An Roinn Iompair
Department of Transport

Project Ireland 2040

National Investment Framework for Transport in Ireland

Background Paper 10: Compact Growth

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Disclaimer

This Background Paper has been prepared as part of the supporting analysis for the National Investment Framework for Transport in Ireland. It reflects the latest data and information available to the author at the time of writing. The views presented in this paper do not represent the official views of the Department of Transport or the Minister for Transport.

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Summary

- Compact Growth is one of the ten Project Ireland 2040 National Strategic Outcomes. Achieving this goal will ensure that our cities develop sustainably, bringing an end to sprawling growth and stagnation in existing inner city areas.
- As demonstrated by international examples of good practice, an integrated approach to land use and transport planning can help to achieve this objective. If appropriate investments in transport are not made at the right time, people will be deterred from living in our cities and Project Ireland 2040 population targets will be undermined.
- For NIFTI, the priorities for urban transport are to deliver a network which can support the increased travel demand arising from population growth, that provides a high level of service, that ensures accessibility to employment opportunities, and which encourages modal shift towards sustainable modes.
- In extensive modelling exercises for each of the five cities, potential areas of constraint and issues on the future urban transport network include widespread congestion in Dublin and Cork, congestion on key links in all cities, and limited modal shift.
- Beyond the NDP, these issues point to areas to potentially prioritise for future investment and intervention to ensure that Project Ireland 2040 population targets are achieved.
- There are limited opportunities to provide additional road capacity within our cities. Consequently, investment in high-quality infrastructure which makes public transport and active travel more attractive and feasible options should be prioritised.
- There may also be a case for additional urban demand management measures in the future.

1. Introduction

On 16 February 2018 Government launched Project Ireland 2040 with the publication of the National Planning Framework (NPF) and National Development Plan (NDP). The aim of this policy initiative is to guide planning and infrastructure investment over coming decades in order to cater for a projected population increase of one million people in a balanced and sustainable manner. To support this vision, the NDP sets out a €116bn public capital investment programme to cover the first decade of the NPF to 2027. Major transport projects to be delivered include BusConnects in all five cities, MetroLink and the M20 Cork to Limerick.

Project Ireland 2040 is underpinned by a set of ten National Strategic Outcomes, the first of which is compact growth. In practical terms, Project Ireland 2040 has defined this outcome as 25% of future population growth being accommodated in Dublin, 25% in Cork, Galway, Limerick and Waterford combined, and the remaining 50% in smaller urban and rural areas. 40% of future housing needs are to be met by building and renewing within existing urban areas. In the five cities, this requirement rises to at least 50% of new residential capacity being delivered within the existing urban footprint.

The National Investment Frame 2040 (NIFTI) is the Department of Transport's contribution to Project Ireland 2040. NIFTI's objective is to develop a framework to inform and guide future investment in land transport, which delivers a transport network that meets the travel needs of the population in the coming decades and supports

the realisation of the National Strategic Outcomes. As part of the development of this framework, five areas relating to the future transport network are being analysed. These are:

1. Compact growth;
2. Interurban connectivity;
3. Rural and regional accessibility;
4. Supporting international connectivity; and,
5. Alternative demand scenarios.

This background paper looks at the first of these themes, compact growth. Transport will play a key enabling role in the achievement of this strategic outcome, aiming to ensure that our urban areas are attractive places to live and work by tackling congestion, providing access to safe walking and cycling infrastructure and delivering affordable and comprehensive public transport.

Drawing on the NPF, the paper will first establish why urban growth matters and consider the present Irish situation with regard to that objective. Looking further afield, Section 4 of the paper will look at examples internationally where planning and transport have facilitated compact urban growth. Section 5 of the paper will draw this preceding contextual analysis together to develop a set of questions relating to urban transport networks, each linked back to the overarching priorities for NIFTI and Section 6 will then identify indicators through which those questions can be addressed. Sections 7 to 11 will look at modelling for each of the five cities in turn across three different scenarios: 2012 Base Scenario, 2040 Do-Nothing Scenario, and 2040 Do-Minimum Scenario. The Do-Minimum Scenario will help to inform investment priorities beyond the current capital plan, which runs to 2027. Drawing on this analysis, Section 12 will identify the areas where the future urban transport networks are likely to be under greatest strain in future and discuss the types and mixes of interventions that might be deployed to address these pressures. Consideration will also be given in this section to smaller urban areas. Finally, the paper will conclude with some summary remarks.

2. Why Compact Growth Matters

The European Environment Agency defines urban sprawl as "the physical pattern of low-density expansion of large urban areas" (European Environment Agency, 2006). Urban sprawl implies little planning control, with patchy and scattered development patterns allowing areas to be leapt over and causing agricultural enclaves to form within urban boundaries. Sprawling cities are the opposite of compact cities, littered with empty spaces indicating inefficient development and uncontrolled growth (European Environment Agency, 2006).

The National Planning Framework has made clear why urban sprawl is something we should seek to avoid. The rapid expansion of our cities and towns at their edges means that infrastructure and services are in a constant state of catch-up, which, combined with a struggle to bring jobs and new homes together, creates high levels of car dependency and makes it difficult and costly to provide good public transport (Government of Ireland, 2018b).

The long-term cost of meeting Ireland's development needs through continued sprawl, which requires the laying of more infrastructure, wider provision of services such as waste collection, and additional schools, police stations and hospitals to service the sprawling population (Bhatta, 2010), is estimated to be at least twice that of a compact growth approach (Government of Ireland, 2018b).

Urban sprawl also takes investment out of our city centres, causing them to become gradually rundown and unattractive places to live and work (Government of Ireland, 2018b). Finally, urban sprawl has worked against the achievement of our climate change targets (Government of Ireland, 2018b), with higher transport and energy demand based largely on fossil fuels contributing to Ireland having the third highest greenhouse gas emissions per capita in the EU in 2016, 55% higher than average.

Living in sprawling urban areas also has consequences in terms of the health and quality of life of inhabitants. To take one example, the greater reliance on the car as a mode of transport exposes the population to higher levels of atmospheric pollution and increases congestion levels. It is estimated that 20 million Europeans suffer from respiratory problems associated with air pollution (European Environment Agency, 2006), while increased congestion pushes up commuter journey durations with high costs in terms of the value of time lost. For Dublin, the cost of congestion has previously been estimated at €358m in 2012 and is projected to grow to over €2bn by 2033 in the absence of intervention (Department of Transport, Tourism and Sport, 2017). In a compact city, reduced car dependency leads to an improved cityscape, while quality of life is improved through shorter commutes and health benefits accrue both through reductions in pollution and greater levels of walking and cycling among the population.

Given all of the above, there is clearly good reason for Government to encourage urban consolidation and densification in favour of urban sprawl. From a narrow transport perspective, a sprawling, low-density urban area requires more investment in terms of laying and maintaining roads and also makes it difficult to deliver an adequate public transport network to meet the population's needs. For example, research suggests that a population density of 3,400 people per square kilometre is the point at which light rail systems like the Luas become viable (Jenkinson, et al., 2017), and once such infrastructure has been delivered it tends to encourage further densification along its route. On the other hand, lack of adequate public transport encourages private car use, and this in turn creates congestion and increases air pollution and per capita emissions.

When it comes to encouraging compact growth, the success of NIFTI is interdependent on the success of the NPF. On the one hand, to make our urban areas attractive places to live and work, transport policy and the transport network need to address urban congestion and provide affordable, comprehensive, frequent and reliable public transport and active travel options. On the other hand, given that the viability of many public transport solutions is contingent on the population density of a given area, the planning regime needs to successfully encourage urban development and densification and discourage sprawl.

3. Irish Context

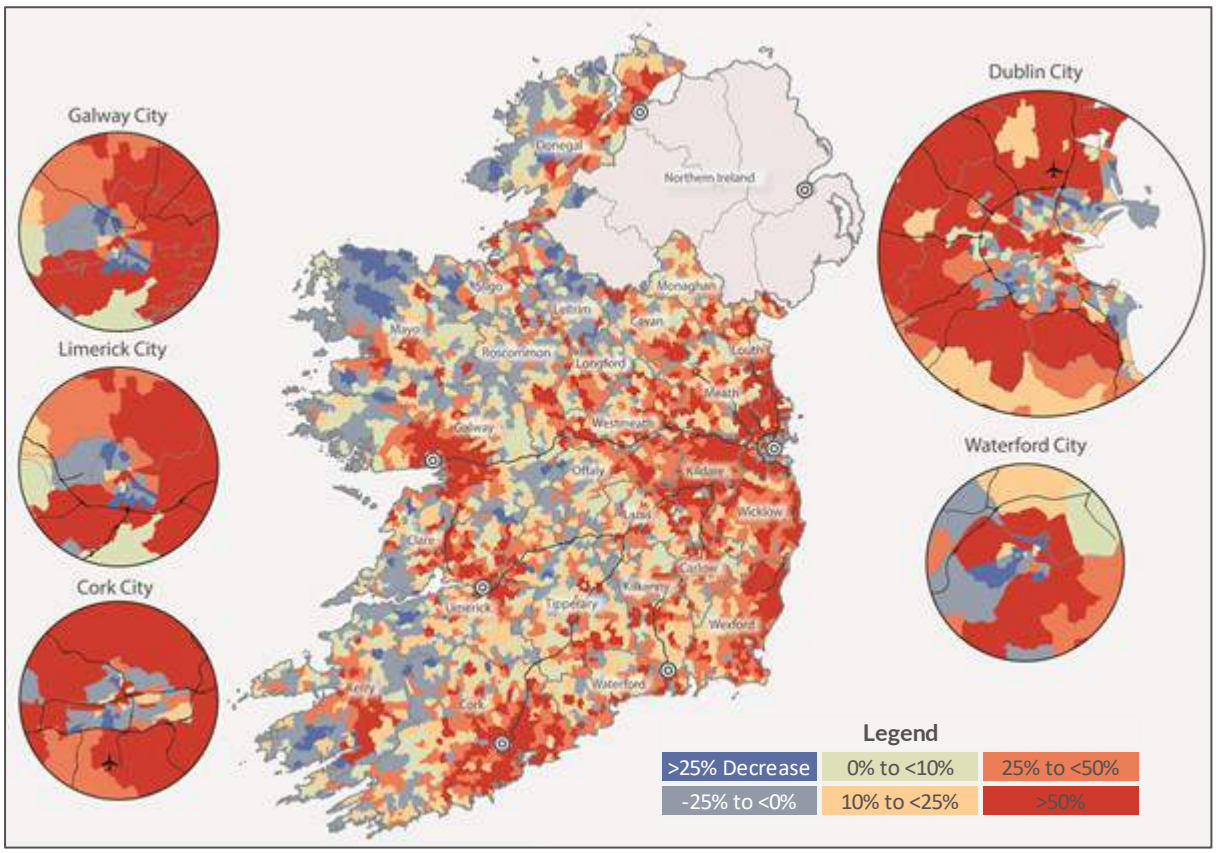
While compact growth might be the first strategic outcome of the current NPF, the Irish experience of the recent past has been one of urban sprawl. In fact, the Greater Dublin Area has been identified by the European Environment Agency as requiring improved land use guidance, zoning and infrastructure if it is to develop sustainably (European Environment Agency, 2006), with almost all residential development in the capital since 1950 having been low density in nature[1] (European Environment Agency, 2006). Nevertheless, Dublin was still by far Ireland's most densely populated city in 2016, as shown in Table 3.1.

Table 3.1: Population density of Ireland's cities, 2016

City	Density (persons per square kilometre)
Dublin	3,678
Cork	1,198
Limerick	1,591
Galway	1,475
Waterford	1,108

Source: CSO

Figure 3.1: Percentage population change by electoral division, 1991 to 2016



Source: Department of Housing, Planning and Local Government

[1] Defined as less than 80% of land surface being covered by buildings, roads and other structures.

The urban sprawl witnessed across all Irish cities in recent decades is clearly demonstrated in Figure 3.1, which maps population change between 1991 and 2016. For most of the country, population increased in that 25 year period, with growth particularly pronounced along the eastern seaboard and around the main cities. Those areas that experienced a decline in population tend to be in the far west of the country and the midlands. However, looking more closely at the five cities, it can be seen that a hollowing out has occurred. The population living on the urban fringes has typically increased by upwards of 50%, while the number of people living in the city centres has declined. As discussed in Section 2, the provision of good quality urban public transport is contingent on population density, which means that these trends have undermined the delivery of an attractive service. As a consequence, an increasing number of inhabitants in our cities have become reliant on the private car as the only practical mode of transport and congestion in our cities has been exacerbated.

3.1 Spatial Strategies

It is worth noting that the urban sprawl of the past three decades was contrary to official policy, at least in the second half of the period. Prior to the current NPF, the National Spatial Strategy for Ireland (NSS) was launched in November 2002 and was intended to cover the period up to 2020. Like the NPF, the NSS had urban consolidation as one of its foremost planning priorities, stating that existing urban settlements should be kept as physically compact and conducive to public transport as possible, and that, where necessary, greenfield development should take place through "the logical extension of existing cities, towns and villages" (Department of the Environment and Local Government, 2002). As Figure 3.1 demonstrates, however, the NSS was unsuccessful in this objective and it was formally abandoned by Government in February 2013.

The unsuccessful implementation of the NSS can be attributed to a number of issues. As it launched in 2002, from the outset it was temporally misaligned with the capital plan covering the period from 2000 to 2006, undermining coordination between spatial policy and infrastructure investment (Kitchin, 2015). Although it did underpin the subsequent capital plan for the period from 2007 to 2013, the onset of the economic crisis in 2008 meant that much of the investment set out in that plan was never realised (Government of Ireland, 2018b). Furthermore, it attempted to create a situation where every area was to grow in population and resources (Kitchin, 2015) but lacked legislative backing and was weakened by misalignment with other Government policy, such as public service decentralisation in 2004 (Government of Ireland, 2018b). Collectively, this signalled limited adherence to the plan at Government level, while the economic crisis finally eroded any economic capacity to implement it (Government of Ireland, 2018b).

To inform the development of the NPF, an expert group reviewed the NSS and its implementation, reporting its findings and recommendations in 2014. This ensured that, unlike the NSS, the NPF launched alongside a dedicated funding stream in the form of the NDP and cross-Government coordination has been introduced through the overarching Project Ireland 2040 initiative, of which NIFTI is a part. The NPF also aims to ensure alignment between different levels of Government, which was a particular issue for the NSS (Ó'Riodáin & van Egeraat, 2016), by setting the context within which each of the three regional assemblies will develop their own strategies. The inclusion of specific targets for population growth in different urban and rural areas and the greater locational focus of the NPF will also help to ensure its success (Government of Ireland, 2018b).

Nevertheless, there will still be a need to carefully manage the ten National Strategic Outcomes of the NPF if it is to be successful. For example, from a transport perspective, outcomes one and two – compact growth and

enhanced regional accessibility – could potentially contradict one another. The rapid expansion of the motorway network, from 176km and 3% of national roads in 2003 to 916km and 17% of national roads in 2015 (Jenkinson, et al., 2017), exemplifies this tension. By improving interurban connectivity, the upgrades to the national road network enhanced regional accessibility. However, combined with rising property prices, these enhancements also made it more attractive to live outside existing centres and undermined compact growth.

To achieve compact growth in our towns and cities, NIFTI will need to ensure that the pursuit of one objective does not have adverse implications for another. How best to sequence investment and implement the framework is given greater consideration elsewhere.

3.1.1 Regional Spatial and Economic Strategies

Sitting between central Government and the 31 local authorities are three Regional Assemblies responsible for coordinating, promoting and supporting the strategic planning within their regions. These three assemblies – corresponding to the Northern and Western Region, Eastern and Midland Region, and Southern Region – have a key leadership role to play in the successful delivery of Project Ireland 2040 by ensuring national policy objectives are implemented at the regional level. To achieve this, following the publication of the NPF, each Regional Assembly was tasked with developing a Regional Spatial and Economic Strategy (RSES) grounded in Project Ireland 2040 National Policy Objectives and National Strategic Outcomes, thereby giving these national-level goals a more regional focus (Government of Ireland, 2018b).

The draft RSES for the Northern and Western Regional Assembly was published on 19 November 2018 and public consultation ran until 8 February 2019. The largest urban settlement in this region is Galway, while Letterkenny and Sligo are important regional centres. Another regional centre, Athlone, straddles this region and the Eastern and Midland Region, while Derry and Letterkenny form a cross-border network due to their proximity (Government of Ireland, 2018b). Other key regional towns in identified in the RSES include Ballina, Ballinasloe, Carrick-on-Shannon, Castlebar, Cavan, Monaghan, Roscommon and Tuam (Northern and Western Regional Assembly, 2018). As well as referencing the Galway Transport Strategy (discussed in greater detail in the following section), transport-related investment to support compact growth in the region discussed in the RSES includes the development of active travel infrastructure and an effective town bus service in Letterkenny (Northern and Western Regional Assembly, 2018) and encouraging the walking and cycling connectivity of new development in Tuam (Northern and Western Regional Assembly, 2018).

The draft RSES for the Eastern and Midland Regional Assembly was published on 5 November 2018 and public consultation ran until 23 January 2019. The largest urban centre in the region is Dublin which, along with regional centres Drogheda and Dundalk, forms a cross-border network with Newry and Belfast. Athlone is partially in the region also (Government of Ireland, 2018b). Key regional towns identified in the RSES include Swords, Maynooth, Bray, Navan, Naas, Wicklow-Rathnew, Longford, Mullingar, Tullamore, Portlaoise and Graigecullen (Eastern and Midland Regional Assembly, 2018). Regional transport investment priorities that can support compact growth include the DART expansion programme, construction of the National Train Control Centre, development of MetroLink, the development of BusConnects, provision of new park and ride facilities and the provision and enhancement of walking and cycling facilities in cities, towns and villages across the region (Eastern and Midland Regional Assembly, 2018).

Finally, the draft RSES for the Southern Regional Assembly was published on 18 December 2018 and public consultation ran until 8 March 2019. Three of Ireland's five cities are located in this region, Cork, Limerick and Waterford (Government of Ireland, 2018b). Key towns in the region identified in the RSES include Kilkenny, Ennis, Carlow, Tralee, Wexford, Clonmel, Killarney, Mallow, Nenagh, Thurles, Newcastle West, Clonakilty, Dungarvan and Gorey (Southern Regional Assembly, 2018). Investment priorities identified in the RSES which can help to facilitate compact growth include the delivery of BusConnects programmes in all three cities, the development of strategic park and ride sites and the delivery of comprehensive walking and cycling networks, with an emphasis on the three cites (Southern Regional Assembly, 2018).

3.2 Transport Strategies

Moving on from spatial and planning strategies, there are a number of important transport plans and frameworks that also shape the context in which NIFTI is being developed. While NIFTI is part of Project Ireland 2040, it is also true that it builds upon the existing framework for transport investment, the Strategic Investment Framework for Land Transport (SFILT), published in 2015. The three priorities for future transport investment identified in SFILT were the achievement of steady state maintenance, addressing urban congestion, and maximising the contribution of the land transport network to national development (Department of Transport, Tourism and Sport, 2015). All three of these priorities remain valid for NIFTI.

The annual steady state fund estimate (by which it is meant, the cost of maintaining the various elements of the land transport network in an adequate state and meeting contractual commitments) has been updated in Background Paper 6 and is anticipated to average at least €1.7bn annually from 2018 to 2040, of which €1.3bn needs to be met by the Department of Transport directly. With the additional capital investment announced in Budget 2018 following the Mid-Term Review of the Capital Plan, it is expected that the annual steady state funding requirement for the transport sector will be met by 2021 (Ross, 2018).

Tackling urban congestion also remains a high priority for the Department of Transport and in 2017 the Department published a report which estimated the costs of congestion for the Greater Dublin Area from 2012 to 2033 in the absence of measures to accommodate rising travel demand (Department of Transport, Tourism and Sport, 2017). Congestion is also a central consideration for this background paper, with interventions to reduce congestion an important part of facilitating compact growth.

Finally, NIFTI as a whole seeks to maximise the contribution of the transport network to society through informed, targeted investment that aligns with spatial planning, facilitating economic activity across the country.

Below the national land transport investment framework, twenty year transport strategies are currently in place for the Greater Dublin Area and Galway, while the Cork strategy was published for public consultation in May 2019. Similar strategies for Limerick and Waterford are also in development. The following sections briefly summarise the Dublin, Galway and Cork strategies.

3.2.1 Greater Dublin Area

The Greater Dublin Area Transport Strategy 2016-2035 was published in April 2016 and covers Dublin city and county, Meath, Kildare and Wicklow. The plan was prepared against a backdrop of little new transport infrastructure being added to the Greater Dublin Area since 2007 due to fiscal consolidation, despite the fact the

region was already suffering from congestion and capacity constraints at that time (National Transport Authority, 2016).

There is a significant amount of existing transport infrastructure and services in the Greater Dublin Area. This includes the DART and Commuter Rail services within the region and heavy rail intercity connections to Belfast, Cork, Galway and Limerick beyond it, two light rail lines running from Tallaght to the Docklands and from Bride's Glen to Broombridge, and an extensive bus network. Bus infrastructure is of varying standards, however, with relatively competitive speeds and journey time reliability only achievable along certain sections of each corridor due to the discontinuity of bus priority (National Transport Authority, 2016).

In terms of active travel, there has been a large increase in the numbers of people cycling in recent years (National Transport Authority, 2016), particularly in central Dublin, which has occurred despite a suboptimal provision of safe, convenient and continuous cycle routes. Although progress in terms of infrastructure provision has been made in certain areas and through certain projects, a comprehensive cycle network has not yet been realised (National Transport Authority, 2016). For pedestrians, clutter on footpaths, a lack of crossings and long crossing times all reduce the attractiveness of walking as an option (National Transport Authority, 2016). According to Census 2016, 22.0% of commuting trips in the Greater Dublin Area were made by active modes.

There has been substantial investment in the road network in the Greater Dublin Area in recent years, particularly in relation to the national road system. Beyond the Dublin metropolitan area, these roads will continue to play a vital role in the movement of people and goods and it will be important to ensure they do not become overly congested and have their benefits prematurely eroded (National Transport Authority, 2016).

To some extent, this is already happening on the M50. Traffic along the road has been increasing steadily since 2010 and, in fact, growth has accelerated as economic conditions have improved (National Transport Authority, 2016). Large stretches of the M50 are now in a state of breakdown or unstable flow during a typical morning rush hour, with knock on effects in terms of journey time reliability. Given this trend, there is a need for a coherent set of interventions to better manage demand along the M50 as well as provide alternative transport modes so that the motorway can continue to facilitate non-local trips of high economic value (National Transport Authority, 2016).

Closely related to the discussion of the M50, it is worth noting that both the busiest port and busiest airport in the country are located in Dublin. The safeguarding of surface access to these national gateways is identified as a priority in the strategy and will continue to be one for NIFTI. Background Paper 13 prepared as part of NIFTI considers access to strategic links, both in Dublin and in the rest of the country, in greater detail.

Planning for the future, the strategy divides the Greater Dublin Area into six radial corridors, each with different characteristics and transport needs. For example, it is proposed that heavy rail capacity be increased to meet travel demand in Corridor A, which captures the area north of the city as far as Drogheda and includes Swords and Balbriggan (National Transport Authority, 2016), while for Corridor E, which comprises mainly suburban residential development in Rathfarnham, south Tallaght and along the N81, improvements to existing bus infrastructure and services are recommended due to the constraints that exist on other types of investment (National Transport Authority, 2016).

There are two recommendations common to all six corridors. The first of these is the strategic provision of park and ride facilities throughout the region so that those living beyond immediate access to rail are able to journey into the city by public transport (National Transport Authority, 2016), thereby reducing traffic levels and congestion. These facilities could potentially be located close to Dunboyne, Swords, Bray and Tallaght, for example, and would integrate with the existing or planned heavy and light rail networks (National Transport Authority, 2016). The second common recommendation calls for the widespread improvement of walking and cycling facilities at the local level (National Transport Authority, 2016), making active travel a more attractive option for short trips.

Other significant elements of the strategy include the reopening of the Phoenix Park tunnel and extension of the DART network to Drogheda, the M3 Parkway, Maynooth and Hazelhatch so that it serves a much greater proportion of the metropolitan area, various extensions of the Luas network to Lucan, Finglas, Poolbeg and Bray, the development of a core bus network, and substantial investment in new cycling infrastructure to develop a comprehensive cycle network (National Transport Authority, 2016). In terms of new road development, a key principle of the strategy is that there will be "no significant increase in road capacity for private vehicles on radial roads inside the M50 motorway."

Some elements of the plan have already been realised or are in the process of being implemented, such as the reopening of the Phoenix Park tunnel, completion of Luas Cross City and rollout of increased capacity along the Luas Green Line, while others are well underway, such as planning for a new National Train Control Centre or the BusConnects redesign of the bus network, for which public consultation began in July 2018. The NDP has also earmarked priority elements of the DART expansion programme and provision of a comprehensive walking and cycling network for delivery by 2027, but it should be noted that further expansion of the Luas network, as well as delivery of DART Underground, are not proposed to be delivered in the lifetime of the current capital plan (Government of Ireland, 2018a).

With the strategy, the National Transport Authority (NTA) hopes to facilitate a 28.5% increase in total trips by 2035 when compared to 2011 levels while reducing the mode share of cars from 60% to 51% (National Transport Authority, 2016) and greatly expanding the radius within which it will be possible to reach the city centre within one hour by public transport (National Transport Authority, 2016). Collectively, the measures set out in the strategy should help to facilitate compact growth by making the urban core much easier to traverse by sustainable modes and, crucially, making it less desirable to commute long distances from outside the city by car.

3.2.2 Galway

The Galway Transport Strategy was published in August 2016. Despite having a compact and walkable urban core (Galway City Council, 2016), characteristics of the city's transport network identified by the strategy include an overreliance on the private car, congestion and journey time unreliability at peak times, a surrounding road network that funnels traffic through the city, and limited road space and priority for cycling and public transport (Galway City Council, 2016). In light of these challenges, the strategy develops seven principles which, taken together, aim to reduce private car use and make it more convenient for transport users to walk, cycle or travel by public transport (Galway City Council, 2016).

One of the key findings of the strategy is the low commuting modal share by bus within the city at 8% in 2011 (Galway City Council, 2016), though this has increased slightly to 9.5% according to Census 2016. Bus infrastructure in the city is discontinuous while services are infrequent and have poor journey reliability as they contend with general congestion. Cycling infrastructure is similarly limited and discontinuous, despite the city's flat topography lending itself to this mode (Galway City Council, 2016). A bike share scheme was launched in the city in 2014.

The River Corrib runs from Lough Corrib north of the city, through the city centre and into Galway Bay. Three of the four river crossings are located in the city centre and the fourth, the Quincentenary Bridge on the national road network, is the main link connecting areas west of the city to the midlands and east of the country. Due to the reliance of through traffic on this connection, delays occur frequently and result in increased city centre traffic volumes as drivers divert to one of the other three links (Galway City Council, 2016). This congestion increases journey times for all road users in the city centre and makes public transport and cycling relatively less attractive options.

The strategy identifies a comprehensive package of measures to address these challenges. To increase the attractiveness of public transport, it is proposed that the Salmon Weir Bridge through the city centre becomes bus-only with improved amenities for walking and cycling also (Galway City Council, 2016). A redesign of the city's road network will direct most traffic over the two most peripheral crossings of the River Corrib, helping alleviate congestion in the urban core (Galway City Council, 2016), and five new bus routes with a target frequency of 15 minutes or better during peak times, with 77% of residential properties within a ten minute walk of a stop (up from 43% currently) and significant upgrades to infrastructure, should further increase the attractiveness of travelling by public transport through the city centre. All five routes will interchange in the core urban area (Galway City Council, 2016) and the provision of park and ride facilities at routes' termini should help to reduce traffic volumes from the surrounding region into the city centre (Galway City Council, 2016).

For active modes, the strategy proposes creating a primary cycle lane network throughout the city centre which will, as far as possible, be segregated from general traffic. Two new greenways will connect suburban areas to this primary network, and there will also be an extensive secondary and tertiary network to ensure that cycling is a viable means of getting around the vast majority of the city (Galway City Council, 2016). As well as general upgrades to the public realm to increase the attractiveness of walking, which at 23% of commutes already commands a reasonable level of modal share (Galway City Council, 2016), the strategy also suggests providing a new pedestrian crossing of the River Corrib close to the Salmon Weir Bridge (Galway City Council, 2016).

Taking these measures together from a compact growth perspective, by making it easier and more attractive to walk, cycle or travel by bus around the city centre while simultaneously making it less desirable to drive, the strategy should encourage densification within existing urban areas, close to employment opportunities and education centres. However, it is important to note that much of the success of the plan is contingent on the delivery of a new ring road and River Corrib crossing north of the city, which the National Development Plan estimates will be completed in 2025 (Government of Ireland, 2018a). In the absence of the ring road, even if every other element of the Galway Transport Strategy is successfully delivered, there will continue to be an issue with through traffic travelling through the city, in turn undermining efforts to make public transport and active travel more attractive.

3.2.3 Cork

The Cork Metropolitan Area Draft Transport Strategy 2040 was published on 14 May 2019, with the public consultation period ending on 28 June 2019. Cork's status as the fastest-growing city in Ireland under NPF projections on a proportional basis will result in significant increases in travel demand, which must be carefully managed if the city is to be an attractive place to live and work in the decades ahead (National Transport Authority, 2018).

At present, the private car is the dominant in the city, accounting for 74% of trips. The walkability of the city is, however, evidenced by the fact that 20% of trips are made by foot. Public transport, which comprises bus services and heavy rail accounts for just 5% of all trips, though this rises slightly to 7% for work commutes. Finally, the remaining 1% of trips are made by bike (National Transport Authority, 2018).

Key challenges for the strategy include ensuring that the urban transport network can support the future population projected by the NPF, and doing so in a way that prioritises sustainable transport modes and reduces the high levels of car dependency that currently exist (National Transport Authority, 2018).

For walking, the objective of the strategy is to make it the instinctive choice for short trips throughout the city (National Transport Authority, 2018). This will be achieved by prioritising pedestrian safety and movement over that of the private car, facilitating walking's role as a part of linked trips with public transport and upgrading walking provision in tandem with improvements to bus, rail and cycling infrastructure (National Transport Authority, 2018).

For cycling, the strategy envisages the delivery of a comprehensive network of routes throughout the city. Depending on location, the infrastructure along these routes may take the form of traditional cycle lanes, segregated cycle tracks, greenways and mixed streets in low traffic environments. Supporting infrastructure measures, such as expanding the bike share scheme will also be put in place (National Transport Authority, 2018).

The BusConnects programme is prioritised for early delivery within the strategy and will see the length of bus lanes within the city grow from 14km to approximately 100km, delivering a core bus network, efficient, reliable and frequent services and enabling interchange with other public transport and park and ride facilities. It is envisaged that the realigned bus network will carry 45m passengers annually and up to 32,000 per hour during morning peak periods (National Transport Authority, 2018).

In terms of rail, the strategy proposes developing the heavy rail access to the city that already exists to the east and northwest with the development of eight new stations, the creation of a suburban rail network Between Middelton, Cobh and Mallow, the electrification of this network and the purchase of new fleet. In the longer term, the strategy also envisages the development of an east-west light rail line which, through its higher capacity than bus rapid transit, will be better able to accommodate the growth in population and travel demand arising from the NPF (National Transport Authority, 2018).

To increase the catchment area of public transport, the strategy envisages the strategic provision of park and ride facilities adjacent to key interchanges such as Dunkettle (National Transport Authority, 2018). There will also be a general reduction in on-street parking provision in the city over the lifetime of the strategy, freeing space for

sustainable modes (National Transport Authority, 2018) and supporting the vision of public transport orientated development (National Transport Authority, 2018).

The foremost priority for road investment will be to maintain existing assets and utilise them more efficiently, though there a limited number of new developments are identified such as an east-west orbital link north of the city to take traffic out of the city centre (National Transport Authority, 2018).

Taking the strategy as a whole, its ambition is to reduce the morning peak private car mode share to 49.3% by 2040, with walking maintaining its 2011 mode share of 21% of trips, public growing to 25.7% and cycling rising to 4% (National Transport Authority, 2018).

3.3 Conclusion

This section has shown that the recent Irish experience with regard to urban development has been one of sprawl, despite official policy. With Project Ireland 2040, steps have been taken to ensure that planning objectives are supported by investment and coordinated across Government. As well as serving as a new transport investment framework temporally aligned to Project Ireland 2040, NIFTI will build on the principles set out in SFILT in 2015 and the transport strategies currently in place for the Greater Dublin Area and Galway, as well as the draft strategy for Cork, with the aim of ensuring that transport facilitates compact growth in our towns and cities.

4. International Case Studies

Having set out Irish context in terms of spatial and transport planning, this section will consider a number of international case studies where the two have been successfully integrated. These case studies indicate possible approaches that can be applied in Ireland's five cities also, ensuring that our urban transport networks support compact growth.

4.1 Freiburg

Freiburg is a medium-sized city in southwest Germany, less than an hour from Strasbourg, France and Zurich, Switzerland. Freiburg has been at the forefront of sustainable transport and land use planning, driven by the vision of a compact city of 'short distances'. Freiburg's record on sustainability has received both national and international recognition, including the German Sustainability Award in 2012, being designated Federal Capital of Climate Protection in 2010 and qualifying as a finalist for the European Green Capital Award in 2009.

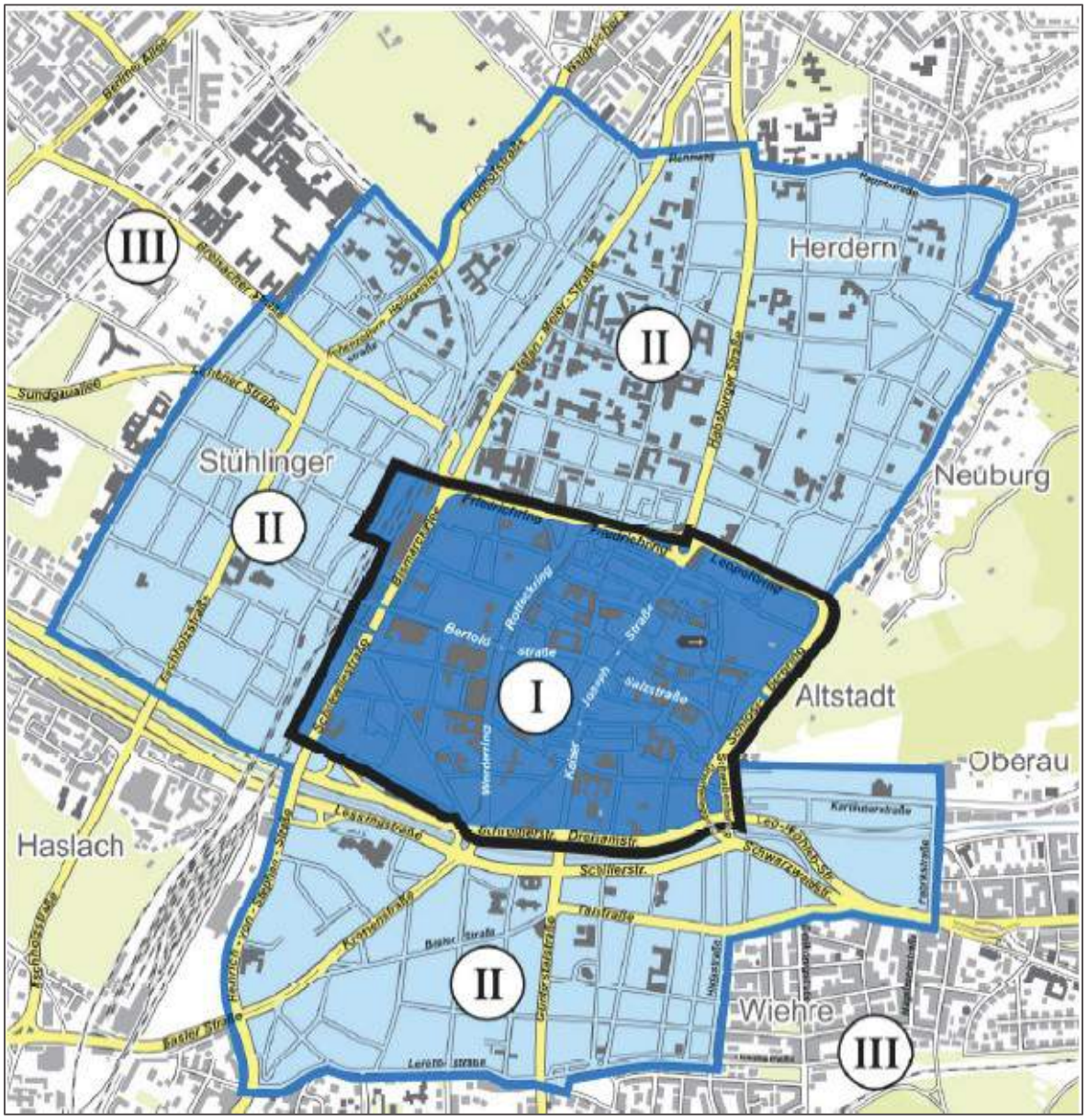
Table 4.1: Freiburg Profile

Population and Density			
Population	230,000		
Population Density	1,500 per km^2		
Modal Share			
Car	Public Transport	Cycling	Walking
21%	16%	34%	29%

A key component of Freiburg's success has been its use of integrated transport and land use planning. Integrated planning of this kind is termed 'sustainable urban mobility planning', or SUMP, and is promoted by the European Commission through the 'SUMPs-UP' programme which launched in Freiburg in October 2016, likely in recognition of Freiburg's record as a first mover in this field (Rupprecht Consult, 2016). Freiburg first implemented an integrated mobility plan in 1969 with the adoption of the inaugural *General Urban Transport Policy* which integrated planning for roads, active travel and public transport (ICLEI, 2018). While this policy was primarily focused on accommodating car use (Buehler & Pucher, 2011), it could be regarded as an early SUMP.

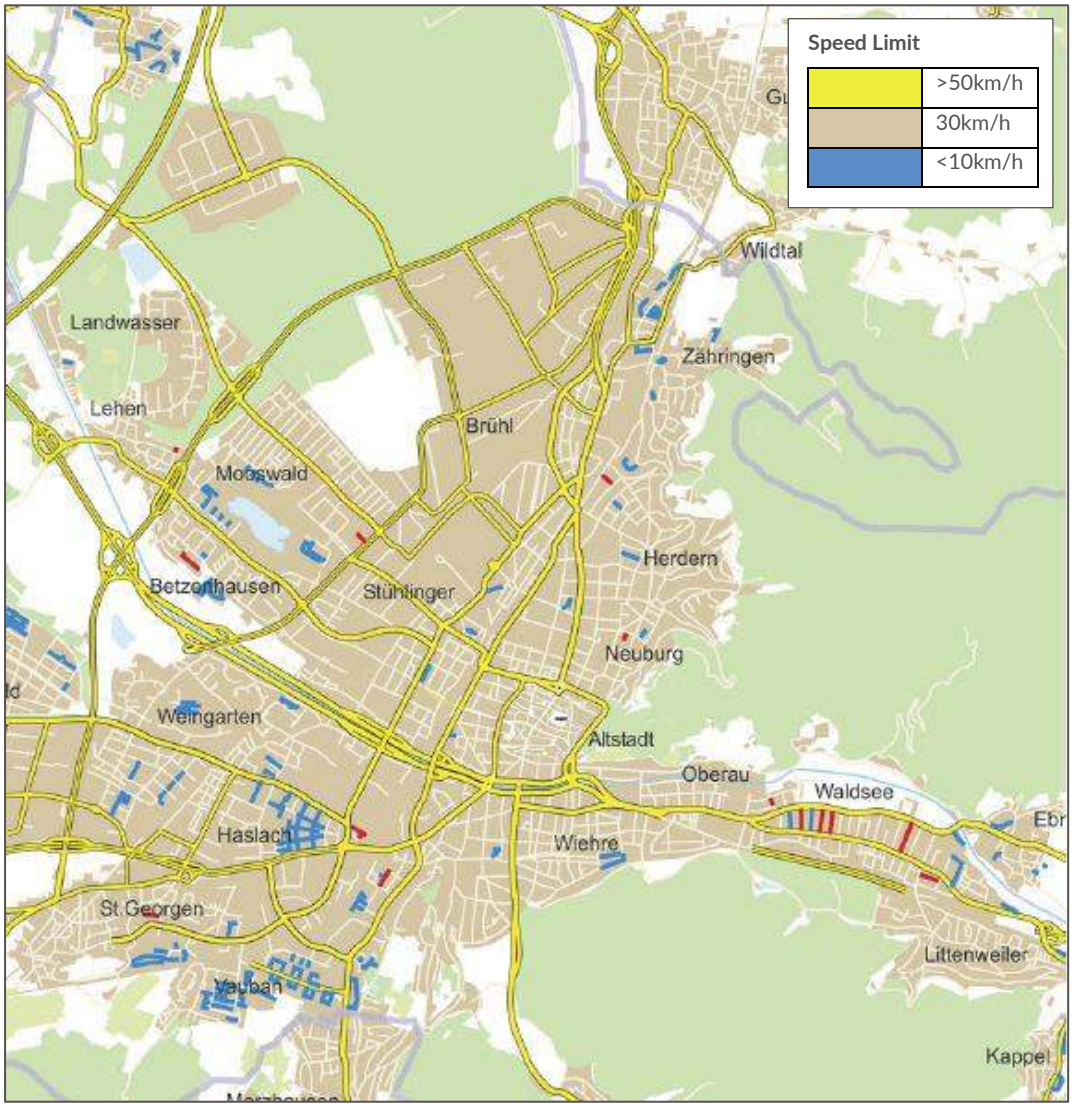
Prior to the 1970s, Freiburg's transport policy was quite similar to that of other European cities and focused on the needs of the car. Despite this, however, Freiburg's post World War II reconstruction included rebuilding the old town in its original compact form. Although cars were at first prioritised, with historic squares being used as car parks, this compact design ensured that sustainable reforms could be made later. Today these squares have been pedestrianized, housing open air markets or outdoor seating and dining. Freiburg was also fortunate that some car-focused reforms were planned but never implemented, such as the Second Land Use Plan (1963-71), and the removal of the tram system. The 1969 plan reversed this recommendation, instead proposing the preservation and expansion of the tram network. The 1970s saw the beginning of cycling infrastructure provision and in 1978 the recommended tramline expansion was initiated (Buehler & Pucher, 2011). Today 90% of residents have a tram stop within 500 metres of their home (ICLEI, 2018).

