Environmental RTDI Programme 2000–2006

Methodologies for the estimation of sustainable settlement size (2000–LS–4.3–M1)

Final Report

Prepared for the Environmental Protection Agency

by

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Executive Summary

1 Project summary

This project aimed to identify the key links between the size of settlements and their sustainability. It was intended to provide information on the development of spatial policies emerging from the National Spatial Strategy relating to optimal ways in which to accommodate Ireland's growing population in a manner consistent with balanced regional development and environmental sustainability.

2 Project findings

2.1 Environmental issues

- Transport: there is a clear relationship between settlement size and use of public transport. There is a threshold population (ca. 20,000–30,000) at which internal bus services become more viable.
- Energy and climatic emissions: energy use in buildings is related to urban density, and climate emissions depend on the energy source. However, settlement size is linked to the viability of combined heat and power units with distributed heating.
- Waste and resource use: larger settlements generate more waste per person, but also enable higher rates of recycling.
- Water quality and treatment: larger settlements are more likely to afford full tertiary sewage treatment, with consequent improvements in local water quality; there is a minimum population threshold of about 1000 for viability of secondary treatment.
- Urban quality: congestion and noise both increase in larger settlements (though there are important Irish exceptions), but open space access is generally better in smaller settlements.

2.2 Development issues

- Overall size thresholds: a minimum population threshold level of 1000–2000 enhances viability for a primary school, some local services and centralised sewage treatment.
- A settlement with 15,000–30,000 people enables a secondary school, public and commercial services, and some environmental infrastructure.
- Urban form effects: many sustainability indicators improve with increasing density rather than just size. However, larger Irish settlements generally have higher densities.
- Urban function effects: the level of services and functions in a settlement may be larger or smaller than its population might indicate, and this affects sustainability performance.
- Spatial development implications: a development pattern with settlement sizes in the 1000–2000 and 20,000–30,000 population bands clustered around public transport nodes is likely to be most sustainable.

3 About this study

Research was undertaken within the EPA Environmental RTDI Programme during the period from March to August 2001 by a partnership formed by the Centre for Environmental Research, University of Limerick, and the Centre for Urban and Regional Ecology, University of Manchester. The main purpose of the project was to provide information on planning in relation to the National Spatial Strategy on the relationship between settlement size and sustainability.

4 Description of methods

4.1 Information collection methods

Three modes of analysis were adopted to obtain data and information on settlements. Initially, both quantitative and qualitative data were collected for a single city and two villages, to provide the most comprehensive analysis possible of the state of the local social, economic and physical environments, the track record in enhancing sustainability, the current policies in place, and the likelihood of these policies proving successful. Following this, 29 quantified sustainability indicators were developed for a set of 11 settlements, selected to include a range of

functions and locations. A review of international literature was then undertaken to search for comparable data, models and case studies, so as to provide a context for the analysis of Irish data.

4.2 Data availability

The scope and reliability of the results of this study were limited by the non-availability of data. Many data are not collected; others are collected but are available in aggregated form at a scale too coarse to allow inter-settlement comparisons (e.g. at county level). Crucial data have been collected but are not available because of commercial sensitivity or the inability of holding organisations to provide them. The report identifies where the information gaps occur, why they are important, and which agencies are in the best position to collect the critical data.

4.3 Definition of sustainability

The literature does not provide generally agreed definitions for sustainability and sustainable development: a key issue is the extent to which trade-offs are allowable between cultural and natural capital. Here we take sustainable development to be a process that enhances well-being by means of improvement in economic and social conditions allied to protection and enhancement of environmental quality, while minimising environmental impacts elsewhere. A sustainable settlement provides inhabitants with a high quality of life, but does not at the same time grow rapidly by attracting migrants from smaller settlements to the extent that they suffer decline. We adopt indicators developed by the European EPA, the WHO, the OECD and the UN. Our framework of significant environmental themes is based on Irish EPA publications.

4.4 Definition of settlement size

The size of a settlement may be defined by area or by population; each of these may be measured by the administrative boundary, to the urban edge, to the surrounding suburbs, or even to the travel-to-work hinterland. These alternatives are discussed in the report, but the way that size is quantified is largely determined by the availability of data.

5 Evaluation of methods

5.1 Which data do we need?

Sustainability is a complex concept, including environmental, social and economic dimensions. At a simple level, this is self-evident – a settlement with immediate economic or social problems is unlikely to be able to focus on the longer-term planning required to approach sustainability. Indicators for sustainability must embrace these dimensions, and it is unwise to rely on a small number of indicators, as this will inevitably result in some aspects of sustainability being ignored or inaccurately represented. Analysis of indicators herein did not show that some were clearly more useful than others. Results indicate that there is no single defining ‘big issue’, and future research should be built on a wider spectrum of indicators than could be developed for this study. There is need for an extensive database to allow analyses of changes over time.

5.2 In-depth investigation of selected settlements

Information on smaller settlements reported herein is not likely to be available for other small settlements, and this form of analysis is only possible following in-depth interviewing of key people. Detailed information on one small settlement provided invaluable insights that were of major significance to the findings of this study.

5.3 Are indicators useful?

Twelve of the 29 indicators developed showed sensitivity to settlement size; indicators were, therefore, able to demonstrate inter-settlement differences in sustainability potential influenced by settlement size, and they provide a crucial basis for our analysis. Our ability to interpret these indicators was enhanced through a review of similar studies elsewhere.

5.4 What was learned from experience in other countries?

Comparable studies have been undertaken in other countries. This experience strongly indicates that sustainability is both highly important and often difficult to quantify. In some instances this has produced models of potential relevance within the Irish context. While these

are very useful for enhancing our ability to interpret Irish data, direct application was not practicable

6 Is the sustainability potential of a settlement influenced by its size?

6.1 Overall findings

Results from the three research methods were broadly similar: it was found that larger settlements in the recent past, at present and in the foreseeable future are more likely to create conditions capable of supporting those types of actions that enhance sustainability.

6.2 Advantages of larger settlements

As a rule, larger settlements have better regional, national and international transport and communication links. Larger settlements contain more services, especially more higher order services, than do smaller settlements, and, under some definitions of sustainability, the availability of diverse services may be considered to counterbalance the negative influences of large size on sustainability, such as a reduction in biodiversity. Findings from other studies have demonstrated that if settlement size increases beyond a threshold, then the negative impacts outweigh the benefits deriving from enhanced service availability and other similar effects, thus providing a means of estimating optimal settlement size. The present study did not include a representative sample of Irish settlements, or the two largest cities, so it was not possible to quantify this threshold in terms of settlement size.

6.3 Disadvantages of smaller settlements

Smaller settlements may attract lower levels of investment and employment, are less well connected within transport networks, rely more heavily on private transport, are unable to sustain wastewater treatment plants based on many modern technologies, and are less likely to have an unpolluted drinking water supply. Smallness of size correlates with low housing density; low density in turn correlates with economic and environmental inefficiencies. For example, smallness of size increases the environmental and economic costs of waste collection, and reduces the efficiency of the recycling and re-use infrastructure. Because of their small size, they are not high priority within local authority development plans, and it is often difficult for communities to raise resources for self-help schemes, which suggests that their relative disadvantage will continue into the future. Further study is required to identify the extent to which such studies are applicable in Ireland.

7 Findings in relation to major environmental themes as identified by the Irish EPA

7.1 Transport

Travel by private car is dominant in all settlements, but smaller settlements (with lower inter-settlement connectivity through public transport provision) rely most heavily on private transport. In larger settlements, the better availability of buses means that these are used to a considerably greater extent, and car-pooling is more common. Larger settlements are better connected to other large settlements, both in Ireland and abroad. National data suggest that road accident fatalities are lower in larger settlements. Trends between 1991 and 1996 show that in all settlements the length of the journey to work/education is increasing – in 1991, there was some evidence that in smaller settlements, daily journeys were shorter, but by 1996 this advantage had largely eroded. Results indicate that in relation to transport, Ireland is not moving towards sustainability, but that opportunities to do so are greater in larger settlements. There is evidence for a minimum settlement size requirement of 15,000–30,000 population to support a viable bus service.

7.2 Energy use and climate change

Irish data on energy use were unavailable. Energy use in buildings is generally related to urban density rather than size, but higher densities are found in larger Irish settlements, although this may not necessarily be the case in the future. Higher density multi-storey flats and maisonettes are more energy efficient, other factors being equal. The climate emissions factors depend on the energy sources, and a shift from coal/peat to gas for domestic heating is environmentally beneficial. Evidence suggests that higher density settlements encourage the adoption of technologies such as combined heat and power generation and district heating networks. A minimum population of ca. 1000 is required to enable district heating

networks. However, smaller settlements might encourage the use of biomass (especially wood, Ireland's principal renewable energy source) for domestic heating.

7.3 Solid waste

In general, data suggest that while the amount of household waste being produced is similar across all settlement sizes, larger settlements create larger per-capita amounts of municipal wastes. This is not surprising, given the greater range of industries and services located in larger settlements. Additional planning for mitigation measures is required. These measures might include a reduction in the creation of wastes, greater provision of recycling banks, increasing the range of materials to be recycled, a greater return for re-use of packaging materials, and greater use of composting. Experience elsewhere suggests that many of these actions are more likely to be successful in higher density settlements or in clusters of settlements with easy transport links. For example, recycling of common materials becomes more viable at a minimum settlement size of 100,000 people.

7.4 Water quality

There are links between effluent quality and surface water quality, but they are not simple or clear. Published data on drinking water quality suggest that rural water schemes are more likely to provide poor-quality potable water. Larger settlements attract a greater number of industries with integrated pollution control (IPC) licences, which may be assumed to be less likely to pollute surface water and groundwater. Larger settlements are also more likely to have, or to be actively developing, modern wastewater treatment plants, while smaller settlements are unable to sustain wastewater treatment using many modern technologies. Evidence to hand, therefore, suggests that larger settlements are less likely to adversely affect natural water, and are more likely to provide a high standard potable water supply.

Threshold effects show no clear limits. Communal secondary treatment becomes more viable when the population exceeds 1000. The priority for tertiary treatment increases where local surface water quality is critical, and hence the threshold size is reduced.

7.5 Urban quality

In Ireland as elsewhere, social infrastructure in general is enhanced as settlement size increases, up to a limit beyond which urban quality of life may suffer. The identification of such a threshold level for Irish settlements fell outside the scope of this study. Outside Ireland, the provision of a wide range of services was related to higher density urban areas. These are found in larger Irish settlements. Findings reported herein in relation to forestry and goldfinches suggest that larger settlements may be less successful in maintaining biodiversity. While there is likely to be a trade-off between enhanced urban services and decreased biodiversity, planning to enhance biodiversity through, for example, the provision of well-managed open spaces, conservation areas and urban forestry, may be expected to mitigate the negative impacts. This study provided some data to suggest that the availability of general practitioner doctors per capita was greater in smaller settlements, but that larger settlements were much more likely to contain a hospital. Again, good planning may be expected to mitigate any deficiencies in larger urban areas. In relation to threshold limits, there are no clear limits for biodiversity, congestion, etc. For public services, there are thresholds for the viability of schools that provide a modern range of facilities. These are populations of 1000–2000 for primary schools and 15,000–20,000 for secondary schools. There may be a higher size band of about 50,000–100,000 people for regional tertiary education institutes.

8 Other development–environment linkages

While this study aimed directly at the issue of 'settlement size', much of the literature also looks at related factors in urban form and function. While 'size matters', the question of sustainable size then depends on how far size is linked to these other issues:

- 'Urban density': clearly this is related to but distinct from 'size'. Environmental issues such as local transport, energy demand and biodiversity are more directly related to density, and these linkages are often more clearly identified in the literature.
- 'Urban pattern': in larger settlements, the degree of clustering and densification of the population and

services within the urban area is crucial to the environmental profile of transport, energy and other effects.

- 'Spatial pattern': this covers the context of functional city-region, county or other kind of hinterland, which may be defined in different ways, including travel to work area, administrative area, bio-region or water catchment area. With certain spatial patterns, a cluster of smaller settlements may achieve the critical mass of a larger settlement.

- 'Urban hierarchy' and the balance of population vs. service provision. For instance, commuter settlements have populations greater than their activities, while 'gateway' cities and towns would have smaller populations relative to their activities.

- 'Socio–economic function': this covers the questions of social structure, economic activity, connection to global networks and other special factors. For instance, a factory town may be quite different to a tourist or university town of the same size. 'Sustainable size' is then a question of maintaining a more balanced, more competitive and less vulnerable economic and social structure, which in turn will bring environmental benefits.

9 Implications for the National Spatial Strategy

Settlement size is a crucial question for the NSS – the rapid changes in Ireland at present may see some settlements doubling in size while others continue to reduce. The NSS covers a variety of regional types, including the Greater Dublin hinterland, and possible 'gateway' cities, the North and South Midlands, the west coast, and the far north. Each of these contains different problems and prospects for settlement development. For instance, in the tourism growth areas, settlements need to be planned for both in-season and off-season populations.

The implication of this study is not necessarily that the whole population should live in larger cities, but that there are a range of thresholds or viable critical masses for environmental, social and economic infrastructure.

- 'Gateway' or strategic towns will benefit from being increased to a size that supports a critical mass in social, economic and environmental infrastructure, but not at the cost of reducing surrounding settlements to below-viable thresholds. However, such growth may well be more beneficial where it clusters populations into distinct but well-connected settlements on a city-region basis, to avoid imbalances between population and functional level.

- In other areas of restructuring, such as the Midlands, the roles of market towns, new estates and rural villages need to be considered in the light of population trends, and the development of key settlements should aim at a hierarchy of viable settlement sizes as above.

- In high growth areas such as the tourism-based west coast, the impact of scattered development on fragile environments is a priority. Enhanced levels of infrastructure for drainage and transport should be considered as part of a strategic plan that clusters new development to viable thresholds as above.

10 Other questions relevant to planning policy

10.1 Is there a single optimum settlement size for maximum sustainability?

As sustainability is a compound of many different themes, the balance point depends on how these are weighted and added together. A recent study of 50 Italian settlements found that negative environmental impacts and positive social/economic benefits were at some kind of optimum with a population of 300,000–400,000.

10.2 Is there a single 'biggest issue' at the top of the list?

This depends on whether local or global concerns are thought to be more important. There is a degree of consensus that today transport has the most far-reaching environmental impacts and, at the scale of strategic planning under the NSS, it is possibly the foremost issue. Clearly though, planning for sustainability must consider much more than just transport.

Section 1 Literature review

1.1 Introduction

It could be argued that sustainable development is in danger of moving from a state of ambiguity to a cliché without ever having passed through a stage of meaningfulness or comprehensibility. The tenuous nature of the concept, coupled with its increasing importance in international and national policies, has led to a contentious political battle for influence over our future, resulting in a wide variety of definitions and interpretations. In the past decade, impetus has been placed on the importance of sustainable development in land-use planning, particularly given the unprecedented increase in the human population. The increasing scarcity of suitable landscape resources relative to demand worldwide, and the increasingly costly measures that must be taken to protect landscape resources, are crucial considerations for settlement planning and management today (Wilkin, 1996). In particular, much attention has been paid to the question of whether the arrangement of physical elements within a settlement, and the intensity of its use, affect the capacity of settlements to function in a sustainable way. This report aims to investigate the political and cultural paradigm of sustainable development within the context of settlement size. It sets out the background to alternative ways of accommodating development, drawing on past experiences, and investigates the characteristics of existing and new settlements.

1.2 The evolution of the sustainable development paradigm

In the second decade since the publication of the World Commission on Environment and Development (WCED) report, *Our Common Future* (Bruntland Commission, 1987), sustainable development remains a concept intuitively understood by many but difficult to express in tangible or operational terms (Lele, 1991). There has been much scientific and political debate about an adequate definition of the concept – not least for the reason that the theory is based more on political compromises than on new scientific achievements (Dietz *et al*., 1992). Development traditionally implies continued economic growth, while sustainable implies that constraints must be applied. Given the severity of human impacts on the environment, the combination of the two concepts, according to Thomas and Furuseth (1997), seems incomprehensible. However, sustainable development represents a transformation in both the way society approaches growth and the attendant stress that growth places on the environment. Patterns of resource use are influenced by each nation's society, environment and economy. This has resulted in different paradigms that are based on 'weak' and 'strong' sustainability principles. Pearce (1989) classified sustainable development into four major headings.

1. Weak sustainability – only the aggregate of stocks and capital, regardless of their type, has to be held constant for future generations; these forms of capital are completely substitutable for each other. It is the aggregate quantity that matters and there is considerable scope for substituting man-made wealth for natural environmental assets.

2. Sensible sustainability – no further decline is accepted for known critical natural stocks, while for others substitution between natural and man-made capital is allowed for.

3. Strong sustainability – the overall stock of natural capital should not be allowed to decline.

4. Absurdly strong sustainability – no substitution is permitted between the various kinds of natural capital stocks; each stock has to keep to at least its current level.

Currently there are over 300 published definitions of sustainable development, the products of diverse worldviews and competing vested interests (European Environment Agency (EEA), 1997). However, the most frequently cited version is that which emerged from the United Nations Conference on Environment and Development (UNCED): sustainable development is:

"*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*".

This definition, according to Kirkby *et al*. (1995), depicts the concept's political coming of age and establishes the content and structure of the present debate. It is based on an ethical imperative of equity within and between generations and implies sustaining the natural life-support systems on the planet, while extending to all the opportunity to improve their quality of life (Hediger, 2000). Fundamentally, sustainable development addresses three major concerns:

1. the need to arrest environmental degradation and ecological imbalance,

2. the need to avoid impoverishment of future generations, and

3. the need for equity in the quality of life among present-day populations (Redclift, 1987).

The first official recognition of sustainable development in Ireland was in the 1990 Environment Action Programme (DoE, 1990). The aim of this programme was to provide a comprehensive and systematic framework for environmental protection in Ireland. In 1992, sustainable development was included in the EPA Act as a guiding principle for the agency's operation (Scannell, 1995). The National Development Plan (NDP), 1994–1999, sought as a fundamental strategic consideration, the integration of environmental and economic objectives in the interests of sustainable development (Stationery Office, 1993). The environmental profile of the NDP was incorporated into the agreed Community Support Framework for Ireland (CSF), 1994–1999, which identifies as a key issue the need to reduce the pollution and destruction of environmental media (Honohan, 1997). The Irish Government, in its policy agreement for a 'Government of Renewal' (Stationery Office, 1994), committed itself to the preparation of a national sustainable development strategy. The report, published in 1997, represented the first attempt to draw together a comprehensive and integrated national agenda for sustainable development (DoE, 1997).

A 1998 report by An Taisce, an environmental NGO, considers that sustainable development rests on two basic considerations. First, development must not deplete the resource base. This is particularly crucial in Ireland because international trade depends on our 'green image', and both tourism and the food industries are subject to a quality environment (Layde, 1998). Second, economic growth must find a balance and harmony with environmental protection. This involves using resources more efficiently, and with less impact on the environment.

Ireland's overall agenda for sustainable development should take account of these considerations. Sustainable development affects all areas of policy and action, not just the more pressing environmental issues. A systematic and comprehensive approach is required. The *Report of the Joint Committee on Sustainable Development* (1997) concluded that sustainable development policies will, in the case of Ireland, lead to sustainable competitive advantage in industries such as food production and tourism, where a green image can enhance job creation (Joint Committee on Sustainable Development, 1997).

1.3 Land-use planning and human settlements – understanding the problems

Global human population growth presents compelling challenges for today's planning professionals. Throughout most of human history, the growth of population, degradation of resources, restructuring of societies, and the development of new technologies have usually been so slow as to be imperceptible during an individual lifespan (Meadows and Randers, 1992). However, in the past two centuries the global economy has shown exponential growth, transforming the character of the planet and especially of human life (Mebratu, 1998). A European city of 1 million inhabitants consumes on average 11,500 t of fossil fuels, 320,000 t of water and 2000 t of food per day (EEA, 1995). Sustainable development is an inter-generation concept but, by 2025, a generation ahead, the world population will grow by over 2.5 billion people (see Fig. 1.1); 80% of this growth is expected to occur in urban areas (Varis and Somlyódy, 1997).

The world's landscapes must provide an adequate quality of life for a rapidly growing and increasingly demanding human population. As urban settlements expand and resource demands and waste outputs exacerbate pressures on the natural environment, the 'ecological footprint' of cities is rapidly extending (Wackernagel and Rees, 1996a,b). As population growth will be virtually synony-

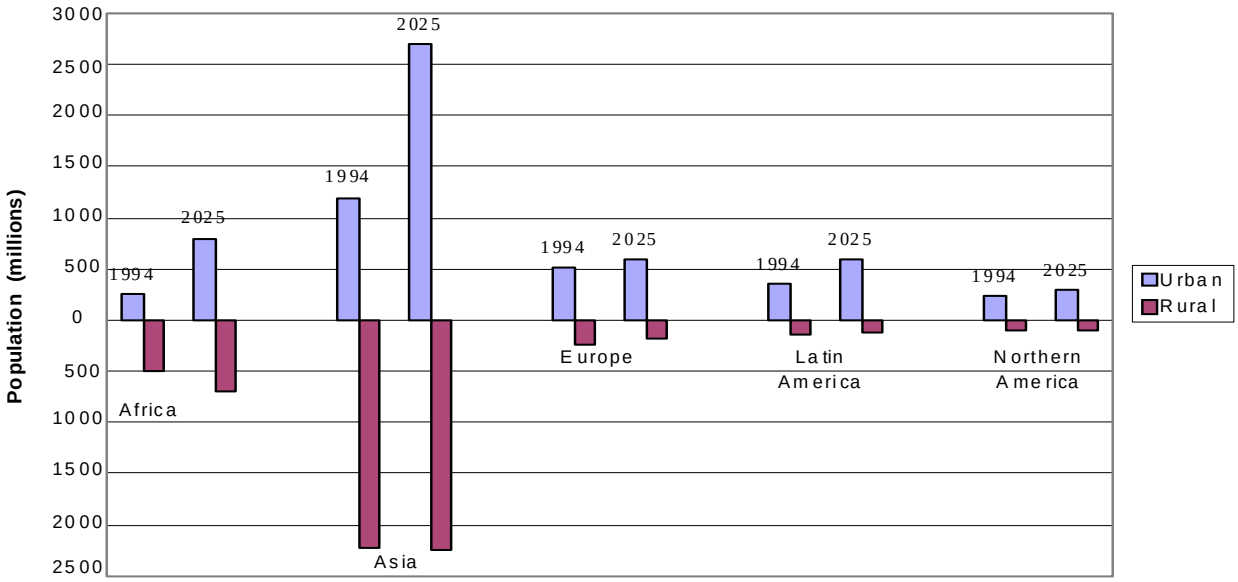

Figure 1.1. Rural and urban population by continent.

mous with urban growth in the coming decades, the focus of efforts at sustainable development must be on urban areas, as these are where economic activity will concentrate, most pollution will be generated and most natural resources will be consumed (United Nations Centre for Human Settlements, 1994). Human settlements are major sites of environmental impact. They are not self-sustaining systems as they require a complex set of importing and exporting arrangements for people, food, goods and waste products. Much evidence now points to the way in which settlements function as nodes in a global 'hypergrid' – networks of motorways and airports for transport of people and goods, and networks of satellites for movement of information and capital. The scale of global urbanisation requires a radical modification of planning policies on behalf of the natural environment. Bindé (1998) stated that over the decades, urban settlements have formed complex relationships with their environment, involving dependency, transformation and negation. The full implication of these links is not yet defined. He argued that settlements will, in the future

"*have to be designed as a new form of environment whose very existence rests on the production, management and consumption of very diverse natural resources and on a rational use of space, that is to say, factors for which urban societies are still ill-prepared*".

International policy agreements have undoubtedly added to the sustainability dilemma for planners. The Bruntland report, *Our Common Future*, made specific mention of the problems of cities and emphasised that environmental problems can no longer be considered in isolation from economic development (Bruntland Commission, 1987). In 1991, DG XI of the European Commission published a *Green Paper on the Urban Environment* which described an initiative for a European city which would be sustainable in environmental and socio–economic terms, reducing the need to travel and maintaining the viability of city enterprises (CEC, 1991). The *Fifth Environment Action Programme Towards Sustainability* (1993–2000) also stressed the role of local authorities (LAs) in a number of key areas including spatial planning, economic development, infrastructure development, industrial pollution, waste management and transport (CEC, 1997b). It represented a definite illustration of the move towards integration, calling for priority to be given to, *inter alia*, sustainable management of natural resources, integrated pollution control and prevention of waste, reduction in the consumption of non-renewable energy, measures to improve environmental quality in urban areas and improved public health and safety. As one of its objectives, Chapter 7 of Agenda 21 (endorsed at UNCED, Rio de Janeiro in 1992) sought the integration of sustainable development concerns into human settlement planning and management. The discussion on sus-

tainable development in relation to settlement size has also gained greater official recognition. In 1993, the Urban Environment Expert Group, together with the European Commission, launched the Sustainable Cities project to promote new ideas on European urban sustainability and to foster the exchange of good practice.

The '*Charter of European Cities and Towns Towards Sustainability*' (CEMR, 1996) describes sustainable development as helping cities and towns to base standards of living on the carrying capacity of nature, while seeking to achieve social justice, sustainable economies and environmental sustainability. The term 'sustainable cities' and 'sustainable human settlements' were much in evidence at the UN Conference on Human Settlements (Habitat II or the City Summit) held in Istanbul in 1996. Habitat II attracted unprecedented local government attention and Ireland was one of the 200 countries represented at the conference. Habitat II adopted a worldwide plan of action, the '*Programme for Habitat*', and a statement on human settlements known as the '*Istanbul Declaration*' (Bindé, 1997). All government delegates appeared to support the idea of sustainable human settlements or sustainable urban development. However, according to Satterthwaite (1997), this apparent unanimity was misleading because there was no clear, agreed definition as to what the terms 'sustainable cities' and 'sustainable human settlements' mean, in the sense that a settlement is not only the buildings within an urban area, but its travel hinterland, social identity, economic arena and physical hinterland. Defining the urban environment is equally difficult. According to a 1990 report from the Organisation for Economic Co-operation and Development (OECD, 1990)

"*the narrowest interpretation of the city is one that is concerned primarily with the appearance of urban places and embraces building design, conservation, townscape and planning*".

Distinct development trajectories in different countries suggest that no single strategy, however sustainable, will apply equally in all countries (Alberti and Susskind, 1996). From the perspective of average levels of resource use, waste generation and production of greenhouse gases, most cities in the developing countries have much lower levels than cities in the developed countries (Boyden, 1992). However, from the perspective of environmental health, cities in the developed countries perform better than cities in the developing countries, as proven by the much lower levels of environmental hazards resulting in illness and injury (World Health Organisation (WHO), 1996). In general, the developed countries, with 25% of the world population and 75% of resource consumption, have an ecological footprint six times greater than the developing countries (Mega, 2000).

1.4 Spatial planning in the EU – recent developments

In its promotion of social and economic cohesion within the Community, the European Union (EU) has invested considerable funds, with important spatial planning implications for the relevant national, regional and local authorities. The impact of the EU has been felt in both the organisation of spatial planning systems (including the introduction of new instruments) and in the policies that the systems pursue. The EU has had direct influence on Member States through (CEC, 1997a):

1. legislation, especially Directives on environmental matters;

2. policy, on matters with a spatial dimension such as the Trans-European Networks and the reform of the Common Agricultural Policy (CAP);

3. policy formulation and implementation, notably cohesion policy supported by the Structural Funds.

The EU has had a direct effect by raising awareness of the importance of transnational and cross-border issues. EU environmental law is the most important factor influencing spatial planning in Member States. The importance of co-operation between levels of administration within the EU is reflected in:

1. Europe 2000: a report intended to provide information on trends in the spatial development of EU territory and 'a framework for cooperation' (CEC, 1991);

2. Europe 2000+: a report that presented the findings of the transnational studies together with policy options (CEC, 1994).

The sustainable development paradigm is not only becoming a major factor for the formulation and implementation of planning policy, but also for the instruments and procedures of planning. In some countries, such as Denmark, the UK and Ireland, environmental assessment has been introduced as an amendment or an addition to spatial planning law. Environmental Assessment as a planning tool will be considered in greater depth in Section 1.8.2.

Continuing urban problems, such as infrastructural deficiencies, unemployment, management of natural resources and poor quality of life, have been linked to poor spatial planning (Cohesion Report, 1996). Some attempts have been made to address these problems through compensatory attempts to protect the environment or infrastructural investments. One of the major disadvantages associated with incentives such as the Structural and Cohesion Funds is the tendency to encourage some Member States to pursue fund-driven developments as opposed to objective-led developments. This often leads to negative impacts on natural resources, distortions in settlement patterns and/or land speculation (Bradley, 1998). One example of a clear relationship between the spatial planning system and EU funding programmes is Ireland, where Objective 1 funding has played a part in the decision to prepare a national spatial planning framework. The National Development Plan (1994–1999) covers the same funding period as the Structural Fund programme. In addition, the establishment of eight regional authorities in Ireland partly arises from the requirement for the review of structural fund spending. The regional authorities have been asked by central Government to prepare strategic regional plans for the next round of EU funding. The task will bring into focus the potential role of the regional authorities in the regional planning process, as distinct from the implementation of centrally determined policy (Layde, 1998). In the post-1999 period, the European Spatial Development Perspective (ESDP) is planning to integrate spatial planning criteria into any future funds allocation process. The main principles of the ESDP are to achieve sustainable and balanced development of EU territory so that spatial planning and development can contribute to the goal of environmental and socio–economic cohesion.

The main political aims are:

1. a more balanced and polycentric system of cities and a new urban–rural relationship,
2. parity of access to infrastructure and knowledge, and
3. prudent management and development of natural and cultural heritage.

These aims are echoed in the Irish NDPs, particularly the most recent NDP 2000–2006, and these are addressed in Section 1.5.1.

1.5 Spatial planning in Ireland – a review of legislation

Urban planning in Ireland operates within the local government system and has long been subservient to central government (Roche, 1982). Physical planning, as carried out under the Local Government (Planning and Development) Acts 1963–1998, is primarily a matter for LAs. Planning control legislation has been in operation since the enactment of the Town and Regional Planning Act, 1934, and the Town and Regional Planning (Amendment) Act, 1939. It was not until the passing of the Local Government (Planning and Development) Act, 1963, that a comprehensive scheme of planning control was established. LAs are required, under Section 19 (3) of the Act, to indicate objectives in their development plans for their own proposed developments. Development is defined under section 3(1) of the 1963 Act as:

"*the carrying out of any works, on, in or under land or the making of any material change in the use of any structures or other land*".

The 1963 Act obliged each LA to prepare a development plan in not more than 3 years. With the exception of 'exempted developments', permission was now necessary for every form of development. However, this new legislation had a major defect (Hogan and Morgan, 1986). The designated power vested in the Minister for Local Government was capable of being exercised in accordance with local and political pressures. The Local Government (Planning and Development) Act 1976 sought to remedy this problem. The appellate functions of the Minister were transferred to a body, a Planning Appeals Board (An Bord Pleanála). The Local Government (Planning

and Development) Act, 1983, establishes the procedure governing the appointment of the chairman and members of An Bord Pleanála. The 1983 Act aims to increase the impartiality of the Bord and reduce political interference (Keane, 1982). The planning authority is bound by terms of the development plan and the manager cannot grant a permission that materially contravenes the development plan. Only An Bord Pleanála can grant a permission that materially contravenes the development plan and Section 39(g) of the 1976 Act allows a planning authority to materially contravene the development plan in certain specified circumstances.

LAs are responsible for the control of land use in their functional areas and they have a wide range of functions relating to sewage, water supplies, waste disposal and the suppression of statutory nuisances. They have power to grant or refuse planning permission under the Local Government (Planning and Development) Act, 1963, the Local Government (Water Pollution) Act, 1977, and the Air Pollution Act, 1987.

The Local Government (Planning and Development) Acts 1963–1998 confer planning authorities with the power to include in their development plans objectives for the preservation of buildings of artistic, architectural or historical interest. The preservation of architectural heritage is an important planning consideration and thus may be considered by the planning authority in judging a planning application, even in respect of a building that is not specifically identified in the plan for preservation. Legal protection for buildings of architectural interest is also contained in the National Monuments Act 1930 and 1994. However, in a 1996 report, the Working Group on Strengthening the Protection of the Architectural Heritage called for drastic changes to the legislation governing the protection of listed buildings (Simons, 1996). In May 1998, the report *Strengthening the Protection of the Architectural Heritage* was jointly launched by the Minister for Arts, Heritage and the Gaeltacht and the Minister for the Environment (Stationery Office, 1999). From 1999 onwards, it is intended to provide £5 million (€6.35 million)/annum between grant-aid for protected buildings and the employment of appropriate conservation experts. Defects in the previous system include the fact that planning authorities could choose not to include objectives for the preservation of listed buildings in their development plans, and the inability of planning authorities to prevent the destruction of listed buildings by owners who fail to maintain their property (Grist, 1998).

1.5.1 Urban development in Ireland

According to McDonald (1994), what has happened in Ireland is not so much urbanisation as a seemingly relentless process of sub-urbanisation, expressed as vast low-density housing estates on the periphery of cities and towns, or even more significantly as a ‘bungalow blitz’ in the countryside. For example, in the mid-1920s, Dublin’s inner city housed 250,000 people, two-thirds of the total for the entire city. However, over the last 30 years, it has been reduced to 73,000. Recent trends towards less intensive urban development have increased the use of private transport which in turn leads to increased energy usage, emissions of air pollutants and reduced effectiveness of public transport infrastructure (DoE, 1997). Consequently, agricultural land surrounding cities and towns, and green spaces within them, are coming under increasing pressure. Although ‘sustainable development’ is the buzzword for the 21st Century, there is little evidence that national governments have fully come to terms with what it entails in an urban context. In Ireland, existing towns and cities expanded in relation to population growth and in this process of urban growth, new settlements and new towns were the exception rather than the rule. Few of Ireland’s towns or villages were established in this century, with the main exceptions being:

1. the villages established by Bord na Móna for peat industry workers, for example, Rochfortbridge;
2. Shannon, a town planned for 25,000 people adjacent to Shannon International Airport, Shannon Industrial Estate and the Customs Free Zone;
3. ‘new towns’ to accommodate the expected growth of the Dublin agglomeration from the 1960s onwards (Bannon and O’Neill, 1991).

In addition to the aggregate urban population (those in urban clusters of 1500 or more), many Irish people reside in smaller settlements as well as in the open countryside, from where they commute to urban centres for work (Bannon, 1983). The DoE report *Sustainable Development – Strategy for Ireland* (1997) states that priority is

to be aimed at promoting higher residential densities in proximity to town centres and public transport modes, in consultation with LAs, architectural and planning professions and the house-building industry (DoE, 1997).

In April 1998, a consultants' report concluded that Irish residential densities are low by comparison to those in mainland Europe and that most residential developments in the past 20 years were in the form of back-to-back detached or semi-detached dwellings (Peter Bacon and Associates, 1999). The report recommended that the Minister for the Environment and Local Government should, by the powers vested in him under Section 7 of the Planning and Development Act 1982, direct planning and development issues as he considers necessary, in order to adopt a more proactive approach towards increasing the density of developments, which would ultimately contribute to the principles of sustainable development (MacCabe, 2000). With renewed emphasis on high-density housing in Ireland, green spaces within legally defined areas are falling under increasing pressure. As illustrated in Fig. 1.2, Limerick and Cork have the highest percentage of green space, with 20% and 15%, respectively (EPA, 2000). Boundary issues, access to countryside and amenities, as well as housing density, differ between and within settlements and affect the significance of the relative amount of green space. This is discussed further in Section 1.6.

The inclusion of housing in the NDP 2000–2006 for the first time reflects national government commitment to address the issue of infrastructural deficit in the size of national housing stock in relation to expanding housing requirements and growing population size (NRA, 2000). The introduction of the Planning and Development Bill 1999 was aimed at revising and extending the Local Government (Planning and Development) Acts 1963–1998 by updating and modernising planning legislation. The proposed legislation deals with the provision of social or affordable housing, including the provision that up to 20% of all land to be developed can be transferred to the LA for its housing requirements, and that this is to be transferred at a market price value that the lands would have obtained prior to rezoning for residential purposes (Oakes, 2000).

1.5.2 Road developments and planning

A county or urban district council or a borough corporation, each of which is a road authority, has the power to acquire land to make new roads, and may declare a road a public road if they are satisfied that it is of general public utility (Roche, 1982). Under Section 4 of the Roads Act 1993, LAs are exempt from obtaining planning permission for the construction or maintenance of any roads. The National Roads Authority (NRA) was formally established as an independent statutory body under the

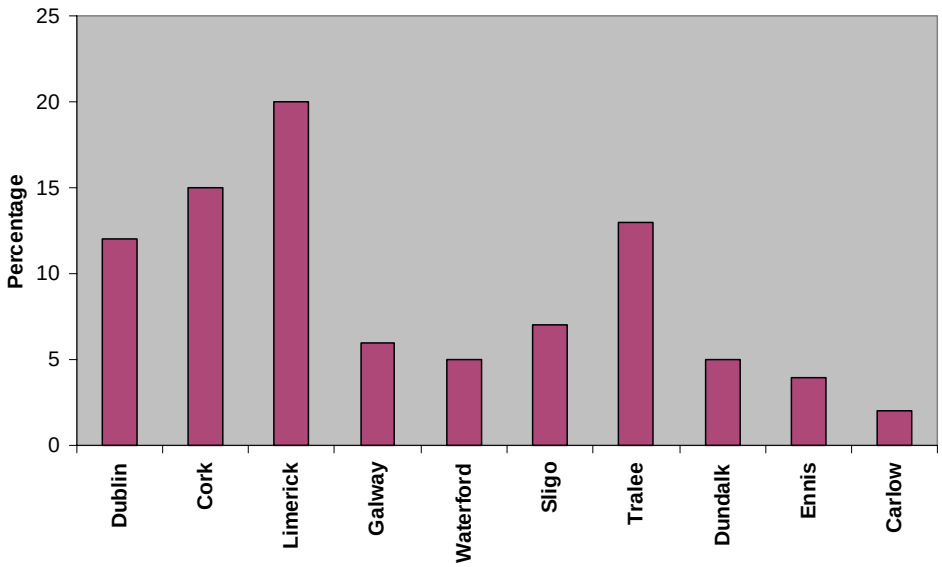

Figure 1.2. Green space in selected Irish cities and towns.

Roads Act, 1993, with effect from 1 January 1994. The Authority's primary responsibility, under the Roads Act 1993, is to secure the provision of a safe and efficient network of national roads. Consequently, it has overall responsibility for planning and supervision of construction and maintenance works on these roads. The NRA is also exempt from obtaining planning permission for any works carried out on the construction or maintenance of a national road. Roads are the primary means of transport in Ireland, accounting for 96% of passenger traffic and 90% of freight transport. The national primary road network has an overall length of 2749 km, secondary roads have a total length of 2694 km, and regional and local roads have a total length of 90,300 km (NRA, 2000). Although demand for road space is always likely to exceed capacity, there is growing interest in shifting from the inertia of addressing transport problems by building new roads and increasing the use of cars (Ravetz, 2000; O'Regan and Moles, 1997). However, Section 50 of the Roads Act obliges a road authority to prepare an Environmental Impact Statement (EIS) of any road development consisting of the construction of a motorway or busway and any prescribed type of road development consisting of the construction or improvement of a proposed public road (Scannell, 1995). Section 22 of the Roads Act obliges the NRA to make recommendations to planning authorities with regards to the development plan of that authority. When either improving or constructing a road, the NRA must consider the characteristics of the area in which the road is to be situated and the effects that the road development will have on the environment of the area concerned (Maguire *et al.*, 1999). The NRA has developed a strong working relationship with LAs and generally avails of their services to design projects and to carry out road construction and maintenance works (http://www.nra.ie). The situation reflects the statutory obligation on the Authority to have these functions undertaken as far as possible on its behalf by the relevant LA. The Authority may, however, become directly involved where it considers that this would be more advantageous for convenience, expediency, effectiveness or cost reasons. The obligation of the Roads Act on road authorities to prepare EISs for certain road developments provides that the European Communities (Environmental Impact Assessment – EIA) Regulations 1989 do not apply to proposed road developments for which an EIS is required under the Act. Under the 1989 Regulations, an EIA is mandatory for projects listed in Annex I, including the construction of motorways and express roads. Annex II projects are subject to EIAs when member states require the construction of roads (Galligan, 1996). The NDP 2000–2006 must, as part of the objective to develop an integrated transport programme, improve internal road transport infrastructure between and within regions and contribute to sustainable transport policies, facilitating continued economic growth and regional development while ensuring a high level of environmental protection.

1.5.3 Wastewater and solid waste management

County councils and borough corporations are the primary agencies concerned with the management of water resources for all purposes. They are responsible for the licensing of industrial and other discharges to water, with the more complex activities now being licensed by the EPA. They are also responsible for the preparation of water quality management plans for river catchments, estuaries and other water bodies. Most major water services schemes are now co-financed by the EU Cohesion Fund, which is administered on a project basis (Reorganisation Commission, 1996).

Ireland is relatively fortunate in having an abundant supply of water resources. However, regular surveys of river quality carried out since the 1970s indicate a steady increase in the number of slightly to moderately polluted rivers, mainly as a result of the increased intensification of agriculture (McClean, 1998). Eutrophication of inland waters is now widespread, and the most recent water quality review noted a continuing deterioration. For these reasons it is perhaps Ireland's most serious environmental pollution problem (EPA, 2000). Dealing with it will require the effective implementation of the Local Government (Water Quality Standards for Phosphorus) Regulations 1998, with significant reductions needed in the major sources of phosphorus noted above. Article 4 of the Regulations provides that a local authority shall take the necessary steps in discharge of its functions under the 1977 Act, and that the EPA shall take such steps as may be appropriate under the 1992 Act to ensure compliance with the water quality standards described in Article 3 of these Regulations (Oakes, 1998).

Waste management is continually growing as one of the most pressing problems of 21st Century society. It had been argued that Ireland's failure to develop an effective waste management strategy was reflected in a low level of environmental awareness and was also a consequence of a low population density, in contrast to The Netherlands, for example, where waste management strategies have been developing since the 1970s and the level of environmental awareness (and population density) is one of the highest in the world (Colleran, 1994). LAs, under Article 4(1) of the EC (Toxic and Dangerous) Waste Regulations, 1982, are required to develop plans indicating suitable disposal sites for toxic and dangerous wastes. Sites should be suitable for the 27 different kinds of waste identified within the EC Directive 78/319/EEC on toxic and dangerous wastes. However, the EPA Act 1992 transferred many of these functions to the EPA, which is now responsible for the licensing and regulation of all significant waste disposal activities, including landfills, and the preparation and periodic updating of a national hazardous waste plan for implementation by other bodies.

1.6 The Irish National Spatial Strategy

In order to meet the elements of the Government's Regional Development Policy and to achieve balanced and sustainable regional development, the Government has mandated the Department of the Environment and Local Government (DoE) to prepare a National Spatial Strategy (NSS), which will provide a detailed blueprint for long-term spatial development in Ireland. Essentially the NSS will (National Spatial Strategy, 2000):

(a) identify broad spatial development patterns for areas, and set down policies in relation to the location of new residential developments, industrial development, rural developments, tourism and heritage, and

(b) develop and present a dynamic conception of the Irish urban system, together with its links to rural areas, which recognises the interdependent relationship between environment, economy and society.

The NSS will draw upon the ESDP, published in May 1999, and will integrate the European policy objectives, including:

(a) economic and social cohesion;

(b) conservation of natural resources and cultural heritage;

(c) more balanced competitiveness of the European territory;

(d) polycentric spatial development and a new urban–rural relationship;

(e) parity of access to infrastructure and knowledge.

In its attempt to define and describe the dynamics and systems of cities and towns, the DoE report *The Irish Urban System and its Dynamics*, published in December 2000, explores the economic and social functions of urban settlements of different sizes. It also attempts to define the urban fields of cities and towns with a population in excess of 5000 in terms of employment, retailing, education, health, cultural, social and public administration. In relation to the distribution and hierarchy of urban settlements, the report concludes that Dublin is the undisputed dominant urban centre in the country. Ireland, therefore, has an urban structure with a strong primate city with almost two-thirds of the national population residing there. There is a good size distribution of urban centres with a population less than 40,000. These centres are geographically spread throughout the country, with a bias towards the East and South-East for larger towns. Urban centres in these regions are also relatively well developed and show a notably higher density than in other parts of the country. The urban structure of Northern Ireland is characterised by a greater density of centres and larger urban settlements than the Republic. The distribution of urban centres is influenced by topography, whilst the road network reflects the distribution of urban centres. The DoE report on *Irish Rural Structures and Gaeltacht Areas* aims to develop a typology of rural areas in Ireland and their main characteristics, using demographic, economic and geographical data. The report also examines trends within rural areas, the urban and rural relationship, and the role of infrastructure in rural area performance. In examining the relationship between urban and rural areas, the aim was to systematically establish the extent to which economic performance differs according to the location of rural areas. There is evidence 'on the ground' that recent economic activity is related to

the quality of infrastructure. Some of the main conclusions include that rural areas situated 'far away' from a major urban centre recorded significantly lower employment rates than those situated 'close' to large urban centres. The size of the rural area was significant in determining the level of economic performance. Small rural areas performed significantly worse, regardless of whether they were close to or far away from a city, than medium and large sized rural areas. The locations of ports, airports, telecoms and third-level institutions, for example, help to explain the concentration of much economic activity in urban areas. In relation to parity of access to infrastructure, areas that are predominantly rural in character may have a relatively high level of transport infrastructure by virtue of their location with respect to Dublin. The study also shows that where exactly a person lives within a largely rural area is critical in determining whether that person has above- or below-average access to transport infrastructure. Rural areas close to national roads perform better than rural areas away from national roads. The report also reveals that rural areas that are close to national roads will generally also be close to urban centres and that economic spillover from urban centres is channelled out to rural areas along the route of major roads.

In terms of future settlement planning, the DoE Paper 13 on *Rural and Urban Roles* attempts to gain a clearer understanding of the close relationship between 'urban' and 'rural'. In relation to rural house-building patterns, the trends show that all rural areas show markedly increased levels of residential development. The proportion of rural housing completions as a fraction of all completions rises as one moves further from the main urban areas. Cavan, Longford, Monaghan, Offaly, Roscommon, Limerick and Tipperary (SR) have been showing an increased proportion of rural to total house building. Donegal, Galway, Laois, Leitrim, Sligo, Westmeath, Cork, Tipperary (NR) and Waterford have shown a decreased proportionality but an aggregate increase in rural house building. Meath, Kildare and Wicklow all indicate a large increase in rural house building. The applications for rural housing in counties Mayo, Sligo, Kerry and Wexford consistently outperform the total number of applications for individual houses. It is becoming increasingly evident that the level of rural housing completions in Ireland is presenting profound challenges in terms of arriving at a settlement structure that is sustainable. Chapter 14 of the Irish national sustainable development strategy recognises that efficiency in the use of transport, energy and natural resources may be encouraged through the careful location of residential, commercial and industrial development, and it controls the shape, structure and size of settlements. New developments must be accommodated in an environmentally sustainable way. In terms of new housing developments, the policy imperatives for the strategy are clear. Unless housing development in rural areas is associated with the needs of the rural community in occupational or similar terms, then the energy needs, landscape, transportation and environmental impacts of dispersed settlement patterns render these contrary to the principle of sustainable development. The strategy also refers to the powers of the planning authorities to distinguish between persons in terms of a decision to grant planning permission for a rural house (DoE, 1997). The publication *Ensuring the Future – A Strategy for Rural Development in Ireland* stated that a key aim of Government policy is to maintain the rural population, not exclusively in terms of numbers but also in terms of balanced spatial distribution (Dept. of Agriculture & Food, 1999).

