Sustainable Travel Demand

Goodbody Economic Consultants
Ballsbridge Park, Ballsbridge, Dublin
Tel: 353-1-641-0482
Fax: 353-1-668-2388
www.goodbody.ie
e-mail – econsultants@goodbody.ie

In Association With
The Department of Urban & Regional Planning UCD
&
Oscar Faber Transportation

Table of Contents

Executive Summary

This report investigates the relationship between settlement patterns and sustainable transport. This work is a crucial element in determining the strategic transportation issues that impinge on economic growth and sustainable development in the context of the National Spatial Strategy. It will also be essential to the task of identifying the capacity for expansion of existing urban areas and the identification of additional gateway centres.

Sustainable development may be defined briefly as concerned with maintaining and enhancing the quality of human life - social, economic and environmental - while living within the carrying capacity of supporting eco-systems and the resource base. Sustainable transport may be defined as transport systems and policies that contribute to this aim.

The pursuit of sustainable development is a key component of land use and transportation policy in Ireland. This has manifested itself through inter alia:

- The incorporation into land use planning policies of the concept of the minimisation of potential growth in transport demand;
- Government support for improved public transport systems and infrastructure, as a means of improving public transport's market share;
- The enhancement of facilities for non-motorised modes; and
- The introduction of tax incentives and other measures to encourage use of more fuel-efficient road vehicles.

There is a general agreement in the literature that the following factors have a positive role in promoting sustainable transport:

- Higher densities;
- Mixed land uses;
- Compact settlements; and
- Concentration of development on transport corridors.

However, the scope for settlement policies to influence sustainable transport may be more limited than is often thought. This is because of the fixity of much of existing land uses, the degree to which existing settlement patterns already support sustainable transport, and the extent to significant segments of the population are already reliant on sustainable transport modes.

While there is a general tendency for sustainability to increase with settlement size, transport sustainability may be more a reflection of settlement patterns within the urban area rather than settlement size. This view is confirmed by an analysis of transport sustainability in Irish towns. Within urban areas in Ireland, use of sustainable transport modes increases somewhat with settlement size. However, use of sustainable transport modes shows a wide variation for towns

of a given population size. It is clear that the settlement pattern and function of individual towns are more important determinants of sustainable transport use.

There is some tendency for long trip lengths to occur more frequently in larger towns. However, it is again evident that that there is considerable variation among towns of the same size, indicating that other factors, such as the settlement pattern, are more important in determining trip lengths. However, larger conurbations do encourage longer trip making.

Within the above context it is generally held that settlements below 25,000 may perform relatively poorly in terms of sustainability. The threshold level for the development of local bus services would also appear to be at approximately this level.

Apart from the major urban areas, only four towns in Ireland have a population over 20,000 (Dundalk, Bray, Drogheda and Swords). This inhibits the development of local bus services. Expansion of town size to the threshold level for bus operations is a factor to be considered when identifying appropriate urban scale in the context of the National Spatial Strategy.

The vast majority of autonomous Irish towns achieved reasonable levels of transport sustainability in 1996, largely by virtue of the use of walk and cycle modes. However, use of sustainable transport modes declined rapidly during the period 1986-96, and the latest evidence for the year 2000 suggests significant further decline. Walk, bus and cycle modes experienced the greatest decline. It is only in the larger conurbations that public (bus) transport makes a significant contribution to sustainability, although public transport use does rise with town size. Even among the larger conurbations, it is only in Dublin that public transport use is high.

The decline in transport sustainability is largely the result of increasing car ownership. However, the separation of home and workplaces and the consequent increase in trip lengths would appear to be a contributory factor.

The rapid decline in the use of sustainable transport modes may mean that in future, the car will dominate to an even greater degree. Given the small population size of many Irish towns, local bus operations may not be viable. This will mean that there will not be a viable public transport alternative to the car, and there will be a continued transfer from walk and cycle modes. In the context of the National Spatial Strategy, this argues strongly for the development of Irish towns, to a scale above the threshold level for the introduction of local bus services.

The analysis of Irish data showed that dormitory towns generally have low levels of transport sustainability, except where public transport provision and particularly rail service levels are high. The international literature shows that it is difficult to achieve self containment in new settlements in terms of a balance between the number of jobs and resident workers in the town. These findings

highlight the dangers in the concentrated decentralisation approach to urban development. Giving the difficulties of ensuring that local residents take local jobs, especially in the light of increasing job mobility, satellite towns will have negative impacts on sustainability unless they are well served by public transport,

As the larger conurbations grow, commuting trip length increases and this reduces the use of walk and cycle modes. In Dublin, public transport has taken the place of these modes to a significant degree, thus maintaining a high level of sustainable transport mode use. However, public transport (bus) use in other conurbations, especially Cork, has not increased in a similar fashion, so that they perform relatively poorly in terms of use of sustainable transport modes. Given the scale of Irish towns outside of Dublin, expansion of public transport services will be based largely on the bus mode. This argues for an enhancement of bus services in Cork, Limerick, Galway and Waterford.

Apart from Dublin, the other major urban areas are not, in general terms, close to a scale that would support significant LRT or Metro systems.

Suburban rail operations will also contribute to sustainability where there are significant dormitory towns in the hinterland of major urban areas, but at some distance. The obvious locations in which suburban rail operations could be extended are in Limerick and Cork.

With regard to the framing of a spatial strategy, the analysis presented in this study suggests that town size is not a dominant factor in determining the sustainability of transport. Provided appropriate settlement patterns are encouraged, the development of larger towns should not result in unsustainable transport patterns. However, in practice, this is likely to require a significant expansion of public transport provision.

1 Introduction

1.1 General

This report investigates the relationship between settlement patterns and sustainable transport. The study is essentially aimed at:

- Establishing the relationship between concentrated and dispersed settlement patterns and trip generation and modal choice;
- Establishing viability thresholds for sustainable transport solutions, including public transport modes; and
- Evaluating the potential for improved inter-regional linkages using under-utilised infrastructure or corridors.

This work is a crucial element in determining the strategic transportation issues that impinge on economic growth and sustainable development. It will also be essential to the task of identifying the capacity for expansion of existing urban areas and the identification of additional gateway centres.

This report is laid out as follows. Section 2 discusses the concepts of sustainable development and sustainable transport modes and travel patterns. In Section 3, a review of the evidence on settlement patterns and sustainable transport is presented. Section 4 discusses viability thresholds for public transport modes. Trends in sustainable transport are outlined in Section 5. The relationship between settlement patterns and sustainable transport is further explored in Section 6, using Irish data. The evidence on regional strategies and sustainable transport is set out in Section 7. Section 8 discusses the implications for policy and particularly land use and regional policies in Ireland.

2 General

2.1 Defining Sustainability

Sustainable development may be defined briefly as concerned with maintaining and enhancing the quality of human life - social, economic and environmental - while living within the carrying capacity of supporting eco-systems and the resource base. [1]

Sustainable transport may be defined as transport systems and policies that contribute to this aim.

In practice, sustainable transport policies are concerned principally, but not exclusively, with constraining the use of fossil fuels. The latter are not only considered an exhaustible resource, but also have a direct relationship with emissions from the transport sector and therefore with environmental pollution and global warming.

Constraining the use of fossil fuels is essentially concerned with:

- Keeping the quantity of travel to the minimum necessary; and
- Ensuring that where mechanised transport modes are used, these are efficient both in terms of fuel use and occupation of road space.

In relation to modes of travel, the car mode is generally seen as contributing little to sustainability. This is because:

- Cars often have poor occupancy, reducing their fuel efficiency per passenger; and
- They are inefficient in their use of road space, imposing congestion costs on other road users.

In contrast, public transport modes, because of their higher occupancies and better use of road space, are usually considered to be sustainable transport modes.

Similarly, walk and cycling modes, which do not make use of fossil fuels, quite clearly contribute to sustainability objectives.

Where use of sustainable transport modes is high, the 'carrying capacity' of urban area will be enhanced and sustainable development objectives promoted.

Because of the above considerations, in terms of the setting of targets for future levels of sustainability, the majority of policies and policy makers tend to describe their headline aspirations in terms of modal shift. This on its own, however, does not fully describe how best sustainability is, or can be, achieved. A more appropriate, though more difficult-to-quantify measure, relates to energy

1. Sustainable Settlements - A Guide for Planners, Designers, and Developers, Faculty of the Built Environment, University of the West of England, 1995.

usage per person. This enables the three main dimensions of travel (mode, distance and frequency) to be combined in one composite measure. In examining the relationship between settlement patterns and sustainable transport in this report, consideration is therefore given not only to the evidence on patterns that influence mode choice and trip length, but also to those that influence transport energy consumption as a whole.

2.2 Settlement Patterns and Sustainable Transport

Settlement patterns may promote sustainable transport in a number of ways. High density settlements tend to have lower car ownership levels for a given income level, and density also contributes to the viability of public transport systems. High density may also encourage walk and cycling modes and reduce journey lengths. The location of jobs is also important. Mixed-use settlement forms, in which jobs and residences are relatively close, encourage short trips and use of walk and cycle modes. The 'job ratio' calculated as the number of jobs within an area as a proportion of the labour force within the same area is a good indicator of the level of mixed use in settlements. [2]

Settlement forms, which are compact and contain mixed uses that encourage autonomy, are likely to promote sustainable transport. In contrast, settlements that are low density and do not have mixed uses promote trip generation and longer trip lengths. Longer trip lengths and dispersed settlement pattern in turn encourage car use.

2.3 Sustainable Transport Policies in Ireland

The pursuit of sustainable development is a key component of land use and transportation policy in Ireland.[3] This has manifested itself through inter alia:

- The incorporation into land use planning policies of the concept of the minimisation of potential growth in transport demand;
- Government support for improved public transport systems and infrastructure, as a means of improving public transport's market share;
- The enhancement of facilities for non-motorised modes; and
- The introduction of tax incentives and other measures to encourage use of more fuel-efficient road vehicles.

An overview of UK policies is presented in Appendix 1.

2. Op.cit.
3. See Sustainable Development: A Strategy for Ireland. Department of the Environment, 1997

3 The International Evidence on Settlement Patterns and Sustainable Transport

3.1 Introduction

In this section, the role of patterns of development in promoting sustainability in transport is explored. A number of the factors, which are believed to play a role in determining the sustainability of a settlement, are examined. These are:

- Urban form;
- Mixed uses;
- Compact settlements;
- Population size;
- Corridors; and
- Densities.

The relationship between sustainable transport and settlement patterns is considered at the disaggregate or micro level, leaving a discussion of the role of regional and local strategies as a whole to Section 6 below. It should be noted that most of the available evidence derives from modelling exercises, rather than actual measurements of the results of sustainable development policies in practice. Some caution must therefore be exercised in using them as a guide to policy.

The section begins by reviewing recent literature on the factors that affect sustainability, as outlined above. The feasibility (or otherwise) of implementing these development guidelines in order to achieve sustainability is then considered. Finally, an attempt is made to draw some of the ideas together to consider how the ideas may have a place in the context of developing towns in Ireland.

