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Adaptation Challenges and Opportunities for Irish Cities

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Introduction

Cities globally are acknowledged to be central in responding to climate change. Local governments as such are increasingly tasked with developing climate action plans that endeavour to mitigate the emissions that contribute to climate change, and to prepare the city and its citizens for the impacts of climate change. This is not without challenges, especially with regards to adaptation. Yet, local governments are rising to the challenge and taking action in spite of barriers from resource and financial constraints to data availability. Irish cities are among these cities taking on a leadership role in climate action.

This working paper sets out to understand the challenges and opportunities facing Irish cities – Dublin City, Cork City, Galway City, Limerick City, Waterford City - in adapting and building resilience to climate change. With city governments increasingly recognised to be the level of government best suited to responding to climate change (Allen *et al.*, 2018), understanding how local governments are responding merits further examination. Additionally, the *National Planning Framework* (Government of Ireland, 2018) anticipates that the population of Irish cities will increase by 50% in the coming years. This growth must be considered when planning for climate change.

Urban development that ignores climate risks increases a city's exposure and vulnerability to climate hazards and misses the opportunities for economic development and improved quality of life that adaptation can bring (Chu et al, 2019). Further, as has been highlighted by COVID-19, the costs of inaction may be far greater than the costs of prevention.

Changes in climate are cumulative and work in combination. This can be seen where climatic factors combine and create what are called 'compound events' where combined weather events may contribute to enhanced risk (for example storm surge and extreme rainfall) and these may be particularly significant in urban areas.

As critical socioeconomic infrastructure is located in cities, their overall resilience depends not only on their adaptation planning and that of their hinterland, but also on the sectoral adaptation strategies put forth by key government departments. Therefore, examining cities also presents an opportunity to consider the capacity of local authorities to respond to climate change in a coherent manner given the complexity of adaptation governance in Ireland.

Irish local government has been described as relatively weak, operating in a centralised system, with limited ability to raise finance and competition between local authorities incentivising poor spatial planning decisions (one of their most important powers) in terms of sustainable development (Moore-Cherry and Tomaney, 2019). To achieve the low carbon,

climate resilient transition deeper cooperation between central and local government and horizontally across local authorities is essential.

In Ireland, the *National Mitigation Plan* (Department of Communications, Climate Action and Environment, 2017), *National Adaptation Framework* (Department of Communications, Climate Action and Environment, 2018b), the Joint Oireachtas Committee Report *Climate Change a Cross Party Consensus For Action* (Houses of the Oireachtas, 2019) and the *Climate Action Plan 2019 to Tackle Climate Breakdown* (Government of Ireland, 2019) highlight the important role of local authorities in responding to climate change. National Government emphasises the role of Irish local authorities as being facilitators and supporters of community-led initiatives. As public sector bodies, local authorities are expected to contribute to national targets for carbon emissions, and lead by example with the uptake of energy efficiency measures across their buildings and more broadly in their service delivery. Further, local authorities are mandated to develop climate adaptation plans that must be coherent with sectoral adaptation plans.

Notably the five cities discussed in this paper all recognise that there are synergies across adaptation responses and that achieving climate resilience also improves the water quality, air quality and liveability of cities. Further, that responding to climate change is an opportunity for innovation, investment and growth.

Local Authority Adaptation Policy Context

The Irish Government's National Adaptation Framework (NAF), which emerged from the Climate *Action and Low Carbon Development Act 2015* (Climate Act 2015), tasked key National Government Departments with the development of statutory sectoral adaptation plans and also charged local authorities with responsibility for developing adaptation strategies that will inform development planning and other statutory plans, and engage communities at all levels (Department of Communications, Climate Action and Environment, 2018b; Government of Ireland, 2015).

Under the NAF local authorities are viewed as central to the implementation of adaptation actions. For example, they are essential in preparing flood emergency response plans. To build the capacity of local authorities to respond to climate change, *Local Authority Adaptation Strategy Development Guidelines* (Department of Communications, Climate Action and Environment, 2018a) were produced by the Department and Ireland's Climate Information Platform, Climate Ireland. These guidelines set out five steps for local authorities to follow as they develop their adaptation plans:

1. Preparing the Ground

2. Assessing the Adaptation Baseline
3. Identifying Future Climate Impacts, Vulnerabilities and Risks
4. Identifying, Assessing and Prioritising Adaptation Actions
5. Drafting, Implementing and Monitoring the Strategy

Local authorities also engaged in public consultation as part of the strategy development process. The adaptation strategy has a key role in 'climate-proofing' existing plans, policies and activities of the local authority and is an essential first step in dealing with climate change effects from a local authority perspective.

It is also worth noting that the recently established Office of the Planning Regulator (OPR) is required to evaluate how local authorities consider both adaptation and mitigation in their development plans.

In October 2019 all 31 local authorities signed a climate charter which, given their potential for leadership, commits local government to taking action and working together to address the impacts of climate. This includes using their planning and regulatory roles in climate action and reducing climate risks and building resilience through their adaptation strategies.

Role of the Climate Action Regional Offices

Established in January 2018, the four Climate Action Regional Offices (CAROs) are intended to support local authorities in the development and implementation of their climate action obligations. The CAROs were established based on regional climate change risks as identified by the Local Government Management Agency (LGMA) and County and City Management Association (CCMA). The proposed groupings were then approved by the Department of Communications, Climate Action and Environment. The resulting four offices are as follows: Atlantic Seaboard North (particularly focused on coastal flooding), Atlantic Seaboard South (particularly focused on sea level rise), Dublin Metropolitan (particularly focused on urban heat island), and Eastern and Midlands (particularly focused on fluvial flooding). The CAROs were provided with €10 million in funding over 5 years to cover staff and administrative costs.

A challenge for the CAROs is resources, both in terms of staff and financial capacity. Their role also continues to evolve, particularly with regards to mitigation, but without any additional regulatory capacity.

Irish Cities' Climate Action Plans

As required by the NAF, Ireland's local authorities completed climate adaptation strategies in 2019. Here we consider the climate adaptation plans of the five Irish cities: Dublin, Cork, Galway, Limerick and Waterford. Note that Dublin includes Dublin City Council, Dún

Laoghaire-Rathdown County Council, Fingal County Council, and South Dublin County Council.