The issue of social infrastructure is addressed in the NSS Study No. 15, with particular reference to Education, Medical and General Social Services, including Social Support (Child Care Facilities), Security and Safety (Gardaí, Fire Services, Court Services), Cultural and Recreational Facilities (Library, Theatres, Museums, Arts Centres, Cinemas). Demand for education places has dropped between 1996 and 2000, and this demand is expected to either stabilise or increase between now and 2011. Early and unqualified school leaving is concentrated in areas of social exclusion mainly in larger urban areas. Investment in third-level education has increased substantially over the years. This is reflected in higher participation rates of the Age Specific Cohort, which has increased from 20% in 1980 to 43% in 1998. Of the 33 State-aided institutions, 25 are located in the South and East region, with the remaining eight located in the Border, Midlands and West (BMW) region. Fourteen of the institutions in the South and East region are located in Dublin. In terms of migration patterns, 46.6% of students from the BMW region migrate to the South and East,

while only 7.3% of students from the South and East migrate to the BMW region. In terms of policy implications, locational choices will have to be to be made in order to facilitate a more even distribution of third-level institutions. With the expected growth in population and the concomitant demand for more third-level places, serious thought must be given to the implications of locating these institutions in and around Dublin.

In terms of medical issues, there are 59 acute and 38 district/community hospitals in the country. All parts of the country appear to be within 40 km of an acute or district hospital. The areas of the country that are beyond 30 km from an acute hospital are limited to the South-West, West and North-West, with a significant concentration of acute hospitals within the Dublin region. The distribution of specialist medical services should be reviewed as part of regional development policy and should have regard to imbalance in the distribution of private hospitals/clinics, which are less controlled by policy instruments. In relation to social infrastructure, a structured approach to investment is needed to support the sustainable development strategy.

1.6.1 Gateways as a strategic consideration for the National Spatial Strategy

The aims of the ESDP (Section 1.3) are echoed in the Irish NDPs, particularly the most recent, 2000–2006. According to Van der Kamp (1996), the Plans meet many of the textbook criteria of planning strategies, not exclusively in terms of physical planning but also in terms of economic and social development. The first NDP (1989–1993) included proposals on roads, airports, sanitary service projects, waste disposal facilities and tourism amenities. The second NDP (1993–1999) outlined areas where action is needed to strengthen the productive capacity of the economy. The Plan was built on the success of the Community Support Framework (CSF) 1989–1993, and target objectives included the development of the growth potential of the economy in agriculture, industry, forestry and tourism. Impetus was placed on infrastructural investment in order to improve the capacity and competitiveness of the economy (Stationery Office, 1993). The latest NDP (2000–2006) follows the same objectives of achieving sustainable economic growth but also sets out coherent development strategies in the key areas of infrastructural development, education and training, the productive sector and the promotion of social inclusion (Stationery Office, 1999). Key national objectives underpinning the latest NDP include:

1. continuing sustainable national economic and employment growth,
2. consolidating and improving Ireland's international competitiveness,
3. fostering balanced regional development, and
4. promoting social inclusion.

A key aim of the Government's Regional Development Policy is to accommodate the development of existing Gateways such as Dublin (national Gateway) and Limerick, Cork, Galway and Waterford (regional Gateways). A fundamental policy consideration is the development of a limited number of strategically placed centres that are currently (2001) displaying characteristics to:

1. achieve strong and sustainable economic growth driven by the interplay between location and market forces, and
2. promote such growth within their zones of influence.

The NDP 2000–2006, as a fundamental consideration, identifies the importance of Gateways as

"*centres which have a strategic location, relative to the surrounding territory, possess good social and economic infrastructure and support services and have the potential to open up their zones of influence to further development by providing transport links with contiguous zones*".

This does not mean that development will be confined to these locations and their immediate hinterlands. The Gateway approach will accommodate the creation of a critical mass to spur growth in the designated areas and in their wider zones of influence. At present, the Government endorses the view of the Economic and Social Research Institute (ESRI) that the designation of a secondary tier of Gateways demands further in-depth study in the context of developing an NSS for Ireland as a whole.

1.7 The importance of greenbelts and corridors in settlement planning – the case of Dublin

Habitat loss associated with land use for human settlements and activities poses perhaps the most severe threat to global biodiversity. The conversion of landscapes for human activities results in widespread changes in landscape spatial structure, such as decreases in landscape heterogeneity and increases in habitat loss and isolation (Soulé, 1991; Noss, 1993). This is referred to as 'habitat fragmentation' (Wilcox and Murphy, 1985) and has increased dramatically over the last century (Groom and Schumaker, 1993). Increasingly, planners are becoming involved in projects aimed at conserving or enhancing biodiversity by proposing design solutions and land conversion scenarios that produce desirable ecological consequences and a more 'sustainable landscape' (Forman and Collinge, 1996). A conceptual consensus is rapidly emerging that future landscapes be spatially structured by a 'patch and corridor' spatial concept, which includes corridors and stepping stones to connect isolated patches and thus help to counter the effects of fragmentation (Forman and Gordon, 1986). The attempt to recreate this experience at the settlement level represented the origin of the 'parkway', 'open space system' and 'greenway' concepts (Turner, 1992). To preserve existing open space, efforts should be made to preserve the non-city characteristics of new settlements. This can be achieved by creating open space corridors between urban developing zones (Antrop, 2000). In the 1940s, Dublin experimented with the concepts of greenbelts and satellite towns; however, nothing substantial came from the proposals. These proposals for 'new towns' were based on the findings of the Myles Wright Advisory Report 1967, which predicted that the population of Dublin would rise by about 300,000 between 1961 and 1985 and that 8000 ha of additional development land would be needed for major urban developments in metropolitan Dublin up to 1985 (Myles Wright and Partners, 1967). The 1972 and 1983 County Development Plans introduced the idea of simultaneously developing three 'western towns' or 'town units' that, between, them would accommodate 336,000 people, Blanchardstown (100,000), Clondalkin/ Lucan (100,000), and Tallaght (136,000). The major constraint on development was the availability of sanitary services, and the construction and completion of a sewer for Blanchardstown was not expected until 1983 (Dublin County Council (1967–1991)). According to Bannon and O'Neill (1991), the Myles Wright report envisaged clear and pristine green belts surrounding each of the 'western towns'. Instead, they developed as a jumble due to rezoning and material contraventions of the development plans. Estates such as Bawnogue in Clondalkin have small identifiable green spaces of high amenity value and accessible to all residents. However, most estates in this town unit lack proper planning and landscaping and are surrounded by areas of 'green desert' which do little to improve amenities and serve only to isolate individual estates. The same too can be said for Blanchardstown where low-density housing estates are surrounded by large areas of vast open land. These 'green deserts' are often bisected by road developments, which even further reduces their amenity value. Figure 1.3 gives an indication of the extent and impact of urbanisation in Dublin. Between 1956 and 1998, the area of residential urban fabric has almost doubled, while the area used for road infrastructure has increased by a factor of 10. Forests and agricultural areas during that time have been reduced by 15%.

Despite the many shortcomings associated with the development of these satellite towns, the authors made several recommendations for future planning, including the following.

1. Special development legislation to assist with the acquisition of land and the co-ordination of development.

2. 'Hands-on Approach' given that Tallaght is now larger than Limerick, and Blanchardstown is the size of Waterford. There is no significant local authority presence or dedicated planning team. Were these towns to achieve the population of 100,000 or more, as set out in the Draft Development Plan Review, they would be larger than many counties in Ireland, including Clare and Kilkenny. Yet none of these towns exist in political terms as they have no local authority dedicated to their development.

3. A Conservation Policy, which in the face of large-scale developments could build upon the resources of the three new towns, having regard for everything –

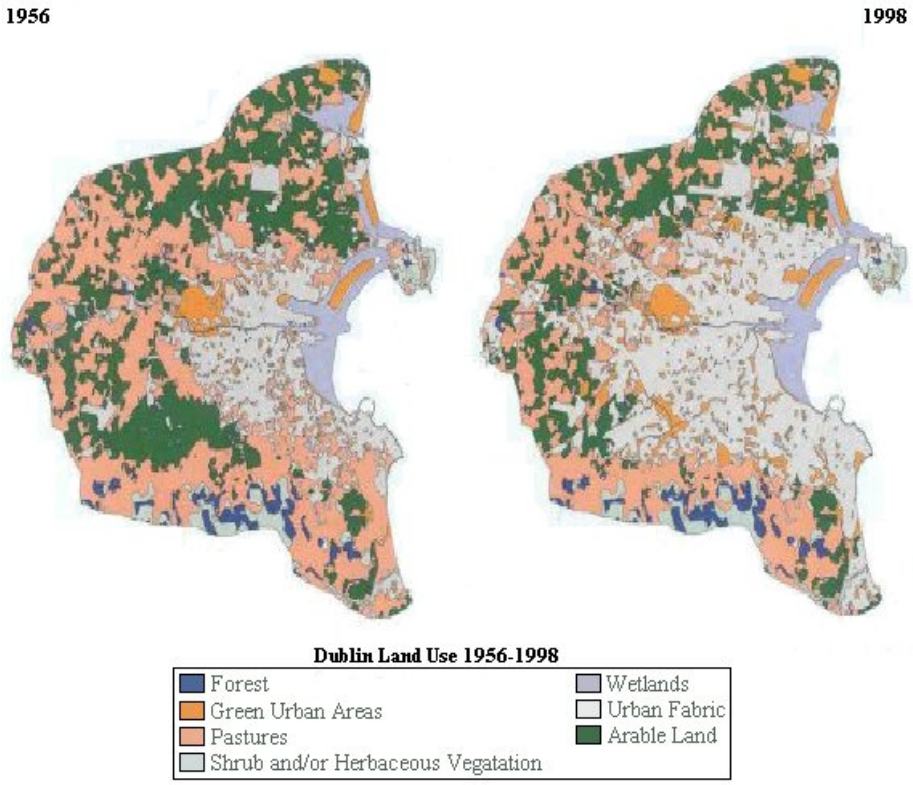

Figure 1.3. Urbanisation in Dublin – land-use changes 1956–1998.

natural amenities, parks, trees, hedgerows and the heritage of villages and small settlements.

4. A Statutory Regional Plan to tackle the issue of phasing. This may have provided a framework to limit development on the 'greenbelts', restrain material conventions and consolidate development.

5. A Regional Transport Plan, which in the case of the three 'new towns' would develop an integrated policy, having due regard to the needs of residents, forms of public transport required and means of securing investment in transport infrastructure.

Given the scale of growth around Dublin, the Minister for the Environment, Mr Noel Dempsey, proposed the development of Strategic Planning Guidelines to assess how best to pursue sustainable development in the Greater Dublin areas. A process of updating and consolidating existing planning laws is currently (2001) under way, in addition to a complete review of planning legislation. This aims of this review are (Dempsey, 1998):

1. to ensure the planned and orderly development of all areas;

2. to facilitate maximum participation in the planning process;

3. to ensure that the principle of sustainable development is at the centre of the planning process.

When the process is complete, the Minister plans to hold a national convention to debate any issues that arise out of the process, to accord with the principles of public participation as enunciated in Agenda 21.

1.8 Settlement size and sustainable development

An examination of the social, economic, political, and ecological processes involved in urban growth will be required in order for cities to move towards a more sustainable pathway. As cited in the EC Expert Group on the Environment report (1998):

"*the sustainability agenda places new emphasis on the interrelationships between the physical environment and the human and economic systems, acknowledging that there is a capacity beyond which the environment cannot sustain these activity levels*".

In reality, viewing the locality as a place entails a conceptual shift to a set of processes and governance structures that operate at sub-national spatial scales, and it is this concept of locality – as a node within multiple networks – that needs to be considered in moving towards sustainable development (National Science Foundation, 2000).

While the intensity and implications of 'internationalising' processes remain open to debate, it is evident that modern economic, social, cultural, and ecological problems all have global dimensions, in that developments occurring in one locality will tend to have implications for other places. Integration of the world economy in this way has been referred to as 'global localisation'. Bennett (1997) claimed that such changes ensure that:

1. a change in one part of the economic system diffuses to affect every area extremely quickly;

2. the scope for 'protectionism' or the existence of 'national' or 'local' markets by government and administrative process is diminishing;

3. there is a growing need for local conditions (including administrative systems) to be orientated towards a greater economic emphasis that can ensure continued economic growth; and

4. there is intense downward pressure on unit costs and profitability of industry, which has also to be reflected in the burdens placed by public administration on business and people if their economies are to compete.

The spatial dimension of environmental sustainability and sustainable development has been largely neglected by environmental and ecological economists alike (Costanza and Patten, 1995). A major element of the sustainability debate focuses on whether settlements can be made sustainable. It has been established that a major strategic factor determining sustainability is urban form, i.e. the shape, size and density of settlement patterns (Breheny and Rockwood, 1993). Roseland (1997) argues that practitioners or planners who turn to the sustainable development paradigm for direction have found much inspiration but little guidance. Efforts have been made to define the concept of 'sustainable settlement' and the terminology includes everything from 'neo-traditional town planning' and 'pedestrian pockets' to 'reurbanisation', 'post-industrial suburbs' and 'sustainable cities'. He (*op. cit.*) also states that, despite the array of jargon, 'sustainable settlements' or 'eco-cities' represent an ethical goal and a direction for community planning and development – not simply a marketing slogan. The outcome of much research into settlement planning has been an advocacy of the high density, mixed-use settlement commonly known as the 'compact city' and this form has increasingly been translated into land-use policy in England and across the rest of Europe (Williams, 1999c). A key assumption here is that such changes in the urban fabric would reduce the need to travel long distances while supporting an extensive and viable public transport system, encouraging people to travel less by private transport, thus reducing energy consumption (Haughton, 1997). Urban transport infrastructures are the most important cause of the ecological fragmentation of landscapes (Antrop, 2000).

The term 'settlement size' is as equally ill defined as sustainable development, because there is no absolute definition that is satisfactory in all cases. What constitutes a 'settlement' varies between nations, with smaller thresholds in countries of smaller size. It can also vary according to the settlement context of an area since, in many cases, a small town close to a large conurbation will functionally be part of the city, whereas a similar sized town in a largely rural area may well be a small market town (Haughton and Hunter, 1994). In other words, settlement units are linked to the 'micro-scale' of their internal structure and the 'macro-scale' of the urban and regional context. In a UK study (Breheny and Rockwood, 1993), a new settlement is defined as:

"*a free-standing settlement, promoted by private and/or public sector interests, where the completed new development – of whatever size – constitutes 50% or more of the total size of settlement, measured in terms of population or dwellings*".

It is becoming increasingly evident that human settlements are an intrinsic component of nature in that their actions affect both the biotic and abiotic environments and that they in turn are affected by everything that shapes those environments. They are complex systems of inter-related and inter-connected human needs and activities. Settlements should be viewed as dynamic and com-

plex entities resident in a wider ecosystem. The main environmental problems and economic costs of settlements are related to the growth of inputs such as energy and materials and managing the increased outputs such as waste and air pollutants. Newman (1999) defined the goal of sustainability in a settlement as a reduction in the use of natural resources and production of waste while simultaneously improving its livability, so that it will avoid compromising the natural capacities of the local, regional and global ecosystems. This is shown in Fig. 1.4 as the 'Extended Metabolism Model of Human Settlements'. The model shows that the physical and biological processes of converting resources into useful products and waste are based on the laws of thermodynamics, which show that anything that comes into a biological system must pass through and that the amount of waste is, therefore, dependent on the amount of resources required.

The metabolism approach to resource management is understood by scientists but not by economists and policy makers, who see only 'open cycles' whenever human technology is applied to nature. This approach has been developed over the past 30 years but has rarely, if ever, been used in policy development for city planning (Girardet, 1992).

This principle is echoed in industrial ecology, which is essentially a biological concept applied to industrial structures. A natural ecosystem produces no wastes because the wastes that are generated by a species are used as inputs by others in the same system. The underlying idea in industrial ecosystems is to assimilate natural ecosystems and evolve so that reduced energy and material inputs from the natural environment are needed to operate the system, and smaller amounts of waste are re-deposited into the natural environment (Pento, 1999). In many cases, an environmental 'bad' can be exported from one medium to another or from one stage in a product's life cycle to another, e.g. from landfills to de-inking sludges in the case of paper life cycles and paper recycling (Korhonen, 2000). Industrial ecology is regarded by many as a powerful analytical framework capable of capturing the systematic and dynamic characteristics of socio–economic systems (Ehrenfeld, 1997). It is seen as an aggregation of several environmental trends, including industrial metabolism, life-cycle analysis, pollution prevention and sustainable development (Anastas and Breen, 1997). According to Hahn (1994), achieving sustainable settlements may mean adopting socio–ecological principles of planning and design, by restructuring the way in which settlements are organised, placing emphasis on energy conservation, waste minimisation, recycling, mixed uses, higher densities, and bottom–up planning with public involvement and consultation. 'Greener' planning demands sustainable symbiosis between economy and environment which, in the urban context, requires innovative instruments such as emission charges, resource tax, environmental accounting, planning laws and strategic subsidies. Such measures may enable planners to evaluate the appropriateness of territorial policies in order to realise the goals of sustainable development.

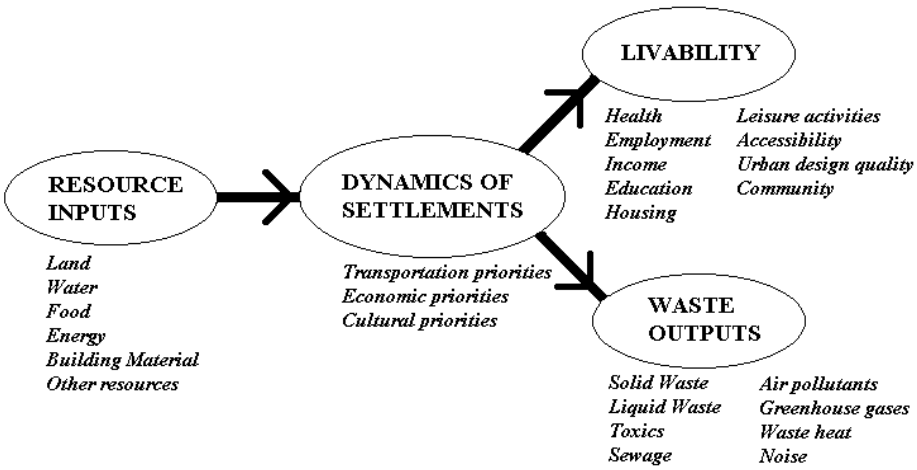

Figure 1.4. Extended metabolism model of human settlements (Newman, 1999).

The purpose here of an outline of the 'urban environmental metabolism' is to provide an overview of key environmental themes, with a chain of causal drivers and effects for each one (Fig. 1.5). These are selected for (a) general significance, and (b) relevance to the urban or local scale of activity. This is then a framework and a basic mass–energy balance model of environmental metabolism. This can be applied to each case-study settlement. The framework helps to select the most significant indicators, or, where data are difficult to find, it provides a rationale for interpolation between the data that are available.

Data and coefficients to describe each of the linkages of the framework are available nationally in the UK, and in some other EU countries including Sweden, Germany and The Netherlands. A set of summary spreadsheets has been constructed for the case studies of Greater Manchester, and recently for the North-West region, through the 'integrated sustainable cities assessment method' (ISCAM) (Ravetz, 2000). At this point, it appears that the available data in Ireland will cover most of these linkages at the aggregated national scale but only some at a disaggregated regional or urban scale. Hence, the relationships based on Irish national and UK regional data may be used as proxies where necessary.

1.8.1 Urban form – local and global interactions

Although the international dimension of sustainable development is acknowledged, it is especially important to recognise 'that there is close mutual interaction between local and global processes' (Nijkamp and Perrels, 1994). Increased understanding of these linkages has led to discourse advocating a regional or urban scale for analysing and promoting sustainability (see for example: Collier and Löfstedt, 1997; Angel *et al.*, 1998; Kates *et al.*, 1998; Brandt *et al.*, 1999; Capello *et al.*, 1999; Satterthwaite, 1999), particularly as changes in the structure of economic activity towards more flexible labour markets, and global interactions between production centres, are leading to urban, regional and local shifts in economies and their population (Bennett, 1997). The 1990s experience has been one of a shifting focus towards sustainable development at the level of local economies. The ideals of the 'new localism' suggest that it is possible to live better whilst using fewer resources, create new jobs and

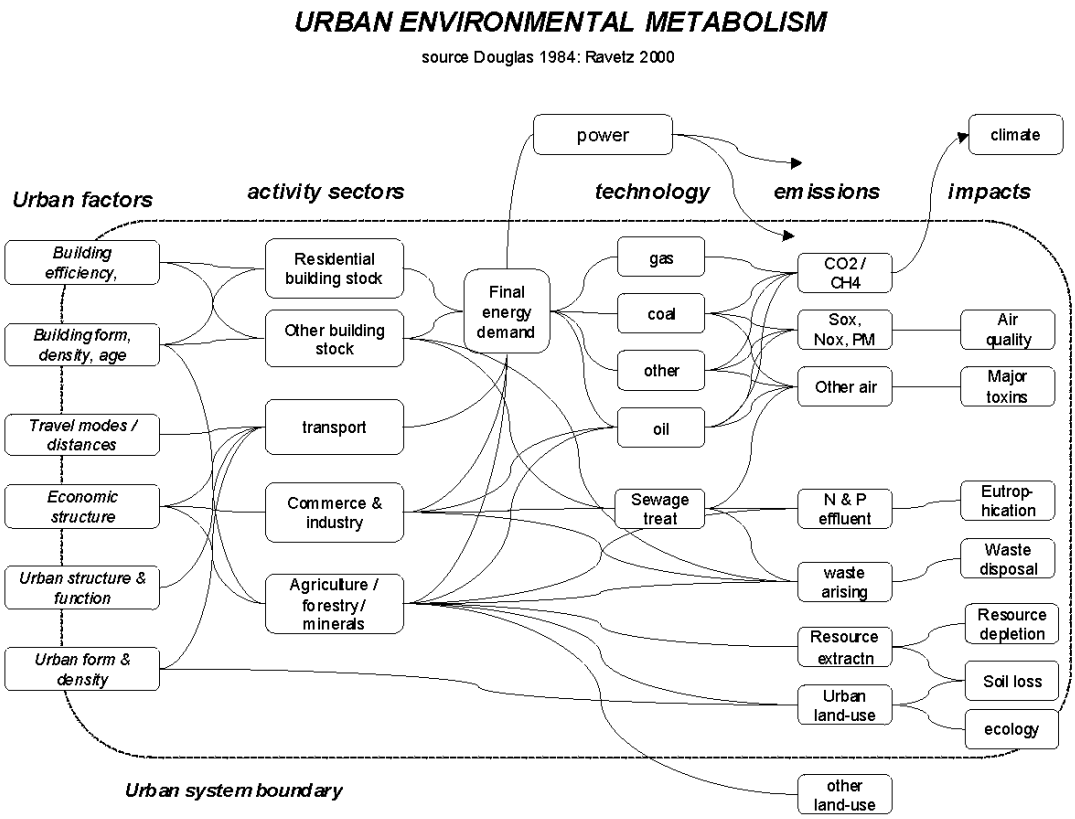

Figure 1.5. Urban environmental metabolism.

strengthen businesses, innovate the state of the environment, and develop more coherent and supportive social systems (Pretty, 1999). A city is, by definition, an artefact environment, where the natural environment aspects have already been sacrificed for the creation of urban agglomerations. Consequently, it is a serious assignment to describe what is meant by a 'sustainable city' (Camagni *et al.*, 1998), particularly as almost 300 definitions of sustainable development have been identified. They are the products of conflicting worldviews, differing ideologies, varied disciplinary backgrounds, opposing knowledge traditions, value systems, and vested interests (European Environment Agency, 1997).

The Amsterdam Department of Environmental Affairs is developing an integrated area-oriented policy, which is intended to provide answers to:

(a) the paradox of the compact city, the contradictory effects at different levels, positive effects at macro levels and negative effects at local levels;

(b) instruments that contribute to the integration of environmental and city planning (includes an environmental matrix); and

(c) problems that are relevant at city level.

An interim report highlights three different environments co-existing in cities: (1) the physical (natural and built) environment, (2) the economic environment, and (3) the social environment, each of them explaining, in part or in combination, the existence and continuity of the city. All three environments generate advantages and disadvantages for the city. All three have to be considered together, because they interact with one another and represent or express at the same time goals, means and constraints to human activity in the city (Camagni *et al.*, 1998). Points 1–3 can be applied to urban sustainability in a static or dynamic way:

1. the economic environment – impact on costs and revenues of economic actors, in particular reduction in production costs, reduction in transaction costs, increase in the efficiency of production resources, valorisation of production, reduction of uncertainty, etc.;

2. social environment – social network externalities (access to public goods, etc.);

3. physical environment – presence of urban green areas and environmental facilities.

1.8.2 Patterns of urbanisation

There is overwhelming evidence in the UK that both population and employment are decentralising, and that this process is most marked in the largest metropolitan areas, i.e. centres with populations of 1 million and more (Hall, 1997), with an outflow of jobs from the old inner cities to new suburbs and expanding country towns continuing into the new millennium (Carley, 2000).

The theoretical framework of these urban configurations is still not well founded and a clear typology or taxonomy is lacking. Spatial planners tend to have a way of looking at polycentric urban regions that differs from that of human or economic geographers (Kloosterman and Musterd, 2001). At the broadest level, in the 1970s, a switch from urbanisation to counter-urbanisation was observed in many countries and, although subsequently the metropolitan migration turnaround has faded in most cases or even reversed itself again, debate continues about the relative role of the large, medium and small settlements in accommodating future population growth (Champion, 2001).

Gottmann (1961) pointed to the emergence of a new type of urban phenomenon involving the interweaving of separate urban centres into a multinodal region or megalopolis, and at the level of the individual metropolitan area, the dominance of the main commercial nucleus (or CBD) has increasingly been challenged by the growth of centres in the suburbs or in essentially exurban locations, exemplified most notably by Garreau's (1991) 'edge cities'. Suburbs have become more urbanised and contrast the contemporary suburban form with both its earlier homogeneously residential embodiment and the traditional monocentric city (Filion *et al.*, 1999).

Polycentrism, as advocated by the ESDP, denotes the existence of multiple centres in one area, and has become one of the defining characteristics of the urban landscape in advanced economies (monocentric urban system denotes a sharp divide between city and suburban hinterland). As the new metropolitan dynamics have not yet been adequately captured by urban theory and models, it is necessary to use a hypothetical conception of a 'pure'

Polycentric Urban Region (PUR). PUR can emerge in three ways (Champion, 2001):

1. centrifugal – continuing growth of a monocentric city;
2. incorporation – large urban centre expanding to incorporate surrounding smaller areas;
3. fusion – fusion of several previously independent centres of similar size.

The most obvious distinction between the PUR and the Monocentric (MC) models concerns, by definition, the spatial patterning of employment and services. In the MC, the functions required both to service the urban region and to provide its 'export base' are located in what is essentially a single centre, comprising the CBD and the 'factory zone' around it. In the PUR, these functions are distributed across a number of centres (Champion, 2001).

Land-use planning in post-war England produced three main effects (Hall, 1997):

1. containment – the amount of land converted from rural to urban uses has been minimised and also compacted;
2. surburbanisation – the growing spatial separation of the new residential areas from the main employment centres; and
3. inflation of land and property values.

In the UK, despite national Planning Policy Guidance (PPG) promoting city 'brownfield' sites for development, out-of-town locations continue to be more profitable for developers of business parks, houses and shops than the thousands of hectares of derelict land in cities (Carley, 2000).

1.8.3 The Compact City – theory and practice

The EC Green Paper (Commission of the European Communities, 1990) developed a conventional wisdom that the ideal urban form is represented by the traditional compact European city, dependent on short distances to work and to shops and supported by generous investment in public transport, which uses fewer non-renewable resources and creates less pollution than the scattered Anglo–American urban form (Hall, 1997). Consequently, a one-sided focus on the compact city might result in further pressure on the green areas in the city (Priemus, 1999). Functional mix is particularly important in helping to curb car-based mobility and electricity consumption.

The so-called compact city has a variety of definitions, but in general it is taken to mean a relatively high-density, mixed-use city, based on an efficient public transport system and dimensions that encourage walking and cycling. The process of achieving urban compactness is usually termed 'intensification', 'consolidation' or 'densification', and involves the re-use of brownfield land, more intensive use of urban buildings, sub-divisions and conversions of existing development and an increase in the density of population in urban areas (Burton, 2000a). There is however, a tendency to focus on the lead role of planning in developing a blueprint of the compact city and rather less attention is paid to the social, economic and technical processes involved in shaping the feasibility of the concept (Guy and Marvin, 2001).

There is no clear evidence that urban size as such causes environmental decay. Rather, land use, the transport system and the spatial layout of a city are the critical factors for urban environmental quality (Nijkamp and Perrels, 1994).

Very large cities tend to have a much greater dependence on public transport, especially rail-based transport, than their medium-sized equivalents. Size is, however, not the only consideration; density is another. What is significant is the urban structure, i.e. cities with strong concentrations of central jobs, and accordingly a better-developed public transport system, have much lower energy use than cities where the jobs are scattered (Hall, 1997). Owens and Cope (1992) concluded that the 'ideal' energy-efficient urban form would combine clusters of relatively small settlements at the regional scale, with compact settlements, probably linear or rectangular in form, at the sub-regional scale, and medium–high residential density, with well-dispersed employment, at the local scale.

The updated version of the Supplement to the Fourth Netherlands National Policy Document on Spatial Planning (Government of the Netherlands, 1998) advocates supplementing the compact city policy with the maintenance and creation of open areas and green structures in

the city. Apart from improving the living climate, the conservation, development and optimisation of green and water structures may make a major contribution to the ecological integration of an urban area into the environment. The sustainable nature of cities may be improved by combining green structures with an intensive use of space (including well-situated high-rise buildings and underground buildings). Furthermore, concentration in the urban area should not be limited to living and work. Other space-demanding functions, such as recreation, waste material processing, food production, wastewater purification and the generation of energy, should also be included in the observations. If these functions are integrated into or near the city, the mobility demand can be restricted (Priemus, 1999).

The dilemma of the compact city is that a number of categories of environmental effects (such as biodiversity) benefit from a certain spatial spread of urbanisation, whilst other effects (such as the restriction of mobility) benefit from a concentration of activities in the city (Priemus, 1999).

Some researchers champion current suburban-type urbanisation, stressing its unique capacity to provide large lots at an affordable price, an option negated by more compact urban forms (Berry and Kim, 1993). However, most studies are highly critical of such spatial organisation. They denounce the environmental consequences, in particular, air pollution, voracious fuel consumption and loss of agricultural land and natural areas (Filion *et al.*, 1999).

Looking beyond 'surface' spatial forms to the underlying functions and interactions, a distinction can be made between 'optimal city size' and 'efficient size', the latter depending on the functional characteristics of the city and on the spatial organisation within the urban system. Capello and Camagni (2000) accept the basic criticism of the optimal city size theory and the idea that there are determinants of urban location advantages other than urban size, including the economic functions developed by the urban centre, the spatial organisation in which the centre operates, and the efficiency of each centre's internal structure. The influence of urban size exists and is important, but cannot be efficiently assessed without overcoming some of the limitations imposed by the theory. It is not a problem of optimal city size but of efficient size, which largely depends on what the city produces, how it produces, and the way in which it co-operates within the urban system.

The claimed advantages of the compact city have been well documented and include conservation of countryside, less need to travel by car (thus reduced fuel emissions), support for public transport, walking and cycling, better access to services and facilities, more efficient utility and infrastructure provision, and revitalisation and regeneration of inner urban areas (Burton, 2000b). Counter-claims include, *inter alia*, that the re-use of urban land might lead to a lack of urban green space and an overcrowded environment.

1.8.4 Competing models for sustainable cities

Concepts and methodologies adopted by previous studies provide useful pointers for the methodological framework to be applied to the sustainable settlement size project.

Haughton (1999) described three models of cities.

1. The 'externally dependent city' (free market) model, which centres on the largely non-spatial views of economists seeking to address urban environmental problems through altering market mechanisms.

2. The 'redesigning the city' model, which has its roots in architectural and land-use planning perspectives, where a central theme is that redesigning the physical fabric of the existing city in various ways can encourage greater resource efficiency. The RDC approach also places much emphasis on improving the individual components of the physical infrastructure of the city, in particular the energy efficiency of buildings, green spaces and public open spaces.

3. The 'self-reliant city' model, which embraces most of the key tenets of the deep green approach to sustainable development. The preservation of natural assets is a central concern, in particular designing cities in ways that best integrate with nature.

Priemus (1999) distinguished three aspects of the urban system: (1) the people, (2) the places where they live, and (3) the material flows maintaining the relationships between people and places. Material flows may be influ-

enced by changes in the development of areas and the behaviour of actors. The classification of an urban system according to areas, actors and material flows forms the basis for an overview of measures capable of increasing the sustainability of urban systems. A major proportion of the required efforts will have to take place at a local level. This applies in particular to spatial integration and an ecological optimisation of functions in the urban area.

Filion *et al.* (1999) acknowledged that space refers to the necessity to secure accessibility to activities with a metropolitan-wide catchment and to maximise accessibility across the entire agglomeration. Place connotes preferences regarding the inherent attributes of a site and building as well as of their surroundings. The proximity principle denotes the influence of activities and features to be found within a long walk or short drive (10 minutes or less). The spatial realm of proximity is intentionally ill defined and occupies the middle ground between space and place. The uneven balance between space and place location principles was inverted by post-war suburban-style transport and land-use patterns. Mounting reliance on the car, massive expressway and arterial investment and a scattering of activities both reflecting and furthering a levelling of accessibility gradients, resulted in a decline of space constraints on place. Reduced concern for space made it possible for an increasingly large segment of the population to achieve place-related preferences. The weight of space was also lessened by a growing importance of proximity prompted by the post-war scattering of structuring activities. Space, place and proximity as factors of sustainability are summarised in Table 1.1.

1.8.5 Towards an Urban Economy–Environment Framework

Optimal city size theory states that the well-known indivisibility and synergy mechanisms, which are at the basis of economies of scale in cities, apply up to a certain urban size, after which diseconomies of scale due to congestion effects take place and decrease the average revenues of an urban location. The optimal city size is calculated as the result of the maximum difference between a location cost curve, defined by Alonso (1964) as the land rent costs associated with urban size, and the aggregate agglomeration advantage curve.

Criticisms of the neoclassical approach to optimal city size theory include:

1. the efficient range of city sizes varies according to the functions and the structure of the cities in question;
2. the theory does not consider the spatial context in which cities operate; and

Table 1.1. Space, place and proximity as factors of sustainability.

	Traditional Monocentric City	**Dispersed City**
Space: metropolitan-wide accessibility	Accessibility to activities serving a metropolitan-wide market is of paramount importance in location decisions	Depleted importance of metropolitan-wide activities on location decisions because of generalised use of the car (leading to higher accessibility potential) and a scattering of many activities previously concentrated in the core
Place: features of buildings, sites and of their surroundings	Preference for large lots and houses is frustrated by the space imperative	With a reduction of the space imperative, place comes to the fore as a factor of location. This leads to an enhanced influence of lot and structure size and of the character of surrounding areas (homogeneity, status, tranquillity)
Proximity: influence of close-by activities, amenities and disamenities	The targeting by activities of either metropolitan-wide and very local catchment areas is not conducive to middle range proximity as a factor of location	Along with place comes increased attention to close-by amenities and disamenities. The tendency for activities to decentralise and target a segment of the agglomeration is also favourable to proximity as a factor of location

3. cities generate a large variety of externalities as a result of the qualitative characteristics of the urban production environment – importance of a diversified and competitive urban production system as a source of urban productivity.

Theories that have superseded the above limitations of the neoclassical theory on city size can be grouped into two different conceptual paradigms. We refer to these two paradigms as the neoclassical city, interpreted within a logic based on the Christaller model, and the network city paradigm (Capello and Camagni, 2000). Neoclassical logic leads to the definition of a hierarchical urban system, where differences in city size can be interpreted as the competition between agglomeration advantages, on the one hand, and higher urban rents and diseconomies of congestion, on the other.

The most important theoretical novelty provided by the network city paradigm is the breaking of the link between urban size and urban function imposed by the Christallerian logic. This is summarised in Table 1.2.

The break in the relationship between urban size and function is one of the main characteristics of the SOUDY (supply-oriented dynamic approach) model (Camagni *et al.*, 1986), which argues that:

(a) higher-order functions are characterised by higher thresholds for the level of appearance in the city (in terms of urban population);

(b) the average (aggregate) benefit–cost curve increases for higher-order functions, due to growing entry barriers, decreasing elasticity of demand (which allows extra profits to be gained in all market conditions), and the increasing possibility of obtaining monopolistic revenues due to the use of scarce, qualified factors; and

(c) the location–cost curve has the traditional form (Alonso, 1964).

This model overcomes some of the limits of the optimal city size theory by suggesting:

Table 1.2. Characteristics of city paradigms.

Paradigms/ Elements	**Optimal City Size**	**The Neoclassical and Christallerian City**	**The Network City**
Characteristics of the approach	Empirical	Theoretical	Theoretical and empirical
Characteristics of the city	Undefined city (aggregated)	Despecialised city	Specialised city linked with a large urban system
Characteristics of the urban system	Not considered	Hierarchical	Networked
Characterising element	Urban size	Urban size interpreted through the urban functions	Distinction between size and urban function. Analysis developed in a spatial context
Urban efficiency	Agglomeration economies	Functional upgrading of economies	Co-existence of network externalities, economies of agglomeration and functional upgrading
Result of the analysis	An intraurban equilibrium exists which has to be reached	An intraurban and interurban equilibrium exists by definition	There exists an intraurban equilibrium which can be reached through interurban system relationships
Urban policy aims	Achievement of an intraurban equilibrium between costs and benefits obtainable through the urban dimension	None: the system is in equilibrium by definition	Achievement of a cost–benefit equilibrium through specialisation policies and/or network integration

(a) the need to replace optimal city size with an interval within which the city size is efficient (where average benefits exceed average location costs);

(b) the interval of efficient city size corresponds to greater urban size, the higher the economic functions developed in the city;

(c) the economic functions characterising the city are an important determinant of the efficient city size.

While the organisational logic underlying Christaller's central place model is a territorial logic, emphasising a gravity-type control over market areas, another logic prevails in the network model. This refers to long-distance competition and co-operation regardless of the distance barrier. The joint application of the SOUDY model and the network city theory has implications for the definition of economies of agglomeration, that size is not the only determinant of factor productivity and economies of agglomeration in large centres. The presence of higher urban functions and integration in the network of urban systems are also extremely important in explaining the size of the city.

1.8.6 Statistical definition of the City Effect and the Urban Overload indicators

The City Effect relates to the types of higher-order economic functions developed in the city. An indicator for this might be share of private tertiary added value. Urban Overloads relate to negative impacts associated with city living: an indicator for this might be vehicle congestion or the crime rate (see Table 1.3). The Network Effect relates to the degree to which the city interacts with the rest of the world. An indicator for this might be the proportion of the population connected to telephone services.

Empirical evidence for the network effect, based on a comprehensive study of 58 Italian cities, shows that the 'city effect' increases with urban size up to a certain point (approximately 361,000 inhabitants) and then decreases. Economies of scale analysis shows that economies of scale exist for public services (such as schools, public transport and banks), and for environmental resources (such as water, petrol and energy use). In relation to the 'urban overload effect', the results show a decreasing trend up to a certain urban size (55,500 inhabitants) and an increasing trend afterwards, once again in line with traditional expectations.

The city effect is exploited up to a certain urban size, after which its slope becomes negative. The expected congestion effects and diseconomies of scale prevail in large cities. Medium-sized cities appear to have a greater endogenous capacity to keep social, economic and environmental costs under control. Urban size is important for explaining economies of scale and the considerable 'city effects' of large cities. Conversely, other determinants are necessary to fully explain the diseconomies of scale and the decreasing overload effects of small cities.

The estimated curve confirms the theoretical hypotheses of the SOUDY model: higher-order functions guarantee a greater 'city effect', due to the positive returns generated.

A minimum threshold of high-order tertiary functions has to be achieved before increasing returns to urban scale manifest themselves. The city can only exploit the advantages of urban size if it achieves a substantial share of tertiary activities (49%). The 'urban overload' effects increase at a decreasing rate when there is a strong presence of high-level functions. This means that the increase

Table 1.3. Interactions between economic, physical and social environments.

	Interaction between economic and physical environments	Interaction between economic and social environments	Interaction between social and physical environments
City effect indicator	Energy use per capita Petrol use per capita Water use per capita	Number of graduates/population Number of schools/population Number of banks/population Supply of public services/ population Urban rent per square metre	Green areas in city (square metres per capita)
Urban overload indicator	NO_x emissions per capita Urban waste (kg per capita) No. of vehicles per square km	Unemployment/population	Number of murders/ population

in tertiary activities tends to entail congestion and location costs, but that this negative aspect does not occur in a disruptive and uncontrollable manner, as in the case of increasing urban size.

For the urban overload effect, the picture that emerges is similar to that for different levels of high-order functions. When the level of network integration increases, urban overload increases too (higher levels of network integration stimulate more economic activities and generate higher city effects, but with the negative counterpart of an increasing overload). Estimated city effect and urban overload are shown in Fig. 1.6.

The influence of urban size exists and is important, but cannot be efficiently assessed without overcoming some of the limitations imposed by the theory. It is not a problem of optimal city size but of efficient size, which largely depends on what the city produces, how it produces it, and the way in which it co-operates within the urban system. The analysis has important normative consequences. Since it is difficult to envisage a large city having a strong city effect without facing high overload costs, local urban policies are vital and they play a significant role in the definition of the growth potential of our cities. These policies should focus on, among other things, upgrading the economic functions within the city, as well as the devel-

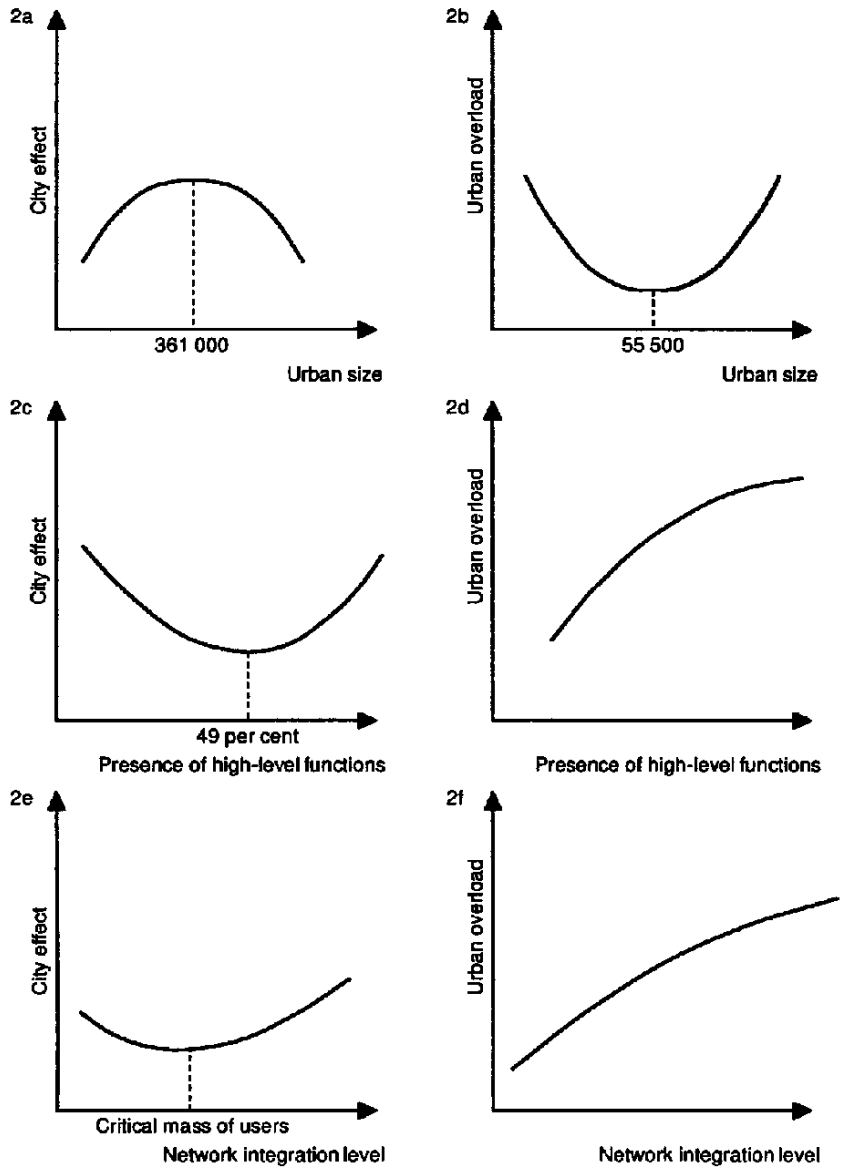

Figure 1.6. Estimated city effect and urban overload.

opment of linkages outside the city, such as alliances, co-operation agreements, and advanced international transport and telecommunications infrastructure. All of these elements are undoubtedly important for guaranteeing the survival of a modern city

1.8.7 Sustainable settlement size – lessons from the UK

Research commissioned on new settlements (UKDoE, 2000) considered the impact of size of settlement on economic, social and environmental costs. This explored the size thresholds required to support basic social infrastructure (e.g. primary and secondary schools), a range of facilities needed for a social life (e.g. a range of shopping and leisure facilities) and the degree to which the provision of these services would influence the need to travel further afield. The report identifies five alternative development types: urban infill, urban extensions, key villages, multiple village extensions and new settlements. These alternatives are assessed against economic, social and environmental criteria. The overall findings on the merits of the five alternatives depend on the weighting attached to the individual criteria, with multiple village extensions giving the overall weakest performance. This is shown in Table 1.4. Overall, urban infill and new settlements fare best.

Table 1.4. Summary assessment of alternative development patterns.

Settlement type	Economic		Social		Environmental	
	Advantages	**Disadvantages**	**Advantages**	**Disadvantages**	**Advantages**	**Disadvantages**
Urban infill	Low infrastructure provision and use costs. Good access to employment.	High development costs.	Good access to social facilities. Good sense of community and social mix.	Moderate–poor affordable housing.	Low loss of land and habitats (depending on circumstances). Low transport energy use (depending on congestion).	Moderate–high pollution levels. Poor contribution to 'Greening'. High town cramming effect.
Urban extensions	Low infrastructure provision and use costs. Moderate access to employment (can be car dependent).	Medium development costs.	Moderate access to social facilities. Moderate sense of community and social mix.	Moderate–poor affordable housing.	Good 'Greening' contribution. Low town cramming effect.	High loss of land. Moderate loss of habitats. Relatively high pollution levels.
Key villages	Low infrastructure provision and use costs. Moderate access to employment.	Medium development costs.	Moderate access to social facilities. Moderate sense of community and social mix.	Moderate–poor affordable housing.	Moderate 'Greening' contribution.	High loss of land. Moderate loss of habitats. High pollution levels/ energy use because of car dependency.
Multiple village extensions	Low maintenance costs.	High development and infrastructure costs. Poor access to employment.	Good sense of community.	Poor access to social facilities. Moderate–poor affordable housing.	Low–moderate loss of habitats. Moderate 'Greening' contribution.	High loss of land. High pollution levels/energy use because of car dependency.
New settlements	Low development and maintenance costs. Moderate access to employment.	Moderate–high infrastructure costs.	Good access to social facilities and sense of community. Moderate social mix. Good availability of affordable housing due to planning gain.		Good 'Greening' contribution.	High loss of land and potentially high levels of pollution and energy use.

The main recommendations of the report include that the minimum viable size of a new settlement should be that which will support a primary school (750–1000 houses), a secondary school and a range of facilities, which would require 3000–5000 houses (ca. 7500–12,500 population), but that 'environmental considerations' would point to schemes even larger than this, perhaps up to 10,000 dwellings (25,000–30,000 population). These and other recommendations are summarised in Table 1.5.

1.9 Sustainable planning tools

1.9.1 Landscape history

Landscapes are dynamic and fluid entities. They are constantly changing, both ecologically and culturally, over time. Marcucci (2000) argues that, in order to plan future settlements, landscapes must be understood within their spatial and temporal contexts. Landscape history is an important tool for describing the evolutionary process of

Table 1.5. Recommended practice in the design of new settlements.

