strategic plans for the region was conducted, including: The Greater Manchester Strategy, the Warrington Local Plan Core Strategy - July 2014, the Liverpool City Region Strategic Housing & Employment Land Market Assessment - January 2017, the Cheshire West & Chester Council Local Plan (Part 1) Strategic Policies – January 2015, and the East Cheshire Local Plan Strategy 2010 – 2030 Adopted 27 July 2017 – July 2017.
It was vital to present the variety of the data in a way that all stakeholders involved would be able to "read and interpret it", and thus maps and infographics were developed for that purpose.

The third workshop with 31 key experts and stakeholders of the project was established to refine the main themes and to establish the principles of the MSC Smart Ecological Blue and Green corridor future scenarios development.
The three areas of development were reviewed and updated. Focus was then, therefore, placed on four sectors:

A. Health and Wellbeing
B. Housing
C. Jobs for the Future
D. Connectedness

All qualitative and quantitative data sets are described in the Data repository section (Table I) and were represented through maps and/or infographics printed on tracing paper and presented digitally at the same scale to facilitate overlapping and the exploration of the data. Section 6 presents the ones that the workshop participants found most relevant for the MSC smart ecological urban corridor development.

In this third workshop each theme was presented with a challenge or a question at the end to instigate the discussions. The themes and concepts, as well as the future scenarios principles, were mapped according to the level of consensus achieved and the initial findings are presented in this paper.

The Delphi technique provided for the creation of a high level of consensus regarding the future potential development of an ecological smart future urban corridor between the different experts and interested parties from along the corridor involved in different sectors and activities (Hsu and Sandford, 2017: Pill, 1971). This was supported through the analysis of the different identified data sets and the assessment of the opinions gathered during the application of the Delphi technique in the iteration process.

4.1.1. PROJECT CATALYSTS

The analysis and discussions from the workshops were analysed in terms of applied/used words and concepts. The frequency was mapped followed by categorisation and clustering of the identified main concepts and catalyst projects. MetaFlow software was then used to input the Excel data with the concepts and frequencies, which then provided the information in the diagram presented in Fig. 4.

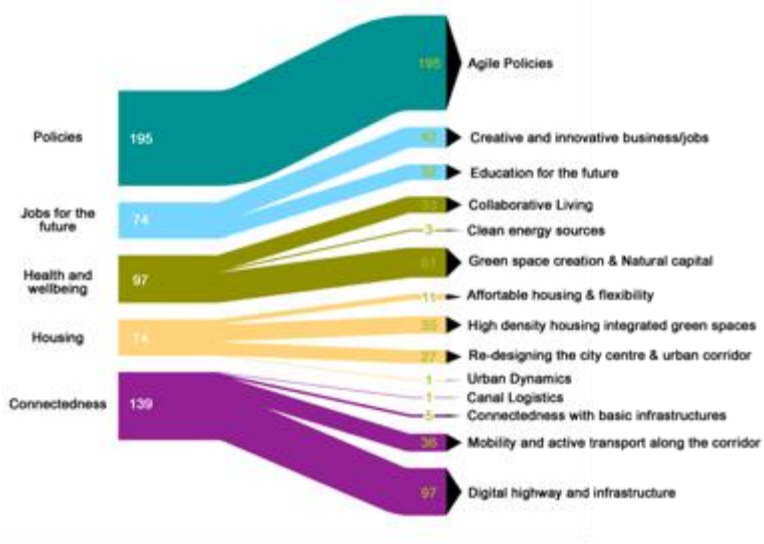


Fig. 4 Themes' Frequencies

The themes and concepts were mapped according to the level of consensus achieved. Within the themes and recognized constraints, enablers and key moves were also identified.

5. DATA ANALYSIS

The data repository in Table I was developed and updated throughout the project and was available to all participants via a shared folder.
The first workshop was used to identify the main themes/drivers, sub-drivers as well as the issues related to both. In the second workshop a basic investigation of the different datasets led to an agreement on a number of catalysts for development. The third workshop allowed for the main themes' refinement and the identification of the principles for the MSC smart ecological corridor scenarios. The data were analysed by overlapping the different layers and strategies and mapping the main constraints and catalysts for development.

TABLE I
IDENTIFIED DATA SETS FOR EACH THEME

Themes	Sub-drivers	Identified issues	Data sets
1. Health & Wellbeing	•Demographics	•Deteriorating Health •Deterioration of the Natural Environment •Cost of Ill Health vs. Value of the Natural Environment	•Population / Density •Education Status •Demographics •Employment vs Unemployment
	•Nature •Wildlife		•Green Infrastructure •Fisheries •Air Quality •Land Use •Sites with Biological Importance •Green Belt Plans •Existing Green Spaces
	•Health: Obesity/Diabetes/Cancer/ Dementia •Ageing Population		•Obesity Data •Life Expectancy •Health Deprivation and Disability Indices •Diabetes •UK Cancer Data •UK Dementia Data •UK Noise Data •Data Relating to Deaths from Circulatory Diseases vs Exposure to Green Space •Existing Green Spaces vs Risk of Death •Morbidity
	•Climate Change		•Flood Maps

2. Housing	•Demographics
	•Urban vs Local
	•Cities' Growth
		•Inequality in Providing Affordable Housing in Greater Manchester Area and Along the Corridor to Liverpool	•Demographics Along the Corridor:
			  •Population
			  •Densities
			  •Age Profile
			  •% of Working Population
			  •Migration Indices Along the Corridor
			  •Crime/Deprivation Index-UK Rank
			  •Housing Services/Deprivation Index-UK Rank
			•Housing Market:
			  •Housing Prices
			  •Annual Earnings: Mean Individual Earnings
			  •Affordability: House Prices/Annual Individual Earnings (Along the Corridor and in the North West Region Overall)
			  •Supply:
			  • Number of Vacant Dwellings
			  • Net Number of New Dwellings 2016/17
			  •Demand: Future Housing Needs (Number of Units Based on Future Population Projections)
			•Land Uses:
			  •Nature
			  •Residential (Densities)
			  •Green Spaces in Urban Areas
			  •Rurban Living (Potential Future Green Areas)
			  •Flood Zones