Adaptation Challenges for Irish Cities

Coastal flooding, low temperatures, strong winds, extreme rain and high temperatures with low rainfall appear to be the highest priority risks in Galway City Council's adaptation strategy.[1] Limerick City and County's strategy identifies fluvial flooding, heatwaves, coastal flooding and wind storms as the highest priority risks.[2] Sea level rise, heat, extreme cold/snow, flooding and wind storms are identified as the highest priority risks in Waterford City and County Council's adaptation strategy.[3] For Dublin the key risks are urban heat islands, sea level rise and flooding both fluvial and coastal.[4] In Cork City the highest priority risks are fluvial and coastal flooding.[5]

The Dublin Local Authorities

Responding to climate change is a key priority of the Dublin Local Authorities' (DLAs) (Dublin City Council, Dún Laoghaire-Rathdown County Council, Fingal County Council, and South Dublin County Council), as flooding, rising sea level, extreme weather events and rising temperatures impact on the region's economic and social growth. As the plans were developed in advance of the NAF the plans include mitigation measures. Therefore, the Climate Change Action Plans set out the actions that the DLAs are taking to adapt to and mitigate climate change within the legislative remits of local government in Ireland.

The DLAs are signatories of the EU Covenant of Mayors for Climate and Energy, which commits them to reducing their carbon emissions by 40% by 2030, from 2006 levels, and to building resilience to climate change through integrated and collaborative responses. More recently, the DLAs have committed to reducing their emissions by 50% by 2030 as per the *Local Authority Climate Action Charter*.

By 2030, the DLAs are to have implemented actions to adapt the region to climate change, such that the risks of flooding, sea level rise, extreme weather, and rising temperatures are reduced. These risks were identified through a Climate Change Risk Assessment process as part of developing the plans.

[1] Available at https://www.galwaycity.ie/uploads/downloads/application_forms/environment/Galway%20City%20Council%20Adaptation%20Strategy%202019-2024.pdf
[2] Available at https://www.limerick.ie/sites/default/files/media/documents/2019-09/Limerick-City-and-County-Council-Climate-Change-Adaptation-Strategy-2019-2024.pdf
[3] Available at https://www.waterfordcouncil.ie/media/environment/WCCC%20Climate%20Change%20Adaptation%20Strategy.PDF
[4] The DLA's plans are available at https://dublinclimatechange.codema.ie/
[5] Available at https://www.corkcity.ie/en/media-folder/environment/final-cork-city-council-climate-change-adaptation-strategy-30-sept-2019-.pdf

Responding to climate change is recognised as an opportunity to strengthen the Dublin Region's economic and social competitiveness, and environmental record. Key to this is undertaking a holistic and integrated approach to building climate resilience. Acknowledging this, the plans were developed by bringing together DLA staff to identify the actions they are engaged in and the actions they would like to undertake in the future pending securing adequate financing.

The process for developing the Dublin Local Authority Climate Change Action Plans commenced in April 2017, with the final plans published in September 2019. The process was led by an agency outside of the local authorities with one person committed full time to engaging with approximately 100 DLA staff members and writing the plans. A number of additional staff were also involved on a part-time basis.

Of value to the process was each of the DLAs having climate action teams, who were engaged in the process with the outside agency. Further, the DLAs were brought together in workshops to discuss their climate change risks and their existing and proposed solutions. These workshops were conducted to facilitate discussion across and within the four local authorities. The purpose of this was to demonstrate that creating climate action plans did not create additional work, but rather provided an opportunity to collaborate with co-workers and to find ways of making available resources (finance, time, and labour) more efficient.

Case Study - Water management

TIDE WATCH TRITON SEA LEVEL RISE

The Triton and Tidewatch are two early warning systems in Dublin Bay that use sensors to provide real time information on changes in sea-level to Dublin City Council staff including warning messages. Tidewatch provides a 1-day advance warning of high tides, while Triton provides a 3-day advance warning. The early warning systems provide information to staff to implement appropriate responses. For example, activating the emergency response strategy which may include closing of flood gates and erection of demountable defences.

LIFFEY FLOOD DEFENCE

The River Liffey is the heart of Dublin, and as a tidal river it poses unique challenges for the city in terms of flood risk. Dublin has grown around this river, and it plays a significant role in the city's history and is a defining feature. Protecting the river and the city calls for a mix of solutions that are developed in collaboration with various agencies, specifically the local authorities, Office of Public Works, Irish Water, Electricity Supply Board, Environmental Protection Agency and Waterways Ireland, as the solutions must have consideration of the

need to balance flood risk management, drinking water supply and water quality, all of which will become more difficult in the context of climate change.

Along sections of the river in the city that are built up, Dublin City Council has enhanced the walls along the river with Dutch Dams which will be manually closed when a flood risk has been detected by an early warning monitoring system. Further upstream Dublin City Council has implemented soft solutions such as increasing the buffer distance from the river's edge to reduce dependency on the hard defences downstream. Additionally, developments adjacent to the River Liffey have been required to incorporate sustainable urban drainage systems and green infrastructure features to absorb rainfall; a development requirement that is now standard for all new developments across the city, as it increases the city's flood resilience.

Cork City

Cork City Council's *Climate Change Adaptation Strategy* recognises that the 'likelihood of a major flood event multiplied by the consequences of such an event in terms of danger and damage to citizens and infrastructure is greater in Cork city than many other cities. Having such a critical mass of infrastructure in the second largest city in Ireland means that when current and future climate change-related conditions and events become either the norm or occur at greater frequency and severity, many people, businesses and organisations will be negatively affected unless measures are put in place to adapt to climate change.'

However, there may be a disconnect between the Strategy's uncompromising assessment of the climate challenges facing Cork and the attitudes, ambitions and expectations of city lobby groups and stakeholders - including other sections of the Council itself. This means that these climate projections may not be properly considered in future plans for the city (McDermott and Surminski, 2018). This is not a unique challenge facing Cork as will be demonstrated in the following section, however, it demonstrates the importance of communication, and narratives around climate policy to form shared visions of the city's future.

The implications of climate change for all cities, including Cork, must inform all decision making, in a deeper and more integrated way than at present.

Case Study – Healthy City

The Healthy Cities programme is a global World Health Organization (WHO) movement. Cork is a WHO designated Healthy City and has started to consider the topic of a healthy city in a changing climate. Mitigation provides clear opportunities for environmental and health co-benefits in cities (such as promoting active transport and reducing air pollution) but

also with adaptation in terms of increased green urban space, for example. Healthy Cities require healthy planning and design, healthy transport, healthy housing and community resilience and participation, confirming the links with climate action.

'Citizen Safety, Health and Wellbeing' is one of the themes within Cork City's Adaptation Strategy and includes actions around ensuring older, vulnerable and isolated people/communities become more climate resilient. The submission from Cork Healthy Cities on the consultation draft adaptation strategy raised issues regarding extreme heat and the role of the City Council in ensuring the design and construction of new buildings takes into account future climate (Cork City Council, 2019).