Economic	Social	Environmental
Land ownership It is essential that all land required for the new settlement is assembled before commencement. It is highly desirable to have control of all land required for off-site infrastructure works. The price paid for land must take account of the cost of development, on-site servicing, structural landscape, off-site infrastructure, planning gains, cost of borrowing development finance, and the profit requirement of the developer.	**Consultation with residents** Public involvement in the new settlement process is both desirable and necessary if popular support for the planning process is to be maintained. The involvement of incoming residents in the later phase of new developments is desirable.	**Greening new settlements** New settlements must be designed to be as environmentally sustainable as possible. Where possible, the promoters and planners of new settlements should minimise the use of land that is valuable in agricultural or ecological terms. New settlements should strike a balance between the need for compactness (for energy efficiency) and the need for green space in public and private areas. Arrangements should be made for communities to recycle as much waste as possible.
Financial assessment Key financial data on new settlement proposals should be made available for scrutiny by the local planning authority. Key data required to carry out financial assessment include, *inter alia*, acquisition cost of land, costs of on/off site infrastructures, costs of planning gains, budgets proposed for master planning and quality control, estimated costs of implementing good environmental practices, and provisions made for long-term management and maintenance.	**Establishing social context** The social characteristics of a new settlement are greatly influenced by its urban design. For new settlement schemes, urban design should consider, *inter alia*, the following urban form as a framework for development: demographic profile, community profile, house price and type, employment and predicted economic activity. Real investment in social development programmes is required, involving capital funding for both the facilities and for the start-up of local organisations until residents are able to manage their own resources.	**Transport and energy** New settlements should, where possible, be close to urban areas as this will reduce journey lengths to work and non-work facilities**.** Alternatively, they should be remote because they are then likely to be relatively self-contained. They should provide as high a level of local jobs and services as possible, in order to achieve some level of self-containment.
Commercial confidentiality To respect the sensitive nature of the information described above, planning authorities must make special arrangements for the receipt and analysis of the data, and for the way in which the data are used in decision-making.	**Delivery of affordable housing** A range of housing types, tenures and prices is essential if the new settlement is to provide opportunities for a balanced population. Schemes such as affordable housing, shared ownership, annuity loan scheme, mortgage relief allowance (as now operated by Irish LAs) may be appropriate.	**Further observations** New settlements should be viable communities in their own right. Larger-scale settlements (up to 6000 houses) should not be precluded from consideration. If sustainability is to be given great weight, new settlements of a scale of 10,000 dwellings (25,000–30,000 population) could be the most desirable form of urban development other than urban infill.

landscape development by exposing its ecological stages, cultural periods and keystone processes. According to Marcucci (*op. cit.*), landscape history may be a valuable instrument as it has the potential to improve description, prediction and prescription in landscape planning.

1.9.2 Strategic Environmental Assessment (SEA)

The integration of Environmental Impact Assessments (EIAs) into planning and policy making has been termed the 'ultimate means by which sustainable development can be achieved' (Partidário, 1996). The debate is still ongoing as to whether EIA is an effective instrument in working towards sustainable development. The former Taoiseach Albert Reynolds stated that an EIA is in fact the procedure by which sustainable development could be achieved. However, there are two problems (Fry, 1999):

1. the EIA Directive 85/337/EEC and the 1989 EIA Regulations predate the general concern with the concept, and they do not refer to it in the text; and

2. current EIA procedures are project based and, by definition, most projects have a finite life span and are inherently unsustainable ('green' critic Jonathan Porritt emphasises that English dictionaries define sustainable development as capable of being kept going on an infinite basis – not 1 week, year or century, but indefinitely (Porritt, 1993)).

Another criticism of current international EIA legislation is that it is perceived by developing countries as an elitist attempt to impose conservation measures on countries badly in need of economic development (Boden, 1982), although the failure of many economic development projects in developed countries may be attributed to the inadequate consideration of environmental impacts (Ayanda, 1988).

Land-use planning tends to focus on individual projects rather than on long-term sustainability goals. Strategic Environmental Assessment (SEA) has subsequently emerged as a comprehensive mechanism for integrating environmental impact considerations into planning policy decisions in order to promote sustainable development (Shepherd and Ortolano, 1996). SEA and eco-auditing may also be used to reinforce and corroborate the identification of the potential environmental impacts of a planning development. EIA and SEA have been classed as identical procedures (Lee and Walsh, 1992). However, SEA is described as a more formalised and comprehensive process which also considers alternatives and uses the findings in publicly accountable decision-making (Therivel and Partidario, 1996).

1.9.3 Ecological footprint

The ecological footprint (EF), developed by Canadian ecologist and planner, William Rees, is an accounting tool that uses land as the unit of measurement to assess per-capita consumption, production and discharge needs. The EF has received much attention over the last few years as a potential indicator for sustainable development. Wackernagel and Rees (1996a) defined the EF as the total amount of ecologically productive land required to support the consumption of a given population in a sustainable manner and as "a planning tool that can help to translate sustainability concerns into public action". In metaphorical terms, the EF is an expression of the impacts of human consumption in terms of a visible footprint made on the natural carrying capacity. The EF refers to the continuing dependency of human societies on nature, in terms of the more obvious dependency of traditional societies on their available land (Van Vuuren and Smeets, 2000). The EF represents the critical natural capital requirements of a defined economy or population in terms of the corresponding biologically productive areas. The area of the footprint depends on the population size, material living standards, technology used and ecological productivity (Wackernagel *et al.*, 1999). According to Wackernagel and Rees (1996b), land is used as the unit of measurement because it not only captures the finiteness of the planet, but it can also be seen as a proxy for the numerous essential life-supporting functions, from gas exchange to nutrient recycling.

However, Van den Bergh and Verbruggen (1999) list some objections against the EF. The first, *inter alia*, relates to the land-use dimension. Although the EF denotes hypothetical land area, there is a danger that it will be interpreted as actual land use, not only by the general public and politicians, but also by environmentalists and academic researchers. Secondly, the EF does not distinguish between sustainable and unsustainable land use. In order to measure the degree of unsustainability of an economy

or activity, indicators that focus on processes that contribute to unsustainability are needed, such as unsustainable resource use and soil degradation, rather than just hypothetical land area measure.

Wackernagel and Rees (1996b) have calculated the EF of the average American to be 5.1 ha of land per capita. The European Environment Agency (1997) stated that if the global population were to adopt American consumer lifestyles, with the 7.4 billion ha of the planet's total surface area of 51 billion ha available for human consumption, we would need two additional planets to produce the resources, absorb the wastes, and provide general life-support functions. In 1997, a new study calculated America's EF to be 10.6 (ha/capita) (Wackernagel *et al.*, 1999).

Despite these shortcomings, EF seems to confirm what many already suspect. Continued throughput-based economic growth can only be realised at the cost of liquidating natural capital. Whether used as an analytical or guidance tool, two of the valuable pedagogical features of the EF are that:

1. it makes issues of ecological scarcity and unequal consumption vividly apparent, making comparison possible (EEA, 1997),

2. the concept is rapidly growing as a sustainability planning tool among planners, academics, NGOs and LAs.

In effect, the EF provides a 'snapshot' of the resources required to support consumption, given the available technology and processes. As such, the EF can be compared with the land available for supporting human consumption, in order to provide a static indicator of sustainability. Any change in technology or resource-use patterns could then be incorporated into subsequent estimates of the ecological footprint (Bicknell *et al.*, 1998).

The recent report on the EF of nations calculated Ireland's EF to be 5.9 (ha/capita) (Wackernagel *et al.*, 1999). Half of the 20 developed countries surveyed have EFs greater than twice the global capacity and are in ecological deficit.

1.10 Indicators as a quantitative tool for estimating sustainable settlement size

Interest in sustainable development and growing public concern and involvement in environmental and socio–economic matters have prompted governments to re-examine their capacity to assess and monitor the state of the environment and the economy, and detect changing trends and conditions. Interest is also growing in the measurement of environmental performance and in examining how successful governments are in their efforts to implement domestic environmental policies and international commitments. Thus, indicators are constantly evolving as vital tools to map the course towards a sustainable future (OECD, 1994).

Since the 1990s, local governments worldwide have experimented with new planning structures and mechanisms to give functional meaning to the sustainable development concept. However, few local governments have developed a management system that could guarantee that a single local community today would agree to operationalise and monitor the implementation of measures necessary to place local consumption and development on a sustainable course (Brugmann, 1996). Most policy makers continue to be frustrated by the lack of tangible progress in identifying useable sustainability indicators that are easy to understand, inexpensive to measure and supported by a political consensus. The only major point of general agreement is that sustainable development means different things to different people (Gustavson *et al*., 1999), and that sustainability indicators are a practical and reasonable vehicle for attempting to deal with the multifaceted nature of the concept (Pannell and Schilizzi, 1999). Bell and Morse, (1999) established that the major criticism regarding sustainability indicators is that they attempt to encapsulate complex and diverse processes in relatively few measures. The world is a complex system and scientists traditionally analyse complex systems by breaking them down into components and studying how these work in isolation and then attempting to bring them together. This reductionist approach has been criticised because some systems are so complex, with numerous non-linear relationships, that it is impossible for the human mind to adequately understand them. Quantitative indicators can establish answers to 'how

many' and 'how much' questions but, in order to understand why things happen, a systems approach should be adopted. It is argued that sustainability indicators present data on isolated variables and these have no meaning outside the context of the system itself.

Concern over the need for sustainability indicators arose in part from the Rio de Janeiro Declaration on Environment and Development and particularly from LA 21, Chapter 40 of which includes:

"*indicators of sustainable development need to be developed to provide a solid basis for decision making at all levels and to contribute to a self-regulating sustainability of integrated environmental and development systems*".

The main policy document coming out of the Habitat II conference included a series of recommendations and agreements relating to the development of indicators of human settlements, and an agreement that local governments worldwide should develop and apply human settlement indicators as part of their commitment to strengthening their existing data collection and analysis capabilities (Flood, 1997).

In Ireland in 1994, a Policy Agreement between Fine Gael, Fine Fáil and Democratic Left agreed to:

"*work towards a set of indicators of sustainable economic development which will take account of environmental and social factors. These indicators will be used alongside the existing measures of economic activity such as Gross Domestic Product (GDP)*".

Sustainable development indicators are a prerequisite for implementing sustainability in practical policy and planning decisions. They are important tools for translating and delivering concise, scientifically valid information in a manner that can be readily accepted, and this information has value primarily as an input to decision making (Pannell and Glenn, 2000). They are increasing in importance because (UK DoE, 1996):

(a) the public needs to be informed about the state of the environment and the economy, and how and why they are changing, so that they can understand and monitor government policies and see how their own personal actions may have an impact,

(b) they provide a measure to link environmental impacts and socio–economic activity, and may in some cases provide early warning of potential environmental problems arising from human activity,

(c) they can help measure the extent to which policies aimed at sustainable development objectives are being achieved, and

(d) they can help to clarify the confusion caused by the mass of environmental and economic data available.

Other factors that explain the growing popularity of sustainability indicators include:

(a) they are seen in a managerial context as tools for planning government and local government environmental initiatives, such as assisting in the setting of targets, the implementation of programmes and the measurement of progress,

(b) they are envisaged as having a role in political objective setting. Defining indicators for sustainability is a way of seeking to provide new political objectives such as reduced energy use or increased recycling (McDonagh and Prothero, 1997).

There is currently little reference to the integration of sustainability indicators into local authority policies and programmes and "unless this is explicitly addressed, one can reasonably assume that the use of indicators will be *ad hoc* or discretionary" (Hardi and Pinter, 1995). Indicators should relate to clear policy objectives, have a clear interpretation and be understandable to non-scientists (Kuik and Verbruggen, 1991).

The OECD Environmental Indicators (1994) report categorises indicators into three groups, namely Pressure–State–Response (P–S–R) (Fig. 1.7):

(a) indicators of environmental pressures: describe pressures on the environment from human activities, including both the quality and quantity of natural resources (Pressure box),

(b) indicators of environmental conditions: relate to the quality and quantity of natural resources. Environmental condition indicators should be developed so as to give a broad overview of the state of the environment and its development over time, and not the pres-

PRESSURE	STATE	RESPONSE
Pressures ⇨	Information ⇨	
Human Activities	**State of the Environment**	**Economic/Environmental Agents**
Energy	Air	Administrations
Transport	Water	Households
Industry	Land	Enterprises
Agriculture	Living Resources	
Others		

Figure 1.7. Pressure–State–Response Framework.

sures on it. In reality, it is often difficult and costly to distinguish between environmental pressures and conditions, so the measurement of environmental pressures is often used as a substitute for measuring environmental conditions (State box);

(c) indicators of societal response: show the extent to which society is responding to environmental changes and concerns. Societal responses refer to individual and collective actions (i) to mitigate or prevent human-induced negative impacts on the environment, (ii) to halt or reserve environmental damage already inflicted, and (iii) to preserve and conserve natural resources (Response box).

The P–S–R framework has been suggested as a mechanism for addressing causal linkages. Hammond *et al.* (1995) summarised the framework with three questions:

(a) What is happening to the state of the environment and natural resources?

(b) Why is it happening?

(c) What are we doing about it?

In 1998, the EPA compiled a list of environmental indicators for Ireland with an emphasis on eutrophication, waste and the urban environment, including transport. The indicators were chosen as key statistics that represent or summarise aspects of the state of the environment. The report *Environment in Focus* is structured around a framework based on causality expressed by the DPSIR framework (Driving Force–Pressure–State–Impact–Response framework). A very brief summary of the main findings is shown in Fig. 1.8, which provides an overview of eco-efficiency in Ireland for a selection of key environmental indicators when compared with economic growth. The chief message emerging from the report is that the environment in Ireland is under increasing threat (EPA, 1999a).

1.10.1 Sustainability indicators – lessons from abroad

When measuring the sustainability of human settlements, cognisance needs to be taken of both the quality of human settlements and the impact that these settlements have on the local and global resource base. When applied to settlements, sustainability requires that the needs of the inhabitants be met without imposing unsustainable demand on local and global resources. The interdependence between settlements and the global environment means that even if settlements reach sustainability at a local level they may not necessarily do so at a global level. Settlements may achieve local sustainability by placing unsustainable demands on natural resources elsewhere and exporting their waste to other regions (Alberti, 1996).

Sustainability indicators are becoming increasingly important as tools for examining sustainable development in urban settlements. Many initiatives have been taken to develop sustainability indicators, and several international organisations have created specific programmes to develop and harmonise urban sustainability indicators. These include the UN Centre for Human Settlements (UNCHS), the UN Commission on Sustainable Development, the World Bank, the Organisation for Economic

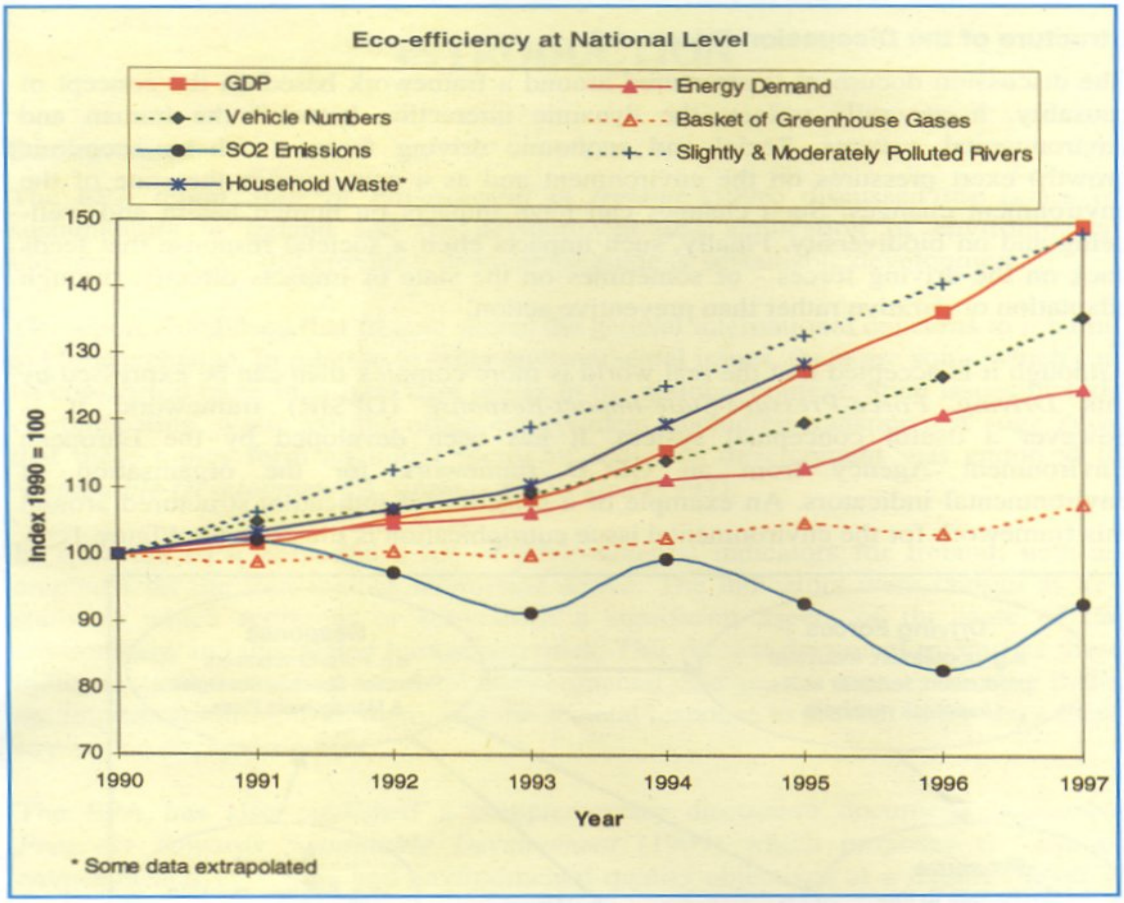

Figure 1.8. Eco-efficiency performance in Ireland 1990–1997.

Co-operation and Development (OECD), The European Environment Agency (EEA) and the World Health Organisation (WHO). The development of indicators must start with a carefully defined concept of the purpose of indicators. The starting point is usually the assessment of environmental conditions, and then the distance between the present state and the expected situation is measured by means of a number of indicators. MacLaren (1996) distinguished urban sustainability indicators from simple environmental, economic, and social indicators by the fact that they are not only integrating, but forward looking, distributional, and with input from multiple stakeholders. Evidence of progress on urban sustainability is important for justifying past expenditures on sustainability initiatives and building support for new initiatives. However, it must be remembered that sustainability indicators are usually site specific, and indicators designed to measure progress toward sustainability in one urban area may not be appropriate for another city (MacLaren, 1996). To be useful, indicators must be able to tell us (a) whether sustainability in settlements is improving or deteriorating in relation to certain sustainability criteria or desirable targets, and (b) how these trends are linked to trends in spatial structure, urban organisation and lifestyles. Alberti (1996) identified three dimensions that need to be considered when measuring urban sustainability: urban quality, urban flows and urban patterns.

Perhaps the best-known case where indicators have been used to measure urban sustainability is Seattle in the USA, where, over a period of 5 years starting in 1990, a set of sustainability indicators were developed to examine whether Seattle was moving towards or away from its goal of sustainable development. Most participation in the project was on a voluntary basis and members came from many sectors of Seattle society – business, government, industry, social and religious groups, environmental groups and educators. The project group adopted "long-term cultural, economic and environmental health and vitality" as their definition of sustainability. The next stage was to decide on the issues of importance that had

an impact on sustainability and to find relationships among them. This was done by the 'Task Team', which consisted of professionals from a wide range of disciplines. Following from that initial list of issues, the team divided them into key indicators, secondary indicators and provocative indicators. It took the team 2 years to arrive at a candidate list of indicators, which were presented to the project leadership for review. This list was then forwarded to a panel for comments and another draft list was produced. This list was then examined by the Project Team under headings such as resource consumption, education, economy, transportation, natural environment, health, social environment, culture and recreation, population and community participation. The criteria for sustainability for each topic were debated and eventually it was decided that the selected indicators must be reflective of trends that were fundamental to long-term cultural, economic and environmental health, statistically measurable with data available for one or two decades, attractive to the local media and comprehensible to the average person (Atkisson, 1996). Finally, a list of 99 indicators was presented by the group at the end of 1992 and these were further reduced to 40 when data availability was considered. The Project Team decided that the most suitable way of using these indicators was that the direction of sustainability for each indicator would be determined and the trend evaluated in terms of this direction, with widening gaps being an indication that Seattle was moving away from sustainability (Sustainable Seattle, 1995).

Taipei is the capital of Taiwan and is the country's most important urban centre. It is located in the northern portion of the island. Like most older cities, Taipei originated along and is located at the mouth of a river in a wide flat plain. Currently, urban development has covered the entire basin and the total population within the metropolitan region has continued to grow; it reached 6 million in 2000. The city suffers from the same environmental problems as many large urban centres in the industrial part of the world. It was recognised that without some indicators of sustainable development, the effectiveness of an environmental or other policy toward this goal could not be assessed. In order to include the concept of sustainable development in the revised version of Taipei's Comprehensive Development Plan, the municipal government funded a study in 1995 to develop indicators and the strategy of sustainable urban development for Taipei City. The purpose of the project was to develop indicators that would be useful to administrators and policy makers in evaluating policy effectiveness for achieving sustainability.

Questionnaires were distributed in order to receive feedback on the proposed lists of indicators. Eighty indicators were selected to represent policy-making indicators for urban sustainability. However, due to the lack of monitoring data, only 63 of these indicators could be measured. In order to provide much simpler indicators for the general public, these were re-grouped into 10 general indicators (Huang *et al.*, 1998):

- ecological sustainability
- water resources utilisation
- economic efficiency
- resource self-sufficiency
- environmental loading
- living comfort
- transport efficiency
- environmental management
- social welfare and public safety
- education

The indicator system for measuring Taipei's urban sustainability is at an early stage of development but has the potential to provide 'early warning' signs of change, enabling preventive action to be targeted. However, there are some weaknesses in the indicator system developed for Taipei. In order to include as many aspects as possible in order to reach a consensus, the indicators were chosen only through meetings with public officials and NGOs, and were not put to vote by citizens.

The Province of Trento (Trentino) is a territory in the north of Italy, situated on the southern side of the Alps, where rapid changes in the economy have transformed the traditional relationships between the local community and the environment. The requirement for effective control of these impacts has been partially met by traditional

tools like territorial plans, sectoral laws, protected areas, and assessment procedures (EIA). A recent initiative is the promotion of a plan for sustainable development. This has been assigned to the Department of Civil and Environmental Engineering of the University of Trento (DICA). The starting point has been the organisation of a number of lists. The first regards the social practices that can produce pressures at a local level, the second represents the use of resources, the third describes the types of release, and the last enumerates the resources to be kept under control. In this context, biodiversity and cultural landscape have been considered as resources. So far, 130 indicators have been chosen in the first phase. These have been organised within three subsystems defined as: (a) water, soil, biotic communities, (b) atmosphere, and (c) non-renewable resources (Diamantini and Zanon, 2000). The sustainable indicator project in Trentino is still in progress.

1.11 Choosing the indicators

In the last 10 years, lower inflation rates, significant foreign investment in light manufacturing and services, a well-educated labour force (Sabel, 1996) and the securing of EU structural funds have contributed to securing consistently high rates of Irish Gross Domestic Product (GDP), reaching a high of 8% in 2000. However, this unprecedented rate of economic growth is rapidly accelerating pressures on the natural environment. The most recently published state of the environment report identifies a number of key trends including (EPA, 2000):

(a) new housing completions had more than doubled and the number of households had increased substantially;

(b) personal consumption of goods and services had increased by one-third in a 5-year period;

(c) the volume of industrial production had more than doubled;

(d) the total number of vehicles had increased by more than 50%;

(e) the country's total primary energy requirement had increased by more than one-third;

(f) there was substantial expansion in forestry, tourism and trade.

These rates of growth are presenting difficult challenges for environmental protection in Ireland. The final list of sustainability indicators must reflect certain themes identified in the EPA report that may be sensitive to settlement size. These include the following.

1. **Emissions to air:** particularly carbon dioxide, methane and nitrous oxide, which contribute to the greenhouse effect, giving rise to climate change. Ireland has committed to limiting greenhouse gas emissions in the period 2008–2012 to 13% above 1990 levels. However, in a 'business as usual' scenario, Ireland's emissions by that period would reach more than twice the limit.

2. **Non-agricultural solid waste:** the largest amounts of waste generated were in manufacturing (4.9 million t), in mining and quarrying (3.5 million t), in construction and demolition (2.7 million t) and in the municipal sector (2.1 million t). Landfill remains the predominant means of disposal.

3. **Eutrophication:** this affects one-third of the river systems in Ireland. The main cause of nutrient enrichment of inland waterways is phosphorus, particularly from agricultural sources. Nitrogen is also of concern in certain areas, in relation to its impact on both surface waters and groundwater. The principal source of nitrogen is again from agriculture. In the most recent water quality review, 24 of the 124 lakes studied were eutrophic and seven of these were highly eutrophic (EPA, 1999b).

4. **Land-use changes**: road building, industrial development, housing, agriculture, afforestation, quarrying, mineral exploitation and recreational and tourism developments are placing increasing pressure on the environment.

5. **Rising vehicle numbers:** this has become the greatest threat to air quality in Ireland, especially in urban areas. The pollutants of concern from this source include nitrogen dioxide, fine particulate matter (measured as PM10) and benzene. It also gives rise to serious traffic congestion and noise.

6. **Urban sprawl:** countryside landscapes are seriously affected by developments such as urban sprawl, inappropriate rural housing development, road construction and the growth of industry.

7. **Conservation issues:** Ireland has 30% of the European lichen species. The populations of certain faunal species, including the freshwater crayfish, lesser horseshoe bat and otter, are particularly important in the European context. Although conservation measures have been relatively successful in protecting these and other species, including the roseate tern and corncrake, they still remain under threat. Another contentious issue is the threat to biodiversity as a result of intensification of agricultural practices.

The following is a candidate list of indicators for measuring the sustainability of human settlements, as developed by UNCHS, WHO, OECD, EEA and the Irish EPA (Tables 1.6–1.9). Some indicators have been included, removed or modified as recommended by the Steering Group at the assessment meeting in St Martin's House, Dublin (26th April, 2001).

Table 1.6. Driving force/pressure indicators (UNCHS, WHO, OECD, Irish EPA).

Social	Potential data sources	Environmental	Potential data sources	Economic	Potential data sources
Unemployment rate	Census, Fás, Dept of Social Welfare	Annual withdrawals of ground and surface water	Environmental Protection Agency, Geological Survey of Ireland	GDP/capita	Dept of Finance, Central Statistics Office
Population growth rate	Census, Central Statistics Office	Emissions of hydrocarbons	Environmental Protection Agency, Local Authorities	Sum of exports and imports as % of GDP	Dept of Finance, Central Statistics Office
Net migration rate	Central Statistics Office	Domestic consumption of water/capita	Environmental Protection Agency, Local Authorities	Energy demand and economic growth	Dept of Public Enterprise, Central Statistics Office, Environmental Protection Agency
Total fertility rate	Health Boards, Dept of Health	Releases of nitrogen and phosphorus to coastal waters	Environmental Protection Agency	Annual energy consumption	Dept of Public Enterprise, Dept of Transport, Energy and Communications, Central Statistics Office, Environmental Protection Agency
Rate of change of school age population	Dept of Education	Releases of nitrogen and phosphorus to rivers and lakes	Environmental Protection Agency	Total ODA given or received as a % of GNP	Dept of Finance, Dept of Foreign Affairs
Primary school enrolment ratio	Dept of Education	Household and commercial waste arisings	Environmental Protection Agency, Local Authorities	Number of foreign and indigenous jobs created	Enterprise Ireland, Industrial Development Authority, Shannon Development
Secondary school enrolment ratio	Dept of Education	Household and commercial waste disposal	Environmental Protection Agency, Local Authorities	Overseas tourist numbers	Bord Fáilte
Adult literacy rate	Dept of Education VEC Offices	Non-agricultural waste arisings	Environmental Protection Agency, Local Authorities		
Per capita consumption of fossil fuel by motor vehicle transport	EPA, Dept of Transport, Energy and Communications	Non-agricultural waste disposal	Environmental Protection Agency, Local Authorities		
New housing completions	LAs, Central Statistics Office, Building Federation of Ireland	Hazardous waste generation (imports and exports)	Environmental Protection Agency, Local Authorities		

Table 1.7. State indicators (UNCHS, WHO, OECD, Irish EPA).

Social	Potential data sources	Environmental	Potential data sources	Economic	Potential data sources
Head count index of poverty	Central Statistics Office	Changes in land condition	Dept of the Environment and Local Government	House price to income ratio	Central Statistics Office
Ratio of average female wage to male wage	Census, Central Statistics Office	Changes in forest cover	Coillte, The Forestry Service, Coford	Environmentally adjusted NDP, intensity of material use	Dept of the Environment and Local Government
Population density	Census, Central Statistics Office	Number of mildly, moderately, and strongly eutrophic lakes	Environmental Protection Agency, Local Authorities	Number of school children /classroom/ school in primary schools and secondary schools	Dept of Education
Children finishing primary education	Dept of Education	Concentration of faecal coliform in water bodies	Environmental Protection Agency, Local Authorities	Local government/ capita income	Dept of the Environment and Local Government, Local Authorities
Informal undeclared employment	Dept of Social Welfare, Revenue Commissioners	BOD/DO, N and P in water bodies	Environmental Protection Agency/ Local Authorities	% local government income by source from taxes, user charges, transfers from higher levels of government, borrowings and other income	Dept of the Environment and Local Government, Local Authorities
School life expectancy	Dept of Education	Concentration of Pb, Cd, Cr, Cu in water bodies	Environmental Protection Agency, Local Authorities		
Women/100 men in the labour force	Central Statistics Office	Area, volume and distribution of green areas	Dept of the Environment, Environmental Protection Agency		
Life expectancy at birth	Dept of Health, Health Boards	Area of land devoted to waste disposal	Environmental Protection Agency, Local Authorities		
Number of persons/ hospital bed	Dept of Health, Health Boards	Number of pedestrian streets, bus and cycling lanes	Environmental Protection Agency, Local Authorities		
Infant mortality rate	Dept of Health, Health Boards	Number of garden bird species	BirdWatch Ireland		
Number of practising GPs	Dept of Health, Health Boards				
% population covered by health insurance	Dept of Health, Health Boards, Voluntary Health Insurance (VHI), BUPA Ireland				
% of population in urban areas	Census, Central Statistics Office				
% Single-parent families	Dept of Social Welfare				

Table 1.8. Response indicators (UNCHS, WHO, OECD, Irish EPA).

Social	Potential data sources	Environmental	Potential data sources	Economic	Potential data sources
GDP spent on education	Dept of Education, Dept of Finance	Wastewater treatment	Environmental Protection Agency, Local Authorities	Environmental protection expenditure as a % of GDP	Dept of the Environment, Dept of Finance
National health expenditure devoted to local health care	Dept of Finance, Dept of Health, Health Boards	Protected areas as % of total area	Dept of Arts, Heritage, Gaeltacht and the Islands, Dúchas	Amount of new or additional funding for sustainable development	Dept of the Environment and Local Government, Dept of Finance
Total national health expenditure related to GNP	Dept of Finance, Dept of Health, Health Boards	Expenditure on waste collection and treatment	Environmental Protection Agency, Local Authorities	Pollution abatement and control expenditure	Dept of the Environment and Local Government, Dept of Finance, Local Authorities
Infrastructure expenditure/capita	Dept of Finance, Dept of the Environment and Local Government	% population connected to wastewater treatment plants	Environmental Protection Agency, Local Authorities	Per/capita expenditure on roads – 3-year average	National Roads Authority
		Waste recycling and reuse rates	REHAB, Local Authorities,	Expenditure on air pollution abatement	Dept of the Environment and Local Government, Dept of Finance
		Number of IPC and waste licenses issued	Environmental Protection Agency	Expenditure on waste management	Dept of the Environment and Local Government, Dept of Finance
		Investment in heritage	The Heritage Council, Dept of the Environment and Local Government	Expenditure on hazardous waste treatment	Dept of the Environment and Local Government, Dept of Finance
		Controls on litter	Dept of the Environment and Local Government		

It must be stressed that these indicators are sensitive to human settlements in general and that some may not be applicable or relevant to settlement size. The final list of indicators for application in the sustainable settlements project rests on a variety of factors, not least of which is data availability. In relation to the development of a final list of environmental indicators, priority must be given, where applicable, to the seven themes or 'hotspots' identified in the EPA *State of the Environment* report.

1.12 Choosing the settlements

The candidate list of settlements is based on three important criteria: size, functionality and geographical spread. The list (Table 1.10) is selected from Appendices 1, 2 and 3 of the scoping document *Priority Environmental Research to Meet the Immediate Needs of the National Spatial Strategy (2000-LS-4-M1)*, and was both modified and ratified at the assessment meeting in St Martin's House, Dublin (26th April, 2001).

Table 1.9. European Environment Agency (EEA) indicators.

Indicators of urban patterns	Potential data sources	Indicators of urban flows	Potential data sources	Indicators of urban env. quality	Potential data sources
Population	Census, Central Statistics Office	Water consumption/ inhabitant in litres/day	Environmental Protection Agency, Local Authorities	O_2 concentration of urban surface water in mg/litre	Environmental Protection Agency
Population density	Census, Central Statistics Office	% of groundwater resources in total water supply	Environmental Protection Agency, Local Authorities	Quality of air annual mean concentrations (SO_x, NO_x, PM10s)	Environmental Protection Agency
Total area (km^2) and total built-up area (km^2), by land use	Dept of Arts Heritage and the Gaeltacht, Dúchas, Ordnance Survey	% of dwellings connected to a sewerage system	Environmental Protection Agency, Local Authorities	Exposure to noise above 65 dB and above 75 dB	Environmental Protection Agency
Total area and total green area (km^2)	Dept of Arts Heritage and the Gaeltacht, Dúchas, Ordnance Survey	Number and capacity of water treatment plants by type of treatment	Environmental Protection Agency, Local Authorities	Number of people killed and injured in traffic accidents/ 10,000 inhabitants	National Roads Authority
Transportation network: motorway length (km), railway length (km) and % of total urban area (km^2)	National Roads Authority, Central Statistics Office, Dept of Transport, Energy and Communications	Electricity consumption in GWh/year	Electricity Supply Board	% of people within 15 minutes walking distance of urban green areas	National Roads Authority, CSO, Dept of Transport, Energy and Communications
Derelict areas – km^2 and as a % of total urban area	Local Authorities, Dept of the Environment	Energy use by fuel type and sector	Dept of Public Enterprise		
Urban renewal areas – km^2 and as a % of total urban area	Dept of the Environment, OS maps	Number and type of power and heating plants in the settlement	Electricity Supply Board		
Urban mobility – no. and length of trips and average length of trips in km/ inhabitant/mode of transportation/day	National Roads Authority, Central Statistics Office, Dept of Transport, Energy and Communications	Amount of solid waste collected in t/inhabitant/year	Environmental Protection Agency, Local Authorities		
Commuting patterns – number of commuters into and out of settlement and as a % of the urban population	National Roads Authority, Central Statistics Office, Dept of Transport, Energy and Communications	Composition of waste	Environmental Protection Agency, Local Authorities		
Traffic volumes – total and inflow/ outflow in vehicle km	National Roads Authority, Central Statistics Office, Dept of Transport, Energy and Communications	% of waste recycled	REHAB, Environmental Protection Agency, Local Authorities		
Number of vehicles on main routes	National Roads Authority, Central Statistics Office, Dept of Transport, Energy and Communications	Number of incinerators and volume of waste incinerated	Environmental Protection Agency		
Trends in journey times/ patterns	National Roads Authority, Central Statistics Office, Dept of Transport, Energy and Communications	Number of landfills and volume received by waste type	Environmental Protection Agency, Local Authorities		

Table 1.10. Candidate set of selected settlements (prior to meeting 26th April 2001).

Functionality	Towns with population over 10,000 in 1996	Towns with population less than 10,000 in 1996	Villages with population less than 1500 in 1996
Dormitory	Portlaoise		Pallasgreen
Tourism	Killarney	Westport	Freshford
Industry	Waterford		
Agriculture/Business	Athlone	Roscrea	Shinrone
Coastal	Sligo		
Gateway	Limerick		

1.13 Implications for the methodology

The following implications for the development of indicators are drawn from the above review.

- Settlements are selected on the basis of a balanced representation of the urban/rural hierarchy and on the availability of data at the local/urban level.
- The selected settlements are classified by size, functionality and geographical spread.
- Environmental and socio–economic pressure indicators will be developed for each.
- Environmental and socio–economic state indicators will be developed for each.
- Environmental and socio–economic response indicators will be developed for each.
- A comparative review of settlements by environmental and socio–economic indicators will be undertaken.
- A further qualitative analysis will follow, using available data to draw conclusions on the relative place of the settlement's environmental profile in relation to its urban hierarchy position.
- The results will subsequently be compared with any available 'response' indicators of environmental actions, policies and management systems.

1.14 Conclusions

In conclusion, the report highlights the growing problems facing settlement planning today. The world's landscapes are facing increasing pressure to provide an adequate quality of life for an ever-increasing human population. One of the chief objectives of the NSS is to identify and recommend apt spatial policies at a strategic level which, if implemented, will enhance the prospects for a sustainable environment across Ireland as a whole. Section 2, *Indicators and Empirical Analysis*, aims to begin to address some of these issues.

Section 2 Indicators and Empirical Analysis

2.1 Introduction

The focus of this section is data gathering and analysis. This task consists of the selection and application of sustainability indicators to settlements of different size, functionality and geographical location (Fig. 2.1). Eight of the 11 settlements are selected from Appendix 3 of the EPA project scoping document. The remaining three settlements form the basis of a qualitative assessment of towns with a population of less than 1500, for which few empirical data are available.

The indicators that exhibit sensitivity to settlement size are identified herein and a basis for long-term work to improve our understanding of the relationship between settlement patterns and environmental quality in Ireland is provided.

One of the main findings of this report is that the relationship between sustainability and settlement size is very complex, embracing not just the physical size of a settlement but also functional characteristics and spatial organisation.

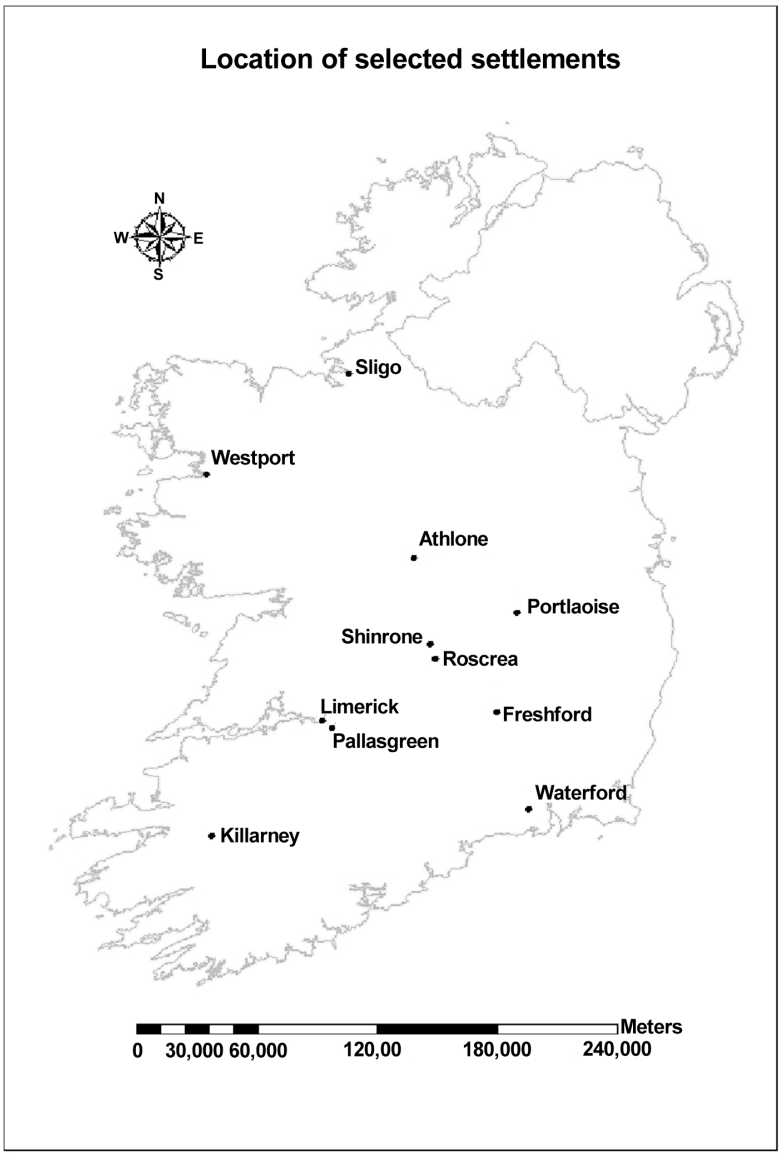

Fig 2.1. Geographical location of selected settlements.

As identified in Section 1 (Literature Review), a settlement is not just the buildings within an urban area but also its travel hinterland, social identity, economic arena and physical hinterland. The absence of an agreed definition of 'settlement size' creates several problems. Consequently, a major implication of this report is the need for further research to tackle issues related to lack of available and accessible data, the uncertain definition of boundaries and the need for a truly representative sample of settlements to allow scientifically based conclusions.

The report highlights, in matrix format, gaps in the information base and areas where in-depth research and data generation are needed. This deficit means that proximate data are used in certain cases and the indicators selected are less than optimally informative. A contributory cause of quantifiable unrepresentativeness in research findings is the absence of a statistically representative sampling frame. More secure conclusions in relation to sustainable settlement size require, as a minimum, that several settlements from each category identified in the scoping document be examined.

An analysis of these indicators is provided so as to identify the overall relationship between settlement size and sustainability. This analysis is taken further in Section 3, in which theoretical approaches, sometimes using proximate data, are used to further elucidate the relationship between settlement size and sustainability.

2.2 Sustainable settlement size

The causes of unsustainability are complex and may be social (including cultural, political, institutional and moral considerations), economic or ecological in nature, or a mixture of these (AFRC-SERC Clean Technology Unit, 1993). This complexity is mirrored in the multitude of works currently seeking to exploit indicators as tools to inform decision-making. The most established work on indicator development is in the economic sphere (for example, GDP); however, efforts to establish environmental and social indicators have also become prolific in the last decade. With the promotion of sustainable development high on policy agendas, efforts to integrate these alternative dimensions have intensified. Sustainable development is typically categorised by the social, environmental and economic triangle (Fig. 2.2) (Ravetz, 2000, Rothman and de Bruyn, 1998). In relation to this model, it can be argued that progress towards sustainability is characterised by a gradual convergence of the three circles, indicating a holistic and co-ordinated approach that fully integrates economy, environment, society and

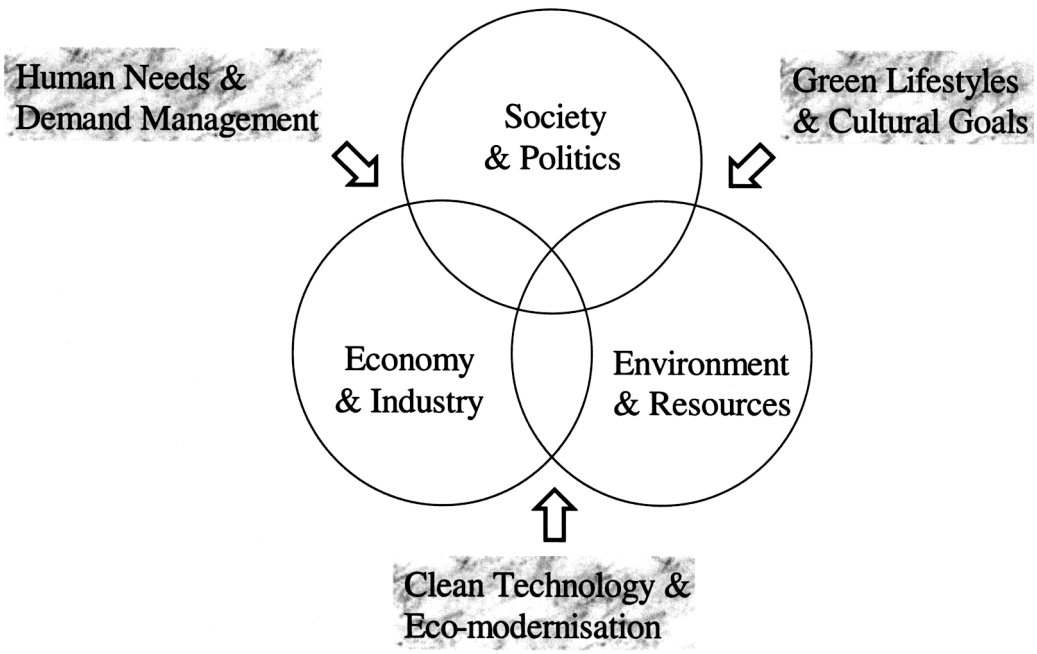

Figure 2.2. Environment–economy–society (Ravetz, 2000). Overlapping discourses in sustainable development.

governance (Dooris, 1999). Each of these categories influences the others. Environmental protection is essential for human life, economic development is needed for environmental protection, social progress is needed for a stable economy and local governance oversees and manages these processes.

Settlements are, by nature, intensive hubs of activity, taking resources and producing goods and services for elsewhere. However, sustainability in this context has a distinctive meaning. At a seminar in California in 1991, the following definition (Dominski *et al*., 1992) was adopted:

Sustainability may be defined as a dynamic balance among three mutually interdependent elements: (1) protection and enhancement of natural ecosystems and resources; (2) economic productivity; and (3) provision of social infrastructure such as jobs, housing, education, medical care and cultural opportunities.

The specific focus of this project is on the relationship between settlement size and sustainability. However, it has been established from the literature review that it is 'efficient size' that is the key. Settlement sustainability is not just influenced by size but also by functional characteristics and spatial organisation within the urban system (Capello and Camagni, 2000). The concept of 'settlement' will, therefore, be addressed as not only the buildings within an urban area, but also the travel hinterland, social identity, economic arena and physical hinterland. Within the indicator framework, settlements need to be viewed as 'dynamic and complex entities resident in a wider ecosystem'.

The importance of social and economic factors introduces more complexity into the choice of, and framework for, sustainability indicators for settlements. Environmental issues are not the sole consideration in terms of either sustainability or sustainable settlement size. Other components such as transport, housing, education and quality of life are equally important. Consequently, the sustainability indicators selected herein must reflect the multi-dimensional nature of the paradigm, taking into account not only environmental and conservation issues but also the interdependent and complex relationship with socio–economic parameters.

It is useful at this stage to examine the theory underpinning the indicator framework employed in this report.

2.2.1 Theoretical framework for indicators

The aim of this report is to establish a framework of sustainability indicators that can be used to assess the environmental performance of selected settlements in Ireland. There would appear to be two main issues that stand out from the rest: (1) preserving the 'green' image of Ireland (considered crucial for tourism and the food industry), and (2) the detrimental impact of the primate city, Dublin, on the sustainability of other smaller settlements in the country. These examples would suggest that the most useful approach to be taken for the study would be one geared towards ecological modernisation, which is founded on the principal that the attainment of high environmental standards is a precondition for sustainable long-term improvements in material well-being (Hajer, 1995).

The main focus for indicators in this report is the description of settlement size and its relationship with the goals of sustainability, with indicator selection conforming to the following criteria:

1. Scientific soundness,
2. Applicable to the urban area,
3. Use of readily available data,
4. Enable comparison between settlements in Ireland, and
5. Resonate with Irish environmental and social concerns relating to urban areas, wider sustainable development objectives, and 'other' indicator sets (where possible).