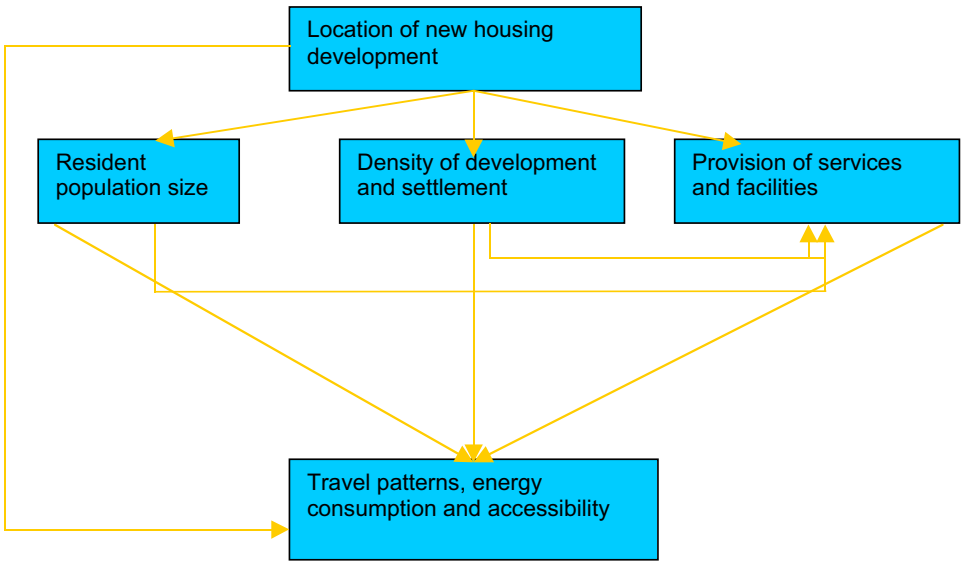
3.2 Relationship Between Sustainable Development and Travel Patterns: Evidence from the Literature

The impact that urban form has on travel patterns and accessibility was considered as part of a recent research overview[4]. This review focused on the relationship between urban form, distance travelled, modal split, energy consumption and access to facilities and services. The study concluded by suggesting future housing strategies that may lead to higher levels of sustainability – measured in terms of reduced travel and energy consumption,

4. Williams and Banister "How Big is Sustainable? The interaction between settlement size and travel behaviour", PTRC 1999

modal shift and increased accessibility. The relationship between development patterns and transport was considered according to the schema set out in Figure 3.1.

Figure 3.1: Planning for Transport Sustainability



A number of general conclusions were identified in the review:

- New development within existing settlements encourages shorter trips, modal diversity, reductions in energy consumption and increased access to services and facilities;
- New housing developments on strategic transport networks increases travel and the modal split reflects the network type; and
- New developments outside existing urban areas increases travel and reduce self-containment; free-standing settlements generally lead to increased travel.

The study concluded that in order to reduce travel and increase accessibility to services and facilities, the following criteria for development should be considered:

- Where possible, housing should be provided in existing urban areas;
- Housing should be located next to local public transport routes or non-car mode strategic networks (e.g. rail and bus);
- Development of a dense and compact urban area should be promoted;
- Development of urban areas with a total resident population of 25-100K or 250K+, either by centralising future development or through the decentralised concentration approach; and
- Provision of a variety of services and facilities locally.

Some of these themes are also developed in a study[5] that used an integrated building stock, transport and energy model to simulate the transport and energy use implications of four different scenarios for the growth of Swindon (Wiltshire, England) up to the year 2016. The work was undertaken using the TRANUS model, which is based upon hypothetical settlement patterns.

The aim of the study was to develop combinations of land use and transport policies, designed to be complementary and so more effective in reducing car travel, promoting use of public transport, cycling or walking, and thus saving fuel in transport. Swindon itself has a population of 125,000 and is reasonably self-contained in terms of employment.

The four scenarios with respect to urban form which were considered were:

- **Containment and increased density:** Reflects the 'compact city' approach. This prohibits development on greenfield sites and elsewhere in the rural hinterland;
- **High-density dispersal:** The inverse of the above scenario. No new land developed in existing urban areas;
- **Limited peripheral expansion:** The greater part of growth to be accommodated within a 'limited town expansion';
- **Trend:** No explicit land use constraints

The form of development as scenarios was not limited merely to urban form. Each of the four 'models' was developed with associated assumptions on land use and transport infrastructure. These were as follows:

- **Containment and increased density:** New development to incorporate housing, services and industry. Ban on car access to town centre and the creation of segregated high capacity busways on main radial roads. Also a network of cycleways and the provision of park and ride facilities.
- **High-density dispersal:** New development also to incorporate housing, services and industry to aid self-sufficiency. Transport systems as above, but with additional enhanced bus services on orbital routes linking satellite towns, plus new commuter stations on existing rail lines.
- **Limited peripheral expansion:** Residential development combined with some industry and services. Re-development of a large former industrial site. New orbital road with bus lanes (segregated), bus based park and ride, one new commuter rail station, plus central area car ban.
- **Trend:** Public transport provision follows demand. No improvements made to transport infrastructure.

5. Frank Brown, 'Modelling Urban Growth' Town and Country Planning, November 1998

The general conclusions arising out of the TRANUS modelling exercise are as follows:

- Effects of land use changes by themselves in reducing car travel or encouraging modal shift to public transport, cycling or walking are small;
- By comparison traffic management and restraint measures are more effective. For example, a combination of central area car ban and park and ride network (segregated bus lanes) can shift 8 per cent of trips from car to other modes (13 per cent reduction in fuel use);
- Modal shifts are slightly larger when land use policy directs new development to satellite villages around the town, than they are for land use policies which contain new development either within or on the edge of town; and
- Changes in behaviour by middle income groups bring about greater part of savings in fuel use in transport. Scope for savings among low-income groups is small to start with because of their lower use of unsustainable modes.

3.2.1 Overview

A summary of some of the various views held on the inter-relationships between a number of factors related to sustainability is presented in the following Table 3.1.

The indicators of sustainability have been identified as distance travelled, modal split, energy consumption and accessibility. These have been measured against factors of location, density of development, size of population and provision of local services and facilities.

There is a general agreement that the following factors have a positive role in promoting sustainable transport:

- Higher densities;
- Mixed land uses;
- Compact settlements; and
- Concentration of development on transport corridors.

However, there is less agreement on the relationship between settlement size and sustainable transport. This is further explored in the next section.

3.3 Settlement Population Size and Sustainable Transport

3.3.1 General

Is there a maximum city size above which sustainable transport is difficult to provide? This is a very difficult question to answer, as certain sustainable transport modes, such as rail rapid transit, require substantial catchment populations, if they are to be successful. This means, in turn, that the viability of sustainable transport modes is more related to densities rather than overall population size.

There appears to be limited evidence to support the view that settlement size is the key factor in determining the levels of travel undertaken by sustainable modes in the UK. However there is research[6] to support at least a weak relationship. A generally applied rule-of-thumb is that the larger the settlement, the shorter the trips and the higher proportion of trips made by public transport (this relationship does not hold for larger cities as longer journeys are undertaken).

Looking at sustainability, there is a generally held view that a minimum population size of 25,000 (or 10,000 households) is required as a threshold for a transport-sustainable settlement. Below this level, public transport provision is poor and most journeys are undertaken by car. If this view is correct, then there are negative implications for sustainable transport in Ireland, as, apart from the County Boroughs only two Irish towns exceed 25,000 in population. (Appendix 1 presents details of Irish towns by population size).

A second view is that between 50,000 and 250,000 size settlements, the rate of improvement in sustainability is slow. It is in the large settlements (250,000+) where better levels of sustainability are achieved.

3.3.2 The Compact Settlement

The issue of settlement size and sustainable transport is often approached from a theoretical viewpoint. For example. One approach to the issue is to define firstly threshold values for residential density and then to consider the settlement size that is likely to favour sustainable transport, given this density. Newman and Kenworthy (1989) examined the relationship between urban density and car use. They suggested that there is a gross density threshold of 30 to 40 persons per hectare, below which car use and thus fuel use tends to escalate. This conclusion has not gone unchallenged on the grounds of statistical validity (Brindle, 1996). Another approach has been to consider optimum density from the point of view of a number of factors. For example, a recent guide for planners

6. Banister,' Planning More to Travel Less', TPR, 70 (3) 1999

proposes an optimum net residential density of 100 persons per hectare (approximately equivalent to a gross density of 30 persons), on the grounds that:

- This is the density necessary to support a good bus service, given a socially mixed economy;
- It is the lowest density that renders district heating schemes viable;
- It is the highest density (at 40 to 50 dwellings per hectare) capable of permitting a good level of solar access, with appropriate layout; and
- Permits a wide variety of dwelling and garden sizes.

Thus, these two sources suggest that a minimum gross (net) density of about 30 (100) persons is desirable on sustainable development grounds.

These thresholds agree broadly with the guidelines issued by the Department of Environment and Local Government, which support net densities in the range of 30 to 50 dwellings per hectare.

Table 3.1: Summary of the Relationships Between Urban Form, Travel, Energy, Consumption and Accessibility

	Distance Travelled	Modal Split	Energy Consumption	Accessibility
Location	Location of new housing development outside existing urban areas increases distances travelled (Headicar, Curtis 1995) Location close to strategic transport networks increases travel (Headicar 1997) Free-standing development increases travel (Headicar 1997)	Location close to transport networks influences modal split, rail or road (Headicar 1997)	Location is an important determinant of energy consumption and car dependency (Banister et al 1997)	Development close to existing urban areas reduces self-containment and thus access to non-car owners (Headicar 1997)
Density of Development	Total distance travelled varies with density – '20% variation in distance travelled results from changing densities' (Banister 1997)	Car use in large cities increases at a greater rate if densities are low (Newman and Kenworthy 1989) As densities increase modal split moves towards greater use of rail and bus (Wood et al 1994) Relationship between density and car use is not linear but the relationship between density and public transport provision is linear (Owens 1991) As density increases average trip length, the use of car and distance travelled reduces (Banister 1996, Fouchier 1997)	Increasing densities reduces energy consumption by transport (Newman and Kenworthy 1989) Density is the most important physical variable in determining transport energy consumption (Banister et al 1997)	

Table 3.1: Summary of the Relationships Between Urban Form, Travel, Energy, Consumption and Accessibility *(continued)*

	Distance Travelled	Modal Split	Energy Consumption	Accessibility
Size of Resident Population	Total distance travelled decreases as settlement size increases, except in London (Williams 1997)	Use of non-car modes (public transport, walk, cycle) increases with increase in settlement size (Williams 1997)	The most energy efficient settlement in terms of transport is one which either has a resident population size of 25-100k or 250k+ (Williams 1997)	Access to services and facilities generally better in large settlements, except for car drivers (Williams 1998)
Provision of local services and facilities	Diversity of services and facilities in close proximity reduces distances travelled (Banister 1996) People prepared to travel further for higher order services and facilities (Banister 1996) Local provision reduces trip length and thus total distance travelled (Farthing et al 1996, Winter et al 1995)	Diversity of services and facilities in close proximity alters modal split (Banister 1996) Local provision does not determine modal choice, personal and household characteristics are the determinants (Farthing et al 1996)	Energy consumption may reduce with local provision as trip lengths reduce and modal split may alter	Accessibility increases with local provision

Source: Williams and Banister, PTRC paper 1999

Taking these densities as given, the optimum size of urban settlements from the point of view of transport sustainability can then be estimated. Barton et al. (1995) propose that urban settlements should have a maximum radius of 5 kilometres because:

- This is the distance which most people who use bicycles appear willing to cycle;
- Trams or buses with an average speed of 20 kph cover it in 15 minutes with walk and wait times adds up to a reasonable half hour journey time;
- The time to reach any part of a 10km diameter settlement for many other part at 20 kph is half an hour;
- 5 kilometres can be walked by the able-bodied in less than an hour;

If we take the 5 kilometre radius and apply the 30 to 40 persons per hectare density, this indicates a compact settlement size of 235,000 to 315,000 persons.