Galway City

Galway City's *Climate Change Adaptation Strategy 2019-2024* includes the following vision for a climate resilient Galway: 'A Regional City that understands how climate change will affect the region, our businesses and communities, and actively works together to reduce our exposure to climate risks and to capture new opportunities'.

Galway city has a 50km coastline along its southern boundary with a high recreational amenity and ecological value. Among the risks identified for the city is coastal flooding which has had a major impact on Galway city. The Winter storms of 2013/2014 and Storm Eleanor in 2018 saw 325 properties flooded in the city, for example. Increases in the frequency and intensity of coastal inundation and erosion are likely. More regular flood events will put increasing pressure on sewage treatment and collection systems that integrate rainwater runoff. Coastal habitats and peatlands around Galway City may shrink significantly as a result of climate change.

Case Study – Tourism and Adaptation

The Climate Change Advisory Council (2019) has noted that the sectors in the National Adaptation Framework required to prepare sectoral adaptation plans do not cover some important areas, including tourism. The transport sectoral adaptation plan produced by the Department of Transport, Tourism and Sport (2019) does however acknowledge that the tourism sector is exposed to numerous direct and indirect impacts from climate change.

Changes in temperature that lengthen the summer season may allow for a longer tourist season. However, increased tourist numbers in a changed climate may lead to potential water stress or have negative consequences for biodiversity and habitats. Further, changes in precipitation and extreme weather may impact negatively on Ireland's natural and cultural heritage which the sector is dependent on.

Galway City is one of Ireland's most popular tourist destinations outside of Dublin, a European Capital of Culture in 2020, and its local adaptation strategy anticipates an increase in visitors due to climate change (due to its coastal location and potential attractiveness to overseas and domestic tourists during any extended summer season) but acknowledges that there are significant risks also. The strategy also seeks to ensure adaptation is considered in Galway City's Tourism Strategy alongside an analysis of potential impacts of climate change and adaptation/mitigation measures on natural, heritage, cultural and amenity sites relevant to tourism. This will require learning from the high temperatures of the Summer of 2018, for example, where increased usage of beaches and public spaces necessitated increased litter management in the city.

Limerick City

The overall objective of Limerick City and County Council's Climate Adaptation Strategy is 'to mainstream climate adaptation in all the functions and activities of the local authority'.

The population within the Limerick City and County Council's geographical boundary (2,790 km2) is 194,899 according to the 2016 Census data. Being situated along the River Shannon, fluvial flooding is a key climate risk for the city.

Limerick City and County's Adaptation Strategy has identified several climate risks facing the city including extreme weather events in the form of windstorms and coastal storms. It is anticipated that a compound of these events will result in increasing risks of flood events and impact on built up areas along the River Shannon. Already it is evident that the frequency and intensity of extreme events is having an effect on the city and county with 44 events occurring between 2014 and 2018 costing €9.5 million, notably 12 of these events occurred in 2016.

The OPW's Flood Risk Management Sectoral Adaptation Plan (2019) includes a case study of coastal flooding and Limerick city based on the findings of the National Catchment Flood Risk Assessment and Management (CFRAM) study which assessed 300 areas or communities believed to be at significant risk of future flooding. The case study, presents flood extents for a 200-year event now compared to such an event with 1m of sea level rise under a climate change scenario. This shows that there is an estimated 1,122 residential properties and 248 business properties currently at risk from flooding during a 200-year event. Under sea level rise of 1m, the number of residential and business properties at risk is predicted to increase by more than double in comparison to the current conditions. The cost of flood damage at Limerick City and Environs is currently estimated at over €83 million for the 200-year event and this is predicted to rise to over €1 billion under the presented

climate change condition. This corresponds to an increase of 12.5 times in comparison to the current condition.

Case Study – Smart Limerick

Technological solutions via smart city initiatives present unique opportunities for engaging private sector, academia and public sector to develop innovative response to climate change. Smart city initiatives such as those presented in Limerick's Digital Strategy also provide an opportunity to test technologies on a small scale with a view to scaling up.

Limerick is one of two EU Lighthouse Cities that is participating in a climate change project, +CityxChange, that is looking to addressing urban emissions by cocreating a future that is low carbon and provides high quality living. The goals and objectives of the project are to achieve increased energy efficiency by designing positive energy blocks that will be scaled to positive energy districts and eventually positive energy cities. Positive energy means producing energy, and from renewable sources that can be distributed to 'peers'. This will involve the installation of smart meters and testing smart grids. It is recognised that there are legislative challenges to peer-to-peer sharing that will need to be addressed in the Irish context.

Given the risks that climate change poses to key infrastructure this project is timely and will demonstrate the value of district energy systems to energy security and supply and wider smart city adaptation. Further district energy systems are a solution to ensuring that citizens have access to energy, as extreme weather events may result in customer supply being lost for several days.

The project is also considering solutions for electric mobility as a service (eMaaS) and will pilot several measures to facilitate the shift from fossil fuel based transport modes.

Waterford City

Like Dublin, Cork and Limerick Waterford City dates back to the late 9th century and the Vikings. The Waterford City and County Adaptation Strategy 2019-2024 includes a number of goals and actions, including one recognising the potential for increased climate migration in the future and the need to cater for those displaced due to climate change along with relevant agencies and departments. The vision of the adaptation strategy is 'to implement best practices and incorporate solutions that will meet climate change adaptation requirements and service the needs to communities'.

Waterford City and County is one of 17 local authorities that make up the Eastern and Midlands CARO. Being located to the southeast of the country and having an extensive coastline (100km) Waterford is vulnerable to sea level rise and coastal flooding. Fluvial

flooding is also a risk as the River Suir runs through Waterford city. The key climatic risks also identified in the plan include: extreme wind events, extreme heat and drought, extreme rainfall and flooding, and extreme freezing and cold events. As with the other cities, compound events pose a significant risk to Waterford. Storms Ophelia and Emma are presented as examples of compound events causing significant disruption to the operations and service delivery of the local authority.

Case Study – Flood Response

Waterford City has experienced severe flooding on a regular basis due to high tidal and water levels in its two rivers. The Waterford City Flood Alleviation Scheme was completed in 2014. The scheme design was amended to incorporate glass walls and address concerns other proposals would cut off the city's relationship with the river. Its implementation shows that when 'grey' engineering interventions are put in place there is scope for sympathetic design solutions in sensitive locations when feasible. The adoption of sustainable urban drainage systems (SuDS) and other design solutions to new development will also be a component of the city centre's future resilience.