Figure 4.1: Freiburg parking zones



Parking management and speed limits are key components of Freiburg's traffic management system. The city is divided into three zones, as shown in Figure 4.1, and parking is more expensive the more central you are. Residential streets in the city centre have permit parking for residents only and the provision of multi-storey car parks minimises the need for on-street parking. 90% of residents live on streets with speed limits of 30km per hour or under and traffic is encouraged on to a small number of arterial roads on which cars can travel efficiently outside the city centre. Drivers are encouraged, through parking costs and speed limits, to park in zones 2 or 3 and to use sustainable transport within the city centre. Access to the city and safe streets for pedestrians and cyclists are prioritised over facilitating motorised transit within it (ICLEI, 2018).

Figure 4.2: Freiburg speed limits



While the entire city of Freiburg is considered to be highly sustainable, two districts, Vauban and Rieselfeld, are considered eco-districts within an eco-city. Vauban in particular has received substantial international attention, in part due to the grassroots community co-creation which drove its development. Vauban is a medium-density urban district 3km from the city centre (Energie Cités, 2008), to which it is connected by a regular tram service. The commitment to an abundance of green space in this urban setting is exemplified by the decision to run the tramline through a grassy verge, which also serves to muffle the sound and to contribute to the districts well developed storm water management system (Coates, 2013). Solar panels on the roof of every building serve not just as a source of renewable energy, but also as a visual cue to the sustainable commitments of this district (Thorpe, 2014).

Vauban is located on the site of a former French military base, which following the fall of the Berlin Wall in 1989, reverted in ownership to the German state. In 1994 the city of Freiburg purchased the site from the German federal government and the formal ground-breaking ceremony, signalling the beginning of residential development, took place in April 1998.

In 1994 the city held a competition for the design of Vauban. The competition rules stipulated that existing natural features such as trees and the creek be preserved. The effect of this is a neighbourhood which is both highly urban, with four to six storey buildings making up the majority of the structures, and also very green. The winning architects Kohlhoff and Kohlhoff made the basic plan for the district as a whole. On the insistence of Forum Vauban, a community centre and stringent environmental goals were included in this plan. Once this plan was established, the city divided land into small affordable plots which were sold to housing cooperatives consisting of small numbers of families who pooled their resources to build medium-density apartment buildings.

The ground floor of these buildings is usually occupied by local businesses. These mixed developments ensure that shops and services are within walking or cycling distance for all residents. It is therefore feasible to exclude cars from most of the streets in this compact district. Access to local businesses ensures that "no supermarkets will be constructed on green meadows" (Thorpe, 2014). This echoes a 2004 policy for the entire city in which so-called 'big box' retailers were banned due to their car dependency, and instead 30 priority locations were identified for the development of small local retailers (Buehler & Pucher, 2011). Many roads are designated as s*pielstrassen* (home zones) in which cars can only drive at walking pace (about 5-7km/hr.) allowing access for cars to pick up and drop off residents while prioritising pedestrians and enabling children to play safely on their street (Buehler & Pucher, 2011).

Home zones are found throughout Freiburg and 90% of residents live on streets with speed limits of 30km per hour or under. The eco-district of Vauban has gone one step further to exclude cars from residential street by banning on-street parking on residential street. The 30% of Vauban residents who own cars must pay to purchase a parking space for about €18,000 in one of the two parking garages on the outskirts of the district. This car-free policy was only feasible through negotiation with the city as the interpretation of regulations requiring the provision of parking at residences had to be relaxed. Eventually the city agreed to these car free streets as long as there was enough green space in the district that car-parking spaces could technically be provided later if required.

Crucially, tramlines were extended to both Vauban and Rieselfeld in advance of extensive residential development (Buehler & Pucher, 2011). This ensured that car-free living was feasible, facilitated and encouraged from the beginning, which would not have been the case if residential development had been sequenced ahead of public transport facilities. This helped to ensure that the city did not need to invest heavily later in behavioural change. Moving to Vauban appears to have triggered behavioural change in many previously car-owning households, 57% of which gave up their car (Thorpe, 2014).

This high rate of behavioural change may be explained by the habit discontinuity hypothesis, which suggests that people are more open to behavioural change during periods of transition. Verplanken and Roy (2016) tested this hypothesis by exposing participants who were moving home to an intervention which promoted more sustainable behaviours compared to a control group who also received the intervention but had not recently moved. The study indicated that sustainability interventions were much more effective at encouraging behavioural change in people if delivered in the 'window of opportunity' within 3 months of relocation. Interventions delivered after this period were much less likely to be successful as other habits were more likely to have become entrenched (Verplanken & Roy, 2016).

4.2 Copenhagen

Copenhagen is the capital city of Denmark and has been repeatedly ranked as the world's capital of cycling, with bicycles now outnumbering cars on the streets of the city centre (Københavns Kommune, 2017). Copenhagen is located on the East coast of Zeeland Island and on a Northern section of the smaller Amager Island, to which it is connected by a series of eight bridges. Copenhagen has been connected to Swedish city Malmö by the Øresund Bridge since it was constructed in 2000. In addition to their geographic proximity, Copenhagen and Malmö have many cultural and economic links, including an emphasis and impressive record on sustainable transport use.

Table 4.2: Copenhagen profile

Population and Density			
Population	591,000		
Population Density	6,200 per km^2		
Modal Share			
Car	Public Transport	Cycling	Walking
34%	18%	19%	29%

In 2014 Copenhagen was named the European Green Capital. This award recognised impressive achievements such as a 40% reduction in carbon emissions between 1995 and 2002. A significant source of this saving was increased cycling rates (Przybylowski & Studzieniecki, 2017). Copenhagen has set the goal of becoming the world's first carbon neutral capital city by 2025 (Cisco, 2018). Copenhagen's goal to see 50% of commuters travelling to work or education via bicycle will support the achievement of this and other public goods including better public health and reduced traffic congestion. Copenhagen's impressive rate of cycling is supported by its compact size, flat terrain and temperate climate; however it has also been supported through consistent investment in infrastructure, in addition to a strong sense of cultural pride in its status as a city and nation of cyclists (Transportministeriet, 2014) (Københavns Kommune, 2017).

Good cycling infrastructure can work alongside public transport provision to provide a high quality alternative to private car travel. Supporting cycling through the provision of a municipal bike rental service, a network of safe, segregated cycle paths, bike repair and maintenance services, and safe, roofed and guarded parking for bicycles can improve the usability of public transport. Passengers can use bicycles to get to their nearest station, make connections, and travel the first or last mile portion of their journey. Such a multimodal transport network is a cost-effective way to ensure that sustainable transport in urban areas is often as or more convenient as private car use (Przybylowski & Studzieniecki, 2017).

The complementarity of cycling and public transport is also key to ensuring that transport is as sustainable as possible for long as well as short distances. Copenhagen's density and compact size makes it ideally suited to city cycling, but when distances exceed 5km even some Copenhageners are likely to seek alternatives which likely explains why rates of cycling are lower among commuters travelling from the suburbs into Copenhagen city. The provision of secure bike parking facilities at stations and the ability to bring bikes onto public transport, for free in some cases or for a modest fare in others, ensures that cycling can be part of a cheap, convenient and multimodal commute for most commuters (Røhl & Severinsen, 2019). The ability to combine cycling with other modes also helps to ensure that it remains accessible to cyclists with a wide range of fitness levels and physical abilities. However, in pursuit of their goal that 50% of commuter trips into Copenhagen be made by bike, the city has also

made significant investment in providing end-to-end cycling infrastructure for longer commutes. Eight 'Cycle Superhighways' have been completed in the region and another five are in the process of being built. 25% of commuters using one these routes formerly drove to work (Københavns Kommune, 2017).

Copenhagen aims to ensure that there is an unbroken network of cycle lanes throughout the city with 'no missing links', increasing both speed and safety for cyclists. These lanes, on which cyclists feel safe and which parents are willing to allow their children to use, ensure that cycling is not just a niche activity. The 2016 Bicycle Account includes several indicators of the success of these policies and infrastructure. 76% of Copenhagen's cyclists feel safe while cycling, up from 51% in 2008, and in 2016 4.9 million kilometres were cycled before there was a serious cycling casualty (Københavns Kommune, 2017).

This investment has ensured that the vast majority (97%) of Copenhagen's residents report satisfaction with Copenhagen as a cycling city. Statistics indicate that although the number of kilometres cycled in Copenhagen is trending upwards, the rate of casualties is trending downward. This is likely explained by the increasing provision of safe cycling infrastructure (Københavns Kommune, 2017). Additionally, there is evidence that both cyclists and pedestrians benefit from 'safety in numbers' and therefore the number of accidents per active traveller decreases as the absolute number of active travellers increases. This is thought to be due to drivers being more aware of the presence of cyclists and pedestrians, and driving more carefully as a consequence (Fyhri, et al., 2017). It is also possible that the ubiquity of cycling increases the likelihood that drivers are also cyclists, and that cyclists are also drivers, and that this improves relations between the two groups.

4.3 Malmö

Malmö is a former industrial city located in the south of Sweden, close to the Danish capital Copenhagen. Malmö's industrial era peaked in the 1970s and its population shrank during the 1980s following several years of economic decline. However the transition towards a service-based economy, the opening of the new university in 1998, and the construction of the Øresund Bridge between Malmö and Copenhagen in 2000, have all helped revitalise the city.

Table 4.3: Malmö profile

Population and Density			
Population	334,000		
Population Density	2,100 per km^2		
Modal Share*			
Car	Public Transport	Cycling	Walking
40%	21%	22%	15%

*Other transport modes account for 2% modal share

At the end of 2017 Malmö's population was 333,633 people and it is one of Sweden's fastest growing metropolitan areas. Malmö is also a very young city, with half of all inhabitants aged below 35. The typical resident is a 28 year old woman or a 30 year old man, and there is a high ratio of children under the age of six, with many couples choosing to remain within the city to raise their children (Malmö Stad, 2016). The needs of these urban families has been a key consideration for Malmö's city planners (Malmö Stad, 2016), and their sustainable focus

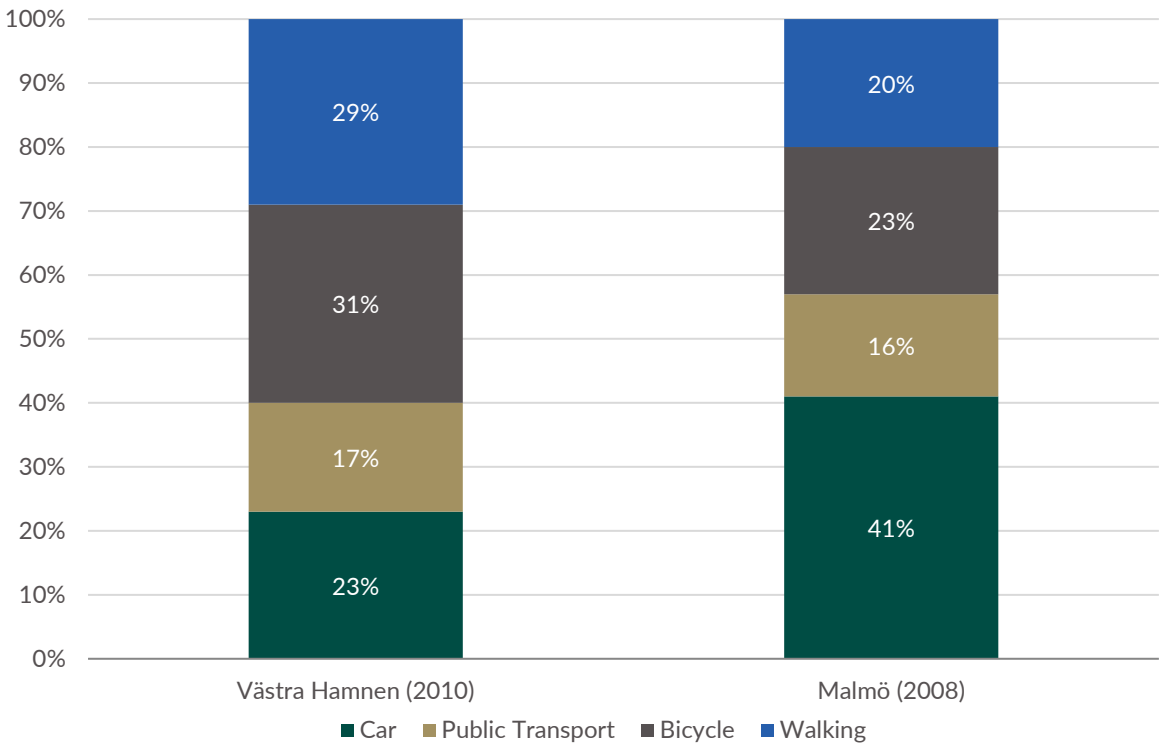
has seen Malmö frequently identified as one of the world's top cities for sustainable urban development (Malmö stad, 2016).

Bo01 is a sustainable urban development project in the Västra Hamnen district of the city, which was formerly a shipyard. The vision for Bo01 was the redevelopment of a brownfield city centre site into a dense eco-district (Austin, 2013). The land chosen for development was in the docklands next to the harbour and contaminated by industrial use. Funding from the Swedish government and the EU allowed for the decontamination of the soil and the freeing of this land for the construction of energy efficient mixed-use development. Located next to the University of Malmö, Bo01 is at the heart of the new knowledge-based, post-industrial Malmö.

Bo01 was designed and constructed to be an eco-district in which residents could easily live without the need for car ownership, and the proximity of the district to the city centre (2km) is a key factor in facilitating this. Developers hoped to discourage car ownership by limiting the availability of parking to 0.7 spaces per household. However, not all residents were willing to eschew car ownership and demand for additional parking facilities eventually led to the construction of a multi-storey car park (Henderson & Foletta, 2016).

Despite the unanticipated demand for car parking in the Bo01 development, Västra Hamnen residents are significantly less likely than other Malmö residents to travel by car, as shown in Figure 4.3. Car journeys account for 23% of trips made by Västra Hamnen residents, compared to 41% of trips in the city more widely, while active modes account for 60% of trips, compared to 43% in the city as a whole (Henderson & Foletta, 2016).

Figure 4.3: Modal share for all trips, Västra Hamnen and Malmö compared

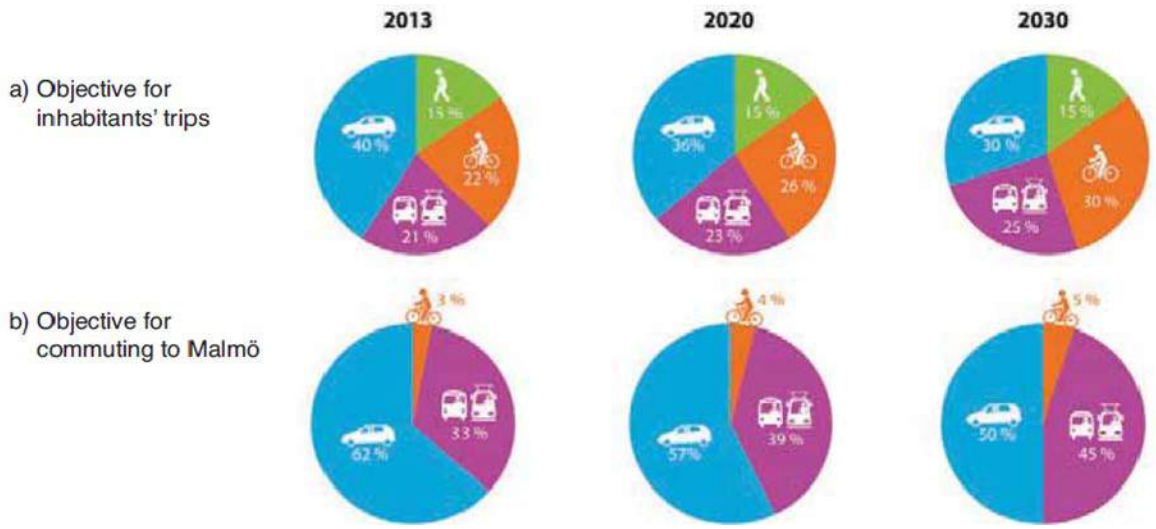


In 2015, Malmö won the European Commission's annual SUMP Award in recognition of "its impressive intermodal transport solutions with a people-friendly focus and its excellence in linking transport planning with the overall urban planning process" (European Commission, 2019). This award-winning SUMP presents a coordinated, proactive framework to ensure that the growing city develops in a sustainable way, ensuring accessibility and a high quality of life for its residents. The plan is informed by factors such as the growing numbers of young families living within the city, environmental constraints and policy goals.

The four main pillars of the plan are a holistic approach (environmentally, socially and economically sustainable), a focus on future traffic, commuting, and urbanised main roads. These roads are sustainable urban spaces populated with businesses and other road facing buildings, with dedicated and adequately sized lanes for walking, cycling, public transport and trees. These roads prioritise active travel modes over private cars, in part through imposing low speed limits to enhance safety for all traffic.

Modal shift is another key objective of Malmö's SUMP. With high rates of commuter traffic (62,000 people commute to Malmö and 31,000 commute from Malmö every day), Malmö aims to shift these journeys in favour of public transport, while for inhabitants of the city itself the focus is on a reduction in car travel in favour of both public transport and active modes.

Figure 4.4: Malmö mode share objectives for commuters and residents



Other measures highlighted by the European Commission include Malmö's pedestrianisation of a major shopping street, efforts to make the city centre safer and more attractive to residents, and the city's bike sharing scheme which includes 500 bicycles across 50 stations. The city's partnership with local businesses and its commitment to dialogue and communications were also remarked upon favourably (European Commission, 2017).

4.4 Amsterdam

Amsterdam, like Copenhagen, is a city known for cycling; with the cycling modal share overtaking private car use in 2005 (City of Amsterdam, 2009). Cycling is a key component of sustainable mobility in Amsterdam, protecting air quality, avoiding noise pollution and promoting public health. Bicycles play a key role in enabling mobility while minimising congestion as they require less space on both public roads and for parking than private cars. Car use is

discouraged within the dense city centre through sparse provision of parking, and the frequency of cul-de-sacs and one way streets, whereas short distances and bike only bridges help to ensure that cycling is frequently both the fastest and easiest way to travel through the city. The promotion of cycling and other sustainable modes in Amsterdam's city centre has helped to ensure that the historic and picturesque narrow streets have been preserved while still enabling mobility.

Table 4.4: Amsterdam Profile

Population and Density			
Population	814,000		
Population Density	4,900 per km^2		
Modal Share*			
Car	Public Transport	Cycling	Walking
20%	17%	32%	29%

*Other transport modes account for 2% modal share

Following public consultation in 2006 to identify the main barriers faced by Amsterdam's cyclists, the city began the implementation of pro-cycling policies which have seen traffic calming measures and investment in: off-road cycle lanes; bike parking facilities; guarded bicycle garages; a comprehensive theft-prevention programme; and, campaigns designed to promote cycling among a range of groups, such as migrants and young people. More recently the Dutch government developed an app which cyclists used during the designated 'National Bicycle Counting Week' in September 2017 to record their speed, route, time of journey, and, crucially, where they encountered delays to enable the government to map out locations in need of infrastructural improvement (Government of the Netherlands, 2017).

Amsterdam also has policies specifically designed to promote multimodal transit, which includes bikes, through the provision of extensive parking for bicycles at train stations, as well as 'park and bike' stations where drivers are encouraged to park their cars on the outskirts of the city and then cycle the rest of their journey (Buehler & Pucher, 2009). This keeps cars off the compact streets of the city centre, reducing congestion and air pollution, while accruing the public health benefits associated with active travel. One study of commuter cyclists in Amsterdam found that while the average distance cycled to work was 6km, for the 10% of participants who lived 16km or more from work, the average distance cycled was 5km. For these longer distance commuters, cycling is combined with other modes (bike and ride) to effectively overcome the key barrier of 'distance from work' to commuting by bicycle. Similarly to studies from other cities, health benefits and exercise were the key motivators for cyclists and distances of under 5km are preferred. Combining cycling with other modes ensures that commuters living further from work can also enjoy the benefits of cycling a moderate distance (Engbers & Hendriksen, 2010).

These multimodal policies reflect the recognition of policy makers, that cycling alone will not meet all transport needs, and sustainable mobility is best promoted through both discouraging car use (particularly within the city centre), and providing high-quality alternatives. In Amsterdam the above-ground tramlines and underground metro system provide accessible, comfortable and high capacity public transport to the city's inhabitants. The metro lines, which run primarily underground, are noted for their speed, accessibility (lift or ramp access to stations is typically available) and, the simplicity of their route design. The modernity of these facilities may be

explained by how recently the first lines were laid – 1977 (Anon., 2019) – and due in part to the careful and innovative engineering required for the construction of an underground metro system beneath a city supported primarily by wooden pillars (Urban Hub, 2015). The combination of cycling and mass transit significantly expands the catchment area of each station (from 0.5-1km^2 to a maximum of 5km^2), enabling trains to run more frequently due to increased demand for services.

While best known for cycling, Amsterdam was also ranked second for 'mass transit coverage' in a 2014 study by PwC, which compared 31 so-called 'Cities of Opportunity' internationally on a range of liveability and ease of doing business measures. Mass transit coverage was determined through calculating the ratio of kilometres of mass transit track to every 100 square kilometres of developable city land (PwC, 2014). A prior connectivity gap between the Northern and Southern regions of the city was recently rectified by the completion of line 52, the North-South metro line which enables travel from the northernmost station to the Central Business District of the city in just 15 minutes (Anon., 2019). While Amsterdam excelled on measures of connectivity, indicating the range of its mass transit, it performed less well on affordability, ranking 'six' on a scale in which 'one' denoted the worst performer (PwC, 2014). This indicates that Amsterdam's mass transit infrastructure is of a high quality, but that economic barriers may exists to its optimal access.

4.5 Lessons for Ireland

Based on the case studies of Freiburg, Copenhagen, Malmö and Amsterdam there are a number of common factors and approaches which appear to encourage compact development. In both Freiburg and Malmö SUMPs are a prominent feature of development, which help to ensure land-use and transport investment are integrated and that sustainable modes are convenient choices for most journeys. The European Commission advocates for the effective use of SUMPs and, with Metropolitan Area Strategic Plans to be developed for Ireland's five cities, there is an opportunity to learn from good practice elsewhere to ensure urban transport networks support compact growth.

The supply of high-quality infrastructure can also encourage modal shift, as is demonstrated by Copenhagen and Amsterdam. By building an extensive network of cycle lanes and supporting infrastructure throughout the city, as well as providing opportunities for interchange with public transport options, Copenhagen has been able to reduce its car modal share to just over a third of journeys, with half of cyclists reporting that cycling is the quickest and easiest way to get around the city. Compact development and modal shift away from private car use within the city can be further encouraged through the effective provision of off-street parking at strategic locations and, as demonstrated by Freiburg, giving cars priority on certain roads and giving active modes priority on others. Amsterdam also demonstrates the importance of integration between modes, with the widespread provision of park and bike facilities and increased catchment of the underground system encouraging greater use of sustainable modes where private car might otherwise be preferred.

Finally, as demonstrated by the Vauban and Rieselfeld districts in Freiburg, interventions to encourage modal shift are likely to be more effective if deployed at moments of transition in people's lives. Both Vauban and Rieselfeld are Transit-Oriented Developments (TOD), in which development is concentrated around public transport nodes. These districts are both served by light rail and, in the case of Rieselfeld, this public transport connectivity was in place in advance of housing (NESC, 2019). With several greenfield sites within Ireland's cities earmarked for extensive residential development in the National Planning Framework, the early provision of sustainable

transport infrastructure and services to these locations can be a potent means of encouraging modal shift away from private car use.

5. Supporting the National Strategic Outcomes

The Project Ireland 2040 National Strategic Outcomes are a single vision and shared set of goals for every community in Ireland. In some cases transport's role in realising these outcomes is explicit, such as delivering sustainable mobility, while in others transport has a facilitating role, such as access to high-quality childcare, education and health services. In support of Project Ireland 2040, transport investment can deliver positive outcomes in the following areas:

1. **Delivering clean, low-carbon and environmentally sustainable mobility**

   A sustainable transport system is one which can meet the needs of the population today without compromising its ability to meet the needs of the population tomorrow. In terms of environmental sustainability, the reduction in greenhouse gas emissions is a foremost priority. This is reflected in National Strategic Outcome 8, which is the transition to a low-carbon and climate resilient society. It is also a national objective to achieve a low-carbon, economically competitive and environmentally sustainable economy by 2050. As the second largest source of greenhouse gas emissions in Ireland, the transport sector has a key role to play in achieving these objectives.

2. **Supporting successful places and vibrant communities**

   The National Planning Framework estimates that the population of Ireland will grow by one million over the next twenty years to almost six million people. Where this population lives and works will be a key factor in how Ireland develops, socially and economically, and the National Planning Framework has set the objective of accommodating one quarter of the growth in Dublin, one quarter in the other four cities, and the remaining half in towns and rural areas. The provision of appropriate transport infrastructure will play a crucial enabling role in the delivery of this objective and supporting quality of life for all Ireland's inhabitants.

3. **Facilitating safe, accessible, reliable and efficient travel on the network**

   Delivering a high level of service means the provision of a transport network that is safe, reliable, efficient and accessible. The growth in population forecast between now and 2040 will result in a significant increase in trips, for both people and goods. Investment in the land transport network must enable this growth without compromising on service levels. Moreover, investment must be financially sustainable, and among other things this means ensuring that the transport network is appropriate to the population's needs rather than delivering high levels of excess capacity.

4. **Promoting a strong and balanced economy**

   Ireland is a small open economy, dependent on high-quality international connectivity. The land transport network plays a key role in our economy by providing access to both national and international markets, the latter through our airports, ports and links with Northern Ireland. Within our towns and cities, the transport network can ensure equitable access to jobs and opportunities for our population.

Figure 5.1: Project Ireland 2040 National Strategic Outcomes

5.1 Urban Transport and the National Strategic Outcomes

The discussion in the preceding sections of this paper has established why we should pursue compact growth in our towns and cities, set out the current state of play in Ireland with regard to that goal, and looked at examples internationally where transport has facilitated urban consolidation. Combining this analysis with the National Strategic Outcomes and the high-level objectives for transport investment listed above, it is possible to derive a number of concrete questions to ask of our urban transport networks. Working with the NTA, the NIFTI project team used these urban transport questions to derive a set of performance indicators, set out in Table 5.1.

Table 5.1: Urban network questions and performance indicators

Outcome	Question	Indicator
Delivering clean, low-carbon and environmentally sustainable mobility	What share of urban journeys is made using sustainable transport modes?	Percentage typical weekday journeys by transport mode
Supporting successful places and vibrant communities	How has the population of urban electoral divisions varied over time?	Population change by electoral district
Facilitating safe, accessible, reliable and efficient travel on the network	How congested are urban roads?	Volume over capacity ratio; Peak hour link delay
Promoting a strong and balanced economy	How accessible are employment opportunities?	Average weekday AM peak journey times to business district

6. Urban Transport Modelling Scenarios

Working with the questions and indicators set out in the previous section, the NTA ran models of all five cities for three scenarios:

1. **Base Scenario (2012):** Based on 2011 Census data and the NTA's National Household Travel Survey;[2]
2. **Do-Nothing Scenario (2040):** – Based on the population and settlement targets included in the NPF; and,
3. **Do-Minimum Scenario (2040)** – The same population and settlement as the Do-Nothing Scenario, supplemented with the delivery of committed transport infrastructure under the NDP to the end of 2027.

Broadly speaking, the Base Scenario indicates areas where the urban transport networks are under strain today as well as existing mode share.

Table 6.1: Targeted pattern of city population growth

City	Population 2016	Population growth to 2040		Minimum target population 2040
		%	*People*	
Dublin	1,173,000	20-25	235,000-293,000	1,408,000
Cork	209,000	50-60	105,000-125,000	314,000
Limerick	94,000	50-60	47,000-56,000	141,000
Galway	80,000	50-60	40,000-48,000	120,000
Waterford	54,000	50-60	27,000-32,000	81,000

Source: National Planning Framework

The Do-Nothing Scenario projects how these pressures and modal shares would shift between now and 2040 if no new infrastructure was delivered whatsoever but NPF population targets were nevertheless achieved—a highly unrealistic assumption. The population targets for Ireland's five cities are stated in Table 6.1, although it should be noted that for the purposes of modelling the NTA has made assumptions about the exact population distribution within these high-level parameters. In line with the National Planning Framework, it has been assumed that the majority of population growth nationally will take place in and around the five cities, particularly Dublin, Cork and Galway.

Finally, the Do-Minimum Scenario considers what impact the infrastructure projects included in the National Development Plan will have on network pressures and modal share under the same population assumptions as the Do-Nothing Scenario. For the purposes of planning future investment in the land transport network, this scenario indicates the types of issues, potential bottlenecks and constraints to be addressed beyond the current NDP.

6.1 Modelling Overview

The regional transport models that support the NTA's transport planning remit are multi-modal, network-based transport models that include all main surface modes of travel. The Regional Modelling System (RMS) captures all-day travel demand, enabling more accurate modelling of mode choice behaviour and complex travel patterns,

[2] At the time of writing, the NTA is in the process of updating its regional modelling system base case scenario to reflect the results of Census 2016. Pending this recalibration, 2012 is currently the base year used in the NTA's regional models.

especially in urban areas where traditional nine-to-five working is decreasing. The five regional models, corresponding to each of the cities, have the following key attributes:

- Full geographic coverage of the relevant region;
- A detailed representation of the road network;
- A detailed representation of the public transport network and services;
- A detailed representation of all major transport modes, including active modes;
- Accurate mode and destination choice modelling of residents;
- A detailed representation of travel demand for five time periods (AM, inter-peak (mid-morning and mid-afternoon), PM and off-peak); and,
- A prediction of changes in trip destination in response to changing traffic conditions, transport supply and policy.

Best practice approaches were applied to the RMS demand modelling modules, including car ownership, constraints on parking, demand pricing, and mode and destination choice. The RMS is responsive to future changes in demographics, economic activity and planning interventions.

6.1.1 Trip-end Integration

The trip-end Integration module converts the 24-hour trip ends output by the National Demand Forecasting Model into the appropriate zone system, tour and time period disaggregation for use in the Demand Model (DM). A tour is, for example, an outbound trip to work in the AM and return home in the PM. Another important 'split' of demand is into car-available demand and non-car-available.

6.1.2 Demand Model

The Demand Model (DM) processes travel demand and outputs origin-destination travel matrices by mode and time period to the assignment models. The DM and assignment models run iteratively until equilibrium between travel demand and the cost of travel is achieved.

6.1.3 Assignment Model

The road, public transport, and active modes assignment models receive the trip matrices produced by the DM and assign them in their respective transport networks to determine route choice and the generalised cost for origin and destination pair.

The road model assigns DM outputs (passenger cars) to the road network and includes capacity constraint, traffic signal delay and the impact of congestion.

The public transport model assigns DM outputs (person trips) to the public transport network and includes the impact of capacity restraint, such as crowding on vehicles, on people's perceived cost of travel. The model includes public transport networks and services for all public transport sub-modes that operate within the modelled area.

6.1.4 Generalised Cost Estimation

In transport models, the 'generalised cost' of travel from point A to point B is the sum of all the monetary and non-monetary costs of undertaking that journey expressed as time. The generalised cost of a journey is dependent on

the mode(s) used, the time of day and the purpose of the journey. In route and mode choice estimation models, trips are assigned to modes and routes based on generalised cost and a set of governing equations which have been calibrated using observed patterns of travel behaviour, such as the CSO's POWSCAR database, the NTA's National Household Travel Survey, the Luas Census, the National Heavy Rail Census. as well as a great many traffic counts, other public transport surveys and counts, and the Department of Transport's tables for individuals' values of time. Equilibrium is found iteratively when all trips are assigned at their lowest possible total generalised cost relative to each other. The generalised costs are calibrated to present existing patterns of behaviour and then forecast into the future using land-use (trip demand) forecasts supplied by Government, which are guided by the CSO's projections and apportioned across the local authorities and down to the level of Census Small Areas.

For the purpose of mode and route choice, the NTA regional modelling system estimates zone-to-zone generalised cost for road, public transport, walking and cycling by time of day and journey purpose. The generalised cost for public transport is estimated based on a sum of:

- Actual walk distance to public transport access node (bus stop, rail platform, etc.) up to a maximum distance;
- Estimated walk time to public transport access node;
- Wait time penalty;
- Boarding penalty;
- Fare penalty;
- Estimated in-vehicle travel time;
- Crowding penalty (increases as crowding increases); and,
- Transfer penalty (applied when interchanging between modes, e.g., bus to DART).

Each component of generalised cost is expressed as a unit of time, based on parameters derived from revealed preference surveys. Normalising the generalised cost of trips to a common unit of time allows direct comparison between different route and mode choice options for a single trip as well as direct comparison of different land-use forecasts, proposed transport infrastructure projects, transport system changes, or policy interventions.

The perceived value of time changes depending on the purpose of the trip and the time of day. For example a commute trip in the morning peak has a higher perceived value of time than a shopping trip in the off peak.

6.2 Limitations

While the NTA regional models are a powerful tool for estimating the likely effects of changes to population and transport infrastructure, there are a number of limitations that should be borne in mind when interpreting the results in the following sections. Firstly, where detailed designs do not exist for a project that has received a funding commitment as part of Project Ireland 2040, proxies for infrastructure have been applied. This affects, for example, cycling and bus services. Where designs do not yet exist, journey speeds and service frequencies have been increased to give an indication of what the impact of investments like BusConnects and comprehensive cycling infrastructure might be. However, to the extent that future networks differ from present day routes and infrastructure, the impact of investment will vary in reality. Even where designs currently do exist, such as for BusConnects in Dublin and Cork, these are likely to change somewhat over the course of consultation and implementation. As such, what is modelled in the following sections is future transport infrastructure and services as they are currently understood.

Another issue to bear in mind is that many of the zones within our cities that are earmarked for dense residential development in future do not, today, possess an adequate transport provision for future travel demand, although many are located adjacent to existing rail links. In the normal course of events, public transport services to these areas will increase alongside population growth. However, the purpose of NIFTI is not to pre-empt future investment decisions beyond those that have already received a funding commitment under Project Ireland 2040 and, as such, services have not been adjusted to reflect this response. This allows for the more accurate identification of areas where the land transport network requires additional interventions if it is to support compact growth, but also means that modal share in certain areas will be unrealistic if, for example, residents within the model are forced to walk long distances in the absence of adequate public transport provision.

Finally, as the analysis is based only on projects which have received a firm funding commitment, other projects mentioned in the NDP to be brought through pre-appraisal and early planning in order to identify priority projects for delivery over the next decade have not been modelled. While many of those projects will be delivered in the next decade, given that the exact list is uncertain, they have all been excluded for the purposes of NIFTI. However, given that the focus of this paper is the five cities and most of the projects that will go through pre-appraisal are on the interurban road network, the impact on the modelling presented here should be marginal. NIFTI Background Paper 11 considers the interurban road and rail network in greater detail.

7. Dublin

This section of the paper considers Dublin for the three modelling scenarios described in Section 6. The assumed growth in population and trip demand for the 2040 scenarios will be set out followed by the NDP investment assumed for the Do-Minimum Scenario. The impact of population growth and investment on modal split, capacity, delay, and generalised journey times will then be shown. The section will conclude with a summary of the main issues and areas of constraint identified in the modelling for the Do-Minimum Scenario, indicating where additional intervention beyond that set out in the NDP may be required between 2027 and 2040 for the transport system to facilitate NPF settlement targets.

7.1. Population and Travel Demand

Table 7.1 presents the assumed population change between the 2012 Base Scenario and the two 2040 scenarios for Dublin city, county and nationally. Figure 7.1 illustrates this increase for the Dublin city area, and it can be seen that the highest levels of population growth are projected to occur in the areas surrounding Dublin Port, such as East Wall, Ringsend and Grand Canal Dock, Ballsbridge, Castelknock Ballymun and Park West. With this growth in population, the typical daily trip demand within Dublin city is estimated to increase by 15.7%, from 2.4m to 2.8m, between 2012 and 2040.

Figure 7.1: Percentage change in population in Dublin city by electoral district

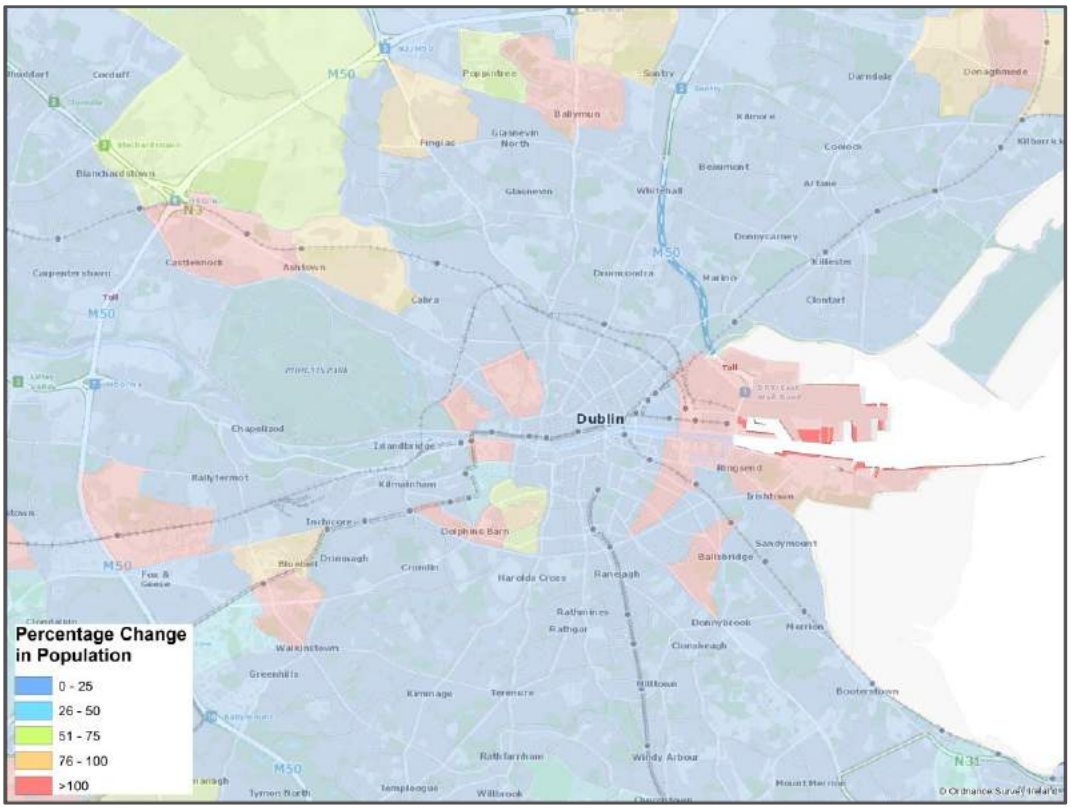


Table 7.1: Population of Dublin city and county between Base and 2040 scenarios

	Base 2012	2040	Change
Dublin City	527,612	678,828	29%
Dublin County	1,007,864	1,274,191	26%
National	4,588,248	5,643,917	23%

7.2 Investment

Besides the population projections set out above, for the Do-Minimum Scenario a number of projects to be delivered by 2027 under the NDP have been included in the East Regional Model (ERM).

BusConnects is modelled in line with the sixteen core bus corridors for which public consultation concluded on 31 May 2019, using journey time proxies and increased service frequencies to deliver a higher-quality bus service along these routes. Additionality, bus rapid transit services have been included running from Blanchardstown to UCD, Clongriffin to Tallaght, and Swords to the city centre. A comprehensive cycle network has been modelled adjacent to the bus corridors and nine additional park and ride facilities have been added at strategic locations[3].

For rail, a MetroLink service running from Estuary to Charlemont via Swords and Dublin Airport has been modelled, in line with the preferred route announced on 1 April 2019. On the existing Luas Green Line, the first phase of the capacity enhancement will see up to 24 trams operating per hour and 9,120 passengers carried on services between Sandyford and Stephen's Green. The DART expansion programme will see electrification and services extended to Drogheda, Dunboyne/M3 Parkway, Maynooth and Celbridge.

New road schemes include the N52 Ardee Bypass, N2 Slane Bypass, M7 Naas to Newbridge Bypass widening, Sallins Bypass, Adamstown and Nangor Road improvements, Portlaoise Southern Distributor Road, Laytown to Bettystown Link Road, Athy Southern Distributor Road, Porterstown Distributor Link Road, R126 Donabate Relief Road, R132 to Portrane Demesne, and the Oldtown-Mooretown Western Distributor Link Road.