3. Jobs for the Future	•Impact of Disruptive Technologies
	•Effect of Artificial Intelligence (AI) and Automation
	•Creative Content / Industry.
	•Self Employment
	•Multiple Skills Set
	•Diversity and Inclusion
		•Lack of Vision for Possible Changes in the Job Market
		•Work/Life Balance
		•Equality of Opportunity
		•Changes in Leisure Time
		•Role of Work in Fulfillment
		•Geographical Locations Along the Corridor (including Land Ownership)
			•Annual Earnings: Mean Individual Earnings
			•Existing Businesses:
			  •Number of Businesses
			  •Age of Businesses
			•Work Status:
			  •Working Population
			  •Long-Term Unemployment
			•Land Ownership
			•Regional Logistic Facilities (Existing and Under Development)
			•Enterprise Zones
			•Prospective Future Industry Needs

4. Connectedness	•Transportation
	•Connectivity (nature and technology)
	•Commute
		•Lack of Connectedness
		•Lack of Communication
			•Transport Networks
			  •Railways and Roads (Existing and Planned)
			  •High Speed Railway
			  •Airports and Airfields
			•Technology and Communication
			  •Drones Highway
			  •Shipping Ports
			  •Rail freight Hubs
			  •Distribution Centres
			  •HyNet Project

			•Waterways + Rivers in Region •Birds' Migration Paths

			•Commuting Patterns
			  •Residence to Workplace Commute Pattern
			  •Daily Commute Flow
			•Regional Connectivity Strategy

5.1 PRESENTATION AND ANALYSIS

The identified datasets in Table I were translated into maps and infographics which were presented, overlapped and analysed to identify the principles for a smart ecological urban corridor around the MSC. Blue sky thoughts were gathered that would identify possible relevant themes in the region that could describe or shape smart urban ecological futures. The analysis was gathered around four main themes: Health and Wellbeing, Housing, Jobs for the Future, and Connectedness.

5.1.1 HEALTH AND WELLBEING

Fig. 5 Life Expectancy Along the MSC
Source: Public Health England:
Health Profiles 2015

The overlap of the maps on health and wellbeing in the region presented some relevant figures on life expectancy (Fig. 5) and on the high obesity levels in both adults and children correlated with health deprivation indices (Fig. 7) along the canal.

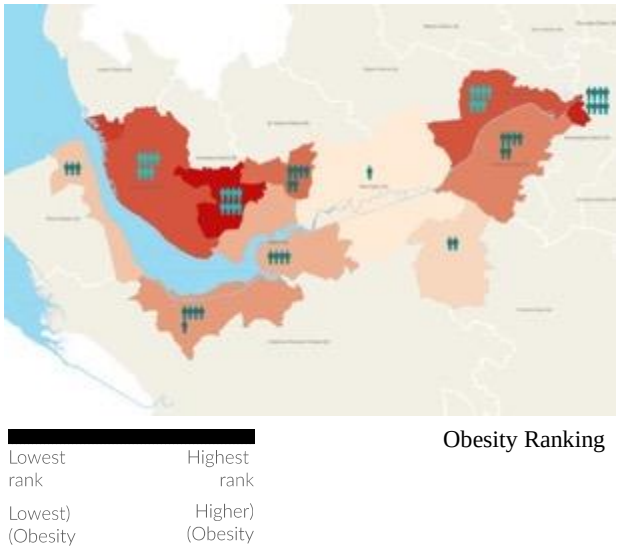


Fig. 6 Obesity Ranking in the UK, along the MSC.
Source: Public Health England: Health Profiles 2015.

The analysis showed that the areas with the highest diseases' rates (such as obesity) are the ones that show restricted or no access to green areas/nature-land use (Fig. 12).

The highest percentage of ageing population is concentrated in the more affluent districts in middle section of the Canal (Fig.5). The need to establish a demographic balance in these areas seemed crucial for the participants. Housing affordability in the area as well as *future jobs* along the MSC are key to such a strategy. An objective was established for high density housing that relates, and guarantees access, to nature and job opportunities in these areas which currently experience a rapid and increasingly ageing population rate.

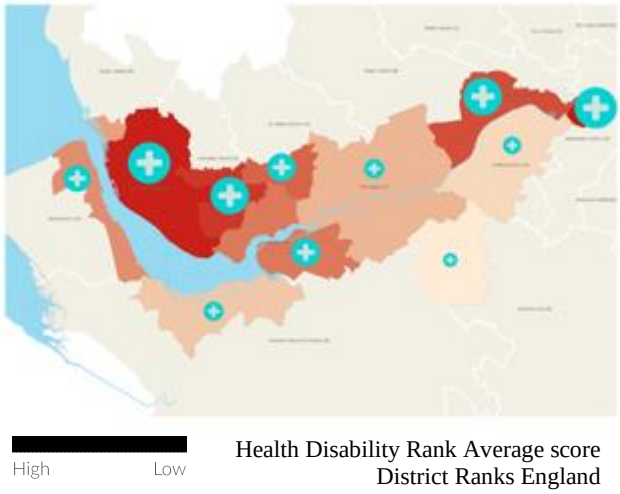


Fig. 7 Health Deprivation and Disability
Source: Department of Communities and Local Government.

5.1.2. HOUSING

New modes of living and working were extensively debated, and it became evident from the data (Figs. 8-10 and 16-17) that housing and future, IT based and logistics hubs, and jobs are increasingly changing and shaping new paradigms. Housing and work environments will have to cater for these changes which will require different approaches to guarantee communities health and wellbeing whilst maintaining and securing a high level of green and blue infrastructure.

Fig. 8 Demographics (Population Analysis by the Middle of 2016)
Source: Office for National Statistics

A major concern around the MSC area is housing provision. Some high-density housing areas, highly priced, are, surprisingly, on flood zones (Figs. 9-11)

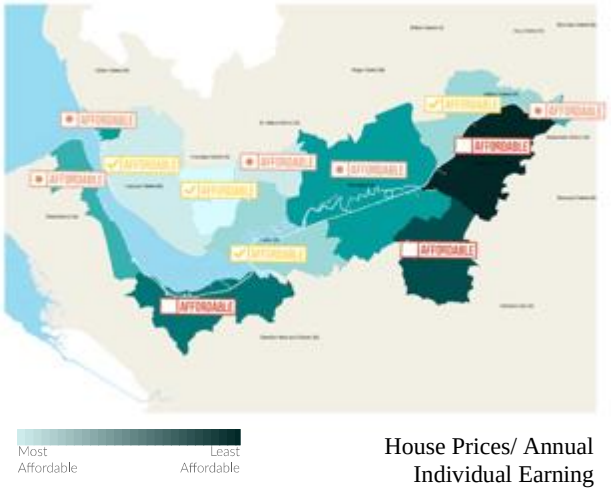


Fig. 10 Affordability– House Prices/ Annual Individual Earnings
Source: Office for National Statistics.
GIS Dataset: Ratio of median house price to median annual

There is an increasing demand for housing in the Greater Manchester area and Liverpool. The Greater Manchester plan, for example, includes the development of 10000 housing units per year during the next 20 years (GM, 2019).