2.2.2 Indicators as information tools

The fact that sustainable development objectives are extremely broad and sometimes difficult to quantify[1] ensures that national governments are increasingly aware of the need to develop specific measures of progress and methods of monitoring. Taking the UK as an example,

1. Some issues are important but are not readily quantified. These include, for example, measures of the aesthetic qualities of landscapes and buildings, and the amenity value of the countryside.

the national strategy provides a set of approximately 150 indicators, including 15 headline indicators. The UK Government has also set targets for a number of indicators (DETR, 2000). The UK indicators report suggested that indicators should ideally have a target or guideline level to monitor movement towards or away from sustainability reference values. Salient recommendations from the UK Round Table on Sustainable Development (1998) include the following:

1. Indicators of sustainable development should if possible have targets attached,

2. Indicators in the state category should have alert zones attached, and

3. They should seek to engage the public.

The consultation process also identified the need for a larger number of more detailed indicators for use as policy and management tools, and for a much smaller set, which encapsulate the main issues, so that an overall picture of performance can be gleaned. Indicators used on different levels of decision-making will obviously need different levels of detail. Therefore, a hierarchy of indicators seems most appropriate, with the highest level of 'headline indicators' (as developed by the UK, Sweden and Germany) particularly useful for communication purposes, with more detailed data used by administration and experts (Spangenberg, 2000).

2.2.3 Other indicator initiatives

It is useful to take account of other indicator work, both to inform the indicator framework and to avoid potential pitfalls. In addition to the multitude of indicators that are currently available, there are also a variety of approaches that have been utilised to form 'families' of indicators (indices). These can differ in a variety of ways. Initiatives can be community-driven (bottom–up) or more strategic and linked to government initiatives (top–down), sectoral or issue led, alternatively linked to environmental, economic, or social agendas, geared towards urban or general sustainable development, and focused (place/issue specific) or generalised (for international comparison). These choices need to be acknowledged when selecting indicators, and when constructing the overall framework.

2.2.4 Addressing the sustainable development agenda

The shift in focus from a combative economic versus environmental agenda, to approaches that seek to balance the three essential elements of sustainability is highlighted by the changing stance of the UK Government (Custance and Hillier, 1998). Previously, the Conservative Government strategy focused on balancing economic development and environmental protection. However, the new Labour Government has placed emphasis on the third dimension of sustainable development, that of achieving social progress that recognises the needs of all people. The revised set of national indicators reflects this wider perspective, and includes indicators covering economic, environmental and social dimensions. The framework for the UK indicators set out 21 'families' of issues that were considered to be important, and for each issue the key objectives were identified, and indicators appropriated. Underlying the consideration of each family of issues is the 'Pressure–State–Response' model developed by the OECD, for environmental indicators. However, for indicators of sustainable development, this model is not felt to be entirely appropriate for describing the interactions, as it does not pick up on the benefits that economic growth can bring, for example, income, employment and goods and services that people need and that also improve their welfare.

Two alternative indicator systems are worthy of mention in this regard. As discussed previously, the UN Committee on Sustainable Development adapted the environmental PSR model to the needs of sustainable development by replacing the concept of pressures with the concept of 'driving force indicators' (Jackson and Roberts, 2000), reflecting those human activities that impact on sustainable development, either in a harmful or beneficial way. Additionally, the American SDI framework has selected indicators that are based on economic, environmental and social subcategories, and are either organised according to issue, or SDI framework categories of long-term endowments and liabilities, processes and current results (http://www.sdi.gov/).

2.2.5 Establishing an indicator framework

In broad terms, the aim of ensuring a city's 'sustainability' is to strike a balance between ensuring access to the functions of high-level urban services (the city effect) and limiting the problem of urban overload (Archibugi, 1997). Capello and Camagni (2000) suggest that the city effect increases until reaching an urban size of around 360,000, whereas the urban overload pivotal value is estimated to be around 55,000. Both city effect and urban overload are said to be influenced by the presence of high-level functions and the level of network integration.

It is also useful to acknowledge some of the findings from the Habitat Agenda (UN, 1996). Some pertinent statements include the following.

1. Sustainable development will depend very largely on the capacity of urban and metropolitan areas to manage the production and consumption patterns and the transport and waste disposal systems needed to preserve the environment (pt 101).

2. Green spaces and vegetation cover in urban and peri-urban areas are essential for biological and hydrological balance and economic development (pt 112).

3. Unsustainable and wasteful production and consumption patterns lead to increasing problems in waste management. It is essential to intensify efforts aimed at minimising the production and discharge of waste, and at recycling and reuse as much as possible, and disposing of the remainder in an environmentally sound manner. This will require changes in attitudes and consumption patterns and in the design of buildings and neighbourhoods, as well as innovative, efficient and sustainable modalities for waste management (pt 133).

4. Managing transport in human settlements should be done in a way that promotes good access for all places of work, social interaction and leisure, and facilitates important economic activities, including obtaining food and other necessities of life. This should be done while reducing the negative effects of transport on the environment (pt 149).

From the collated information, it is possible to begin to develop a framework for the family of sustainable settlement indicators that will be useful for this project. At this stage, it is desirable to break down the different facets that need to be addressed.

2.2.5.1 Functionality

Grading settlements according to population and functional characteristics can act as a form of 'base' variable. Population is important with respect to producing sufficient critical mass for the benefits of the 'city effect' (as discussed previously, and in greater detail in Capello and Camagni (2000) and in Archibugi (1997)). Functionality can have international, national and sub-national connotations, though for this project the size of settlements is likely to be much more influenced by the regional or national scale.

The upgrading of functions within a city can be extremely important in enhancing both image and services. Linkages outside the city are particularly important in this regard, e.g. networking and advanced transport and telecommunications infrastructure. It is evident that technology also has a role to play here. From the work of Capello and Camagni (2000), it is suggested that the extent of tertiary functions is an important factor. They suggested that there is a minimum threshold of high-order tertiary functions that has to be achieved before increasing returns to urban scale manifest themselves (49%).

2.2.5.2 Form

Urban form is a major strategic factor determining sustainability, i.e. the shape, size and density of settlement pattern (spatial organisation). This will involve aspects such as monocentric versus polycentric patterns, travel to work distances and modes of travel. For example, the European emphasis on high-density housing means that urban green spaces are increasingly under pressure. Work on local-level ecological performance indicators may also be of benefit to the project (Whitford *et al.*, undated). Their approach quantifies the effects of urbanisation on surface temperature, hydrology, carbon storage and sequestration and biodiversity.

2.2.5.3 The issue of spatial scale

These issues bring into focus the importance of including the influence of spatial scale within this analysis. Firstly, impacts may either be local or much wider in scope. The

argument against the compact city format is that although it may be desirable on global environmental grounds, it may not perform so well in terms of the 'social' dimension, or in terms of local environmental objectives. Additionally, action may need to be implemented at different spatial scales (national, regional or borough) and it may be useful to link indicators with the relevant actors and spatial scales for action. These trade-offs need to be made explicit.

2.2.5.4 Flows

Urban settlements are not closed systems. It is, therefore, necessary to take into account resources that are both brought within (resource use), and excreted from (waste) the settlements. The hinterland is the area needed to service a settlement and is now commonly measured by way of an ecological footprint (though there is likely to be insufficient detail at the local scale to construct a valid footprint).

Indicators will need to focus on the whole production and consumption life cycles of the settlements under scrutiny (including material, energy and water), with an understanding that all inputs to a settlement will at some point become waste material.

2.2.5.5 Indicator framework

It is evident from the literature review that the format of choice would appear to be of the DPSIR (Driving Force–Pressure–State–Impact–Response) typology (Fig. 2.3). To some extent, this will loosely match metabolism models applicable to urban settlements. Due to the complexity involved, and the need to address all of the above variables, it would appear that the best structure or layout for the indicators would be to utilise a combination of hierarchical layout (economic, environmental and social) and a matrix structure to establish all the relevant links.

It is appropriate at this stage to consider the environmental and socio–economic issues in Ireland from which the sustainability indicators evolved (Section 2.2). This sets the scene for the development and application of the indicators selected to evaluate 11 Irish settlements of varying size, function and geographical location.

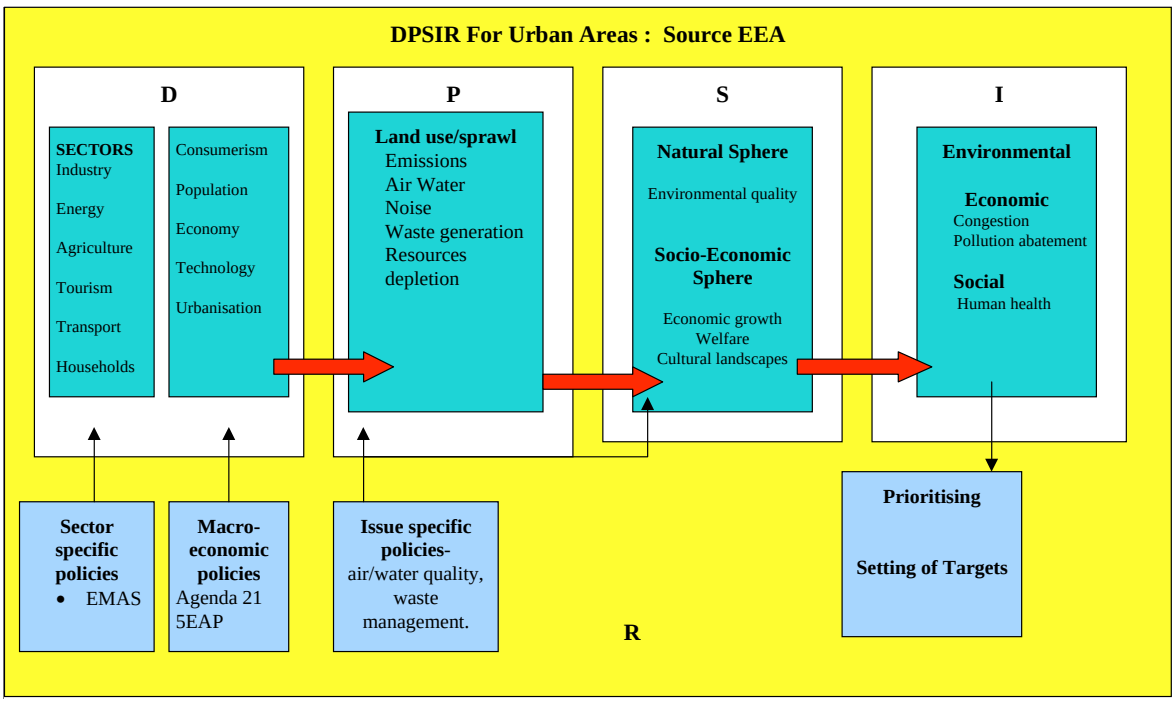

Figure 2.3. Driving Force–Pressure–State–Impact–Response (DPSIR) framework.

2.3 The Irish context

The National Development Plan 2000–2006 is the primary political and institutional expression of Ireland's proposed response to the extraordinary rate of growth of the economy over the last decade. The changing balance of people, land and urban form is under continuous pressure from development, not just the development of buildings, but also the dynamics of demand for space and amenity (Ravetz, 2000). Ireland's urban fabric and built environment are major factors in continued economic development. Although many recent policy initiatives, such as the Local Government Planning and Development Bill (DoELG 2000), have focused on improving the socio–economic conditions of built-up areas, many environmental problems are still intensifying, such as waste management, air and water pollution, traffic congestion, degradation of urban landscape and loss of open space.

A range of key environmental concerns identified in *Ireland's Millennium Report* (EPA, 2000), in addition to fundamental socio–economic concerns, are examined in Section 1, Literature Review.

2.4 Indicators and information sources

This report describes the indicator framework that informs the selection of a comprehensive set of indicators for the Irish Sustainable Settlements project. The framework is a combination of hierarchy and matrix format. Initial classification is in the form of a three-level hierarchy tree.

2.4.1 Framework hierarchy

Level 1: domains
Functional, environmental, social, economic, and governance

Level 2: issues/sectoral
Due to the complexity and inter-connectivity of the many sustainable development issues, some of the areas will inevitably overlap between different domains. Where this is the case, the most obvious categorisation is selected.

Functional
The functional data act as a baseline and will involve issues such as:

1. Demographics
2. Income distribution
3. City size
4. Households
5. Transport infrastructure
6. Networking capability.

The remaining data are placed within a hierarchical structure according to three levels (domains, issues/sectoral categories, and indicators).

Environmental
The issues have been selected to mirror the EU 5th Environmental Action Programme and to cover the issues of most concern to settlements in Ireland (therefore omits ozone layer, dispersion of toxins, marine environment and coastal zones):

1. Rate of growth across strategic sectors
2. Increasing environmental pollution
3. Wastewater treatment
4. Area of tourism
5. Substances entering inland waters (nutrients)
6. Waste disposal.

Therefore, the main issues for the Ireland project are:

1. Air pollution
2. Climate change
3. Water quality
4. Resource use
5. Waste
6. Urban quality
7. Biodiversity.

This classification covers the main environmental issues as cited in *Ireland's Environment – A Millennium Report* (EPA, 2000). There is also added value in classifying the environmental indicators according to sectoral categories:

1. Energy
2. Transport
3. Industry
4. Households

5. Waste
6. Tourism.

Social
Social indicators are categorised according to:

1. Education
2. Health
3. Individual
4. Social cohesion.

Economic
A typical breakdown for economic indicators is:

1. Economic performance
2. Infrastructure
3. Poverty.

However, for the purposes of this report infrastructure will be addressed within the functional domain, with poverty under a social classification. Therefore, indicators will be based on general economic performance.

Governance
Typical breakdown for governance indicators is:

1. Democracy
2. Environmental protection programmes
3. Sustainable development spending.

Level 3: selected indicators
This section attempts to place the indicators that have been selected within the above framework and group them according to a DPSIR format. This enables an initial evaluation of the comprehensiveness of the data set, and provides an assessment of where gaps in information exist.

Environmental
Driving force
1. Mode of journey to work (data tables and sensitivity)
2. Accessibility by public transport (data tables and sensitivity)
3. Number of vehicles registered (data tables and sensitivity)
4. Traffic growth (sensitivity only)
5. Number of passengers/car (sensitivity only)
6. Municipal waste/capita (sensitivity only)

State
1. Changes in forest cover (data tables and sensitivity)
2. BOD (N & P) in water bodies (data tables and sensitivity)
3. Pb, Cd, Cr, Cu, in water bodies (data tables and sensitivity)
4. Birds (indicators of biodiversity) (data tables and sensitivity)

Response
1. Wastewater treatment (data tables and sensitivity)
2. Protected area as % of total area (data tables and sensitivity)
3. Percent population connected to wastewater treatment plants (data tables only)
4. Waste recycling and re-use rates (data tables and sensitivity)
5. Number of Integrated Pollution Control (IPC) and waste licenses issued (data tables and sensitivity)

Social
Driving force
1. Unemployment rate (county and city level only) (data tables only)
2. Rate of change of school age population (data tables only)
3. Road fatalities (sensitivity only)

State
1. Children finishing primary school (data tables only)
2. Number of persons/hospital bed (data tables only)
3. Number of practising GPs (data tables and sensitivity)

Response
1. Infrastructure (roads) (to be included in functional domain)
2. Accessibility by public transport (data tables and sensitivity)
3. Lotto payment to tourism (sensitivity only)

Economic
Driving force
1. Number of foreign jobs created (data tables only)
2. Overseas tourists (use of B&Bs as proxy) (data tables

and sensitivity)

3. Jobs gained/lost (sensitivity only – to be included as impact)

State

1. House price to income ratio (data tables and sensitivity – to be included as driving force)
2. Number of primary school children (data tables only – to be included as driving force, social)
3. Distance travelled to work <2 miles (sensitivity only)
4. Stock of jobs (sensitivity only – to be included as impact)
5. Occupations (sensitivity only – to be included as impact)

Response

1. Per-capita expenditure on roads (sensitivity only)
2. Road improvement needs (sensitivity only)

The presentation of the indicators (Tables 2.1–2.12) is structured around a framework based on the concept of causality, and known as the DPSIR framework (illustrated in Fig. 2.3). While it is accepted that the real world is generally more complex than can be expressed by the DPSIR framework, it is however a useful conceptual system (EPA, 1999a). Data sources identified, and the status of data available to the research team, are indicated in these tables.

Table 2.1. Driving force/pressure indicators (social).

Indicator	Data sources	Data status
Unemployment rate	Census, Fás, Dept of Social Welfare	County data only
Population growth rate	Census, CSO	National figures only
Net migration rate	CSO	National figures only
Total fertility rate	Health Boards, Dept of Health	National figures only
Rate of change of school age population	Statistics Section, Dept of Education	Data available for all but smallest settlements
Primary school enrolment rate	Statistics Section, Dept of Education	National data only
Secondary school enrolment rate	Statistics Section, Dept of Education	County data only
Adult illiteracy rate	Dept of Education, VEC Offices	National data only
New housing completions	LAs, CSO, Building Federation of Ireland, building firms	County data only

Table 2.2. Driving force/pressure indicators (environmental).

Indicator	Data sources	Data status
Annual withdrawals of ground and surface water	EPA, GSI	No data at settlement scale
Emissions of hydrocarbons	EPA, LAs	No data at settlement scale
Domestic consumption of water/capita	EPA, LAs, reports	No data at settlement scale
Release of nitrogen and phosphorus to coastal waters	EPA	Data available for larger water bodies, not per settlement
Release of nitrogen and phosphorus to rivers and lakes	EPA	Data available for larger water bodies, not per settlement
Household and commercial waste arisings	EPA, LAs	Data at LA level only
Household and commercial waste disposal	EPA, LAs	Data at LA level only
Non-agricultural waste disposal	EPA, LAs	Data at LA level only
Hazardous waste generation (imports and exports)	EPA, LAs	Data at LA level only
Population density	OS, Census	Data available
Accessibility by public transport	Timetables	Data available

Table 2.3. Driving force/pressure indicators (economic).

Indicator	Data sources	Data status
GDP/capita	Dept of Finance, CSO	National data only
Sum of exports and imports as % of GDP	Dept of Finance, CSO	National data only
Energy demand and economic growth	Dept of Public Enterprise, CSO, EPA, ESB	Data held by ESB but not released: commercial sensitivity
Annual energy consumption	Depts of Public Enterprise, Transport Energy and Communications, CSO, EPA, ESB	Data held by ESB but not released: commercial sensitivity
Total ODA given/received as % of GNP	Depts of Finance and Foreign Affairs	Not applicable
Number of foreign and indigenous jobs created	Enterprise Ireland, Industrial Development Authority, Shannon Development	Data available
Overseas tourist numbers	Bord Fáilte	Proxy: data available on numbers of guesthouses, hotels, B&Bs

Table 2.4. State indicators (social).

Indicator	Data sources	Data status
Head count index of poverty	CSO	National data only
Ratio of average female:male wage	Census, CSO	County data only
Children finishing primary school	Dept of Education	Data available
Informal undeclared employment	Dept of Social Welfare, Revenue Commissioners	No data
School life expectancy	Dept of Education	Data at county level only
Women/100 men in labour force	CSO	County data only
Life expectancy at birth	Dept of Health, Health Boards	County data only
Number of persons/hospital bed	Dept of Health, Health Boards	Data available
Infant mortality rate	Dept of Health, Health Boards	Data at national level only
Number of practising GPs	Dept of Health, Health Boards, Golden Pages	Data available
% population covered by health insurance	Dept of Health, Health Boards, VHI and BUPA Ireland	Data not released: commercial sensitivity
% population in urban areas	Census, CSO	Not applicable
% single parent families	Dept of Social Welfare	County data only

Table 2.5. State indicators (environmental).

Indicator	Data sources	Data status
Changes in land condition	Dept of Environment and Local Govt, OSI	Cost of data too high
Changes in forest cover	Coillte, Coford	Data available
Number of mildly, moderately and strongly eutrophic lakes	EPA, LAs	Data available for larger lakes
Concentration of faecal coliforms in water bodies	EPA, LAs	No data at settlement level
Area, volume and distribution of green areas	LAs	Not applicable
Area of land devoted to waste disposal	EPA, LAs	County data only
Number of pedestrian streets, bus and cycling lanes	EPA, LAs	Not applicable
Birds as indicators of biodiversity	BirdWatch Ireland	Data available

Table 2.6. State indicators (economic).

Indicator	Data sources	Data status
Environmentally adjusted NDP intensity of material use	Dept of Environment and Local Govt	National/pilot basis only
Number of school children/classroom/ school in primary and post-primary schools	Dept of Education	Data available for primary level only
Local government/capita income	Dept of Environment and Local Govt, LAs	National data only
% local government income by sources from taxes, user charges, transfers from higher levels of government, borrowings and other incomes	Dept of Environment and Local Govt, LAs	National data only

Table 2.7. Impact indicators (social).

Indicator	Data sources	Data status
Trends in journey time	Dept of Environment and Local Govt	National data only
Number of persons killed or injured in road accidents	National Roads Authority	Data available

Table 2.8. Impact indicators (environmental).

Indicator	Data sources	Data status
Biological and chemical status of river and lake water quality	EPA, LAs	Data available but for 1998 only
Biological and chemical status of drinking water quality	EPA, LAs	County data only
Means of travel to work	Census	Data available

Table 2.9. Impact indicators (economic).

Indicator	Data sources	Data status
Average house prices	CSO, auctioneers	Data available from auctioneers
Level of inflation	CSO	Not applicable
Tax rates	Dept of Finance	Not applicable

Table 2.10. Response indicators (social).

Indicator	Data sources	Data status
GDP spent on education	Depts of Education, Finance	National data only
National health expenditure devoted to local health care	Depts of Finance and Health, Health Boards	Regional data only
Total national health expenditure related to GNP	Depts of Finance and Health, Health Boards	National data only
Infrastructure expenditure/capita	Depts of Finance, Environment and Local Government, NDP policy	Data available on NDP expenditure on roads

Table 2.11. Response indicators (environmental).

Indicator	Data sources	Data status
Wastewater treatment	EPA, LAs	Data available for larger settlements
Protected area as % of total area	Dept of Art, Heritage, Gaeltacht and the Islands, Dúchas	Data available
Expenditure on waste collection and treatment	EPA, LAs	Limited data available from Mr Binman
% population connected to wastewater treatment plants	EPA, LAs	Data available
Waste recycling and re-use rates	REHAB, LAs	Data available
Number of IPC and waste licences issued	EPA	Data available
Investment in heritage	The Heritage Council, Dept of Environment and Local Government	National data only
Controls on litter	Dept of Environment and Local Government	National data only

Table 2.12. Response indicators (economic).

Indicator	Data sources	Data status
Environmental protection expenditure as % of GDP	Depts of Environment and Local Government, Finance	No data available
Amount of new or additional funding for sustainable development	Depts of Environment and Local Government, Finance	No data available
Pollution abatement and control expenditure	Depts of Environment and Local Government, Finance, LAs	No data available
Per capita expenditure on roads	National Roads Authority	Data available, no trends over time
Expenditure on air pollution abatement	Depts of Environment and Local Government, Finance	No data available
Expenditure on waste management	Depts of Environment and Local Government, Finance	National data only
Expenditure on hazardous waste treatment	Depts of Environment and Local Government, Finance	No data available

2.4.2 Sectoral classification

A hybrid framework is constructed to improve the effectiveness of the indicator set. Changes to the traditional structure include the movement of biodiversity within the urban quality category, the combination of resource use and waste to form an urban metabolism section, and the merging of air pollution with the sectoral classification of transport. Suggested indicators (drawn from many international indicator initiatives, in particular the UK Regional Sustainable Development Framework) have been added to the proposed framework to enhance the coverage of the indicator set. The comprehensive nature of this new set is also highlighted through a sectoral analysis (Tables 2.13–2.15).

2.4.2.1 Sectoral analysis

Energy

1. Energy use
2. Renewable energy share
3. Presence of CHP
4. Fossil fuel consumption
5. Energy initiatives

Table 2.13. Sectoral classification of environmental issues.

Environmental issues	Driving force/pressure	State	Impact	Response
Air pollution and transport	Mode of journey to work Accessibility by public transport Number of vehicles registered Traffic growth Number of passengers/ car Built-up area/density	Air quality index	Respiratory illness	Cycle-ways Numbers of passengers/ car
Climate change	Energy use Renewable energy share Presence of CHP			Energy initiatives Energy efficiency rating of housing
Water quality		BOD (N & P) in water bodies Pb, Cd, Cr, Cu in water bodies	Drinking water quality	Wastewater treatment % population connected to wastewater treatment plants
Urban metabolism (resource use and waste)	Amount of municipal waste produced/capita Water consumption. Fossil fuel consumption Food consumption Amount of municipal waste going to landfill	Eco-efficiency	Industrial waste arisings	Waste recycling and re-use rates Number of IPC and waste licenses issued Waste minimisation actions Litter fines Street cleaning Number of recycle bins
Urban quality	New house completions	Changes in forest cover Birds (biodiversity) Amount of green space Spread of urbanised area	Noise complaints Derelict land	Protected area as % of total area Investment in environmental/ regeneration schemes

Table 2.14. Sectoral classification of social issues.

Social issues	Driving force/pressure	State	Impact	Response
Education	Rate of change of school age population Children finishing primary school	% of 16-year-olds staying on in post-compulsory education % of population of working age with no qualifications		
Health	Number of persons/ hospital bed Number of practising GPs	Access to emergency medical services Sport and leisure facilities		% of children fully immunised
Individual	Road fatalities	Floor area per person		Housing investment
Social cohesion	Unemployment rate Income support beneficiaries	Population size trends	Crime figures	Lotto payments to tourism

Table 2.15. Sectoral classification of economic issues.

Economic issues	Driving force/pressure	State	Impact	Response
Economic performance	Number of foreign and indigenous jobs created Overseas tourist numbers House price/ income ratio Disposable income per household	Distance travelled to work Employment in high-tech industries	Jobs gained/jobs lost Stock of jobs Occupations	Road improvement needs Per-capita expenditure on roads

Transport

1. Mode of journey to work
2. Accessibility by public transport
3. Number of vehicles registered
4. Number of passengers/car
5. Cycle ways

Industry

1. Industrial waste arisings
2. Eco-efficiency
3. Waste minimisation action

Households

1. Percent population connected to wastewater treatment plants
2. Food consumption
3. New houses built
4. Energy efficiency rating of housing

Waste

1. BOD (N & P) in water bodies
2. Pb, Cd, Cr, Cu in water bodies
3. Wastewater treatment
4. Number of IPC and waste licenses issued
5. Litter fines
6. Street cleaning
7. Number of recycle bins
8. Amount of municipal waste produced
9. Amount of municipal waste going to landfill

Tourism

1. Protected area as % of total area
2. B&Bs

Miscellaneous

1. Built-up area/density
2. Water consumption
3. Amount of green space
4. Spread of urbanised area
5. Noise complaints
6. Drinking water quality
7. Investment in environmental/regeneration schemes
8. Derelict land

The final list of sustainability indicators for inclusion in this study is shown in Table 2.16. These include original indicators from Tables 2.1 to 2.12, some modified, and additional new indicators. The final list of indicators presented here is selected on the basis of data availability and accessibility.

2.4.3 Indicators sensitive to sustainable settlement size

Each indicator presented in Table 2.16 was examined and empirically analysed for sensitivity to settlement size. For those indicators not displaying sensitivity, gaps in the information base are examined in Section 2.4.3.1. Only those indicators displaying sensitivity to settlement size are examined here. Of those indicators found to be sensitive to settlement size, the initial analysis of some indicators signals that larger settlements are more sustainable, while others suggest that smaller settlements are more sustainable. The purpose of this section is to evaluate the significance of these indicators in order to arrive at an overall assessment of the relationship between settlement size and sustainability.

Table 2.16. Sensitivity of indicators to settlement size.

Indicator	Sensitivity	
	Yes	No
Driving force/pressure indicators		
Municipal waste/capita (Env)	√	
Number of passengers/Car (Soc)	√	
State indicators		
Goldfinch numbers (Env)	√	
Population density (Env)	√	
Forest cover (Env)	√	
Number of GPs (Soc)	√	
Public transport (Soc) urban bus service settlement connectivity	√	
Impact indicators		
Means of travel (Env)	√	
Distance travelled to work <2 miles (Econ)	√	
Road fatalities/injuries (Soc)	√	
Response indicators		
IPC (Cumulative) (Env)	√	
Recycling (Env)	√	
Driving force/pressure indicators		
Number of vehicles registered (Env)		√
Urban wastewater discharges (Env)		√
N & P loads (Env)		√
Traffic growth (Env)		√
Jobs gained/jobs lost (Econ)		√
State indicators		
River water quality (Env)		√
Conservation areas (Env)		√
Hospital activity (Soc)		√
Number of pupils attending primary schools (Soc)		√
Population size trends (Soc)		√
Stock of jobs (Econ)		√
Occupations (Econ)		√
Impact indicators		
Average house prices (Econ)		√
Response indicators		
B&Bs, guesthouses, hotels (Env)		√
Roads to be upgraded under the NDP (Env)		√
Lotto payment to tourism (Soc)		√
Road improvement needs (Econ)		√

2.4.3.1 Gaps in the information base

The lack of available or accessible data significantly impacted upon the number and quality of indicators. Consequently, a major implication of this report is the identification of the need for further research to tackle issues related to data availability, the uncertain definition of settlement boundaries and the need for a representative sample of settlements to allow more scientifically based quantitative analyses and modelling. As indicated above, Tables 2.1–2.12 examine the status of each indicator and determine whether data were available to settlement level. In addition, the following list highlights gaps in the information base for those indicators not displaying sensitivity to settlement size.

Driving force/pressure

1. Number of vehicles registered (**Environmental**) – data for the number of vehicles registered were obtained from the National Roads Authority. These data exist at county level only and, therefore, provide only an indication of differences among settlements.

2. Urban wastewater discharges (**Environmental**) – data on urban wastewater discharges were obtained from the *Urban Waste Water Discharges in Ireland* reports 1994/1995, 1996/1997 and 1998/1999. There are no data in these reports for Freshford, Shinrone and Pallasgreen.

3. N and P loads (**Environmental**) – data for total N and P discharged to rivers were obtained from the EPA. Total nitrogen was not analysed in 1997–1999. The mean of the ratio of total N (which was analysed in each year) was, therefore, used to produce estimated total N loads for 1997–1999 for each individual river. Data were supplied for the Shannon Estuary and Waterford Harbour catchment areas only and could not, therefore, be used as indicators for the estimation of sustainable settlement size.

4. Traffic growth (**Environmental**) – data on traffic growth on national primary and national secondary routes were obtained from the *National Road Needs Study* report (NRA, 1998). Although it is generally agreed that this indicator ties in with the growth in number of vehicles registered/settlement, the lack of a representative time frame for annual daily traffic renders this indicator unsuitable for use in this study.

5. Jobs gained/jobs lost (**Economic**) – data on job numbers were obtained from Enterprise Ireland and relate to full-time jobs in companies under the remit of Enterprise Ireland, Shannon Development or Udaras na Gaeltachta. Data were available for all settlements (from 1991) with the exception of Freshford and Pallasgreen. Consequently, comparisons across smaller settlements were not possible.

State indicators

1. River water quality (**Environmental**) – the biological quality of river water is assessed by the EPA at some 3200 locations on a 3-year basis. The chemical sampling of the rivers is significantly less extensive, with a total of 2100 monitoring locations. The data were obtained from various contacts within the EPA and also from the EPA website. Chemical data exist for rivers in all settlements. However, these do not cover a representative time frame and are, therefore, unsuitable for application to settlement size.

2. Conservation areas (**Environmental**) – data on conservation areas were supplied by Dúchas in map format. These include National Heritage Areas, Special Protection Areas, Special Areas of Conservation, Nature Reserves and National Parks. However, the small number of settlements examined in this research project renders this indicator unsuitable for measuring sustainable settlement size.

3. Hospital activity (**Social**) – data on hospital activity were obtained from the *Health Statistics* (Department of Health, 1999) report. Only three settlements have hospitals located within their boundaries. Inhabitants of the remainder must travel to other settlements for treatment. Insufficient data and the limited time frame reduce the value of these data as indicators of sustainable settlement size.

4. Number of pupils attending primary schools (**Social**) – data on the number of children attending primary school were obtained from the Department of Education. Addresses of the schools were taken from the Primary School Database. Two schools were selected at random from each town (except Shinrone). The overall totals and totals by standard do not agree for schools that also have special needs pupils. Information was supplied for the school years 1993/1994, 1995/1996, 1997/1998 and 1999/2000. The lack of a representative sampling frame reduces the value of these data as an indicator of sustainable settlement

size.

5. Stock of jobs (**Economic**) – data on the stock of jobs in each settlement were obtained from Enterprise Ireland and relate to full time jobs in companies under the remit of Enterprise Ireland, Shannon Development or Udaras na Gaeltachta. Data were available for all settlements (from 1991) with the exception of Freshford and Pallasgreen. Consequently, comparisons across smaller settlements were not possible. This indicator does not display sensitivity to settlement size for larger settlements.

6. Occupations (**Economic**) – data on the number of persons working in each occupation were obtained from the 1996 Census, but for larger settlements only. Consequently, comparisons across smaller settlements were not possible.

Impact indicators

1. Average house prices (**Economic**) – all house prices were obtained from a range of auctioneers located within each settlement and are based on housing developments sold in each period. No prices were available for Freshford, Shinrone or Pallasgreen. Insufficient data available and the limited time frame reduce the value of these data as an indicator of sustainable settlement size.

Response indicators

1. B&Bs, guesthouses, hotels (**Environmental**) – the number of B&Bs, guesthouses and hotels are used as a proxy for tourist numbers in each settlement between 1990 and 2000. Bord Fáilte was able to provide tourist numbers at county level only from 1997 to 2000. The accommodation data were obtained from *Hotels and Guesthouses Ireland 2001* (Irish Hotels Federation, 2001) and *Bed & Breakfast Ireland 2001* (Town and Country Homes, 2001) and are only representative of the current status (2001) of tourist accommodation in Ireland. It is acknowledged that not all B&Bs, guesthouses or hotels may advertise in these guides and so the data are not fully representative of inter-settlement differences.

2. Lotto payment to tourism (**Social**) – data on lottery expenditure were obtained from the Department of Finance. The 1997 report listed the names of each club in receipt of funding. However, it did not specify the settlements in which the clubs were located. Insufficient data and the limited time frame reduce the value of these data in providing an indicator of sustainable settlement size.

3. Road improvement needs (**Economic**) – data on expenditure on national road improvements were obtained from the *National Road Needs Study* report (NRA, 1998). Insufficient data and the limited time frame reduce the value of these data as an indicator of sustainable settlement size.

2.4.3.2 List of ideal indicators

A list of ideal indicators and the additional data required is presented in Table 2.17.

2.5 Environmental indicators displaying sensitivity to settlement size

2.5.1 Driving force/pressure indicators

2.5.1.1 Municipal waste

Data on municipal waste production were obtained from the *National Waste Database* reports 1995 and 1998 (EPA, 1996, 1999e). The management of municipal solid waste poses a complex and costly problem for society, largely due to rapid urbanisation processes (Mato, 1999). Ireland is experiencing annual growth in the production of all kinds of waste: household, commercial, industrial, agricultural and hazardous waste (Tables 2.18–2.22). The generation of waste is at present an unavoidable consequence of domestic and economic life, but by the late 1980s it was accepted that the quantities of waste produced by developed countries are unsustainable, as is the manner in which these wastes are managed (Boyle, 1987). It is estimated that over 2 million t of municipal waste were generated in Ireland in 1998. Nearly 70% of all solid waste produced in Ireland is either landfilled or disposed of on site by the producer. A total of 11% is recycled. On average, more than 60% of municipal waste and about 70% of hazardous waste was disposed of in landfill sites in member countries of the Organisation for Economic Co-operation and Development (OECD) in 1987 (Stanners and Bordeau, 1995). In virtually all countries, the practice is to landfill this waste *en masse* as collective and undifferentiated waste (Colleran, 1994).

Table 2.17. List of 'Ideal Indicators'.

Ideal Indicator	Additional Data Required
Waste (municipal solid waste, hazardous waste, waste treatment/disposal)	Data on each category of waste collected/settlement/year from local authorities
Water (quality of drinking water, level of wastewater treatment, surface and groundwater quality, % population connected to wastewater treatment plants)	Data on each category of water quality/settlement from local authorities and the EPA. Data from annual field-based studies
Transport (range of public transport services, cycle ways, pedestrianisation, quality and network of roads, travel control measures, travel time and distance to services and work)	*Census Reports* to include data on smaller settlements. Additional data from field studies
Energy (source – renewable energy share, per-capita usage, industrial usage, presence of CHP, energy efficiency rating of housing)	Data on energy supplied from renewable and non-renewable sources. Data on energy use by sector/settlement/year. Additional data from field studies on conservation measures
Renewable and non-renewable resource consumption (food, water, construction materials, etc.)	Data from Dept of Agriculture, Food and Rural Development, Dept of Energy, Bord Bia, Bord na Mona/settlement/year Additional data from field surveys
Air (quality, emissions to air, greenhouse gases)	Data on ambient levels for each type of air pollutant/settlement/ month. Data on greenhouse gas emissions/settlement/month. From local authorities, the EPA and Regional Health Boards. Additional data from field studies
Noise (loudness, type, frequency, duration)	Data on noise complaints from local authorities and additional field-based research
Biodiversity (sensitive species – number and frequency, special protection areas)	Data on indicator species/settlement/year from Dúchas. Additional data from NGOs and field work
Education (access, number of children per teacher, school leaving age, number attending third level)	Dept of Education data reported to settlement level
Income (per-capita income, percentage claiming social welfare assistance, percentage in top and bottom 10% of earners, sources of income)	Dept of Social Welfare data to settlement level
Housing (quality, cost, ownership, number of people per square metre of floor space, rent costs)	*Housing Bulletin* data to settlement level. *Census Reports* to settlement level. Additional field-based data
Employment (type, foreign or indigenous owned business, average working life, average age starting work and retiring)	IDA and Enterprise Ireland data to settlement level/year. *Census Reports* to settlement level. Additional field-based surveys on annual basis
Access to basic services (type and range of services provided)	Chambers of Commerce data/settlement/year. Additional field-based surveys on annual basis
Health (mortality, health services, type and frequency of diseases requiring medical aid)	Data from Regional Health Boards, HIPE Data Unit (ESRI) to settlement level/year Additional field-based surveys on annual basis

Table 2.18. Total waste produced, by Local Authority.

Local Authority	County pop.	Household waste (t/annum)		Commercial (t/annum)		Street cleaning (t/annum)		Total (t/annum)		Total waste/ capita	
		1995	1998	1995	1998	1995	1998	1995	1998	1995	1998
Limerick Corp.	52,039	24,000	26,000	14,000	25,000	7000	2000	45,000	53,000	0.86	1.02
Limerick Co. Co.	11,3003	26,800	29,500	19,000	16,000	600	600	46,400	46,100	0.41	0.41
Waterford Corp.	42,540	16,650	18,280	6747	8800	2360	520	25,757	27,600	0.61	0.65
Sligo Co. Co.	55,821	12,230	17,890	815	5854	715	1745	13,760	25,489	0.25	0.46
Kerry Co. Co.	12,6130	18,911	26,845	14,612	31,784	4134	1702	37,657	60,331	0.30	0.48
Westmeath Co. Co.	63,314	13,094	23,020	3006	3276	300	0	16,400	26,296	0.26	0.42
Mayo Co. Co.	11,1524	10,546	52,356	23,759	10,821	2200	0	36,505	63,177	0.33	0.57
Tipperary (NR) Co. Co.	58,021	17,000	18,403	0	4763	0	818	17,000	24014	0.29	0.41
Laois Co. Co.	52,945	14,000	23,352	2500	6336	500	500	20,000	33,587	0.38	0.63
Kilkenny Co. Co. and Corp.	75,336	17,400	24,559	11,550	5254	200	1744	29,150	31,557	0.39	0.42
Offaly Co. Co.	59,117	12,500	17,510	4200	7513	100	0	16,800	25,023	0.28	0.42

Table 2.19. Total municipal waste/capita.

Settlement (ranked by population size)	Settlement population	Total tonnes waste/settlement		Waste/capita for each settlement	
	1996 Census	1995	1998	1995	1998
Limerick CB	52,039	45,000	53,000	0.864736	1.018466
Waterford CB	42,540	25,757	27,600	0.605477	0.648801
Sligo MB	17,786	4384	8121	0.246486	0.456595
Killarney UD	8809	2630	4214	0.298558	0.478374
Athlone UD	7691	1992	3194	0.259004	0.415290
Westport UD	4253	1392	2409	0.327298	0.566423
Roscrea	4170	1222	1724	0.293045	0.413429
Portlaoise UD	3531	1134	2013	0.321155	0.570093
Freshford	632	245	265	0.387658	0.419303
Shinrone	479	136	203	0.283924	0.423799
Pallasgreen	303	124	124	0.4092409	0.409240

Table 2.20. Total household waste/capita.

Settlement (ranked by population size)	Settlement population	Total tonnes household waste/settlement		Household waste/capita for each settlement	
	1996 Census	1995	1998	1995	1998
Limerick CB	52,039	24,000	26,000	0.461193	0.4996
Waterford CB	42,540	16,650	18,280	0.391396	0.4297
Sligo MB	17,786	3897	5700	0.219105	0.3205
Killarney UD	8809	1321	1875	0.14996	0.2129
Athlone UD	7691	1591	2796	0.206865	0.3635
Westport UD	4253	402	1997	0.094522	0.4696
Roscrea	4170	1222	1323	0.293046	0.3173
Portlaoise UD	3531	934	1557	0.264514	0.441
Freshford	632	146	206	0.231013	0.3259
Shinrone	479	101	142	0.210856	0.2965
Pallasgreen	303	72	79	0.237624	0.2607

Table 2.21. Total commercial waste/capita.

Settlement (ranked by population size)	Settlement population	Total tonnes commercial waste/ settlement		Commercial waste/capita for each settlement	
	1996 Census	1995	1998	1995	1998
Limerick CB	52,039	14,000	25,000	0.2690	0.4804
Waterford CB	42,540	67,47	8800	0.1586	0.2069
Sligo MB	17,786	260	1865	0.0146	0.1049
Killarney UD	8809	1021	2220	0.1159	0.252
Athlone UD	7691	365	398	0.0474	0.0517
Westport UD	4253	906	413	0.2130	0.0971
Roscrea	4170	0	342	0	0.082
Portlaoise UD	3531	167	423	0.0472	0.1198
Freshford	632	97	44	0.1534	0.0696
Shinrone	479	34	61	0.0709	0.1273
Pallasgreen	303	51	43	0.1683	0.1419

Table 2.22. Total street waste/capita.

Settlement (ranked by population size)	Settlement population	Total tonnes street waste/settlement		Street waste/capita for each settlement	
	1996 Census	1995	1998	1995	1998
Limerick CB	52,039	7000	2000	0.135	0.038433
Waterford CB	42,540	2360	520	0.055	0.012224
Sligo MB	17,786	228	556	0.013	0.031261
Killarney UD	8809	289	119	0.033	0.013509
Athlone UD	7691	36	0	0.005	0
Westport UD	4253	84	0	0.02	0
Roscrea	4170	0	59	0	0.014149
Portlaoise UD	3531	33	33	0.009	0.009346
Freshford	632	2	15	0.003	0.023734
Shinrone	479	1	0	0.002	0
Pallasgreen	303	2	2	0.007	0.006601

Figures 2.4 and 2.5 show the total tonnes of municipal waste produced and household waste produced/settlement, respectively. These graphs show linear relationships, with the total tonnes of waste produced increasing with population size. Figures 2.6 and 2.7 show little variation in the total tonnes of commercial and street waste produced/settlement, with the exception of the larger urban centres, Limerick and Waterford. The same applies to Fig. 2.8, where little variation exists in the per-capita production of municipal waste/settlement, with Limerick and Waterford as definite outliers. However, Fig. 2.9 shows that the per-capita production of household waste in 1998 is almost uniform for both the larger and smaller settlements. In 1995, Limerick and Waterford again show a greater per-capita production of household waste than the other settlements. Figures 2.10 and 2.11 show little variation between settlements (except the outlier Limerick) in the per-capita production of commercial and street cleaning waste.

Why this indicator is relevant to sustainable development

Waste arises as a consequence of the use of non-renewable resources and energy generation; the greater the waste production, the less efficient the use of resources. Waste disposal creates many environmental problems. Landfill remains the primary means of waste disposal in Ireland, where in 1998, 91% of municipal waste was landfilled. Landfill sites not only consume space, which is a non-renewable resource, but they also create pollution problems

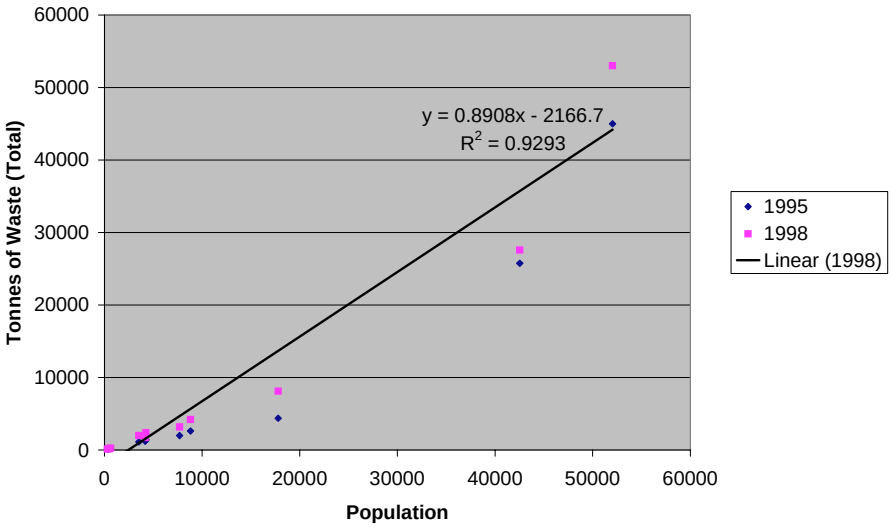

Figure 2.4. Total tonnes of municipal waste produced/settlement.

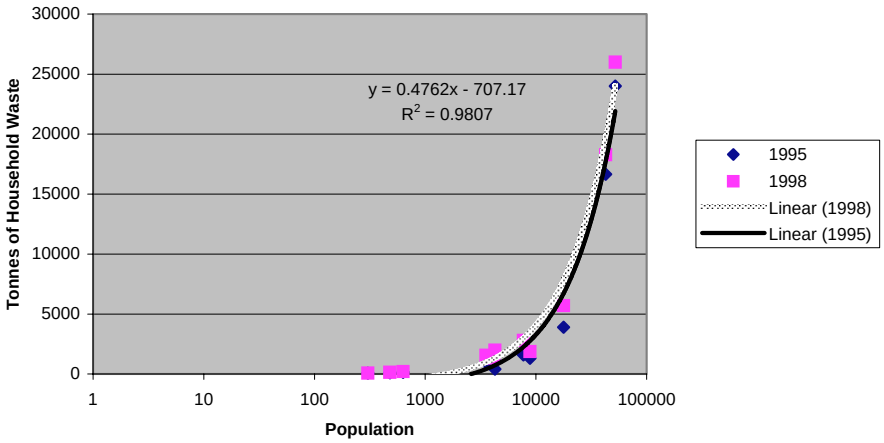

Figure 2.5. Total tonnes of household waste produced/settlement.

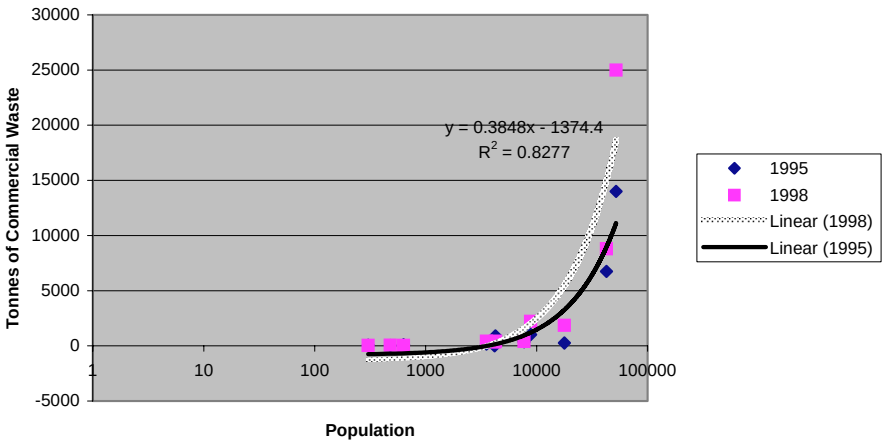

Figure 2.6. Total tonnes of commercial waste produced/settlement.