7.3 Modal Split

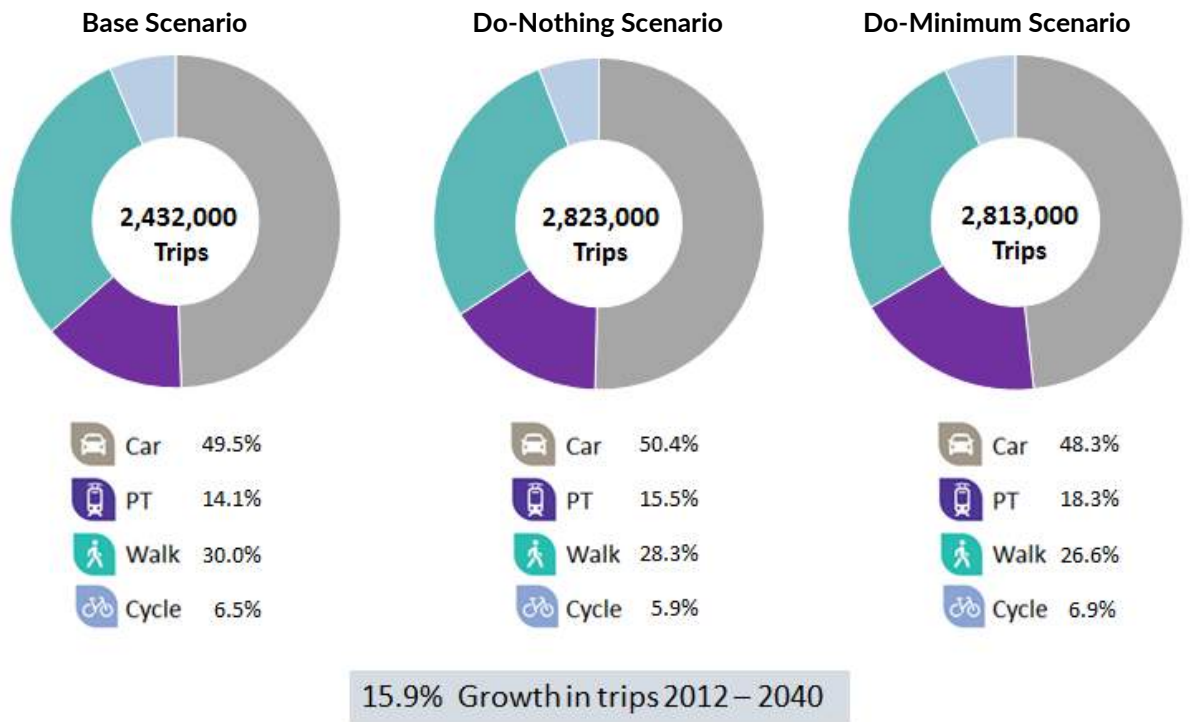
Figure 7.2 displays mode shares for the East Region across the three scenarios. The results show a relatively minor change in mode share between the Do-Nothing and Do-Minimum scenarios, with roughly a one percentage point shift away from both private car and walking and a two percentage point increase in public transport. Overall, there is expected to be a 20% increase in total trips in the East Region between 2012 and 2040, from 6.5m to 7.8m.

The mode shares for Dublin city are illustrated in Figure 7.3.[4] Within the city, car modal share is expected to fall by two percentage points between the Do-Nothing and Do-Minimum scenarios, representing less than half of all trips in the latter. Both public transport and cycling increase their modal share between the Do-Nothing and Do-Minimum scenarios, by three and one percentage points respectively, while walking is expected to fall by almost two percentage points. Overall, it is projected that there will be a 16% increase in trips in the city between 2012 and 2040.

[3] Adamstown, Dunboyne, Greystones, Woodbrook, Estuary, Carrickmines, Finglas, Liffey Valley Shopping Centre and Naas Road.
[4] See Appendix 1 for a map of the city area for modelling purposes.

Figure 7.2: Mode shares for East Region (typical weekday)

Figure 7.3: Mode shares for Dublin city (typical weekday)

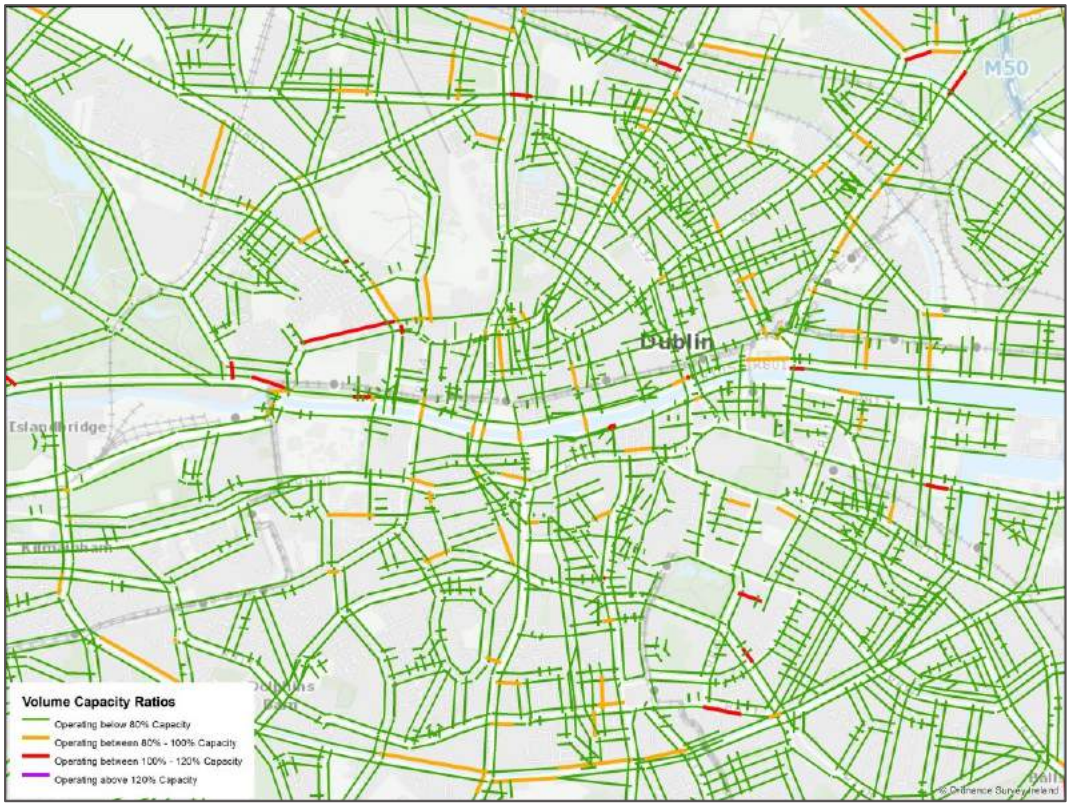


7.4 Congestion and Mobility

Figure 7.4 displays the volume-capacity ratios for the Base Scenario in Dublin city. In the base year, many of the road links in the inner city are either approaching full operational capacity or are at full capacity, as indicated in

orange. There are also a number of links operating at between 100% capacity and 20% over capacity, as indicated in red in the figure, particularly in Fairview and in the areas just north of Heuston Station and around Stephen's Green.

Figure 7.4: Dublin city volume-capacity ratios, Base Scenario, 2012



The modelling for the Do-Nothing Scenario indicates that, in the absence of intervention, a number of existing capacity issues will worsen and other challenges will emerge in Dublin city centre. Pressures are scattered around the city but are most pronounced in the area north of Hueston Station and close to Phoenix Park, with various other links estimated to operate at between 80% and 100% of operational capacity, as represented in orange in Figure 7.5.

The volume-capacity ratios for the Do-Minimum Scenario, presented in Figure 7.6, demonstrate little or no improvement as a result of the schemes and projects listed in Section 7.2, which are mainly targeted at the wider East Region with respect to roads Capacity issues are apparent throughout the city centre and, in particular, there are expected to be severe capacity issues in the northwest inner city, along the quays and on Liffey crossings

Figure 7.5: Dublin city volume-capacity ratios, Do-Nothing Scenario, 2040

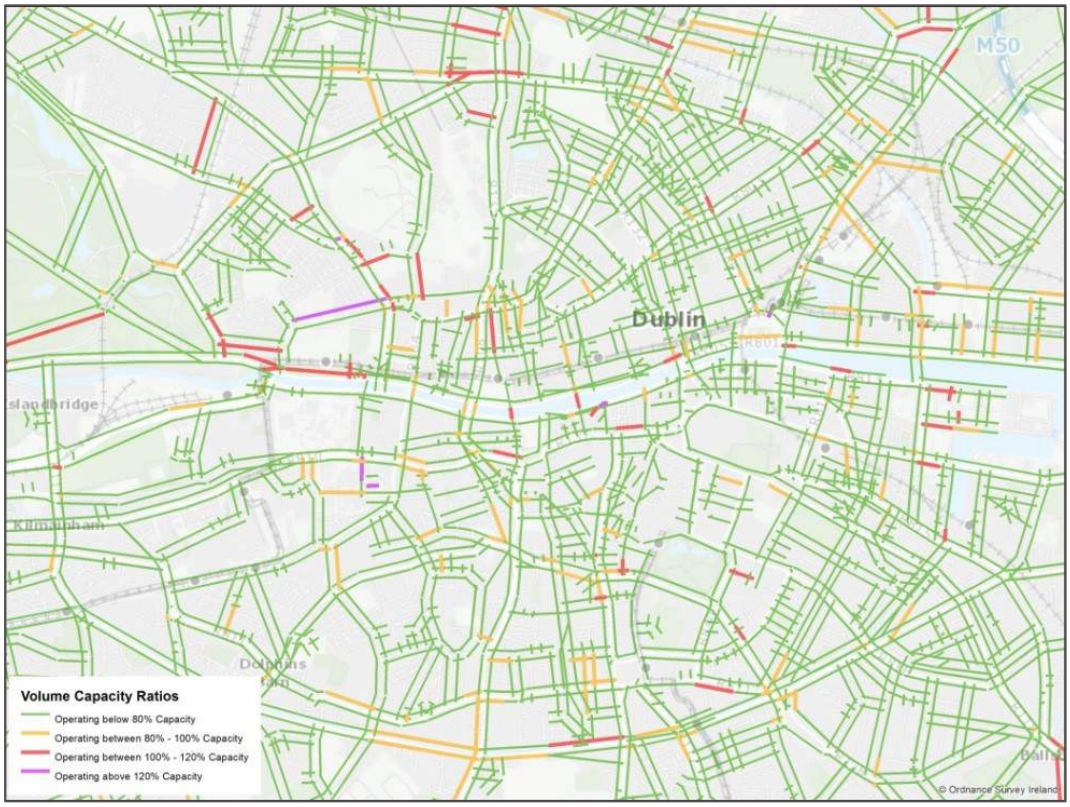
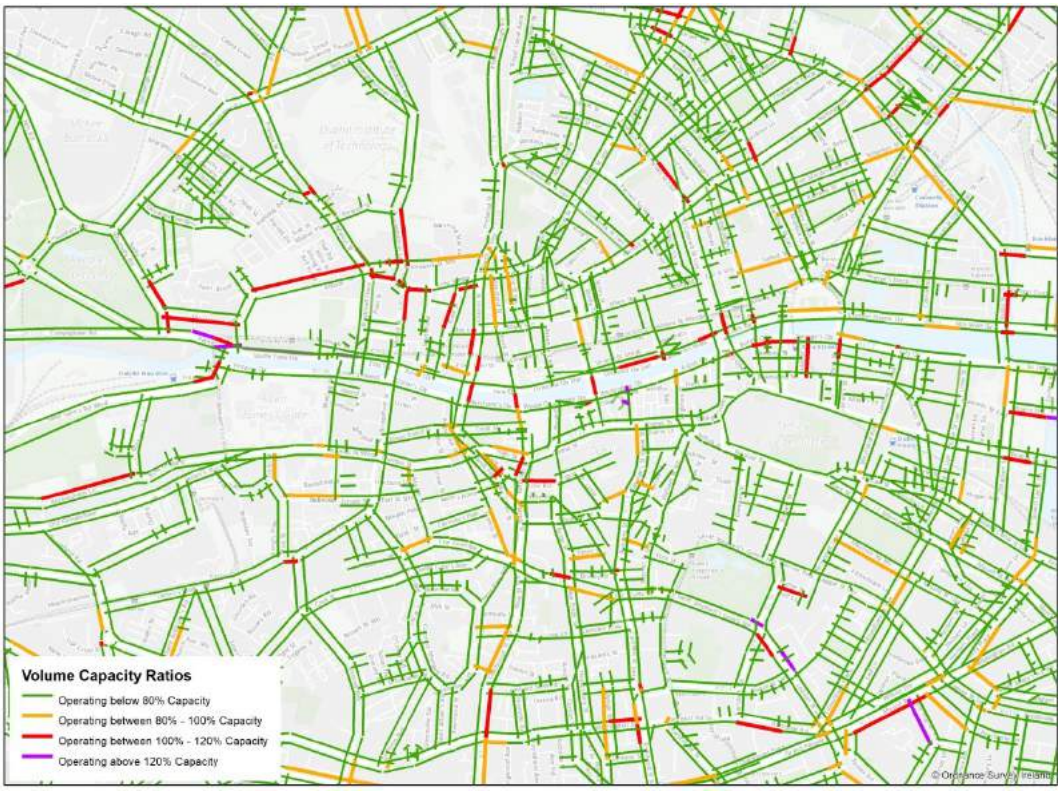


Figure 7.6: Dublin city volume-capacity ratios, Do-Minimum Scenario, 2040



Peak hour delays on links in Dublin city centre for the Base Scenario are illustrated in Figure 7.7. Compared with free flow, many links throughout the city centre are experiencing long delays in percentage terms, with those that are facing capacity issues such as in Fairview, Islandbridge and north of Heuston Station reporting journey times increases in excess of 250%. Significant delays are also found on sections of the South Circular Road and on links adjacent to the Samuel Beckett Bridge.

Estimated delays on the Dublin city road network for the Do-Minimum Scenario are shown in Figure 7.8. With the population increase targeted by the NPF and associated rise in travel demand, links which were already reporting lengthy delays in the Base Scenario – such as Fairview, Islandbridge and sections of the South Circular Road – see delays increase even further and spread to surrounding areas. Other notable clusters of links experiencing significant delays when compared with the Base Scenario include the IFSC and Grand Canal Dock.

Peak hour delay is projected to remain a significant issue in the Do-Minimum Scenario also, as shown in Figure 7.9. Even with NDP investment, without additional intervention between 2027 and 2040 significant delays are predicted throughout the city centre at peak times, with issues particularly pronounced along the quays and on both the North and South Circular Roads.

Figure 7.7: Dublin city percentage increase in peak hour journey times, Base Scenario, 2012

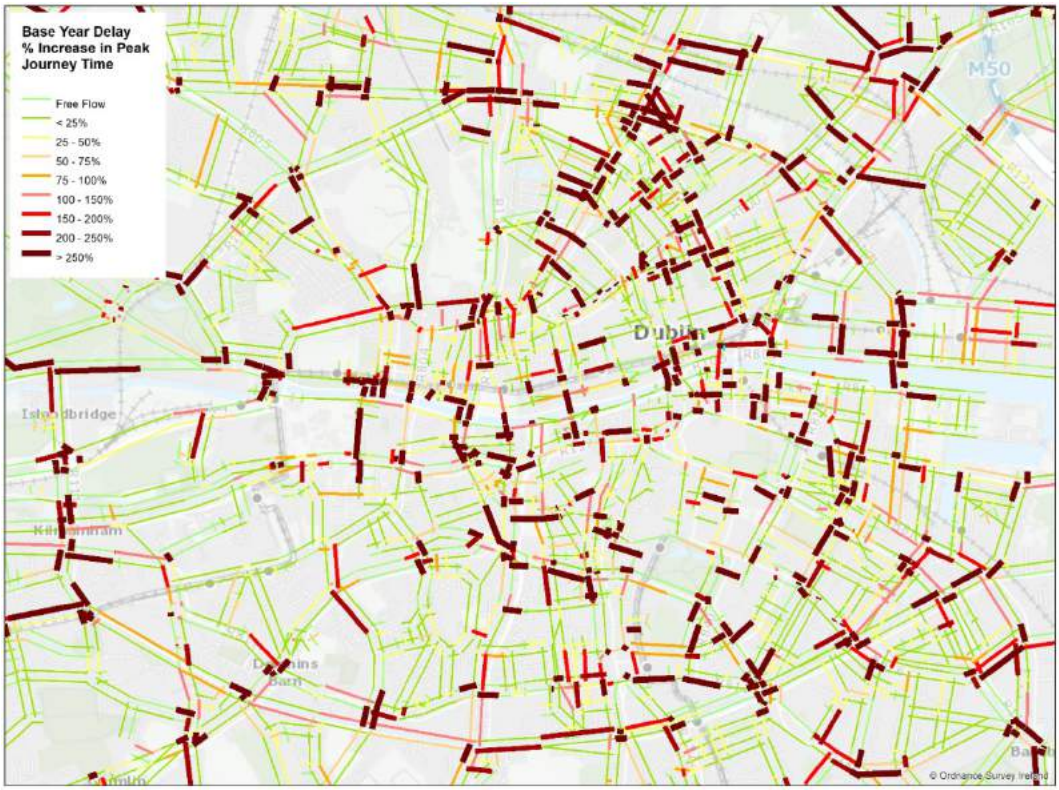


Figure 7.8: Dublin city percentage increase in peak hour journey times, Do-Nothing Scenario, 2040

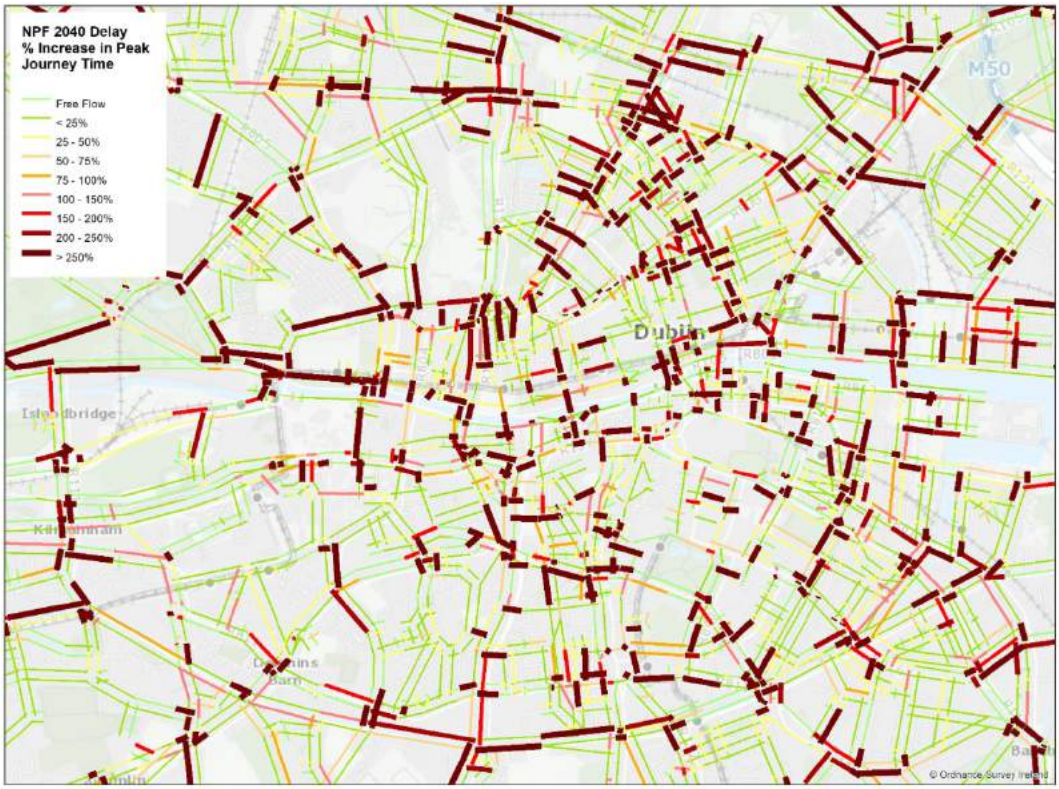
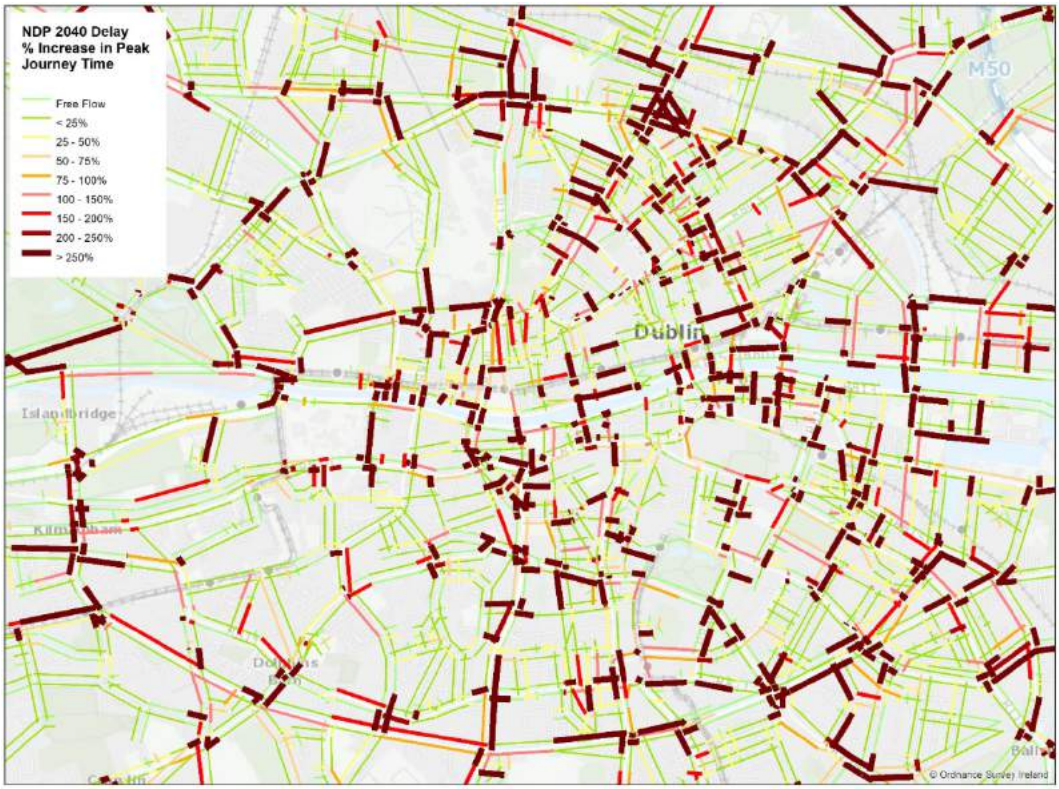


Figure 7.9: Dublin city percentage increase in peak hour journey times, Do-Minimum Scenario, 2040



7.5 Accessibility

Figure 7.10 illustrates generalised journey times to Dublin city centre by public transport in the Base Scenario. As discussed in Section 6.1.4, generalised journey times are a standard tool used in transport modelling but should not be interpreted as equivalent to actual journey times. In the Base Scenario, shorter generalised journey times are concentrated along the DART and Luas lines, with generalised journey times of 30 minutes or less found in areas such as Milltown and Mount Brown. Generalised journey times of 31 to 45 and 46 to 60 minutes were found on the main radial bus corridors such as the N1, Rathmines Road Lower, Shelbourne Road, Harold's Cross Road and North Stand Road. The longest generalised journey times of 120 minutes or more were recorded in areas such as Baldoyle, Poppintree and Templeogue.

Public transport generalised journey times to Dublin city centre for the Do-Nothing Scenario are illustrated in Figure 7.11. Unsurprisingly given the lack of investment in this scenario, generalised journey times are virtually unchanged when compared with Base Scenario, with the shortest journey times concentrated between the canals.

Generalised public transport journey times to Dublin city centre in the Do-Minimum Scenario are presented in Figure 7.12. As a result of investment in projects such as BusConnects, MetroLink and DART expansion, the area estimated to be accessible to the city centre within one hour is estimated to increase quite considerably, with the bus new bus corridor 'spines' and MetroLink rail line clearly visible when compared to the Do-Nothing Scenario.

Figure 7.10: Generalised public transport journey time to Dublin city centre, Base Scenario, 2012

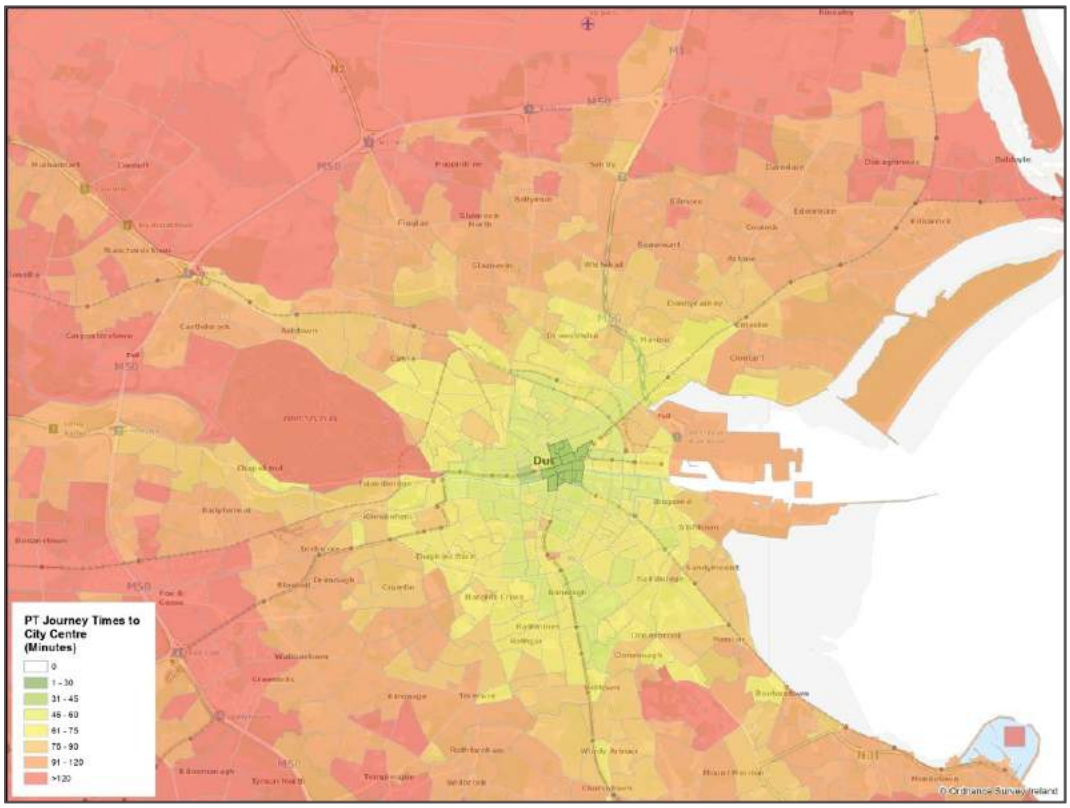
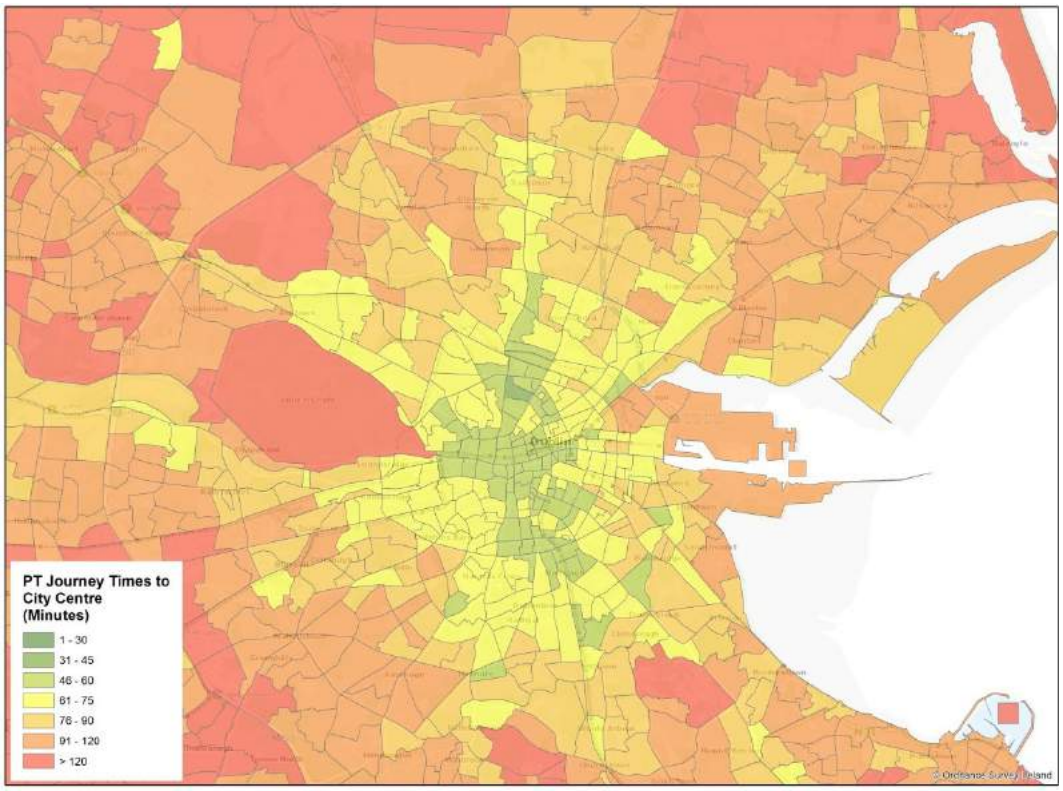


Figure 7.11: Generalised public transport journey time to Dublin city centre, Do-Nothing Scenario, 2040

Figure 7.12: Generalised public transport journey time to Dublin city centre, Do-Minimum Scenario, 2040



Generalised journey times to Dublin city centre by car in the Base Scenario are shown in Figure 7.13. In this scenario, an area bounded by Ballymun to the north, Ballyfermot and Park West in the west and Knocklyon, Ballinteer and Foxrock in the south can access Dublin city centre in 30 minutes or less. Areas outside of this boundary were found to experience generalised journey times of up to 45 minutes in most areas, with the exception of areas west of Ronanstown, such as Celbridge, Rathcoole and Tallaght which showed journey times of up to 60 minutes or more.

Generalised journey times by car to Dublin city centre in the Do-Nothing Scenario are presented in Figure 7.14, which indicates that the area that can access Dublin city centre in 30 minutes or less has reduced in size, particularly north of the Liffey. In the Do-Nothing Scenario the 30 minute boundary only extends as far as Whitehall in the north, Bluebell and Greenhills in the west, and Templeogue, Dundrum and Mount Merrion in the south. Areas beyond this boundary are estimated to experience journey times of up to 60 minutes in many areas and even higher in areas west of Ronanstown, where times of up to 90 minutes are estimated.

Generalised journey times by car to Dublin city centre in the Do-Minimum Scenario, illustrated in Figure 7.15, exhibit minor changes when compared to the Do-Nothing Scenario, with the areas that can access the city centre within 30 minutes and 45 minutes shrinking slightly. This is likely the result of greater priority being given to sustainable mobility in terms of NDP investment within the city.

Figure 7.13: Generalised car journey time to Dublin city centre, Base Scenario, 2012

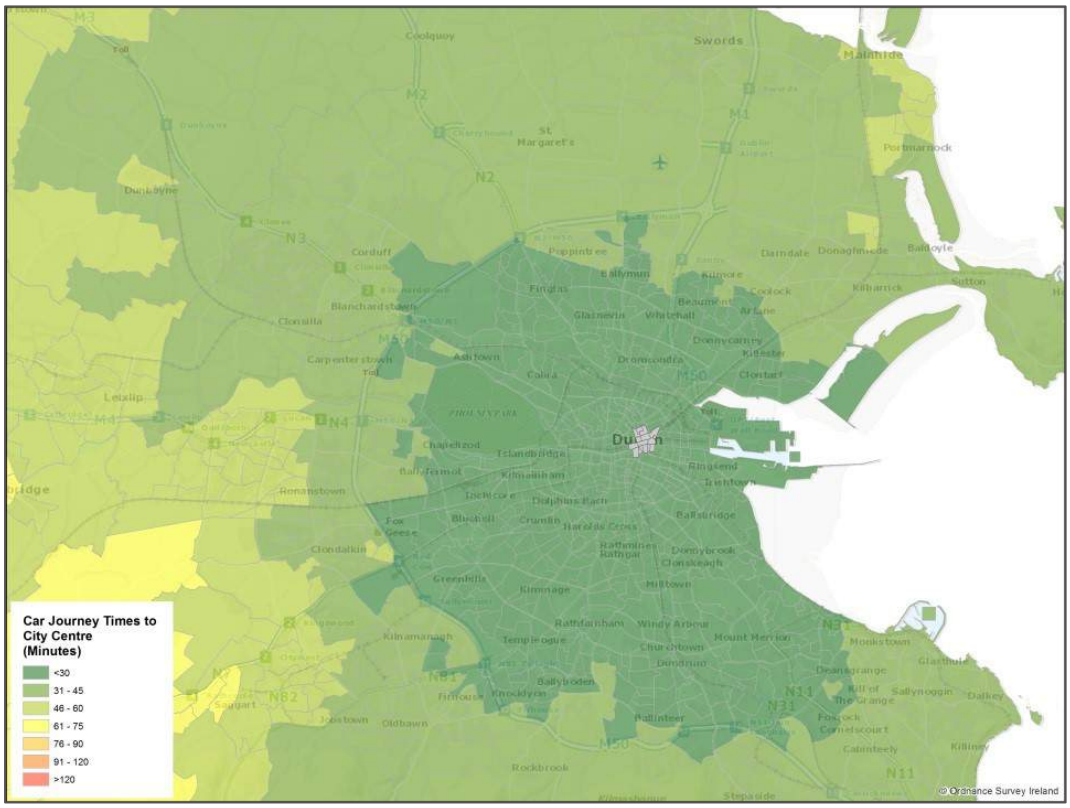


Figure 7.14: Generalised car journey time to Dublin city centre, Do-Nothing Scenario, 2040

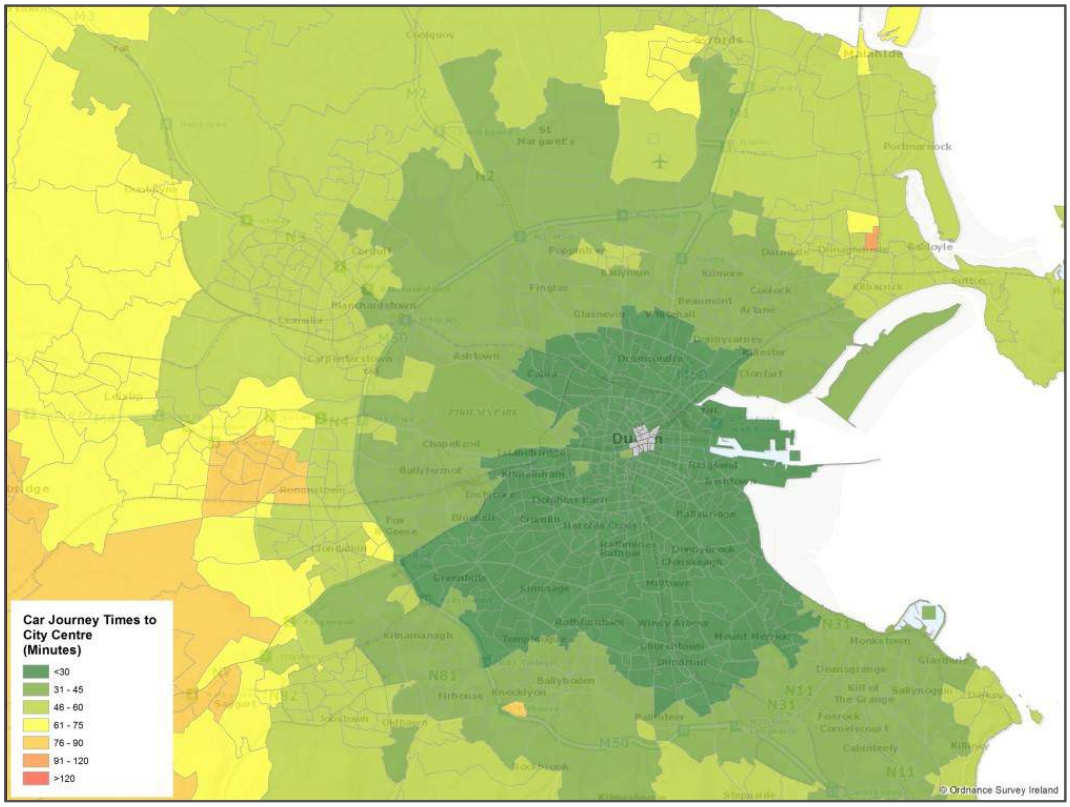
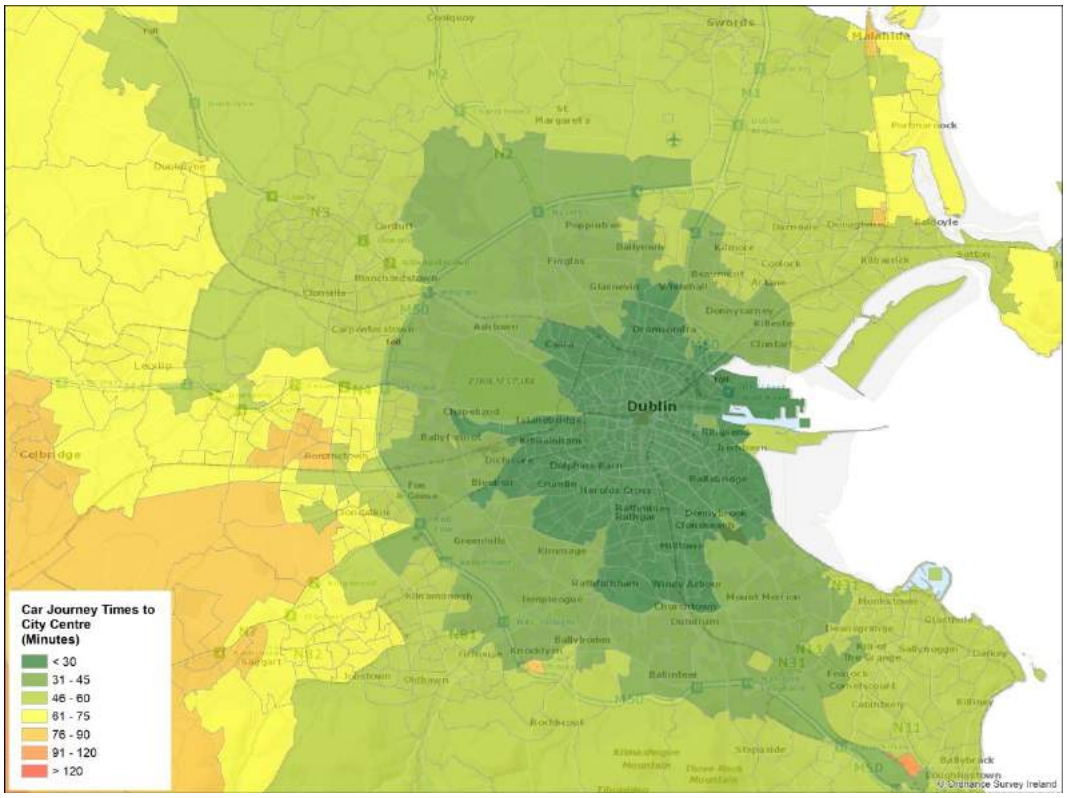


Figure 7.15: Generalised car journey time to Dublin city centre, Do-Minimum Scenario, 2040



7.6 Summary

Overall, the modelling estimates that there will be a 20% increase in trips in the East Region between 2012 and 2040, from 6.5m to 7.8m. In the Do-Minimum Scenario it is estimated that 36.2% of these trips will be taken by sustainable modes, which represents an increase of one percentage point when compared to the Base Scenario. Within Dublin city, the number of trips is estimated to increase by 16%, from 2.4m to 2.8m. 51.3% of journeys are estimated to be by sustainable modes in the Do-Minimum Scenario, which again represents an increase of roughly one percentage point when compared to the Base Scenario.

In the Do-Minimum Scenario there is projected to be widespread capacity constraints and delays on the road network in the city centre by 2040, although it should be noted that this is in the absence of any additional intervention beyond that already planned for delivery between now and 2027.

Additional travel demand and deteriorating journey times on the road network will also see the area that can access the city centre by car within 30 minutes shrink between 2012 and 2040. On the other hand, journey times by public transport are significantly improved between the Do-Nothing and Do-Minimum scenarios as a result of NDP investment in sustainable mobility.

8. Cork

This section of the paper considers Cork for the three modelling scenarios described in Section 6. The assumed growth in population and trip demand for the 2040 scenarios will be set out followed by the NDP investment assumed for the Do-Minimum Scenario. The impact of population growth and investment on modal split, capacity, delay, and generalised journey times will then be shown. The section will conclude with a summary of the main issues and areas of constraint identified in the modelling for the Do-Minimum Scenario, indicating where additional intervention beyond that set out in the NDP may be required between 2027 and 2040 for the transport system to facilitate NPF settlement targets.