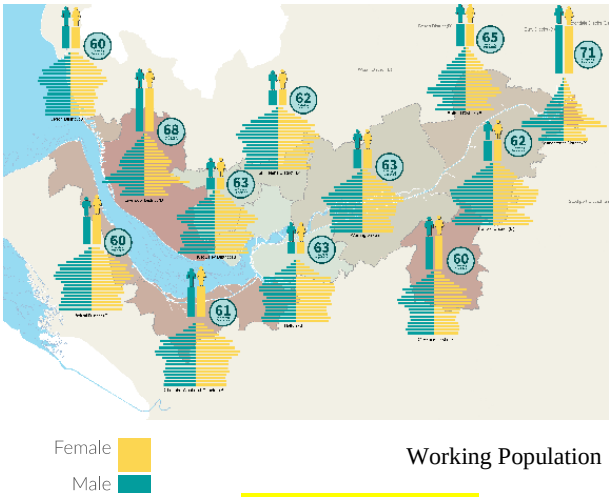


Fig. 9 Working Population (%)
Source: Office for National Statistics.

Fig. 11 Flooding Map
Source: Environment Agency.

Fig. 12 Nature-Land Use
Source: Copernicus Land Monitoring Service.
GIS Dataset: Urban Atlas 2012.

The redesign of town and village centres along the Canal was also highlighted by the participants. The urban centres around the Canal have been the focus of a number of urban planning experiments in the past, such as The New Town Act in Runcorn and Warrington in 1946 which was based around car mobility with little consideration for people and nature. Liverpool and Manchester at both ends of the Canal have heightened problems because of their high densities, low to null housing affordability, limited access to green spaces and poor health outcomes and low life expectancy. The connectedness between the different districts along the Canal is also limited (Figs. 16-17).

5.1.3. JOBS FOR THE FUTURE

Connectedness has been acknowledged by all the participants as a key factor for development in the area. The data shows a considerable lack of connectedness between the north and south areas of the Canal with high commuting patterns over very short distances (Figs. 16 and 17).

The current existing transport networks (Fig. 16) are not sufficient for the density of some areas, mainly in the middle section of the Canal length (i.e. Warrington and Halton) and present real challenges in terms of public transport and road traffic.

The Canal has experienced an increase in the percentage of business and technology and science industries' establishment and development along its length (Fig. 14) and the existing strategies predict a significant increase in some areas as per Fig. 15.

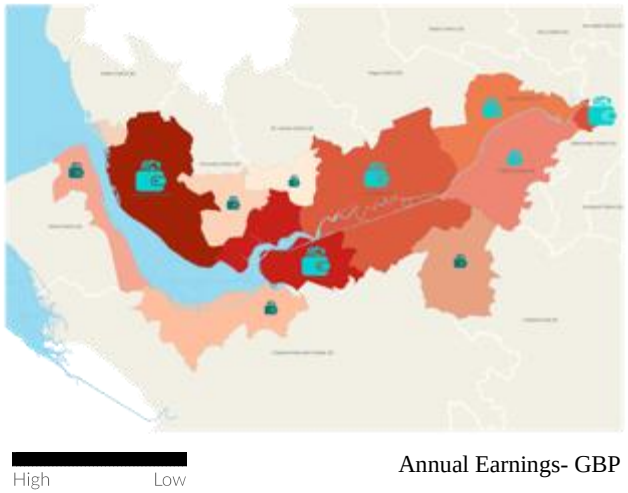


Fig. 13 Annual Earnings- Mean Individual Earnings
Source: Office for National Statistics.
GIS Dataset: Ratio of median house price to median annual earnings 2015.

Included in the plans of the Northern Powerhouse are energy and nuclear plants in Cheshire West and Chester and Warrington, logistic hubs in Halton and Salford, manufacturing centres in Cheshire West and Chester and Halton, science and bio-medical centres in Cheshire East and technology and business hubs in Halton, Warrington, Trafford and Manchester. All this will have an impact on the corridor area that is not assessable at this point but is likely (if these plans are put into action) to contribute to the increasing value of the development in the area.

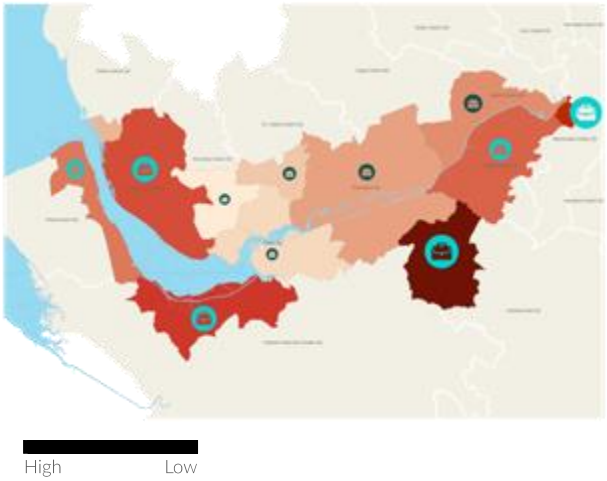


Fig. 14 Number of Businesses
Source: Office for National Statistics.
GIS Dataset: UK Business: Activity, Size and Location 2015.

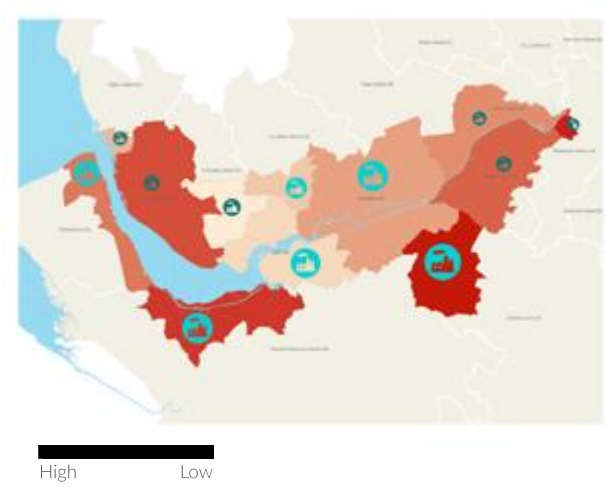


Fig. 15 Prospective Industry Needs
Source: Digimap – Ordinance Survey - 2018.
Data source: The Greater Manchester Strategy

As for industries' future needs and expansion as shown in Fig. 15, the areas of Cheshire West and Chester, Cheshire East, Liverpool and Manchester are likely to be in demand. This presents a significant impact in land use along the corridor with flood zones and green spaces already evidencing high urban density which will, no doubt, increase with the growth of the industrial areas.