While this is a useful way of looking at optimum settlement sizes, it is worth noting that:

- Some of the factors that informed the adoption of a 5 kilometre radius are somewhat arbitrary; and
- If higher densities were achieved along high capacity public transport corridors, the carrying capacity of the urban area in sustainable transport terms would be greater.

It is also worth emphasising that this analysis considers optimum urban size from the point of view of sustainability only. From an economic viewpoint the optimum urban size may be considerably larger.

It is difficult to draw overall conclusions on the relationship between settlement size and sustainable transport. However, the broad indications would appear to be that:

- Transport sustainability may be more a reflection of settlement patterns within the urban area rather than settlement size;
- While the relationship between settlement size and sustainable transport may therefore be a weak one, there is a general tendency for sustainability to increase with size.
- Within the above context, settlements below 25,000 may perform relatively poorly in terms of sustainability; and
- Sustainability may be enhanced in settlements of 250,000 or more.

3.4 Practical Effects of Land Use Policies for Sustainable Transport

The studies and analysis cited above appear to lend substantial credence to the hypothesis that urban form significantly affects travel behaviour. The impact of this relationship in practices has been challenged on two counts: [7]

- Individuals' demand for travel is of critical importance and reflects much more sophisticated tastes and circumstances than are allowed for in planners' view of their needs; and
- The observation that average population densities significantly affect the amount of travel, does not imply that achievable changes in the urban form will have a significant effect; that is, the extent to which existing urban structure can be altered may limited

The National Travel Survey (NTS) data in the UK on individuals' travel mileage showed it to be significantly affected by a range of variables:

- Area characteristics (ward densities, urban size/status, accessibility to urban facilities);
- Socio-economic factors (incomes, socio-economic grouping, housing tenure, gender, working hours)

Two-thirds of the variations in per-capita energy use (as a proxy for distance travelled and modal split) for personal journeys were attributable to the above two factors in almost equal measure. The findings were that lower socio-economic status and higher densities/smaller urban sizes were linked to energy-saving modal splits as well as to shorter mileages. However, only small minorities of the population live in places where small size and/or low density generate substantially higher levels of transport energy usage.

7. Densities, urban form and travel behaviour", Ian Gordon

Further research[8] was undertaken which investigated the effect of settlement patterns on journey to work related travel demand in England. This showed that both spatial and social factors were important sources of area differences in travel-to-work distance and in the energy intensity of the modal split. A clear link was established between residential densities and distance travelled, although a doubling of densities resulted in only a 7 per cent reduction in energy for travel-to-work journeys. A relationship was also established between (weighted) workplace densities and modal split. Areas where more jobs were concentrated in small areas were found to have a higher public transport take-up for journeys to work. If these jobs were contained with 'suburban ring' areas then an even more favourable modal split was observed.

3.5 Conclusions

This section has examined the key determinants of transport sustainability in towns. The following themes emerge:

There is a general agreement that the following factors have a positive role in promoting sustainable transport:

- Higher densities;
- Mixed land uses;
- Compact settlements; and
- Concentration of development on transport corridors.

Transport sustainability may be more a reflection of settlement patterns within the urban area rather than settlement size;

While the relationship between settlement size and sustainable transport may therefore be a weak one, there is a general tendency for sustainability to increase with size.

Within the above context, settlements below 25,000 may perform relatively poorly in terms of sustainability; and

Sustainability may be enhanced in settlements of 250,000 or more

The scope for settlement policies to influence sustainable transport may be more limited than is often thought. This is because of the fixity of much of existing land uses, the degree to which existing settlement patterns already support sustainable transport, and the extent to significant segments of the population are already reliant on sustainable transport modes.

The next section looks more closely at the relationship between settlement size and the viability of public transport modes.

8. Newman and Kenworthy: 'Gasoline consumption and cities: a comparison of US cities with a global survey' (1989)

4 Viability Thresholds for Public Transport

4.1 Introduction

In assessing the minimum settlement size for ensuring adequate public transport, interest inevitably focuses on the bus mode. This is partly because the capacity of the bus mode is more malleable than that of rail based modes, and can thus be altered to suit levels of demand. Additionally, the bus mode usually makes use of existing road infrastructure and therefore does not incur infrastructure capital costs. It is therefore the first option when public transport services are being expanded.

Buses are used to cater for different markets:

- The local urban market;
- The inter-urban market; and
- The rural market.

Settlement size is most critical for the development of local urban bus services. This is because a certain scale and density of demand is needed to make these services viable. In particular, there must be sufficient demand to warrant a reasonable balance between off-peak and peak services.

In the case of interurban services, many such services in Ireland are provided as through routes between the major urban centres of Dublin, Cork, Limerick Galway and Waterford. This means that smaller urban areas along the route obtain relatively high levels of service, which are not dependent on their traffic generating capacity and population size. Similarly, rural bus services are aimed at providing minimum services to remoter towns and villages. They are social services and the economics of their operations is not the prime consideration.

The discussion of minimum settlement size below therefore centres on the settlement size necessary to support local urban bus services, and then gives some consideration to the settlement pattern that tends to support rail-based local urban services.

4.2 Defining Minimum Settlement Size for Urban Bus Public Transport

4.2.1 Service Viability

The viability of bus services along a particular urban route is determined by a number of factors including:

- The population within the route catchment;
- The distribution of trip destinations within the catchment;
- The profile of the resident population;

- The profile of demand by time of day and seasonally;
- The ease of movement along the route; and
- The extent of any subsidy available.

The catchment population is obviously a primary determinant. However, for a given population, bus use will tend to be higher if there is a relative concentration of trips to a particular destination, such as a supermarket or college of education. This is because a dominant destination such as a supermarket will often focus travel demand, so as to create the density of travel needed to sustain a service. The easiest service to initiate is, perhaps, between two such destinations and serving a resident population in between. Demand for that service from the resident population will be influenced by the latter's characteristics. If the population has high incomes and are car-owning, it will be more difficult to attract them to the bus mode. However, those with very low incomes may not be able to use bus intensively. This suggests that upper working class populations are more likely to give rise to significant bus demand.

If that demand arises in the peak only or for part of the year only, then the economics of bus operation will be adversely affected. This is because buses and, to a certain extent, crews will be idle for part of the time. The most economical bus routes are those for which there is an all-day demand and all year round.

Even where all day demand arises, the economics of bus operation will be affected by the ease of movement along the route. If, for example, the route is through a congested town centre and journey times are excessive, more vehicles and drivers will be required to service that route. Finally, because of these factors, subsidies may be required to ensure viability.

The implication of the above is that two towns of similar population may offer quite different scope for the development of bus services because of the operation of these factors.

4.2.2 Population Size

However, one way of determining, in broad terms, a minimum population size above which bus services may become viable is to consider the trip distance and time above which people are not prepared to walk. If we take 15 minutes as the maximum time above which the average person will prefer not to walk, this translates into 1.5 kms at a walking speed of 6 km per hour. An urban area with a radius of 1.5 kilometres would have an area of approximately 700 hectares. Average gross densities of Irish urban areas vary from 10 to 40 persons per hectare, with the bulk of towns in excess of 15 persons per hectare. For bus transport to be viable a relatively high density would be needed, otherwise too few people would have ready access to a bus route. Taking a reasonably high figure of 30 persons per hectare would suggest a population of 21,000 as a threshold for bus services.

Consultations with bus operators yielded the view that a minimum town size of about 20,000 was required before consideration could be given to developing bus services. However, it was also clear that operators regarded this as a necessary but not sufficient condition for local services. Whether any given route would become a reality would depend on the factors outlined in paragraph 4.2.1 above.

The probability of a viable local bus service emerging increases, as population rises from 20,000 to 40,000, with services invariably being fully viable at the latter figure. In fact, in the Irish situation, only four towns with populations below 40,000 – Dundalk, Navan, Sligo and Athlone - have local bus services, and in some cases these are small in scale and marginal in terms of commercial viability.

4.3 Rail-Based Options

Rail based urban options such as Light Rail and Metro systems are generally viable in larger conurbations only. An indication of the scale of the traffic flows that are required may be obtained by examining the maximum capacity of different modes. Table 4.1 shows the maximum route capacities of various modes.

Buses can service up to 5,400 passengers per hour, with light rail or metro type systems being required to achieve higher loadings. In practice, light rail comes into consideration above 2,000 passengers per hour and operates up to 20,000 passengers per hour. The transition from bus to light rail is more likely to be feasible at about 3,500 passengers per hour. Given a density of 30-40 persons per hectare, and making certain other assumptions, suggests as minimum town size of 0.9m to 1.2m (see Box 1). Thus, on this calculation, Dublin is above the threshold of LRT viability. These results are sensitive to population density. If the latter increases to 60 persons per hectare the minimum town size falls to 600,000. [9]

Table 4.1: Maximum Capacity of Modes

Mode	Maximum Capacity (pass/hr)
Bus	5,400
Guided Bus	7,800
Light Rail	20,000
Metro	80,000

Source: Barry (1991)

9. These results must be interpreted as indicative only. LRT may be introduced in smaller urban areas on routes through dense catchments or for other policy purposes such as traffic restraint.

The viability of the commuter rail mode is determined by a different set of factors. As these are high capacity systems, their use in a low-density urban environment, such as prevailing in Ireland, is largely that of linking dormitory towns to urban centres. Analysis of the DART and Dublin Outer Suburban Line catchments indicate that suburban rail typically achieves a 20 per cent capture of commuters who travel more than 2 miles to work. The probability of using suburban rail also increases with trip length.[10] Thus, suburban rail becomes a viable mode when there are towns of significant size in the hinterland of an urban area. A case study of the viability of suburban services in the Limerick area concluded that a small-scale service from Ennis to Limerick would be viable at current population levels. This was because of the relatively large Ennis population commuting to Limerick and the relatively long trip length involved.[11]

Box1: City Size and LRT Viability

Assuming a catchment of 1 kilometre and station spacing at less than this, each kilometre of LRT track would have a 200 hectare catchment. This represents a population of 6,000 at 30 persons per hectare. A population of 6,000 would give rise to a work and school commuting population of some 3,000. Given the incidence of local working and the competition of other modes, 15 per cent or 450 persons would be a reasonable capture for an LRT line.

In practice, an LRT line would have to attract 3,500 passengers per hour to compete with bus. In a 1.5 hour commuting peak, this amounts to 5,250 passengers. Assuming that each LRT user has a trip length half of the total line length indicates that a patronage of 5,250 would require a line length of some 23 kms. This, in turn, indicates a town of 42,000 hectares with a population of some 1.3m people at 30 persons per hectare.

If the density increases to 40 persons per hectare (equivalent to the density of Dublin City and County) then the threshold populations falls to 0.96m.

4.4 Conclusions

Given the scale of Irish towns outside of Dublin, expansion of public transport services will be based largely on the bus mode. Suburban rail operations will also contribute where there are significant dormitory towns in the hinterland of major urban areas, but at some distance.

Apart from the major urban areas, only four towns in Ireland have a population over 20,000 (Dundalk, Bray, Drogheda and Swords). This inhibits the development of local bus services. Expansion of town size to the threshold level for bus operations is a factor to be considered in the context of identifying appropriate urban scale.

Apart from Dublin, the other major urban areas are not, in general terms, close to a scale that would support significant LRT or Metro systems.

10. Evaluation of the Suburban Rail Plan. Report to Iarnrod Eireann. Goodbody Economic Consultants in association with Electrowatt Engineering, 1998.
11. Potential for Commuter Rail Services in the Limerick Area. Report to Shannon Development. Goodbody Economic Consultants, 1999.