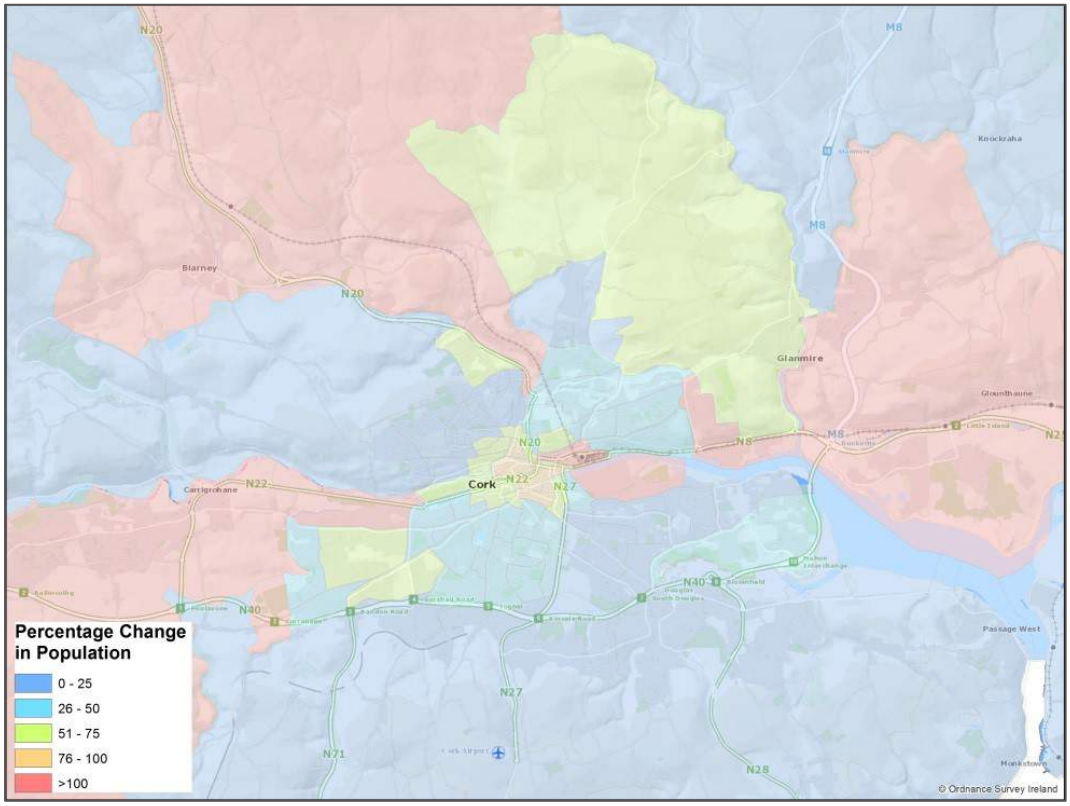
8.1 Population and Travel Demand

Table 8.1 presents the assumed population change between the 2012 Base Scenario and the two 2040 scenarios for Cork city, county and nationally. Figure 8.1 illustrates this increase for the Cork city area, with the highest levels of population growth projected to occur in the areas of Little Island, Glounthaune, Carrigrohane, Blarney and Mallow. With this growth in population, the typical daily trip demand within Cork city is estimated to increase by 49%, from 450,000 to 670,000, between 2012 and 2040.

Table 8.1: Population of Cork city and county between Base and 2040 scenarios

	Base 2012	2040	Change
Cork City	119,230	203,620	71%
Cork County	519,032	700,930	35%
National	4,588,248	5,643,917	23%

Figure 8.1: Percentage change in population in Cork city by electoral district



8.2 Investment

Besides the population projections set out above, for the Do-Minimum Scenario a number of projects to be delivered by 2027 under the NDP have been included in the South West Regional Model (SWRM).

The BusConnects programme is modelled using journey time proxies and service frequency increases along the bus corridors identified in the Cork Metropolitan Area Draft Transport Strategy 2040, which went out to public consultation on 14 May 2019. For rail, through-running will be in operation at Kent Station, allowing for service frequencies to Mallow to increase. Finally, high-quality cycling facilities have been modelled adjacent to all bus corridors as a proxy for the future cycling network. New road schemes include the M20 Cork to Limerick, N22 Ballyvourney to Macroom, N28 Cork to Ringaskiddy Road, N69 Listowel Bypass, Dingle Relief Road, Tivoli Docks, Docklands Bridge, Dunkettle Upgrade, N72/N73 Mallow Relief Road, and the Carrigaline Western Distributor Road.

8.3 Modal Split

Figure 8.2 displays mode shares for the South West Region across the three scenarios. Between the Do-Nothing and Do-Minimum Scenarios, the modelling indicates a one percentage point decrease in each of private car use, walking and cycling, and a substantial four percentage point increase in the use of public transport. Overall, there is expected to be a 27% increase in total trips in the South West Region between 2012 and 2040, from 1.8m to 2.3m.

The mode shares for Cork city are illustrated in Figure 8.3.[5] Within the city, car modal share is expected to fall by two percentage points between the Do-Nothing and Do-Minimum scenarios, representing 54% of all trips in the latter. Public transport increases its modal share by six percentage points to 15%, a two-thirds increase on the Do-Nothing Scenario, while the combined active travel mode share falls by four percentage points from 35% to 31%. Overall, it is projected that there will be a 49% increase in trips in the city between 2012 and 2040.

[5] See Appendix 1 for a map of the city area for modelling purposes.

Figure 8.2: Mode shares for South West Region (typical weekday)

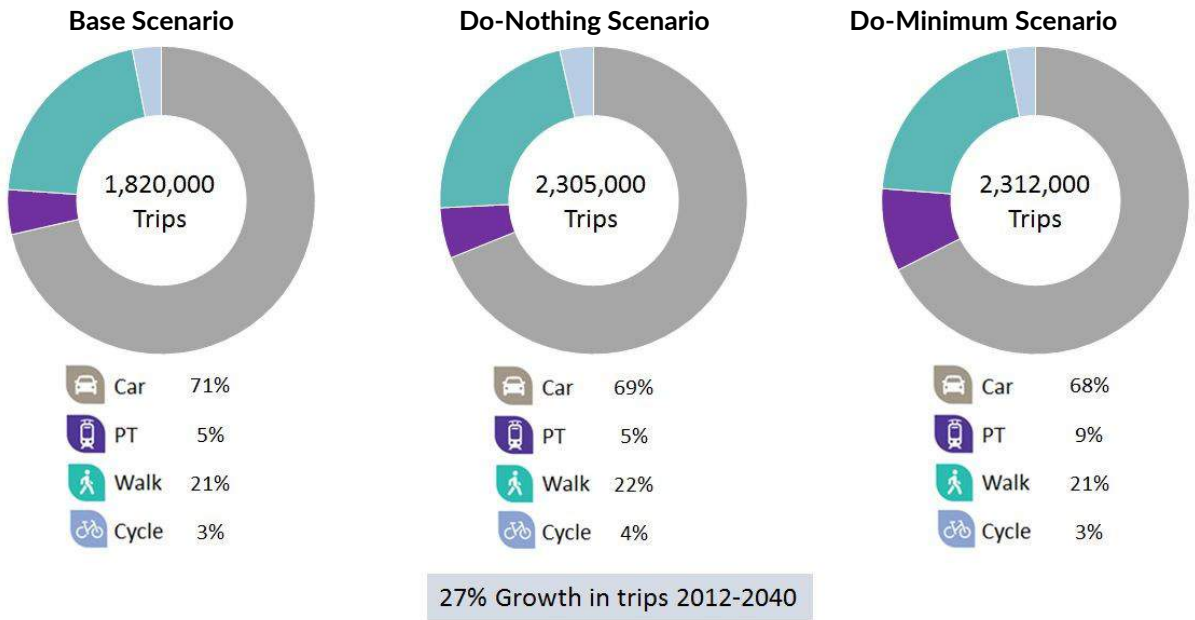
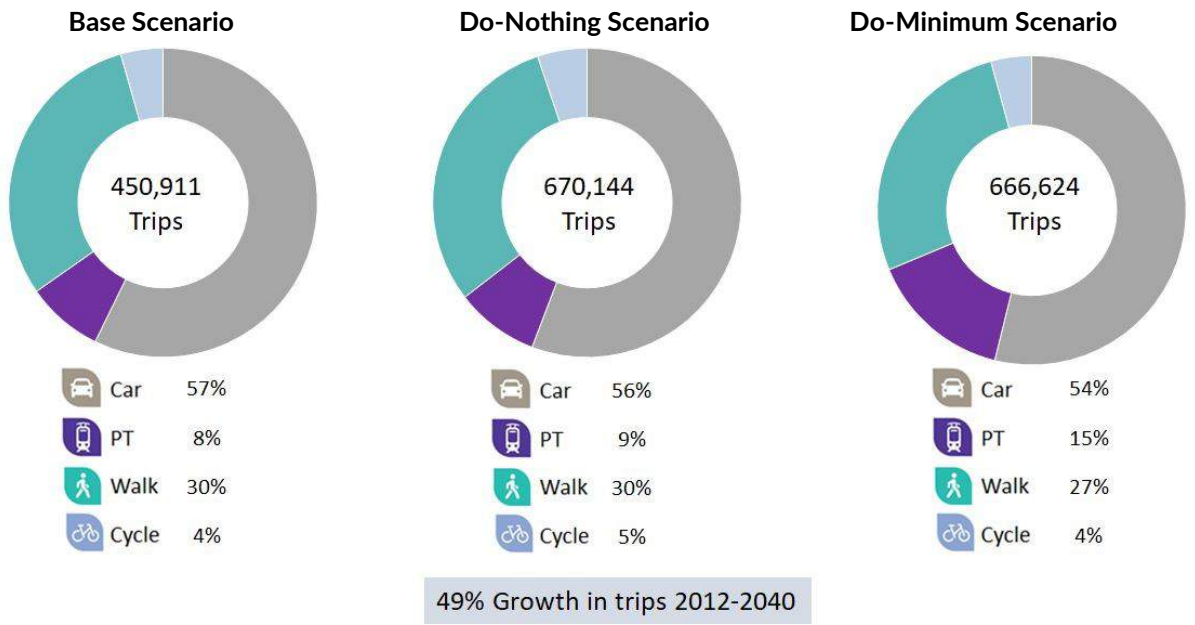


Figure 8.3: Mode shares for Cork city (typical weekday)



8.4 Congestion and Mobility

Figure 8.4 displays the volume-capacity ratios for the Base Scenario in Cork city. In the base year, the majority of links in are operating below 80% capacity, although several links are approaching full capacity as indicated in orange. Additionally, a number of links in the network are operating at between 100% and 20% over capacity, particularly to the west of the city centre.

The modelling for the Do-Nothing Scenario indicates that, in the absence of intervention, there will be a significant deterioration in volume-capacity ratios across the Cork city road network. Capacity issues to the west of the city centre are more severe and widespread, while many of the links in the city centre and east of the city

which had been approaching capacity in the Base Scenario are estimated to operate significantly above capacity, as indicated in red in Figure 8.5.

The volume-capacity ratios for the Do-Minimum Scenario, presented in Figure 8.6 indicate some improvement in the operational capacity on the Cork city road network with the introduction of the schemes and projects listed in Section 8.2. While many links which had been operating in excess of 100% operational capacity in the Do-Nothing Scenario are now found to operate at less than full capacity, there are nevertheless many links still operating at above 100%, particularly close to the river.

Figure 8.4: Cork city volume-capacity ratios, Base Scenario, 2012

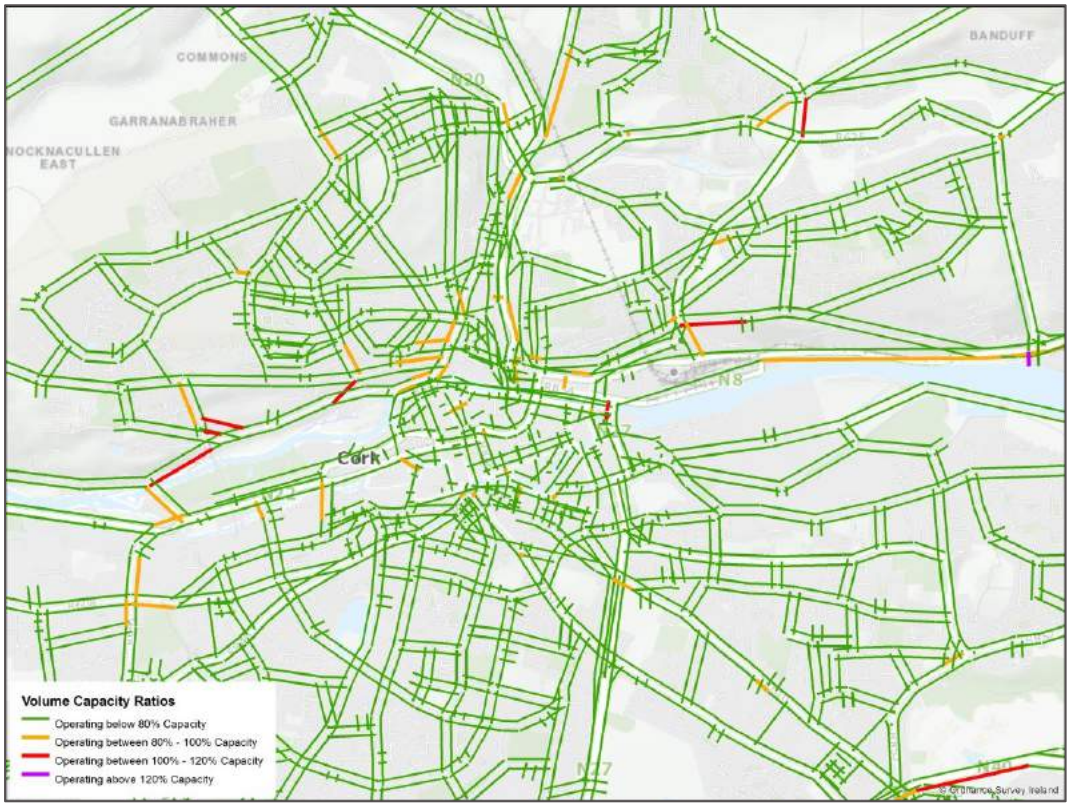


Figure 8.5: Cork city volume-capacity ratios, Do-Nothing Scenario, 2040

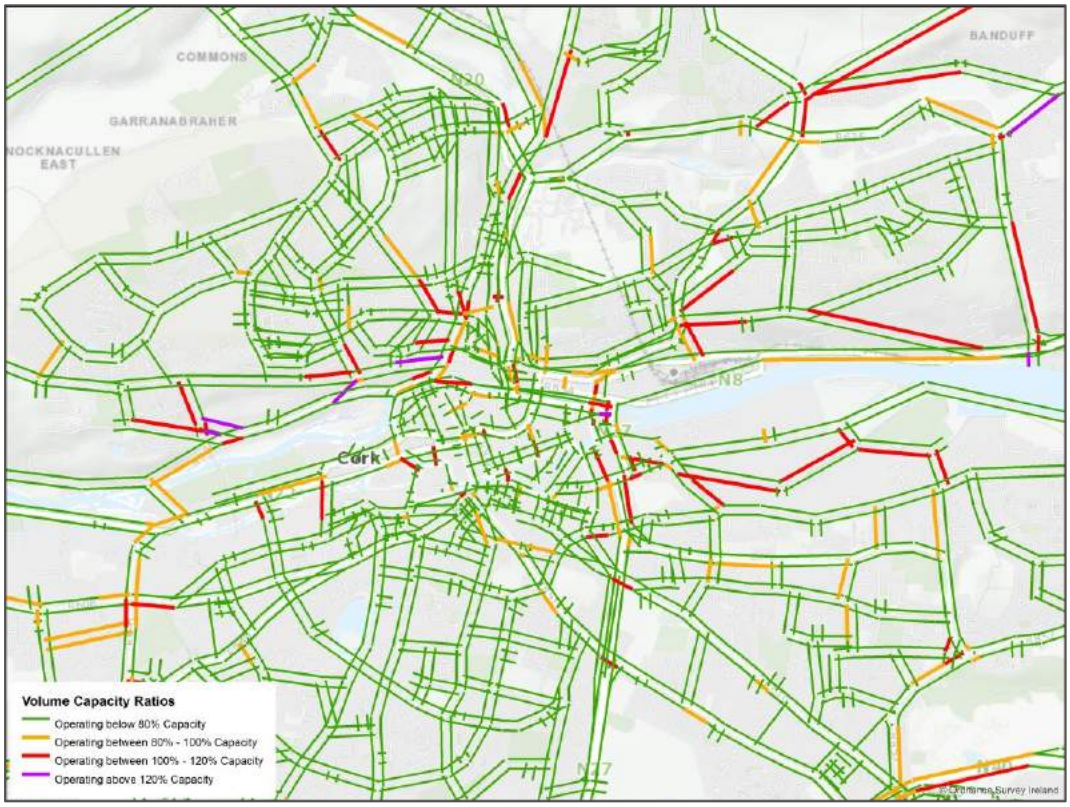
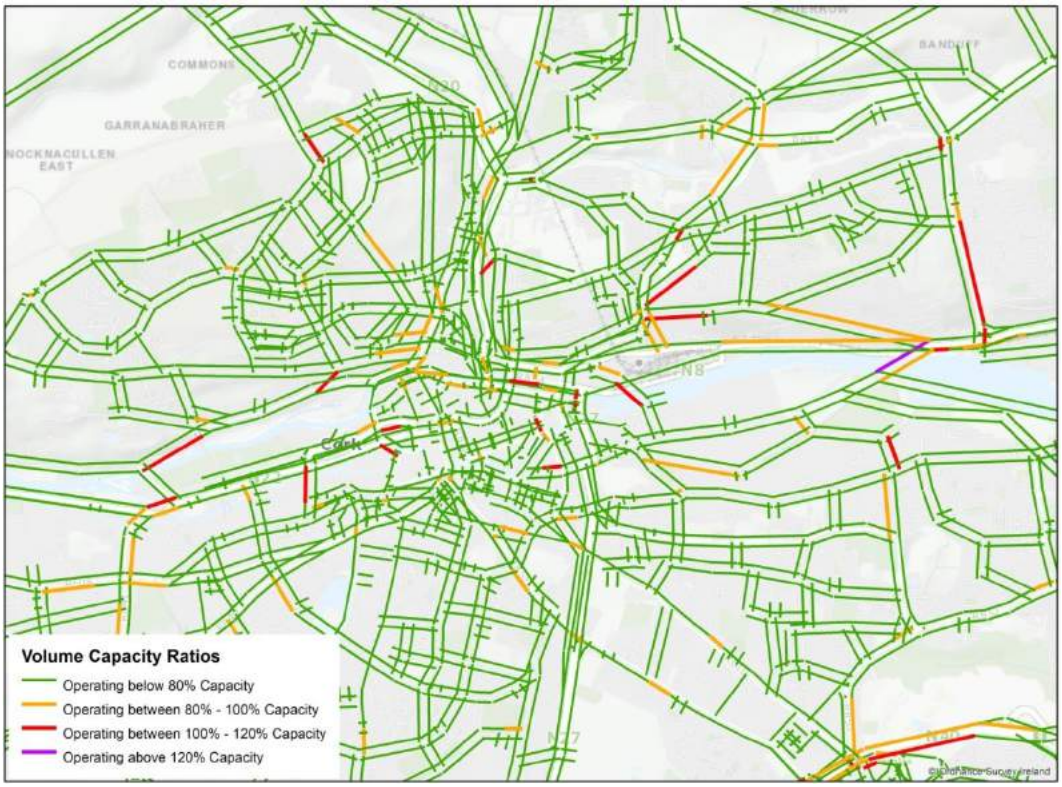


Figure 8.6: Cork city volume-capacity ratios, Do-Minimum Scenario, 2040



Peak hour delays on links in Cork city centre for the Base Scenario are illustrated in Figure 8.7. Compared with free flow most of the road network performs well in the Base Scenario, though there are some areas where delays are an issue. This is especially true around the city centre, on crossings of both channels of the River Lee and on links adjacent to crossings, where percentage delays in excess of 250% are relatively common.

Estimated delays on the Cork city road network for the Do-Minimum Scenario are shown in Figure 8.8. With the population increase targeted by the NPF and associated rise in travel demand issues that existed in the Base Scenario in the city centre and to the west of the city centre have grown more severe, but it is to the east of the city where the deterioration is most stark. Many links which had no issues with delays in the Base Scenario now report delays of 200% or more, especially in the Banduff area to the northeast of Kent Station.

Peak hour delay is projected to remain an issue in the Do-Minimum Scenario, as shown in Figure 8.9. There are some improvements to delay as a result of NDP investment, most notably in the areas to the east of the city centre. However, various links around the city centre are still projected to experience significant delays in the absence of additional intervention between 2027 and 2040.

Figure 8.7: Cork city percentage increase in peak hour journey times, Base Scenario, 2012

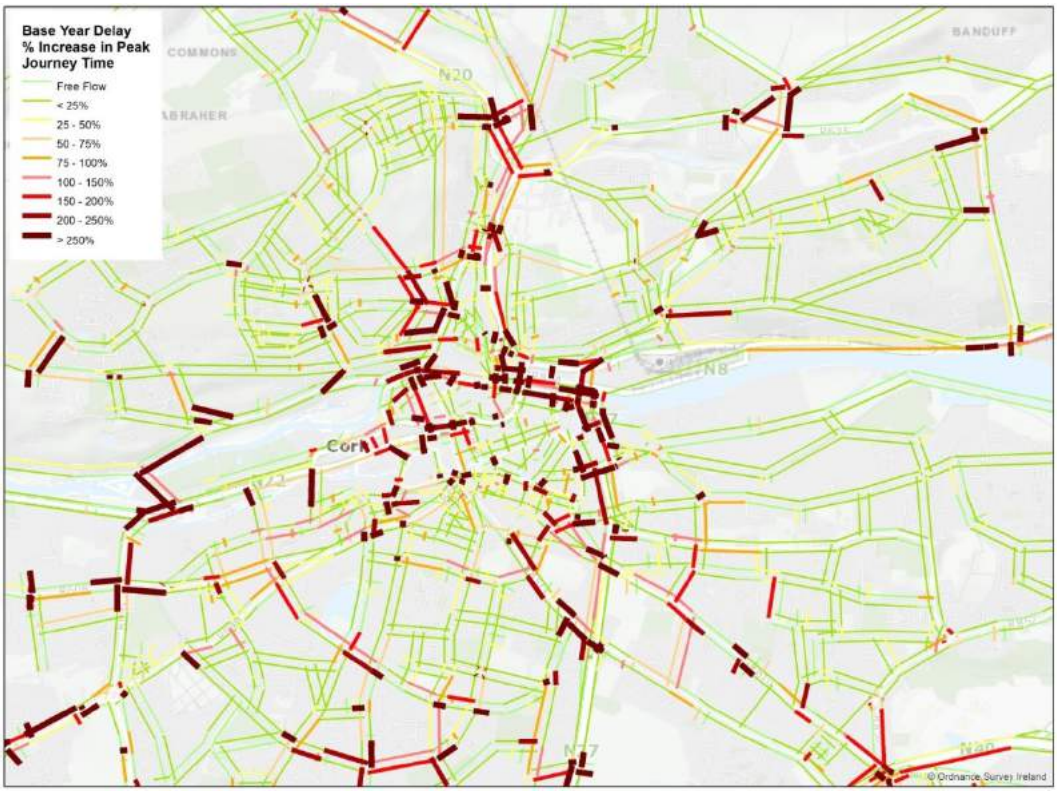


Figure 8.8: Cork city percentage increase in peak hour journey times, Do-Nothing Scenario, 2040

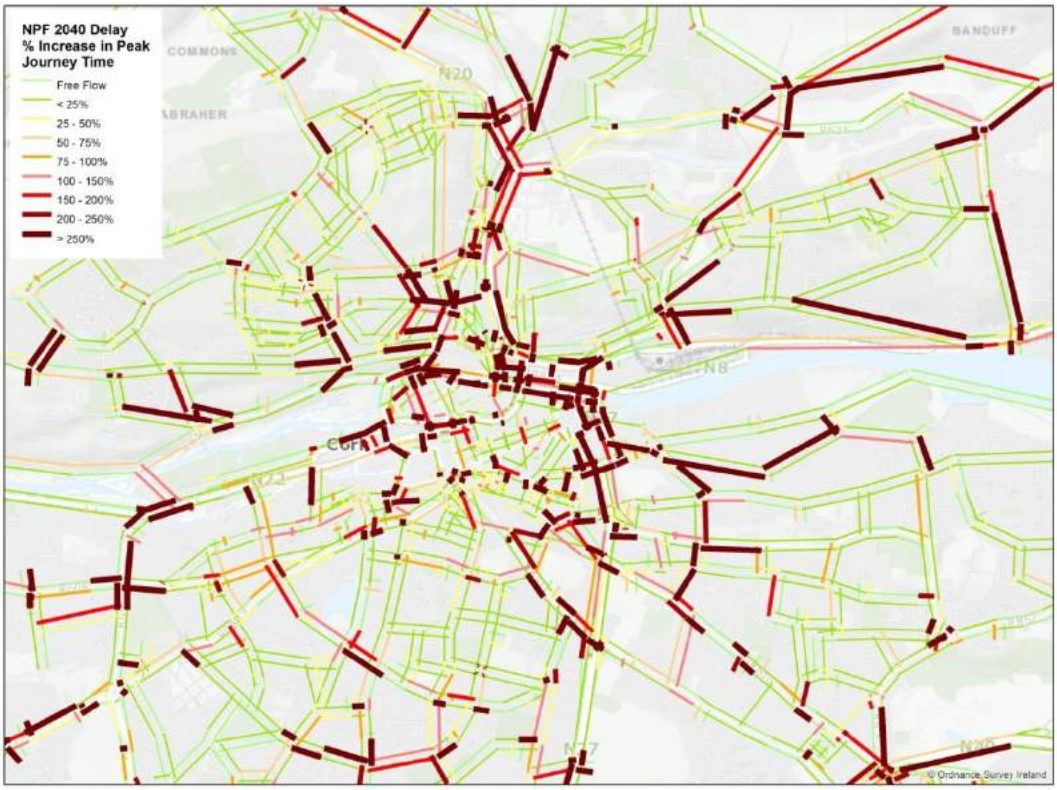
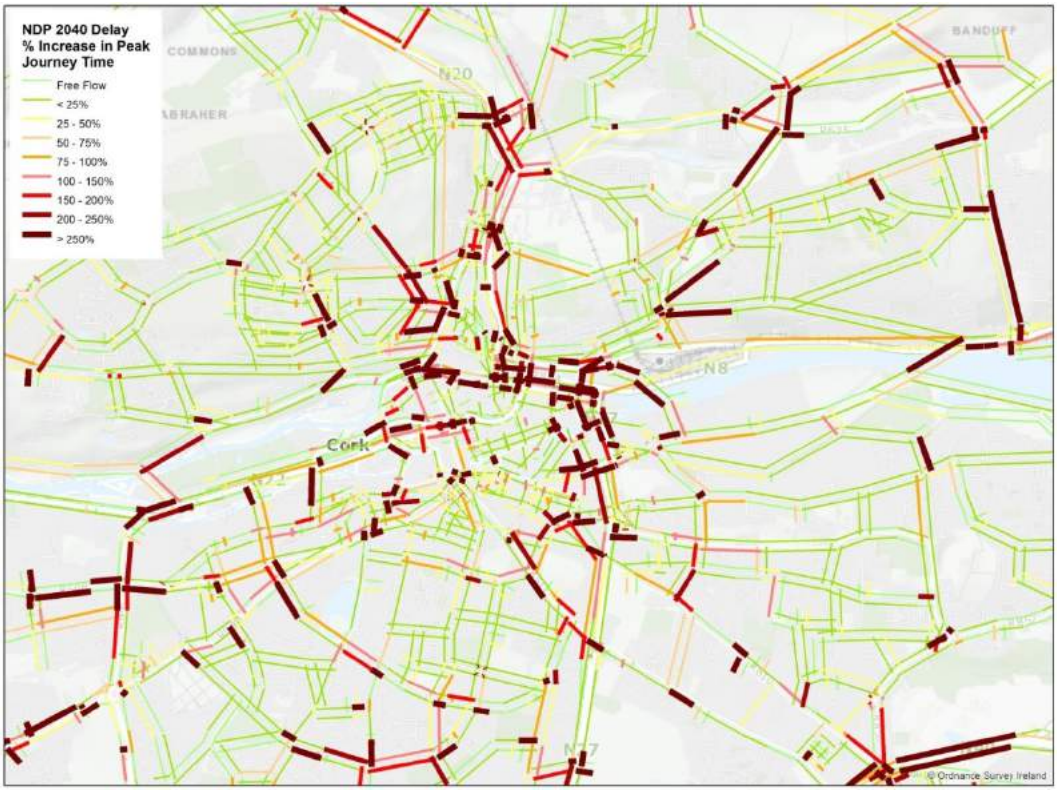


Figure 8.9: Cork city percentage increase in peak hour journey times, Do-Minimum Scenario, 2040



8.5 Accessibility

Figure 8.10 illustrates generalised journey times to Cork city centre by public transport in the Base Scenario. As discussed in Section 6.1.4, generalised journey times are a standard tool used in transport modelling but should not be interpreted as equivalent to actual journey times. In the Base Scenario, the city centre can be accessed in 30 to 45 minutes from Douglas and Wellington Bridge, and in less than 60 minutes from areas such as Glanmire, Maryborough Hill, Wilton and Blackpool. Areas with journey times in excess of 120 minutes include Ballyandreen, Blarney, Butlerstown and Little Island.

Public transport generalised journey times to Cork city centre for the Do-Nothing Scenario are illustrated in Figure 8.11. Areas close to the city centre experience similar generalised journey times to the Base Scenario. An increase in generalised journey times is, however, found in peripheral areas to the north and west of the city. In these areas generalised journey times were found to increase to over 120 minutes, which represents an increase of over 30 minutes compared to the Base Scenario.

Generalised public transport journey times to Cork city centre in the Do-Minimum Scenario are presented in Figure 8.12. There is a marked improvement in public transport generalised journey times to the city centre compared to the Do-Nothing Scenario. The area which could previously access the city centre within 45 minutes can now, generally, access it within 30, while many more peripheral areas surrounding the city have seen their journey times decrease to less than one hour.

Figure 8.10: Generalised public transport journey time to Cork city centre, Base Scenario, 2012

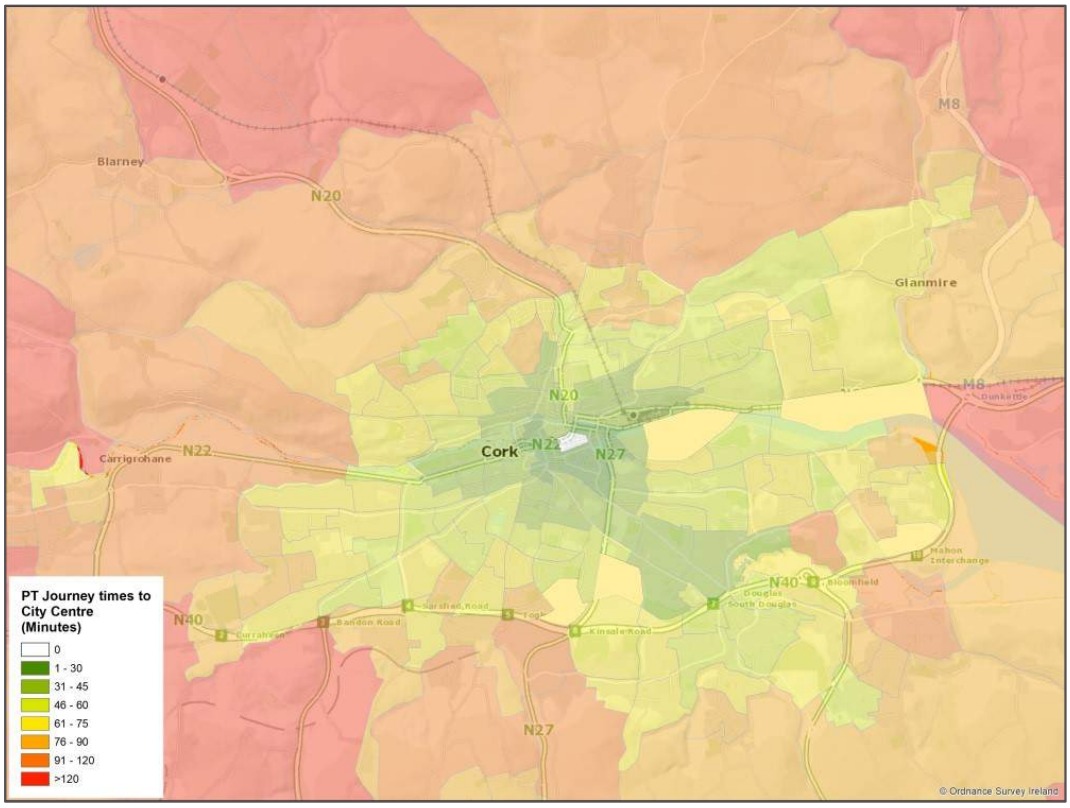


Figure 8.11: Generalised public transport journey time to Cork city centre, Do-Nothing Scenario, 2040

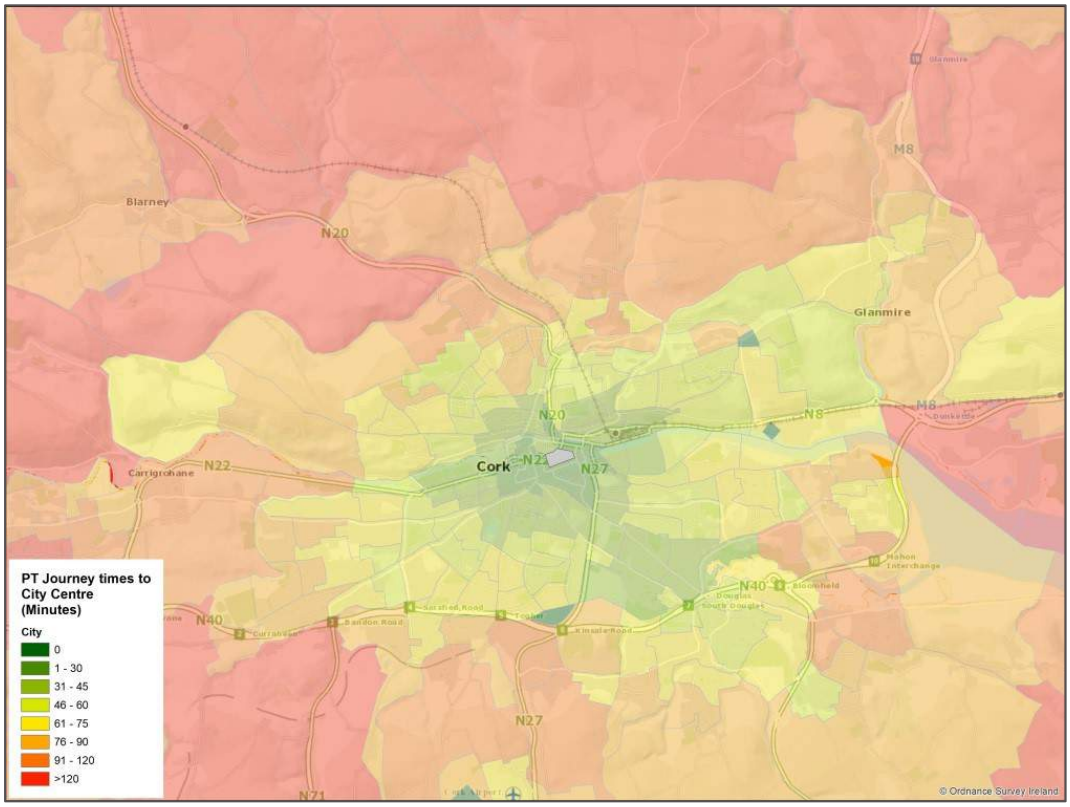
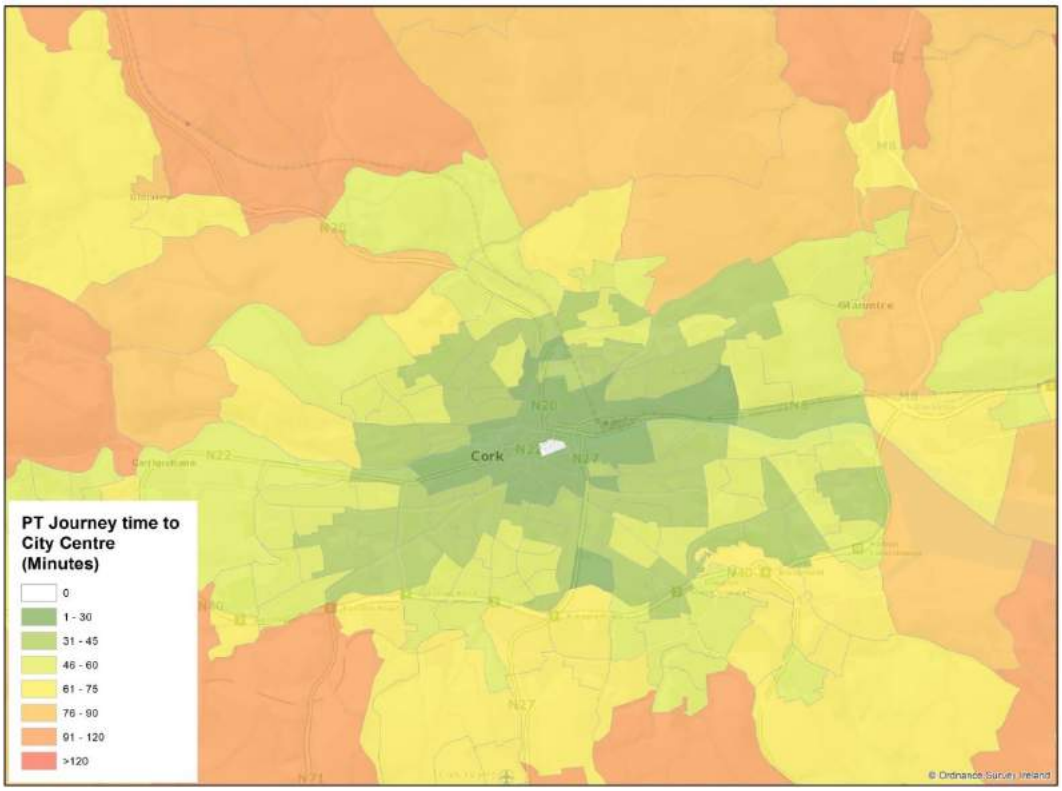


Figure 8.12: Generalised public transport journey time to Cork city centre, Do-Minimum Scenario, 2040



Generalised journey times to Cork city centre by car in the Base Scenario are shown in Figure 8.13. The area within which the city centre can be accessed in 30 minutes or less extends from Ballynamona in the north, Middleton in the east, Kinsale in the south and Crookstown in the west. Shorter journey times are concentrated along the main radial roads approaching Cork city.

Generalised journey times by car to Cork city centre in the Do-Nothing Scenario are presented in Figure 8.14, which shows a notable increase in car journey times, particularly to the north and east of the city where generalised journey times are estimated to increase by 15 minutes. Areas such as Castlemartyr, Conna and Mount Uniacke are found to have longer journey times of up to 60 minutes. This increase is also evident in areas in the west of the city along the N22 from Crookstown to Macroom and beyond.

Generalised journey times by car to Cork city centre in the Do-Minimum Scenario, illustrated in Figure 8.15, exhibit relatively little change compared to the Do-Nothing Scenario. The area that can access the city centre within 30 minutes has extended northward somewhat in areas close to the planned M20 motorway between Cork and Limerick, while there has been a slight decrease in accessibility in areas to the south and west of the city.