The adaptation strategy includes a goal to improve understanding of the risks associated with increasing sea levels, coastal erosion and possible loss of coastal/maritime ecosystems and how best to deal with, prepare for and minimise impacts due to increasing sea levels and sea temperatures.

Global Lessons in Adaptation

As cities are increasingly viewed as being the level of government best able to respond and to form policy that will build climate resilience (Betsill and Bulkeley, 2007; Dodman, 2009; Rosenzweig *et al.*, 2010; Carter *et al.*, 2015), exploring how they address issues in their own context is valuable in building the capacity of cities globally. This section is a discussion of the experiences and adaptation and resilience measures being undertaken by cities in other jurisdictions to demonstrate how responses can be adapted to specific contexts. The examples below serve to illustrate the challenges and opportunities of adaptation, and that learning is ongoing.

City Networks - Knowledge Sharing

Internationally a number of organisations and initiatives have been established to progress climate action at city level. For example:

- The C40 Cities Climate Leadership Group (C40) is a group of cities around the world, working to collaborate effectively, and replicate and improve measurable and

sustainable action on climate change, including research on topics relevant to all Irish cities such as infrastructure interdependencies (C40, 2019).

- Energy Cities is a network of 1,000 local governments in 30 countries which links strengthening local participation to the low carbon energy transition. Dublin City Council and Cork County Council are Irish members of the network.
- ICLEI - Local Governments for Sustainability is a global network of more than 1,750 local and regional governments committed to sustainable urban development, with Cork City Council as a member.
- 100 Resilient Cities was a philanthropic programme launched by the Rockefeller Foundation is 2013. Each city has appointed a Commissioner for Resilience - a role to help collaboration across cities. Belfast has been a member of 100 Resilient Cities, working globally to reduce vulnerabilities, taking a targeted approach to issues which pose the greatest risk to the city, its economy and its people. In 2020 Belfast is preparing a Resilience Strategy which, in considering vulnerabilities wider than climate change and extreme weather events, offers a model for future proofing cities and linking inclusion and cohesion to the transition to low carbon climate resilience. The Strategy will form a framework for action in relation to climate change and a number of key strategic challenges, which face the city.

The Covenant of Mayors initiative was launched by the European Commission in 2008, with the objective of engaging and supporting mayors to commit to reaching the EU climate and energy targets. The Covenant of Mayors was a unique bottom-up movement that succeeded in mobilising a great number of local and regional authorities to develop action plans and direct investments towards climate change mitigation measures.

Building on the success of the Covenant of Mayors, the Mayors Adapt initiative was launched in 2014, relying on the same governance model, inviting cities to make political commitments and take action to anticipate and prepare for the unavoidable impacts of climate change.

In 2015, the initiatives merged under the new integrated Covenant of Mayors for Climate and Energy. In 2016 it joined with another city initiative, the Compact of Mayors to create the Global Covenant of Mayors for Climate and Energy.

The *National Adaptation Framework* states that initiatives such as the Covenant of Mayors may present further opportunities to align both adaptation and mitigation, enhance local adaptation strategies and build local awareness and support for such actions while the Climate Change Advisory Council's 2019 Annual Review recommends that synergies and learning from the Covenant should be strengthened.

Cities are also one of the areas of focus of the Global Commission on Adaptation which seeks to ensure that by 2030 all cities put in place inclusive, interlinked, polices, projects, and structures that will deliver climate-resilient cities.

For Ireland, lessons from such networks show that building urban resilience will require a long term vision, innovation in institutions and governance and consideration of equity issues, while taking the opportunities for mutual learning across Europe and beyond and particularly with regards to implementation.

Flood Adaptation – Honolulu

The Ala Wai Watershed located in Honolulu, is a 12,064 acres area with a population of 200,000 residents. In the mid-20th century the Ala Wai Canal was constructed to drain the wetland which permitted the development of Waikiki making it an area of economic importance contributing 7% of state GDP and 7% of jobs in the state. However, climate change is increasing the risk of a major flood that could bring the area to a halt. King tides (especially high spring tides) have already posed a problem, forcing water up Ala Wai's storm drains. A partnership between Hawaii's Department of Land and Natural Resources and the Army Corps saw the initiation of the Ala Wai Canal Flood Risk Management Project which is comprised of flood walls along the length of the canal, six debris and detention basins, a series of pumps and dredging. The project is anticipated to costs $345,076,000 USD.

With its focus on grey infrastructure the project has raised concerns with local environmental groups, which were initially supportive as the earlier plan included ecosystem services and other green infrastructure. Further, as public consultation and engagement by the Army Corps is not a requirement under federal law this is notably a failure of the project and has contributed to objections. The ongoing challenge with implementing the project is highlighting the importance of acknowledging culture and history of indigenous populations, and their connections to the land. Engaging with citizens who value the watershed and see ecological management as central to flood adaptation and mitigation may enable the design of a project that has community buy-in and respects the heritage and culture of the area, as well as a project that protects not just the immediate area but the communities surrounding Waikiki and improves water quality for generations to come.

Urban Heat Islands – Mexico City: Calle Verde

Launched in 2016 Mexico City's complete streets programme known as Calle Verde works to address the city's challenges with rising temperatures, drainage, public transit, and the needs of pedestrians and cyclists. The programme involves using green infrastructure to

improve the city's streetscape. Streets are made wider to accommodate pedestrians, cyclist and public transport users.

Highlights:

- Local businesses are estimated to experience a 25% increase in sales.
- Project was financed by Metrobus, the city's bus rapid transit bus system.

Extreme Weather Events – Paris' Chaleur Extreme

Paris, after the 2003 heat wave, recognised the importance of preventing heat related deaths. As part of their heat plan that included green infrastructure measures, they developed CHALEX (Chaleur Extreme) a registry of vulnerable individuals and their addresses that would enable municipal workers to visit or call these individuals during extreme heat events to ensure that their health is not compromised.

Sea Level Rise – Venice's MOSE

Venice's key risk is sea level rise. While life with high tides, 'Acqua Alta' is accepted by Venetians, climate change is exacerbating the frequency and intensity of these events. As a response the Venice Water Authority under the guidance of the Ministry of Cultural and Environmental Heritage requested the University of Architecture in Venice to design a flood defence. The result was the Mose system. The Mose system is comprised of three gates situated to the east of Venice at Bocco di porto di Lido, Bocca di porto di Malamocco and Bocca di porto di Chioggia. The barriers are comprised of mobile gates that can be moved into place by a hydraulic system to protect the lagoon from the sea during a high tide event. The gates take approximately 4 to 5 hours to rise and remain in place for the duration of a high tide event.