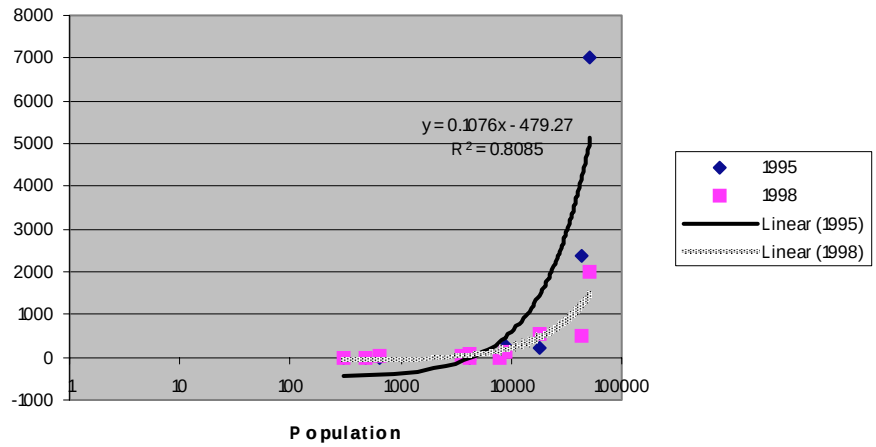

Figure 2.7. Total tonnes of street waste produced/settlement.

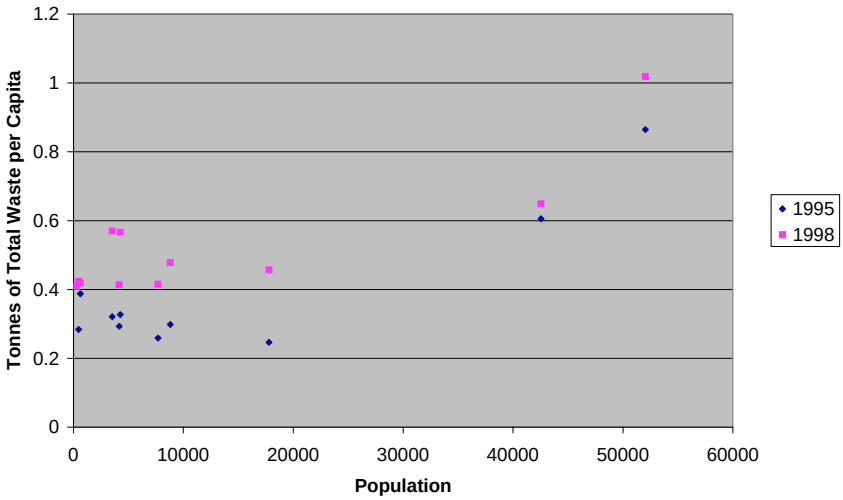

Figure 2.8. Total tonnes of municipal waste/capita.

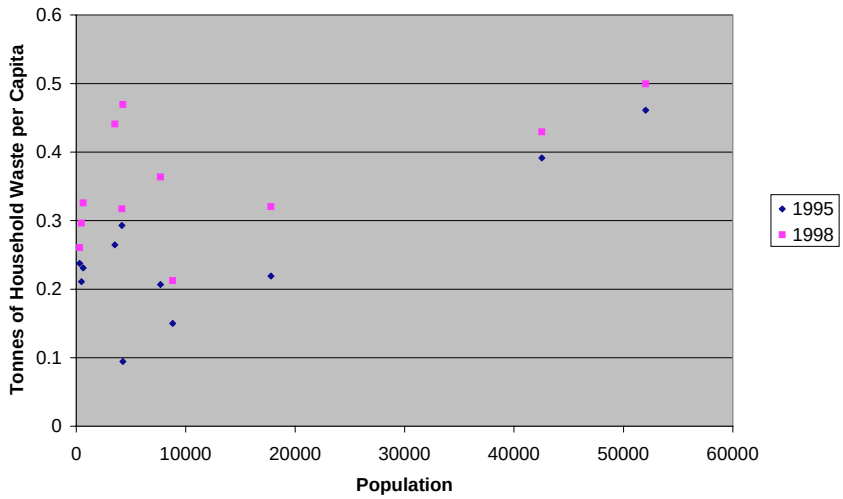

Figure 2.9. Total tonnes of household waste/capita.

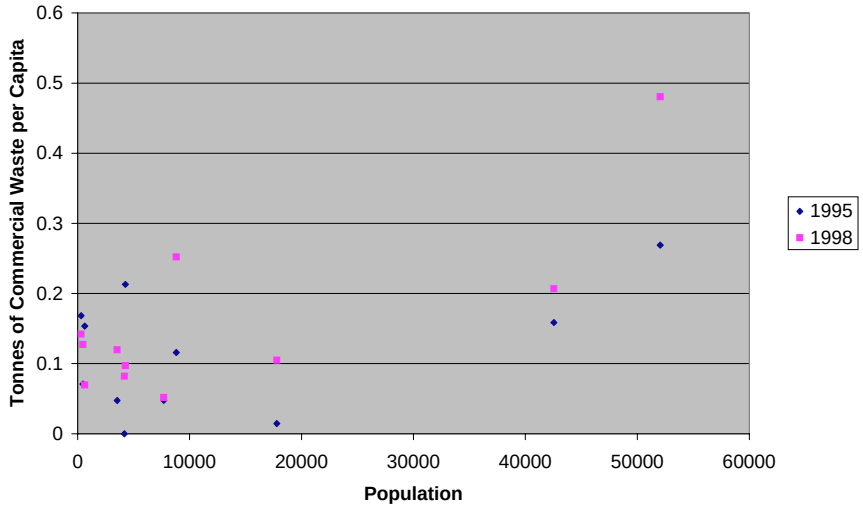

Figure 2.10. Total tonnes of commercial waste/capita.

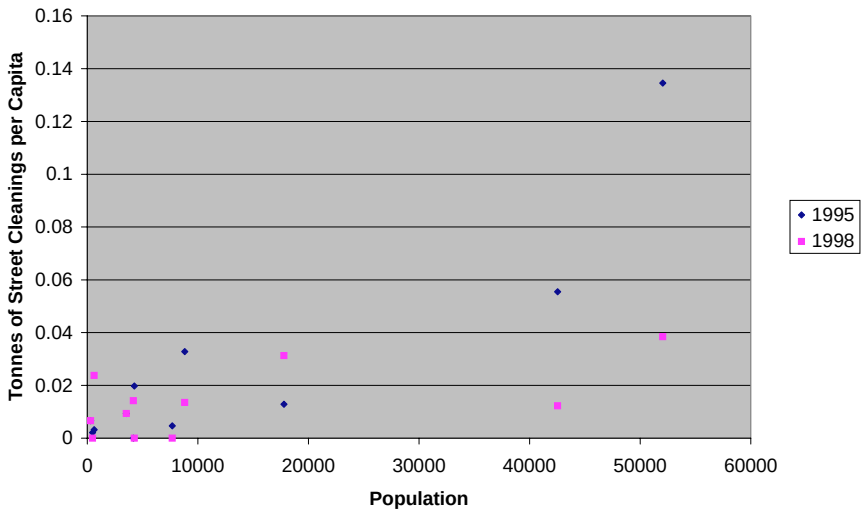

Figure 2.11. Total tonnes of street waste/capita.

such as the generation of biogas, leachate, odour, and aesthetic nuisances. A primary objective in a sustainable society must be to reduce, reuse or recover waste. As indicated in *Changing Our Ways* (DoELG, 1998), Ireland should aim to divert 50% of household waste and 65% of biodegradable waste away from landfill.

An objective of the *National Sustainable Development Strategy* (DoE, 1997) is to achieve a 20% reduction in the volume of municipal waste disposed to landfill by 2010. By ensuring that polluters pay for the cost of waste collection, treatment and disposal, public attention can be focused on the problems associated with current levels of waste generation and the importance of sustainable waste management, to ensure a better quality of life for future generations. Therefore, waste arising is an important indicator of sustainable development

What the analyses show

Although research findings seem to favour smaller settlements, it must be remembered that data were available at DED (District Electoral Division) level only and, therefore, had to be extrapolated to settlement size. This may present a somewhat misleading picture in favour of smaller settlements, which typically occupy only parts of DEDs.

2.5.2 State indicators

2.5.2.1 Garden birds – goldfinches

Birds were selected as indicators of biodiversity, as data on species present in urban gardens were provided by BirdWatch Ireland, generated through the Garden Birds Census that has operated since 1994. The help provided by BirdWatch Ireland is acknowledged. Here, the data for the years 1994–2000 are aggregated and gardens in all settlements are included (i.e. not only the 11 sample settlements) with the exception of Dublin and environs, which were considered a special case. An analysis of total number of species recorded in gardens showed no relationship between total species number and the size of the settlement in which the garden was located. The analysis was then taken a stage further, during which individual species were considered. The goldfinch was selected because it is less common (recorded in a total of 169 gardens outside of Dublin), and has particular habitat requirements (arboreal nesting, more specialist winter feeding requirements). Goldfinches, therefore, might be considered representative of less abundant species with narrower niches. It was found that goldfinches were more likely to be found in gardens within smaller settlements (Fig. 2.12).

Why this indicator is relevant to sustainable development

The maintenance of biodiversity is an important component of sustainability. It is not possible to quantify total biodiversity, as too many taxa are present. Therefore, selected taxa may act as indicators of biodiversity. While the total number of species of birds in gardens was not related to settlement size, goldfinches were more likely to be observed in gardens in smaller settlements. The goldfinch is a brightly coloured, easily identifiable and somewhat uncommon species with well-known habitat requirements, especially the availability of trees for nesting in summer and plant seed heads for food in winter. It is, therefore, a more specialist, or narrow-niched species, sensitive to the availability of particular habitats, especially woodland and rough ground. These habitats are perhaps less likely to be present in built-up areas. The goldfinch, therefore, represents a less common, more specialist species, and for that reason it may be considered a useful indicator of biodiversity.

What the analyses show

Goldfinches are more likely to be recorded in the gardens of smaller settlements, though differences between gardens of larger and smaller settlements were not significant, and data on numbers of individual goldfinches were not available. Moreover, considering all common bird species together, community diversity is not reduced in the gardens of larger settlements. While data for eight species were examined, it was not possible to identify any others that showed a relationship with settlement size similar to that of the goldfinch. Therefore, use of the goldfinch as an indicator of biodiversity is somewhat problematic, as the interpretation of findings is uncertain. On the other hand, in the absence of other data, this indicator deserves some attention.

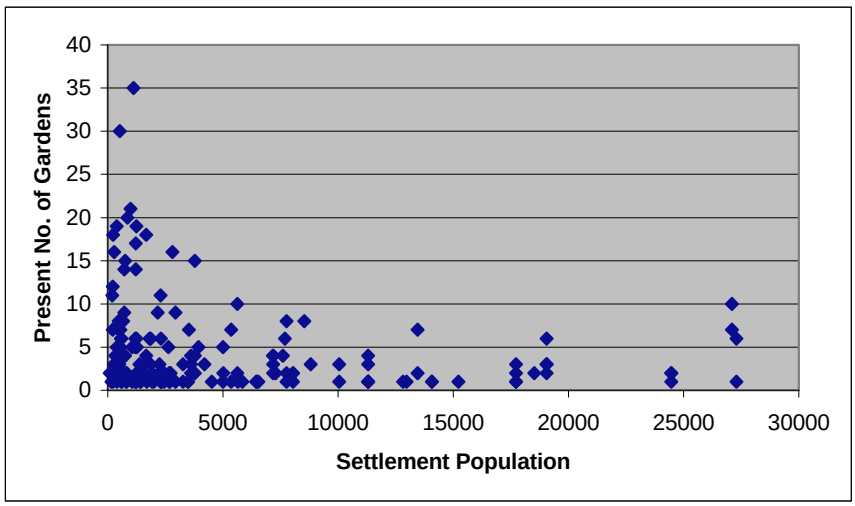

Figure 2.12. Number of individual sightings of goldfinches.

2.5.2.2 Population density

Data on population density were obtained from the *Census of Population 1996* and from the Ordnance Survey of Ireland 1:50,000 Discovery Series Maps of Ireland.

The average population density in Ireland is low, at 51 persons/km^2 but ranges from over 100 persons/km^2 in eastern and southern areas to less than 25 persons/km^2 in many western areas. The population density of certain rural districts has increased, particularly in the vicinity of major settlements such as Dublin, Limerick, Cork, Galway and Waterford (EPA, 2000).

It has been argued that Ireland's failure to develop an effective waste management strategy is reflected in our low level of environmental awareness and is also a consequence of our low population density, in contrast to The Netherlands, for example, where waste management strategies have been developing since the 1970s and the level of environmental awareness (and population density) is one of the highest in the world (Colleran, 1994).

Population data for each settlement are derived from the 1996 Census. Within larger settlements, the Census distinguishes between borough and environs. Herein, the population of a settlement is taken to be the combined figures for borough and environs. The extent of settlements is estimated on the basis of the Ordnance Survey of Ireland 1:50,000 Discovery Series Maps of Ireland and is quantified using the superimposition of a grid pattern. The extent of a settlement is taken to be the shaded grey area on these maps. One smaller settlement (Pallasgreen) was not mapped as a shaded area and the extent was estimated by field measurements. Areas in Table 2.23 are given in square kilometres, and population density in numbers of people per square kilometre, in order to facilitate comparisons. As a rule, smaller settlements have lower densities (Fig. 2.13). Shinrone has the lowest population density. Killarney has the second highest density, which is surprising given that much of the settlement takes the form of hotels and other tourism infrastructure. Freshford has a higher population density than other comparable settlements in the sample. The extent of Waterford is greater than Limerick, but the population density of Limerick is considerably greater.

Why this indicator is relevant to sustainable development

The average population density in Ireland is low, by European standards, at 51 persons per km^2. However, this figure ranges from over 100 persons per km^2 in the East and South to less than 25 persons per km^2 in the West. Ireland's settlement fringe housing development is often characterised by one-off detached residences or low-density suburban-type housing. In the mid-1920s Dublin's inner city housed 250,000 people. This figure has since reduced to 73,000. Low density suburban housing provides insufficient numbers of passengers to support public transport, resulting in increased dependency on private transport, which in turn leads to increased energy usage, emissions of air pollutants and congestion. Low numbers of passengers and congestion in turn leads to the reduced effectiveness of the public transport infrastructure.

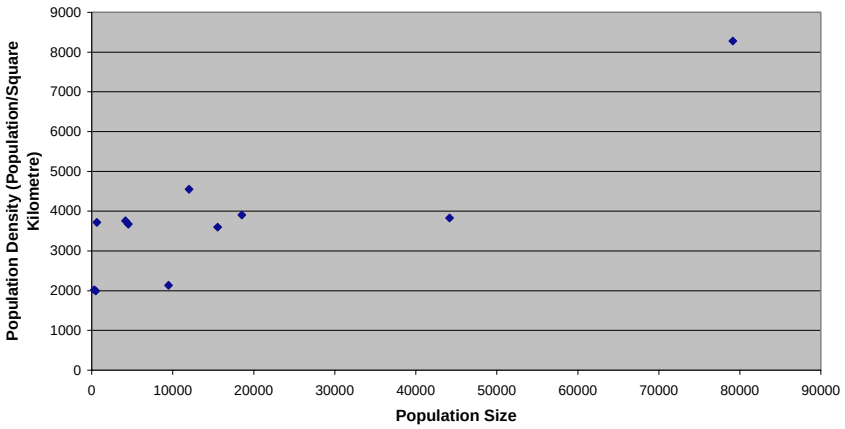

Figure 2.13. Population density vs. population size.

Table 2.23. Population density.

Settlement	Urban districts plus suburbs (1996 Census)	Total area (square kilometres)	Population density (population per square kilometre)
Limerick	79,137	9.56	8277
Waterford	44,155	11.53	3830
Sligo	18,509	4.74	3905
Athlone	15,544	4.32	3598
Killarney	12,011	2.64	4550
Portlaoise	9474	4.44	2134
Westport	4520	1.23	3675
Roscrea	4170	1.11	3757
Freshford	632	0.17	3718
Shinrone	479	0.24	1996
Pallasgreen	303	0.15	2020

Higher-density housing also increases the efficiency of other services, such as waste collection, recycling and reuse of materials, CHP and district heating and the reduction of travel distances to facilitate walking and cycling. It has been argued that low-population density is characterised by a low level of environmental awareness, while countries such as The Netherlands, which has one of the highest population densities in Europe, perform best in terms of civic responsibility and environmental consciousness. In general, it is considered that the compact city model is more sustainable, though contrary opinions have been expressed.[2] Therefore, population density is an important indicator of sustainable development.

What the analyses show

Research findings indicate that population density increases with settlement size. Many authors have cited population density as fundamental to planning for sustainability, as this is crucial to, *inter alia*, the efficient provision of services, maintenance of public transport systems, area heating schemes, collection of waste for recycling, and the replacement of purchasing by hiring. The DoE report *Sustainable Development - Strategy for Ireland* (1997) states that priority is to be aimed at promoting higher residential densities in proximity to town centres and public transport modes, in consultation with LAs, architectural and planning professions and the house building industry (DoE, 1997).

2. In order to establish which form of development is in fact most sustainable, further in-depth study is required in relation to settlement patterns, size, spatial organisation and infrastructural quality.

In a report published in 1998, it was concluded that Irish residential densities are low and that most residential developments in the past 20 years were in the form of back-to-back detached or semi-detached dwellings (Peter Bacon & Associates, 1999). The report recommended that the Minister for the Environment and Local Government, by the powers vested in him under Section 7 of the Planning and Development Act 1982, should direct planning and development issues, in order to adopt a more proactive approach towards increasing the density of developments (MacCabe, 2000).

2.5.2.3 Forest cover

Data on changes in forest cover were obtained from Coillte and the Forestry Service under the FIPS Inventory System for each DED (Table 2.24). Data were unavailable for Shinrone and Pallasgreen. The figures supplied relate to 1997 and were compiled using satellite imagery. This means that some very young forests may not have been identified and, therefore, may not be included in the tables. Figures 2.14 and 2.15 are trend graphs showing forest cover (ha) and classes of forest/settlement. As shown in Figs 2.16 and 2.17, the smaller settlements rank considerably higher in relation to both area under forest and classes of forest than the larger urban areas (494.01 ha under forest in Roscrea, compared to just 8.87 ha in Limerick). Killarney ranks highest with 689.33 ha under forest, although a considerable area of Killarney is National Park. In relation to the classes of forest planted, the smaller settlements again score higher than the larger urban centres (Table 2.25).

Table 2.24. Area under forest for each settlement.

Settlement	Settlement population	Total area under forest (hectares)
Limerick	52,039	8.87
Waterford	42,540	12.28
Sligo	17,786	1.28
Killarney	8809	689.33
Athlone	7691	2.49
Westport	4253	134.31
Roscrea	4170	494.01
Portlaoise	3531	242.68

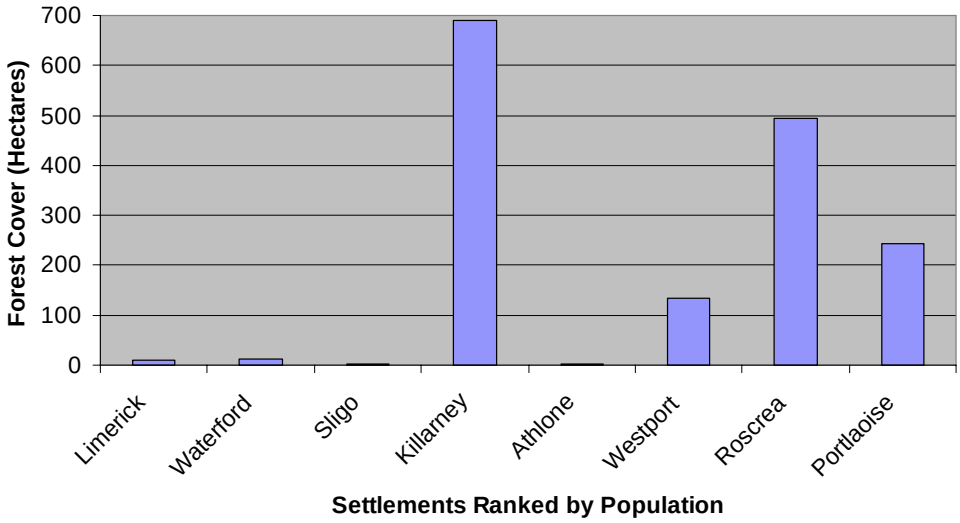

Figure 2.14. Forest cover (ha)/settlement.

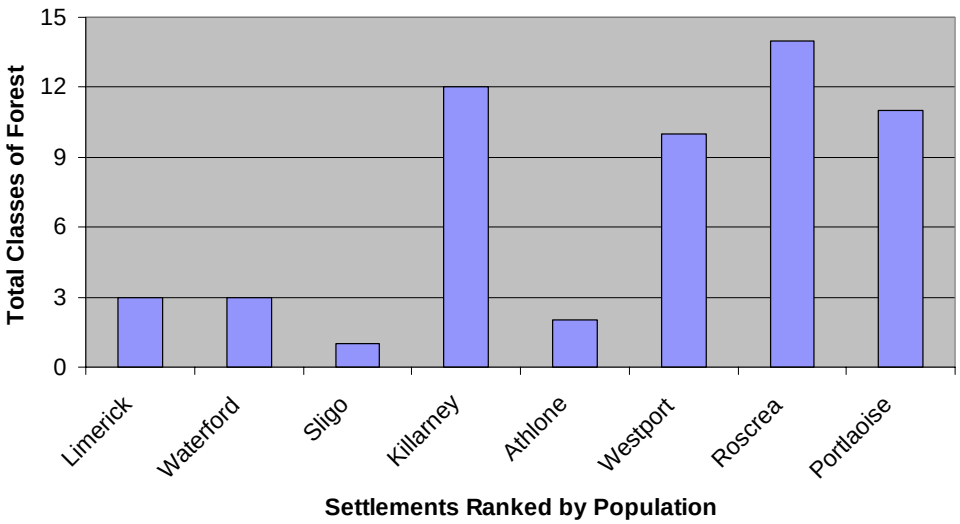

Figure 2.15. Classes of forest/settlement.

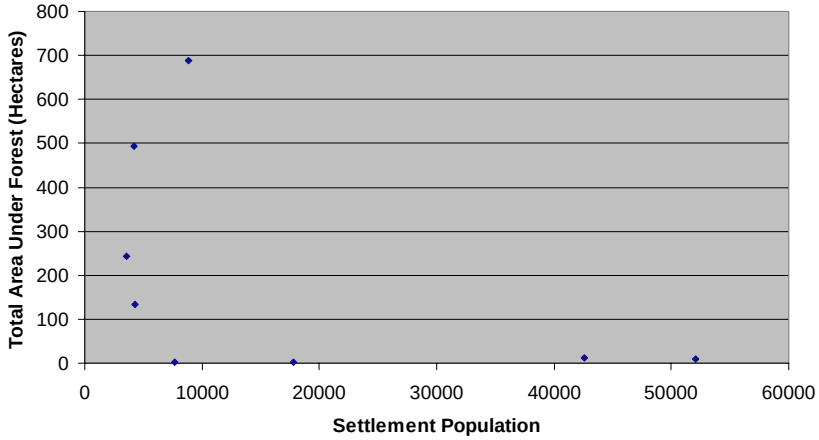

Figure 2.16. Area under forest vs. population size.

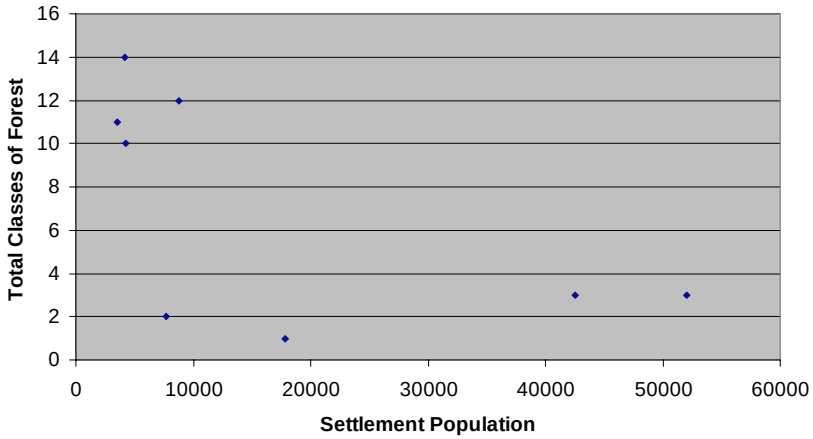

Figure 2.17. Classes of forest vs. population size.

Table 2.25. Classes of forest for each settlement.

Forest class	Settlement							
	Limerick	Waterford	Sligo	Killarney	Athlone	Westport	Roscrea	Portlaoise
Conifer young spruce						✓	✓	✓
Conifer mature spruce				✓			✓	✓
Conifer mature pine				✓		✓	✓	✓
Conifer mature larch							✓	
Conifer mature other				✓		✓	✓	
Conifer young pine–spruce mix							✓	✓
Conifer mature pine–spruce mix				✓			✓	
Broadleaf young beech							✓	
Broadleaf young other				✓	✓	✓	✓	✓
Broadleaf mature oak				✓				
Broadleaf mature other broadleafs	✓	✓	✓	✓		✓	✓	✓
Mixed young forests				✓		✓	✓	✓
Mixed Forest Mature	✓	✓		✓		✓	✓	✓
Cleared and young forests				✓		✓	✓	✓
Private grant aided				✓		✓	✓	
Forests <0.2 ha	✓	✓		✓	✓	✓		✓

Why this indicator is relevant to sustainable development

Forested areas are important providers of habitats for wildlife and are valuable amenity/recreational areas. Forests located close to urban centres act as important carbon sinks for the large quantities of carbon dioxide produced, in particular, by the transport and domestic heating sectors. Woodlands act as effective barriers to noise pollution. Approximately 9% of Ireland is under forest. A target of 17% of land area forested has been set for 2035. The EU average is approximately 35% of total area under forest. Seventy-eight percent of forest cover in Ireland is Sitka spruce. The possible negative impacts of forestry require consideration, including the effects on land drainage, the dominance of exotic conifers, impacts on landscape and cultural heritage, isolation of rural dwellings and acidification of waters. However, in the urban and urban-fringe zones, forestry has many more positive than negative impacts so increasing the area under forestry enhances sustainability. Therefore, area under forest is an important indicator for sustainable development.

What the analyses show

Research findings favour smaller settlements as most planting to date has taken place close to smaller settlements in rural areas. However, data were available at DED level only. DEDs for larger settlements are fully urbanised. Only part of the DED may be built up for smaller settlements.

In addition, the greater occurrence of planting in smaller rural settlements may be due to the significant increase in urban land prices in recent years as a consequence of Ireland's unprecedented rate of economic growth. This may present a misleading picture in favour of smaller settlements. Furthermore, current policy focuses on farm forestry, which is now the largest single component of the forestry programme. Farmers, most of whom live close to smaller rural settlements, accounted for 89% of private afforestation in 1998. Therefore, results are difficult to interpret; there is a bias in favour of smaller settlements resulting from the method of data collection necessarily adopted.

2.5.3 Impact indicators

2.5.3.1 Means of travel to work

The 1991 and 1996 Censuses provide data on means of travel. Proportions of respondents using travel modes are tabulated (Tables 2.26 and 2.27) and displayed graphically (Figs. 2.18–2.24). Travel by car is the dominant mode of transport in all settlements (Figs. 2.25–2.30). Relatively low values recorded for smaller settlements in 1991 were not replicated in 1996, with the possible exception of Killarney, so that by 1996, car use was similar in all settlements. Travel by foot was lowest in Limerick, the largest settlement by population in the sample, but other than this no clear relationship with population size was evident. Bicycle use was marginally lower in larger settlements (Limerick and Waterford), and bicycle use declined everywhere between 1991 and 1996, though by very little in Killarney. Bus use was greatest in the larger settlements (Limerick and Waterford), and smallest in smaller settlements, though Sligo values were the exception to this pattern. However, bus use declined in Limerick between 1991 and 1996, presumably reflected in the increase in car use.

Why this indicator is relevant to sustainable development

Transport accounts for a growing proportion of consumption of non-renewable energy resources. All modes of mechanised transport have important environmental impacts at global, national and local levels. Use of the car for single-purpose journeys is particularly unsustainable. Almost 80% of people employed in Ireland travel to work by car. Buses are used by 6.9% of the workforce, with just 1.6% using the train or DART. Eleven percent of the workforce walk to work and 2% cycle. However, more than 40% of the workforce in the Dublin and Mid-East region regard public transport as not being a practical option, while 13% prefer private transport irrespective of public transport provision. Road transport contributes substantially to the production of atmospheric carbon dioxide, nitrogen oxide, volatile organic compounds (VOCs) and particulates. A car with driver uses twice as much energy per person/distance as a commuter train and more than ten times as much energy as a full double-decker bus. Choice of means of travel has implications for air quality, road safety, access to basic services and land quality. Sustainable development must aim at im-

Table 2.26. Means of travel.

Settlement	Year	Total workforce	On foot	Cycle	Bus	Train	Motorcycle	Car (driver)	Car (passenger	Other	None
Limerick	1981	17,857	4946	1307	2409	19	204	5931	1850	409	904
	1986	15,612	4153	1344	2324	11	138	4822	1405	402	516
	1994	23,225	4278	1308	2395	31	179	9585	2394	656	1550
	1996	27,538	5344	1275	2480	33	179	12,850	3019	777	1021
Waterford	1981	11,993	3868	407	564	26	202	4925	1129	194	571
	1986	11,522	3523	884	426	19	152	4423	1094	272	431
	1994	13,266	3417	870	458	17	143	5375	1462	380	573
	1996	15,097	3482	688	587	25	166	6736	1972	427	648
Sligo	1991	5997	1851	392	179	2	25	2183	456	196	425
	1996	6813	1975	357	129	5	31	2950	691	194	330
Killarney	1991	2959	685	264	32	5	19	1057	215	102	456
	1996	3687	917	321	29	4	29	1477	275	140	332
Athlone	1991	5085	1166	467	132	33	29	2015	424	162	464
	1996	5482	1134	396	157	18	25	2485	562	226	353
Portlaoise	1991	2435	584	195	29	54	13	999	155	99	242
	1996	3179	685	186	45	63	5	1546	267	124	65

Table 2.27. Percent workforce and means of travel.

Settlement/year	Foot	Bicycle	Bus	Train	Car
Limerick 1991	18.4	5.6	10.3	0.1	51.6
Limerick 1996	19.4	4.6	9.0	0.1	57.6
Waterford 1991	25.7	6.6	3.5	0.1	51.5
Waterford 1996	23.0	4.5	3.9	0.2	57.7
Sligo 1991	30.8	6.5	2.9	0.1	44.0
Sligo 1996	28.9	5.2	1.9	0.1	53.4
Killarney 1991	23.1	8.9	1.1	0.2	42.9
Killarney 1996	24.8	8.7	0.8	0.1	47.5
Athlone 1991	22.9	9.1	2.6	0.6	47.9
Athlone 1992	20.7	7.2	2.9	0.3	55.6
Portlaoise 1991	23.9	8.0	1.2	2.2	47.4
Portlaoise 1996	21.5	5.8	1.4	1.9	57.0

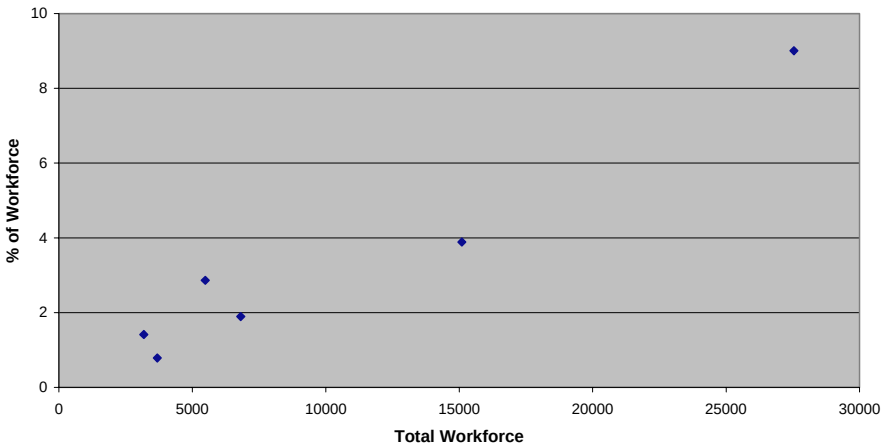

Figure 2.18. Percentage of workforce travelling by bus/settlement.

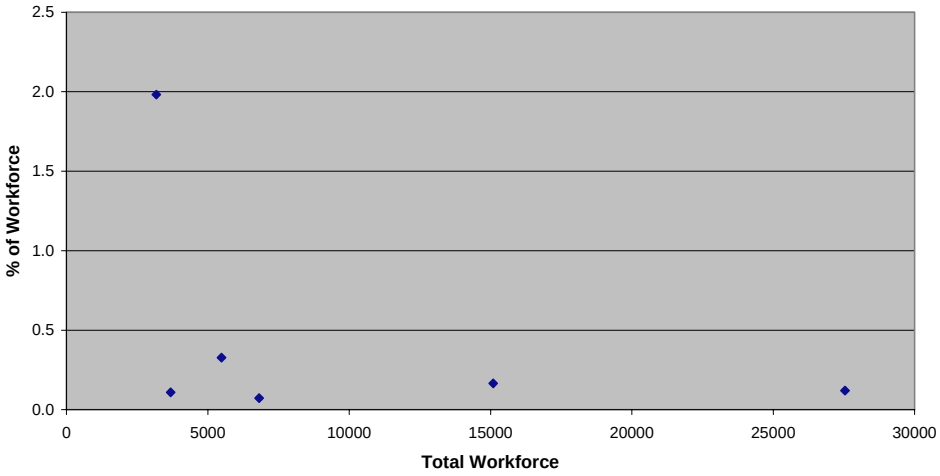

Figure 2.19. Percentage of workforce travelling by train/settlement.

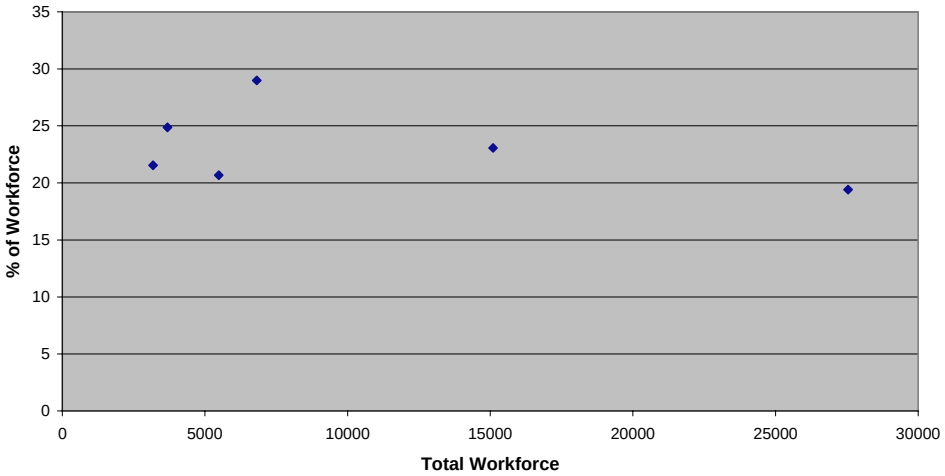

Figure 2.20. Percentage of workforce travelling by foot/settlement.

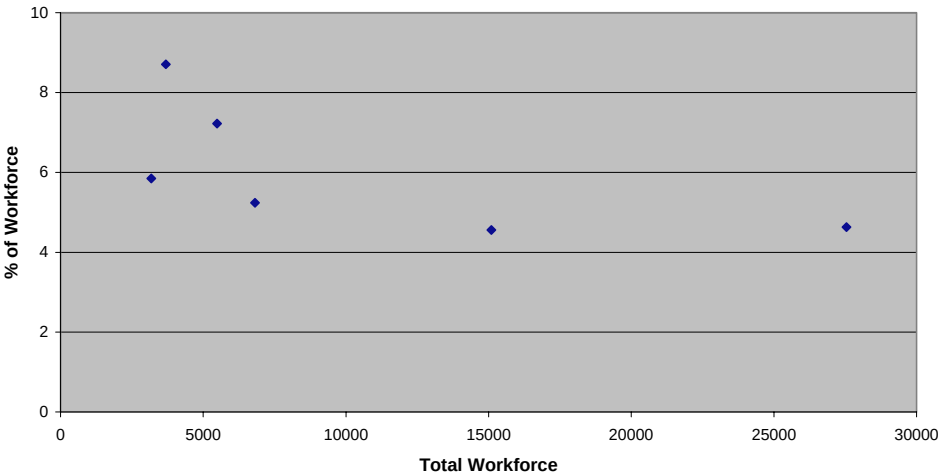

Figure 2.21. Percentage of workforce travelling by motorcycle/settlement.

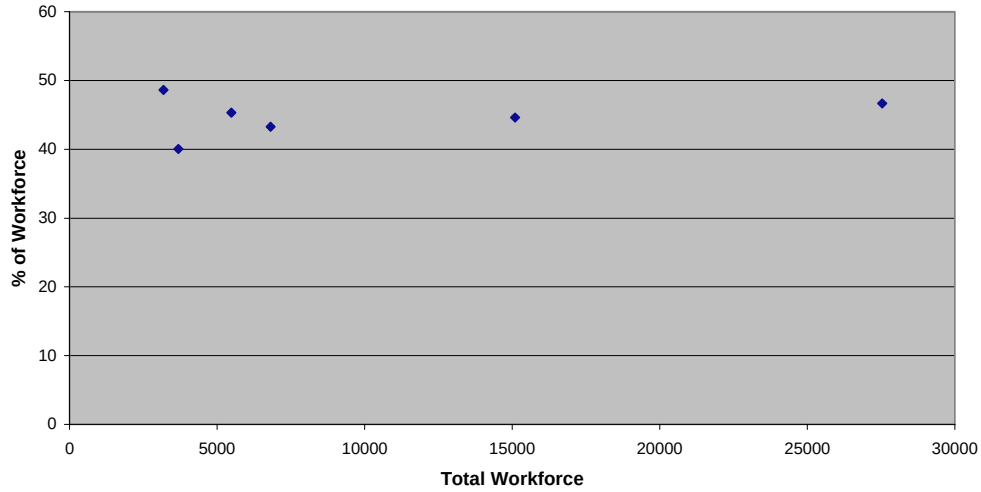

Figure 2.22. Percentage of workforce travelling as car drivers/settlement.

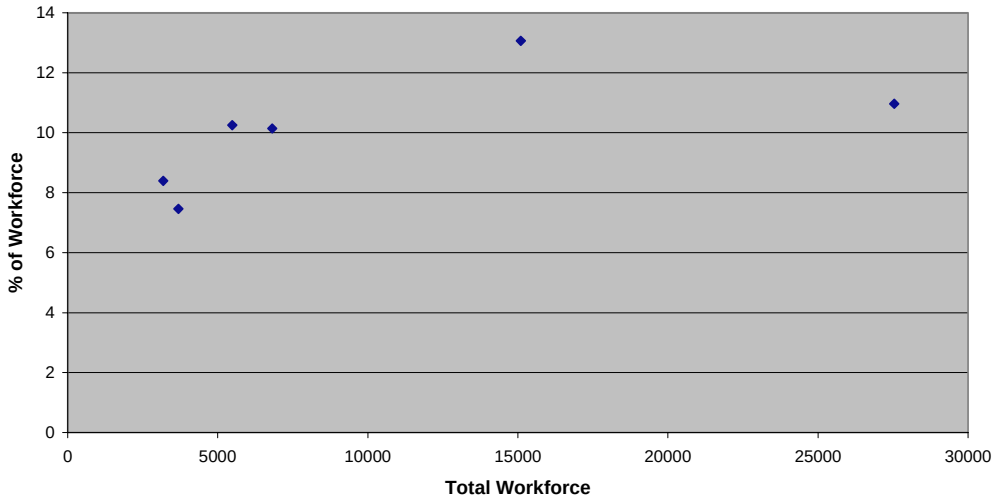

Figure 2.23. Percentage of workforce travelling as car passengers/settlement.

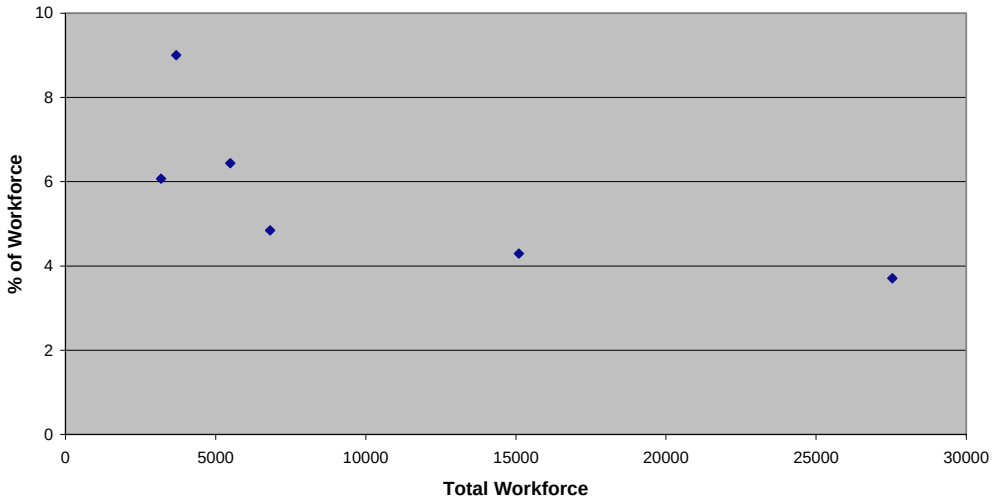

Figure 2.24. Percentage of workforce not travelling/settlement.

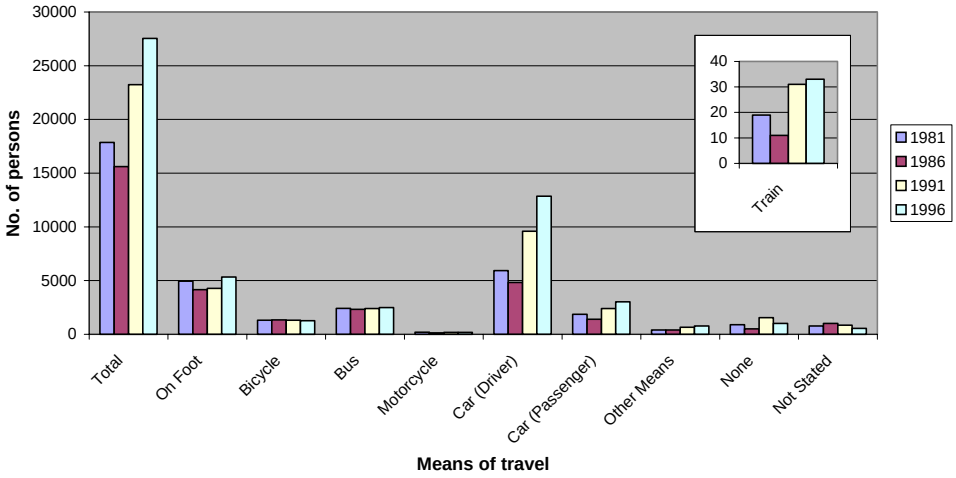

Figure 2.25. Means of travel by persons in Limerick County Borough.

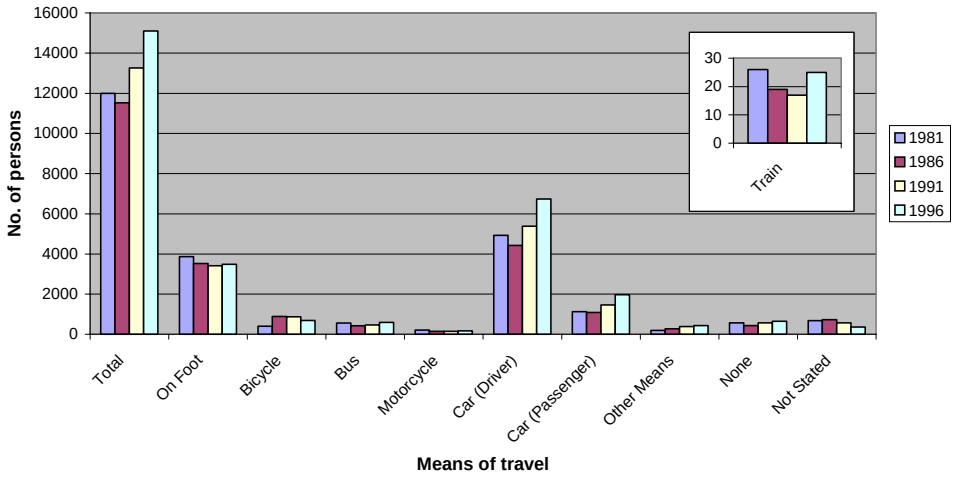

Figure 2.26. Means of travel by persons in Waterford.

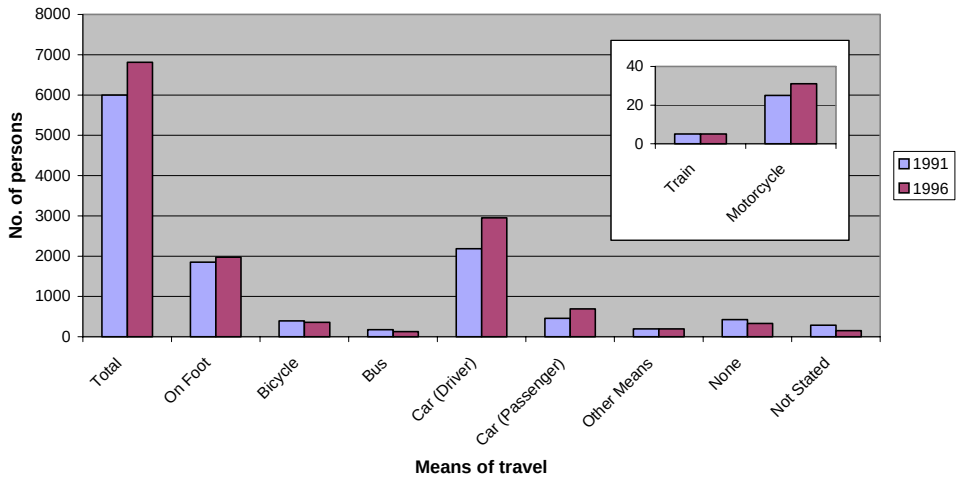

Figure 2.27. Means of travel by persons in Sligo.