Figure 8.13: Generalised car journey time to Cork city centre, Base Scenario, 2012

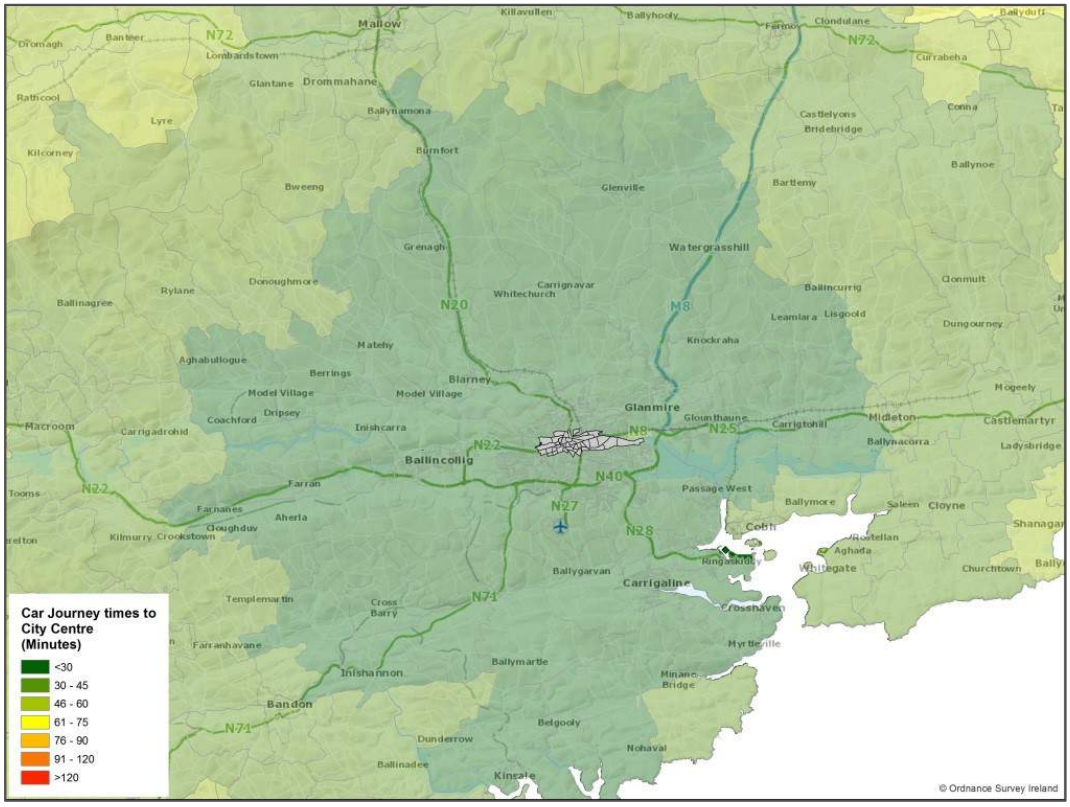


Figure 8.14: Generalised car journey time to Cork city centre, Do-Nothing Scenario, 2040

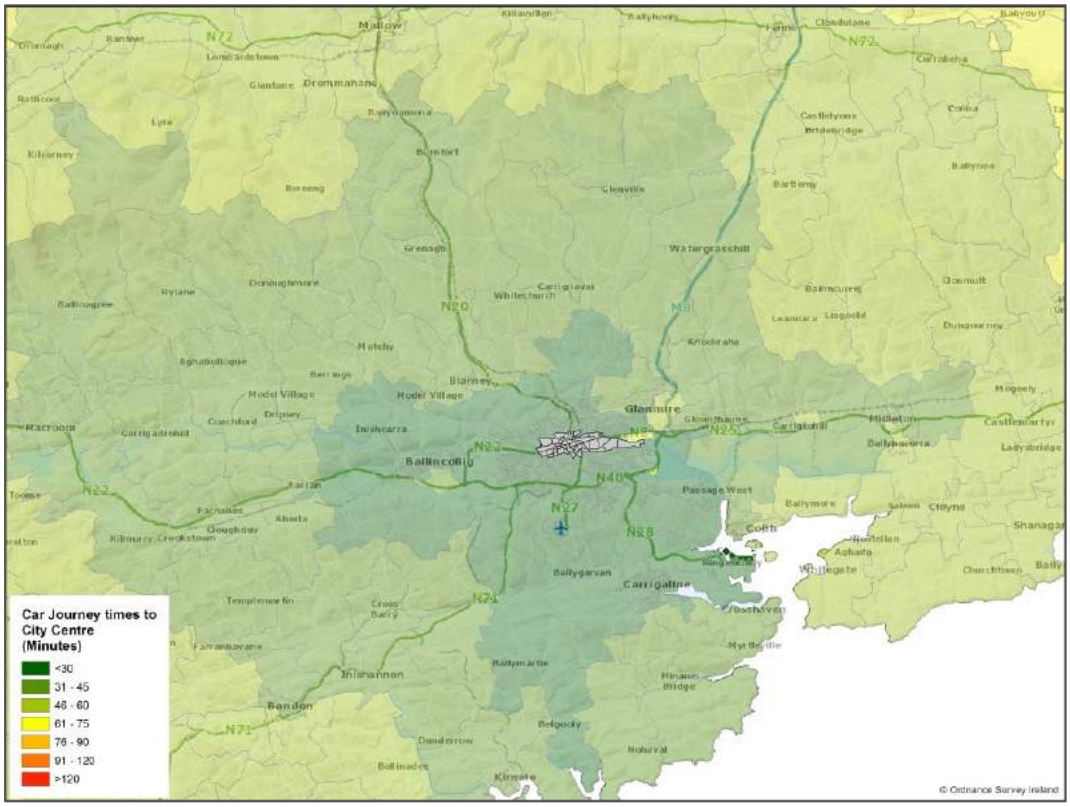
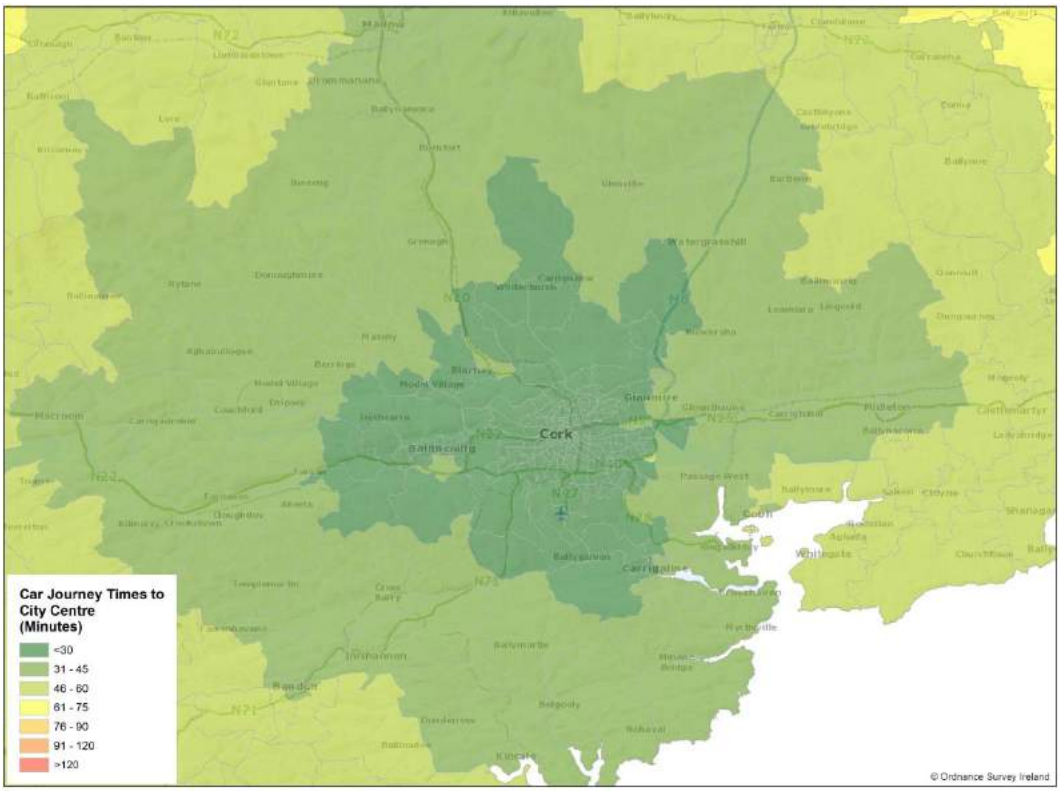


Figure 8.15: Generalised car journey time to Cork city centre, Do-Minimum Scenario, 2040



8.6 Summary

Overall, the modelling estimates that there will be a 27% increase in trips in the South West Region between 2012 and 2040, from 1.8m to 2.3m. In the Do-Minimum Scenario, it is estimated that 32% of these trips will be taken by sustainable modes, which represents an increase of three percentage points when compared to the Base Scenario. Within Cork city, the number of trips is estimated to increase by 49%, from 451,000 to 667,000. 56% of journeys in the city are estimated to be made by sustainable modes in the Do-Minimum Scenario, which represents an increase of three percentage points when on the Base Scenario.

The modelling highlights the challenges that the Cork transport network faces in accommodating the population objectives set out in the NPF. The demands that certain links in Cork city centre will be placed under is particularly evident in the estimated volume-capacity ratios and peak hour delays, where it is estimated that many road links will be operating at 20% or more above designed capacity and experience delays of 200% or more compared with free flow. While the road schemes proposed in the NDP result in some improvement, the modelling suggests that investment planned between now and 2027 will be insufficient to mitigate increased traffic congestion arising from population growth in the coming two decades. More positively, however, NDP investment was found to result in generalised journey time savings to Cork city centre by public transport from virtually all areas and by car to the north of the city.

9. Galway

This section of the paper considers Galway for the three modelling scenarios described in Section 6. The assumed growth in population and trip demand for the 2040 scenarios will be set out followed by the NDP investment assumed for the Do-Minimum Scenario. The impact of population growth and investment on modal split, capacity, delay, and generalised journey times will then be shown. The section will conclude with a summary of the main issues and areas of constraint identified in the modelling for the Do-Minimum Scenario, indicating where additional intervention beyond that set out in the NDP may be required between 2027 and 2040 for the transport system to facilitate NPF settlement targets.

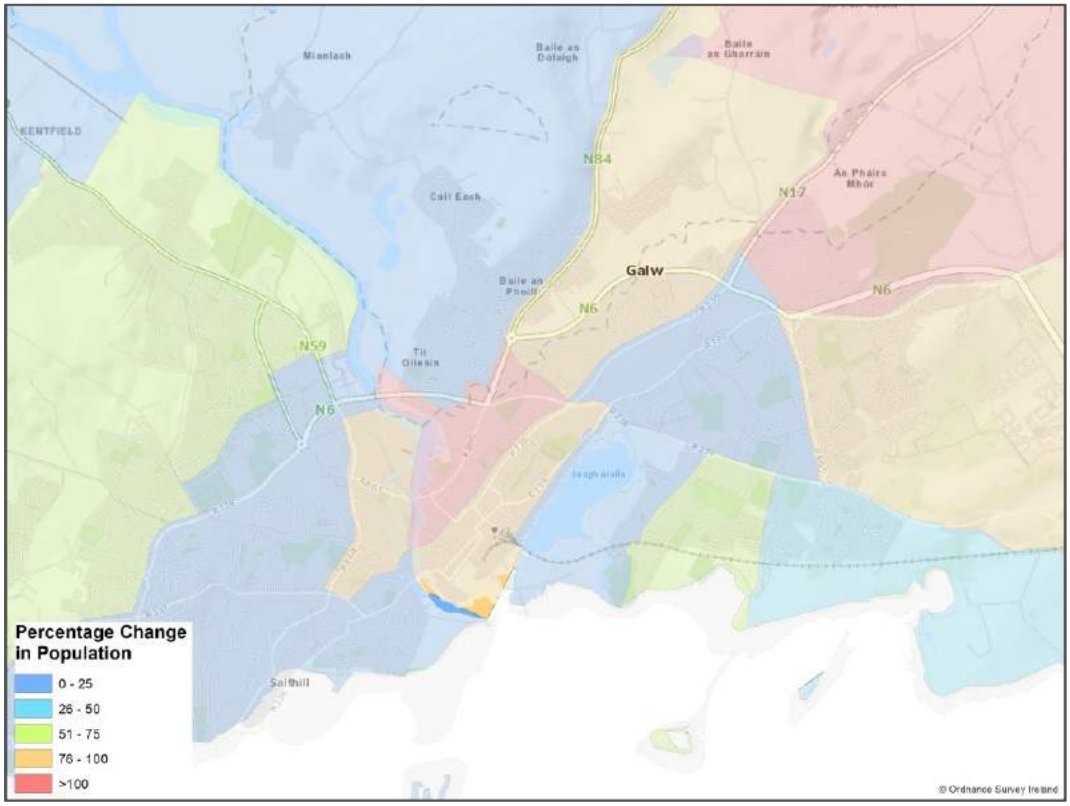
9.1 Population and Travel Demand

Table 9.1 presents the assumed population change between the 2012 Base Scenario and the two 2040 scenarios for Galway city, county and nationally. Figure 9.1 illustrates this increase for the Galway city area, and it can be seen that the highest levels of population growth are projected to be in the city centre, along Headford Road and in the area of Hazelwood and Gortnahoe. With this growth in population, the typical daily trip demand within Galway city is estimated to increase by 48%, from 264,000 to 393,000, between 2012 and 2040.

Table 9.1: Population of Galway city and county between Base and 2040 scenarios

	Base 2012	2040	Change
Galway City	75,529	118,997	58%
Galway County	250,653	356,765	42%
National	4,588,248	5,643,917	23%

Figure 9.1: Percentage change in population in Galway city by electoral district



9.2 Investment

Besides the population projections set out above, for the Do-Minimum Scenario a number of projects to be delivered by 2027 under the NDP have been included in the West Regional Model (WRM).

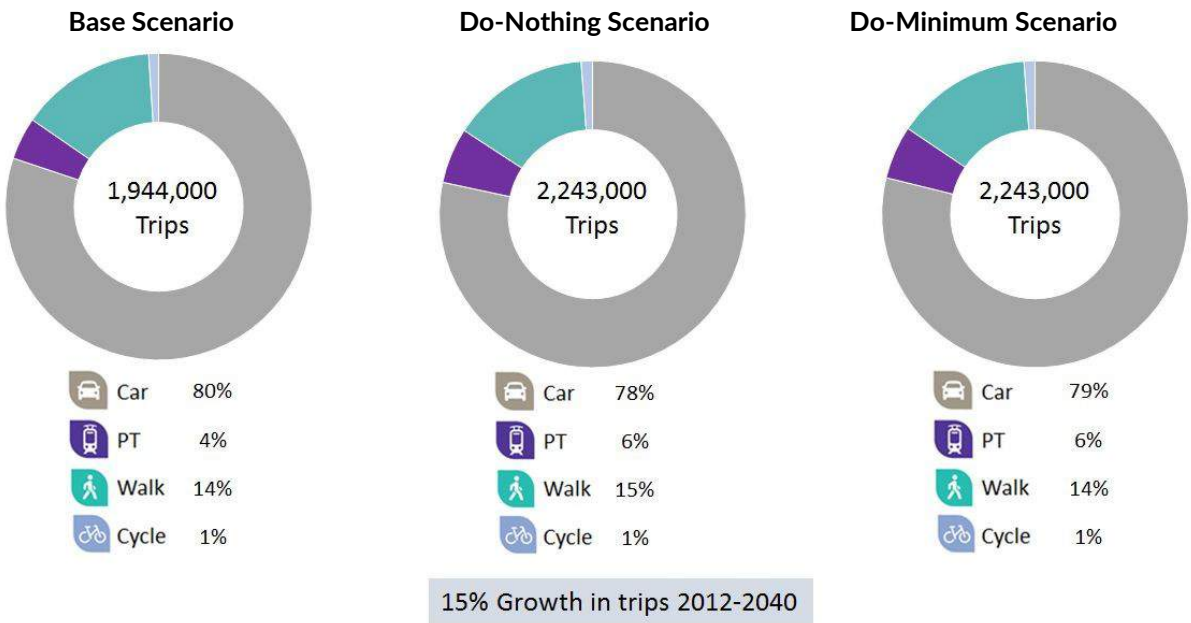
The BusConnects programme is modelled using journey time proxies and service frequency increases along existing bus routes. High-quality cycling facilities have been modelled adjacent to all bus corridors as a proxy for the future cycling network. New road schemes include the N6 Galway City Ring Road, N59 Moycullen Bypass, N4 Collooney to Castlebalwin, N5 Westport to Turlough, N5 Ballaghdereen to Scramogue, N56 Dungloe to Glenties, N56 Mountcharles to Inver, Garavogue Bridge Scheme, and Sligo Western Distributor Road.

9.3 Modal Split

Figure 9.2 displays mode shares for the West Region across the three scenarios. Between the Do-Nothing and Do-Minimum scenarios, the modelling indicates a one percentage point increase in private car use with a corresponding decrease in walking, while public transport and cycling remain unchanged. Overall, there is expected to be a 15% increase in total trips in the West Region between 2012 and 2040, from 1.9m to 2.2m.

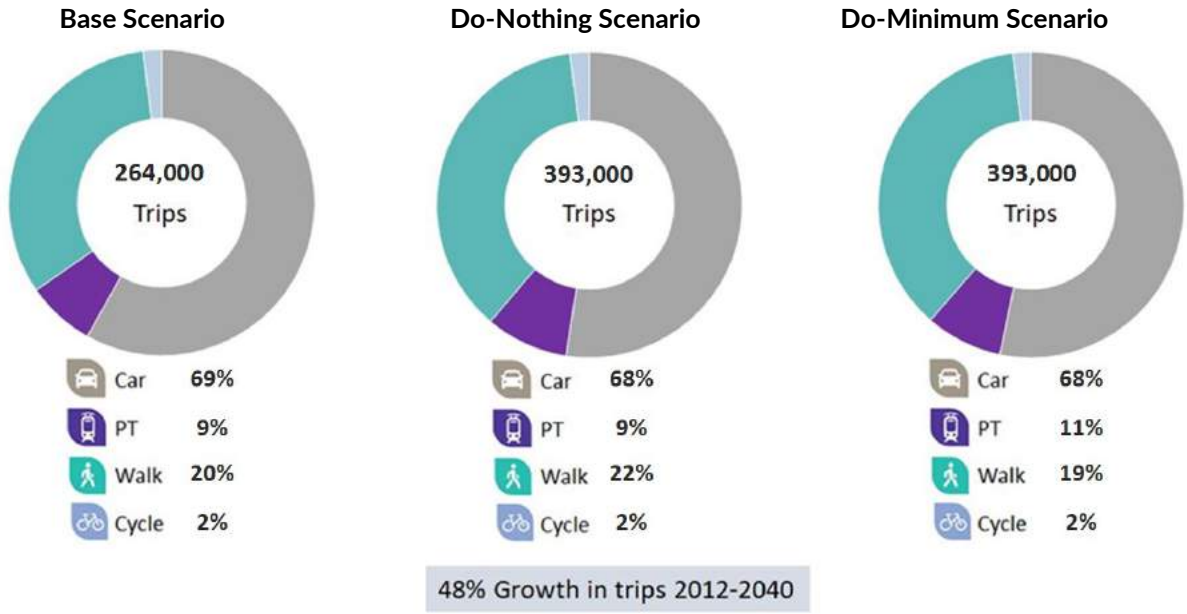
The mode shares for Galway city are illustrated in Figure 9.3.[6] Within the city, the car and cycling modal share is estimated to remain unchanged between the Do-Nothing and Do-Minimum scenarios at 68% and 2% respectively. Public transport use is projected to increase its modal share by two percentage points to 11%, but this comes at the expense of walking which falls from 22% modal share to 19%. Overall, it is projected that there will be a 48% increase in trips in the city between 2012 and 2040.

Figure 9.2: Mode shares for West Region (typical weekday)



[6] See Appendix 1 for a map of the city area for modelling purposes.

Figure 9.3: Mode shares for Galway city (typical weekday)



9.4 Congestion and Mobility

Figure 9.4 displays the volume-capacity ratios for the Base Scenario in Galway city. In the base year, most links in are operating below 80% capacity. However, several links are approaching full capacity, notably the Quincentenary Bridge and adjacent roads, while slightly further east most of the links surrounding Joyce and Kirwan Roundabouts are operating at over 100% operational capacity.

The modelling for the Do-Nothing Scenario indicates that, in the absence of intervention, many links which were approaching full capacity will be operating in excess of 100% capacity, particularly the Quincentenary Bridge and surrounding links and the area around Joyce and Kirwan Roundabouts. There are also several links approaching or exceeding 100% capacity in the city centre, as shown in Figure 9.5.

The volume-capacity ratios for the Do-Minimum Scenario, presented in Figure 9.6, indicate that the operational capacity of the road network improves in a number of areas with the introduction of the schemes and projects listed in Section 9.2, most notably the Galway City Ring Road. Capacity issues on the Quincentenary Bridge and surrounding the Kirwan Roundabout have been alleviated to a large extent, though issues remain at the Joyce Roundabout and capacity issues are expected to worsen northwest of the university adjacent to the ring road.

Figure 9.4: Galway city volume-capacity ratios, Base Scenario, 2012

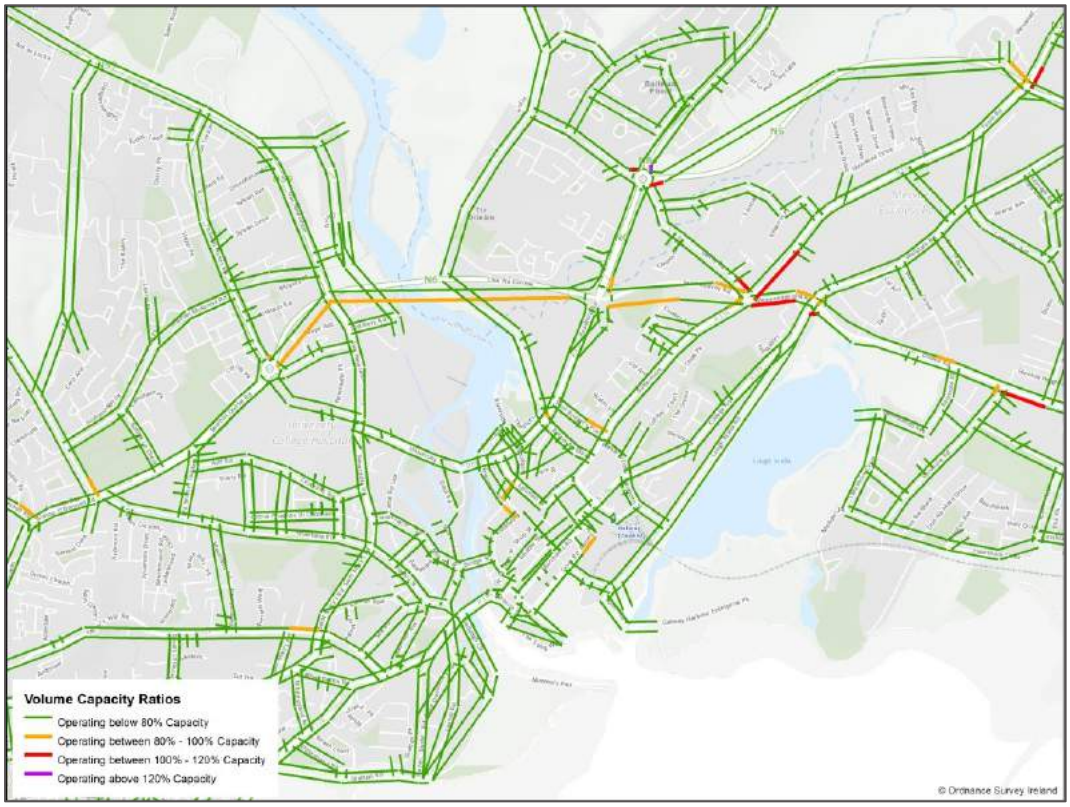


Figure 9.5: Galway city volume-capacity ratios, Do-Nothing Scenario, 2040

Figure 9.6: Galway city volume-capacity ratios, Do-Minimum Scenario, 2040

Peak hour delays on links in Galway city centre for the Base Scenario are illustrated in Figure 9.7. Compared with free flow most road links in Galway city do not experience significant peak hour delay. However, clusters of lengthy delay do exist on links adjacent to Kirawn and Joyce Roundabouts, consistent with the fact that these roads are operating above full capacity. Delays are also an issue on links to the southwest of the hospital and where the N6 and N83 meet to the northeast of the city.

Estimated delays on the Galway city road network for the Do-Minimum Scenario are shown in Figure 9.8. With the population increase targeted by the NPF and associated rise in travel demand, the most severe delays are generally found in the same locations as in the Base Scenario.

Peak hour delay is projected to remain an issue in the Do-Minimum Scenario, as shown in Figure 9.9. As a result of NDP investment, there are greater delays northeast of the university, adjacent to the new ring road. Lengthy delays remain an issue on busy links to the northeast of the city centre and on the west side of the Corrib.

Figure 9.7: Galway city percentage increase in peak hour journey times, Base Scenario, 2012

Figure 9.8: Galway city percentage increase in peak hour journey times, Do-Nothing, 2040

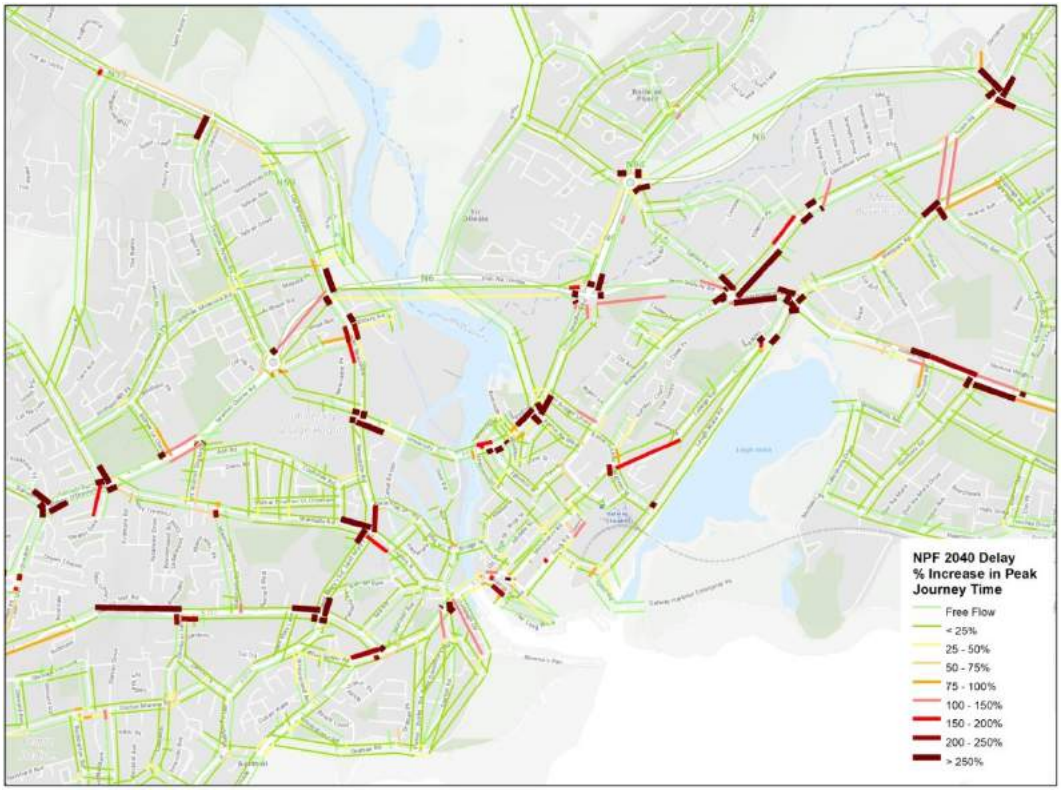
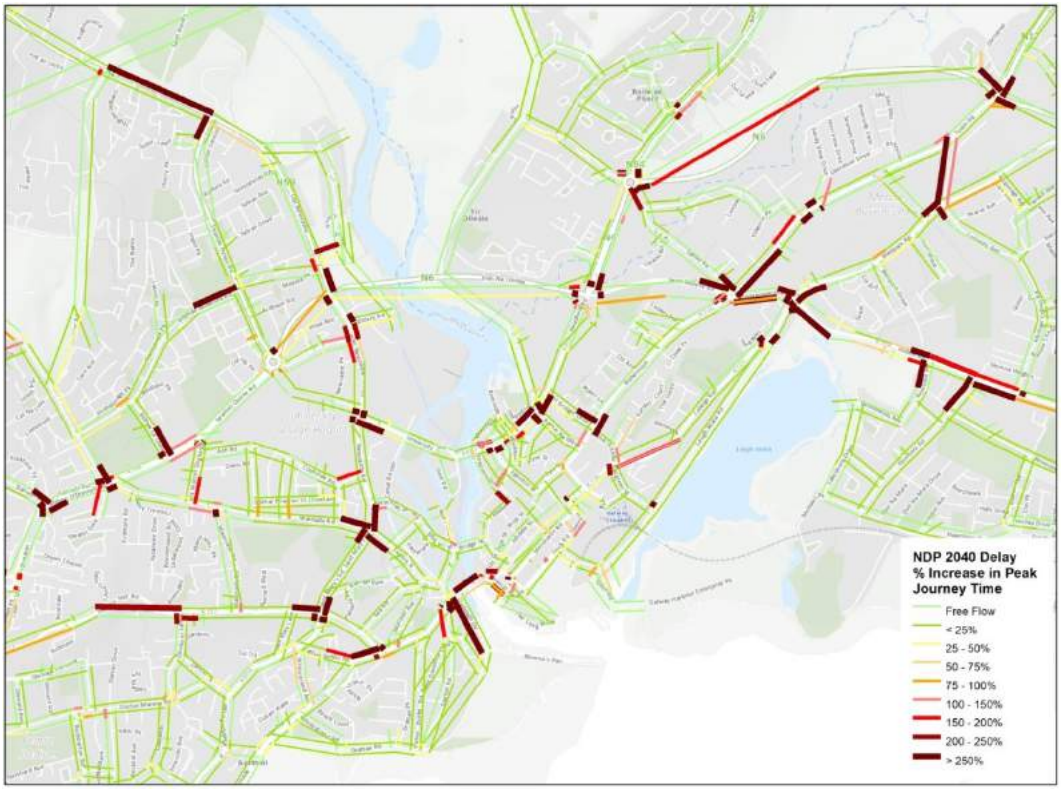


Figure 9.9: Galway city percentage increase in peak hour journey times, Do-Minimum, 2040



9.5 Accessibility

Figure 9.10 illustrates generalised journey times to Galway city centre by public transport in the Base Scenario. As discussed in Section 6.1.4, generalised journey times are a standard tool used in transport modelling but should not be interpreted as equivalent to actual journey times. In the Base Scenario, accessibility is generally better on the main arterial routes approaching the city and the Sean Quirke Road. On these roads journey times are noticeably lower than areas not served by such direct routes. Areas such as Dangan, Boleybeg and Glennascaul Business Park were found to have the highest journey times of 90 to 120, while areas such as Mervue, Newcastle and Rockbarton were found to have some of the lowest journey times of 60 minutes or less. Figure 9.10 also highlights that a number of areas surrounding Galway city have no public transport access. These areas are the shown as white in the map.

Public transport generalised journey times to Galway city centre for the Do-Nothing Scenario are illustrated in Figure 9.11. In the absence of intervention, the increase in population and travel demand projected out to 2040 is expected to increase generalised journey times in the peripheries of the city. Examples of this are Doughiska, Galway Technology Park, Coolough and Mincloon, where an increase of up to 45 minutes was estimated compared to the Base Scenario, with journey times increasing from 75 minutes to up to 120 minutes.

Generalised public transport journey times to Galway city centre in the Do-Minimum Scenario are presented in Figure 9.12, which shows only marginal improvements compared to the Do-Nothing Scenario. The shortest journey times of less than 30 minutes are clustered immediately around the city centre while areas to the northwest of the city experience public transport generalised journey times in excess of two hours.

Figure 9.10: Generalised public transport journey time to Galway city centre, Base Scenario, 2012

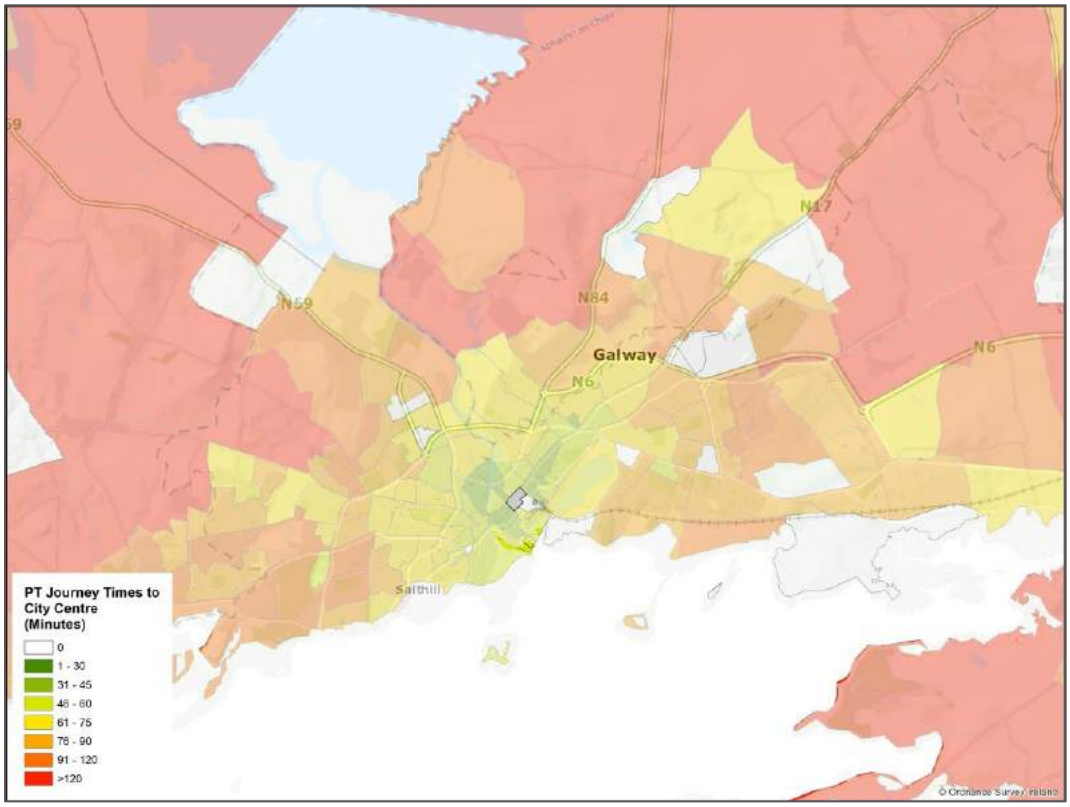


Figure 9.11: Generalised public transport journey time to Galway city centre, Do-Nothing Scenario, 2040

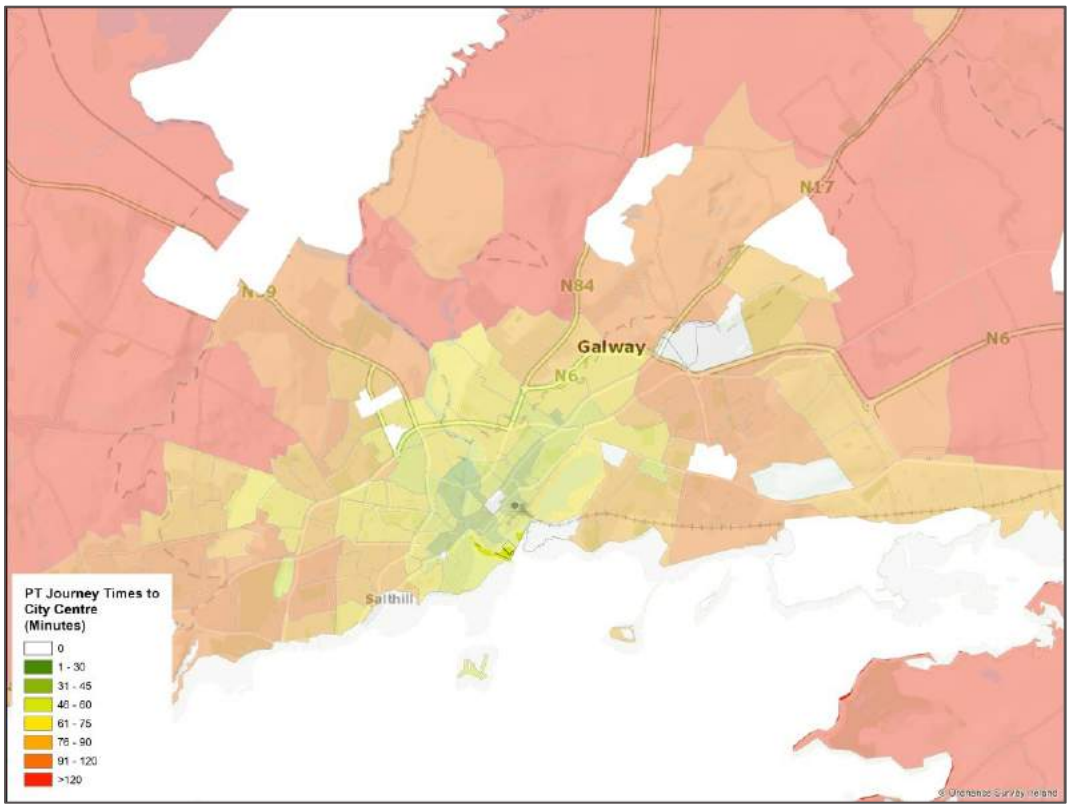
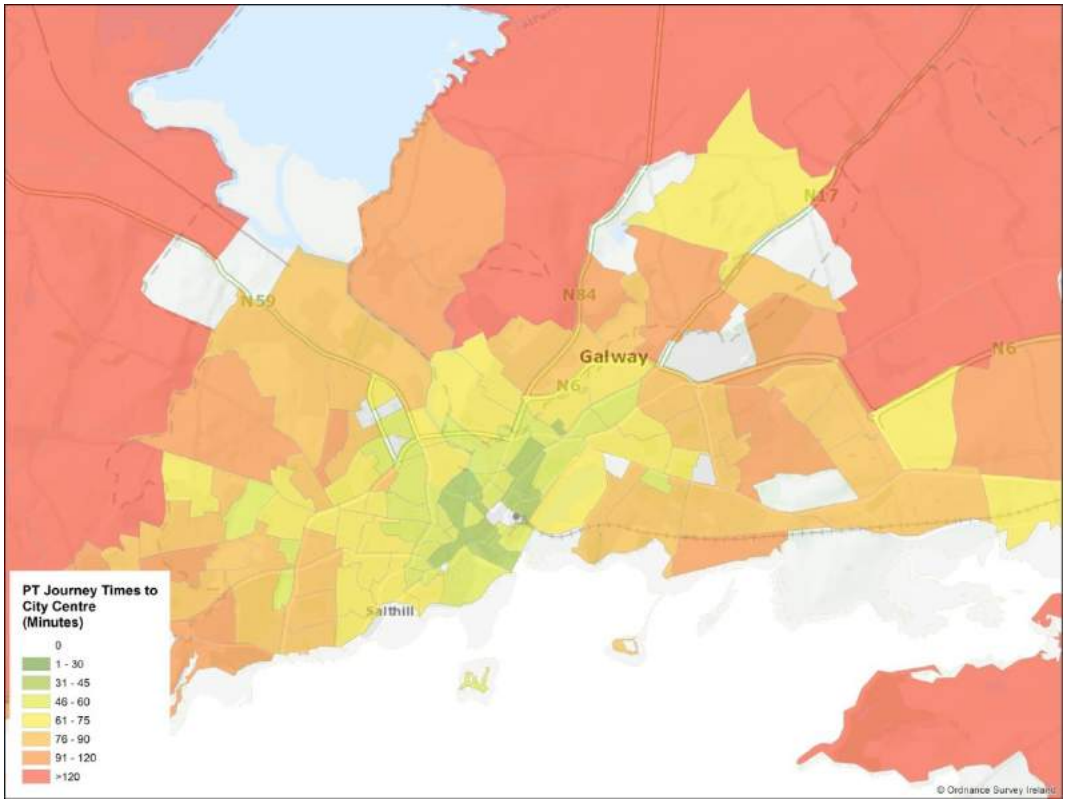


Figure 9.12: Generalised public transport journey time to Galway city centre, Do-Minimum Scenario, 2040



Generalised journey times to Galway city centre by car in the Base Scenario are shown in Figure 9.13. The areas that can access the city centre within 30 minutes are concentrated in the west and northwest, such as Bearna and Moycullen. To the east of the city, generalised journey times of between 31 and 45 minutes and 46 and 60 minutes are estimated. This is particularly evident in relation to the N63 and M6, which show journey times of up to 60 minutes, in contrast to journey times of up to 45 minutes along the N64 and N59.

Generalised journey times by car to Galway city centre in the Do-Nothing Scenario are presented in Figure 9.14, which shows that areas with access to Galway city within 30 minutes and 45 minutes remain concentrated to the west and northwest of Galway, such as Moycullen and Oughterard, primarily along the N59 corridor. Areas in the east part of Galway were estimated to experience longer journey times of up to 60 or 75 minutes, namely Athenry, Loughrea and Mountbellew. Ballyvaughan and Lisdoonvarna were also estimated to have particularly poor accessibility to Galway city in terms of generalised journey times in the Do-Nothing Scenario. In these areas, journey times increased from 75 minutes in the Base Scenario to up to 120 minutes.