5 An Overview of Sustainable Transport Trends in Ireland

5.1 General

There is no comprehensive database on personal travel in Ireland that would facilitate an analysis of the degree to which transport patterns support sustainability or of the relationship between settlement patterns and sustainable transport. However, over they years, the Census of Population has gathered data on the journey-to-work behaviour of workers and students. The information collected relates to the mode of transport used for the journey-to-work and the trip length. Analyses of the use of the sustainable modes of transport (walk, cycle, bus and rail) and average distance travelled for the journey to work are feasible using these data.

5.2 Use of Sustainable Transport Modes

Table 5.1 presents an overview of the trends in the use of sustainable transport modes between the two Census years 1986 and 1996. [12]

In 1986, 29.6 per cent of workers in the State used sustainable transport modes for the journey to work. By 1996, this had fallen to 25.2 per cent, a reduction of almost 15 per cent.

Use of sustainable modes differs as between rural and urban areas. In 1996, 35.9 per cent of workers in urban areas used sustainable modes as compared with only 10 per cent in rural areas. This is an unsurprising result, given the separation of land uses and the poor economic viability of public transport systems in rural areas. It is noteworthy, however, that use of sustainable transport modes is declining more rapidly in urban areas.[13]

5.3 Sustainable Transport Modes and Size of Urban Area

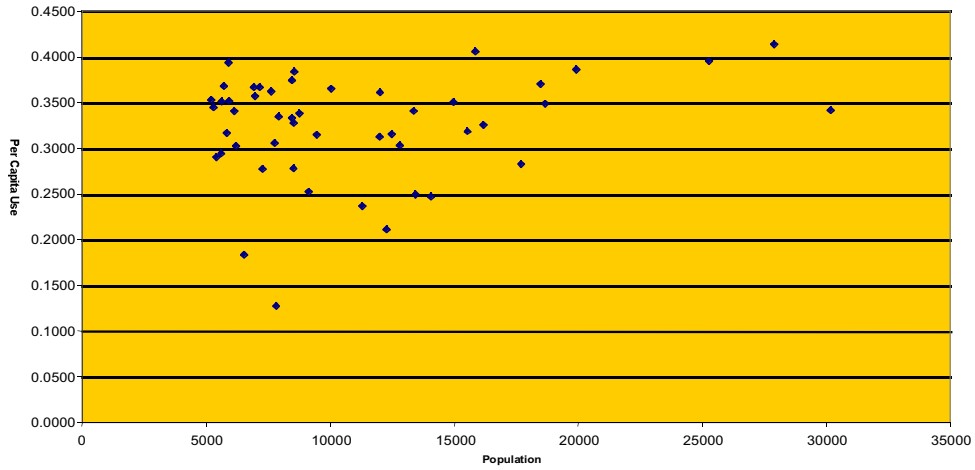
The trends for urban areas of different sizes are examined in Table 5.2. This shows that use of sustainable transport modes is declining across towns of all sizes, but particularly in the larger towns (10,000 + population) where a decline of approximately one-fifth has occurred.

12. The tables and figures in Sections 5 and 6 of this report are based on analyses of the Census of Population for the years 1986 and 1996
13. In September 2000, the CSO published results of a nation-wide Travel to Work Survey. This indicates that the decline in the use of sustainable transport modes for the journey to work has continued to decline rapidly since 1996.

Table 5.1: Proportion of Workers Using Sustainable Transport Modes for the Journey to Work 1986 and 1996

Area	Proportion of Workers 1986 (%)	Proportion of Workers 1996 (%)	Growth Rate (%)
Aggregate Town Areas	43.7	35.9	-17.9
Aggregate Rural Areas	11.3	10.0	-11.5
The State	29.6	25.2	-14.9

Figure 5.1: Per Capita Use of Sustainable Transport



In part, the poor performance of the towns in the 10,000 + category reflects changes in the number of towns in this category in the ten years. In particular, a number of towns with low levels of sustainability grew rapidly during this period and transferred from the 5,000 to 9,999 category to the 10,000+ category in 1996. This raised the transport sustainability of the 5,000 to 9,999 category in 1996, and contributed to the decline in the 10,000+ category.

The data for both 1986 and 1996 support the view that use of sustainable transport modes increases somewhat with town size. Town level data are presented in Figure 5.1. This depicts the relationship between population size and transport sustainability for towns and cities with over 5,000 persons (excluding County Boroughs).

Table 5.2: Proportion of Workers Using Sustainable Transport Modes for the Journey to Work 1986 and 1996 by Type of Urban Area

Area	Proportion of Workers 1986 (%)	Proportion of Workers 1996 (%)	Growth Rate
County Boroughs and Greater Dublin	46.2	38.0	- 17.7
Towns 10,000+	41.7	33.3	- 20.1
Towns 5,000 to 9,999	37.6	31.7	- 15.7
Towns 3,000 to 4,999	35.4	29.8	-15.8
Towns 1,500 to 2,999	33.4	28.3	-15.3

This Figure indicates an apparently positive relationship between transport sustainability and town size. However, it also shows a wide range of sustainability values for towns of a given population size. This suggests, in turn, that factors other than population size may be more important in determining sustainability levels. Section 6 of this paper explores this issue further.

5.4 Modal Shifts

Table 5.3 compares the use of different modes in the years 1986 and 1996 for all urban areas and for County Borough areas (including Greater Dublin). A very similar picture emerges for both types of urban area. Walk, bus and particularly cycle modes experienced a sharp decline, while the numbers driving to work grew rapidly. Rail was the only sustainable transport mode to gain market share.

These figures suggest that increasing car ownership has caused modal shifts and that, of sustainable transport modes, only rail was able to compete with the attractions of the car.

Looking separately at the Greater Dublin Area, the only differences are that the cycle mode has experienced only a slight decline in market share, while the rail mode has been even more successful – increasing its market share by 23.5 per cent.

Table 5.3: Change in Use of Modes 1986 –1996

Mode	Aggregate Urban Areas			County Boroughs		
	1986 (%)	1996 (%)	% change	1986 (%)	1996 (%)	% change
Walk	19.08	16.40	- 13.55	15.68	13.86	- 11.61
Cycle	8.10	5.15	- 36.49	8.77	5.53	- 36.89
Bus	14.09	11.59	- 17.78	19.12	15.60	- 18.41
Train	2.44	2.68	+10.01	2.66	3.04	+14.33
Motor Cycle	1.59	1.00	- 37.19	1.89	1.17	- 37.93
Car Driver	40.15	46.67	+16.25	39.63	46.46	+17.23
Car Passenger	7.33	8.03	+ 9.54	6.69	7.33	+ 9.59

5.5 Contribution of the Different Modes

Table 5.4 illustrates the contribution of different modes to transport sustainability. Generally speaking, It is only in the larger conurbations that public transport makes a significant contribution to sustainability, although public transport use does rise with town size. Even among the larger conurbations, it is only in Dublin that public transport use is high (See Table 5.5). The fact that public transport use in Galway and Waterford is not higher than the average rate of usage in towns of population 5,000 to 9,999, raises questions about the adequacy of public transport services in those towns. Similarly, as remarked above, the level of public transport use in Cork is surprisingly low.

Table 5.6 confirms the very low use of the bus mode for the journey to work in throughout the country, with the exception of the major urban areas. In fact, it is only in Dublin that the bus mode achieves significant modal shares. This must be a cause for concern, as with growing car ownership, it will lead to a decline in use of sustainable transport, as walk and cycle journeys transfer to car.

Table 5.4: Contribution of Different Modes to Transport Sustainability, 1996

Urban Area	Proportion Sustainable (%)	Proportion Walk & Cycle (%)	Proportion Public Transport (%)
County Boroughs and Dublin	38.04	19.39	18.65
Towns with Population 10,000+	33.32	26.89	6.43
Towns with Population 5,000 -10,000	31.72	25.28	6.44
Towns with population 3,000 - 4,999	29.84	25.53	4.31
Towns with population 1,500 - 2,999	28.29	24.41	3.88
Aggregate Town Areas	35.91	21.64	14.27

Table 5.5: Contribution of Different Modes to Transport Sustainability in Larger Urban Areas, 1996

Urban Area	Proportion Sustainable (%)	Proportion Walk & Cycle (%)	Proportion Public Transport (%)
Greater Dublin	40.53	18.19	22.34
Cork County Borough	27.21	18.71	8.50
Limerick County Borough	33.85	24.53	9.31
Galway County Borough	35.92	29.11	6.81
Waterford County Borough	32.46	28.31	4.15
Greater Dublin	40.53	18.19	22.34

Table 5.6: Use of the Bus Mode for the Journey to Work

Area	Proportion Using Bus (%)
County Boroughs and Dublin	15.60
Towns with Population 10000+	4.09
Towns with Population 5,000 -10,000	3.77
Towns with population 3,000 - 4,999	3.61
Towns with population 1,500 - 2,999	3.39
Aggregate Town Area	11.59
Aggregate Rural Area	2.54
State	7.84

5.6 Commuting Trip Lengths

Table 5.7 presents information on the trip length of commuters. The proportion of trips greater than one mile and 3 miles is presented. These represent respectively the trip lengths beyond which walk and cycle modes are unlikely to be adopted.

For the State as a whole, 71.2 per cent of trips are greater than one mile and 60.5 per cent greater than 3 miles. Rural areas have a slightly lower proportion of greater than 1-mile trips, reflecting presumably the level of on-farm working. However, longer trips are also more prevalent in rural areas.

With regard to urban areas, these generally exhibit much lower trip lengths than rural areas. Larger urban areas are an exception, with 79.6 per cent of trips in CBs and Dublin being greater than 1 mile and 65.3 per cent being greater than 3 miles. However, more detailed analysis of the data reveals that it is only in Dublin, Cork and Limerick that the proportion of trips greater than 3 miles increases significantly.

It is interesting to note that the proportion of trips in excess of 3 miles declines with population size for towns other than CBs and Dublin. This is broadly consistent with the findings of the literature review as set out in Section 3.

Table 5.7: Commuting Trip Lengths, 1996

Area	Proportion of Trips greater than 1 mile (%)	Proportion of Trips greater than 3 miles (%)
County Boroughs and Greater Dublin	79.58	65.28
Towns 10,000 +	58.55	41.20
Towns 5,000 to 9,999	56.36	44.37
Towns 3,000 to 4,999	54.78	46.40
Towns 1,500 to 2,999	55.39	49.30
Aggregate Urban Areas	72.02	58.00
Aggregate Rural Areas	69.91	64.27
The State	71.17	60.52

5.7 Factors Underlying the Decline in Transport Sustainability

Apart from the relationship between settlement pattern and transport sustainability, the reasons for the large decline in sustainability across towns of all sizes deserves some comment. The most obvious reason for the decline is the increase in car ownership and consequent use of that mode for the journey to work. Between 1986 and 1996, car ownership per adult increased by almost 35 per cent in the country as a whole. By 1996, almost one in every two adults owned a car. In general terms, few car owners opt to use public transport for the journey to work, unless the quality of public transport on offer is very high. This means that, as car ownership advances, the use of the car mode for the journey to work automatically increases.

Another possibility is that over this period, there was a tendency for workers to take up jobs outside their immediate locale, thus requiring the use of mechanised modes (an particularly the car mode) for the journey to work. Some indication of whether this was a contributory factor can be gleaned from an examination of changes in the trip length distribution between 1986 and 1996 (see Table 5.8)

There has been a tendency over this period for the proportion of long trips (over 10 miles) to grow. This is particularly true of the larger towns. There is evidence, therefore, of increased long distance commuting. There is also evidence that short distance commuting (less than one mile) is in decline in larger towns. This would contribute to the decline in walk and cycle modes.