Sustainable Urban Drainage Systems (SuDS) – New Orleans: Gentilly Resilience District Project

The Gentilly Resilience District is a combination of efforts across Gentilly to reduce flood risk, slow land subsidence, and encourage neighbourhood revitalisation. It is New Orleans' first Resilience District using various approaches to water and land management that have been successfully piloted. The projects of the Gentilly Resilience District seek to provide multiple solutions and address complex issues such as crumbling streets, overburdened drainage systems, and sinking soils; projects will take place in streets, in neutral grounds, in parks, on schoolyards, and on open lots. The projects are designed to reduce risk from flooding and subsidence by creating spaces to capture rainwater in the urban landscape.

They are designed to beautify neighbourhoods, improve health, and provide opportunities for recreation.

Highlights:

- Considered that dollar spent on the project creates benefit greater than one dollar: increased property value, reduced flood risk, environmental value, and recreational benefits.
- Created new jobs in water management.

Building for Climate Resilience – Resilient Citizens: People Make Glasgow

'People Make Glasgow' is Glasgow City Council's endeavour to engage with citizens in the development of policies that improve the quality of life in the city. Achieving this shift in focus started with the development of Glasgow's Climate Change Strategy, which used the social determinants of health (SDH) as the foundation. The decision to use the SDH may have emerged from a need to understand why the 'Glasgow Effect' of residents' low life expectancy and poor health persists. This saw urban policy makers looking more closely at the demographics to identify vulnerable communities, specifically those that were benefit reliant. The value (and lessons) for Glasgow in developing its climate change strategy around the SDH is that the process revealed the need for planning to return its focus to people and place. Consequently, Glasgow embarked on a branding exercise to engage citizens, which resulted in the slogan 'People Make Glasgow', a theme that is now embedded in its policy development. For Glasgow, the focus of policy is people and creating a place that meets their needs and makes them resilient to climate change.

Highlights:

- Engaging with residents of Lambhill to learn their hopes and concerns for their community and the future they desired, is illustrative of how communities have the capacity to develop solutions (which may be similar to those suggested by experts) to their problems and they are empowered to do so by being included in a dialogue.
- Shift in the way Glasgow City Council forms policy from planners 'know best' to planners work with citizens to create a place that is about 'People Make Glasgow'.

Integrated Water Management - Singapore

Singapore is a unique city, in that it is a city-state, thus planning is the responsibility of the national government (Singapore, 2013). Further, Singapore's geography and political context lend themselves to the city-state's ability to do more than the average city.

Irrespective of these factors Singapore has since its beginnings strived to be at the forefront of urban innovation and policy practices, learning from other cities and bettering policies for the benefit of their citizens. One example is NEWater. Water being a scare resource has forced Singapore to innovate in the area of water management. Water policy in Singapore consists of '4 National Taps': the first being a comprehensive system of urban water catchments, the second is a bilateral agreement with Malaysia for water imports, the third is NEWater, and the fourth is desalination. It is the third tap that demonstrates Singapore's commitment to finding a sustainable means by which to provide a scarce essential resource. NEWater involves the purification of wastewater to potable quality through reverse osmosis. In the beginning, the idea of drinking purified wastewater was not well received. However, due to concerted efforts to demonstrate its safety, as well as the vulnerability of Singapore's water supply and the need for citizens to be mindful of water use, it is accepted.

Behaviour Change: Hong Kong 'Use Less, Waste Less'

Recognising that citizens are key in moving towards the city's sustainability goals, the Environment Bureau developed Community Green Stations to help citizens 'Use Less, Waste Less'. The stations are part of the city's ten-year plan to reduce waste by 40% per capita. Operated by non-profit organisations, the stations will provide education on waste, recycling and the environment.

Highlights:

- The stations are designed as low carbon structures, built from recycled materials like shipping containers and powered by solar PV for energy.
- They are also designed to be a place where people can gather, learn, and socialise.

Barcelona's Superilla (Super Blocks)

Barcelona's Super Blocks have improved the quality of life in the city. Mayor Colau used the city's historic plan to devise the plan for the super blocks, with a view to pedestrianising the city. The blocks consist of 9 city blocks that have been closed off to car traffic, with the exception of residential cars. The intersections have been converted into play grounds, green spaces and gathering spaces. Residents have reported improved health and well-being, as well as higher levels of social cohesion.

Highlights:

- The project was implemented in areas with social housing that is subsidised to mitigate the risk of gentrification.
- At present there are nine super blocks but the plan is for 500.

Innovation – Waterfront Toronto: Public Private Partnership

Waterfront Toronto was created by the Government of Canada, the Province of Ontario and the City of Toronto in 2001 to revitalise the waterfront in the city of Toronto. As Waterfront Toronto is funded by all three levels of government, it is accountable to each and requires their approval for projects that aim to revitalise the area. Central to revitalising the waterfront is public private partnerships, it is from this that the Quayside project emerged.

Quayside is a 4.9 hectare site, 1.5 km east of the central business district. In 2017, a request for proposals (RFP) was launched 'seeking an Innovation and Funding Partner to help think through tough urban challenges and create a strong and compelling vision for Quayside'. The successful RFP was received from Sidewalk Labs, a Google Company. The project is not without controversy particularly over issues of data privacy and the future marketed by Sidewalk Labs, who then withdrew from the project in May 2020.

Highlights:

- The district's development plan's vision for sustainability is to create truly climate positive communities.
- It was estimated that emissions would be reduced by 89% compared to the City of Toronto.
- Proposed 6-part pathway to achieving climate positive development: energy efficient building designs, digital management tools, district energy system, an advanced power grid, smart disposal chain, and green infrastructure and digital stormwater management systems.

Considerations for Urban Adaptation: Lessons and Observations

Urban adaptation is not without challenges. For example, the actions and measures to adapt to climate change are not as easily monitored and evaluated as in the case of mitigation which can be assessed against the reduction of greenhouse gas emissions. Adaptation is abstract in that it is about responding to a range of risks and vulnerabilities that may or may not necessarily arise.

Yet, what is evident from the plans by Irish cities and the examples from cities internationally is that there are opportunities and potentially multiple benefits. The literature highlights that mitigation and adaptation responses are intertwined, for example green infrastructure is well documented to have co-benefits for both and benefits to human health and quality of life (Barton, 2009; Galvão *et al.*, 2009).