Generalised journey times by car to Cork city centre in the Do-Minimum Scenario, illustrated in
Figure 9.15 show some improvement as a result of NDP investment in all directions. However, the fastest journey times of less than 30 minutes continue to be concentrated to the northwest of the city

Figure 9.13: Generalised car journey time to Galway city centre, Base Scenario, 2012

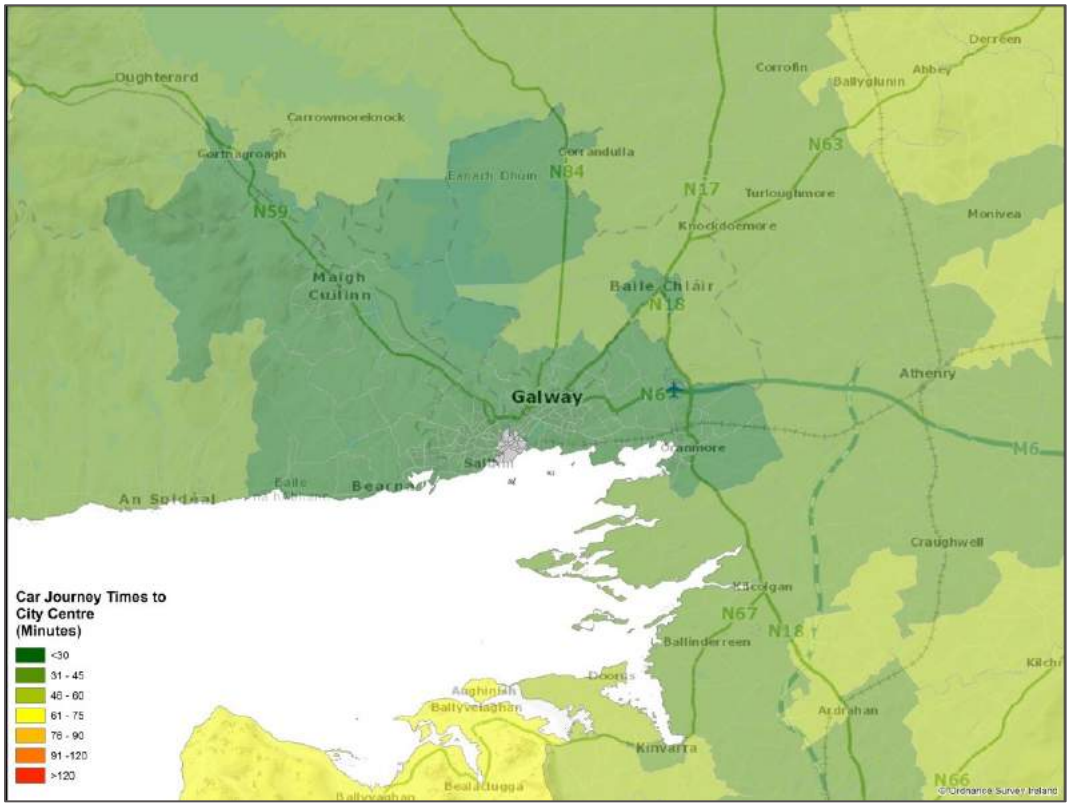


Figure 9.14: Generalised car journey time to Galway city centre, Do-Nothing Scenario, 2040

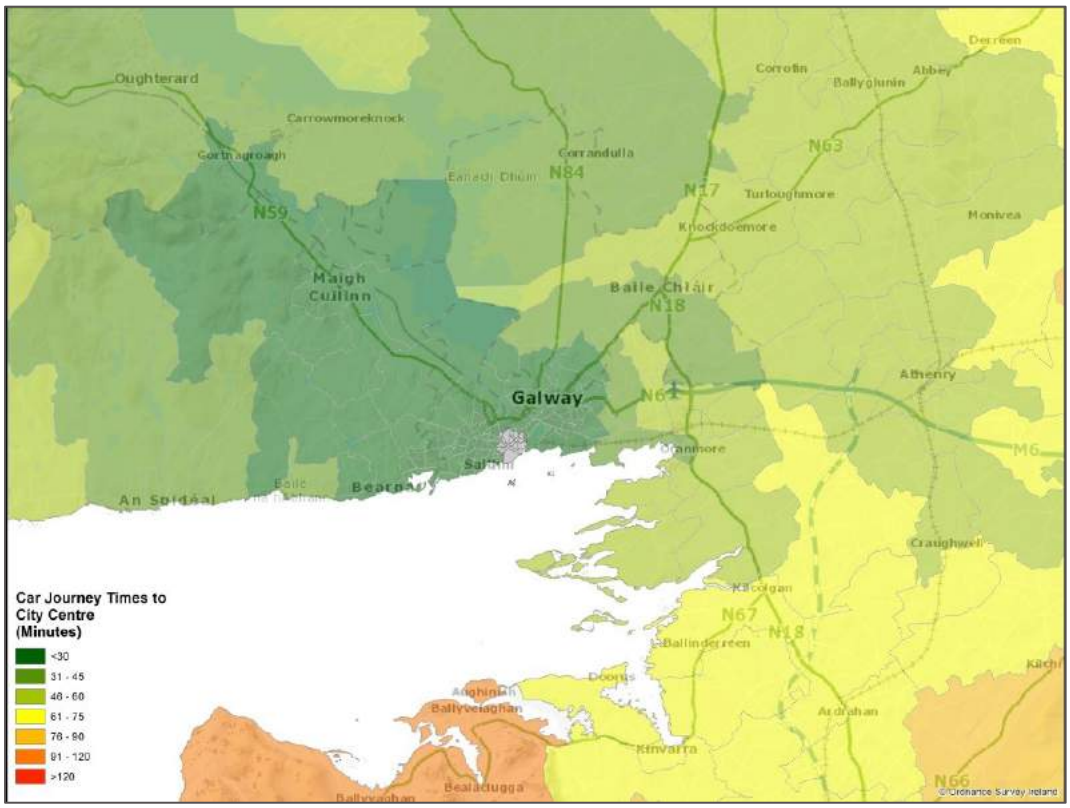
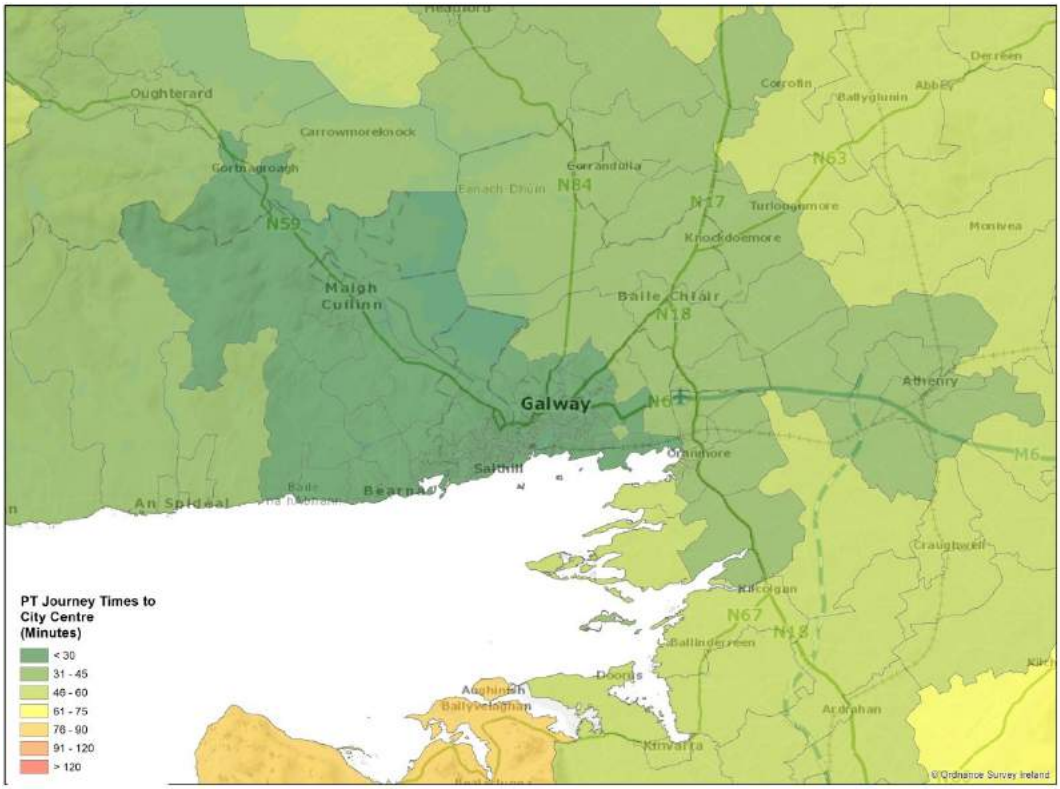


Figure 9.15: Generalised car journey time to Galway city centre, Do-Minimum Scenario, 2040



9.6 Summary

Overall, the modelling estimates that there will be a 15% increase in trips in the West Region between 2012 and 2040, from 1.9m to 2.2m. In the Do-Minimum Scenario it is estimated that 21% of these trips will be taken by sustainable modes, which represents an increase of two percentage points when compared to the Base Scenario. Within Galway city, the number of trips is estimated to increase by 48%, from 264,000 to 393,000. 32% of journeys are estimated to be made by sustainable modes in the Do-Minimum Scenario, which represents an increase of one percentage point when compared to the Base Scenario.

Between the Do-Nothing and Do-Minimum scenarios, the modelling indicates that NDP will have a positive impact by alleviating capacity and delay issues on the Quincentenary Bridge and adjacent links and in the area surrounding Kirwan Roundabout. However, considerable pressures will continue to exist surrounding the Joyce Roundabout and the introduction of the ring road will exacerbate pressures northwest of the university. Car journey times to the city centre are marginally improved by NDP investment, though shorter journeys continue to be concentrated to the northwest of the city. On the other hand, public transport journey times show only marginal variation between the Do-Nothing and Do-Minimum scenarios and in some areas are very uncompetitive when compared to travelling by car.

10. Limerick

This section of the paper considers Limerick for the three modelling scenarios described in Section 6. The assumed growth in population and trip demand for the 2040 scenarios will be set out followed by the NDP investment assumed for the Do-Minimum Scenario. The impact of population growth and investment on modal split, capacity, delay, and generalised journey times will then be shown. The section will conclude with a summary of the main issues and areas of constraint identified in the modelling for the Do-Minimum Scenario, indicating where additional intervention beyond that set out in the NDP may be required between 2027 and 2040 for the transport system to facilitate NPF settlement targets.

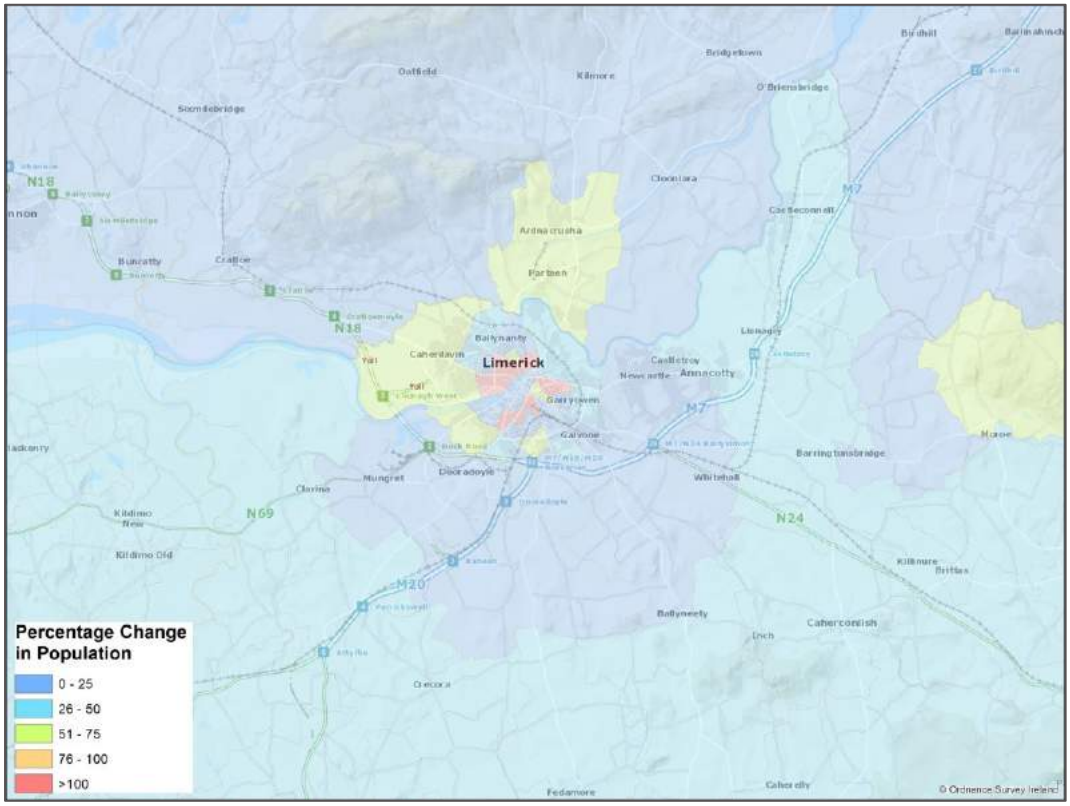
10.1 Population and Travel Demand

Table 10.1 presents the assumed population change between the 2012 Base Scenario and the two 2040 scenarios for Limerick city, county and nationally. Figure 10.1 illustrates this increase for the Limerick city area, with the highest levels of population growth projected to occur in the city centre and the areas of Ardnacrusha, Parteen and Caherdavin. With this growth in population, the typical daily trip demand within Limerick city is estimated to increase by 41%, from 243,000 to 343,000, between 2012 and 2040.

Table 10.1: Population of Limerick city and county in Base and 2040 scenarios

	Base 2012	2040	Change
Limerick City	57,106	99,802	75%
Limerick County	191,809	274,507	43%
National	4,588,248	5,643,917	23%

Figure 10.1: Percentage change in population in Limerick city by electoral district



10.2 Investment

Besides the population projections set out above, for the Do-Minimum Scenario a number of projects to be delivered by 2027 under the NDP have been included in the Mid-West Regional Model (MWRM).

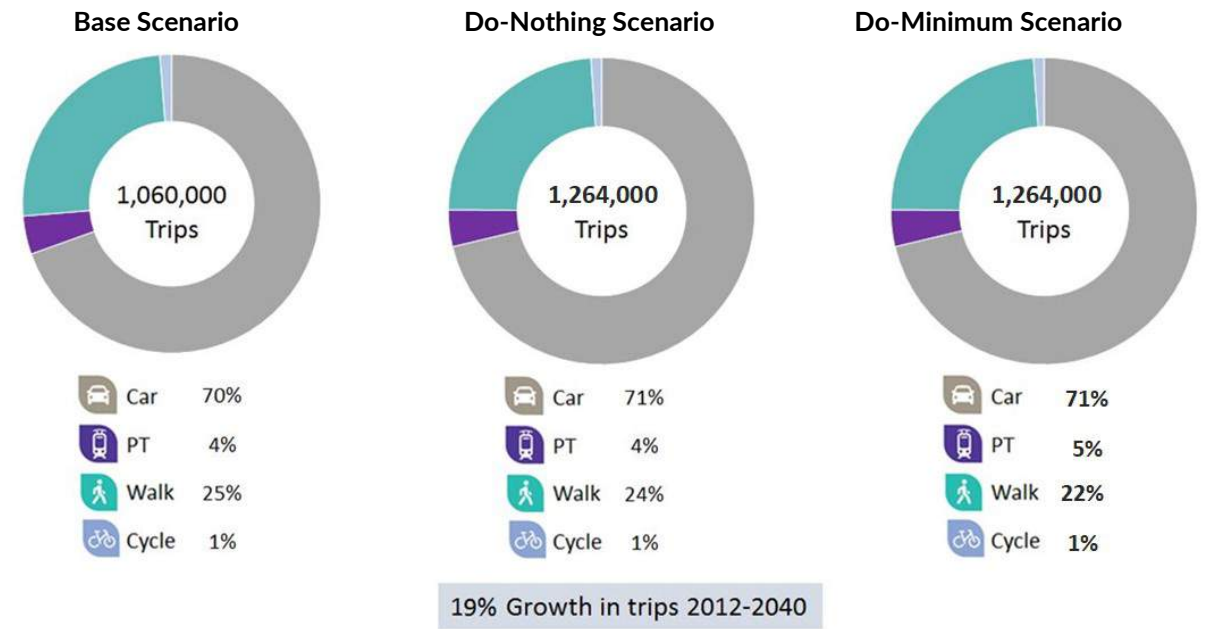
The BusConnects programme has been modelled using journey time proxies and service frequency increases along existing bus routes. High-quality cycling facilities have been modelled adjacent to all bus corridors as a proxy for the future cycling network. New road schemes include M20 Cork to Limerick, the N21/N69 Limerick to Adare/Foynes, realignment of the R498 Neagh/Thurles Road at Latteragh, Shannon Crossing, Coonagh to Knockalisheen (Main Contract), and Killaloe Bypass/R494 upgrade.

10.3 Modal Split

Figure 10.2 displays mode shares for the Mid-West Region across the three scenarios. Between the Do-Nothing and Do-Minimum Scenarios, the modelling indicates a one percentage point increase in public transport use to 5%, while private car and cycling modal share remain at 71% and 1% respectively and walking modal share declines from 24% to 22%. Overall, there is expected to be a 19% increase in total trips in the Mid-West Region between 2012 and 2040, from 1.1m to 1.3m.

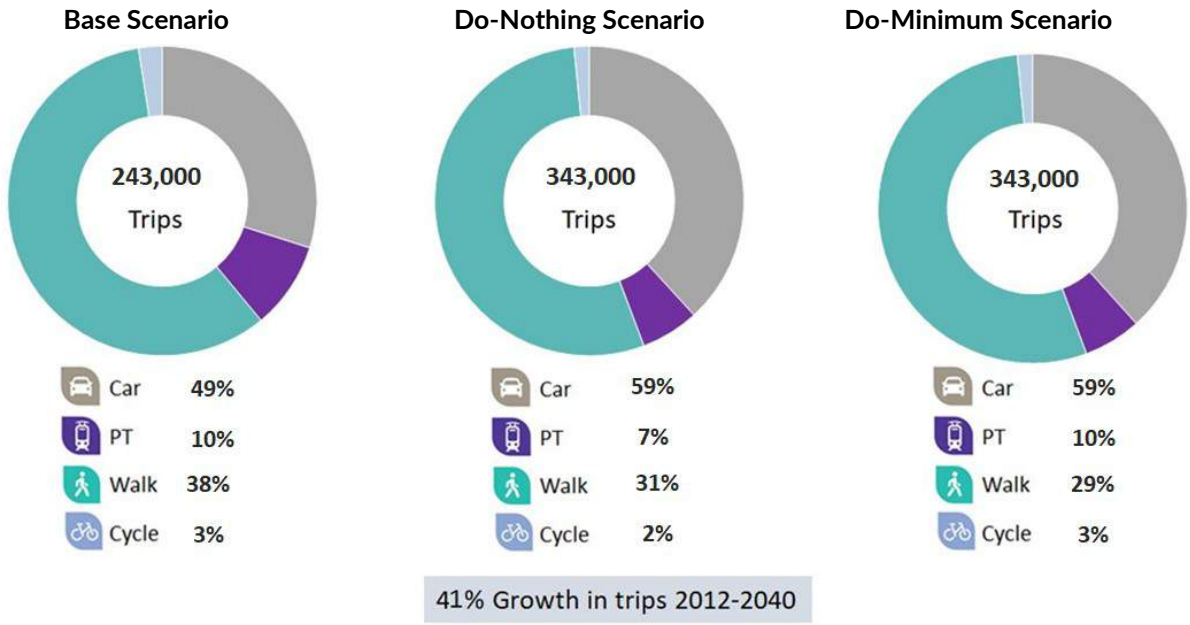
The mode shares for Limerick city are illustrated in Figure 10.3.[7] Within the city, a ten-percentage point increase in the mode share of private cars is estimated between the Base Scenario and the two 2040 scenarios, although it should be noted that this is due to modelling issues resulting in an artificially low car modal share in the Base Scenario. Between the Do-Nothing and Do-Minimum Scenarios, car modal share is unchanged while public transport and cycling increase by three and one percentage points respectively, to 10% and 3%. Walking mode share declines by two percentage points between the Do-Nothing and Do-Minimum Scenarios, from 31% to 29%. Overall, it is projected that there will be a 41% increase in trips in the city between 2012 and 2040.

Figure 10.2: Mode shares for Mid-West Region (typical weekday)



[7] See Appendix 1 for a map of the city area for modelling purposes.

Figure 10.3: Mode shares for Limerick city (typical weekday)



10.4 Congestion and Mobility

Figure 10.4 displays the volume-capacity ratios for the Base Scenario in Limerick city. In the base year, the majority of links in the city road network are operating at below 80% capacity. However, some links were found to be operating at 80% to 100% capacity, such as the Sarsfield Bridge and on sections of the Roxboro Road.

The modelling for the Do-Nothing Scenario indicates that, in the absence of intervention, the Roxboro Road, Sarsfield Bridge and Island Road will all see an increase from 80% to 100% operational capacity to up to 20% over capacity. Various other roads are estimated to be approaching full operational capacity in the Do-Nothing Scenario, as indicated in orange in Figure 10.5.

The volume-capacity ratios for the Do-Minimum Scenario, presented in Figure 10.6, a minor improvement in volume-capacity ratios for the Limerick city road network with the introduction of the schemes and projects listed in Section 10.2. O'Callaghan Strand and the Sarsfield Bridge travelling northbound are found to operate at between 80% and 100% capacity respectively in this scenario, which were operating over capacity in the Do-Nothing Scenario. Island Road is also estimated to have an improvement in volume-capacity between the two 2040 scenarios, with sections of this road returning to 80% or lower operational capacity—equivalent to the Base Scenario.

Figure 10.4: Limerick city volume-capacity ratios, Base Scenario, 2012

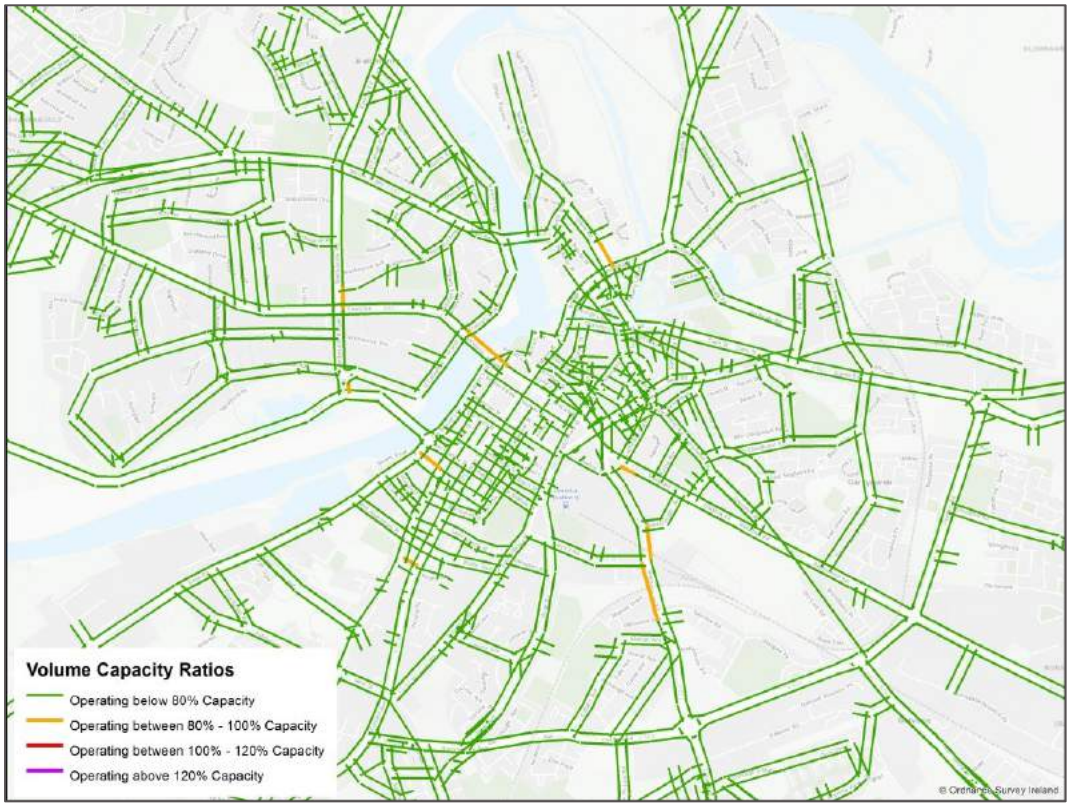


Figure 10.5: Limerick city volume-capacity ratios, Do-Nothing Scenario, 2040

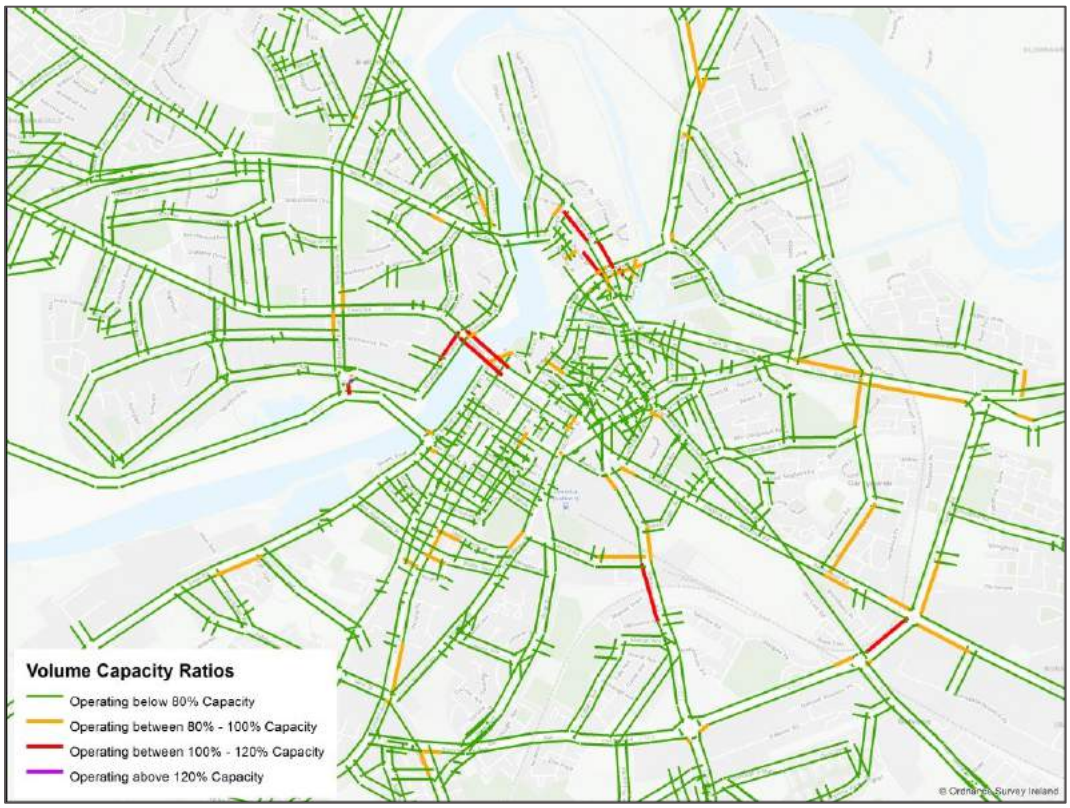
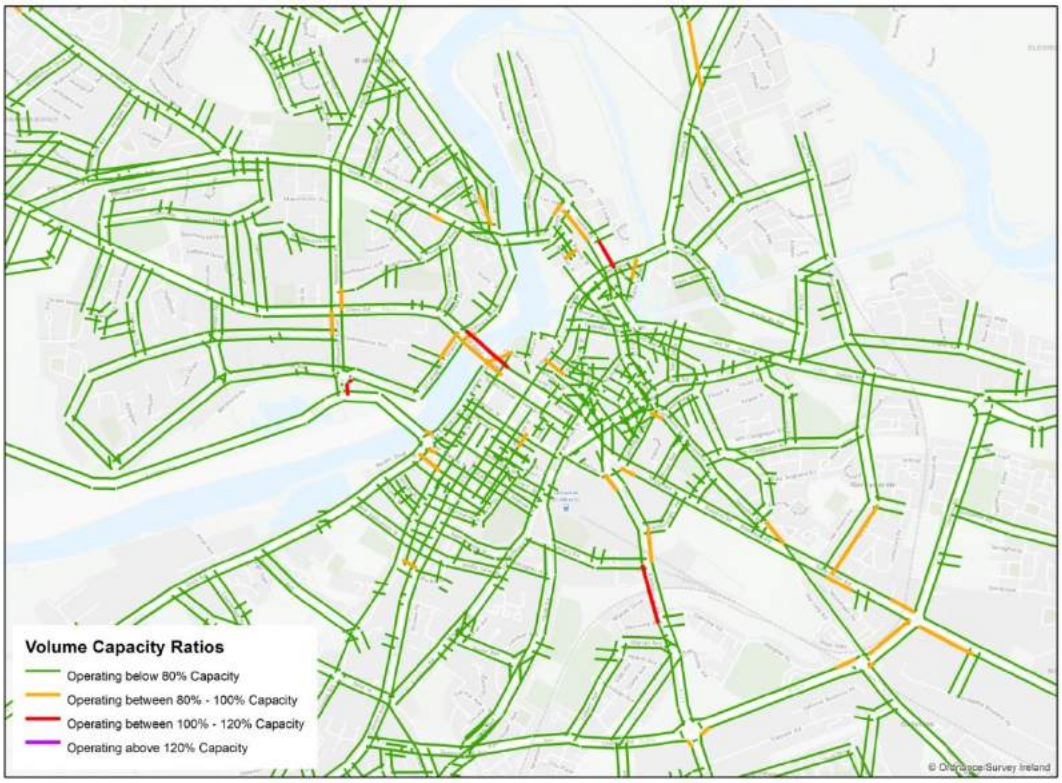


Figure 10.6: Limerick city volume-capacity ratios, Do-Minimum Scenario, 2040



Peak hour delays on links in Limerick city centre for the Base Scenario are illustrated in Figure 10.7. Compared with free flow most of the road network performs well in the, though there are some areas around the city centre where delays are an issue, especially close to the river.

Estimated delays on the Limerick city road network for the Do-Minimum Scenario are shown in Figure 10.8. With the population increase targeted by the NPF and associated rise in travel demand, links that are projected to be operating over capacity, such as the Sarsfield Bridge and Island Road, also experience lengthy delays in excess of 250% compared to free flow.

Peak hour delay is projected to remain an issue in the Do-Minimum Scenario, as shown in Figure 10.9, with the links suffering from significant peak time delay virtually unchanged from the Do-Nothing Scenario in spite of NDP investment.

Figure 10.7: Limerick city percentage increase in peak hour journey times, Base Scenario, 2012

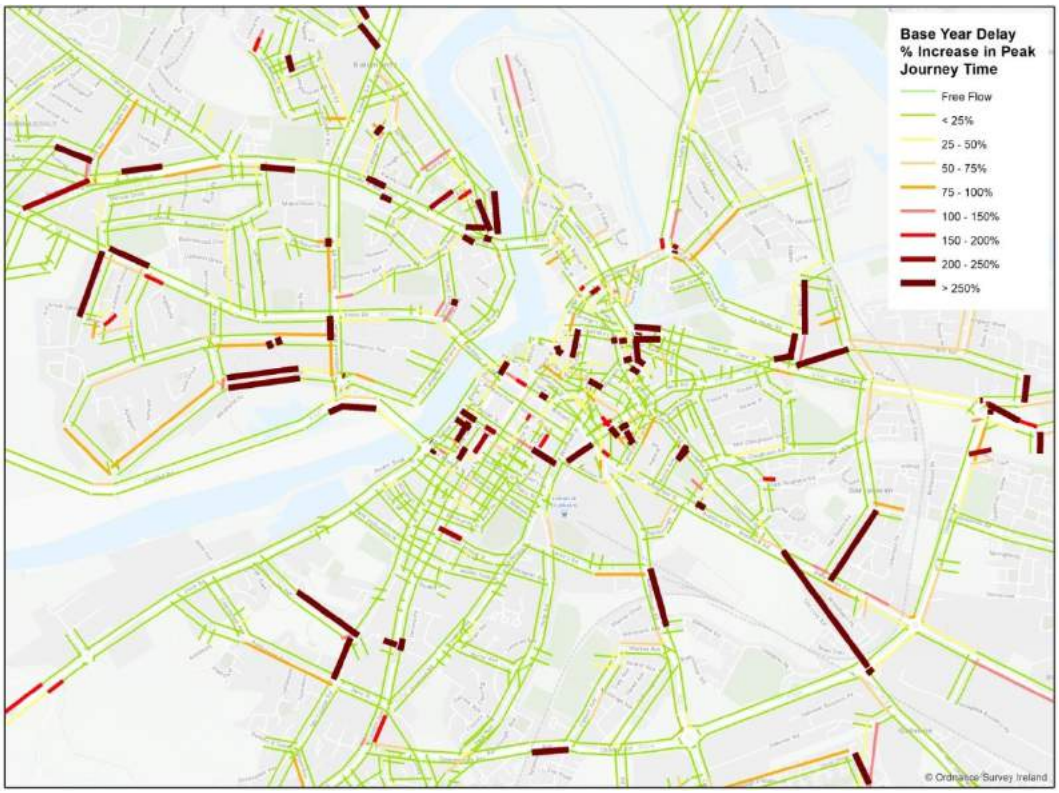


Figure 10.8: Limerick city percentage increase in peak hour journey times, Do-Nothing Scenario, 2040

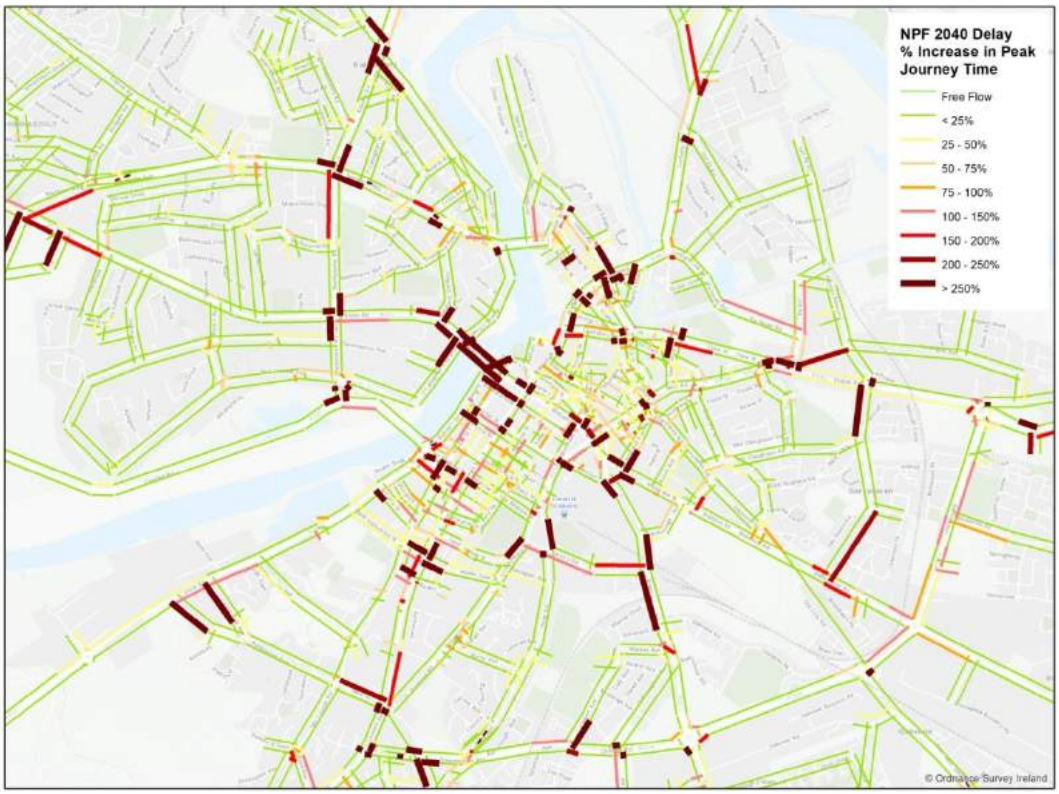
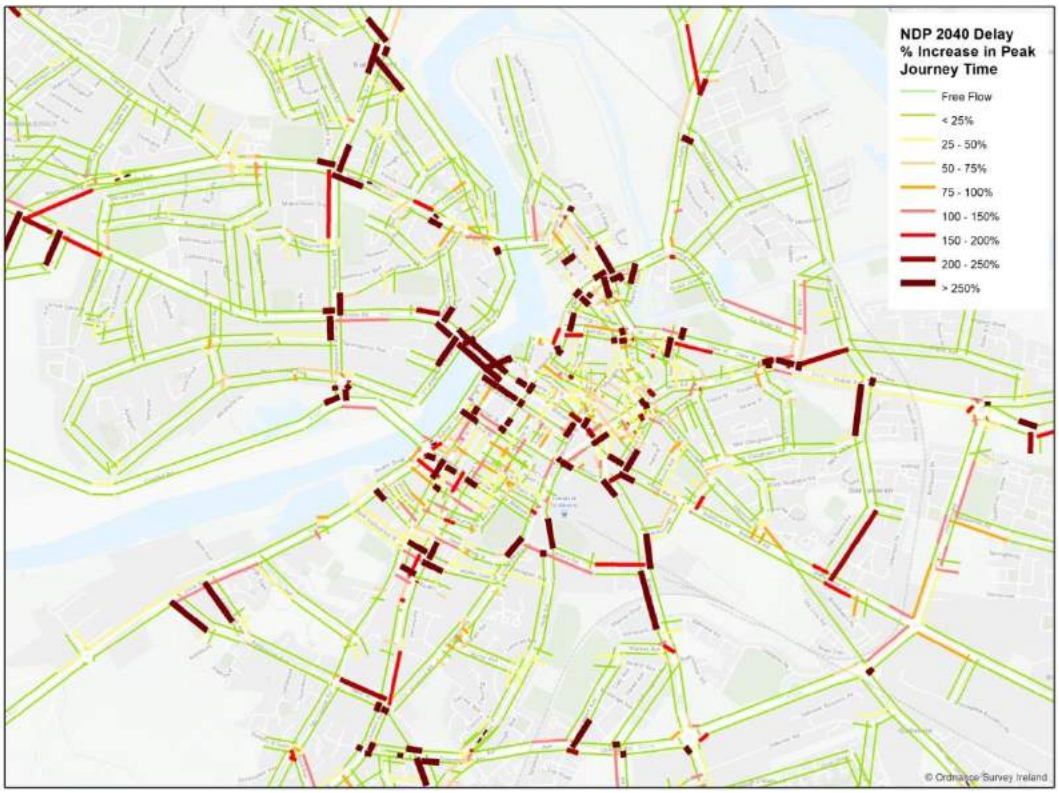


Figure 10.9: Limerick city percentage increase in peak hour journey times, Do-Minimum Scenario, 2040



10.5 Accessibility

Figure 10.10 illustrates generalised journey times to Limerick city centre by public transport in the Base Scenario. As discussed in Section 6.1.4, generalised journey times are a standard tool used in transport modelling but should not be interpreted as equivalent to actual journey times. In the Base Scenario, the city centre is accessible by public transport modes within 30 minutes from the Tipperary roundabout on the Ballysimon Road, Ballinacurra Weston and Rathbane, while in areas such as Galvone, Ballynanty, Newcastle and Dooradoyle the journey time increases to 60 to 75 minutes. The longest journey times to the city of 120 minutes or more were recorded in Whitehall, Ardnacrusha, Annacotty and Raheen.

Public transport generalised journey times to Limerick city centre for the Do-Nothing Scenario are illustrated in Figure 10.11, which indicates some deterioration compared to the Base Scenario. This is particularly pronounced to the northwest and west of the city in areas along the N18 and N69, with estimated journey times increasing to between 91 and 120 minutes.

Generalised public transport journey times to Limerick city centre in the Do-Minimum Scenario are presented in Figure 10.12. Several areas in Limerick city and suburbs were found to experience journey time savings thanks to the BusConnects programme, with the areas that can access the city centre within 30 minutes and within 45 minutes both growing in size in all directions, particularly to the southwest.