Thus, there is evidence to support the view that the increasing separation of home and work locations is contributing to the decline in transport sustainability. This may in turn reflect increased job mobility. However, the Table also supports the view that this has been a less important factor than increases in car ownership. If towns with a population of between 1,500 and 2,999 are examined, it is seen that changes in the trip length distribution have not been large. Nevertheless, these towns have experienced a decline in sustainability of 15.3 per cent over the period (see Table 5.2), which is not significantly below that for the larger towns.

Table 5.8: Changes in Trip Lengths, 1986-1996

Town Category	Journey to Work Distance (Miles)	Proportion of Trips (%) 1986	Proportion of Trips (%) 1996
County Boroughs and Dublin	< 1 mile	22	20
	2-4 miles	42	39
	5-9 miles	28	28
	> 10 miles	08	13
Towns with Population 10,000+	< 1 mile	50	41
	2-4 miles	27	26
	5-9 miles	05	07
	> 10 miles	18	25
Towns with Population 5,000 -10,000	< 1 mile	51	43
	2-4 miles	17	19
	5-9 miles	11	10
	> 10 miles	21	28
Towns with population 3,000-4,999	< 1 mile	52	45
	2-4 miles	12	13
	5-9 miles	11	10
	> 10 miles	25	31
Towns with population 1,500-2,999	< 1 mile	55	52
	2-4 miles	12	12
	5-9 miles	11	10
	> 10 miles	22	25

5.8 Conclusions

Use of sustainable transport modes is much higher in urban than in rural areas. Within urban areas, use of sustainable transport modes increases somewhat with settlement size. However, use of sustainable transport modes shows a wide variation for towns of a given population size.

Use of sustainable transport modes declined rapidly during the period 1986-96. Walk, bus and cycle modes experienced the greatest decline. It is only in the larger conurbations that public (bus) transport makes a significant contribution to sustainability, although public transport use does rise with town size. Even among the larger conurbations, it is only in Dublin that public transport use is high.

Commuting trips lengths are higher in rural than in urban areas. Within urban areas, there is a tendency, up to a point, for long distance trip making to decline with increasing settlement size. However, larger conurbations encourage longer trip making.

The decline in transport sustainability is largely the result of increasing car ownership. However, the separation of home and workplaces and the consequent increase in trip lengths would appear to be a contributory factor.

The rapid decline in the use of sustainable transport modes may mean that in future, the car will dominate to an even greater degree. Given the small population size of many Irish towns, local bus operations may not be viable. This will mean that there will not be a viable public transport alternative to the car, and there will be a continued transfer from walk and cycle modes.

6 Analysis of the Use of Sustainable Transport Modes in Irish Towns

6.1 Introduction

In Section 5.3, a positive relationship between urban area size and use of sustainable transport modes was established. However, the variation in transport sustainability for towns of the same population indicated that population size may not be the most relevant explanator, and that other factors may be more important in determining use of sustainable transport modes. To gain further insight into the possible reasons for this relationship, it is necessary to consider data for individual towns. This section explores such data and develops simple models to explain variations in use of sustainable transport modes.

6.2 Sustainable Transport Modes and Irish Towns

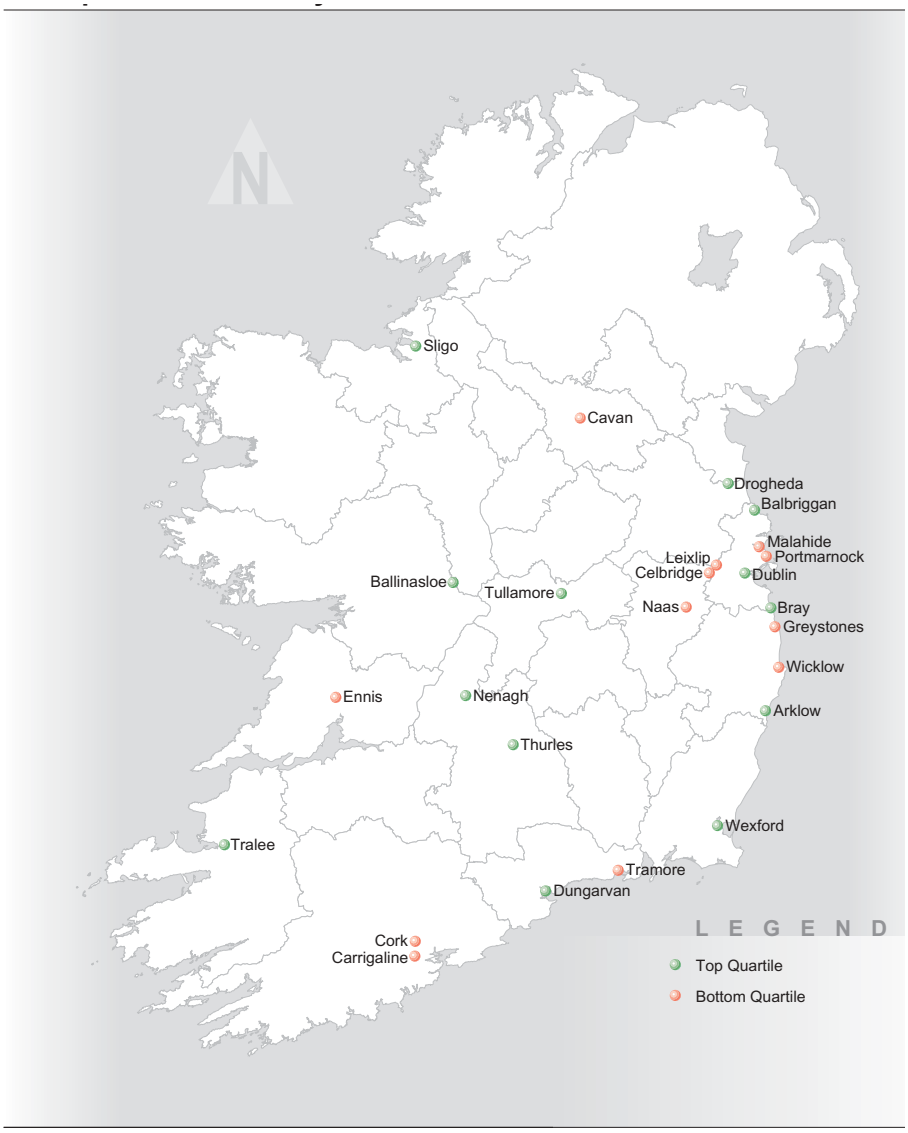
In Table 6.1 and Figure 6.1, the ten Irish towns, over 5,000 in population size, that exhibit the highest level of transport sustainability are set out, together with the ten with lowest levels. A full ranking by transport sustainability of the 54 Irish towns with over 5,000 persons is given in Appendix 1. The town of Bray has the highest use of sustainable transport modes for the journey to work, with 41.3 per cent of the population using either walk, cycle or public transport modes. The Greater Dublin area also performs very well in this regard. The lack of a close correspondence between population size and transport sustainability is seen by the fact that both the largest town in the sample (Dublin) and one of the smallest (Nenagh) figure in the top ten. It is also clear that towns may exhibit high levels of sustainability for different reasons. For example, Bray has high use of public transport modes (21.1 per cent) and a similar level of use of walk and cycle modes (19.6 per cent). In contrast, in Nenagh, walk and cycle modes dominate (37.6 per cent), while only 1.8 per cent of workers use public transport. Of the top ten towns, seven are similar to Nenagh in that their transport sustainability is high, by virtue of high use of walk and cycle modes. For Bray, Greater Dublin and Balbriggan, the reason is high levels of public transport use combined with moderate use if walk and cycle modes. With regard to Bray and Balbriggan, it is the high level of rail rather than bus use that raises sustainability.[14]

With regard to the towns that performed poorly, it is significant that they all perform a dormitory function, with the exception of Cork County Borough. Because of their role as dormitory towns, commuting trip lengths are long and use of walk and cycle modes is very low. Transport sustainability levels in Tramore and Carrigaline are particularly poor. This is because of the dormitory

14.In 1996, Bray had 22 inbound morning peak rail services and Balbriggan had 9.

function that they perform and the inadequate public transport services available. Other towns in this grouping such as Leixlip and Celbridge are rail linked, but with a relatively low level of services.[15]

Figure 6.1: Towns Over 5,000 in Top and Bottom Quartile of Transport Sustainability



15.In 1996, Leixlip and Celbridge had 3 and 4 inbound morning peak rail services, respectively

The poor performance of Cork County Borough is surprising and is due entirely to low levels of public transport usage. Only 8.5 per cent of workers use public transport, as compared with 22.3 per cent in Dublin.

Table 6.9: Irish Towns and Use of Sustainable Transport Modes

Town	Population	Proportion Using Sustainable Transport Modes (%)
Towns with Highest Use:		
Bray	26,953	41.31
Wexford	15,393	40.57
Greater Dublin	929,090	40.53
Drogheda	24,656	39.52
Nenagh	5,825	39.37
Tralee	17,862	38.59
Arklow	7,987	38.34
Balbriggan	7,724	37.42
Sligo	17,964	37.02
Ballinasloe	5,892	36.76
Towns with Lowest Use:		
Maynooth	6,027	27.81
Wicklow	6,215	27.70
Cork County Borough	174,400	27.21
Portmarnock	9,173	25.19
Leixlip	13,194	24.90
Naas	11,141	24.69
Greystones	10,778	23.64
Celbridge	9,629	21.10
Tramore	6,064	18.32
Carrigaline	6,482	12.72

6.3 Explaining the Use of Sustainable Transport Modes in Irish Towns

6.3.1 Introduction

The analysis conducted so far suggests that:

- There is a weak positive relationship between town size and use of sustainable transport modes; however the extent to which this reflect factors other than population remains unclear;
- Towns which have a dormitory function have low levels of sustainability; however where the towns are rail served, this has a counteracting positive effect;
- Only dormitory towns with high levels of public transport services, achieve high levels of sustainability; and
- The vast majority of autonomous Irish towns achieve reasonable levels of transport sustainability largely by virtue of the use of walk and cycle modes.

In order to gain a more precise understanding of the role of various factors in determining transport sustainability, some simple regression models were developed.

6.3.2 Model Estimates

These models related transport sustainability (TS), as measured by the proportion of workers using sustainable transport modes, to a number of possible explanatory factors. The explanatory factors considered were:

- The population level (P);
- The level of local working (LW); and
- The provision of rail commuting services (RS); and
- The provision of local bus services (Bus).

The model thus took the form:

TS = a + b P + c LW + d RS + e Bus;

Where a, b, c, d and e are parameters to be established.

The level of local working is usually measured by the jobs ratio, which is defined as the proportion of workers resident in an urban area that also work in that area. Jobs ratio data cannot be calculated from the Census of Population, because data on work locations are not gathered. However, the Census does provide information on the trip length of commuting journeys. Using these data, the extent of local working was measured by the proportion of workers that travel less than 1 mile to their place of work. Where towns have mixed land uses and residents find jobs locally, this proportion will tend to be high.

The level of rail services was defined in two alternative ways: firstly by a dummy variable representing whether the town was served by commuter rail or not (RS1), and secondly by the number of weekday commuting services in the morning peak (i.e. up to 9am) (RS2).

The model was first calculated for:

1. all 54 Irish towns with population over 5,000 (N=54),
2. all Irish towns excluding Dublin (N=53);
3. All Irish towns excluding Dublin and all County Boroughs (N=49)

The results are presented in Table 6.2. For the All Towns model, equation (1a) shows that transport sustainability increases with the proportion of local working, the population level and the presence of commuter rail and local bus services. However, equation (1b) shows that when the actual level of rail services is used in the model, town population has a negative impact. Equation (1b) is also to be preferred to (1a) on grounds of fit (R square of 0.71 as against 0.58)

The population of Dublin is very large relative to other towns. This raises the possibility that much of the explanatory power of the model comes from the inclusion of the Dublin observation. This issue was evaluated by removing Dublin from the set of observations. Model type (2) shows the results. With regard to equation 2(a), the population variable is no longer statistically significant. Equation 2(b) is to be slightly preferred to 2(a). The population variable is insignificant in 2(b).