As local authorities in Ireland work to build the resilience of Irish cities to climate change it is important to acknowledge that there are a range of actions and solutions to respond. Identifying the tools that are best suited to the unique characteristics of each city is key. Further engaging with counterparts in other local authorities via networks such as the All Ireland Smart Cities group, to innovate around solutions will be essential; as technology used in one context may be applied in another.

Adaptation and mitigation responses in our cities and their hinterland need to be coordinated to maximise synergies and achieve inherent co-benefits. In particular, there is an opportunity for cities to address key issues such as energy poverty, 'transport deserts' (when a community lacks necessary public transport options to live without driving) and 'food deserts' (areas with limited access to affordable and nutritious food), while responding to climate change (Foster *et al.*, 2019). Cities have the capacity to embed equity in responses to climate change, in other words implement policies that enable a Just Transition through spatial planning, for example (Castán Broto, Oballa and Junior, 2013; Bulkeley, Edwards and Fuller, 2014).

In the Irish context there is an opportunity to implement reforms that will enable local authorities to not only physically adapt Irish cities and towns to climate change, but to support the resilience of the people and communities who live in rural and urban Ireland to climate change. This will call for changes to planning legislation and practice and the Climate Act 2015 that will signal the importance of adaptation actions and measures in the planning of cities and towns. While strategic flood risk assessments (SFRAs) are a requirement in any planning process, measures such as sustainable urban drainage systems (SuDS) may not be implemented due to costs.

Resources and Finance

Adaptation needs to be financed and resourced effectively to achieve the physical adaptation of cities and behavioural adaptation of citizens. Local authorities are expected to address both of these under the NMP, Climate Action Plan and NAF. However, to date the green and soft measures that enable adaptation have not been adequately resourced within local authorities, both in terms of finance and expertise. The failure to resource and finance is resulting in the opportunity to maximise synergies between engaging communities and implementing green infrastructure projects which may pay in dividends in the future being lost. Local authorities acknowledge that citizens recognise the value of green infrastructure to adaptation and mitigation, as well as its role in strengthening social cohesion and improving health and well-being.

Local authorities in Ireland have endeavoured to respond to the readiness of citizens and small and medium sized enterprises to take action on climate change. Two examples of this come from the Dublin local authorities. The first is the Small Business Innovation and Research programme which provides grants to start ups to test ideas that will improve life in Dublin. The second is the MODOS programme which works with business to embed sustainability and transition them to the circular economy. However, the existing finance and resource capacity within local authorities remain tethered to the requirements of parent departments. As such, there is a need to reconsider local authority financing within the context of climate change. Further the legislative capacity of local authorities must be considered simultaneously. In the interim, Irish cities must continually look to cities around the world for novel and innovative ideas to address climate change, paying attention to how other cities address constraints. The resource and finance constraints are not unique to Irish local authorities, and it is critical to understand how other jurisdictions respond to these challenges, whether it is partnerships with academia to philanthropy and crowd funding. There are examples of these in cities around the world, from CityStudio in Vancouver which is a partnership between academia and the city; to Colu in Tel Aviv, a platform which enables cities to engage with citizens and reward them for taking action (colu.com).

Monitoring and Evaluation

In January 2020 the LGMA published 'A Profile of Local Government Climate Actions in Ireland' (Tugnoli, 2020). This recognises that as climate change impacts take effect through extreme weather, on the ground responses are required to deal with those extreme weather events as they arise, i.e., emergency response.

The Profile is based on a questionnaire issued to local authorities. Much of the information gathered may be useful for future adaptation indicator work – capturing for example the total number of flood schemes completed, the adoption of SuDs policies, development plan policies in place and the number of times the local authority emergency plan has been activated in response to extreme weather events and estimated costs.

Other cities have instituted their own oversight and advisory structures – for example in 2019 Bristol established a Bristol Advisory Committee on Climate Change to advise the City Council on reducing greenhouse gases and preparing for climate change and monitoring progress.

Data

As urban mitigation and adaptation policy continues to evolve, the need to address gaps in knowledge and provide enhanced evidence to support policymaking will grow. Developing

how adaptation and our cities' resilience is measured and evaluated is essential, as is enhanced cooperation and data sharing both within and across local authorities as well as across departments, agencies and other bodies. There is a need to undertake a mapping exercise to identify who holds relevant data that will inform adaptation actions and measures.

Further research focusing on adaptation issues specific to our cities is necessary but the available recent research provides useful insights. The recent EPA funded 'Large Urban Area Adaptation' (Urb-ADAPT) research project focused on the Eastern and Midlands Regional Assembly (EMRA) region and aimed to support the development of robust strategies to make the Dublin urban area and hinterland more resilient to climate change. Urb-ADAPT´s primary objective is to assess the spatial and temporal variations in levels of priority urban impacts for the EMRA region (urban overheating, pluvial flooding and coastal inundation) for the current period and for a number of future climate change scenarios from the 2020s to the 2050s and beyond (Paranunzio *et al.*, forthcoming).

Irrespective of the future climate scenario used, Urb-ADAPT found that the EMRA region will be exposed to increasing levels of climate impacts in terms of heat, pluvial flooding and coastal inundation in the coming decades. Its recommendations include further consideration of heat adaptation in development plans and development management and that greater coherence is needed between flood risk management plans, marine spatial plans, climate adaptation plans and local authority development plans.

It is noted that a recently begun EPA research project 'BE-Resilient: Built Environment Resilient Futures - Best practice in implementing climate adaptation' will consider the role of the planning system and the resilience of the built environment and may provide insights.

Collaboration and Communication

Throughout this paper it has been acknowledged that collaboration between local authorities and central government is needed to adapt Irish cities to climate change. Collaboration and communication though are not limited to these stakeholders. The literature highlights that a key reason for cities responding to climate change is their proximity to citizens, as local governments have an impact on the day to day life of citizens (Rosenzweig *et al.*, 2010; Carter *et al.*, 2015).

Engaging with citizens is necessary for climate adaptation, the challenge is *how* citizens are engaged. Historically, local authorities engaged with citizens on planning and policy issues through public consultation, which in Ireland can include a public notice in a newspaper to inform public of a consultation and making the document available on line or in public

buildings such as libraries. Action on climate change demands an evolution in this approach.

Public participation and engagement in the development of climate action plans is necessary to the successful implementation and monitoring of these plans, as has been evident in cities like Vancouver (Dekker, 2018). People need to have ownership of the problem and the solutions to climate change. This will involve policy makers actively seeking out individuals and communities to engage. This will involve finding a narrative with which to engage citizens and communicate the scope of the challenge and the opportunities.