5.1.4. CONNECTEDNESS

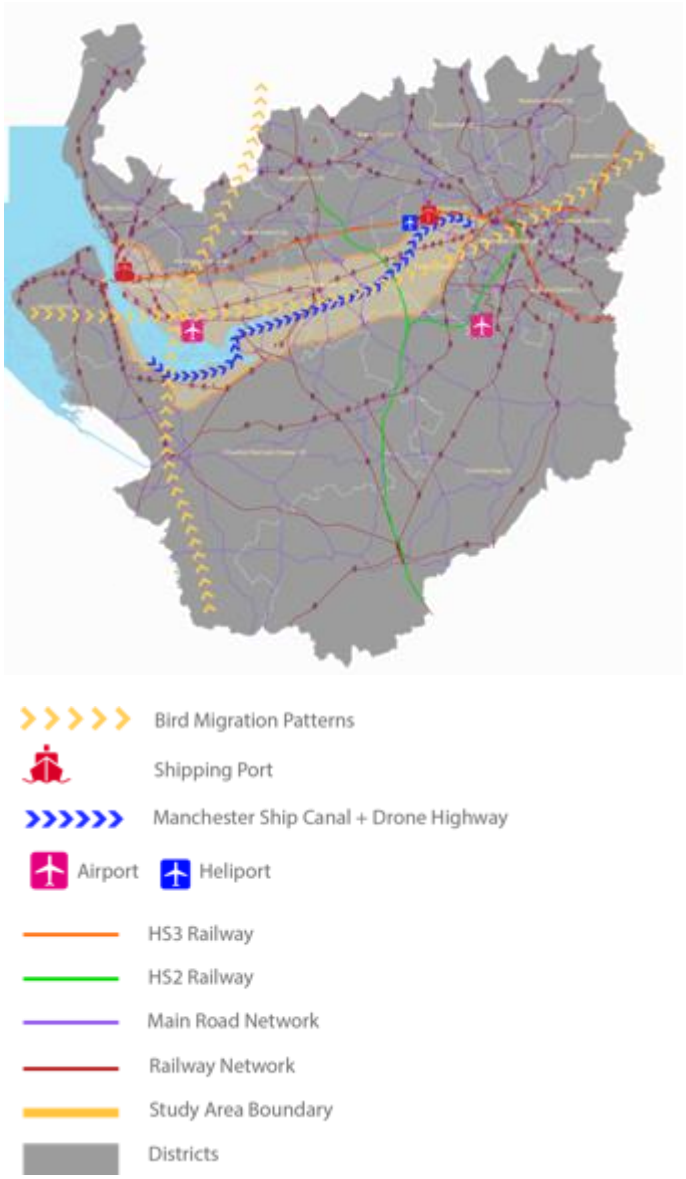
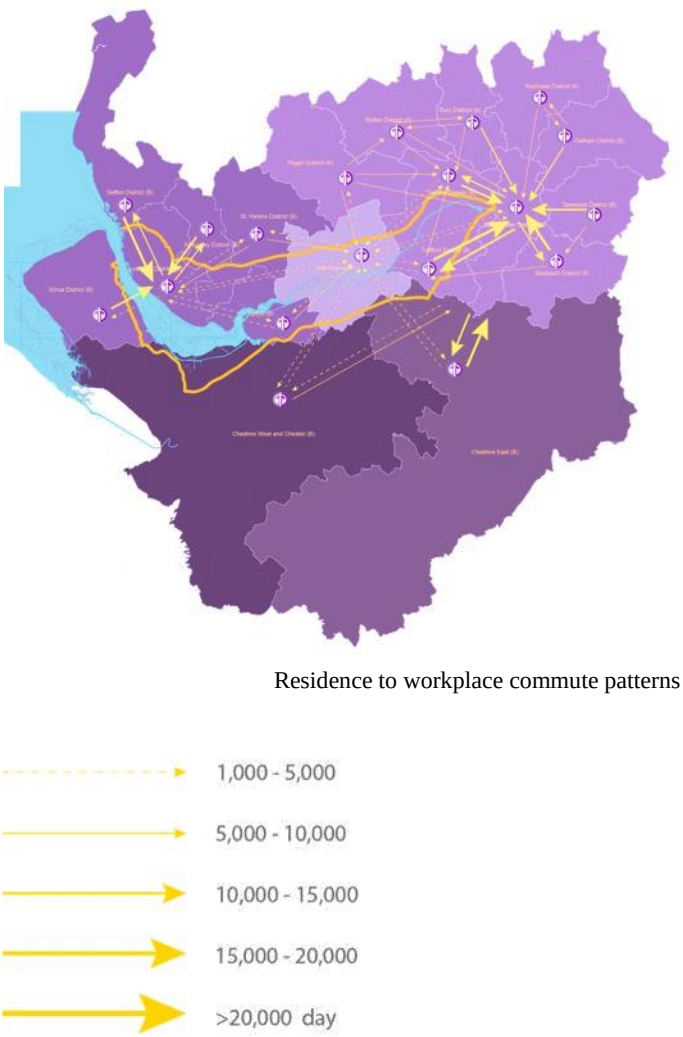


Fig. 16 Transport Networks, High Speed Railway, Airports and Airfields, Digital highway, Birds' migration paths
Digimap – Ordinance Survey - 2018.



Residence to workplace commute patterns

Fig. 17 Commuting Patterns
Source: Digimap – Ordinance Survey - 2018.

Business and industries' growth will need to be supported by digital and physical infrastructures that can accommodate future working and living conditions. This will ensure the regional development and the establishment of population.
Net-zero carbon mobility modes of active transportation for both cargo and people were part of the discussion around the MSC's growth, to assist in attracting investment, a young population and in order to catapult innovative industries' internationalisation.
The high-speed railway route, while useful, does not present a relevant solution, as it will only cross the area in Trafford and Warrington (Fig.16). The most relevant finding from the transport networks' and commuting patterns' analysis is poor and ineffective connectedness between the north and the south of the Canal.