The final test (3) was to exclude both Dublin and the County Boroughs from the analysis. The results are very similar to Model 2, except that the population variable is significant in the (a) equation. The bus variable is insignificant in (3). This may reflect the fact that, outside of the county boroughs, there are only three towns with local bus services.

Table 6.1: Model Results

Model Type	Estimated Model	R Sq.	F
All Towns (1)	(a) TS = 17.05 + 0.32LW + 0.01P + 4.99RS1 + 2.79Bus (7.96) (2.15) (3.30) (1.68) (b) TS = 17.08 + 0.32LW – 0.02P + 0.82RS2 + 4.07Bus (10.29) (-3.20) (6.07) (2.88)	0.71 0.58	29.8 17.1
All Towns exc. Dublin (2)	(a) TS = 17.03 + 0.32LW - 0.03P + 5.23RS1 + 5.81Bus (8.55) (-1.22) (3.67) (3.21) (b) TS = 17.20 + 0.31LW – 0.002P + 0.72RS2 + 2.79Bus (9.84) (- 0.12) (5.21) (1.69)	0.62 0.69	19.8 26.9
All Towns exc. Dublin and CBs (3)	(a) TS = 14.29 + 0.33LW + 0.24P + 5.18RS1 + 0.29 Bus (8.62) (2.34) (3.42) (0.12) (b) TS = 16.29 + 0.32LW + 0.04P + 0.80RS2 + 1.73Bus (10.16) (0.36) (5.09) (0.78)	0.65 0.72	20.3 28.3

Note: figures in parentheses are t values

These results suggest that the degree of local working is a prime determinant of transport sustainability and that the presence of commuter rail services is also very important. The importance of local bus services is, largely, in promoting sustainability in the larger urban areas is supported.

There is no apparent direct relationship between town size and transport sustainability. However, this does not rule out an indirect relationship, if larger towns are more likely to support viable public transport services.

6.3.3 Elasticity Values

Elasticity values may be derived from the various model equations. These elasticities, which measure the proportionate response in transport sustainability to a one per cent change in explanatory variables, are useful for determining the strength of the impact of these variables. The results show that elasticity with respect to the extent of local working is very stable across a range of equations. The impact of this variable is also very substantial: a 1 per cent increase in the proportion of workers with local jobs increases the proportion adopting sustainable modes of transport by 0.4 per cent approximately.

The elasticity with respect to rail service levels is also stable across model equations. However, it does not have such a strong impact: each 1 per cent increase in service levels raises transport sustainability by approximately 0.04 per cent.

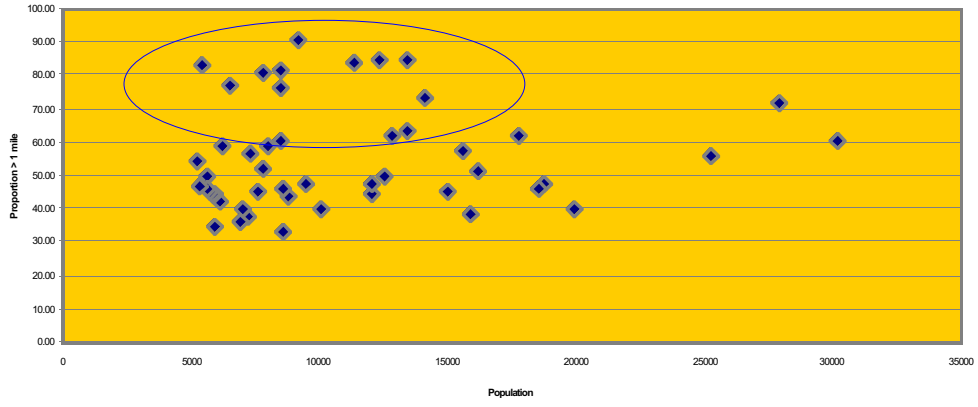
6.3.4 Conclusions

There is no apparent direct relationship between town size and use of sustainable transport modes. It is clear that the settlement pattern and function of individual towns are more important determinants of sustainable transport use. Public transport provision is also important, and plays an important part in ensuring that larger conurbations have acceptable levels of use of sustainable transport modes. Dormitory towns generally have low levels of transport sustainability, except where public transport provision and particularly rail service levels are high.

6.4 Town Size and Commuting Trip Length

Figure 6.2 depicts the relationship between the proportion of trips in excess of 1 mile and the town population (excluding County Boroughs). The observations ringed at the top of the graph represent towns of relatively low population but high proportion commuting more than 1 mile. These towns, almost exclusively, have a significant dormitory function.[16] Apart from this group, there is some tendency for long trip lengths to occur more frequently in larger towns. However, it is again evident that that there is considerable variation among towns of the same size, indicating that other factors, such as the settlement pattern, are more important in determining trip lengths.

Figure 6.2: Proportion of Commuting Trips greater than 1 mile in Irish Towns



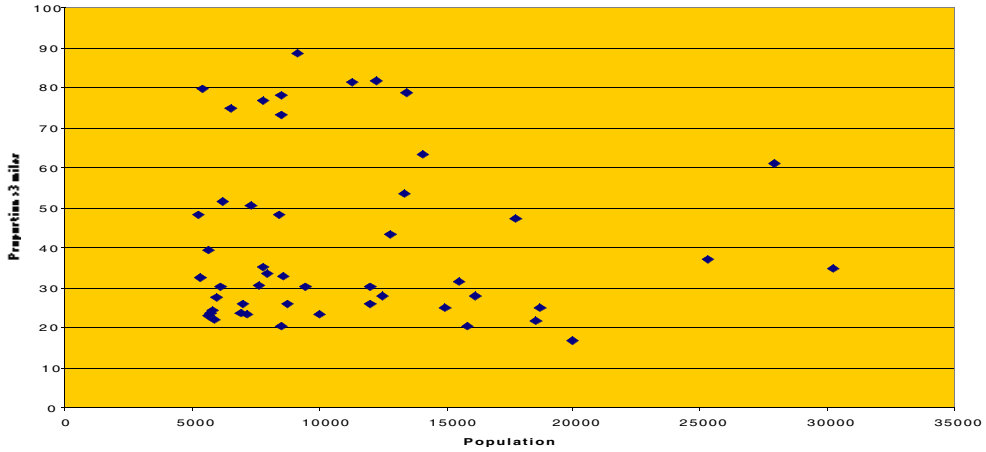
16. They comprise: Bray, Leixlip, Naas, Celbridge, Greystones, Portmarnock, Maynooth, Balbriggan, Tramore, and Rush

The tendency, up to a point, for trip lengths to decline as town size increases, to which reference was made in Section 5.1 does not stand up to this more detailed analysis. In fact, it arises because many dormitory towns with long trip lengths happen to have relatively small populations.

Figure 6.3, which depicts the relationship between the proportion of trips in excess of 3 miles, tells much the same story. However the relationship between town size and trip length is even less pronounced.

However, for Dublin, Cork and Limerick – the most populous centres – trip lengths are much higher.

Figure 6.3: Proportion of Commuting Trips greater than 3 miles in Irish Towns



6.5 Conclusions

Use of sustainable transport modes is much higher in urban than in rural areas. Within urban areas, use of sustainable transport modes increases somewhat with settlement size.

However, there is no simple relationship between town size and use of sustainable transport modes. Use of sustainable transport modes shows a wide variation for towns of a given population size. It is clear that the settlement pattern and function of individual towns are more important determinants of sustainable transport use. Public transport provision is also important, and plays an important part in ensuring that larger conurbations have acceptable levels of use of sustainable transport modes. Dormitory towns generally have low levels of transport sustainability, except where public transport provision, and particularly rail service levels, is high.

Use of sustainable transport modes declined rapidly during the period 1986-96. Walk, bus and cycle modes experienced the greatest decline. It is only in the larger conurbations that public transport makes a significant contribution to sustainability, although public transport use does rise with town size. Even among the larger conurbations, it is only in Dublin that public transport use is high.

Commuting trips lengths are higher in rural than in urban areas. There is some tendency for long trip lengths to occur more frequently in larger towns. However, it is again evident that that there is considerable variation among towns of the same size, indicating that other factors, such as the settlement pattern, are more important in determining trip lengths. However, larger conurbations do encourage longer trip making.

Towns that have a dormitory function have low levels of sustainability; however where the towns are rail served, this has a counteracting positive effect. Only dormitory towns with high levels of public transport services, achieve high levels of sustainability; and

The vast majority of autonomous Irish towns achieve reasonable levels of transport sustainability largely by virtue of the use of walk and cycle modes.

As the larger conurbations grow, commuting trip length increases and this reduces the use of walk and cycle modes. In Dublin, public transport has taken the place of these modes to a significant degree, thus maintaining a high level of sustainable transport mode use. However, public transport use in other conurbations, especially Cork, has not increased in a similar fashion, so that they perform relatively poorly in terms of use of sustainable transport modes.

With regard to the framing of a spatial strategy, the analysis presented in this study suggests that town size is not a dominant factor in determining the sustainability of transport. Provided appropriate settlement patterns are encouraged, the development of larger towns should not result in unsustainable transport patterns. However, in practice, this is likely to require a significant expansion of public transport provision.

The analysis also confirms the negative impact that the development of dormitory towns has on sustainability, unless these towns are linked to the urban area that they serve by a high frequency rail service.

7 Regional Strategies and Sustainable Transport

7.1 Introduction

This section of the report considers further the individual variables discussed in Section 3 and provides an overview of a selection of spatial strategies assessed or adopted at the national, regional and county levels, and the level of success of these in achieving sustainable travel patterns.

Firstly, the well-documented Dutch national spatial strategy is discussed, in which the commitment to this policy is questioned. This is followed by the spatial strategy adopted in recommending locations for new residential development within the Yorkshire and Humberside Region. The final two articles discussed, relate to spatial strategies at the county level. One presents empirical results on the travel patterns resulting from new residential development in various towns in Oxfordshire, whilst the other considers the merits of adopting alternative strategies in an area of New Jersey in the US.

A key consideration in developing ideas relating to the examples described here is that the regional strategies are evaluated from a modelling perspective, rather than through an analysis of policy outcomes. The Oxfordshire example, which is considered below, does investigate applied measures. However, since this relates to new residents in a town, there is a slight concern that the issues arising may be as a result of a 'settling down' period. The over-riding issue that needs to be considered in assessing these strategies is what actually happens on the ground? As yet, there is little published information/evidence to provide a definitive answer to this question.

7.2 Policies and Approaches: National Spatial Strategy

The well-documented environmental strategy adopted in the Netherlands, which seeks to integrate land use and transport planning at the national level, is outlined in literature[17]. This work goes on to question the continued adoption of the strategy.

Between 1990 and 2015, Dutch national planners predict a population growth of one and a half million. Pressures are currently concentrated around the four large urban areas of the Randstad. The fourth report on physical planning in the Netherlands ("On the Road to 2015") outlines a policy to cope with the predicted pressures in the region. This has three strands:

- A location policy that keeps distances to a minimum;

17. David Banister "Transport and the Urban Environment"

- Superior amenities for slower traffic and public transport; and
- Promotion of public transport through stricter parking policy, and perhaps other measures.