Identifying a narrative for climate action is necessary for communicating and fostering collaboration with citizens. The example of Glasgow presented above presents one possible narrative for Irish cities, i.e. health.

A Narrative - Population Health, Climate Change and Cities

Recognising that climate change has adverse consequences for human health in a myriad of ways it is perhaps a logical narrative with which to engage citizens. Further, the sectoral adaptation plan for the Department of Health (2019) highlights the risks that climate changes poses to human health from increased respiratory illnesses and cardiovascular diseases, to skin cancer, and mortality and physical injury from extreme weather events. International research shows that causal pathways linking health and climate change are numerous (Younger *et al.*, 2008). The World Health Organisation (WHO), has assessed the risk of existing non-communicable diseases such as asthma, respiratory diseases and cardiovascular diseases to rise and pollution increases. Further, the risks of communicable diseases, those transmitted via vectors human (cholera), animals (hanta virus, swine flu) or insects (malaria, dengue, zika, yellow fever) have been assessed and it is anticipated that with climate change the geographical range of certain communicable diseases will change and spread, and the rates of infection will rise (Campbell and Jovchelovitch, 2000; Campbell-Lendrum and Corvalán, 2007; World Meteorological Organization, 2012; World Health Organization, 2018). Responding to climate change will protect population health.

Simultaneously, the research highlights the co-benefits to human health in addressing climate change (Lee and Moudon, 2004; Barton, 2009; Galvão *et al.*, 2009; Rydin, 2012; Braubach *et al.*, 2017). Barton's (2009) work is illustrative of the co-benefits of land-use planning that considers human health. Further, Galvão, L. A. C. *et al*. (2009) works presents a framework from which to design policies, the social determinants of health. Briefly the social determinants of health consider the impacts of an individual's living conditions on their health. This means considering their ability to access a community of people, to access

housing, access education and employment opportunities and their living environments, specifically the quality of housing, access to green spaces and recreation opportunities.

Health has come to the fore globally in 2020. The rapid spread of the coronavirus disease COVID-19 has seen varying responses by governments which have included measures such as nationwide quarantines, self-isolation, social distancing, and a global campaign with the simple message of handwashing to reduce the spread, led by the WHO. From a climate change perspective COVID-19 has incidentally contributed to an emissions reduction in areas prone to pollution and the return of species to many areas, where polluting economic activities were temporarily ceased in order to slow the spread of the virus and 'flatten the curve'.

There are policy lessons in the experience of COVID-19. The response has seen intra- and inter- governmental cooperation at a scale that is needed for climate action - global. The communication of the problem and the actions by the WHO has demonstrated that people understand science, data, and risk. The global experience illustrated the importance of trust in experts and institutions while ensuring their resilience, and leadership by governments to act in the best interests of citizens in order for people to take ownership of their responses.

Perhaps more critically in the context of climate adaptation, which akin to COVID-19 is an intangible opponent, is the importance of preventative action. Whilst, Asian nations learned from the experience of SARS in 2003, others were complacent even to the emerging lessons from Italy. It is evident that the costs of inaction were higher than the costs of prevention would have been. Globally, the discussion of the impacts of the pandemic has evolved well beyond to the direct costs to the health systems to the indirect costs for society, the environment and the economy (Karliner, 2020). The interconnected nature of health, housing, employment, transport, and education became evident as individuals lost jobs and faced the risk of eviction and others were forced to place their and family's health at risk due to the essential nature of their work. There is an acute awareness of the far-reaching costs of inaction and that a return to pre-COVID life is not necessarily possible. Perhaps most critically COVID-19 has placed the spot light on the inequity our societies and how we cannot return to business-as-usual (C40, 2020). Globally, it has highlighted the vulnerability of individuals, families and communities living on precarious and low income and their capacity to access health and other services.

Cities in particular, as has been noted, will not return to normal, instantaneously (Florida, 2020). In resilience and adaptation terms Irish cities and cities globally will have to bounce forward. What is emerging from the experience of lockdown in cities globally is that the design of cities continues to impact human health. Urban planning grew out of the public

health and sanitation movement and COVID-19 is re-focusing planning on how we make cities healthy. This time though we will need to embed climate adaptation and mitigation into planning for health cities. For example, social distancing measures will have an impact on how public realm is viewed and is bringing to the fore questions around the allocation of space to pedestrians, cyclists, public transport and cars (Florida, 2020). Public spaces in our cities has the potential to support and improve health and well-being of citizens while adapting the urban environment to climate change. It will be essential as we re-open cities, and towns that the actions taken address the inequities that have been revealed through this pandemic (C40, 2020). While the costs of improving the public realm may be high now, the costs of not doing so could be higher.

In the Irish context, this is also an opportunity for rural Ireland, throughout this crisis it is evident that remote working is possible and may become a norm as we emerge from the crisis. Understanding how remote working will impact on emissions and lend itself to climate action is on-going, but it is an action that employers can take now as they consider the resilience of their organisations.

Ultimately, there is an opportunity as we bounce forward from the pandemic to implement solutions to the problems that came to fore in the midst of the pandemic and achieve a Just Transition to a low carbon, climate resilient future in cities.

References

Allen, M. *et al.* (2018) *IPCC Global Warming of 1.5 °C: Summary for Policymakers SPM*, IPCC.

Barton, H. (2009) 'Land use planning and health and well-being', *Land Use Policy*, 26, pp. 115–123. doi: 10.1016/j.landusepol.2009.09.008.

Betsill, M. and Bulkeley, H. (2007) 'Looking back and thinking ahead: A decade of cities and climate change research', *Local Environment*, pp. 447–456. doi: 10.1080/13549830701659683.

Braubach, M. *et al.* (2017) 'Effects of Urban Green Space on Environmental Health, Equity and Resilience', in, pp. 187–205. doi: 10.1007/978-3-319-56091-5_11.

Bulkeley, H., Edwards, G. A. S. and Fuller, S. (2014) 'Contesting climate justice in the city: Examining politics and practice in urban climate change experiments', *Global Environmental Change*. Elsevier Ltd, 25(1), pp. 31–40. doi: 10.1016/j.gloenvcha.2014.01.009.

C40 (2020) *"No Return to Business as Usual": Mayors Pledge on COVID-19 Economic Recovery*, *Press Release*. Available at: https://www.c40.org/press_releases/taskforce-principles (Accessed: 7 May 2020).

Campbell-Lendrum, D. and Corvalán, C. (2007) 'Climate change and developing-country cities: Implications for environmental health and equity', *Journal of Urban Health*. Springer, pp. 109–117. doi: 10.1007/s11524-007-9170-x.