The analysis highlights the urgent need for a shift in post 18 years old education. The increase in technology-based industries requires highly qualified professionals that are willing to settle in the region. The fact that a number of educational institutions within the area already focus on technology is perceived as a large advantage. The challenge is also to provide a green infrastructure that will improve livability and livelihoods.

The outcomes from the basic analysis were presented at the follow up workshop for discussion. Groups of participants from different fields throughout the corridor area investigated a particular theme with its related challenges. Each group was asked to envision projects and drivers that could potentiate a catalyst for development along the MSC corridor.

6. Discussion

6.1. Proposed Key Moves

The MSC is currently mainly used for freight transport and logistics' hubs along its length alongside some key industry infrastructures. The Canal could be transformed into an autonomous highway and a route for digital infrastructure, potentially with a drones' highway. This would mimic the Canal's previous role as a driver in the first industrial revolution. Such development would attract business investors and subsequent technological jobs for highly qualified professionals.

Economic corridors are gaining popularity internationally particularly in terms of regional development. Transport routes and hubs are planned connecting factories to markets, serving industrial clusters as well as the commuters who work in those industries. Classic examples are the Pacific belt connecting the region between Tokyo and Osaka in Japan (International Growth Centre, 2015) and the Maputo Development Corridor in South Africa (Hope and Cox, 2015) connecting the port of Maputo and Johannesburg. Such a development approach often uses a trunk infrastructure as a catalyst to connect diverse stakeholders and portfolios into a large clustered organic economic body.

Recent developments include the Mumbai-Delhi industrial corridor (Hope and Cox, 2015: International Growth Centre, 2015), the ASEAN southern corridor connecting Ho Chi Minh City, Phnom Penh, and Bangkok to Dawei in Myanmar (Dunseith, 2017) and, at a much smaller scale, the Iskandar economic corridor (Malaysia, 2010), a crescent shaped regional plan on the Malaysian shore opposite to Singapore.

The physical and environmental characteristics of the Canal and the landscape along its banks are considered as key assets. The creation and establishment of spaces of green and blue infrastructure can support the development of healthier living whilst supporting wildlife safe corridors along the corridor (e.g. for black-necked grebes, grasshopper warblers, falcons, blackcaps and common whitethroats and, more recently, fish species as salmon). A number of areas along the MSC banks are highly prone to flooding. Urban/rural interconnections and exploring urban agriculture along the urban fringe connected to housing and working hubs can provide a sustainable solution for such areas. The green spaces and natural capital preservation will increase air quality and the livelihood of their residents and visitors.

Modern cities have generally developed into large urban sprawls where private vehicles are heavily depended upon for travel. In a large, low density urban environment residents are distanced from both amenities and nature (Rosenberg, Kano et al., 2016). On the other side of the spectrum, high density development lacking greenspace causing a heat island effect which increases the temperature of the city by 1-3 degrees Celsius, intensifies the impact of a heatwave increasing the health risk to both the old and infant population (Rosenberg, Kano et al., 2016).

Due to climate change and rainfall, the flood risk in Britain has severely increased over recent years (Reynard, 2017). Apart from strong rainfall, cities suffer from flood effects because of a number of factors such as: widespread impermeable surfaces that cause water run-off; general scarcity of greenspace to absorb water flow; rudimentary drainage systems that are often clogged by waste and ill-advised development of marshland and other natural buffers (Rosenberg, Kano et al., 2016).

Well explored and planned parklands are some of the key solutions to the discussed problems along the MSC. Green spaces may serve as a connection between places offering an environment for outdoor exercise, local access to nature, a countermeasure to the heat island effect, and a measure to reduce the risk of flooding. Initially introduced to limit urban growth post-war, the greenbelt policy has attracted criticism in recent times regarding its effectiveness to safeguard wildlife habitats, to facilitate flood prevention, and to provide public access for health and wellbeing (Landscape Institute, 2018). Many greenbelt lands are used as intensive agricultural land providing no shelter and restricting public access to greenspace. As cities expand to similar scales to those of London and Manchester, the greenbelt becomes too distant away from the inner city for regular recreation opportunities.

Internationally, there are some alternative tools and examples to learn from. The greenway network adopted by Vancouver, Canada, is working towards a maximum 25 minutes' walk from any neighbourhood to the nearest greenspace, providing active transport corridors for commuting and access to amenities (Jafarian, Rahmani et al., 2014: City of Vancouver, 2018). Stockholm, Sweden, has adopted the green wedge approach utilizing its extensive waterway within the city boundary. Ten green wedges extend from the periphery to the city centre offering accessible greenspace, active transport corridors, and shelter for local wildlife (Åkerlund, 2011: Xiu et al., 2017). Cheonggyecheon restoration project in Seoul, Korea, not only restored a waterway back to naturebut also served as the catalyst to regenerate its previously overdeveloped neighbourhood. Vision2 in Geelong, Australia, transformed the city centre into an ecological spine adding $2b to the local economy. The green spine has also mitigated against climate change by using the flood water to irrigate the spine (Elkadi 2020).

Innovative jobs are the main driver to balance the MSC demography. The poor connection between the north and the south along the corridor is a major blocker to its development. The lack of active and effective transport makes the MSC unattractive to innovative business and people.

The transport along the corridor requires radical improvements that can be based on making the Canal an active transport link between urban areas. Improving access to the Canal will make the areas around the watercourse appealing to investors and people. Integrated cycling and walking lanes will provide the smart modes of an active transport system. The creation of a drones' highway that can transport goods can divert traffic from main roads. Car share schemes and electric vehicles' implementation will also have an impact on air quality and on active transport efficiency.

In modern British urbanism, maintaining the health and wellbeing of the populace is one of the key public interests. It not only seeks a good coverage of utilities and education but also the maintenance of a healthy lifestyle that consumes quality, locally produced food, and that encourages interaction with natural environment, and regular exercise.

The new urban landscape may be more personal in scale and more accessible to essential amenities than those of the current contemporary designs. With the advancement in communication technology, the approach to participation in productive activity has diversified.

The digital and disruptive technologies have a major impact on education for the future. Today's expectations in terms of adaptability and jobs throughout an individual's life cycle are not the same as in previous generations.

Education has become one of the biggest industries in the North West region, providing 31,085 jobs directly and generating 48,810 jobs outside universities contributing 1.7bn to the local economy (SUUK, 2017). The growth in education is a key indicator of a shift away from manufacturing/industry towards a knowledge-based industry in innovation and research.