The key is to concentrate residences, work areas and amenities so as to produce the shortest possible trip distances, most being possible by bicycle and public transport. So, housing sites are being sought first in the inner cities, next on the urban periphery and only in the third place at more distant locations.

Businesses and amenities are planned by relating their user requirements to location features. Those activities involving a large number of workers or visitors per hectare, for example, offices oriented to the general public, theatre and museums, are rated A-profile, that is they should be located close to city centre stations. B-locations are those with both good station access and good access to the motorways, making them suitable for both car and public transport, such as hospitals, and research and development. C-locations, close to motorways, are suitable only for activities with relatively few workers and visitors per hectare, and with a need for high accessibility by car or truck.

Associated with this, the national report calls for integrated transport/land use planning, so as to enhance the role of public transport. Three spatial levels are linked to three types of public transport network, for example inter-city rail at the national level and regular trams at the local level. Related to this is a third element: restricting long-term parking space whilst promoting and providing good public transport.

Banister concludes by questioning the Dutch national strategy. He criticises the lack of evidence on how the Dutch derive their policies, and on research relating to the effectiveness of the policy. He adds that whilst it is sensible to encourage activities close to public transport access, it is questionable whether consequences of the dominance of town cramming in the Randstad region (e.g. higher levels of congestion) justify such an approach. It may be more appropriate to promote medium size and density cities in other parts of the country.

It is worth noting that a recently published report[18], bases some of its advice on the Dutch approach. This report includes guidance on the formulation of spatial strategies for a Structure, Local or Unitary Plan, which cover areas from the district to county level in England and Wales. The strategies are concerned with the spatial dynamics of human activity. Consequently, the guidance is only partial, since is does not take account of economic and social forces, mediated by political decision-making, which are the primary cause of dynamic change in settlements. The guidance focuses on land use/transport systems and physical form, and recommends that the first stage of the process is to define ‘A’ and ‘B’ locations, based on the Dutch national strategy.

18. Barton et al. Sustainable Settlements: A Guide for Planners, Designers and Developers. University of the West of England, 1995

7.3 Policies and Approaches: Regional Strategies

In the consideration of strategies at the regional level, a useful reference[19] outlined the methodology adopted in developing a spatial strategy for the Yorkshire and Humber Region. This work was prepared for the Regional Conference and Assembly.

The results of the study were to inform the review of the Regional Planning Guidance (RPG) and the next round of (land use) development plan and Unitary Development Plan reviews. The recommended strategy contributes over the long term to the sustainability objectives established for the Region, through the influence that RPG can have over the location of the development requirement up to 2016. The scope of the study was limited to residential land use.

One of the principal elements of the strategy is:

"the favouring of development patterns which would allow trip lengths to be shorter, enable walking and cycling to be the most appropriate means of travel in more instances, and provide for the highest proportion of the population to have access to public transport services".

Seven key transport criteria were adopted (as shown in Table 7.1 below) to analyse and assess the transport elements of the Region, which had been split into seven sub-regional areas. The various criteria were given weightings to reflect their relative priority.

Table 7.1: Transport Criteria

Criteria	Weighting
Trip distance	10
Environmental impact of travel	9
Fuel and resource consumption of travel	7
Risks to travellers' safety and security	7
Diversity of transport modes available	6
Journey time and delays	4
Financial cost of transport infrastructure	3

An initial selection was made of areas in the region, which offer some potential for effective transport to and from a possible new development location. This assessment of effective transport was made using two criteria, in essence, sustainable transport and optimum accessibility. As can be seen from the table above, it was decided that minimising the sustainability 'costs' of transport is currently a more important concern than overcoming the accessibility 'costs' of travel.

19. "Yorkshire and the Humber Region: Settlement Potential and Development Options Study".

The emphasis on sustainable transport, not surprisingly guided the selection of sites towards dense centres of activity and places with strong existing public transport infrastructure.

The study recognised that whilst sustainable transport can be encouraged for substantial new developments in peripheral locations, such as rural parts of North Yorkshire, self containment of the community cannot be assured. Therefore, the study adopted the lowest risk approach in transport terms, in which development was directed towards core parts of the Region where travel distances can be minimised.

Strategic transport corridors were identified which could potentially be used by travel movements to access new development locations. The preferred development locations to be carried forward for detailed evaluation (using the above multi-criteria framework) were initially assessed on the following three key features

- The presence of a sustainable transport network;
- The existence of spare capacity on the available infrastructure; and
- The potential for improvements to transport facilities.

The results of the study were that, from a transport point of view, over 75 per cent of development in the region should take place in the South and West Yorkshire conurbations. These areas are targeted due to he prominence of multi-modal transport corridors, many urban centres, bus priority measures, local and strategic heavy rail lines and motorways, and the capacity for rail (but also road) network improvements. In these areas potential exists for the levels of use of sustainable modes to be increased, and travel distances to be reduced.

The report recommended that in the sub-regional areas based upon a single medium to large city (Hull and York) and the more rural sub-regions, new development should take place in or adjacent to existing cities and towns, to take advantage of current facilities. Where any out of settlement development takes place, it is suggested that this should be associated with a smaller number of larger towns. A limited number of new settlements are put forward, most of which are on public transport corridors.

The approach adopted in the report could usefully be considered for application to other areas.

7.4 Strategy Implementation

At the county level in the UK, work has been undertaken[20] to establish empirical evidence on the travel impacts resulting from new residential development. This project investigated the travel patterns of households who had recently moved to new housing areas. The research work took place within Oxfordshire, where surveys were conducted at five locations within a fifteen mile radius of Oxford City (population 115,000).

With a Green Belt in place around Oxford, Oxfordshire County Council has, since the 1970s, focused new development in the county's 'country towns' (e.g. Bicester and Witney), which are located at similar distances from Oxford. This sought to achieve self-containment (and hence minimise travel) through the towns' ability to provide a suitable level and mix of land uses for its resident population. However, there is concern that the policy has resulted in considerable levels of commuting to Oxford, since many of the jobs (and other facilities) remain concentrated here.

The locations surveyed were chosen in order to provide a range of strategic accessibility conditions, e.g. in relation to Oxford and to major transport routes. In broad terms they also represent most of the sort of strategic options available to planning authorities in considering future major housing areas. The locations were:

- Periphery of a built-up area of the city (Botley);
- Dormitory settlement close to the city (Kidlington); and
- Free standing towns approximately 10-15 miles from Oxford served by:
  - national motorway (Bicester)
  - long distance rail (Didcot)
  - neither of these (Witney).

The surveys were undertaken by a detailed personal interview at households. The results reported in the paper deal with only regular journeys (at least twice a week) and therefore the significance of work-business journeys of all travel is likely to have been exaggerated.

Various explanations of the variations in travel patterns between the areas surveyed were considered. It was concluded that:

- Differences in basic socio-economic characteristics do not appear to be a primary source of variation;
- No clear relationship exists between distance from Oxford and travel patterns, except in the levels of use of some non-motorised modes;

20. Headicar P and Curtis C "Residential Development and Car-Based Travel: Does Location Make a Difference?".

- No straightforward relationship exists between accessibility levels (based upon the number of jobs with a 30 minute drive) and the distance from Oxford;
- A very strong positive correlation exists with the proximity to major transport routes (particularly in the case of the proximity to a major road and the proportion/length of car trips); and
- A strong correlation exists with decisions made at the time of move. In particular it was found that accessibility (including to workplaces) was a dominant factor when considering areas to move to, but the final choice is primarily down to finance related matters. It was also established that only 9 per cent worked in the town before the move (and still only 11 per cent after). Average journey times before and after the move were similar, although significantly, there was a modal and distance shift towards the car.

In summary, the study has established that variations in travel behaviour are clearly not simply a result of size and density. Further it suggests that, in practice, the notions of 'self containment' and 'balance' as far as the numerical relationship of workers and jobs in individual towns is concerned, are to some extent irrelevant. The work established that only 1 in 10 of residents surveyed actually work in the town, even though they recently moved there. However, it is clear that proximity to major transport routes and particularly roads is the main consideration here.

The study demonstrates that the adoption of planning policies which restrict housing provision in/close to the main sources of employment, can very easily result in the creation of long distance (and often car) commuting. Hence the objectives of maintaining sustainability through the control of 'urban cramming' are being undermined by the increases in travel distance, and in the case of Oxfordshire, a shift to more travel by car. This is one of the key reasons for the current review of the Green Belt policy in England and Wales.

A final report reviewed [21]onsiders the interaction between suburban land use trends and regional traffic conditions in New Jersey. The study, undertaken in 1989 and 1990, was in response to the problems associated with increasing levels of travel. The MSM Regional Council had concluded in a suburban mobility and growth management report that "concentrating growth in higher density, mixed-use centres" would be " expected to reduce the growth in vehicular traffic" in the area. The study would test this conclusion.

21. The Impacts of Various Land Use Strategies on Suburban Mobility". Middlesex Somerset Mercer (MSM) Regional Council (Central New Jersey)

The study tested the traffic impact of locating the region's new employees in the towns of Trenton (population 90,000) and New Brunswick (40,000), as well as in tightly clustered suburban employment centres. Three models were developed and tested, which incorporated the residential and employment growth expected in the region by 2010, i.e. a 30 per cent increase in population (187,950 new residents) and a 54 per cent increase in employment (182,581 new jobs). The three models are shown in Table 7.2 below:

Table 7.2: Model Scenarios

Model	Density	Residents	Jobs	Target Modes
Transit	High	12,000+	13,000+	Transit, car-sharing, walking
Short Drive	Medium	6,700+	9,500+	Car-sharing, walking
Walking	High	4,500	Minimal	Walking

The study team considered how much less car travel could be expected from the models, compared to that generated by the same amount of development dispersed in less dense, single-use settlements. They established that the Transit model would create 28 per cent fewer vehicle trips, the Short Drive model 24 per cent and the Walking model 18 per cent.

Two scenarios were developed to accommodate all new regional development between 1988 and 2010. These were:

- Scenario 1: Much of the growth would be absorbed into suburban employment centres located throughout the region, whilst a major resurgence of growth would occur in New Brunswick and Trenton; and
- Scenario 2: All growth would be absorbed into the employment centres, making them larger than those in Scenario 1.

The results of the assessments were as follows. The figures shown are savings as compared to the forecast increase in new suburban vehicle trips and distances assuming an alternative locational policy is not in place.

Table 7.3: Results of the Modelling Exercise

	Vehicle trip saving	Vehicle miles saving (AM peak)
Scenario 1	61%	43%
Scenario 2	33%	33%

The overall conclusion of the study is that the predicted number of car vehicle trips and distance travelled can be suppressed by directing new development to existing cities in addition to suburban areas generally.

7.5 Broad Conclusions

This section has assessed the contribution of a selection of spatial strategies at the national, regional and county levels, to sustainable travel patterns. With the exception of the Oxfordshire research, all are concerned with evaluating theoretical or practical options.

Since the various approaches to spatial planning have been assessed in different ways, it is difficult to draw conclusions. However, the following themes have been identified:

- There is a general desire to target new development in existing urban areas, where mechanisms are in place to maximise the use of sustainable modes and minimise travel distances;
- In assessing the spatial options available, greater prominence is given to sustainability objectives rather than accessibility objectives;
- Seeking to reduce pressures on existing principal urban areas by concentrating new development in other more medium-sized towns, can result in higher levels of commuting, which may consequently be less sustainable;
- It is difficult to achieve self containment in new settlements in terms of a balance between the number of jobs and resident workers in the town;
- Proximity to a principal transport corridor, and in particular major roads, is likely to lead to much lower levels of self-containment, with long distance commuting; and
- Outside of major urban areas, in assessing the levels of public transport provision, the focus is very much on rail rather than bus.