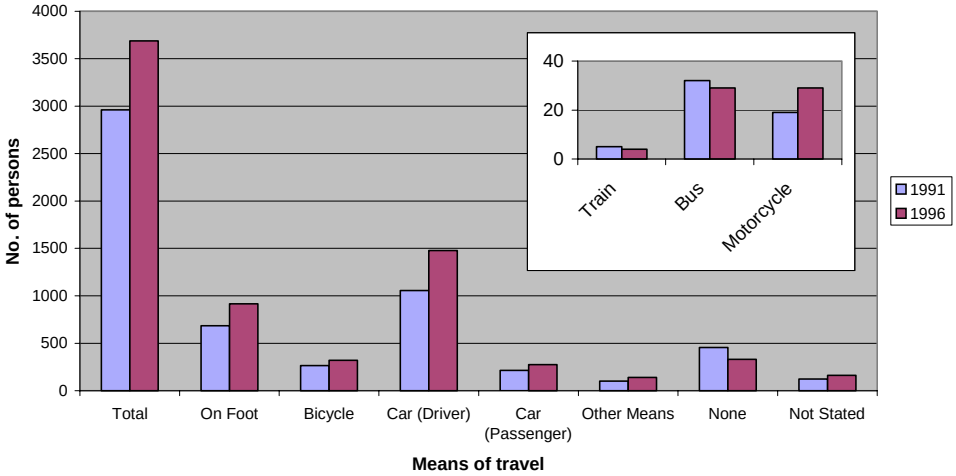

Figure 2.28. Means of travel by persons in Killarney.

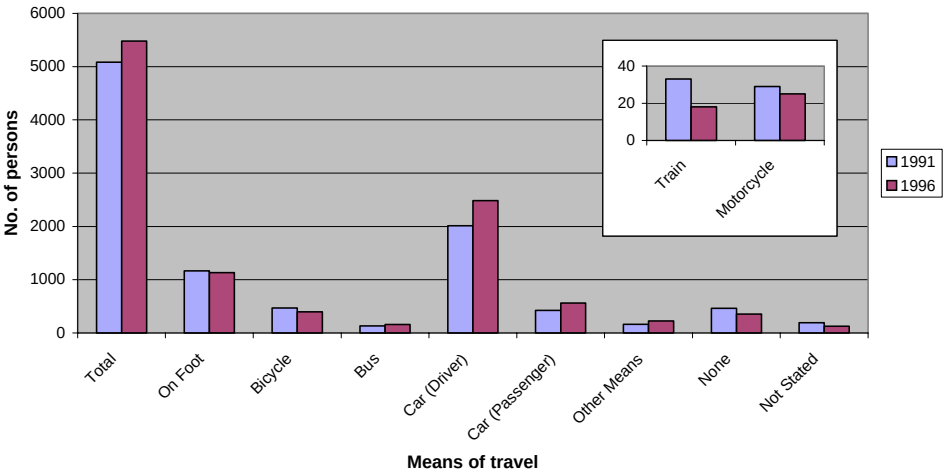

Figure 2.29. Means of travel by persons in Athlone.

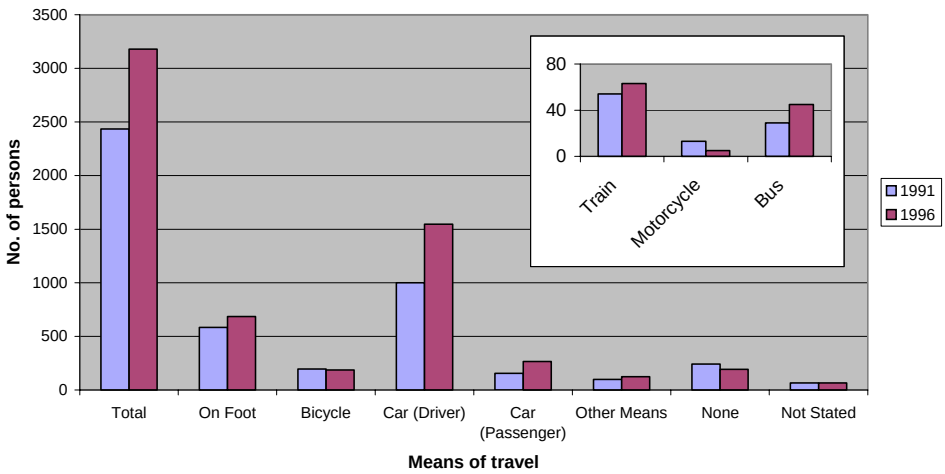

Figure 2.30. Means of travel by persons in Portlaoise.

proving public transport availability and accessibility, thereby reducing public dependence on private transport. Additional incentives may be required to encourage switching from private to public transport use (see Goodbody Economic Consultants, 2000). Therefore, mode of travel is an important indicator for sustainable development.

What the analyses show

Evidence from the Irish case studies appears to be contrary to what would normally be expected. Distance travelled tends to be highest for the larger settlements, with travel of less than 2 miles also low in comparison to the smaller settlements (urban shape/land use may better account for these results). Data presented on workplace/education and the mode of transport to workplace/education do not present a very clear picture of differences between settlements of varying sizes. Although travel by private car is the dominant mode of transport in all settlements, smaller settlements rely heaviest on private transport. Larger settlements utilise public transport to a significantly greater extent. Larger settlements have:

(a) a greater proportion of the workforce using buses for the journey to work/education (public transport provision and use are again central to planning for sustainability);

(b) a greater proportion of the workforce travelling as car passengers (indicative of greater car-pooling).

2.5.4 Response indicators

2.5.4.1 Integrated Pollution Control Licensing

IPC licenses were first issued in 1994. All new and existing industrial and manufacturing facilities in Ireland with significant pollution potential are subject to IPC. IPC focuses on the elimination or reduction of waste at source, incorporating the use of Best Available Technology Not Entailing Excessive Costs (BATNEEC). A single license is issued to cover all aspects of water, air, waste and noise management. The Environmental Management System (EMS) component of IPC requires industrial and manufacturing facilities to develop and implement an EMS so that measurable objectives and targets can be set. The main objective here is to mitigate or eliminate potentially adverse environmental impacts. The second element of IPC, Annual Environmental Report (AER), is intended to provide detailed information on the environmental performance of the activity concerned.

Table 2.28 and Fig. 2.31 show the total number of IPC licenses issued for each settlement between 1995 and 2001. The settlements are ranked in terms of population size, with Limerick being the highest and Pallasgreen the lowest. Figure 2.32 shows that the number of IPC licenses issued in the 6-year period is directly proportional to population size, i.e. settlements with the highest population size have the greatest number of IPC licenses, with the exception of Portlaoise. No reasons are offered here as to why Portlaoise has a greater number of IPC licenses than Sligo, Killarney, Athlone, Westport and Roscrea. Several factors may be at play including, *inter alia*, functionality, geographical location and proximity to national roads.

Although, IPC licenses versus population size shows no definite or distinguishable relationship to settlement size, this does not apply to cumulative numbers of licenses issued (Fig. 2.33).

Why this indicator is relevant to sustainable development

The main purpose of IPC licensing is the reduction of industrial wastes and emissions. By 1999, 409 IPC licenses were issued by the EPA within Ireland, and in future all new and existing industrial facilities with significant pollution potential will be subject to the IPC process. IPC licensing is a powerful tool for encouraging more sustainable production in manufacturing processes. In the case where industries fail to meet all the conditions attached to the license, the EPA may take appropriate measures to bring that industry back into compliance by serving summary notices or, ultimately, through prosecution. Industrial developments with IPC licenses are, therefore, taken to be more sustainable than those without. Therefore, the cumulative number of IPC licensed industries in a settlement represents an important indicator of sustainable development.

What the analyses show

Although IPC licenses versus population size shows no definite or distinguishable relationship to settlement size, this does not apply to cumulative numbers of licenses issued. Cumulative IPC licenses favour larger settlements,

Table: 2.28. Total IPC licenses issued.

Settlement	Population	1995	1996	1997	1998	1999	2000	2001	Total
Limerick	52,039		2	1	5	3	1		12
Waterford	42,540	1	2	5	5	3	3	1	20
Sligo	17,786		3		2		1		6
Killarney	8809			1				1	2
Athlone	7691		1	1					2
Westport	4253			1					1
Roscrea	4170			1	1				2
Portlaoise	3531		1	1	3	2	1		8
Freshford	632								0
Shinrone	479								0
Pallasgreen	303								0

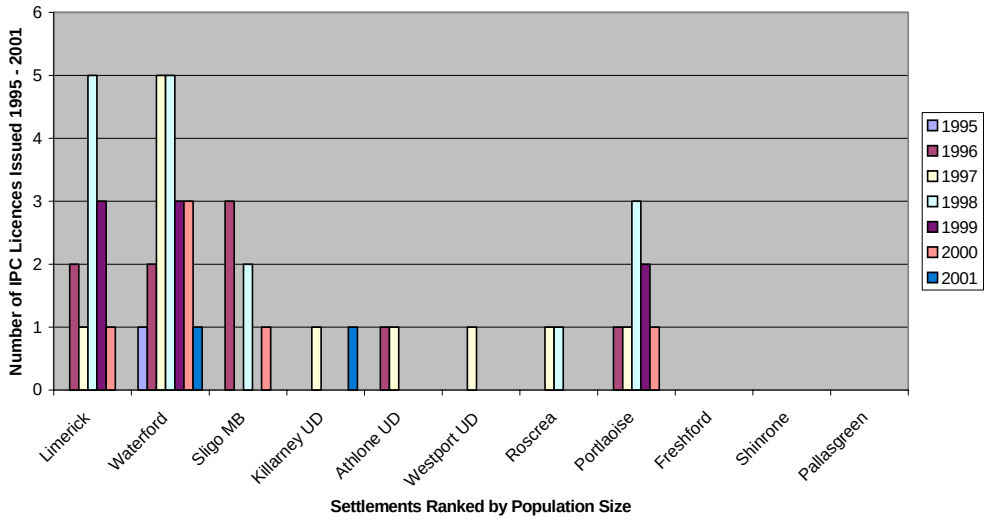

Figure 2.31. Number of IPC licenses issued 1995–2001.

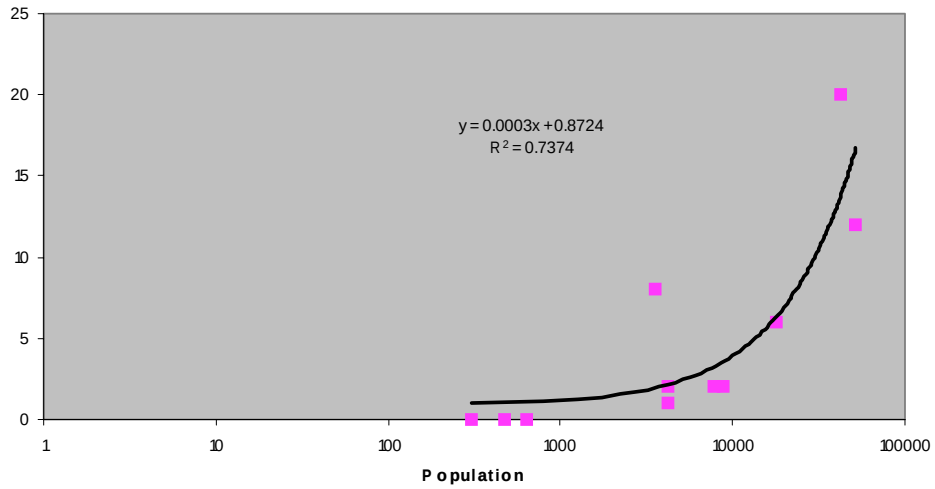

Figure 2.32. IPC licenses issued 1995–2001 vs. population size.

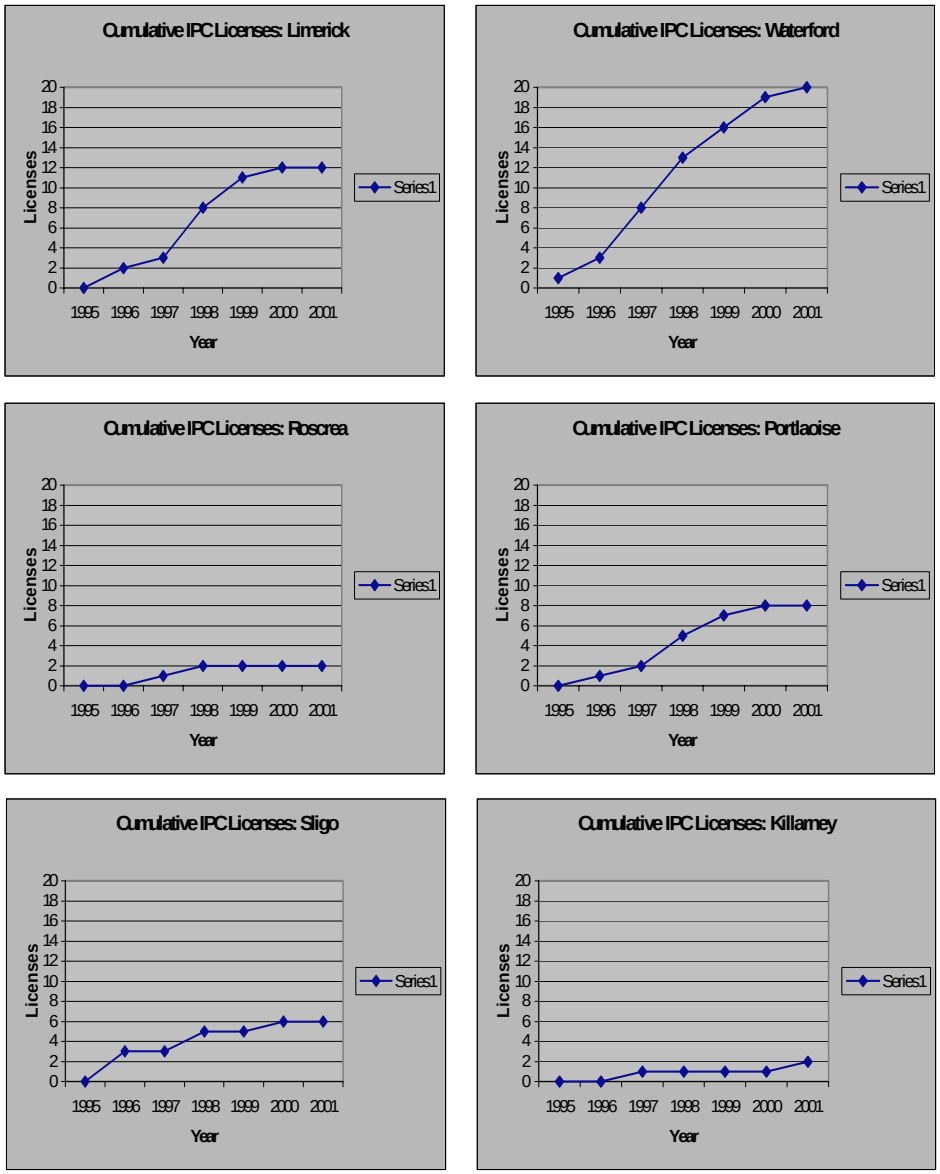

Figure 2.33. Cumulative number of IPC licenses issued 1995–2001.

with Waterford (20 licenses) and Limerick (12 licenses) faring better than all other settlements. This suggests that larger settlements are able to attract consistently more modern, cleaner manufacturing. Again, this is a strong indicator and the data are reliable.

2.5.4.2 Recycling facilities

Figure 2.34 shows an inverse relationship between the number of recycling banks/1000 population and settlements ranked in order of population size. The availability of recycling banks/1000 population increases as settlement size decreases (Table 2.29), but with important exceptions where no recycling facilities are available. Although the actual number of recycling facilities is greater in the larger settlements, the per/1000 figures indicate the inverse, with Killarney, Freshford and Pallasgreen scoring highest. Data on the actual volumes of municipal waste recycled over a given time-scale were unavailable at settlement level. In general, there has been an increase in Ireland's level of waste recovery since 1995, with glass recovery, for example, increasing from 28,500 t/annum in 1995 to 36,000 t/annum in 1998.

Why this indicator is relevant to sustainable development

Following government policy on waste management, the next best environmental alternative after waste preven-

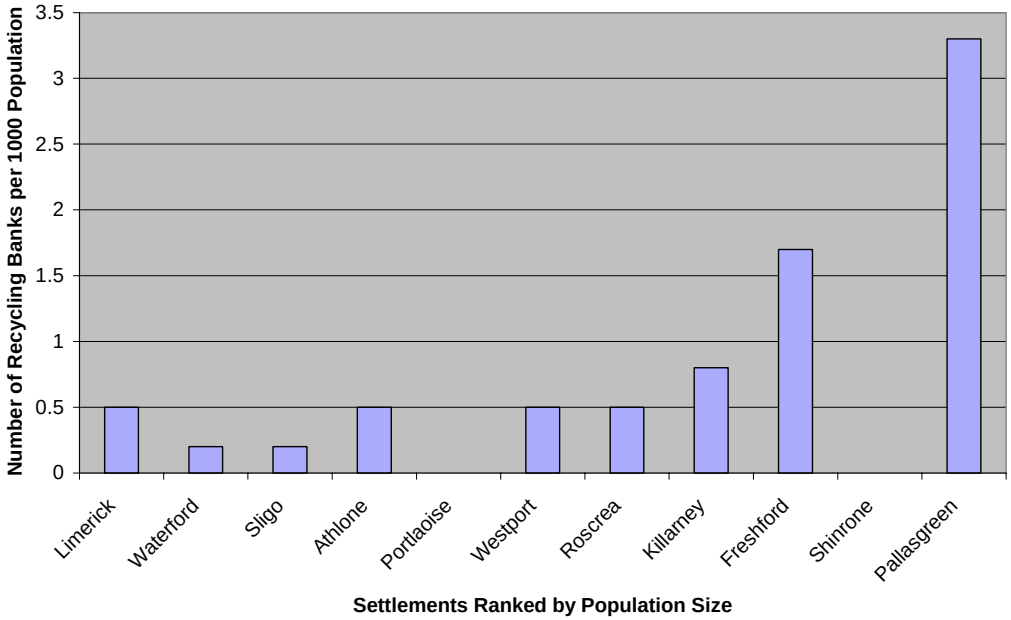

Figure 2.34. Number of recycling banks and facilities/1000 population.

Table 2.29. Number of recycling banks/1000 population.

Settlement (ranked by population size)	Population	Material recycled	Number of banks	Number of recycling banks/1000 population
Limerick	52,039	Glass, aluminium cans	25	.5
Waterford	42,540	Glass, aluminium cans	8	.2
Sligo	17,786	Glass, aluminium cans	3	.2
Killarney	8809	Glass, aluminium cans, textiles	7	.8
Athlone	7691	Glass, aluminium cans	4	.5
Westport	4253	Glass, aluminium cans, textiles	2	.5
Roscrea	4170	Glass, aluminium cans	2	.5
Portlaoise	3531	None	0	0
Freshford	632	Glass, aluminium cans, textiles	1	1.7
Shinrone	479	None	0	0
Pallasgreen	303	Glass, aluminium cans	1	3.3

tion and minimisation is reuse and recover. Recycling of waste reduces the use of virgin materials and the need for resource-intensive and polluting processing.

Under the Waste Management (Packaging) Regulations 1997, producers of packaging waste have a choice either to participate in a waste recovery activity operated by an approved body, or otherwise take steps to comply with the Regulations by recovering packaging waste.

There is increasing pressure on the private sector to deliver a 27% recovery target for packaging waste by the year 2002. The policy statement *Changing Our Ways* (DoELG, 1998) calls for recycling of 35% of all municipal waste and 50% of construction and demolition waste. Progress in Irish recycling rates was made between 1993 and 1995, with an increase from 10.3% to 15.6%. Effectiveness of recycling largely depends on the provision of facilities available to the public. Consequently, access to recycling banks is an important indicator of sustainable development.

What the analyses show

In general, larger settlements have a greater number of recycling facilities. The overall capacity for recycling is highest in larger settlements. The apparent greater per-

capita provision of recycling banks in the smallest settlements is by and large a statistical artefact, and some smaller settlements have no banks at all. Clearly, recycling is crucial within the definition of sustainability.

In addition, no indication is given of the proximity of recycling facilities to smaller settlements. As dependency on the private car is greatest in smaller settlements, the nearest recycling facility may be located several kilometres away. When considering the net impact to the environment, the saving that may be accrued from recycling must be balanced against the cost to the environment in terms of energy usage and pollution that may arise from private transport to the nearest recycling facilities.

2.6 Social indicators displaying sensitivity to settlement size

2.6.1 Driving force/pressure indicators

2.6.1.1 Number of passengers/car

Data on the number of passengers/car were obtained from the 1996 Census using figures on the number of car drivers and number of car passengers for each of six larger settlements (Table 2.30). No data are available for Westport, Roscrea, Freshford, Shinrone or Pallasgreen. Figures 2.35 and 2.36 show little variation between settlements for the number of passengers/car vs. population and workforce, with the exception of Waterford, where car-pooling practices are greater than in any other settlement. It may be assumed that car-pooling operates more frequently in larger urban centres, such as Limerick. However, the number of passengers per car is almost equal to that of Athlone and Sligo, which have a considerably smaller population and available workforce. This may be due to greater reliance on public transport in Limerick.

Why this indicator is relevant to sustainable development

Although travel by private car is the least sustainable mode of transport, car-pooling (i.e. increasing the number of passengers per car journey) may contribute to reduced environmental impacts and increased energy efficiency through a reduction in the number of cars in use. In cases where members of the workforce live in rural areas or areas with poor public transport infrastructure, car-pooling is, at present, probably the most feasible and sustainable option. Therefore, number of passengers per car is an important indicator of sustainable development.

What the analyses show

The level of car sharing in the journey to work/education category is greater in larger settlements. Again, data are reliable, and more effective use of transport is central to planning to approach sustainability, so as to reduce resource use and pollution, and combat congestion.

2.6.2 State indicators

2.6.2.1 Number of general practitioners

Data on the number of general practitioners/settlement were obtained from the *Golden Pages* (Table 2.31). Data were not available from the Department of Health at a sufficiently disaggregated level. Figure 2.37 shows a proportional linear relationship, with the number of GPs increasing with population size. However, Fig. 2.38 illustrates that the number of GPs/capita is greater in smaller settlements, with Pallasgreen (smallest population size) scoring higher than all other settlements in the study.

Table 2.30. Number of passengers/car.

Settlement	Population	Workforce	Car driver	Car passenger	Passenger/car
Limerick	52,039	27,538	12,850	3019	0.234941634
Waterford Co. Borough	42,540	15,097	6736	1972	0.292755344
Sligo	17,786	6813	2950	691	0.234237288
Killarney	8809	3687	1477	275	0.186188219
Athlone	7691	5482	2485	562	0.226156942
Portlaoise	3531	3179	1546	267	0.172703752

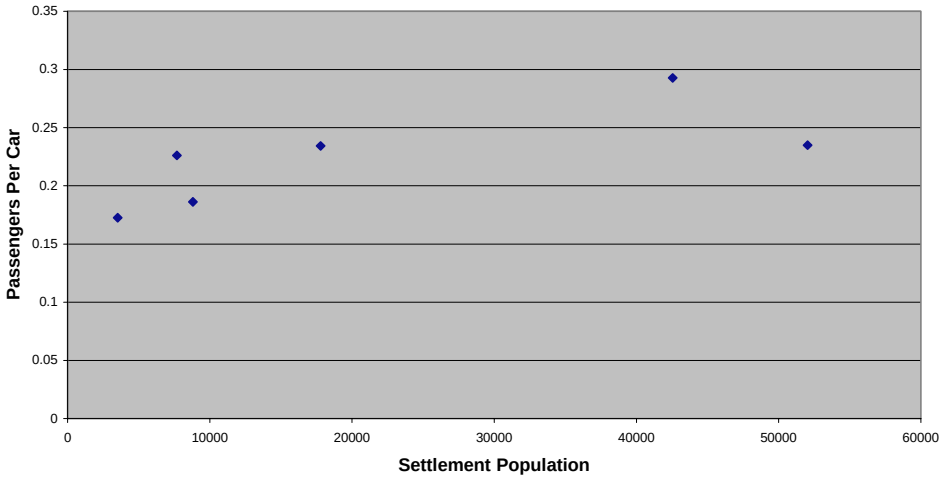

Figure 2.35. Number of passengers/car vs. population size.

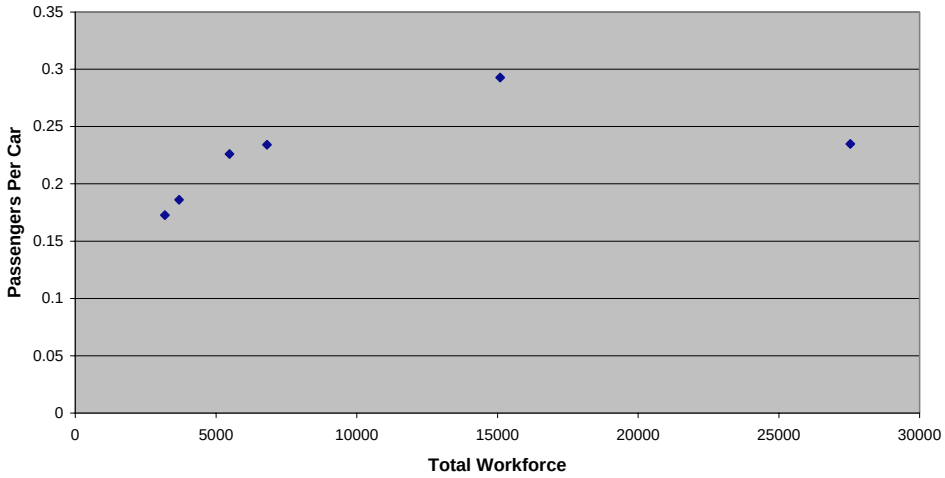

Figure 2.36. Number of passengers/car vs. workforce.

Table 2.31. Number and per-capita number of GPs/settlement.

Settlement (ranked by population size)	Population	Number of GPs	Number of GPs/capita
Limerick	52,039	63	0.0012
Waterford	42,540	23	0.0005
Sligo	17,786	19	0.0011
Killarney	8809	14	0.0016
Athlone	7691	12	0.0016
Westport	4253	9	0.0021
Roscrea	4170	6	0.0014
Portlaoise	3531	5	0.0014
Freshford	632	1	0.0016
Shinrone	479	0	0.0000
Pallasgreen	303	1	0.0033

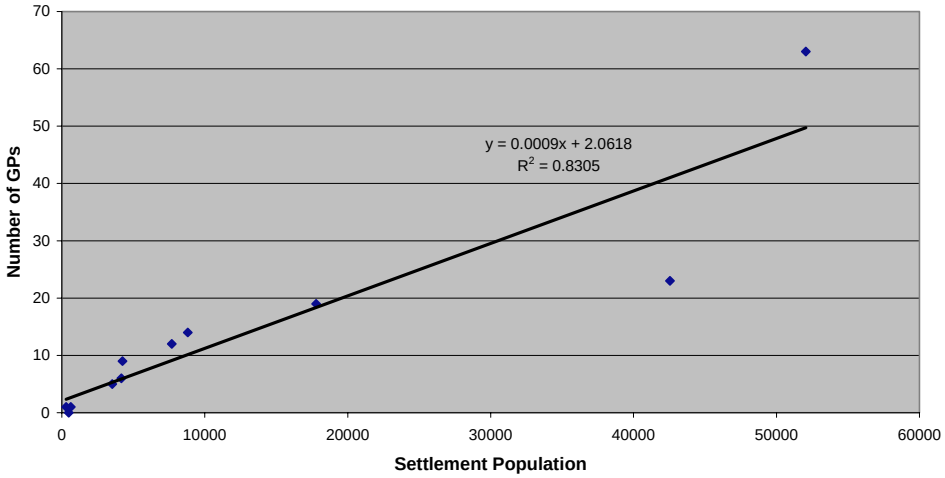

Figure 2.37. Number of GPs/settlement.

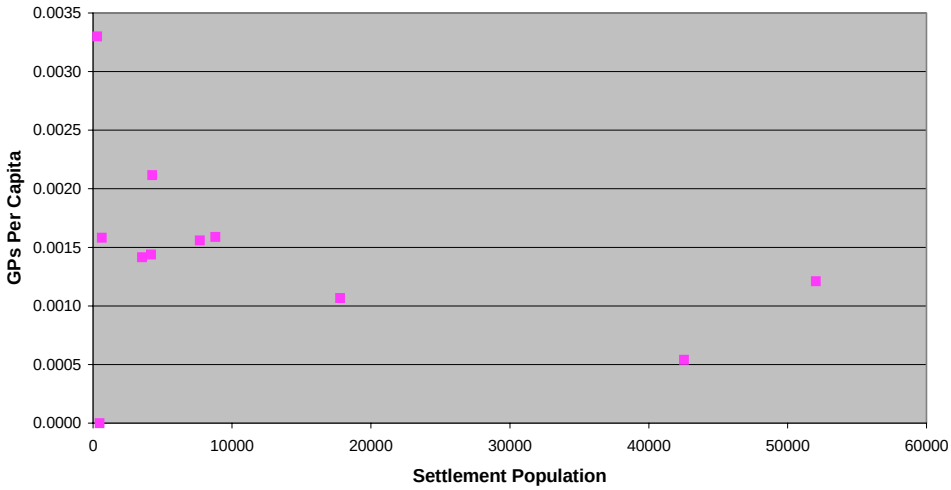

Figure 2.38. Number of GPs/capita.

Why this indicator is relevant to sustainable development

Sustainable development embraces the concept of social welfare; it is argued that a society with a welfare deficit is likely to be characterised by unrest and will not, therefore, be sustainable. Welfare is a broad concept, not easily quantified. One very important facet of welfare is access to health care. An indicator of the availability of health-care facilities is the number of GPs per 1000 people.

What the analyses show

Data presented indicate that smaller settlements have larger numbers of GPs per capita. At the time of information gathering, the only source of data available was the *Golden Pages*, and it is acknowledged that GPs select to be listed. Furthermore, it is clear that GPs resident in smaller settlements may service a number of other villages and have patients who reside in surrounding rural areas. Consequently, the interpretation of the data is problematic.

2.6.2.2 Public transport

The settlements do not exhibit any sensitivity with respect to connectivity (Fig. 2.39) (number of routes serviced from the settlement (Table 2.32)). However, the number of urban bus routes is greater in larger settlements. As shown in Fig. 2.40, none of the small settlements have urban public transport systems.

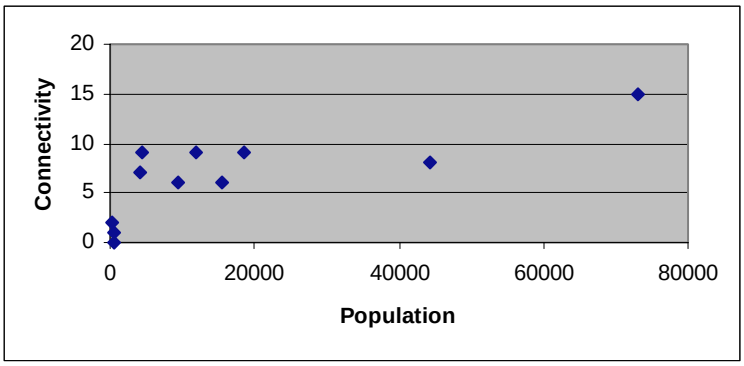

Figure 2.39. Public transport.

Table 2.32. Public transport system.

Settlement (ranked by population)	Bus Éireann	Urban bus	Private bus	Overseas	Taxi	Rail
Limerick	Dublin, Roscrea, Cork, Tralee, Galway, Ennis, Killarney, Portlaoise, Westport, Shannon, Ballina, Waterford, Sligo, Derry, Athlone	12 routes	4 per day: • Limerick–Dublin • 4 per day: • Limerick–Roscrea	2 per day: • Limerick–Bristol/ London 1 per day: • Limerick–Portsmouth 1 per day: • Limerick–Birmingham	✓	10 per day: • Dublin–Limerick
Waterford	Dublin, Limerick, Shannon, Killarney, Cork, Wexford, Waterford, Longford	6 routes	7 per day: • Waterford–Dublin	one per day: • Waterford–Birmingham)	✓	5 per day: • Dublin–Limerick–Waterford
Sligo	Dublin, Galway, Cork, Derry, Athlone, Longford, Limerick, Belfast, Dundalk	1 route	2 at weekends only: • Sligo–Dublin • 1 at weekends only: • Sligo–Westport	1 per day: • Sligo–London	✓	5 per day: • Dublin (Connolly Station)–Sligo
Killarney	Dublin, Cork, Limerick, Tralee, Dingle, Ennis, Galway, Waterford, Wexford	None	None	2 per day: • Killarney–Bristol/ London 1 per day: • Killarney–Portsmouth 1 per day: • Killarney–Birmingham	✓	6 per day: • Dublin–Tralee–Killarney
Athlone	Dublin, Galway, Sligo, Portlaoise, Roscrea, Limerick	None	5 per day: • Athlone–Galway 5 per day: • Athlone–Dublin	None	✓	8 per day: • Dublin–Galway/Westport
Westport	Dublin, Cork, Limerick, Galway, Clifden, Sligo, Waterford, Belfast, Derry	None	1 at weekends only: • Sligo–Westport	1 per day: • Westport–London	✓	8 per day: • Dublin–Galway/Westport
Roscrea	Dublin, Limerick, Portlaoise, Cork, Athlone, Tralee, Sligo	None	6 per day: • Roscrea–Limerick 4 per day: • Roscrea–Dublin	None	✓	2 per day: • Dublin–Limerick (via Nenagh)
Portlaoise	Dublin, Limerick, Cork, Waterford, Athlone, Longford	None	3 per day: • Portlaoise–Dublin 2 per day: • Portlaoise–Carlow 2 per day: • Portlaoise–Kilkenny	None	✓	12 per day: • Dublin–Limerick line
Freshford	None	None	None	None	✓	None
Shinrone	Shinrone–Nenagh (1/day)	None	None	None	✓	None
Pallasgreen	Tipperary/Limerick route, 7 times per day	None	None	None	✓	None

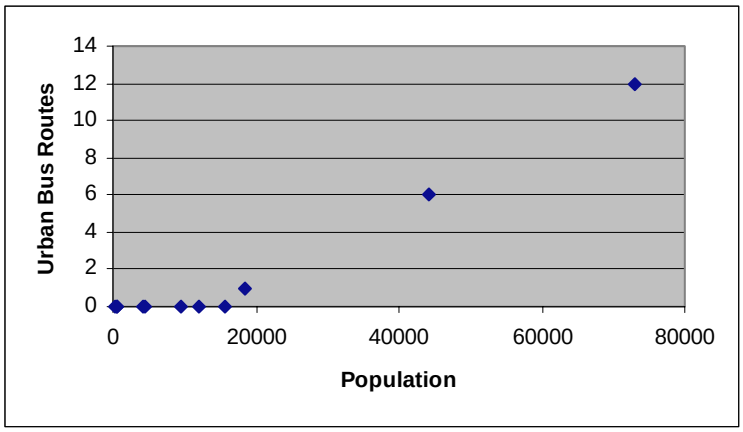

Figure 2.40. Urban bus routes vs. population size.

Why this indicator is relevant to sustainable development

As the majority of people work in the same place every day, these repeated and predictable journeys to and from work are ideally suited to public transport. Policies such as the provision of bus lanes and cycle lanes in Dublin and the construction of the light rail network (LUAS) are designed to increase provision of public transport. The greater the provision of public transport, the greater choice individuals have in selecting travel modes other than private car. Therefore, availability of public transport is a meaningful sustainability indicator.

What the analyses show

Larger settlements fare best in terms of the number of urban bus routes (important for reduction in dependence on car transport) and in terms of between-settlement connectivity to public transport (important to economic sustainability).

2.6.3 Impact indicators

2.6.3.1 Road fatalities and injuries

Data on road fatalities and injuries were obtained from the National Roads Authority (NRA). Tables 2.33 and 2.35 show the total number of persons killed and injured on Irish roads at county level from 1990 to 1998. These data were available at county level only and, therefore, only provide a guide at settlement level (Tables 2.34 and 2.36). Figures 2.41 and 2.42 show plots of total fatalities/settlement and total injuries/settlement over the last decade versus settlement population. In general, the total number of fatalities/injuries/settlement increases with population size. This is particularly true in the case of injuries, which show an almost directly proportional linear relationship.

Why this indicator is relevant to sustainable development

Data on road fatalities and injuries were obtained from the NRA. Each year the NRA produces a comprehensive analysis of all reported road accidents involving fatalities, personal injury or material damage that occur on Irish public roads. This report is based on road accident information recorded by the Garda Síochána and supplied to the NRA for processing and analysis. The numbers of both fatalities and injures on Irish roads are increasing exponentially. According to the *National Roads Needs Study* (NRA, 1998), 40% of accidents and 64% of fatal accidents occurred in rural areas, while 26% of injury accidents and 38% of fatal accidents occurred on national routes. The occurrence of deaths and injuries on the roads detracts from social and economic sustainability; therefore, numbers of deaths and injuries represents an important indicator of sustainability.

What the analyses show

Although research findings indicate that the number of fatalities/injuries/settlement increases with population size, national figures reveal the opposite, with the majority of fatal and non-fatal accidents occurring in rural areas. As data were available at county level only, this indicator is not completely reliable and may present a misleading indication in favour of smaller settlements.

Table 2.33. Persons killed/county (1990–1998 inc.).

County	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Limerick	26	20	23	23	13	21	21	29	23	199
Waterford	5	5	10	9	14	10	10	12	11	86
Sligo	9	6	5	6	3	6	6	4	2	47
Kerry	15	10	9	13	16	22	13	14	10	122
Westmeath	11	11	11	9	9	10	9	8	9	87
Mayo	15	15	11	14	21	16	15	12	17	136
Tipperary	20	12	27	29	14	12	16	22	23	175
Laois	11	8	10	9	9	7	13	17	14	98
Kilkenny	16	12	9	14	6	10	15	12	11	105
Offaly	6	9	10	10	6	6	10	7	10	74

Table 2.34. Total fatalities/settlement (1990–1998 inc.).

Settlement	Settlement population	Total fatalities	County population	Fatalities/capita	Fatalities/settlement
Limerick UB	52,039	199	165,042	0.001206	62.74622
Waterford	42,540	86	94,680	0.000908	38.64005
Sligo	17,786	47	55,821	0.000842	14.9754
Killarney	8809	122	126,130	0.000967	8.520558
Athlone	7691	87	63,314	0.001374	10.56823
Westport	4253	136	111,524	0.001219	5.186399
Roscrea	4170	175	58,021	0.003016	12.57734
Portlaoise	3531	98	52,945	0.001851	6.535801
Freshford	632	105	75,336	0.001394	0.880854
Shinrone	479	74	59,117	0.001252	0.599591
Pallasgreen	303	199	165,042	0.001206	0.365343

Table 2.35. Persons injured/county (1990–1998 inc.).

County	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Limerick	593	491	570	538	578	596	680	631	619	5296
Waterford	208	222	293	281	291	273	286	314	303	2471
Sligo	200	237	188	181	148	188	181	208	176	1707
Kerry	385	327	433	352	435	426	475	444	404	3681
Westmeath	208	153	206	188	170	225	160	242	176	1728
Mayo	286	307	302	335	291	279	339	438	330	2907
Tipperary	361	330	399	353	366	352	409	449	450	3469
Laois	171	154	133	141	113	183	200	171	182	1448
Kilkenny	175	156	192	211	204	227	265	233	267	1930
Offaly	140	168	123	141	148	165	117	156	154	1312

Table 2.36. Total injuries/settlement (1990–1998 inc.).

Settlement	Settlement population	Total injuries	County population	Injuries/capita	Injuries/settlement
Limerick UB	52,039	5296	165,042	0.032089	1669.869
Waterford	42,540	2471	94,680	0.026098	1110.228
Sligo	17,786	1707	55,821	0.03058	543.8939
Killarney	8809	3681	126,130	0.029184	257.0834
Athlone	7691	1728	63,314	0.027293	209.9069
Westport	4253	2907	111,524	0.026066	110.8593
Roscrea	4170	3469	58,021	0.059789	249.3189
Portlaoise	3531	1448	52,945	0.027349	96.5698
Freshford	632	1930	75,336	0.025619	16.19093
Shinrone	479	1312	59,117	0.022193	10.63058
Pallasgreen	303	5296	165,042	0.032089	9.722907

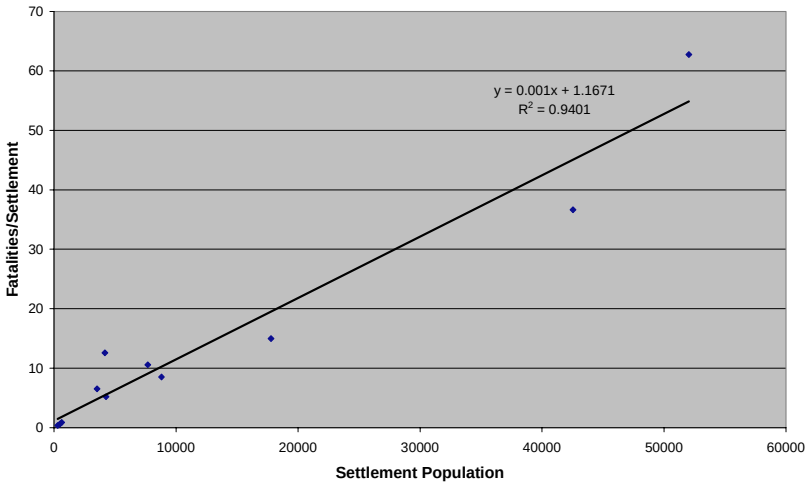

Figure 2.41. Total road fatalities/settlement (1990–1998 inc.).

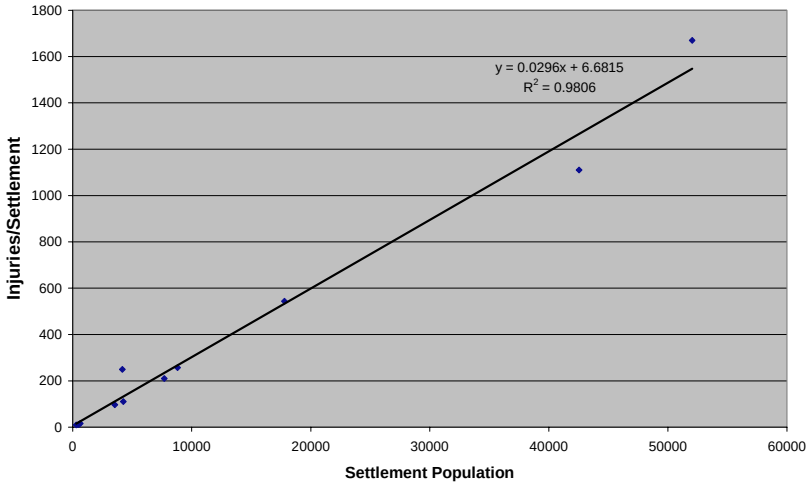

Figure 2.42. Total road injuries/settlement (1990–1998 inc.).

2.7 Economic indicators displaying sensitivity to settlement size

2.7.1 Impact indicators

2.7.1.1 Distance travelled to work

The 1991 and 1996 Censuses provide data on distance of daily travel. While it is recognised that, at national scale, average distance to work/school/college tends to increase in a zone surrounding larger settlements, no such pattern was evident for the sample of settlements considered herein (Table 2.37; Figs. 2.43–2.50). The percentage increase between 1991 and 1996 in number of people travelling 10 miles or more was 23.9% for Limerick, 31.1% for Sligo, 37% for Athlone, 64.2% for Killarney, 70.7% for Portlaoise, and 77.4% for Waterford. The comparable percentage increases for people travelling 5 miles or more were 10.5% for Waterford, 10.9% for Sligo, 14.4% for Athlone, 16.8% for Killarney, 25.5% for Limerick and 25.9% for Portlaoise. Data for other settlements were not available. On the basis of this sample of settlements, it is not possible identify a clear relationship between settlement size and temporal trends in length of journey to work/education for those travelling relatively longer daily journeys. Also analysed were data for persons travelling distances of up to and including 2 miles (Table 2.38).

Table 2.37. Distances travelled by workforce in larger settlements.

Settlement	Year	Total workforce	<2 miles	2 miles	3 miles	4 miles	5–9 miles	10–14 miles	15 miles	Not stated
Limerick	1981	17,857	6081	3850	1918	815	722	498	2044	1933
	1986	15,612	4928	3243	1816	884	768	542	1262	2169
	1994	23,225	6530	4133	3438	1621	1814	827	2136	2726
	1996	27,538	7240	4787	4284	2142	2651	1072	2599	2763
Waterford	1981	11,993	4705	3027	1728	535	372	85	196	1345
	1986	11,522	4245	2883	1505	509	401	89	184	1706
	1994	13,266	4980	3123	2042	644	549	95	264	1569
	1996	15,097	5536	3436	2359	879	793	163	474	1457
Sligo	1991	5997	2928	1221	302	99	202	67	235	943
	1996	6813	3219	1467	483	160	255	91	305	833
Killarney	1991	2959	1399	417	175	63	51	67	190	597
	1996	3687	1688	559	201	78	88	98	324	651
Athlone	1991	5085	2049	1089	560	149	156	63	270	749
	1996	5482	2025	1255	614	198	236	87	368	699
Portlaoise	1991	2435	1306	348	45	18	111	76	248	283
	1996	3179	3179	1508	496	96	31	192	101	452

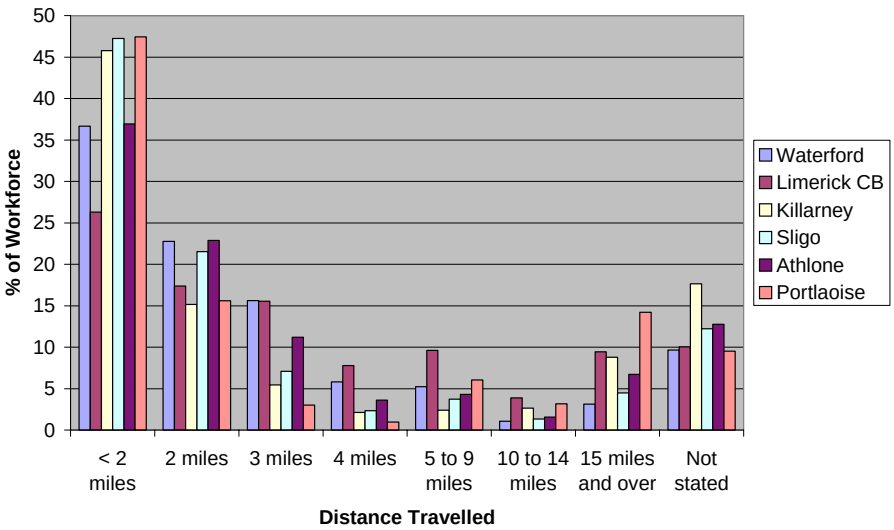

Figure 2.43. Distance travelled to work by persons in larger settlements.

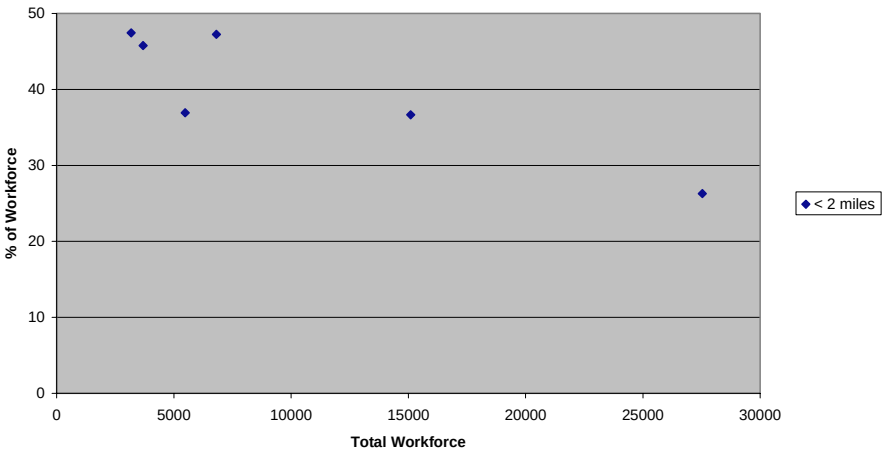

Figure 2.44. Percent workforce travelling <2 miles in larger settlements.