Technology will have a major role in education for the future and given education's strong presence in the Quays' area more can be envisioned including the establishment of relations between education and innovative businesses in the area. These relations can be explored further in many areas such as digital, media, creative industries, professional services and new distribution and logistics businesses' models.

To achieve the key moves agile policies have been identified as the main drivers for the MSC urban corridor regeneration. These will be further explored with the networks already established and will be further strengthened as the development of the vision unfolds.

Through the identification of the key moves and catalyst projects, it was possible to develop different potential scenarios for the development of a smart ecological urban corridor alongside the MSC.

Six key moves were identified to unlock the development constraints that the MSC is currently experiencing. Addressing these constraints will allow for a number of opportunities to become available.

a) **Create an autonomous highway and digital infrastructure to support business, working and living connectivity**
b) **Green space creation and natural capital**
c) **Creative and innovative jobs**
d) **Create high-density affordable housing integrated with the natural environment and easy access to green spaces**
e) **Re-designing the town centres across the urban corridor to improve livelihoods**
f) **Education for the future**

6.2. FUTURE SCENARIOS

The key challenges and opportunities to create smart urban futures at the MSC are centered around the four themes of health and wellbeing, housing, jobs for the future and connectedness. The drivers, catalysts and keywords and principles were converted into possible future scenarios for the development of a smart ecological urban corridor along the MSC.

The process used in this project led to development of six scenarios with the stakeholders. The scenarios were also developed in line with ecological principles in order to provide alternative models for the MSC.

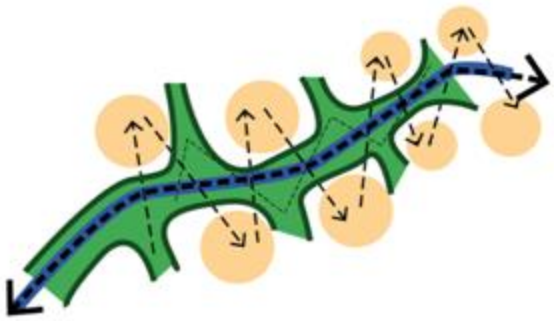


Fig. 18 Scenario 1

Scenario 1 (Fig. 18) proposes 2 spines parallel to one another, with the Canal as a main connectivity spine, as well as a green spine connecting parts of the flood zones. Urban residential areas are to be developed around the existing green spaces with connections through a hierarchy of roads and pathways parallel to and perpendicular to the Canal.

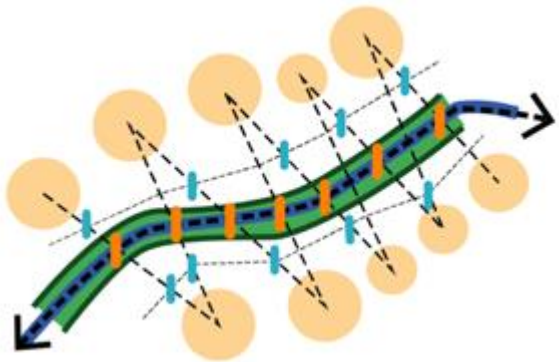


Fig. 19 Scenario 2

Scenario 2 (Fig. 19) proposes residential development on the fringes, which maintains smaller and more localised communities. At the same time, high connectivity and various intersection points are proposed. These connections are predominantly for commute as well as leisure in green spaces around the canal.

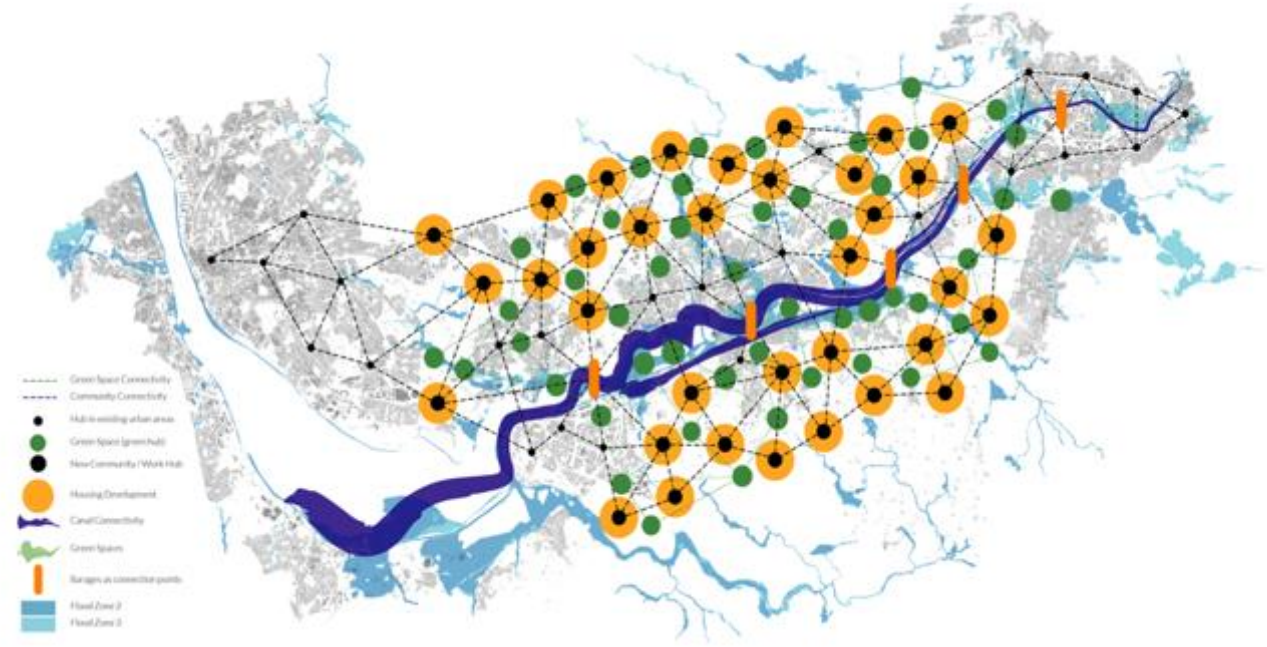


Fig. 20 Scenario 3

Scenario 3 (Fig. 20) builds on the "working hubs" concept, in which new residential areas are developed around work/community hubs, as well as having community green hubs for leisure and living with nature. These hubs are interconnected with a strong web of connections that include the barrages as crossing points along the Canal.

Scenario 4 (Fig. 21) proposes a third development magnet in between the already existing two major developments on the Canal, Manchester and Liverpool.

Developing this magnet would include different strategies such as hub creation, community spaces, and links focusing on North/South connectivity.