8 Conclusions and Implications for Irish Policy

8.1 Overall Conclusions

There is a general agreement in the literature that the following factors have a positive role in promoting sustainable transport:

- Higher densities;
- Mixed land uses;
- Compact settlements; and
- Concentration of development on transport corridors.

However, the scope for settlement policies to influence sustainable transport may be more limited than is often thought, especially in the short term. This is because of the fixity of much of existing land uses, the degree to which existing settlement patterns already support sustainable transport, and the extent to significant segments of the population are already reliant on sustainable transport modes.

While there is a general tendency for sustainability to increase with settlement size, transport sustainability may be more a reflection of settlement patterns within the urban area rather than settlement size. This view is confirmed by an analysis of transport sustainability in Irish towns. Within urban areas in Ireland, use of sustainable transport modes increases somewhat with settlement size. However, use of sustainable transport modes shows a wide variation for towns of a given population size. It is clear that the settlement pattern and function of individual towns are more important determinants of sustainable transport use.

There is some tendency for long trip lengths to occur more frequently in larger towns. However, it is again evident that that there is considerable variation among towns of the same size, indicating that other factors, such as the settlement pattern, are more important in determining trip lengths. However, larger conurbations do encourage longer trip making.

Within the above context it is generally held that settlements below 25,000 may perform relatively poorly in terms of sustainability. The threshold level for the development of local bus services would also appear to be at approximately this level.

Apart from the major urban areas, only four towns in Ireland have a population over 20,000 (Dundalk, Bray, Drogheda and Swords). This inhibits the development of local bus services. Expansion of town size to the threshold level for bus operations is a factor to be considered in the context of identifying appropriate urban scale in the context of the National Spatial Strategy.

The vast majority of autonomous Irish towns achieved reasonable levels of transport sustainability in 1996, largely by virtue of the use of walk and cycle modes. However, use of sustainable transport modes declined rapidly during the period 1986-96, and the latest evidence for the year 2000 suggests significant further decline. Walk, bus and cycle modes experienced the greatest decline. It is only in the larger conurbations that public (bus) transport makes a significant contribution to sustainability, although public transport use does rise with town size. Even among the larger conurbations, it is only in Dublin that public transport use is high.

The decline in transport sustainability is largely the result of increasing car ownership. However, the separation of home and workplaces and the consequent increase in trip lengths would appear to be a contributory factor.

The rapid decline in the use of sustainable transport modes may mean that in future, the car will dominate to an even greater degree. Given the small population size of many Irish towns, local bus operations may not be viable. This will mean that there will not be a viable public transport alternative to the car, and there will be a continued transfer from walk and cycle modes. In the context of the National Spatial Strategy, this argues strongly for the development of Irish towns, to a scale above the threshold level for the introduction of local bus services.

The analysis of Irish data showed that dormitory towns generally have low levels of transport sustainability, except where public transport provision, and particularly rail service levels, is high. The international literature shows that is difficult to achieve self containment in new settlements in terms of a balance between the number of jobs and resident workers in the town. These findings highlight the dangers in the concentrated decentralisation approach to urban development. Giving the difficulties of ensuring that local residents take local jobs, especially in the light of increasing job mobility, satellite towns will have negative impacts on sustainability unless they are well served by public transport,

As the larger conurbations grow, commuting trip length increases and this reduces the use of walk and cycle modes. In Dublin, public transport has taken the place of these modes to a significant degree, thus maintaining a high level of sustainable transport mode use. However, public transport (bus) use in other conurbations, especially Cork, has not increased in a similar fashion, so that they perform relatively poorly in terms of use of sustainable transport modes. Given the scale of Irish towns outside of Dublin, expansion of public transport services will be based largely on the bus mode. This argues for an enhancement of bus services in Cork Limerick, Galway and Waterford.

Apart from Dublin, the other major urban areas are not, in general terms, close to a scale that would support significant LRT or Metro systems.

Suburban rail operations will also contribute to sustainability where there are significant dormitory towns in the hinterland of major urban areas, but at some distance. The obvious locations in which suburban rail operations could be extended are in Limerick and Cork.

With regard to the framing of a spatial strategy, the analysis presented in this study suggests that town size is not a dominant factor in determining the sustainability of transport. Provided appropriate settlement patterns are encouraged, the development of larger towns should not result in unsustainable transport patterns. However, in practice, this is likely to require a significant expansion of public transport provision.

Bibliography

Barton et al, *"Sustainable Settlements: A Guide For Planners, Designers and Developers"*, UWE, 1995

Banister, *"Energy Use, Transport and Settlement Patterns"*, Sustainable Development and Urban Form, Breheny 1992

Banister, *"Planning More to Travel Less"*, Town Planning Review, 70 (3) 1999

Banister et al, *"Sustainable Cities: Transport, Energy, and Urban Form"*, Environment and Planning B Vol 24 1997

Banister, Transport and the Urban Development, 1995

Brown, *"Modelling Urban Growth"*, Town and Country Planning, November 1998

Cawley, *"Town Population Change in the Republic of Ireland: The Need for an Urban Policy Review"*, Regional Studies 30 1996

Gordon, *"Densities, urban form and travel behaviour"*, Town and Country Planning, September 1997

Headicar and Curtis *"Residential Development and Car-Based Travel: Does Location Make a Difference?"*, PTRC 1995

McGrath, *"Environmental Sustainability and Rural Settlement Growth in Ireland"*, Town Planning Review 69 (3) 1998

Newman and Kenworthy: *"Gasoline consumption and cities: a comparison of US cities with a global survey"*, 1989

Snellen, *"The Relationship Between Urban Form and Activity Patterns: Multi-Variate Analysis of Frequently Made Trips"*, PTRC 1999

Williams and Banister *"How Big is Sustainable? The interaction between settlement size and travel behaviour"*, PTRC 1999

Evaluation of the Suburban Rail Plan. Report to Iarnrod Eireann. Goodbody Economic Consultants in association with Electrowatt Engineering, 1998.

The Impacts of Various Land Use Strategies on Suburban Mobility, Middlesex Somerset Mercer (MSM) Regional Council (Central New Jersey), 1995

Potential for Commuter Rail Services in the Limerick Area. Report to Shannon Development. Goodbody Economic Consultants, 1999

Sustainable Development: A Strategy for Ireland. Department of the Environment, 1997

Sustainable Settlements: A Guide for Planners, Designers, and Developers, Faculty of the Built Environment, University of the West of England, 1995

Yorkshire and the Humber Region: Settlement Potential and Development Options Study: Final Report, Baker Associates et al, 1998

Brindle, Transport and Urban Form: The Not So Vital Link, ARRB, 1996

OECD, Land Use Planning and Sustainable Urban Travel, 1998

Barry, Through The Cities: Revolution in Light Rail, Frankfurt Press, 1991

Appendix 1

UK Policy

The UK Government's strategic policy on sustainable transport was set out in the 1998 White Paper 'A New Deal for Transport : Better For Everyone', which provided a comprehensive policy framework for an integrated approach to transport. The White Paper was subsequently supported by a range of subsidiary documents which set out in fuller details the proposals identified in the White Paper, providing advice on sustainable transport to transport providers.

The main objective of A New Deal for Transport is to deliver an integrated transport policy. This means integration:

- Within and between different types of transport;
- With the environment;
- With land use planning; and
- With policies of education, health and wealth creation.

In July 2000, the Government published 'Transport 2010 : The 10 Year Plan' which focussed on an investment plan for delivering the integrated transport objectives contained in the White Paper.

Within the White Paper, land use planning was seen as a key role in delivering the Government's integrated transport strategy. By influencing the location, scale, density, design and mix of land uses, it was acknowledged that planning could help to reduce the need to travel, reduce the length of journeys and make it safer and easier for people to walk, cycle or use public transport.

Planning Policy Guidance (PPG) Notes set out the Government's policies on different aspects of planning. They are taken into account by regional planning bodies and local planning authorities in preparing regional planning guidance and development plans and are also material to decisions made on individual planning applications and appeals. The guidance contained within the various PPG notes incorporates the principles adopted by the Integrated Transport White Paper.

Of particular relevance to the integration of land use and transport are:

- PPG11 - Regional Planning

Guidance on the preparation of Regional Transport Strategies, as an integral part of Regional Planning Guidance, which provides a long term strategic framework which informs development plans, local transport plans, and transport operators in developing their plans and programmes;

- PPG3 – Housing

Introduces a new approach to housing, to promote more sustainable patterns of development and better use of previously developed land; and

- PPG13 – Transport

Guidance on the integration of planning and transport at the national, regional and local level to promote more sustainable transport choices and reduce the need to travel, especially by car.

At a local level, transport infrastructure investment is through the Local Transport Plan (LTP) process. Since publication of the White Paper, investment in local infrastructure has been built around 5-year integrated transport strategies, devised at a local level in partnership with the community. The emphasis is on the development of sustainable transport strategies rather than the merits of individual minor schemes.

The objectives contained in local authorities Local Transport Plans must be consistent with the Government's integrated transport policy. These are:

- To protect and enhance the built and natural environment;
- To improve safety for all travellers;
- To contribute to an efficient economy, and to support sustainable economic growth in appropriate locations;
- To promote accessibility to everyday facilities for all, especially those without a car; and
- To promote the integration of all forms of transport and land use planning, leading to a better, more efficient transport system.

The development of a more integrated and sustainable transport and land use policy is clearly a long-term process. However, the UK experience demonstrates that it is essential for the necessary strategic policy to be in place, the detailed local guidance to be provided, and appropriate level of investment to be made available.

Appendix 2

Ranking of 54 Irish Towns by Use of Sustainable Transport Modes

Town	Population	Proportion Using Sustainable Transport Modes (%)
Bray	26,953	41.31
Wexford	15,393	40.57
Greater Dublin	929,090	40.53
Drogheda	24,656	39.52
Nenagh	5,825	39.37
Tralee	17,862	38.59
Arklow	7,987	38.34
Balbriggan	7,724	37.42
Sligo	17,964	37.02
Ballinasloe	5,892	36.76
Dungarvan	6,920	36.67
Thurles	6,955	36.64
Tullamore	9,430	36.48
Enniscorthy	7,655	36.17
Killarney	9,950	36.07
Galway County Borough	50,853	35.92
Longford	6,824	35.66
Carrick-on-Suir	5,143	35.28
Youghal	5,828	35.13
Tuam	5,540	35.07
Carlow	14,027	35.03
Kilkenny	17,669	34.87
Athy	5,204	34.42
Dundalk	30,061	34.15
Droichead Nua	12,069	34.05
New Ross	6,079	34.01
Limerick County Borough	75,436	33.85
Ballina	8,167	33.79
Shannon	7920	33.45
Cobh	8,219	33.26
Castlebar	7,648	32.77
Clonmel	15,562	32.50
Waterford County Borough	41,853	32.46
Athlone	15,358	31.83
Monaghan	5,946	31.63
Mullingar	11,867	31.52
Portlaoighise	8,360	31.44
Letterkenny	10,726	31.22
Mallow	7,521	30.56

Town	Population	Proportion Using Sustainable Transport Modes (%)
Navan (An Uaimh)	11,706	30.27
Midleton	5,951	30.24
Cavan	5,254	29.42
Rush	4,839	29.03
Ennis	16,058	28.27
Maynooth	6,027	27.81
Wicklow	6,215	27.70
Cork County Borough	174,400	27.21
Portmarnock	9,173	25.19
Portmarnock	9,173	24.90
Naas	11,141	24.69
Greystones	10,778	23.64
Celbridge	9,629	21.10
Tramore	6,064	18.32
Carrigaline	6,482	12.72