Campbell, C. and Jovchelovitch, S. (2000) 'Health, community and development: towards a social psychology of participation', *Journal of Community & Applied Social Psychology*. John Wiley & Sons, Ltd, 10(4), pp. 255–270. doi: 10.1002/1099-1298(200007/08)10:4<255::AID-CASP582>3.0.CO;2-M.

Carter, J. G. *et al.* (2015) 'Climate change and the city: Building capacity for urban adaptation', *Progress in Planning*. Elsevier Ltd, 95, pp. 1–66. doi: 10.1016/j.progress.2013.08.001.

Castán Broto, V., Oballa, B. and Junior, P. (2013) 'Governing climate change for a just city: challenges and lessons from Maputo, Mozambique', *Local Environment*. Routledge , 18(6), pp. 678–704. doi: 10.1080/13549839.2013.801573.

Climate Change Advisory Council, C. (2019) *Annual Review 2019*. Available at: www.climatecouncil.ie (Accessed: 21 March 2020).

Cork City Council (2019) Chief Executive's Report on Submissions Received to the Cork

City Council Draft Climate Change Adaptation Strategy 2019-2024. Available at: https://www.corkcity.ie/en/media-folder/environment/final-ce-report-on-climate-change-adaptation-strategy-submissions-30-sep-.pdf (Accessed 11 May 2020).

Dekker, S. (2018) *Cities leading climate action: urban policy and planning*. London: Routledge.

Department of Communications, Climate Action and Environment, D. (2017) *National Mitigation Plan*. Available at: http://www.dccae.gov.ie/documents/National Mitigation Plan 2017.pdf (Accessed 11 May 2020).

Department of Communications, Climate Action and Environment (2018a) *Local Authority Adaptation Strategy Development Guidelines*.

Department of Communications, Climate Action and Environment (2018b) *National Adaptation Framework Planning for a Climate Resilient Ireland*. Available at: https://www.dccae.gov.ie/documents/National Adaptation Framework.pdf.

Department of Health (2019) *Climate Change Adaptation Plan for the health sector (2019 – 2024)*. Available at: https://assets.gov.ie/38322/fd5750277357421cb2472687e9b33d8f.pdf Accessed 11 May 2020.

Department of Transport, Tourism and Sport (2019) *Transport Climate Change Sectoral Adaptation Plan*. Available at: https://assets.gov.ie/39222/284b27f3507a411b982d8aff91e1bf49.pdf (Accessed 11 May 2020).

Dodman, D. (2009) 'Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories', *Environment and Urbanization*. SAGE Publications: London, England, 21(1), pp. 185–201. doi: 10.1177/0956247809103016.

Florida, R. (2020) *How to Adapt Cities to Reopen Amid Coronavirus - CityLab*, *CityLab*. Available at: https://www.citylab.com/equity/2020/03/coronavirus-cities-adapt-future-plan-economy-infrastructure/608908/ (Accessed: 6 April 2020).

Foster, S. *et al.* (2019) 'New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity', *Annals of the New York Academy of Sciences*, 1439(1), pp. 126–173. doi: 10.1111/nyas.14009.

Galvão, L. C. A. *et al.* (2009) 'Panel Climate change and social determinants of health: two interlinked agendas 1 Pan American Health Organization-Area of Sustainable Development and Environment'. doi: 10.1177/1757975909103761.

Government of Ireland (2019) Climate Action Plan 2019 To Tackle Climate Breakdown. Available at: https://www.dccae.gov.ie/en-ie/climate-action/publications/Documents/16/Climate_Action_Plan_2019.pdf (Accessed 11 May 2020).

Government of Ireland (2015) *Climate Action and Low Carbon Development Act 2015*. Available at: http://www.irishstatutebook.ie/eli/2015/act/46/enacted/en/html (Accessed: 21 March 2020).

Houses of the Oireachtas (2019) Report of the Joint Committee on Climate Action Climate Change: A Cross-Party Consensus for Action. Available at: https://data.oireachtas.ie/ie/oireachtas/committee/dail/32/joint_committee_on_climate_action/reports/2019/2019-03-28_report-climate-change-a-cross-party-consensus-for-action_en.pdf (Accessed 11 May 2020).

Karliner, J. (2020) *Coronavirus and the climate crisis - Health Care Without Harm - Medium*. Available at: https://medium.com/@HCWH/coronavirus-and-the-climate-crisis-227c36bf07d0 (Accessed: 3 April 2020).

Lee, C. and Moudon, A. V. (2004) 'Physical Activity and Environment Research in the Health Field: Implications for Urban and Transportation Planning Practice and Research'. doi: 10.1177/0885412204267680.

McDermott, T. and Surminski, S. (2018) 'How normative interpretations of climate risk assessment affect local decision making: an exploratory study at the city scale in Cork, Ireland'. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 376 (2121).

Moore-Cherry, N. and Tomaney, J. (2019) 'Spatial planning, metropolitan governance and territorial politics in Europe: Dublin as a case of metro-phobia?', *European Urban and Regional Studies*. SAGE Publications Ltd, 26(4), pp. 365–381. doi: 10.1177/0969776418783832.

Office of Public Works (2019) *Flood Risk Management Climate Change Sectoral Adaptation Plan*. Available at: https://www.gov.ie/pdf/?file=https://assets.gov.ie/46534/3575554721374f7ab6840ee11b8b066a.pdf#page=1 Accessed 11 May 2020.

Rosenzweig, C. *et al.* (2010) 'Cities lead the way in climate-change action', *Nature*, pp. 909–911. doi: 10.1038/467909a.

Rydin, Y. (2012) 'Healthy cities and planning', *The Town Planning Review*. Liverpool University Press. doi: 10.2307/41509860.

Tugnoli, A. (2020) *Climate change – global issue, local leadership: A Profile of Local Government Climate Actions*. LGMA. Available at: https://www.lgma.ie/en/publications/local-authority-sector-reports/a-profile-of-local-government-climate-actions-in-ireland.pdf (Accessed 11 May 2020).

World Health Organization (2018) 'COP24 Special report: Health and Climate Change', *Who*, p. 38. Available at: https://www.who.int/globalchange/publications/COP24-report-health-climate-change/en/.

World Meteorological Organization. (2012) *Atlas of health and climate.* World Meteorological Organization.

Younger, M. *et al.* (2008) 'The Built Environment, Climate Change, and Health. Opportunities for Co-Benefits', *American Journal of Preventive Medicine*. Elsevier, pp. 517–526. doi: 10.1016/j.amepre.2008.08.017.