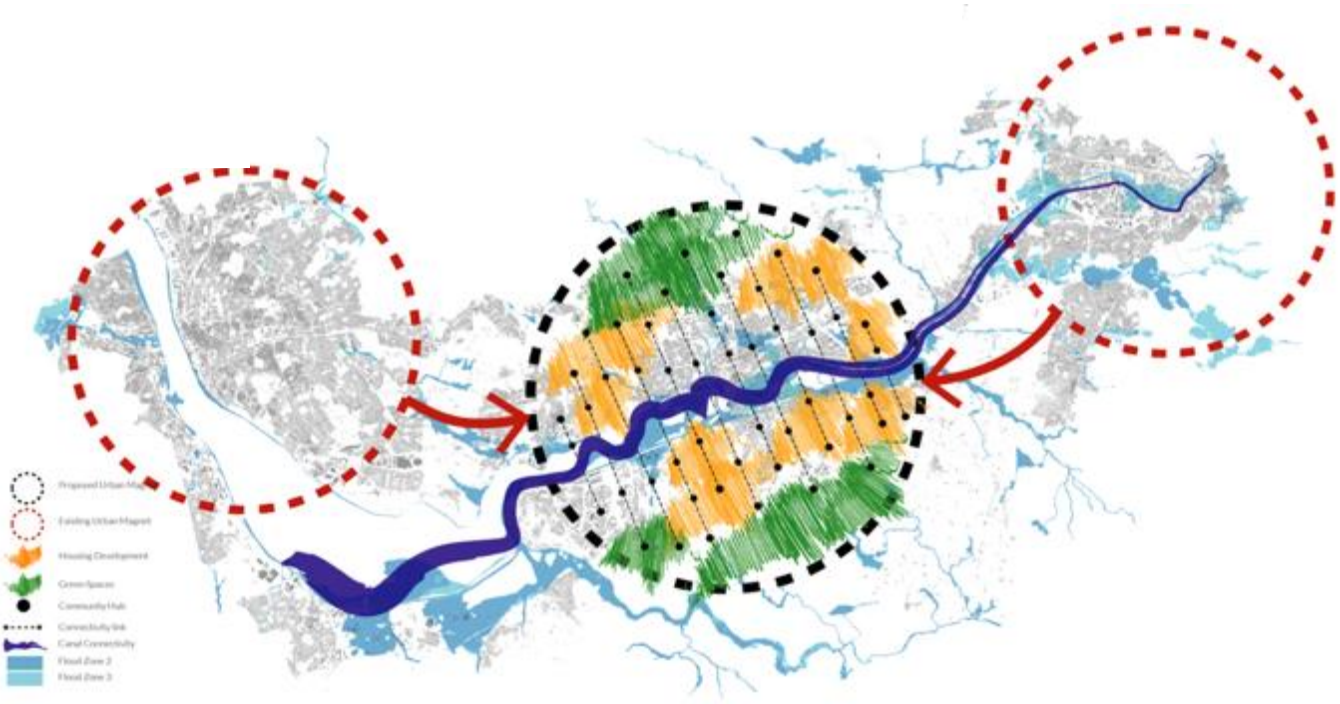


Fig. 21 Scenario 4

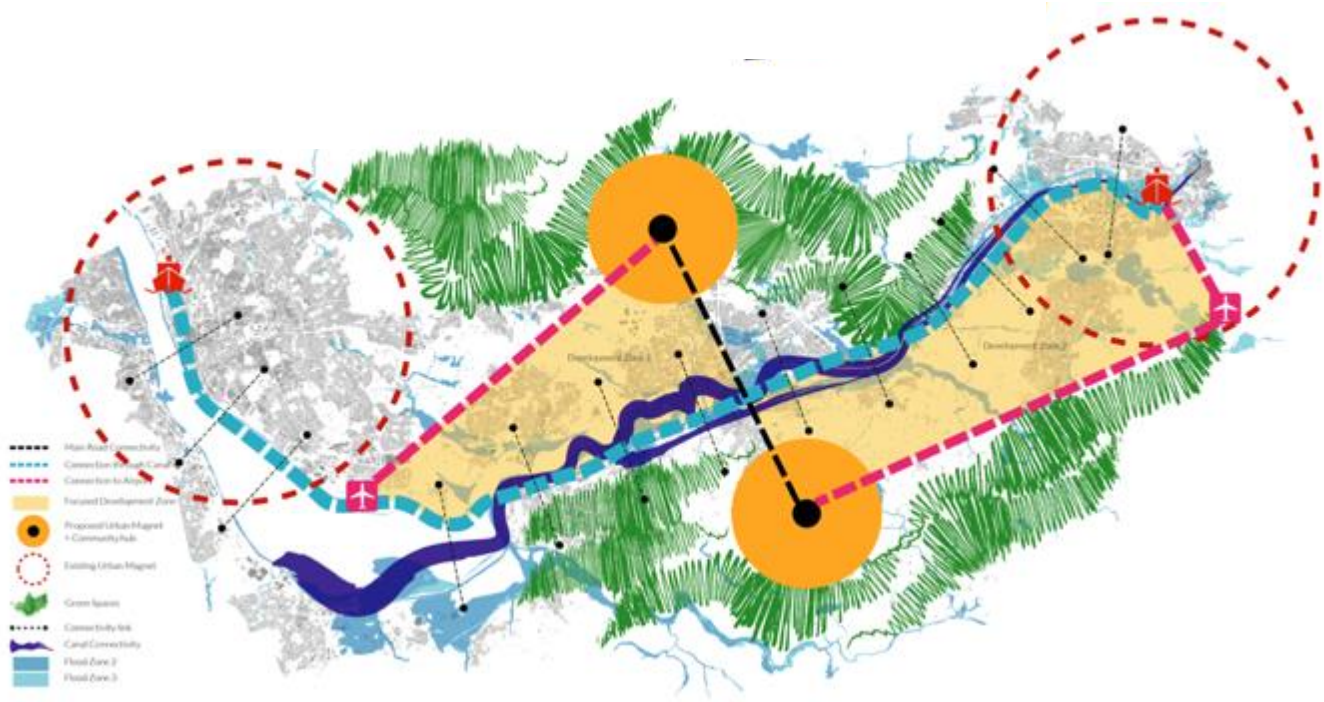


Fig. 22 Scenario 5

Scenario 5 (Fig. 22) focuses on utilising main transport hubs as the primary driver for connectivity. The connections between the ports, airports and cities shape the borders of the focus areas inside which the housing developments will be concentrated.
It is proposed that the surrounding areas should be utilised to preserve natural habitats (made up of large areas), complementing the high concentration of development by the Canal.