Figure 10.10: Generalised public transport journey time to Limerick city centre, Base Scenario, 2012

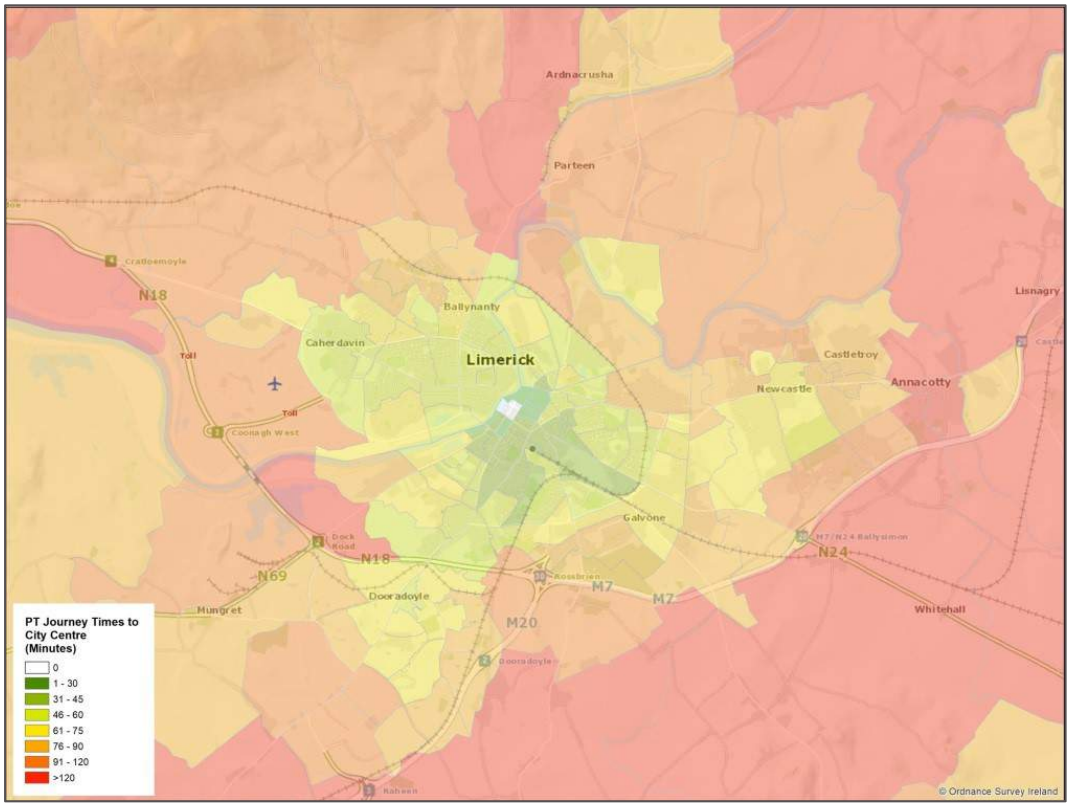


Figure 10.11: Generalised public transport journey time to Limerick city centre, Do-Nothing Scenario, 2040

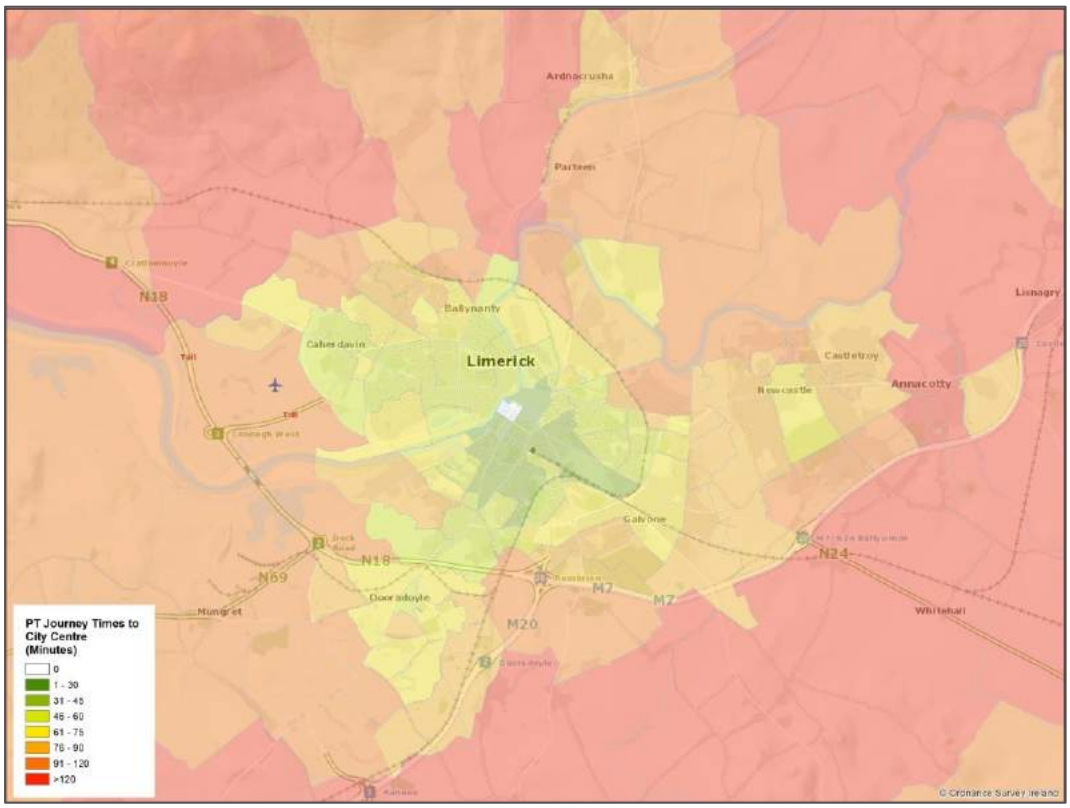
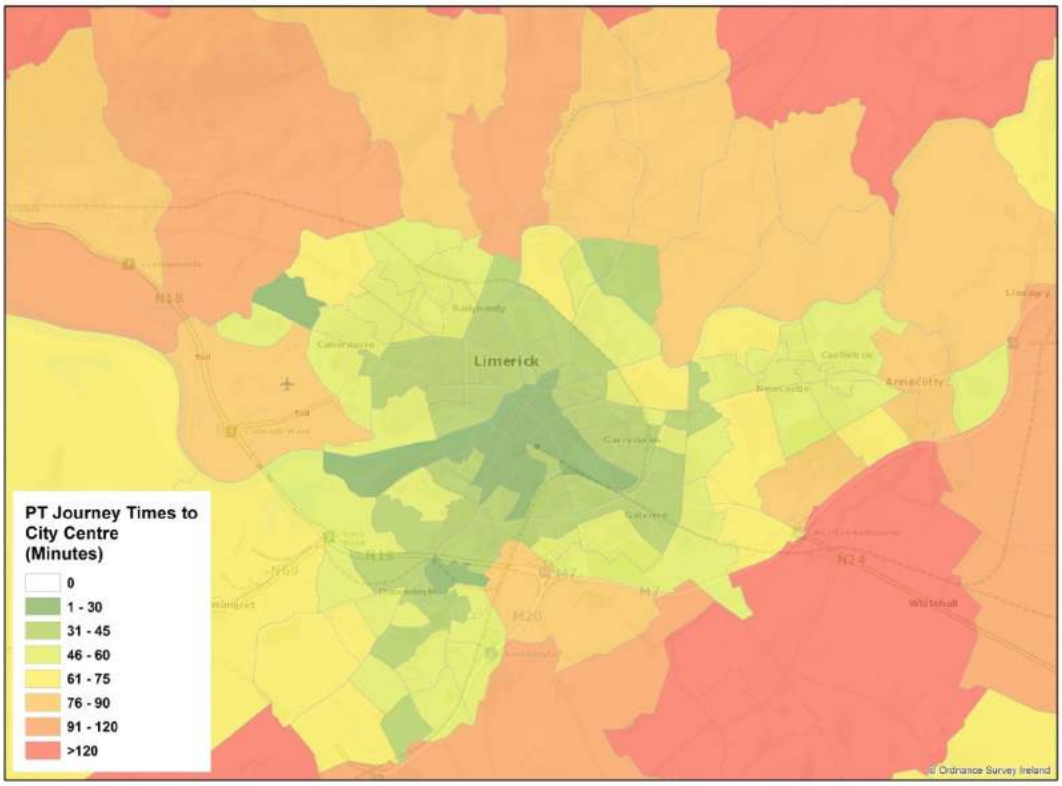


Figure 10.12: Generalised public transport journey time to Limerick city centre, Do-Minimum Scenario, 2040



Generalised journey times to Limerick city centre by car in the Base Scenario are shown in Figure 10.13. In the Base Scenario, the city centre can be accessed in 30 minutes or less from areas such as Ballina to the northeast, Bruff in the south and Shannon Airport in the west, while generalised journey times from Ennis and Nenagh were found to be between 31 and 45 minutes. Longer generalised journey times of 91 to 120 minutes are found in areas north of Tuamgraney

Generalised journey times by car to Limerick city centre in the Do-Nothing Scenario are presented in Figure 10.14, which shows a marked reduction in the area representing generalised journey times of 30 minutes or less to Limerick city centre. Areas that could access the city within 30 minutes in the Base Scenario, such as Ballina, Bruff and Shannon airport, now experience journey times of up to 45 minutes. Areas such as Tarbert and Millford were similarly found to have increases in journey times of up to 20 minutes, with average times estimated at up to 90 minutes.

Generalised journey times by car to Limerick city centre in the Do-Minimum Scenario, illustrated in Figure 10.15, indicate a small increase in the size of the area that can access Limerick city within 30 minutes and within 31 to 45 minutes. The journey time savings are particularly evident to the south and southwest of the city, where journey time savings of up to 20 minutes are estimated as a result of the upgrade of the N20 Limerick to Cork road to motorway standard.

Figure 10.13: Generalised car journey time to Limerick city centre, Base Scenario, 2012

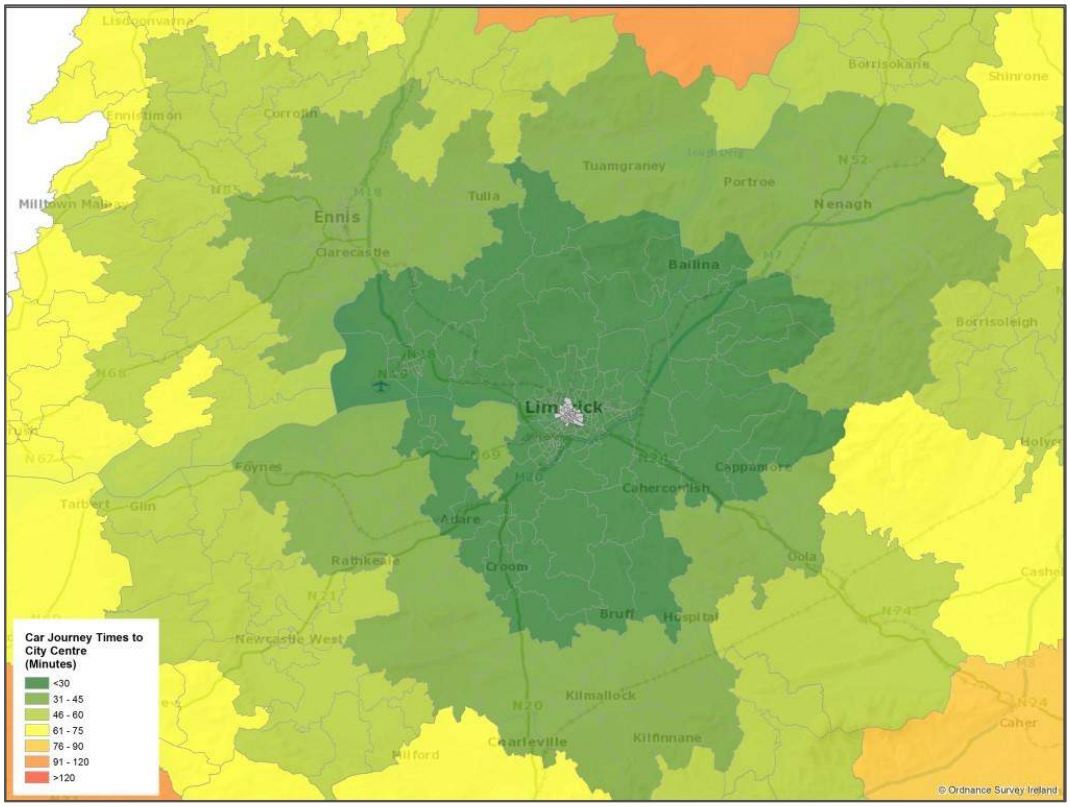


Figure 10.14: Generalised car journey time to Limerick city centre, Do-Nothing Scenario, 2040

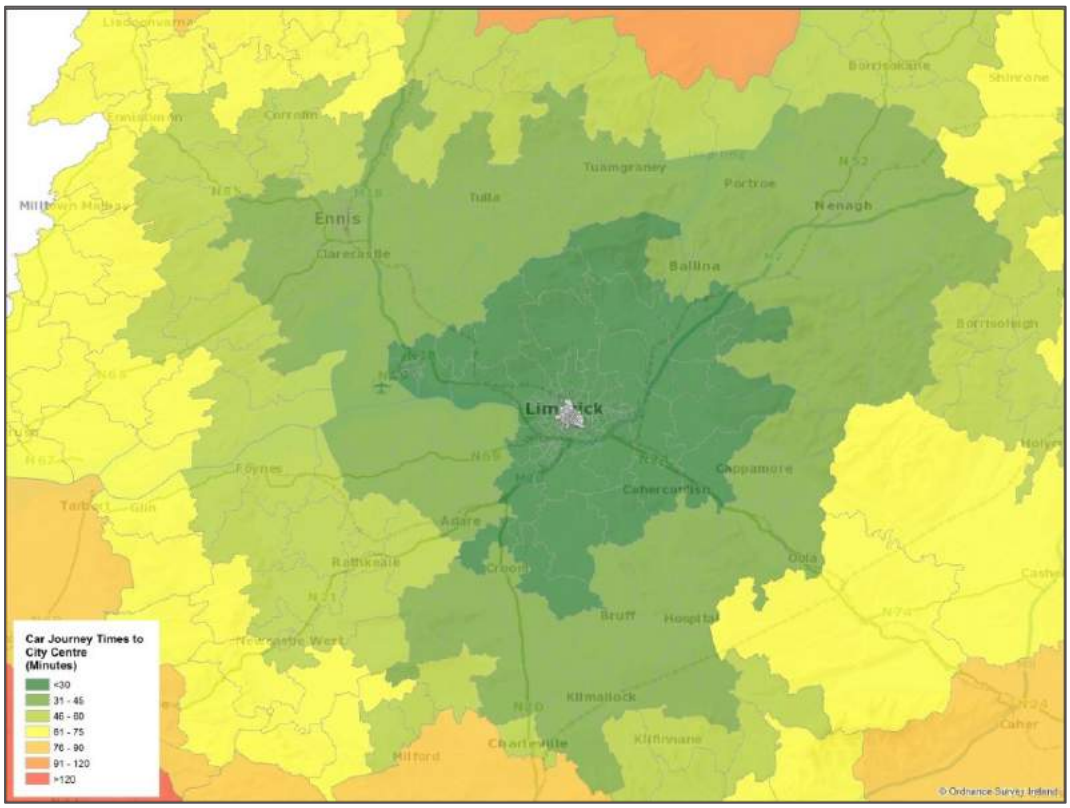
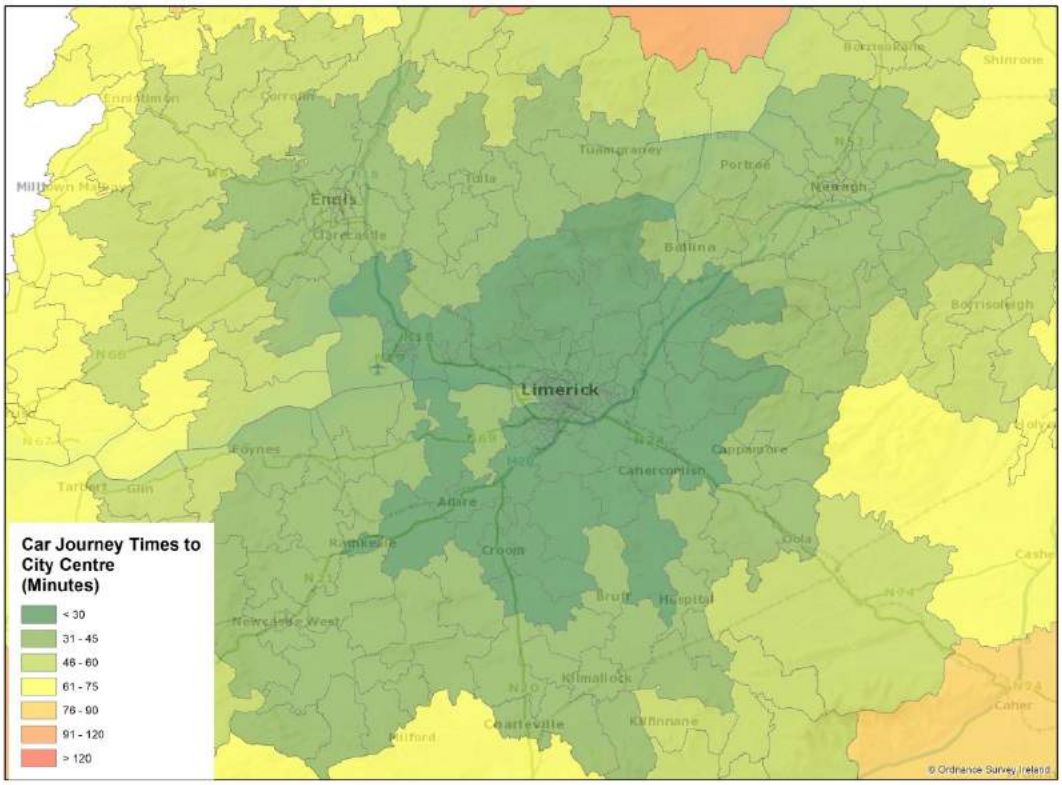


Figure 10.15: Generalised car journey time to Limerick city centre, Do-Minimum Scenario, 2040



10.6 Summary

Overall, the modelling estimates that there will be a 19% increase in trips in the Mid-West Region between 2012 and 2040, from 1.1m to 1.3m. In the Do-Minimum Scenario it is estimated that 29% of these trips will be taken by sustainable modes, which represents a decrease of two percentage points when compared to the Base Scenario. Within Limerick city, the number of trips is estimated to increase by 41%, from 243,000 to 343,000. 41% of journeys are estimated to be made by sustainable modes in the Do-Minimum Scenario, which represents a decrease of ten percentage points when compared to the Base Scenario. However, there are known issues with the Mid-West Regional Model, so caution most be exercised when comparing the 2040 modelling outputs with the base case.

Between the Do-Nothing and Do-Minimum scenarios the modelling indicates that NDP investment will have some positive impact on capacity issues on the Sarsfield Bridge and Island Road. However, lengthy delays will still exist on the bridge and on certain sections of the Island Road, and also to the south and southeast of the city centre. The size of the areas that can access the city centre by public transport in 30 minutes and in 45 minutes or less increase between the two 2040 scenarios, through in peripheral areas to the east of the city journey times of two hours or more are still experienced. Car journey times to the city centre are also found to improve between the Do-Nothing and Do-Minimum scenarios, most notably in the areas adjacent to the upgraded M20 between Cork and Limerick.

11. Waterford

This section of the paper considers Waterford for the three modelling scenarios described in Section 6. The assumed growth in population and trip demand for the 2040 scenarios will be set out followed by the NDP investment assumed for the Do-Minimum Scenario. The impact of population growth and investment on modal split, capacity, delay, and generalised journey times will then be shown. The section will conclude with a summary of the main issues and areas of constraint identified in the modelling for the Do-Minimum Scenario, indicating where additional intervention beyond that set out in the NDP may be required between 2027 and 2040 for the transport system to facilitate NPF settlement targets.

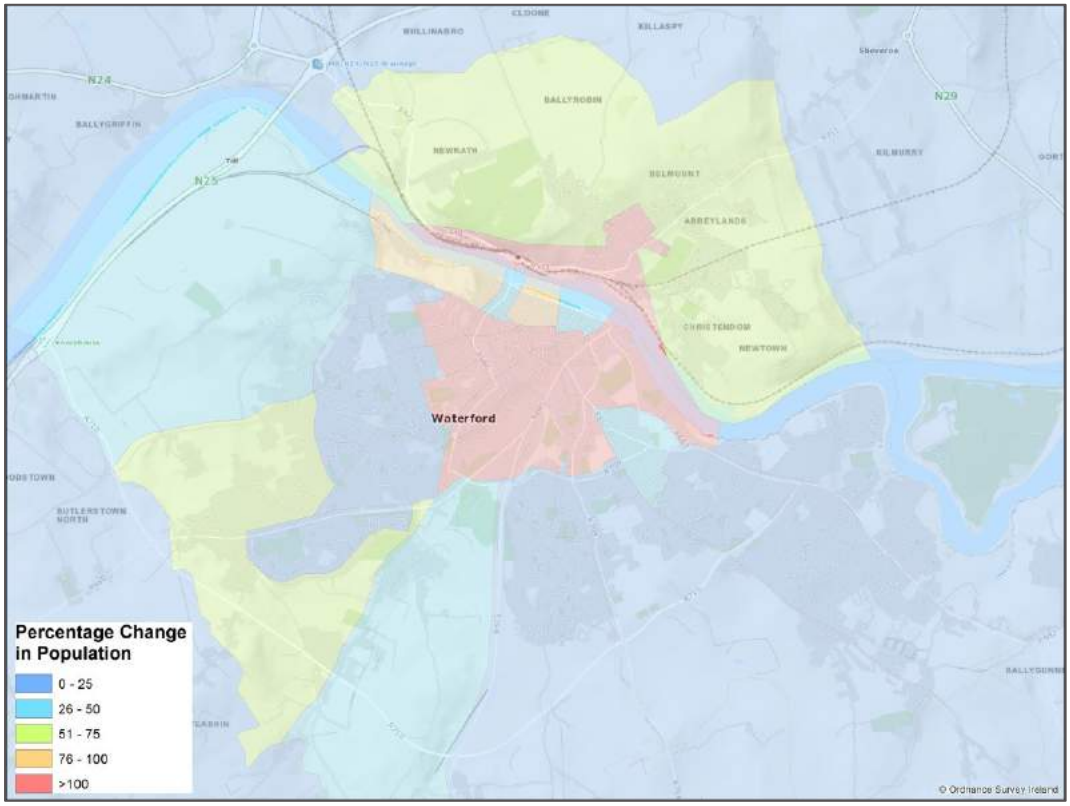
11.1 Population and Travel Demand

Table 11.1 presents the assumed population change between the 2012 Base Scenario and the two 2040 scenarios for Waterford city, county and nationally. Figure 11.1 illustrates this increase for the Waterford city area, and it can be seen that the highest levels of population growth are close to the River Suir, particularly on the south bank. With this growth in population, the typical daily trip demand within Waterford city is estimated to increase by 29%, from 160,000 to 210,000, between 2012 and 2040.

Table 11.1: Population of Waterford city and county in Base and 2040 scenarios

	Base 2012	2040	Change
Waterford City	46,731	72,541	55%
Waterford County	113,794	140,223	23%
National	4,588,248	5,643,917	23%

Figure 11.1: Percentage change in population in Waterford city by electoral district



11.2 Investment

Besides the population projections set out above, for the Do-Minimum Scenario a number of projects to be delivered by 2027 under the NDP have been included in the South-East Regional Model (SERM).

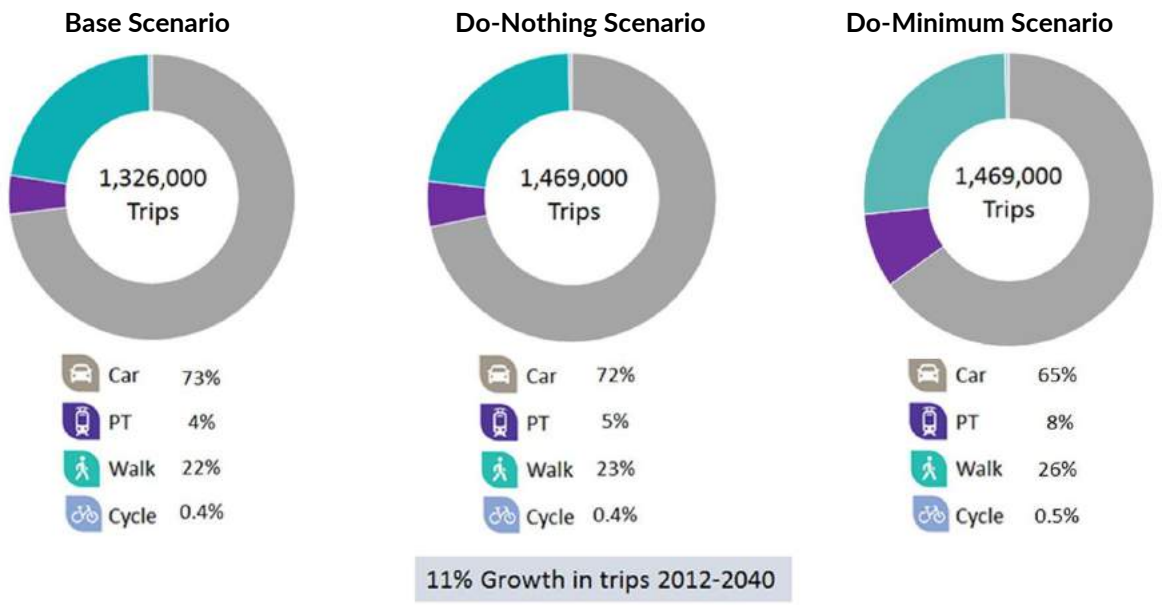
The BusConnects programme has been modelled using journey time proxies and service frequency increases along existing bus routes. High-quality cycling facilities have been modelled adjacent to all bus corridors as a proxy for the future cycling network. New road schemes include the N25 New Ross Bypass and M11 Gorey to Enniscorthy.

11.3 Modal Split

Figure 11.2 displays mode shares for the South East Region across the three scenarios. Between the Do-Nothing and Do-Minimum Scenarios, the modelling indicates a seven percentage point decrease in private car use, which is offset by a three percentage point increase for both public transport and walking. Overall, there is expected to be an 11% increase in total trips in the South East Region between 2012 and 2040, from 1.3m to 1.5m.

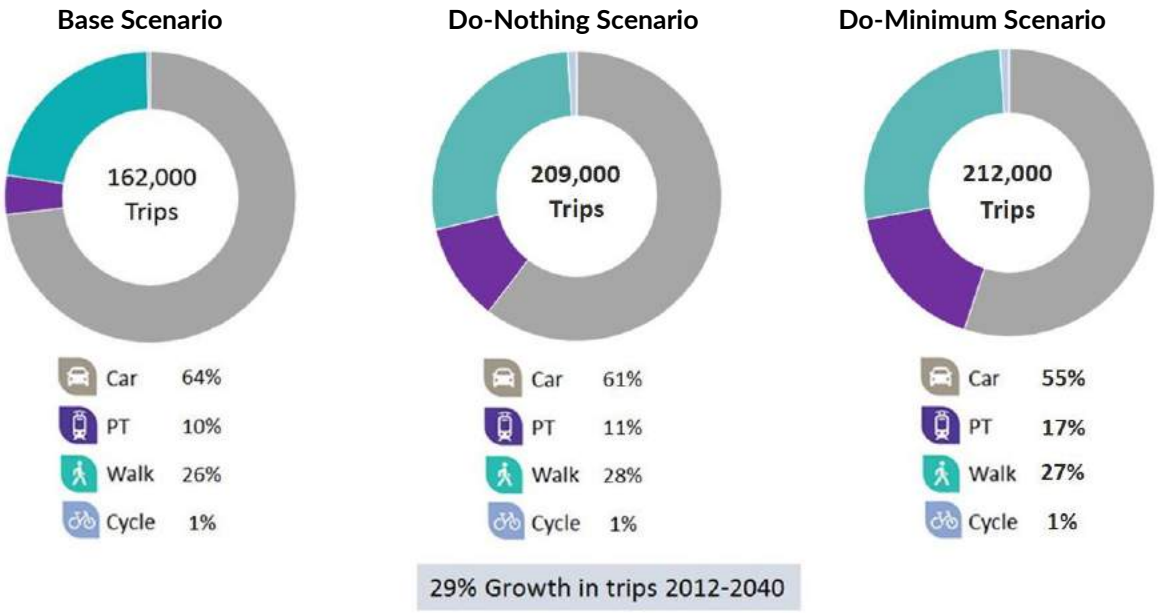
The mode shares for Waterford city are illustrated in Figure 11.3.[8] Within the city, car modal share is expected to fall by six percentage points between the Do-Nothing and Do-Minimum scenarios, representing 55% of all trips in the latter. Public transport increases its modal share by six percentage points to 17%, while the combine active travel mode share is more or less unchanged at 28%. The overall number of trips made each day in the city is estimated to increase by 29%, from 162,000 in 2012 to 212,000 in 2040.

Figure 11.2: Mode shares for South East Region (typical weekday)



[8] See Appendix 1 for a map of the city area for modelling purposes.

Figure 11.3: Mode shares for Waterford city (typical weekday)



11.4 Congestion and Mobility

Figure 11.4 displays the volume-capacity ratios for the Base Scenario in Waterford city. In the base year, most of the road network in Waterford city is operating at or below 80% capacity. Links in the network that do exhibit signs of pressure are in the vicinity of Plunkett station, where Terminus Road is approaching full capacity, and Dock Road, which is operating at between 100% capacity and 20% over capacity.

The modelling for the Do-Nothing Scenario indicates that, in the absence of intervention, there will be deterioration in the performance of the Dock Road approach to the roundabout at Plunkett Station, which is estimated to operate at more than 20% over capacity, and on the Lower Grange Road R708, which is estimated to operate at between full capacity and 20% over capacity. Other road links showing signs of pressure are Ballybeg Drive at the Waterford Institute of Technology and the Outer Ring Road approaching the roundabout with the Old Kilmeaden Road, both of which are operating at between full capacity and 20% over capacity, as shown on Figure 11.5.

The volume-capacity ratios for the Do-Minimum Scenario, presented in Figure 11.6, indicate some improvement in the operational capacity on the Waterford city road network with the introduction of the schemes and projects listed in Section 11.2. However, the Dock Road approaching Plunkett Station is estimated to continue to operate at above 120% capacity while Ballybeg Drive at the junction with the Cork Road and the R710 approaching the roundabout with the Old Kilmeaden Road are estimated to remain operating close to or above capacity.

Figure 11.4: Waterford city volume-capacity ratios, Base Scenario, 2012

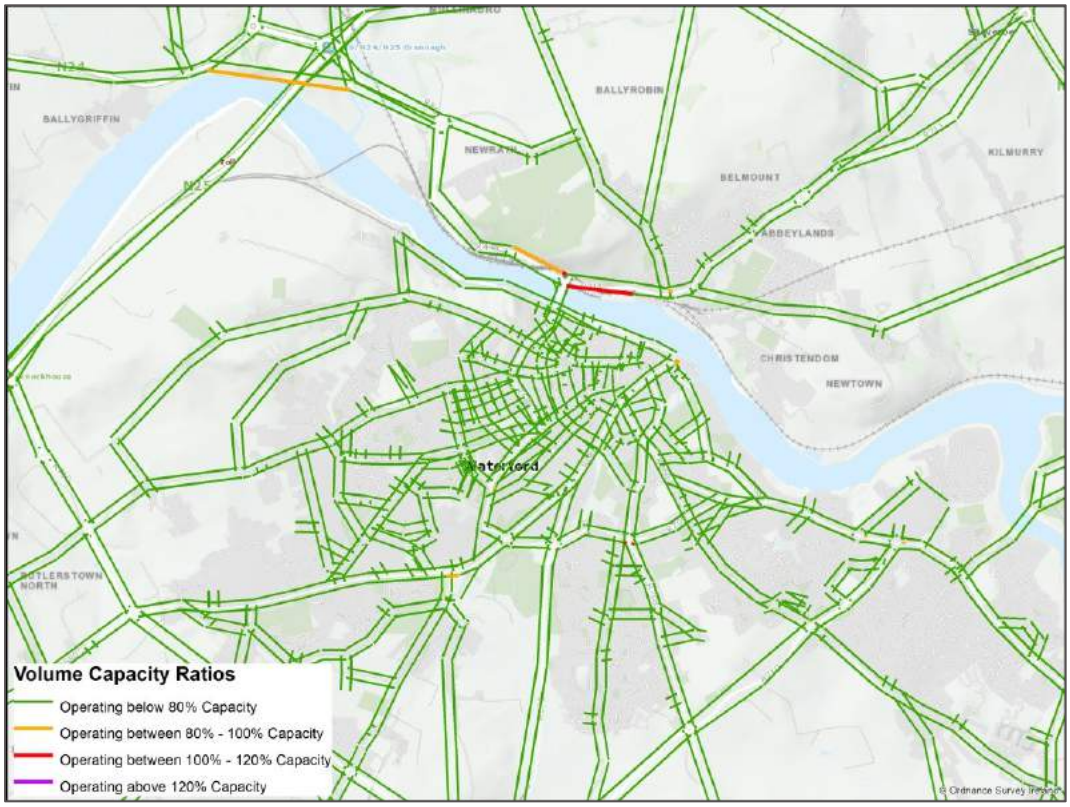


Figure 11.5: Waterford city volume-capacity ratios, Do-Nothing Scenario, 2040

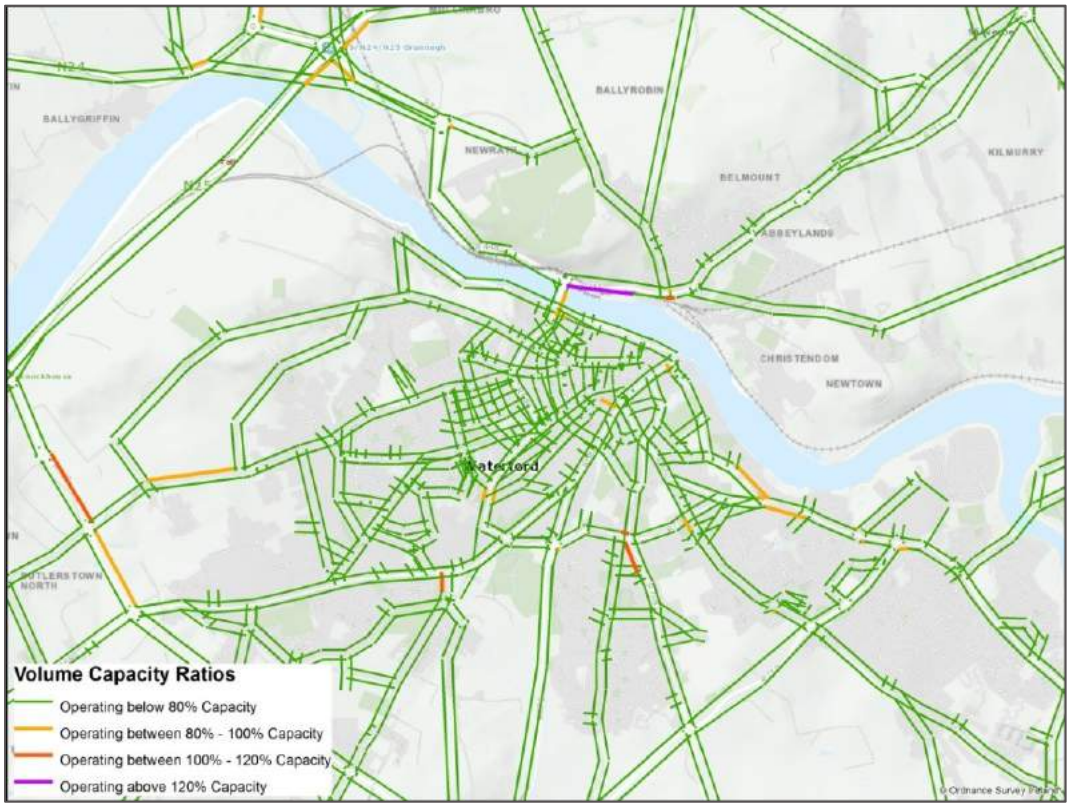
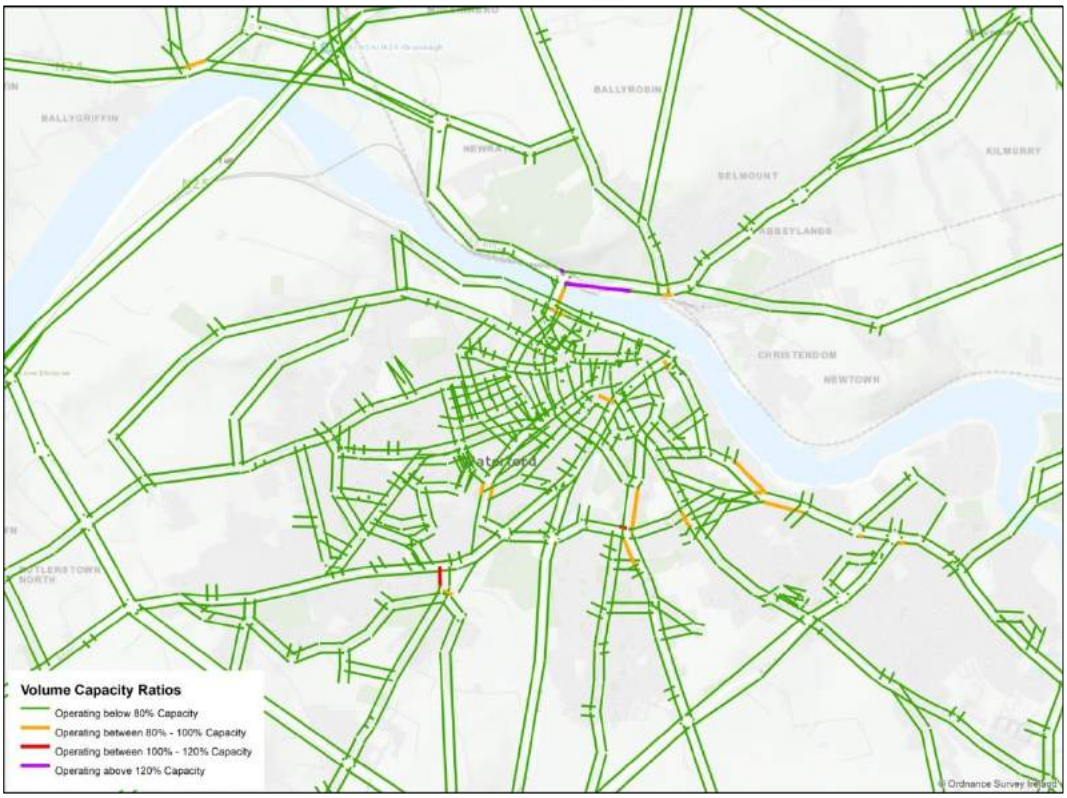


Figure 11.6: Waterford city volume-capacity ratios, Do-Minimum Scenario, 2040



Peak hour delays on links in Waterford city centre for the Base Scenario are illustrated in Figure 11.7. Compared with free flow most of the road network performs well in the Base Scenario. Areas where delay is an issue include the Dock Road, the Cork Road at Ballybeg Drive and the Newton Road.

Estimated delays on the Waterford city road network for the Do-Minimum Scenario are shown in Figure 11.8. With the population increase targeted by the NPF and associated rise in travel demand, there continues to be substantial delay on the Dock Road approaching the roundabout at Plunkett Station. Delays are also found on O'Connell Street at the junction with Bridge Street, and on Ballybeg Drive at the junction with Cork Road. Elsewhere in the city remains largely the same as the Base Scenario with delays of between 40 and 60 seconds on some roads and less than 40 seconds on others.

Peak hour delay is projected to remain an issue in the Do-Minimum Scenario, as shown in Figure 11.9, with negligible changes in the performance of the network compared to the Do-Nothing Scenario. The Dock Road approaching Plunkett Station and Ballybeg Drive at the Waterford Institute of Technology continue to experience significant delays while various other links around the city report delays in excess of 250% compared to free flow.

Figure 11.7: Waterford city percentage increase in peak hour journey times, Base Scenario, 2012

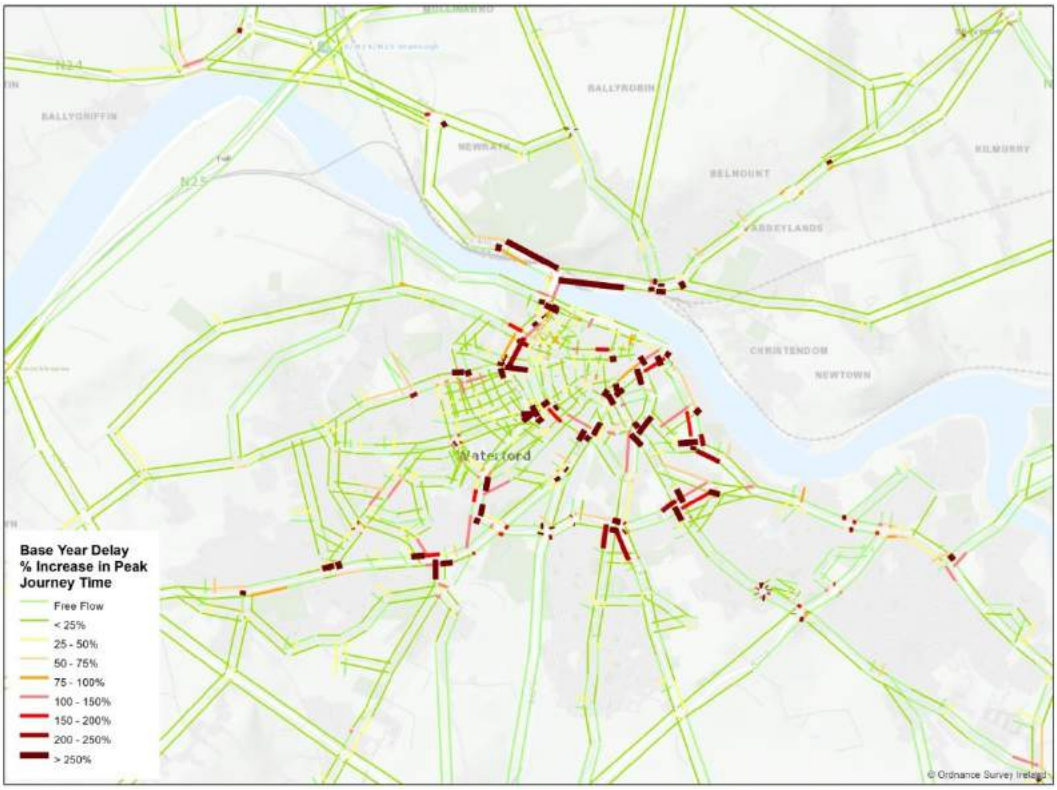


Figure 11.8: Waterford city percentage increase in peak hour journey times, Do-Nothing Scenario, 2040

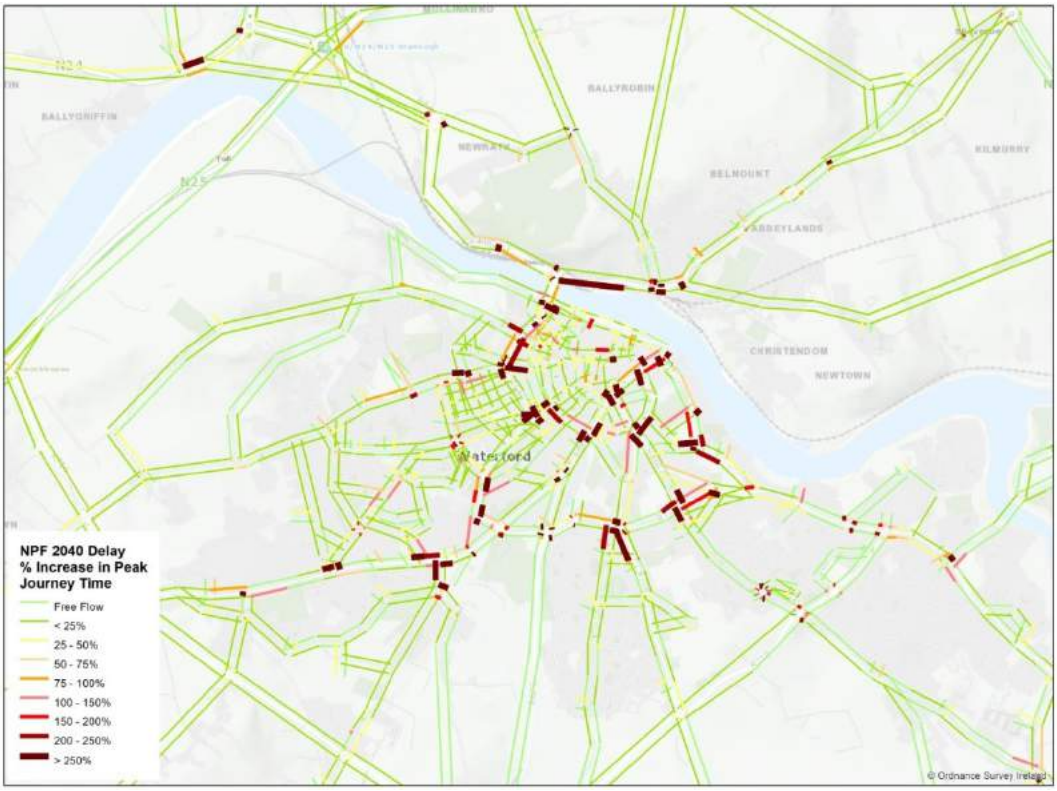
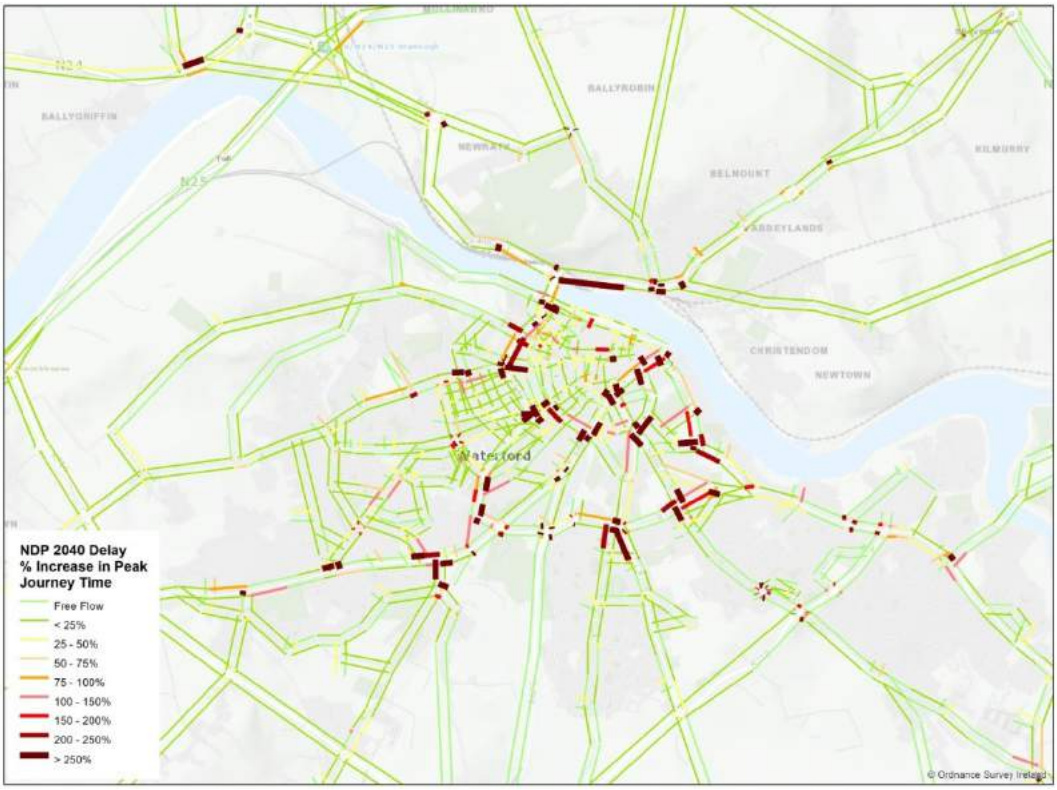


Figure 11.9: Waterford city percentage increase in peak hour journey times, Do-Minimum Scenario, 2040



11.5 Accessibility

Figure 11.10 illustrates generalised journey times to Waterford city centre by public transport in the Base Scenario. As discussed in Section 6.1.4, generalised journey times are a standard tool used in transport modelling but should not be interpreted as equivalent to actual journey times. In the Base Scenario, faster public transport generalised journey times are generally found to the east and southeast. The city centre can be accessed in 30 minutes or less from Passage Cross and Ferrybank and in 31 to 45 minutes from Woodstown, Belmont Park and Waterford Retail Park. Particularly long journey times of over 120 minutes are shown in Buckstown, Dunhill and Slaught.