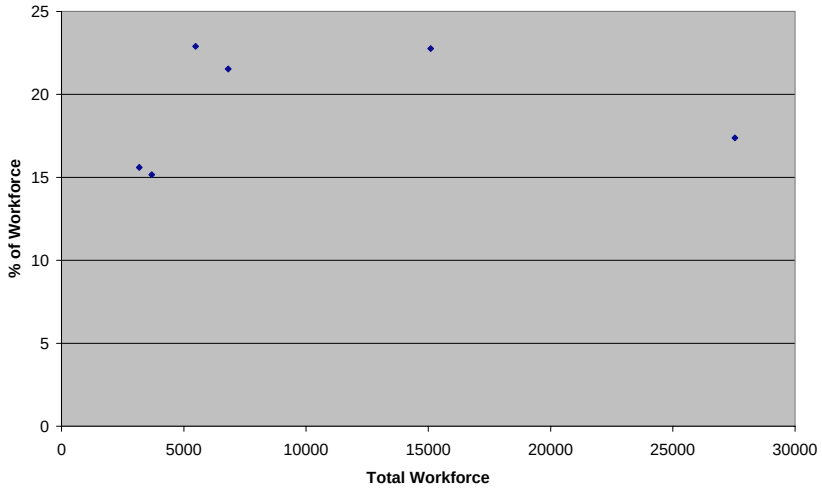

Figure 2.45. Percent workforce travelling 2 miles in larger settlements.

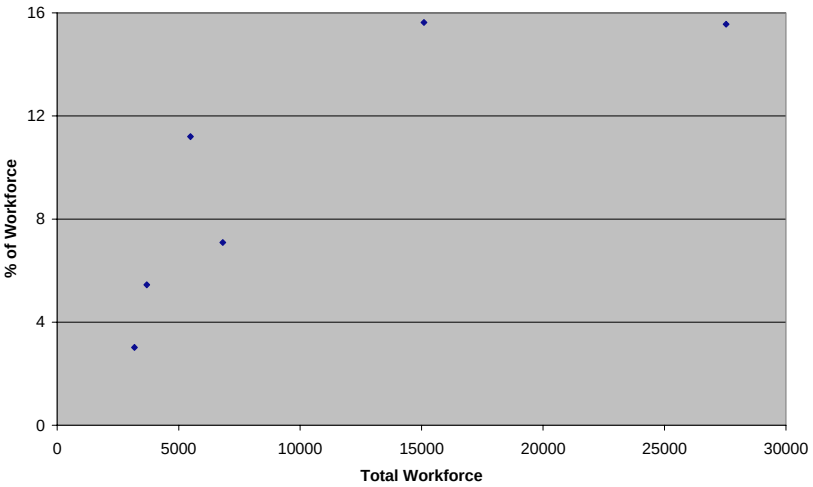

Figure 2.46. Percent workforce travelling 3 miles in larger settlements.

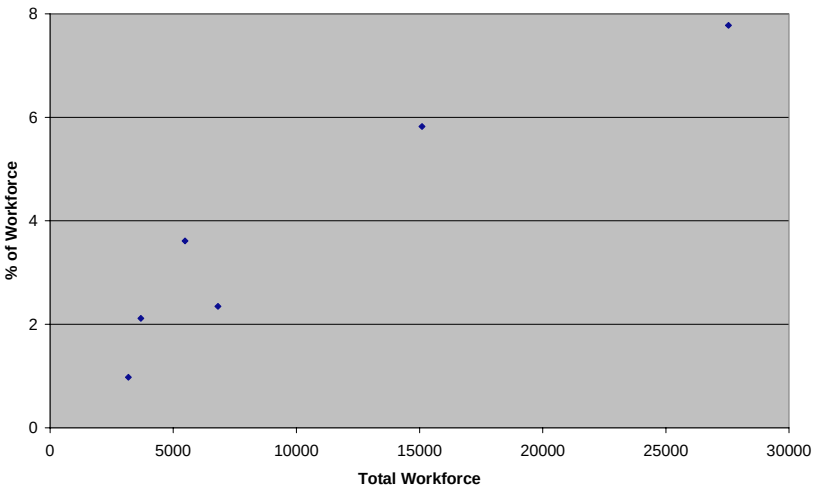

Figure 2.47. Percent workforce travelling 4 miles in larger settlements.

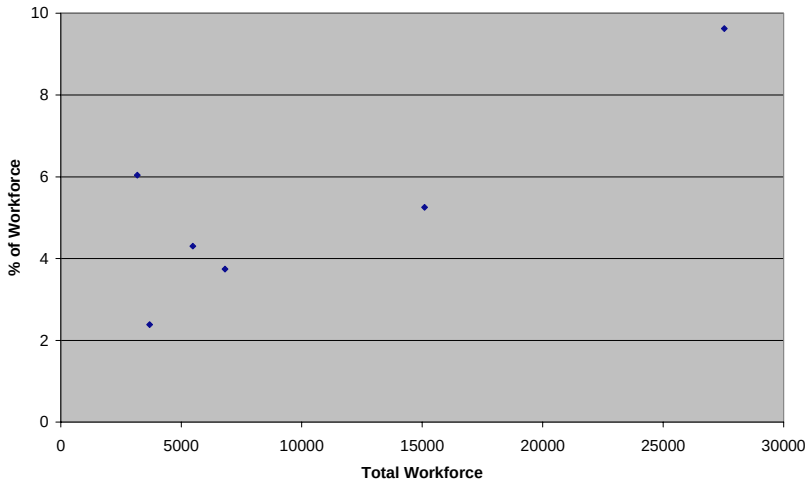

Figure 2.48. Percent workforce travelling 5–9 miles in larger settlements.

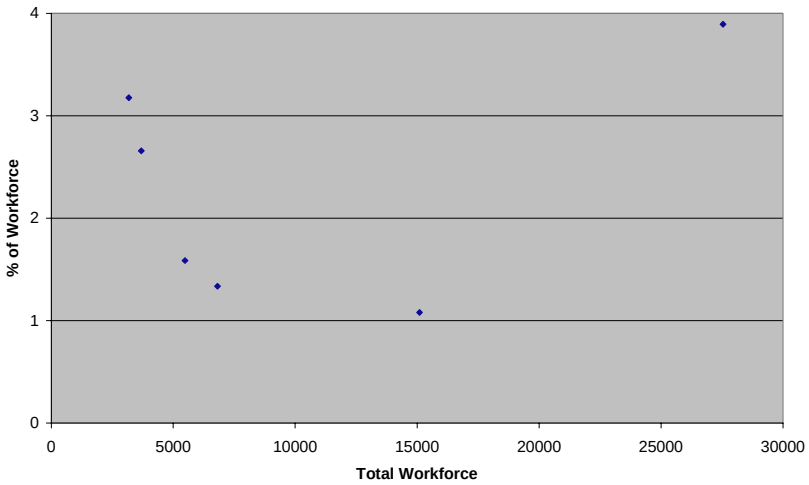

Figure 2.49. Percent workforce travelling 10–14 miles in larger settlements.

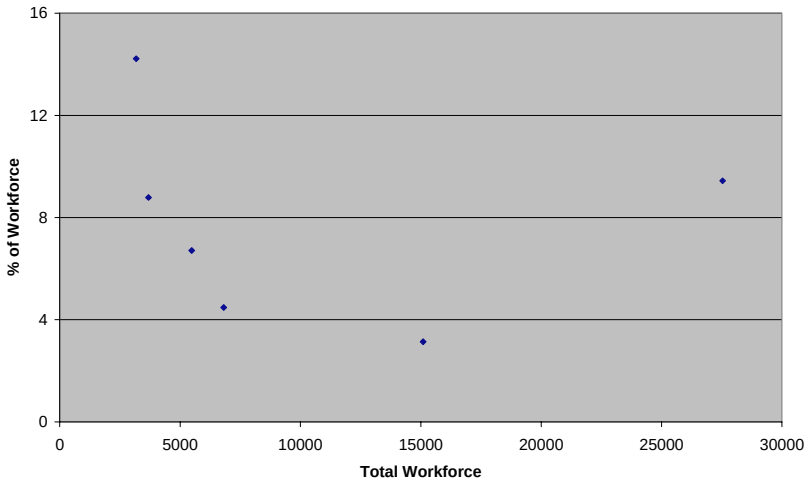

Figure 2.50. Percent workforce travelling 15+ miles in larger settlements.

Table 2.38. Travel 2 miles or less to work.

Settlement (ranked by population size)	Percentage of Census respondents 1991	Percentage of Census respondents 1996	Change 1991–1996 (%)
Limerick	28.1	26.3	–1.8
Waterford	37.5	36.7	–0.8
Sligo	48.8	47.2	–1.6
Killarney	47.2	45.8	–1.4
Athlone	40.3	36.9	–3.4
Portlaoise	53.6	47.4	–6.2

Table 2.39. Travel 3 miles or less to work.

Settlement	Percentage of Census respondents 1991	Percentage of Census respondents 1996	Change 1991–1996 (%)
Limerick	60.7	59.2	–1.5
Waterford	76.5	75.1	–1.4
Sligo	74.2	75.9	+1.7
Killarney	67.3	66.4	–0.9
Athlone	72.2	71.0	–1.2
Portlaoise	69.8	66.1	–3.7

Larger settlements had smaller proportions of people travelling relatively short daily distances. As a rule, smaller settlements contained a greater proportion of people travelling shorter journeys, but there was a relatively greater reduction between 1991 and 1996 in some of these settlements. Values calculated for journeys of up to and including 3 miles (Table 2.39) failed to show a similar pattern.

Why this indicator is relevant to sustainable development

The greater the distance travelled each day, the greater the per-capita use of resources and generation of pollution. Distance travelled to work has a major impact on the mode of transport most frequently used. Typically, the longer the journey, the greater the reliance on private cars, with resultant greater inefficiencies. In 1996, workers travelled on average 10.7 km to their place of work (an increase of 7.6 km since 1991). Secondary school children travelled on average 6.2 km in 1998, and third-level students travelled 7.3 km in 1981 and 11.6 km in 1996. Trends, therefore, suggest that Ireland is moving counter to sustainable development; planning has resulted in greater distances between places of work and places of residence. The distance of journey to work/education is, therefore, an important indicator of sustainability.

What the analyses show

A reduction in the need to travel long distances to workplace/education is significant in planning for sustainability, as travel uses resources and generates pollution. Congestion reduces urban quality of life. Data presented on distance to workplace/education and the modes of transport to workplace/education do not present a clear picture of differences between settlements of varying size. The sample size of settlements was perhaps too small to provide adequate data. While in larger settlements a smaller proportion of people walked to work/education, this was offset by the larger number of people using buses. Within larger settlements, it is perhaps not surprising that fewer people live within walking distance of work/education. Clear differences in daily distances travelled within settlements between 1991 and 1996 were recorded for six settlements only. A clear pattern did not emerge, thus preventing straightforward analysis. People in some smaller settlements generally travelled shorter distances, but such differences were less apparent in 1996 than in 1991. Thus, it could not be shown that smaller settlements offer significant long-term benefits in relation to daily movements of people.

2.8 Qualitative assessment and model settlements

Table 2.40 provides a qualitative description of employment, waste management, services and transport infrastructure for Shinrone, Co. Offaly, and Pallasgreen, Co. Limerick (for which few or no empirical data exist). Given the overall lack of indicator data, it was decided to use Freshford, Co. Kilkenny (as an example of a small rural settlement), and Limerick City (large urban centre) as 'model settlements'. These are described in Sections 2.8.3 and 2.8.4.

2.8.1 Pallasgreen, Co. Limerick

Pallasgreen or Pallasgreane (Pailis Ghreine in Irish translates as Grian's Palisade) is a village in County Limerick. It is situated at a crossroads approximately 22 km from Limerick City and 20 km from Tipperary Town. Some 5 km north-east stands the former stronghold of Castle Garde. This consists of a five-storied tower linked to a more modern wing and is thought to be County Limerick's oldest inhabited house. South of the Castle, the Dead River and the Bilbao River unite to form the Mulkear River, a tributary of the River Shannon.

Table 2.40. Qualitative description of Shinrone and Pallasgreen.

Village	Population	Employment	Transport	Waste	Services
Pallasgreen, Co. Limerick	303 (1996)	Data commercially sensitive	Tipperary/Limerick bus – runs 7 times daily	Co. Council and private refuse collectors operating in area. Village is linked to mains water supply and some dwellings outside the village have septic tanks. The municipal waste collected by Limerick Co. Council is disposed at Gortadroma Landfill. Water supply is from boreholes and shallow well sources. This supplies a population of 1600. Water treatment is by chlorination. The sewage treatment facility is a package plant that serves a population of 1600 and requires upgrading to allow further development in the area.	Garda station, school, playschool, post office, butchers, small supermarket and petrol, 3 pubs, hairdressers, butchers, insurance agent, nursing home, hardware and agri. supply, community centre, church, undertaker
Shinrone, Co. Offaly	479 (1996)	Data commercially sensitive	Shinrone is serviced by the Limerick–Dublin bus, which runs every hour (quarter to the hour). The bus does not service Shinrone directly but stops at Roscrea, which is a 15-min drive from Shinrone. From the Limerick direction, one daily bus serves Shinrone stopping in Nenagh, Co. Tipperary. It leaves Limerick at 4.30 p.m. and arrives in Shinrone at 6.45 p.m.	Wastewater treatment plant constructed in 1973 for a 500 p.e. Secondary treatment consisting of oxidation ditch and clarifier. Receiving water is tributary of Little Brosna. Sludge is disposed of by mobile desludging unit and then disposed to landfill. Shinrone water supply is sourced from boreholes (groundwater). Treatment is by disinfectant (sodium hypochlorite). Daily water consumption is 42,000 gallons. Capacity of source is 240, 000 gallons/day. Domestic waste collection is by private collector.	School, library, post office, 4 pubs 3 shops – 1 with petrol, 3 pubs, B&B, nursing home, hardware and agri. supply, community centre, 3 churches, furniture workshop and glass factory

The population in 1996 was 303 people; however, this has increased, as there have been a number of new dwellings constructed recently. Most services in the settlement are on or close to the main Limerick–Tipperary Road, while most dwellings are situated off it. Pallasgreen and its hinterland are experiencing difficulties with water treatment and sewage facilities and the village is 18th in line to have these water treatment facilities replaced. The sewage is treated in a package plant, which serves a population of 1600. The plant is at full capacity and future development will require upgrading. Employment opportunities in the village itself are limited although they have improved in recent years. Most people leave the village and travel to either Tipperary or, most commonly, Limerick for employment. The public transport service is adequate and there is some car-pooling arranged locally. At present, there are plans to build a €95m by-pass of the village.

2.8.2 Shinrone, Co. Offaly

County Offaly is situated in the heart of Ireland, covering some 493,836 acres (199,934 ha) and has common boundaries with Meath, Kildare, Laois, Tipperary North, Galway, Roscommon and Westmeath. The east of the county is within commuting distance of the rapidly expanding metropolitan area of Dublin. In 1996, the population of Shinrone was 479 people but this has increased recently with the completion of some new dwellings. Shinrone has a good range of services but is not directly serviced by any public transport.

2.8.3 Freshford, Co. Kilkenny

Freshford is situated 13 km north-west of Kilkenny City on the R693. The village is located on the River Nuenna, a tributary of the River Nore, and is built on an ancient monastic site that dates back to the 6th Century.

Freshford District 2020 was formed in January 2000 and comprises members of the local business community and local residents and stakeholders of Freshford Heritage and Tidy Towns committee. It was envisaged that Freshford would become a model village incorporating renewable energy sources such as wind, solar and hydropower.

The findings of a Freshford District 2020 survey regarding the future development of Freshford were submitted to the County Development Board. The main recommendations of the Freshford District 2020 Draft Proposal include upgrading the existing sewage works to accommodate a greater capacity for sewage treatment, and the development of a virtual business park in the village. Other recommendations include expanding community facilities to allow development of a Community Resource Centre, which would accommodate new business enterprises, provide adult education, house a public library, IT centre and Credit Union.

2.8.3.1 Demographics

Statistics from the 1991 and 1996 Censuses show a decline in the numbers of both male and female residents in Freshford Village. In 1991, the number was 651 residents compared to 632 residents in 1996. The majority of residents are in the 25–44 and the 65+ age brackets.

The high numbers in the 65+ category can be explained by the presence of two residential homes for the elderly in the village.

2.8.3.2 Culture

Eleven percent of Freshford residents speak Irish in their households, while 43% watch TG 4, 12% listen to Radio na Gaeltachta, 14% partake in Irish dancing and 20% play an Irish instrument.

The Heritage Council of Ireland has just completed a conservation plan for St Lachtain’s Church in the village. The Council has established Freshford as a village of significant architectural and historical importance. There is a Millennium Park planned for the future, to be developed on a 0.6-ha site on the outskirts of the village. This will provide a valuable recreational amenity for locals and visitors alike.

2.8.3.3 Employment

The results of the survey revealed that 60% of respondents felt that employment opportunities in the village were adequate. Freshford is largely an agricultural community and many of the larger businesses in the area are based on agriculture or its by-products. These include, for example, Honey Clover, Glanbia and B+C Cheese Processing. Dairy, tillage and beef are the main farming activities, although pig and deer farming and horse breed-

ing are not uncommon. Other significant employers in the area include Uppercourt Antiques, Tallis Construction and J&G Printers. There are upwards of 300 people employed in the village, with vacancies still available in the meat industry, construction and printing. There are a number of Eastern Europeans employed due to the non-availability of local labour. Most industries are undergoing expansion.

In the past, agriculture had been the main industry and source of employment. However, Ireland's unprecedented rate of economic development is currently channelling members of the Freshford workforce into industry and the building trade.

2.8.3.4 Industry

The meat industry is the traditional industry in Freshford. However, there is also an expanding printing works and a growing packaging and processing industry. The level of activity in the construction and service industries is moderately high but static and is unlikely to increase until the present sewage treatment problems are resolved. The growth in information technology and Kilkenny's status as an Information Age Town provide the ideal opportunity for the development of a virtual business park in the Freshford area.

2.8.3.5 Environment

The River Water Quality Report (EPA, 1999c) includes the sample test results for the River Nuenna taken at three locations. The assessment concludes that nitrates are elevated, but otherwise the physico–chemical data are satisfactory. However, the biological data indicate a loss of quality in the Freshford area. The report explains that in cases where the median levels of nitrate exceed 5 mg/l, a chronic level of enrichment is indicated. In the case of the River Nuenna, median levels were in the range of 6.20–8.20 mg/l. However, it was stressed that these levels did not exceed the maximum limits set down in the national regulations, i.e. 11.3 mg/l. Nitrate pollution is largely due to run-off from farms and slurry spreading, and other sources of pollution include over-spill from sewage plants, chemical sprays, pesticides, herbicides and sheep dip. There is also a possible risk of pollution from local industrial waste and factory run-off.

Of the Freshford residents surveyed, 73% were not satisfied with the quality of the drinking water. This statistic represents those in the County Council water scheme and those with private wells. Approximately 25–30 m^3/h is pumped along the Freshford spur from the Troyswood treatment plant.

The supply of domestic water in Kilkenny County and City is free of charge, but there are indications that this may change, and water for industrial uses is metered and charged. One of the aims of the 2020 Group is to seek alternative sources of drinking water in the area.

Of the households surveyed, 72% expressed serious concerns about the existing sewage treatment facilities in Freshford. The Council will allow no new housing developments in Freshford unless the developers provide their own sewage treatment plants. This may have a knock-on effect on potential investment in the area. An aim of the 2020 Group is to achieve a sustainable and ecologically sound sewage treatment system. This would probably be based on a Bio Gas Digester, which would pasteurise and digest sewage, farm slurry, abattoir waste and all other organic material. It would transform organic waste into a readily usable and non-toxic liquid fertiliser for farmers and growers in the area, while also producing sufficient gas for low-cost industrial energy requirements.

2.8.3.6 Planning and development

At present, no development plan exists in Freshford. There are development plans being formulated by Kilkenny County Council for Graiguenamanagh, Callan, Thomastown and Castlecomer, scheduled for completion by November 2001. Kilkenny County Council will then formulate development plans for the smaller villages and towns. Kilkenny County Council indicates that all interested parties will be afforded the opportunity to make submissions and have discussions regarding the proposed plan. At the moment, unless the sewage system is updated it is impossible to obtain planning permission.

Currently, there are 20 people on the waiting list for social housing. The numbers of houses built recently are low, with only four being built in 1998, and none subsequently. Future housing developments are dependent upon an upgraded and more environmentally benign sewage treatment plant.

2.8.3.7 Roads and traffic

Of those surveyed, 58% expressed concern at the volume of traffic in the village. The current road system is barely adequate for present needs and is not capable of handling more traffic. The main problems are that the streets are not wide enough to cater for on-street parking and passing traffic, and the volume and size of vehicles has increased in recent years. Almost every approach road has a bridge and while these add to the 'old-world' charm of the village, they were not designed with current traffic volumes in mind.

Although Freshford District 2020 development committee is in the process of submitting proposals to Kilkenny County Council as part of working towards a more sustainable future for the village, there are a number of key environmental and socio–economic issues that must be urgently addressed. A strategic and fundamental weakness is the lack of a well-managed and environmentally efficient sewage treatment plant in the village. Although Kilkenny County Council has acknowledged this problem, Freshford is low on the list of priorities, which favour larger settlements in County Kilkenny. There is also growing local concern about the quality of drinking water in the village. These environmental problems are having an effect on the population in the area, as the rate of house building (both private and local authority) has declined considerably in recent years. This is because few planning permission requests can be granted until the sewage treatment infrastructure is significantly upgraded. Similarly, this problem is discouraging potential industrial and commercial investors to the area. Planning permission will not be granted unless investors include specific plans for sewage and wastewater treatment in their planning applications. The current roads through the village are too narrow to accommodate annually growing traffic. This results in serious congestion problems in the village on a daily basis. As no development plan currently exists for Freshford (see section 2.8.3.6), for the moment, there is no clear indication that improvements to sustainability will take place.

We acknowledge invaluable assistance provided by Freshford District 2020.

2.8.4 Limerick City

Limerick is the focal settlement of the Mid-West region in terms of geographical location and transport infrastructure. The topography of the Limerick hinterland is characterised by relatively flat, fertile and low-lying agricultural land. The city is a significant administrative, commercial and industrial centre, partly due to its location near Shannon Airport in Co. Clare and Limerick Harbour. The University of Limerick (UL), Limerick Institute of Technology (LIT) and Shannon Airport are major catalysts for inward investment and research and development. As a result of its central location and accessibility, the *National Development Plan (NDP) 2000–2006* identifies Limerick as a potential 'Gateway' for wider regional development. The NDP 2000–2006 identifies the importance of Gateways as:

"*centres which have a strategic location, relative to the surrounding territory, possess good social and economic infrastructure and support services and have the potential to open up their zones of influence to further development by providing transport links with contiguous zones*".

A goal of the NDP is to achieve sustainable economic growth but it also sets out coherent development strategies in the key areas of infrastructural development, education and training, the productive sector and the promotion of social inclusion (NDP, 1999).

Local development in Ireland is primarily guided by local authority County and City Development Plans, and the 1998 Limerick City Development Plan is the current plan.

The Limerick City Borough area, which covers the inner city, is administered by Limerick Corporation. This plan is currently under revision by a newly created Limerick City Development Board, which is required, by early 2002, to deliver a strategic development plan for the next 5 years. The total area within the administrative boundary is 2086 ha. The population of Limerick City was in decline during the 1980s and early 1990s. The fall in population in Limerick County Borough has coincided with a significant increase in the population of the suburbs. As the Limerick suburbs are under the jurisdiction of Limer-

ick County Council, this has created administrative problems for both local authorities.

In 1996, Limerick Corporation prepared an application to government to extend its authority over a further 6541 ha, to cover the greater city area. This would result in some land currently in Counties Limerick and Clare being included within the administrative boundary of Limerick Corporation, and an increase in the present population from 52,039 to 82,257, an increase of 30,218. This proposed extension is creating several administrative problems for Limerick Corporation and County Council. The lack of available development land within the Corporation's jurisdiction means that the majority of new housing completions are in the suburbs, contributing to low-density urban sprawl. Raheen Industrial Estate lies within the functional area of Limerick County Council; therefore, Limerick Corporation is losing revenue from land rates and rent. By extending the city boundary, Limerick County Council will lose this revenue to Limerick Corporation.

2.8.4.1 Urban wastewater treatment

Approximately 68% of the population of Ireland live in urban areas and are connected to sewage systems. The remainder live in rural areas and use septic tanks for treatment of sewage. The capacities of sewage treatment plants in Ireland vary quite substantially, from those with a capacity of less than 2000 p.e. (population equivalents), to those with the capacity to process over 10,000 p.e. There are 619 sewage schemes in the country serving populations greater than 200. Of the 619 schemes, 95 have no treatment (these discharge to tidal waters), 218 have primary treatment, 289 have secondary treatment, and 17 have tertiary treatment. Limerick Corporation is responsible for the provision of adequate water supplies and the treatment of sewage and drainage in Limerick County Borough. In 1996, Limerick Corporation spent in excess of IR£4.5 million on water services and sewage treatment systems.

Limerick has over 70,000 people living within a 5-km radius of the city centre. There are over 21,000 households that use the city sewage system. Each household generates, on average, 150–250 gallons of waste water per day. The city drainage infrastructure covers a catchment area of 30 km^2. Presently, there are no wastewater treatment facilities in the city and consequently, approximately 4 million gallons of waste water are discharged daily to the Abbey and Shannon Rivers and canal through 50 separate outfalls.

Limerick Corporation was, until very recently, in breach of the EPA Act (1992) and the Urban Waste Water Regulations (1994). These requirements state that for a population greater than 15,000 with freshwater or estuarine receiving waters, secondary treatment should be installed by the 31st of December 2000. This would then satisfy all relevant legislation, such as the Freshwater Fish Directive, the Water Pollution Act, the Shellfish Directive, the Bathing Water Directive and the Surface Water Directive (EPA, 2000).

The Limerick Main Drainage Project is currently (2001) under way, with the purpose of rectifying the problem of the untreated sewage discharges into the Abbey and Shannon Rivers. The existing drainage system is to be significantly upgraded through the provision of new interceptor sewers and pumping stations. The overall investment in the project will be in excess of IR£130 million, which will result in an improved infrastructure necessary for the development of the city and the protection of the water quality of the Shannon Estuary. Preliminary work on the Limerick Main Drainage Scheme commenced on the 5th of October 2000. The overall contract time is 2 years, with completion due in October 2002.

The main sewer will be constructed using a tunnel-boring machine similar to the technology used in the construction of the Channel Tunnel. The machine has been designed specifically to suit the ground conditions in Limerick, based on studies carried out by specialist tunnelling consultants and geologists. The treatment plant site is located to the south-west of Limerick City centre and the main sewer will be 2.7 m in internal diameter and 2.58 km in length, with 12 access shafts for maintenance.

2.8.4.2 Drinking water quality

More than 3.3 billion gallons of water were produced, with over 6 million gallons per day being consumed in the city alone.

Several parameters are used to determine the quality of drinking water. These include measurements of the levels of aluminium, fluoride, total and faecal coliform. The respective maximum admissible concentrations (MACs), as identified in the Quality of Water Intended for Human Consumption Regulations 1988, are 0.2 mg/l Al, 1000 mg/l Fl and 0 coliform/100 ml.

Figure 2.51 shows drinking water quality in Limerick City from 1990 to 1997, as analysed by Limerick Corporation's Water Pollution Laboratory. The current (2001) treatment processes used for Limerick City's drinking water supply are: (1) flocculation, (2) RG filtration, (3) pH control, (4) fluoridation, (5) chlorination and (6) activated carbon.

With the exception of 1991 and 1992, 10% of the samples analysed exceeded the MAC for aluminium, with the worst results in 1993, when 50% of samples had concentrations over 0.2 mg/l Al. Aluminium has been implicated in the pathology of Alzheimer's disease. Currently there are insufficient data to derive a standard for aluminium in drinking water based on health effects, and, therefore, the MAC level is currently under debate.

The quality of drinking water from the mains is often poor, and leakage is a problem, estimated to be approximately 30% of total consumption.

2.8.4.3 Air quality

Air pollutants can be divided into two categories: primary and secondary. Primary pollutants include sulphur dioxide (SO_2), nitrogen oxide (NO_x), hydrocarbons (HC), carbon monoxide (CO) and heavy metals such as lead and cadmium. Secondary pollutants are sulphur and nitrogen compounds. SO_2 and particulates are classified as primary air pollutants as they are both emitted directly into the air. SO_2 is a colourless, odourless gas, which once emitted into the atmosphere may be converted into fine particulate sulphate, which has many adverse effects on animal and plant life. Because of their toxicity and harmful effects on human health, the EC in the late 1970s set as a priority the reduction of SO_2 and suspended particulates in the atmosphere. This led to the adoption of Council Directive 80/779/EEC, which established annual and winter limit values and guide values for SO_2 and suspended particulates in the atmosphere.

Atmospheric pollution monitoring is carried out by the Environmental Health Section of the Mid-Western Health Board on behalf of Limerick Corporation.

The work unit consists of:

1. Legislative control of atmospheric pollution under:
   (i) Local Government (Sanitary Services) Act 1962, the Control of Atmospheric Pollution Regulations 1970
   (ii) Local Government (Planning and Development) Acts and Regulations, 1963–1982
   (iii) EEC Directive (80/779/EEC) on Air Quality Standards
   (iv) Air Pollution Act, 1987 and Regulations made thereunder;

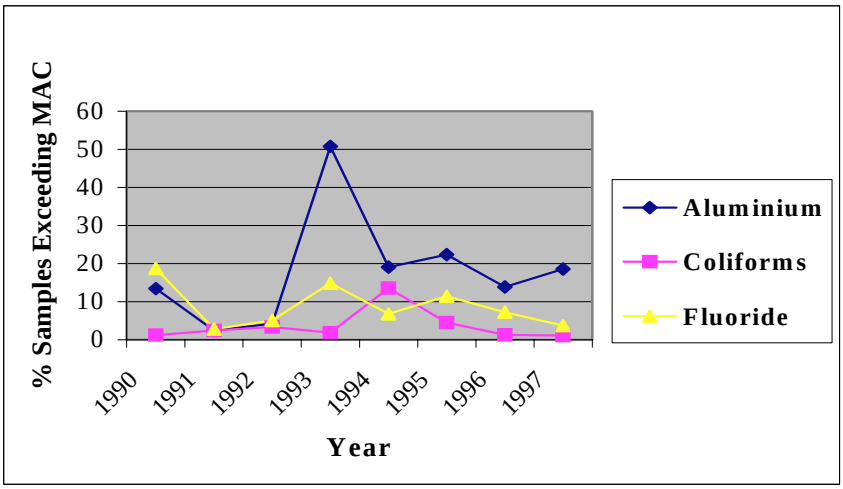

Figure 2.51. Drinking water samples exceeding MAC levels.

2. Daily monitoring of suspended particulates (smoke) and SO_2 levels in the city area, and

3. Investigation of complaints in relation to atmospheric pollution.

The purpose of the work is to advise Limerick Corporation on:

1. the current state of air quality in Limerick City and the trends in air quality,

2. the concentration of pollutants exceeding or approaching levels that could be injurious to public health generally or to a susceptible or vulnerable section of the population,

3. the highest concentrations of air pollutants found in the city,

4. whether air quality is in compliance with the EU limit values for smoke and SO_2, and

5. whether the air quality is in compliance with any standards or emission limit, values that may be specified by the Minister (Sections 50 and 51 of the Air Pollution Act, 1987).

There are three sampling stations in the Limerick Corporation functional area:

Station 1: Moyross Depot, 2.5 m above ground level: residential;

Station 2: Southill Depot, 2.5 m above ground level: residential/ commercial;

Station 3: Todd's City Centre, 15 m above ground level: commercial.

Figure 2.52 shows smoke levels recorded at Limerick City's three sampling stations from 1994 to 1999 (data for previous years unavailable). The commercial sampling site, a shop in the main commercial street, consistently recorded the highest levels of smoke. However, the highest recorded concentration in 1994 did not exceed the air quality standard of 40 $\mu g/m^3$.

SO_2 and particulates are relatively harmless when found in isolation in the atmosphere. However, they have a tendency to react with other constituents, resulting in secondary pollutants. Particulates that enter the lungs may lodge there and have chronic effects. The most significant fine particulate matter pollutants are sulphates. From 1st October 1998 the ban on the marketing, sale and distribution of bituminous coal was introduced in Limerick City and adjoining built-up areas in Limerick County and Clare. This ban accounts for the drop in annual mean smoke levels from 1998 onwards. The bans were introduced to address the concomitant smog problem, which adversely affected public health and resulted in increased hospital admissions.

The ban on bituminous coal in Limerick inadvertently resulted in an increase in the levels of SO_2 (Fig. 2.53). This increase was attributed to the burning of illegal smokeless fuels such as unblended petroleum cokes (petcokes).

The most obvious increase in SO_2 occurred in the Moyross area. This may be due to difficulties in monitoring fuels burned in some residential areas.

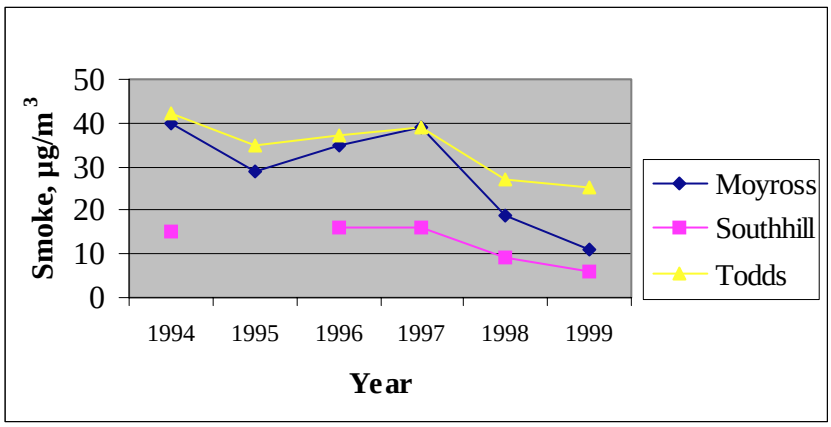

Figure 2.52. Average smoke levels in Limerick City 1994–1999.

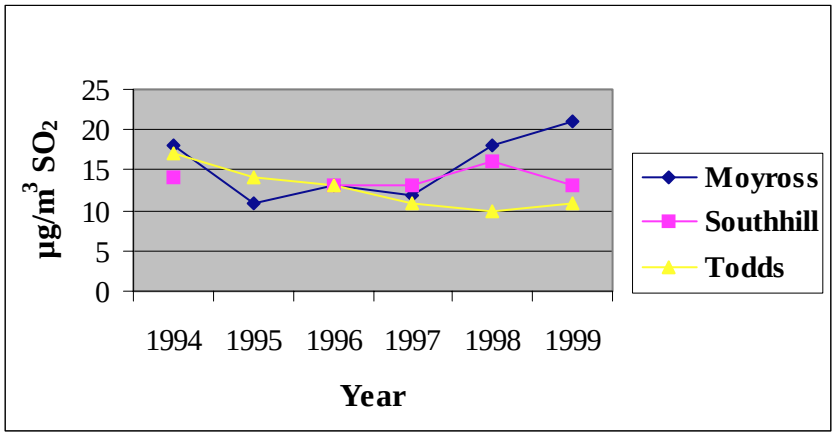

Figure 2.53. Average SO_2 levels in Limerick City 1994–1999.

2.8.4.4 Waste disposal

The *National Waste Database Report* estimates that the per-capita production of household waste is 0.38 t (380 kg) per annum. On this basis, the theoretical waste arisings in Limerick City, based on the population in the 1996 Census of Population, is 19,775 t per annum.

It is estimated by Limerick Corporation that 50,000 t domestic waste, 37,000 t industrial waste, 21,000 t commercial waste, 50,000 t commercial waste and 2000 t of street-sweeping litter are produced each year in Limerick City and County. The annual costs to Limerick Corporation include IR£800,000 for refuse collection, £1.1 million for waste transfer and disposal, and £1 million for street sweeping.

As part of fulfilling the requirements of the DoELG Waste Management Policy Statement, *Changing Our Ways* (1998), Limerick Corporation was the first borough corporation to introduce the 'wheel bin' domestic refuse collection service. A scheme was introduced in 1997 to recover some of this waste material. The DoELG requested Limerick Corporation to operate a pilot scheme for the composting of organic waste. The organic fraction is essentially vegetable-derived organic waste, for example, vegetable peelings, cardboard, grass clippings and newspapers. The objective of this pilot scheme was to reduce the amount of municipal waste going to landfill by 30%. The compost was intended to be used as cover material for landfill, for road verges and ultimately for sale to gardeners. The material is also suitable for the production of briquettes.

Mr Binman, a private waste disposal company established in 1993, was one of the first companies in the region with a full EPA waste license. In 1995, it began operating a waste transfer station at Luddenmore. Since then, Mr Binman has expanded to provide a wide range of waste disposal and recycling facilities to an ever-increasing customer base.

With growing environmental concerns about the quantities of waste produced and its disposal, Mr Binman recognises the need to explore new and improved methods of management and disposal. Mr Binman is committed to reducing the amount of waste going to landfill and is currently in the process of installing a number of new facilities for the recovery of recyclables.

Mr Binman has replaced the waste collection service previously supplied by Limerick Corporation. It now serves a domestic customer base of 28,000, with an additional 2000 commercial clients, making it the largest commercial waste disposal company in the Mid-West region.

Waste collected by the refuse vehicles is transported to Luddenmore, where it is categorised and re-compacted prior to being transported to Limerick County Council's landfill site at Gortadroma. Some goes to Co. Clare when windy conditions prevail. As well as the transfer of waste, Mr Binman also operates a recycling scheme for glass, cardboard, aluminium, timber and demolition wastes.

Mr Binman prepares regular reports on the operation of the transfer station and recycling centre. Due to the recent expansion in business, it is currently in the process of ap-

plying for a new waste license that will allow transfer in excess of 100,000 t per annum. As a requirement of this application, Mr Binman is preparing an extensive EIS, and the company now employs two full-time environmental scientists.

2.8.4.5 Recycling facilities

Table 2.41 outlines the current recycling facilities in Limerick City and the type of material collected at these sites.

The Park Road depot also accepts the following:

1. newspapers: a cabin has now been placed at the depot to accept dry newsprint
2. fluorescent lighting tubes for mercury recovery
3. waste oils and oil filters
4. books and toys
5. refrigerators for CFC recovery

Mr Binman currently operates a range of recycling services. Cardboard is collected from commercial outlets, where it is the responsibility of the customer to separate the cardboard from the main waste stream. The cardboard is transported to the transfer station where it is baled prior to being transported for further recycling. Similarly, glass and aluminium cans are separated at source. An automated glass crushing plant has recently been installed at the company premises. The plant consists of a conveyer belt onto which the separated glass fractions are loaded. The glass on the conveyer belt is screened manually to ensure that all the glass is of the same colour before it reaches the crusher. The glass crusher allows for the removal of contaminants such as corks, rings and labels, separated by a combination of a magnet, an eddy current separator and a turbine. The screened and crushed glass is removed to storage bunkers. When a sufficient quantity of glass has been collected, it is transported to Irish Glass for further recycling. Currently, all but brown glass is recycled. Cans collected are separated into ferrous and non-ferrous and are baled.

The majority of demolition waste collected is from skips. The rubble is crushed and used in road building and for sub-filling for houses, while the timber fraction is shredded and transported for use by Finsa timber products.

The transfer station has recently been extended to house a new picking station. This picking station has six stations, each of which are utilised to remove a specific recyclable fraction. These fractions include glass, plastic, cardboard, steel, aluminium and building materials. With the introduction of this picking station, it is envisaged that all waste entering the facility will eventually be screened for recyclables. Current recycling rates are shown in Table 2.42.

Table 2.41. Recycling facilities in Limerick City.

Area	Glass	Cans	Textiles	Oils	Batteries
Park Road Depot	√	√	√	√	√
Garryowen Service Station, Dublin Rd	√	√			
Statoil Dock Road	√	√	√	√	√
Bishop's Quay	√	√	√		
Parkway Shopping Centre	√				
Roxboro Shopping Centre	√				
Southville Service Station	√	√			
Moyross Community Centre	√	√			
O'Brien-Kelly, Ennis Road	√	√			
Scoil Ide, Corbally	√	√			
Mary Immaculate College		√			
Jury's Hotel	√				
CBS, Sexton Street		√			
St. Mary's School Corbally	√	√			
St Camillus' Hospital	√	√			

Table 2.42. Current rates of recycling (Mr Binman).

Glass (t/week)	35
Cans (cans/week)	35,000
Cardboard (t/week)	30
Timber (t/week)	6

2.8.4.6 Transport

As shown in Fig. 2.54, the annual number of new vehicles registered is steadily increasing. This annual growth may mean that roads will reach their capacity earlier than envisaged by the NRA (NRA, 1998). In response to the national increase in the number of new vehicles on the road, the NRA conducted a *National Roads Needs Study* to provide a basis on which policy decisions for the development of the network of national roads can be made for the 20-year period between 2000 and 2019. Traffic cannot continue to grow indefinitely, and the maximum traffic level, having regard to demographic factors, car ownership and utilisation, is known as the 'saturation' traffic level. In the study, specialist investigations were carried out to define future traffic growth, based on international experiences, in terms of range of relevant parameters. Recent traffic data suggest that current growth rates in Ireland are in the order of 5–6% per annum. Such growth rates are not sustainable indefinitely and must be attenuated as the saturation level is approached. One of the long-term objectives of this study is to determine the appropriate type of roadway for each segment of the national road network in order to cater for projected traffic flows over the 20-year period.

2.8.4.7 Job gains and losses

The local economy in Limerick has expanded greatly in recent years. It has become, what the Limerick City Manager terms, a mini 'Silicon Valley' with a proliferation of 'high-tech' industries employing graduates from two major third-level colleges, UL and LIT. Also located in the city are the regional headquarters of the Army, the Garda divisional headquarters, the regional head offices of the Electricity Supply Board, Revenue Commissioners and Irish Rail, the area headquarters of the district and circuit courts and land registry, and the regional local office of FÁS. The unprecedented rate of economic growth in Ireland has resulted in a knock-on boom in Limerick's local economy, attracting significant foreign and indigenous investment.

As shown in Fig. 2.55, job gains increased substantially in Limerick from 1997 to 1999 with a drop-off in 2000. This parallels a concomitant decrease in job losses from 1998/1999 onwards. Major investors such as the DELL Corporation, which employs almost 2000 people in Limerick, have recently announced a reduction in the numbers employed in their Limerick plant. This is a consequence of the slow-down in the American econo-

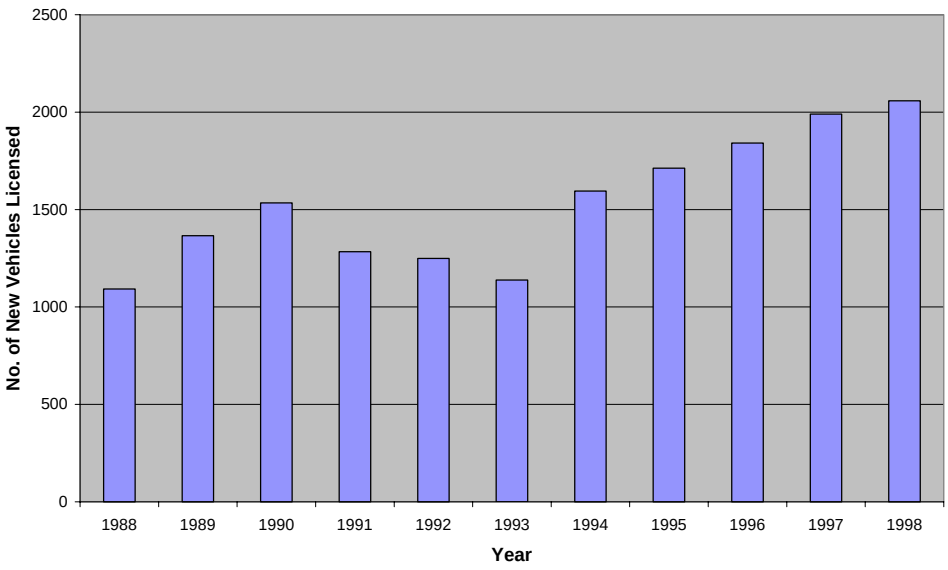

Figure 2.54. Number of new vehicles registered in Limerick City.

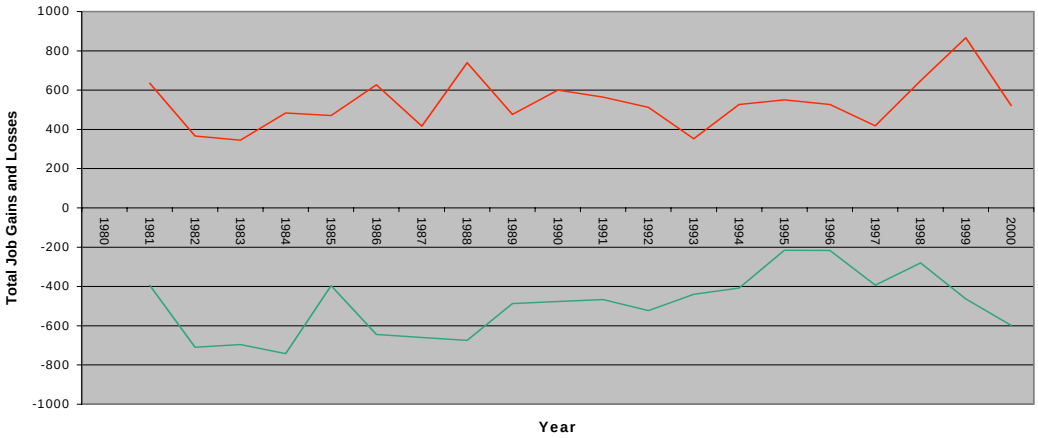

Figure 2.55. Job gains and losses in Limerick 1980–2000.

my, which is predicted to have serious and long-term consequences for the state of the Irish economy. However, as shown in Fig. 2.56, the stock of jobs in Limerick in 1999 was at its highest in over 20 years, with a slight downturn in 2000.

2.8.4.8 Built heritage and tourism

Limerick has experienced increasing tourist numbers over the past 4 years, with 1999 particularly significant in terms of revenue generated (€70m) (Fig. 2.57). The city is divided into English Town, on King's Island, and Irish Town, which includes the oldest part of the city (dating from the 9th-Century Norse settlement). Limerick City contains a medieval core with later and very well preserved Georgian additions. Of particular importance are King John's Castle, built between the 12th and 16th Century, St Mary's Cathedral, some of which was built in 1172, and the Old Exchange facade and Almshouses, located on King's Island. Other attractions in the Limerick/Clare area include Bunratty Castle and Folk Park (one of Ireland's leading tourist attractions) and the heritage villages of Adare, Castleconnell and Killaloe.

2.8.4.9 Household composition

The number of single parents in Limerick is on the increase, with a sharp rise from 1981 to 1996 in the numbers of lone mothers and fathers in Limerick County, and a rise in the numbers of single mothers in Limerick Coun-

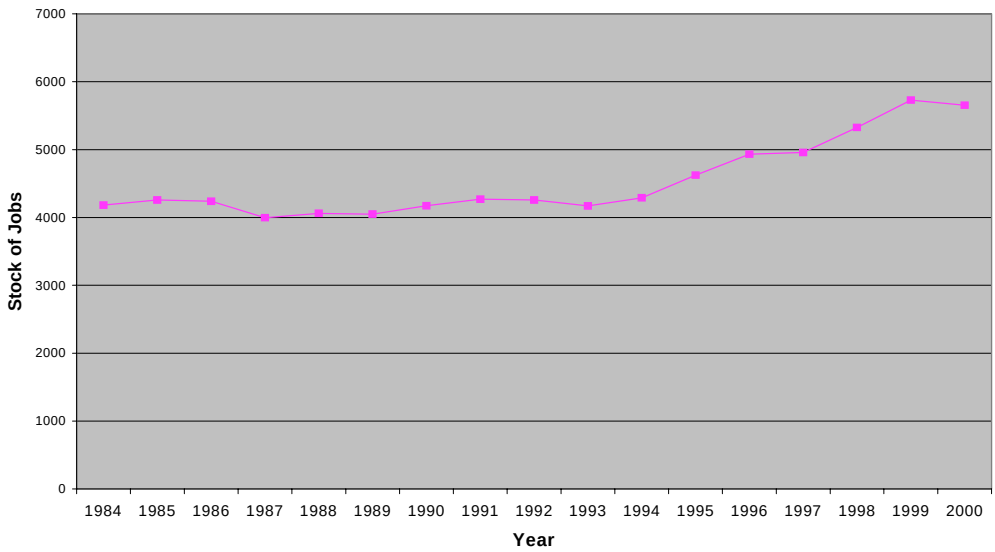

Figure 2.56. Stock of jobs in Limerick 1980–2000.