Scenario 6 (Fig, 23) builds on the idea of extending water bodies in relation to the urban environment, through extending the Canal North and South via flood zones. Through this approach, connectivity is linked to water, and the developed residential areas become more directly in touch with green infrastructure; the housing development would take place directly on waterfront zones to the North and South of the Canal.

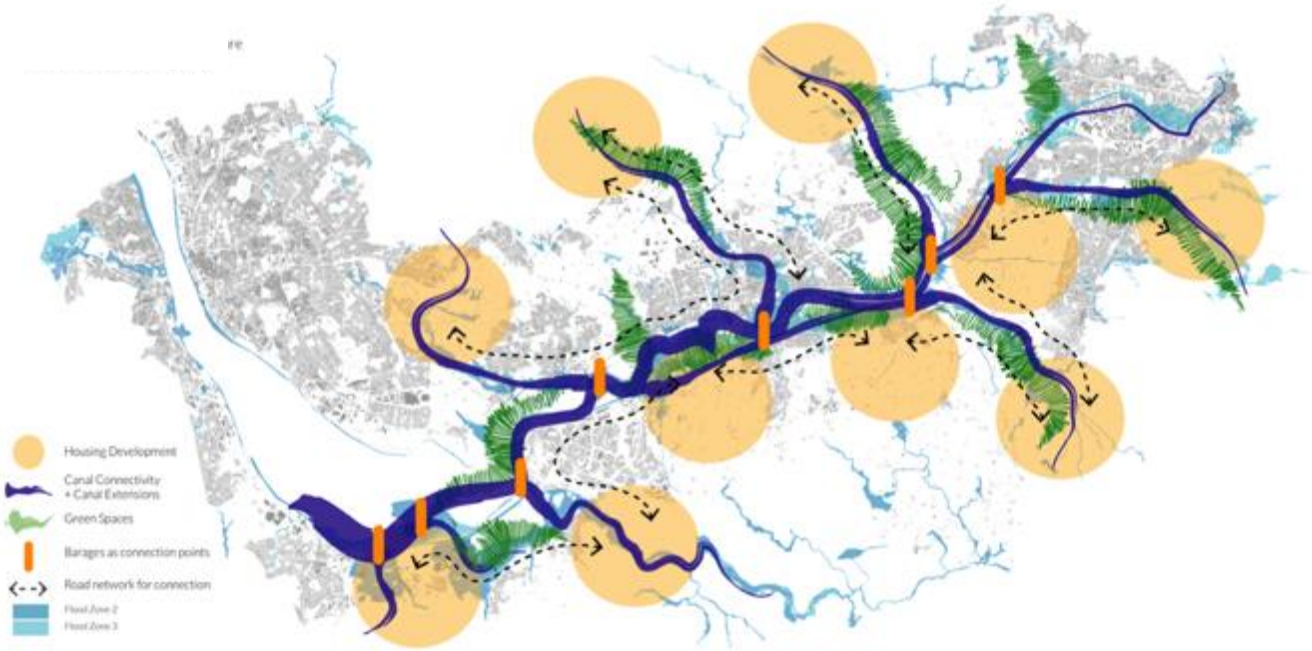


Fig. 23 Scenario 6

7. CONCLUSIONS

This paper presents an innovative methodological approach for the development of a smart ecological urban corridor along the MSC. Through a multi-disciplinary participatory approach, the paper looks at integrating qualitative, quantitative and spatial interpretations underpinned by blue sky collaborative thinking. Sets of data were carefully provided in different stages throughout the workshops. The provided information at each stage was the basis for the identification of catalysts' projects for the corridor and later shaped the discussion and the visions/scenarios' development.

The combination of historical analysis and more recent development (such as the influence of disruptive technologies and digital infrastructures) have together energized the discussion. Emphasis on ecological dimensions have also guided the development of smart ecological urban scenarios away from political constraints. While the six scenarios each provide a different canvas for future development across the MSC, there was consensus on a number of general principles that underpinned those scenarios.

All the participants have recognized the need to improve connectedness in the area such as high-speed railway development, airports and airfields; there is also the potential for a drone's highway along the Canal. The residence to workplace commuting patterns show that the time spent commuting from and to the cities of Manchester and Liverpool is very high.

Through the analysis of the different levels of health issues along the corridor, the wide scale of poor health conditions among all age groups became apparent.

Given the conditions along the MSC corridor, potential ideas to engage people with nature were suggested/presented for discussion which included green roof spaces, urban farming, urban parks (i.e. fruit and nut trees for harvesting, allotment spaces, walking spaces and community activities), native trees and flora that are able to flourish naturally. Participants were united on making the corridor more sustainable and resilient through improved health and well-being, and having clear air and water, reduced pollution levels and flood mitigation measures

Housing on offer in the region requires a major shift and was a focus in all the proposed scenarios. There is an increasing demand for housing in both Greater Manchester and Liverpool. Participants agreed that the Ecological Smart corridor could present a different and better option to address future demand. Affordable housing connected with works' hubs and easy access to green spaces is proposed in the different scenarios.

Without economic growth that includes future jobs, it would be difficult to offer affordable quality housing or healthy liveable places.

The economic uncertainty experienced nowadays makes it difficult to envision what the future jobs' situation might be. However, the increase in digital living combined with disruptive technologies encompasses opportunities for growth. The MSC already has an infrastructure base that would serve the required logistics for such a transformation in the job market.

The participants also stressed the importance of implementing more agile policies that allow for the development of the ecological green and blue urban corridor along the MSC.

The differences between urban and rural, for example, should be reviewed to make space for a healthier life-work balance with less commuting and a new approach to education and jobs for the future along the MSC.

The approach taken in this paper has, however, its limitations. The different stages were carefully designed in a hierarchical progression. While iteration was encouraged to review previous stage(s) in the light of new ideas/information, time was limited for a full exploration. There was also less disagreement than expected regarding the general direction in this case as all the participants were knowledgeable and very familiar with the MSC.

The developed scenarios provide a consensus platform and a direction of travel for a future smart urban corridor along the MSC. The blue sky thoughts at the first workshop have matured through different stages and the outcomes are well thought out strategies derived from unconstrained multi-disciplinary discussions underpinned by accurate and updated data.

Further work is planned to test and validate the developed scenarios through similarly designed workshops with policy makers.

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