Public transport generalised journey times to Waterford city centre for the Do-Nothing Scenario are illustrated in Figure 11.11. There is a marked increase in journey times compared to the Base Scenario. Journey times of between 30 and 45 minutes are mainly concentrated in a small area along the south bank of the River Suir as far as Waterford Regional Hospital, while accessibility to the city centre in an hour or less is restricted to areas such as Passage Cross, Blenheim Heights, along the Tramore Road to the east and south of the city, and Slieveroe in the north. Areas beyond those listed are estimated to experience higher journey times of 75 minutes or more, such as Passage East, Kilmacow, Dunhill and Portlaw.

Generalised public transport journey times to Waterford city centre in the Do-Minimum Scenario are presented in Figure 11.12. There is a marginal improvement in public transport generalised journey times compared to the Do-Nothing Scenario, particularly to the south and west of the city.

Figure 11.10: Generalised public transport journey time to Waterford city centre, Base Scenario, 2012

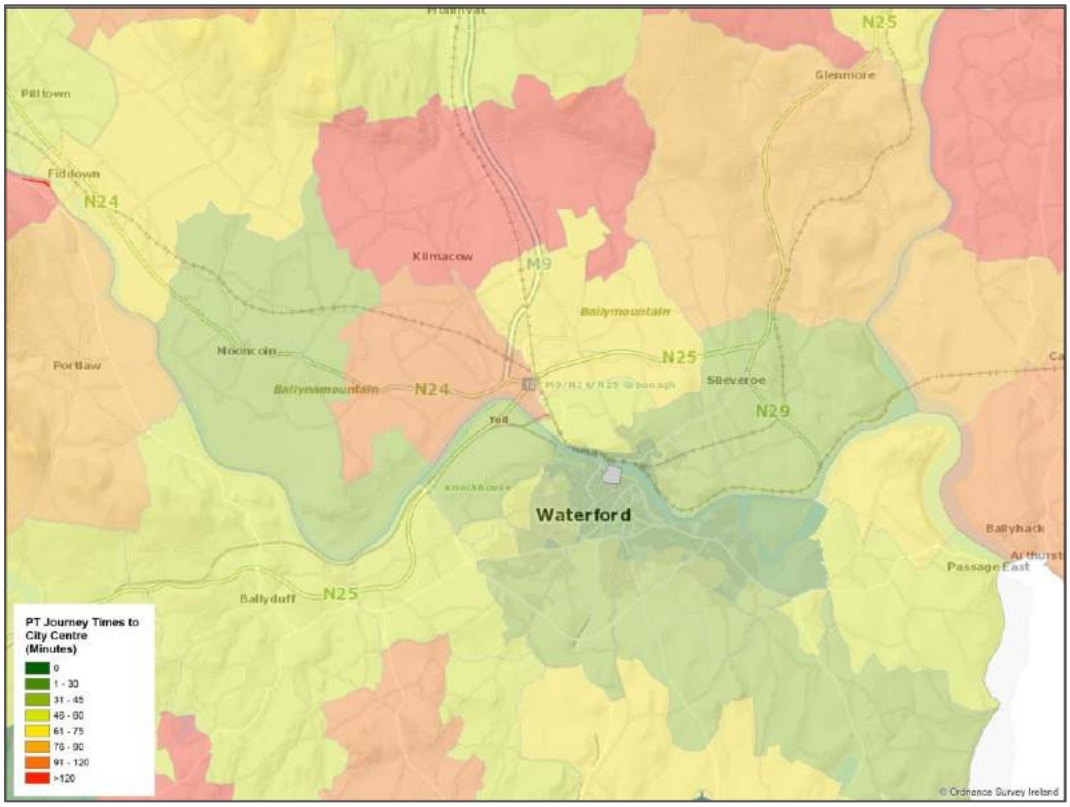


Figure 11.11: Generalised public transport journey time to Waterford city centre, Do-Nothing Scenario, 2040

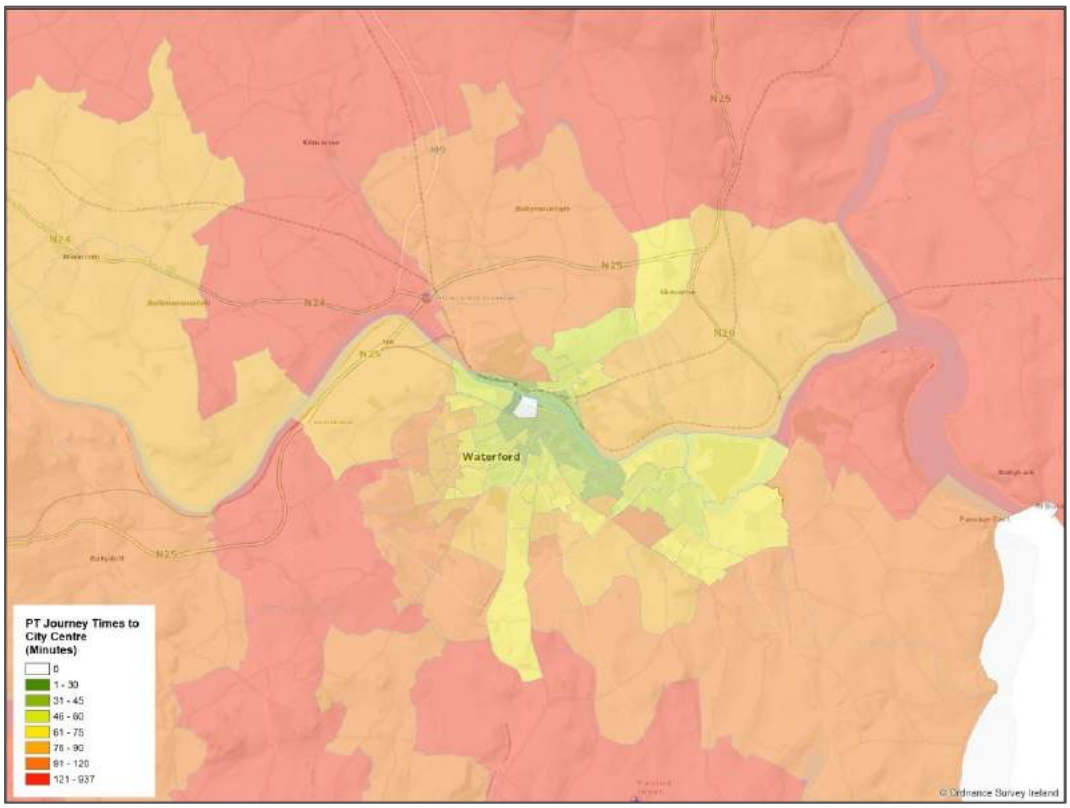
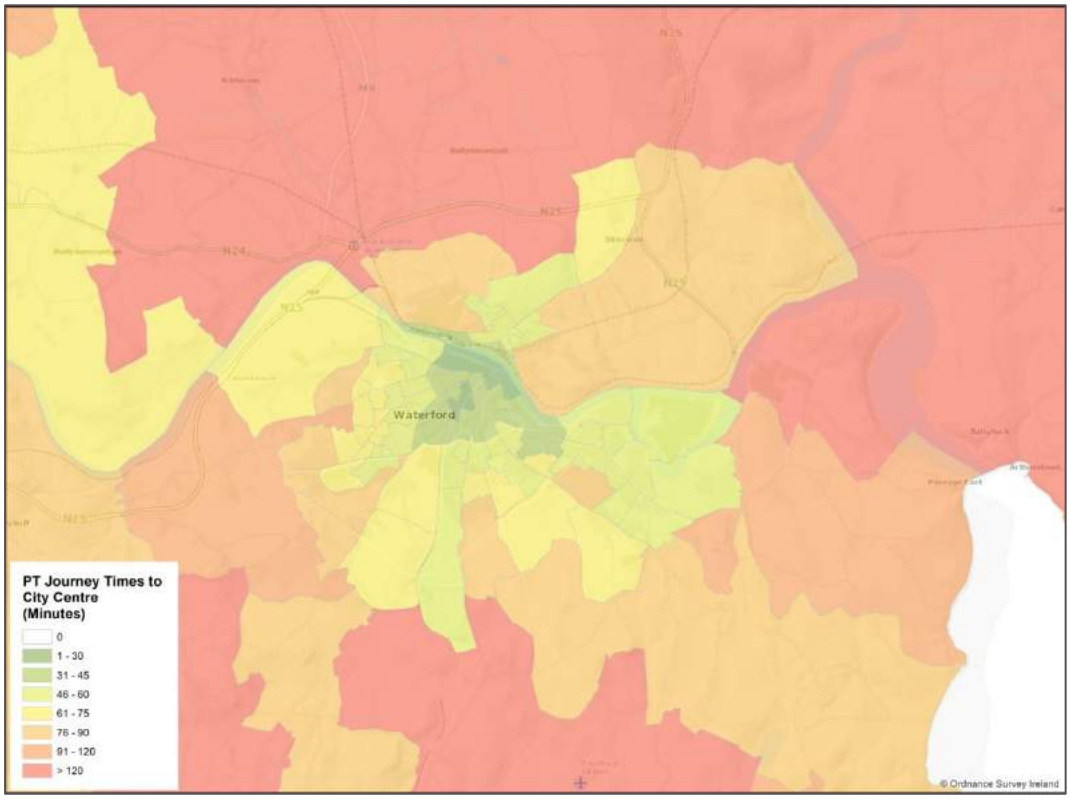


Figure 11.12: Generalised public transport journey time to Waterford city centre, Do-Minimum Scenario, 2040



Generalised journey times to Waterford city centre by car in the Base Scenario are shown in Figure 11.13. In the Base Scenario the area that can access the city centre by private car in 30 minutes or less is concentrated along the M9, N25 and N29. Journey times of 30 to 45 minutes exist from areas such as New Ross, Kilkenny and parts of Clonmel. From Enniscorthy and Kilmore Quay journey times of between 60 and 75 minutes were estimated, while from Thurles it is 76 to 90 minutes.

Generalised journey times by car to Waterford city centre in the Do-Nothing Scenario are presented in Figure 11.14, which shows an increase in car journey times and a noticeable reduction in the area within which trips of 30 minutes or less and 30 to 45 minutes are possible. In areas such as Clonroche and Clonmel, generalised journey times to Waterford city centre have increased to 45 to 60 minutes, while in Enniscorthy the journey time has increased from 60 to 75 minutes to between 90 and 120 minutes.

Generalised journey times by car to Waterford city centre in the Do-Minimum Scenario, illustrated in Figure 11.15. The picture is relatively similar to the Do-Nothing Scenario but there are some improvements as a result of NDP investment. To the east and northeast of the city, generalised journey times have improved by up to 30 minutes.

Figure 11.13: Generalised car journey time to Waterford city centre, Base Scenario, 2012

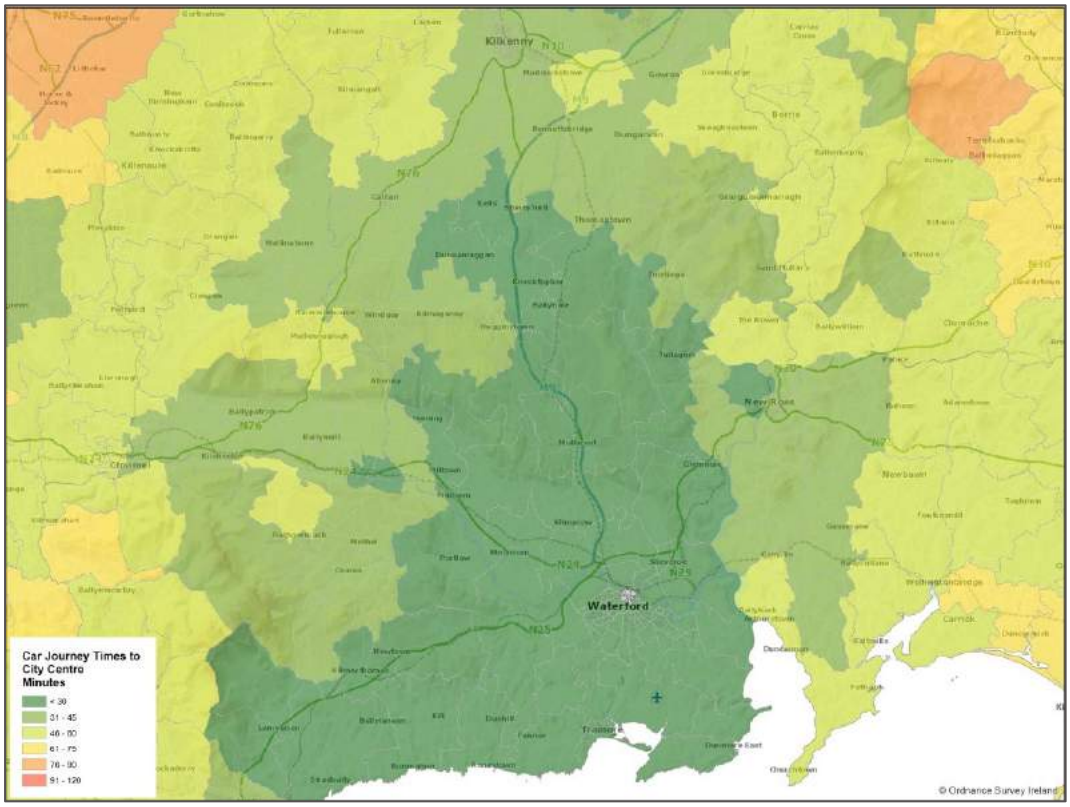


Figure 11.14: Generalised car journey time to Waterford city centre, Do-Nothing Scenario, 2040

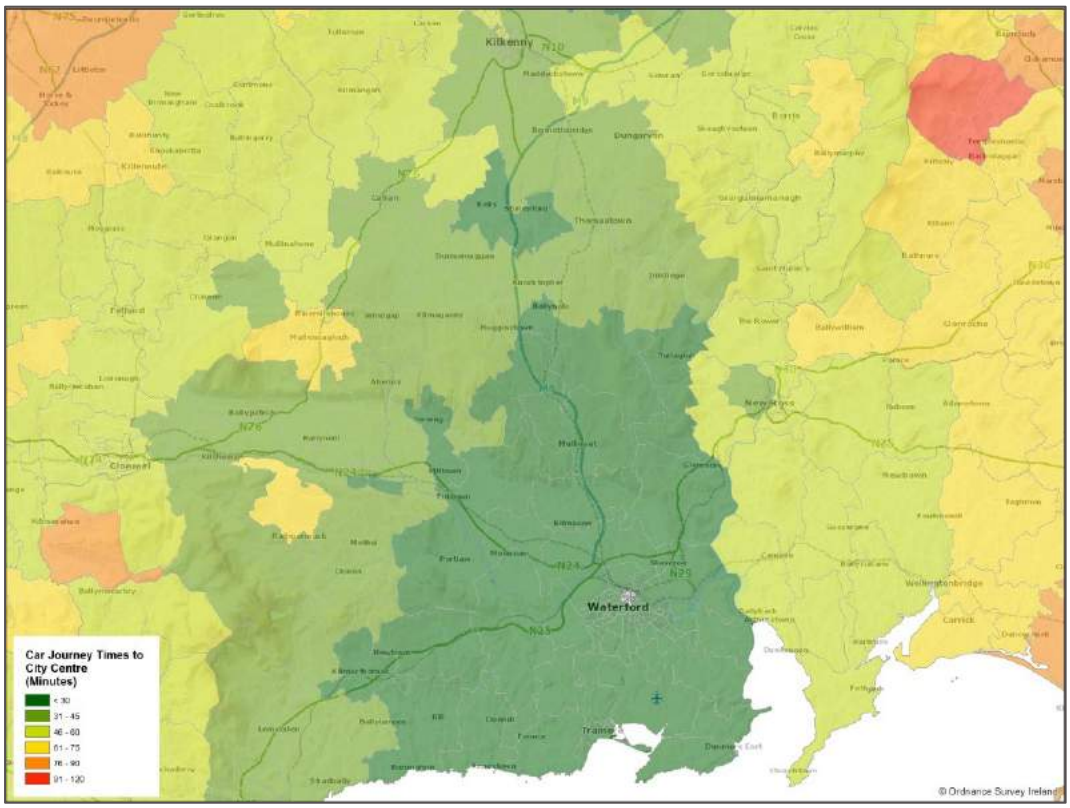
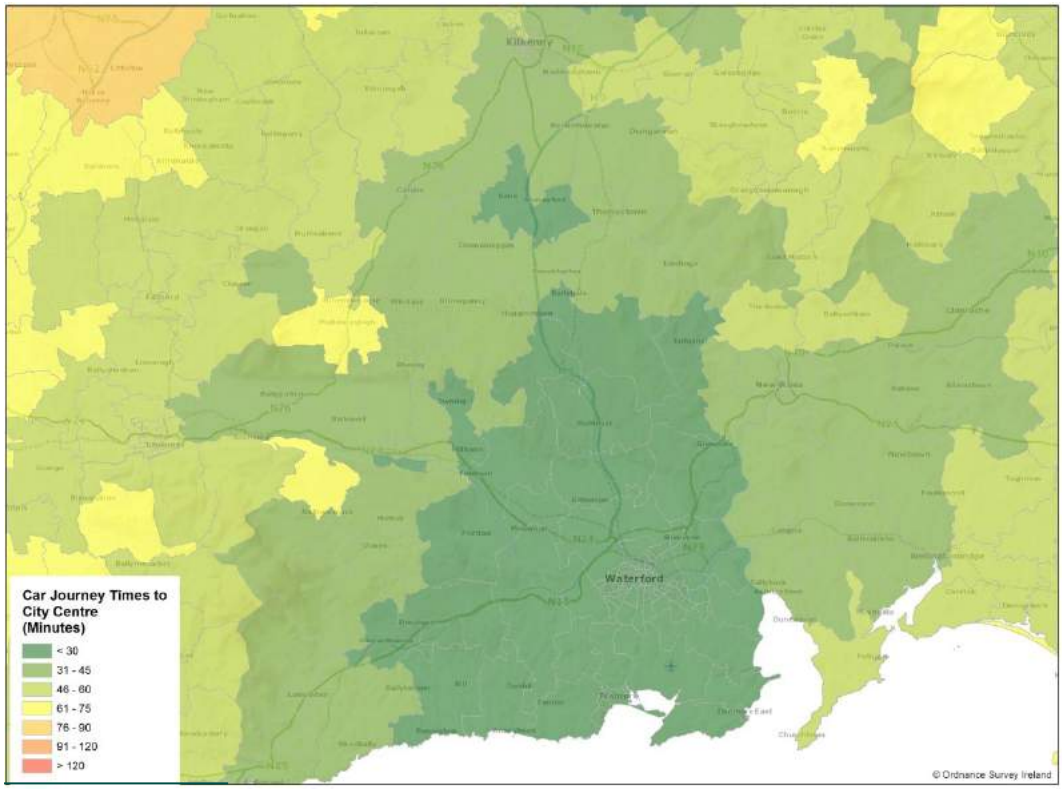


Figure 11.15: Generalised car journey time to Waterford city centre, Do-Minimum Scenario, 2040



11.6 Summary

Overall, the modelling estimates that there will be an 11% increase in trips in the South-East Region between 2012 and 2040, from 1.3m to 1.5m. In the Do-Minimum Scenario it is estimated that 25% of these trips will be taken by sustainable modes, which represents an increase of eight percentage points when compared to the Base Scenario. Within Waterford city, the number of trips is estimated to increase by 29%, from 162,000 to 212,000. 45% of these journeys are estimated to be made by sustainable modes in the Do-Minimum Scenario, which represents an increase of nine percentage points when compared to the Base Scenario.

Aside from increasing the sustainable transport mode share, between the Do-Nothing and Do-Minimum scenarios the modelling indicates that NDP investment will have some positive impact on capacity issues in the west of the city, though lengthy delays will remain an issue close to Plunkett Station and the Waterford Institute of Technology. The impact of NDP investment on car and public transport generalised journey times between is also positive, albeit only leading to marginal improvements in each case.

12. Consideration of Interventions

How transport can facilitate the Project Ireland 2040 National Strategic Outcomes was discussed in Section 5, while the urban modelling exercises discussed in the previous sections have identified areas where the transport network may be operating under constraint by 2040 in the absence of interventions beyond those included in the NDP. This gives an indication of the types of issues that future transport investment will have to address if it is to enable Project Ireland 2040.

It must be emphasised, however, that for the purposes of modelling the future population of Ireland's five cities has been assumed and is consistent with the achievement of NPF targets. In reality, if our urban transport networks do not operate efficiently and effectively the cities will not be attractive places to live and work. People will be deterred from living in them and the objective of compact growth will be undermined. As such, identifying and tackling issues on the land transport network in a timely fashion will be a key enabler of Project Ireland 2040.

The following section will outline where the main areas of constraint emerging from the modelling are in each of Ireland's five cities. Drawing on national transport strategies and international case studies, it will then consider the types of interventions that might address these issues. Finally, consideration will be given to how the transport network can support compact growth in smaller urban areas.

12.1 Projected Constraints

Within Dublin city, daily trip volumes are estimated to grow by 16% to 2.8m by 2040, with 52% of these journeys made by sustainable modes. There are, however, widespread capacity and delay issues on the road network, particularly on and around the North and South Circular Roads, the north inner city including the IFSC, and in the vicinity of Stephen's Green. Accessibility to the city centre for car is reduced, though investments in public transport are projected to increase the one-hour catchment area for bus and rail services. Overall, the main issue identified by the modelling is widespread congestion.

For Cork city, which in proportional terms is targeted to experience the largest increase in population and travel demand, the average daily number of trips is projected to grow by 49% to 667,000 by 2040. Between the Base Scenario and 2040 investment in public transport is expected to see its mode share grow significantly from 9% to 15%, with private care use falling from 57% to 54%. However, the combined active travel mode share declines by 3 percentage points. Given the large increase in travel demand, many links in the road network are expected to experience capacity and delay issues, particularly crossings of the River Lee and to the northeast of Kent Station. City centre accessibility in terms of car journey times is reduced but considerably improved for public transport. Overall, the main issues for Cork identified in the modelling are the decline in active travel mode share and urban congestion.

Galway is expected to experience a 48% growth in average daily trips to 393,000 in 2040. Of these trips, 68% are expected to be made by private car, only a modest fall from 69% in the Base Scenario. Public transport is expected to increase its mode share to 11% from 9% in the Base Scenario but active travel is virtually unchanged. With the introduction of the Galway City Ring Road much of the congestion in the city centre is alleviated, though key junctions still report capacity and delay issues in the northeast of the city. City centre accessibility is reduced for

car journeys but slightly improved for public transport. Overall, the main issues in Galway identified by the modelling are congestion at key junctions and the persistently high car modal share.

In Limerick, the average number of daily trips is expected to increase by 41% to 343,000 by 2040. Within this total, the car modal share is expected to increase by ten percentage points to 59%, although that must be caveated by the fact the Base Scenario may model an artificially low car modal share for 2012. Public transport and cycling are unchanged at 10% and 3% respectively, while walking is projected to fall by nine percentage points. Generally speaking, congestion is not projected to be a widespread issue the city, though some links do report capacity and delay problems in 2040 such as the Sarsfield Bridge and Island Road. Accessibility to the city centre by car is expected to deteriorate slightly from the Base Scenario but NDP investment will see accessibility and journey times improve by public transport. Overall, the main issue for Limerick is congestion on certain links.

Finally, in Waterford the average number of daily trips is projected to grow by 29% to 212,000 by 2040. 55% of trips are expected to be made by car, a fall of nine percentage points, while public transport and walking are projected to increase, by seven and one percentage points respectively. Cycling remains at 1% of trips. Broadly speaking, the existing Waterford road network is expected to be able to cope with increases in travel demand, though some targeted interventions may be required in the city centre and in the vicinity of Plunkett Station. Compared to the Base Scenario, journey times are expected to lengthen and accessibility worsen for trips by both car and public transport.

12.2 Interventions

A consistent constraint emerging in the modelling is urban congestion, especially in Dublin and Cork. Given the lack of space within developed city centres, this issue will primarily have to be addressed by encouraging modal shift and deterring traffic from the city. The provision of park and ride at strategic locations beyond the cities can increase the catchment of public transport and provide an alternative means of reaching the city centre. Within the cities themselves, frequent and reliable public transport services and high-quality active travel infrastructure can also discourage people from travelling by car. Car travel is also dependent on the availability of parking close to destinations which, if gradually reduced, could serve as a further disincentive to drive. Finally, options such as congestion charging could also be explored.

To ensure that the entire city transport network operates efficiently, it is important that bottlenecks at key junctions and links are addressed. It is notable that may of the links experiencing capacity issues in the modelling are adjacent to public transport hubs, such as train stations, or are links with few alternative routes available, such as bridges and roundabouts. Investment beyond the city can help to address these pressures if traffic is diverted from entering the city centre, which the modelling indicates will be a result of the Galway City Ring Road. As far as possible, infrastructure investment should take trips out of cities which do not necessarily need to be there, such as heavy goods vehicles travelling to ports.

Achieving modal shift away from the private car and towards sustainable modes will help to alleviate issues of congestion and will also be crucial to decarbonising the transport sector. Generally speaking, the modelling suggests NDP investment will lead to increases in public transport usage but not in active modes. This may partly be the result of more attractive public transport options being available and, in the absence of detailed network designs, journey time proxies were applied for cycling in Galway, Limerick and Waterford which may not be an

accurate reflection of the final cycle networks. Investment in good quality cycling infrastructure, including segregated lanes, parking and bike sharing, has been a driver of modal shift elsewhere, such as the example of Copenhagen discussed in Section 4.

As part of Project Ireland 2040, a number of sites have been identified within the existing footprints of our cities for special development. The experience of Freiburg, as discussed in Section 4, is worth bearing in mind as these areas begin to develop. Interventions to encourage modal shift have been found to be much more effective just after someone moves house rather than after they have become settled. Many areas earmarked for development are located adjacent to existing rail links but in others there may be an opportunity to encourage modal shift by ensuring that services and infrastructure are in place when people move in.

12.3 Other Urban Areas

Besides the five cities, there are 41 towns in Ireland with a population exceeding 10,000, accounting for 16% of the total population, and 200 urban settlements with populations exceeding 1,500, accommodating 63% of the population (Government of Ireland, 2018b). For smaller urban areas, it is likely that the private car will continue to be the predominant mode of transport. However, as discussed in the previous subsection, the provision of park and ride facilities can help to mitigate the need for commuters from these towns to drive into the cities. Smaller urban areas, by virtue of their size, are also particularly conducive to active modes while investment in greenways can serve a transport as well as a tourism function. For particularly large towns, such as Drogheda and Dundalk, a further key question will be the point at which urban bus services are introduced.

13. Conclusions

This paper has considered how the Project Ireland 2040 objective of compact growth can be supported by the transport system, particularly in the cities. Achieving this goal will be key to ensuring that our cities develop in a sustainable manner, that residents enjoy a good quality of life and that Ireland can meet its climate change commitments. Good examples of transport facilitating compact growth in Freiburg, Copenhagen, Malmö and Amsterdam through the integration of land use and transport planning, provision of high-quality infrastructure and targeting interventions at key points of transition in people's lives were considered.

Within our urban areas, delivering a transport network capable of supporting the population targeted by the NPF and realised Project Ireland 2040 will require addressing urban congestion, ensuring accessibility to employment and achieving modal shift to sustainable modes. Using the NTA's five regional models, a number of scenarios were analysed to understand how the transport network performs against these metrics today, with the increased travel demand arising from NPF population projections out to 2040, and finally with that travel demand and also committed NDP investment to 2027. This incremental analysis helps to isolate which elements of the network improve and deteriorate over time, the impact of investment, and identify areas of potential future constraint to be prioritised for future investment. If such constraints are left unaddressed, it is likely the transport network will undermine Project Ireland 2040's spatial objectives rather than supporting them.

Key issues emerging from the modelling include widespread urban congestion in Dublin and Cork, capacity issues on key links such as roundabouts and bridges and a relatively low level of modal shift, particularly for active travel. While this modelling should only be seen as indicative of potential future issues, investment in high-quality active travel and public transport infrastructure can both address congestion and help to encourage further modal shift and ensure that Ireland's cities are attractive places to live and work.

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Appendix 1: Modelling Boundaries for City Areas

Figure A1.1: Dublin city modal share modelling area

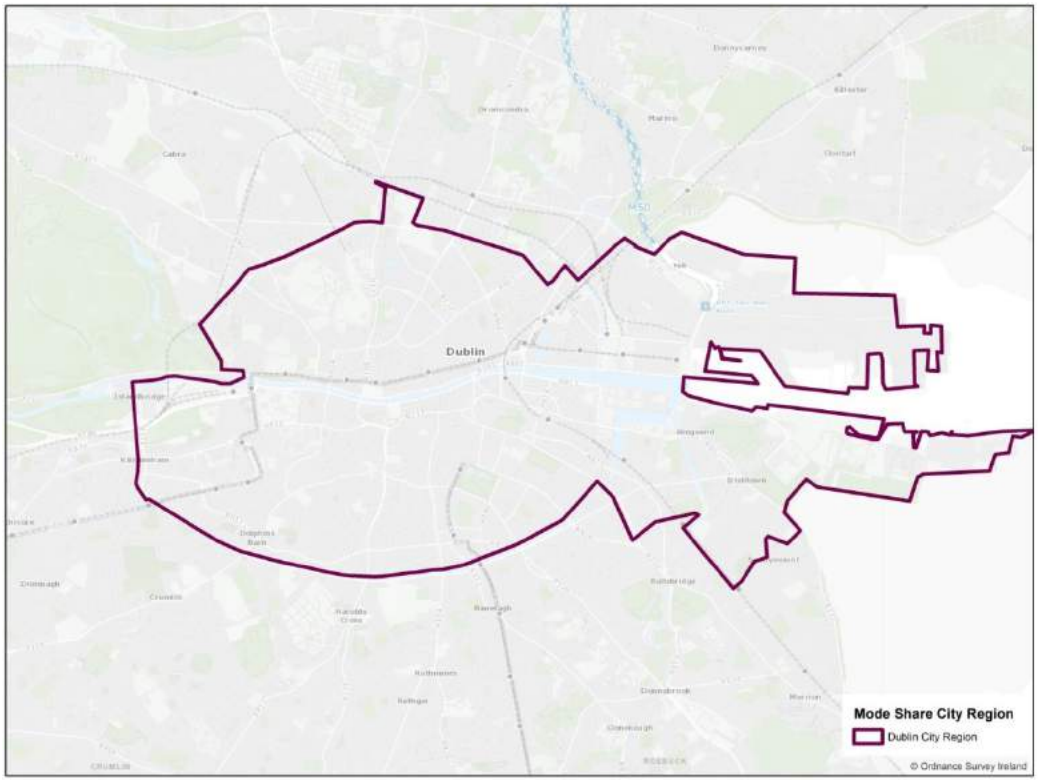

Figure A1.2: Cork city modal share modelling area

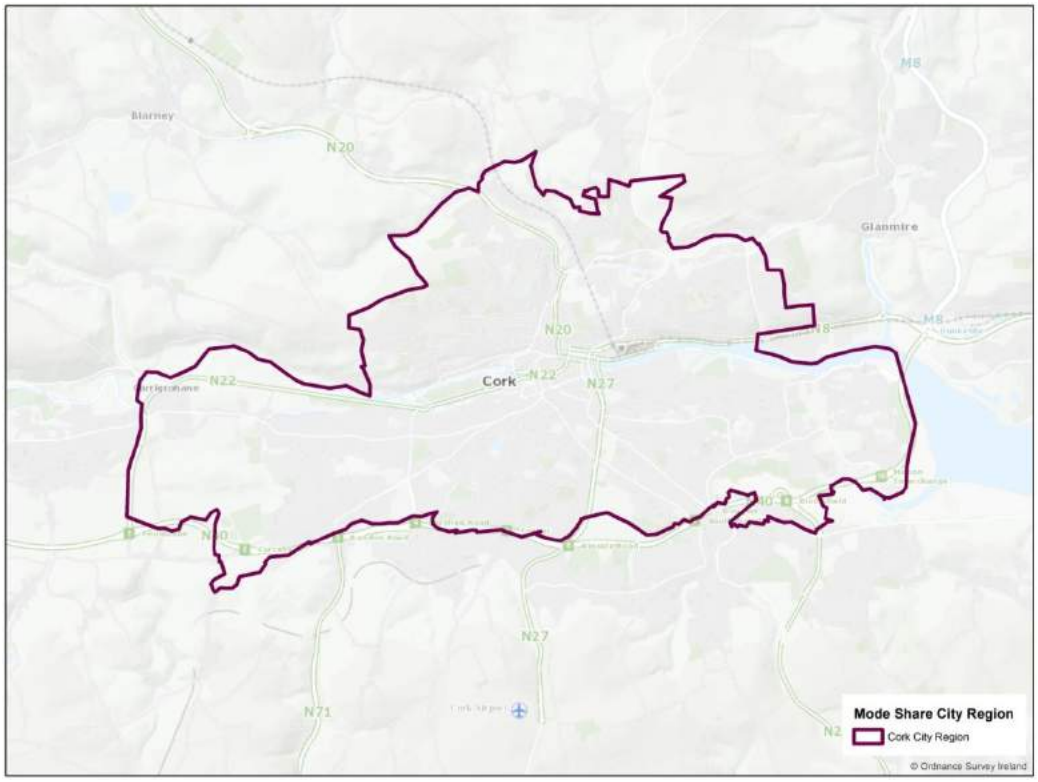

Figure A1.3: Galway city modal share modelling area

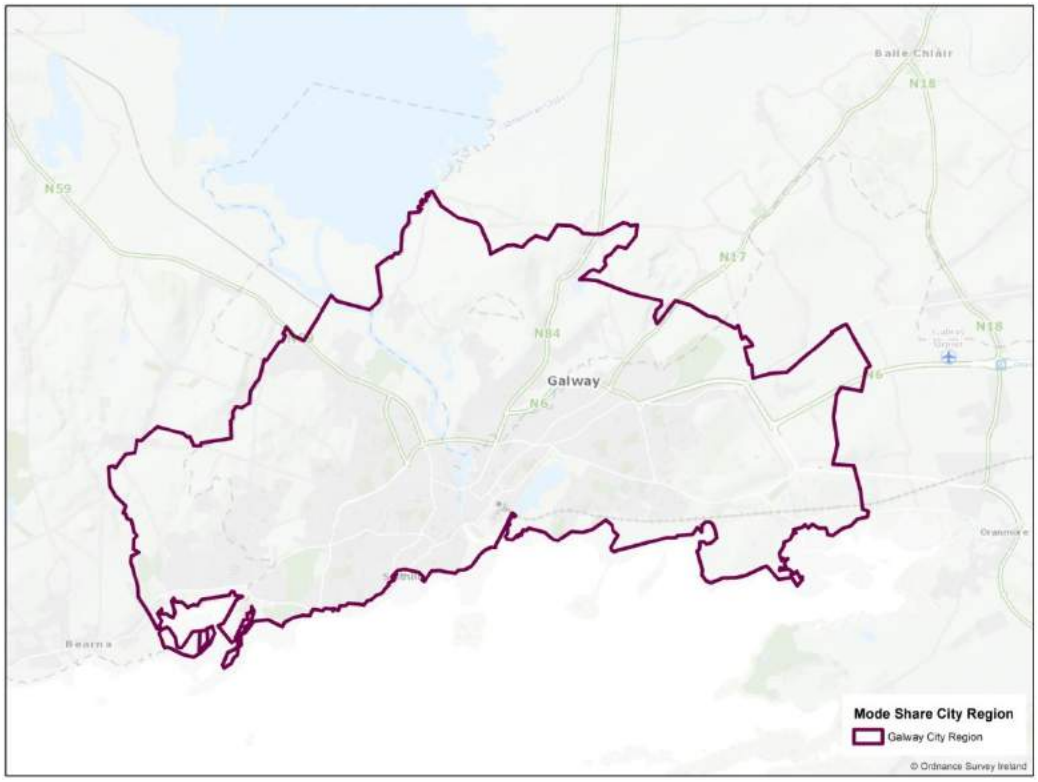

Figure A1.4: Limerick city modal share modelling area

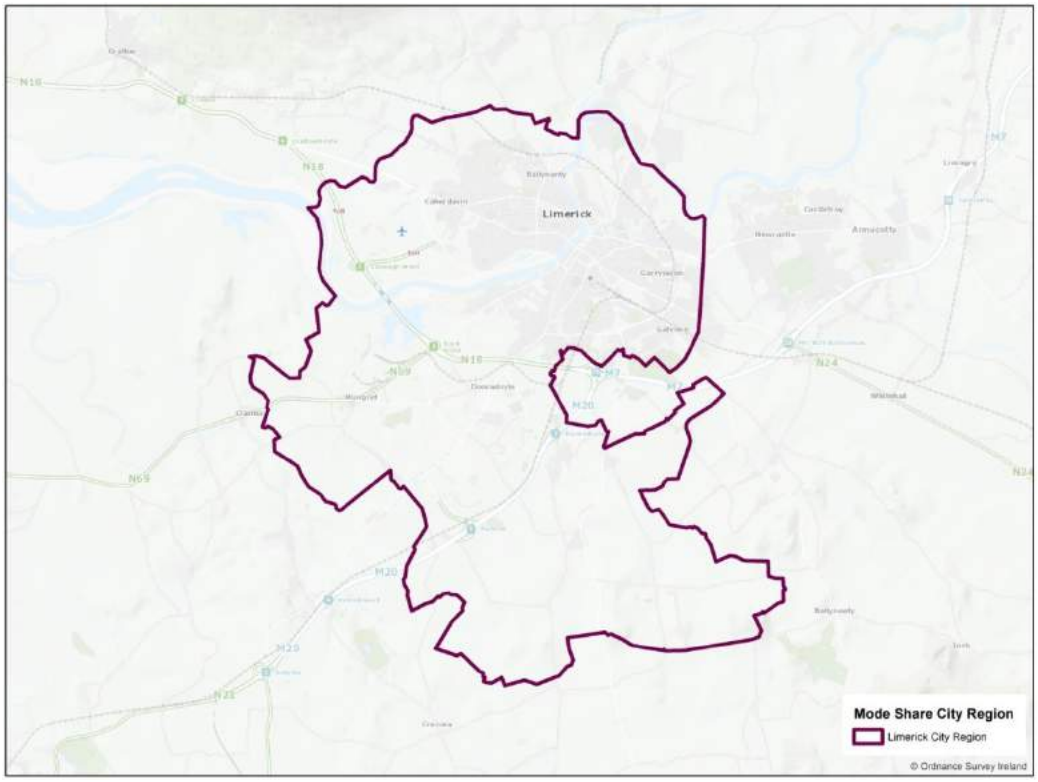

Figure A1.5: Waterford city modal share modelling area