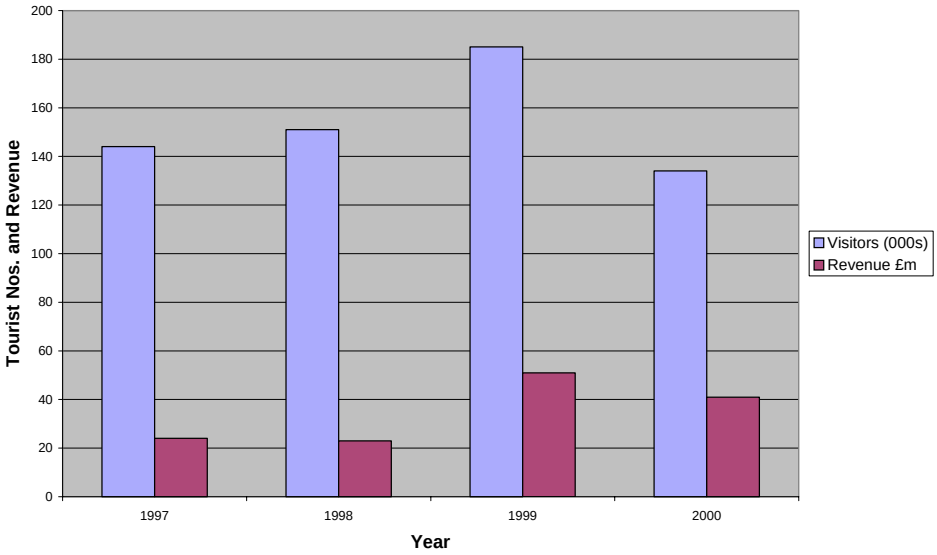

Figure 2.57. Tourist numbers and revenue generated 1997–2000.

ty Borough (Figs. 2.58 and 2.59). There has been a slight decrease in the numbers of lone fathers in the city over the same period.

The Limerick City Development Board is currently in the process of preparing a development plan for Limerick County Borough, to be completed by early 2002, to deliver a strategic development plan for the next 5 years. Sustainability issues are important within this planning process. The fall in population in the city in the past 2 decades has been accompanied by a concomitant increase in the population of the suburbs. This process of suburbanisation has prompted Limerick Corporation to prepare an application to government to extend its authority over a further 6541 ha, to cover the greater city area. This proposal has met with resistance from surrounding County Councils.

Limerick's sewage treatment infrastructure is currently undergoing major upgrading as part of the Limerick Main Drainage Scheme (following the requirements of the EU Urban Wastewater Treatment Directive).

Air quality is improving in the city, with a significant reduction in average smoke and SO_2 levels in the past 6 years. This may be as a result of the ban on bituminous coal in Limerick City in 1998. Although waste generation has increased in Limerick City over the past decade, Limerick Corporation was one of the first borough corporations to introduce the 'wheel bin' service and one of the first to undertake a pilot composting scheme in association with Limerick County Council. Waste collection is

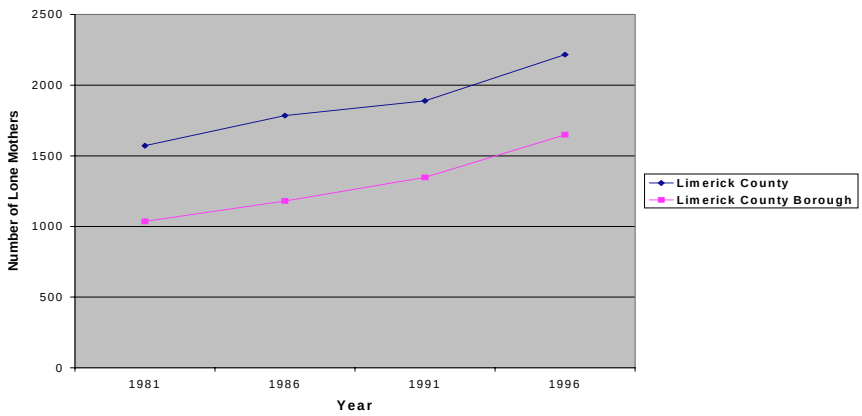

Figure 2.58. Number of lone mothers in Limerick 1981–1996.

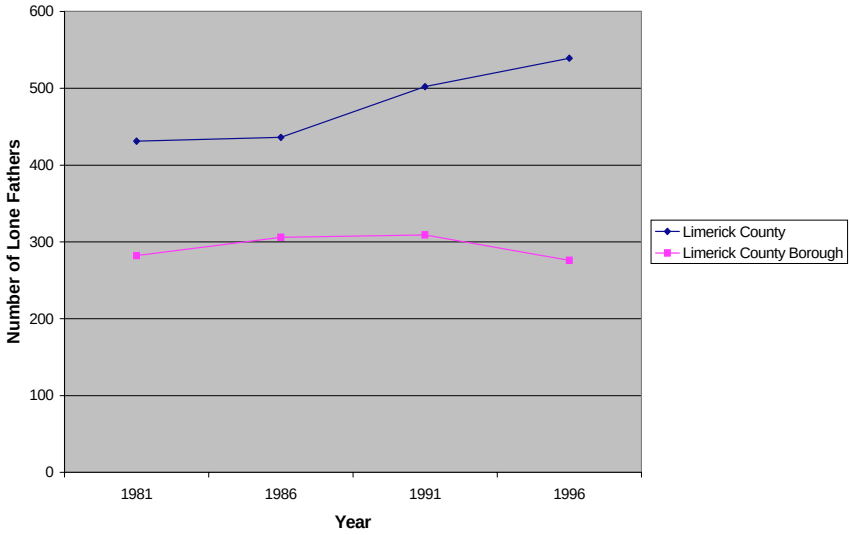

Figure 2.59. Number of lone fathers in Limerick 1981–1996.

now privatised and under the remit of Mr Binman. Although vehicle numbers continue to grow and congestion increases, major upgrading of the existing road infrastructure is planned under the *National Roads Needs Study* (NRA, 1998), and a new Shannon River crossing has been agreed by government. Limerick City has experienced a significant growth in the number of jobs available in recent years and unemployment figures have (until the very recent downturn in the economy) been at their lowest levels in over 20 years. Major investment in Limerick's architectural and cultural heritage in the past decade has resulted in increased tourist numbers and revenue to the city. Overall and at present, therefore, there are initiatives under way that collectively may be expected to enhance the future sustainability of Limerick City.

2.8.5 Statistical annex

Forestry cover arising from private and public planting is shown in Figs. 2.60 and 2.61; Figs. 2.62 and 2.63 present distance travelled and means of travel, respectively, of persons in Limerick CB; numbers of persons in private households in Limerick CD (urban) are shown in Fig. 2.64 while Fig. 2.65 presents persons classed by occupational category in Limerick CB; Figs. 2.66 and 2.67 present in-patient and day activities at Limerick Regional Hospital and at St. John's Hospital Limerick, respective-

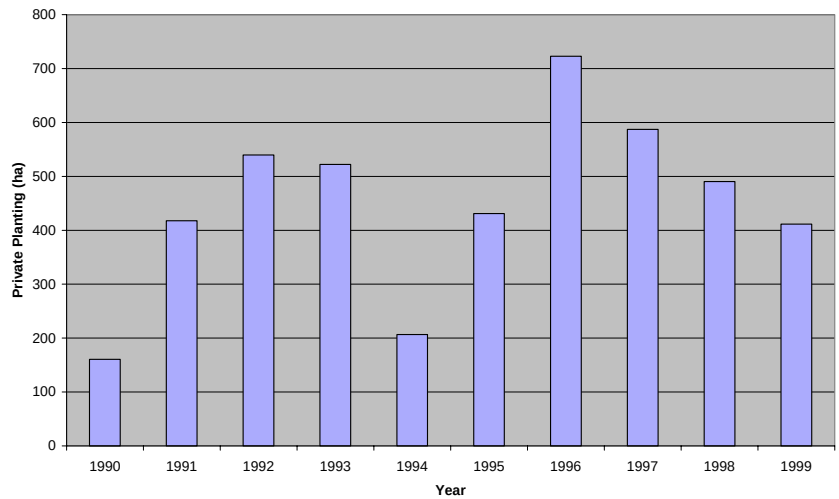

Figure 2.60. Changes in forest cover (private planting).

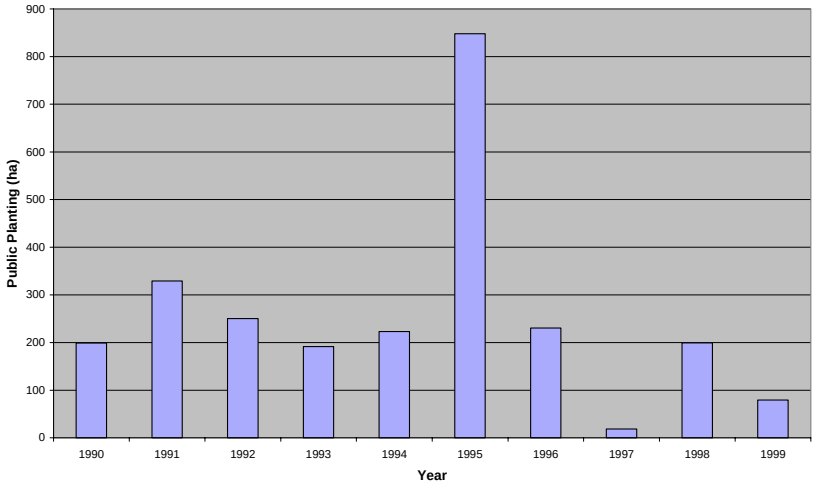

Figure 2.61. Changes in forest cover (public planting).

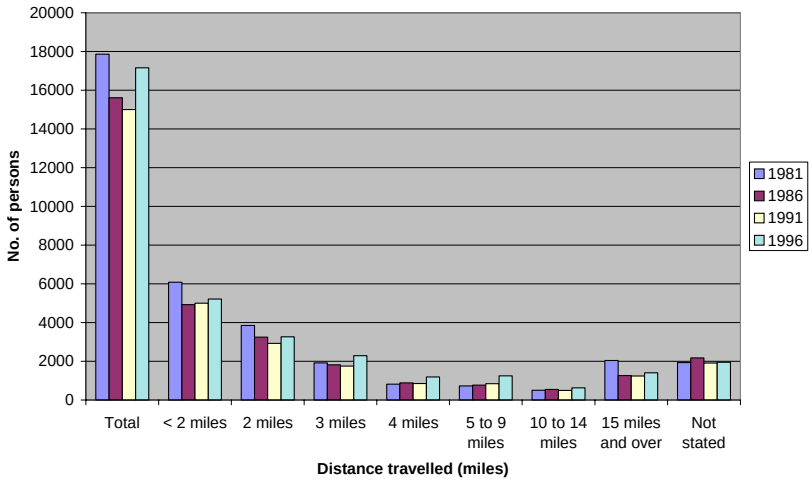

Figure 2.62. Distance travelled by persons in Limerick CB.

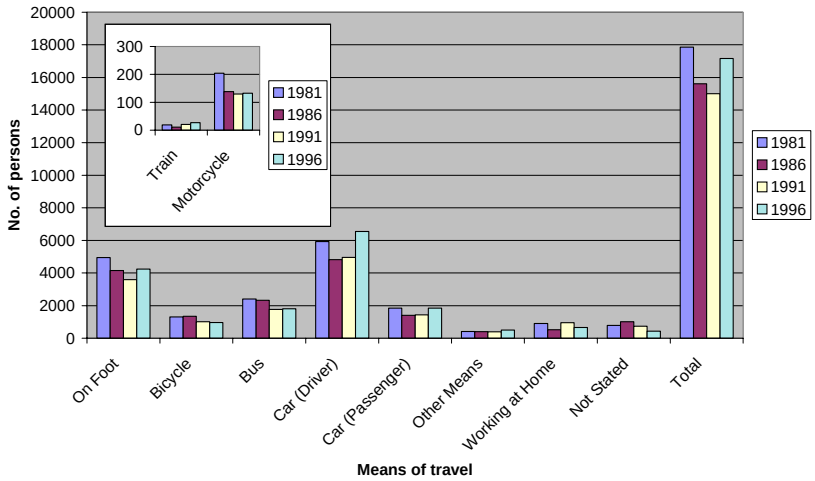

Figure 2.63. Means of travel by persons in Limerick CB.

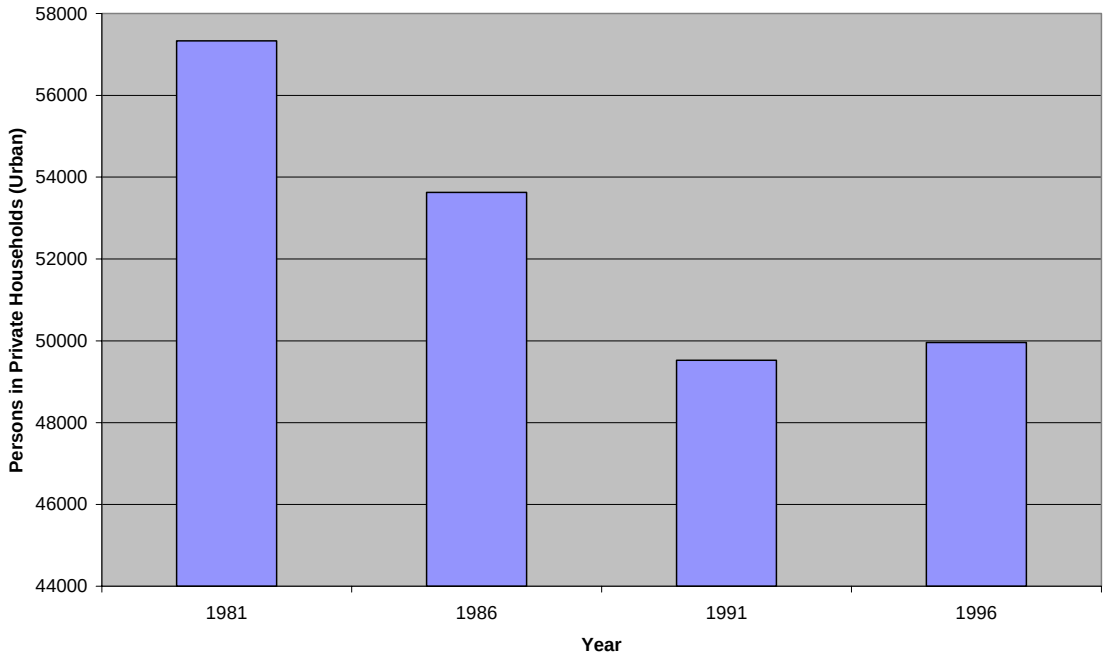

Figure 2.64. Persons in private households in Limerick CB (urban).

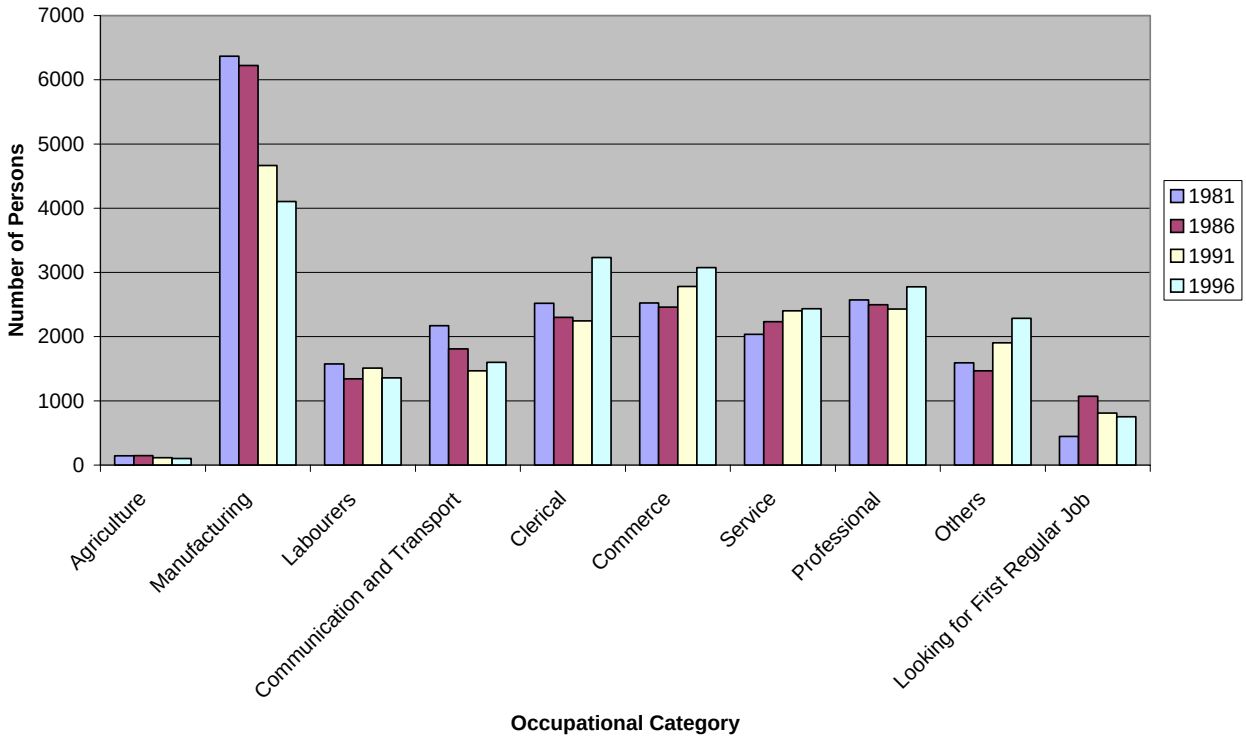

Figure 2.65. Persons classed by occupational category in Limerick CB.

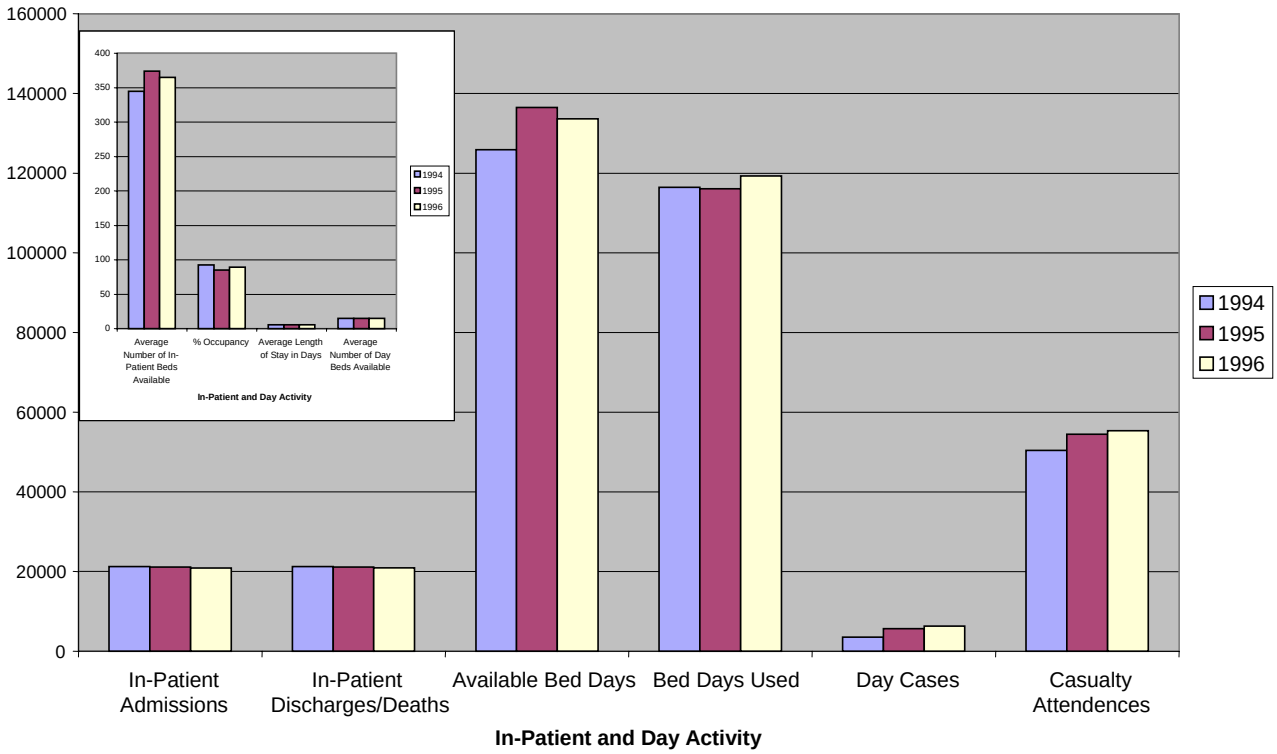

Figure 2.66. In-patient and day activities at Limerick Regional Hospital.

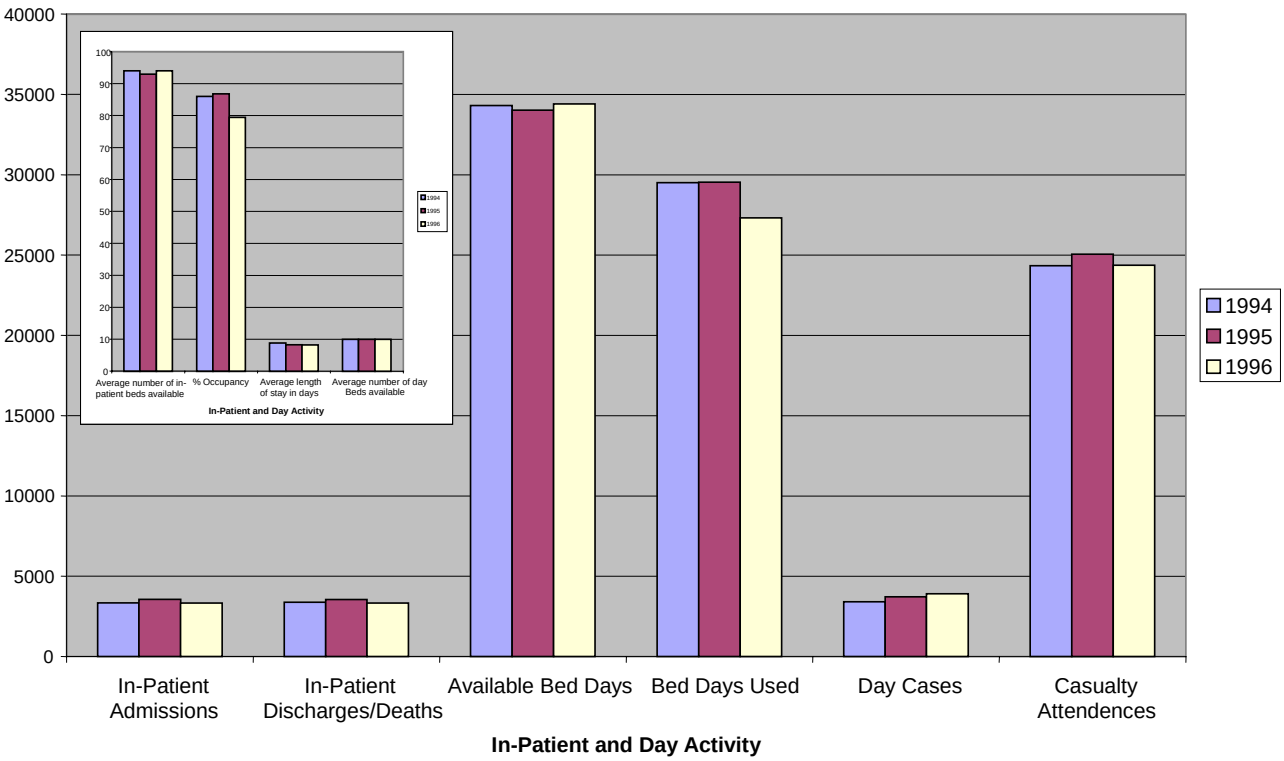

Figure 2.67. In-patient and day activities at St John's Hospital Limerick.

ly; Fig. 2.68 presents the number of Irish speakers in Limerick City Borough.

2.9 Evaluation of findings based on the use of indicators

The relationship between the size of a settlement and the environmental and socio–economic systems it supports is complex. Rather than seeking to define optimum settlement size, 11 existing settlements are evaluated in terms of their population size and geographical location. This is carried out by examining existing settlements in terms of performance, in relation to relevant sustainability indicators.

This section provides an empirical analysis of a range of sustainability indicators as applied to the selected settlements, and also identifies gaps in the information base.

The lack of available and accessible data proved to be the most frequent limiting factor influencing the quality of research outcomes. Tables 2.1–2.9 show the candidate list of indictors as agreed at the first meeting of the Steering Group. Several of these indicators had to be either modified, dropped or substituted by new indicators because of poor data accessibility. The final list of indicators for inclusion in this study is shown in Table 2.10. These indicators are categorised under the DPSIR framework and are grouped into those showing sensitivity to settlement size and those showing no such relationship. To summarise, less than half of the indicators developed gave an indication of sensitivity to settlement size. These include 6 environmental indicators, 3 social indicators and 2 economic indicators. In terms of settlement size, environmental indicators such as total forest cover (ha), total classes of forest, recycling facilities per head of population and number of goldfinches/garden all favour smaller settlements. The social indicator examining the number of GPs also favours smaller settlements with a higher number of GPs/capita than in larger settlements. In relation to means of travel, the proportion of persons travelling on foot is greater for smaller settlements, with a larger proportion walking to work. Overall, a small majority of indicators suggest that larger settlements are more sustainable.

However, as indicated above in relation to each indicator, it is reasonable to place greater weighting on those that identify larger settlements as being more sustainable. For these, data are more reliable, interpretation is more secure, and the relevance to sustainability more clear-cut. On this basis, empirical findings taken together suggest that larger settlements show more signs of approaching sustainability.

However, this report describes a pilot study only. To undertake a more scientifically accurate study of the relationship between settlement size and sustainability, replicate settlements for each size, functionality and geographical category should be examined. This section serves to provide a methodological foundation for longer-term work in understanding the relationship between sustainable development and settlement size.

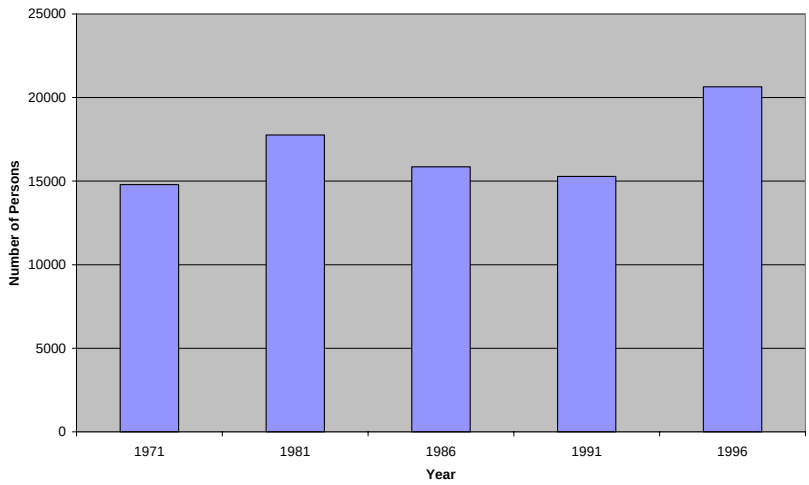

Figure 2.68. Number of Irish speakers (aged 3 and over) in Limerick CB.

Section 3 Experience Elsewhere and Theoretical Analysis

3.1 Introduction

The underlying assumptions behind this study are as follows:

(a) that 'settlement size' is a significant factor in spatial development patterns and spatial development strategies;

(b) that there are significant relationships between 'settlement size' and key indicators of environmental impact directly related to activity in that settlement;

(c) that this information is significant for strategic decisions on spatial development via the NSS.

There are a number of caveats arising from the available evidence and literature, which put each of these themes into context. The implications of these can be summarised as follows:

(a) 'Settlement size' is one of a number of factors in the 'spatial development pattern' of cities, towns and villages. A greater understanding of the issues can be gained by looking at such patterns as whole systems, including the size, density, shape, function, inter-dependence and development prospects of settlements. The implication is that the study evidence should be related as far as possible to the broader spatial development patterns and prospects outlined by the NSS.

(b) Key indicators of environmental impact/quality are scarce and patchy at the local level, though increasing the number of case studies would be costly. Many of the potential relationships are skewed by intervening factors, and the interdependence of settlements and their functions makes it difficult to establish definitive evidence. The implication is that available data should be steered towards the level of spatial development patterns – with a focus on trends, prospects and potential for improvement under alternative development scenarios.

(c) The application of this information to the NSS is not necessarily straightforward, as there are few, if any, major new settlements being planned that could be guided directly by these findings. The implication is that the study findings may be more relevant for providing information on thresholds for settlement size, impacts of physical infrastructure, general profiles of spatial development patterns, and baseline data for the available/feasible spatial development options.

To follow through the logic of these implications, this section aims to:

(a) review the question of 'sustainable settlement size' in light of the evidence;

(b) draw together existing literature that presents the available evidence for key environmental themes;

(c) review the evidence in relation to each of the case study settlements, in the context of the NSS;

(d) review the trends, prospects, alternative scenarios and implications for spatial development;

(e) review the implications of the methodologies selected for similar studies elsewhere.

This section draws together evidence linking the priority environmental themes with the most important parameters of a sustainable 'settlement'. These relationships are then to be aligned with the refined indicators (see Section 2) to produce an operational framework for estimating sustainable settlement size, and will subsequently be used in practical application for the selected case study settlements. As discussed in Sections 1 and 2, the most pressing issues affecting Ireland are considered to be (EPA, 2000):

(a) Rate of growth across strategic sectors

(b) Dominance of Dublin

(c) Increasing environmental pollution

(d) Wastewater treatment

(e) Area of tourism (green image)

(f) Agriculture

(g) Substances entering inland waters (nutrients)

(h) Waste disposal

The five main environmental issues thought to merit particular attention are eutrophication of inland waters, waste and litter, urban environment and transport, climate change and greenhouse gases, and protection of natural resources. In terms of the built environment, these are manifested at the local scale as: waste management, traffic congestion, loss of open space, degradation of the urban landscape, and air, water and noise pollution (*ibid.*). For the purposes of this final working package, the environmental theme categories derived from Section 2 are to be examined in terms of settlement 'form' parameters such as population size, density, function, thresholds, etc., including empirical evidence from international studies where possible. To maintain synergy, the issues are categorised according to the refined indicator framework derived for Section 2. In terms of this framework, the issue categories are:

(a) Air pollution and transport

(b) Climate change

(c) Water quality

(d) Urban metabolism

(e) Urban quality.

3.2 An overview of sustainable settlement 'size' – functional characteristics

3.2.1 Functional settlement size

Clearly the urban socio–economic profile is a key determinant of its environmental performance, and hence of its 'environmental sustainability'. For instance, a dormitory suburb of Dublin is likely to have a very different profile to that of a market town in the Mid-West, even if their overall populations and densities are the same. Where the functional profile can be classified effectively, it should provide a sound basis for cross-comparison of environmental and other indicators between different settlements of different sizes and locations. However, the functional profile is not a simple question and there is no single way to provide this classification. In this section we review and summarise several cross-cutting perspectives on the question of urban structural and functional profiles:

(a) simple determinants of population growth or decline, and/or economic growth or decline;

(b) functional–geographical profile: a combination of physical size, location, and relation to the hierarchy of urban/regional functions, and national/global functions;

(c) the context of the urban hinterland and rural area type;

(d) spatial development structure of the settlement in the context of its hinterland and urban hierarchy at a regional scale;

(e) types of linkages from urban infrastructure to environmental performance;

(f) summary of functional specifications and data sources within this study.

There are several outstanding factors in the social and economic profile of any settlement, and hence the inter-urban and inter-regional regional flows of population and economic activity (Table 3.1).

(a) Growth or decline in housing or employment markets.

(b) Particular types and sectors of employment, i.e. regional imbalances of supply or demand.

(c) Spatial displacement of housing from employment and services, i.e. increasing commuting or dual-career distances make inter-urban or inter-regional commuting flows quite possible.

(d) Territorial types and activity spaces that cross existing regional boundaries.

(e) Sunrise territory: areas of major economic innovation with access to high skills, high amenity and major global finance, likely to be exporters of housing demand.

(f) Metropolitan hubs: principal urban centres of international significance.

(g) Affluent ex-urbia: extended commuting/service hinterland of Dublin and other principal hubs.

Table 3.1. Area types and sectoral indicators*.

Area type	Example sub-regions (Ireland)	Housing & households	Employment & economy	Transport & environment
Sunrise territory	M50 corridor and hinterland	Very high demand, low supply	Very high growth/ skills/investment, inward commuting	Infrastructure pressure, high amenity
Metropolitan hubs	Dublin, Cork	Re-urbanisation and regeneration	Decentralisation to fringe, new cultural hubs in centre	Pressure on fringe, mixed amenity
Affluent ex-urbia	SE Ireland	Rapid in-migration and high demand	Out-commuting, high skills, some inward investment	Infrastructure pressure, high amenity
Retirement and tourism	SW and west coast areas	Moderately high housing demand: affordability problems	Services growth and investment, low indigenous skills	Infrastructure pressure, high amenity
Rural restructuring	North Midlands	Moderate in-migration, social change and local stress	Services growth and investment, low indigenous skills	Mixed amenity
Industrial restructuring	Waterford	Out-migration, net level demand, poor stock	Zero relative growth, low skills/investment	Mixed amenity
Bootstraps territory	(No single equivalent)	Rapid out-migration, falling demand, very poor stock	Negative growth, very low skills/investment	Basic infrastructure, low net amenity

*Source: Ravetz *et al*. (2000), except for the Irish examples in the second column, which were added by the authors.

(h) Dormitory territory: with high amenity and accessibility, likely to be importers of housing or housing demand with excess of regional quotient.

(i) Rural restructuring: shift from former land-based agricultural and primary activity to tertiary activity in tourism, leisure, diversified agriculture and retirement resorts.

(j) Industrial restructuring: older industry and housing stock, less skilled workforce, more dependent population.

(k) Bootstraps territory: regions where dis-investment has slowed to the point where restructuring has to be kick-started with large public funds.

Up to a point, these inter-regional flows can be seen as an aspect of functional specialisation, i.e. where each kind of settlement and region has a distinct and specialised part to play in the national framework. However, beyond that point there may be distinct negative impacts of such specialisation:

(a) environmental pressures and external costs in transport, land use and natural resources;

(b) increased problems for disadvantaged or excluded communities;

(c) inefficiencies and constraints on economic development and competitiveness.

The balance point between positive effects and negative impacts is generally a complex assessment in the social and political arena.

3.2.2 Economic and functional geography

This perspective looks not so much at the internal profile of the settlement itself, but at its place in the inter-urban

and inter-regional pattern and hierarchy, in economic and functional terms. Again this is a key determinant of the environmental profile and performance, where, for instance, a small university town may be quite different to a fishing town of the same size. The simplest perspective looks at the balance of economic functions with population, as developed in the Urban Structure study of the NSS (Brady Shipman Martin, 2001):

(a) those with a level of function significantly higher than their population level would indicate. These are mainly market centres, providing goods and services to rural hinterlands. Letterkenny, Monaghan, Thurles, Castlebar and Enniscorthy are examples;

(b) those with a level of function broadly in keeping with their population levels. These include the major cities as well as centres such as Ennis, Clonmel, Carlow and Portlaoise;

(c) those with a level of function significantly lower than their population level would indicate. These are mainly commuting centres, within the sphere of influence of the larger cities, especially Dublin. Examples include Balbriggan, Malahide, Leixlip and Swords, as well as Carrigaline and Cobh. Shannon is also in this category, explained by its lack of established hinterland;

(d) a small number of centres have a high level of specialised function. Killarney, with its concentration of tourism and leisure facilities, is an example.

3.2.3 Rural area context

The third perspective that applies to some settlements, if not all, is to place the urban area within its rural context. Here the NSS report on 'Irish Rural Structure' provides a ready typology with detailed quantitative analysis (Fitzpatrick Associates, undated). The rural typologies need to be related to the urban typologies, but the degree of interaction between rural and urban will need to be judged in each case.

3.2.4 Rural typologies

Area Type 1: peri-urban areas

Area Type 2: very strong agricultural areas

Area Type 3: strong agricultural areas

Area Type 4: structurally weak areas

Area Type 5: marginal areas

Area Type 6: highly diversified areas.

Rural typology key components: the NSS report analysed a large dataset and extracted the most significant variables. These will also be related to the parallel typologies of urban areas and other contingent factors.

1. Non-agricultural employment
2. Labour force participation
3. Demographic viability
4. Strength of agriculture sector
5. Socio–economic profile
6. Population and employment dynamics
7. Rural diversification
8. Agricultural employment change.

3.2.5 Spatial development structures

This perspective considers the inter-dependency of settlements in larger-scale urban and regional spatial development 'patterns'. This is at the core of the approach of the European Spatial Development Perspective (ESDP), although much remains to be done in describing the various types of spatial structures. The following outline is taken from work in progress on the UK Spatial Planning Framework (Ravetz *et al.*, 2000), drawing on previous work on the 'compact city' philosophy. The framework is based on two kinds of phenomena:

(a) functional concentration: i.e. measure of centralisation of services and spatially distributed activities; and

(b) spatial nucleation: i.e. measure of 'clustering' of residential location.

This scheme leads to a simple four-fold classification, which characterises the most common spatial structures on the ground:

(a) Concentrated nucleated

(b) Concentrated poly-nucleated

(c) Deconcentrated nucleated

(d) Deconcentrated poly-nucleated.

3.2.6 Summary of functional specifications with data sources

Common specifications and/or indicators for 'functional' settlements/regions would include, together with the data sources in this study:

(a) effective travel to work radius: proxies drawn from rural studies mapping;

(b) position of settlement in urban hierarchy: from NSS data on health/education services;

(c) position/distance of settlement to next higher hubs: i.e. small towns, major towns, Dublin;

(d) position/distance of settlement in relation to strategic transport networks;

(e) general socio–economic profile of rural hinterland: from 'rural typologies' study;

(f) general socio–economic profile of settlement urban area: various sources;

(g) general development prospects and pathways: from NSS draft framework.

3.3 Other factors relating to sustainable settlement size

3.3.1 Population size

Settlement size is considered to be an influential element affecting the range of jobs, services, and public transport that can be viably supported by any settlement. Theoretically, in the case of smaller settlements that are unable to support a large range of services and facilities, local residents may be forced to travel longer distances to access the services and facilities they require. In addition, real-world evidence shows that in larger settlements, the use of non-car modes is far greater than in smaller, more rural, settlements where the use of the car predominates (Stead *et al.*, 2000).

A useful study for comparative purposes is the research carried out by Williams (1999a) on 'population thresholds and sustainable hierarchies of development'. Her case study was based on Gloucestershire, an English county with similar characteristics to Ireland. Similarity exists in that the county is predominantly rural with many smaller settlements. Gloucester (population: 134,967) and Cheltenham dominate as the major urban areas, with approximately 65% of the population found in the 17 settlements with a population over 2000. The services/facilities and employment opportunities selected were chosen to provide examples of:

(a) services/facilities and employment opportunities that represent the journey purposes generating the greatest amount of travel;

(b) services/facilities and employment opportunities whose provision can be controlled by the planning decision process;

(c) services/facilities and employment opportunities that represent public- and private-sector involvement;

(d) services/facilities and employment opportunities that reflect variation in frequency of use;

(e) services/facilities and employment opportunities that are provided locally and centrally;

(f) availability of appropriate data.

Results from the research suggest the presence of a discernible population hierarchy in terms of the distribution, range and scale of facilities in the region (Table 3.2). The highest order services/facilities were found exclusively in the main urban areas (theatres and higher education colleges), with medium order facilities (leisure centres, banks, clinics, textile manufacturing services) concentrated in the Central Severn Vale. Lower order facilities were well spread geographically (pubs, schools, convenience stores, garages, financial services). The exceptions to the hierarchical findings were supermarkets (although of medium order, they tended to be found in the main urban areas) and local government services (although high order, they were situated in the Central Severn Vale, though not necessarily within the main urban areas). From the results it was suggested that certain facilities

Table 3.2. Summary of current estimated population thresholds in Gloucestershire (Williams, 1999a).

Population threshold	Facilities/services
100k+	HE colleges
50k+	Theatres
20k+	Leisure centres, clinics
5k+	Supermarkets and banks
Under 5k	Convenience stores, financial services, garages, pubs, schools, local government services, textile manufacturers.

could be either over (pubs, garages, etc) or under provided (supermarkets, theatres, etc.) in smaller settlements.

An important caveat relates to methodological considerations, as population thresholds can vary according to the methodology used to calculate them. Two important variables were: how user groups were defined, and where the spatial boundaries were set (i.e. at ward, settlement, catchment or county level). The thresholds for provision of services and facilities are likely to be greater in rural areas, where the population is more dispersed.

For the research, modal boundaries were set at the following distances: walking (960 m), cycling (3200 m), local bus-ride (6400 m). Least accessible were local government services, HE colleges and theatres. Most accessible were schools, pubs, convenience stores, garages, and financial services. The application of statistical analysis identified two key factors that influenced the provision of the 13 facilities and services considered: resident population and affluence. The provision of facilities and services per 1000 inhabitants showed variation for settlements where resident populations were fewer than 25,000. In contrast, when the resident population was greater than 25,000, the levels of provision appeared to stabilise. Relating to previous research, the author suggested that in settlements of 25,000–100,000, less total distance tends to be travelled, with a greater use of non-car modes. Thus, it is possible that the stabilisation in total distances travelled and modal shift towards non-car modes may be linked to the apparent stabilisation in facilities provision. A possible explanation for the stabilisation of total distances travelled in settlements with populations of 25,000–100,000 is the number of facilities/services that are provided, linked to the location of the user group. It is suggested that the level of provision of services and facilities in settlements of this size may be explained by resident population size (number of users) and affluence. A major finding from the study is that there is an apparent relationship between settlement size, affluence, number of users, provision of facilities and travel patterns. Williams (1999a) also compared her results with those collated by an earlier study from 1992–1994 (see Table 3.3).

Table 3.3. Comparison of population thresholds (Williams, 1999a).

Facilities/services	Coombes *et al.** Thresholds (000s)	Williams Thresholds (000s)
Leisure centres	25–40	20
Supermarkets	5–10	5
Banks	–	5
Convenience stores	2–5	Under 5
Garages	–	Under 5
Primary schools	2.5–4.5	Under 5
Pubs	5–7	Under 5
Financial services	–	Under 5
Local government services	5–10	Under 5
Textile manufacturers	5–10	Under 5
Clinics	9–12	20
Theatres	–	50
HE colleges	25–40	100

Coombes et al. as cited in Williams (1999a)

3.3.2 Density

In general, density increases with population size (this was true for the Irish case studies). The claimed advantages of the compact city have been well documented. They include conservation of the countryside, less car travel and associated emissions, better support for public transport and walking and cycling, increased access to services and facilities, more efficient utility and infrastructure provision, and the revitalisation and regeneration of inner urban areas (Burton, 2000a). That said, even compact city advocates recognise that the evidence to support sustainability claims are complex and often contradictory (Guy and Marvin, 2000). For instance, others have highlighted the potential side-effects of intensification, including loss of greenery in towns, upgrading of the local built and natural environment brought about by new buildings and high quality design, and increased environmental wear and tear (Williams, 2000).

Adversely, although higher densities may have the potential to reduce trips by car, the subsequent loss of urban open space may actually result in a reduction of ecologically important land, and a loss of space for trees and other greenery. This is an important issue for Ireland, which exploits its green image as a tourist attraction. Similarly, whilst reduced travel leads to energy savings, the opportunities for developing renewable energy sources may be hindered if increased density is not properly managed (over-shading will limit benefits of solar technologies). Intensification can take a number of forms, some of which may be more appropriate in a given area than others, and research has shown that the existing characteristics of an area are an important component in determining the type and extent of intensification that will be acceptable to existing residents (Williams, 1999a).

A variety of issues have been investigated to assess the validity of claims relating to the social equity of the compact city (Burton, 2000a). Results were as follows.

Supported evidence:

Better access to facilities

Poorer access to green space

Better public transport

Reduced domestic living space

Reduced social segregation

Lack of affordable housing.

Supported in some respects:

Greater opportunities for walking and cycling

Poorer health.

Evidence is weak but tends to support claim:

Increased job opportunities.

Evidence ambiguous:

Better accessibility.

Contradicts claim:

Reduced crime

Increased wealth.

The following benefits were identified as being associated with higher-density developments:

(a) improved public transport use;

(b) lower death rate from mental illness;

(c) reduced social segregation;

(d) with remedial measures, possibly greater scope for walking and cycling;

(e) better job opportunities for the lower skilled;

(f) better access to facilities.

However, the compact city is likely to be negative in relation to five other issues:

(a) less domestic living space;

(b) lack of affordable housing;

(c) poor access to green space;

(d) increased crime levels;

(e) higher death rate from respiratory disease.

Overall, results from this research suggest that high densities are positive for four aspects of social equity: access to superstores, public transport use, lower death rates from mental illness and lower social segregation; mixed land uses for three: walking and cycling, general health and job opportunities; and intensification for three: social

segregation, job opportunities and affordable housing (Burton, 2000b).

It, therefore, appears that higher densities alone may not be the solution; a combination of higher densities and mixed land uses are needed to maximise the potential for sustainability. Physical improvements are achievable through responsive architecture and urban design, including (Newman and Kenworthy, 2000):

(a) sufficient greenery, open space and high quality local parks;

(b) appropriate pavements for safe, comfortable and convenient walking;

(c) adequate privacy of dwellings via appropriate design; and

(d) better design of backcourts and front gardens to ensure optimum use by residents.

Although research is pointing away from density being the only variable influencing urban sustainability there is no doubt that it remains a major factor in influencing car dependence. Higher-density areas tend to have lower levels of car ownership (Stead *et al.*, 2000). Achieving a more sustainable urban form inevitably involves the development of densities that can enable public transport, walking and cycling to be viable options (Newman and Kenworthy, 1989). Another study, analysing urban intensification processes and the consequences for residents' quality of life (Williams, 2000), highlighted the economic objectives as:

(a) to improve vitality and viability of centres and contribute to regeneration – higher population densities provide a critical mass to support businesses, and planning policies help reduce competition from out-of-town developments;

(b) improved access to employment for urban residents because homes are located near workplaces.

Wider quality of life impacts were considered to be:

(a) a reduction in private space, smaller houses and smaller gardens, or no gardens;

(b) impacts of traffic, such as air pollution, noise and a generally poor environment for cyclists and pedestrians would be improved;

(c) potential bad neighbour effects of high density or mixed-use developments, e.g. noise, disturbance and litter.

The findings portray councillors and planners as believing that intensification in existing urban centres had a positive impact on quality of life, though in suburban areas intensification was consistently linked to a reduction in quality of life (perceptions of 'town cramming', a dislike of new people in the area, loss of character and more traffic). This duality of opinion is illustrated further by research conducted by Jenks (2000). In this instance, the author made a distinction between intensification of built form and intensification of activity.

Intensification of built form

(a) Development of previously undeveloped urban land

(b) Redevelopment of existing buildings or previously developed sites

(c) Subdivisions and conversions

(d) Additions and extensions.

Intensification of activity

(a) Increased use of existing buildings or sites

(b) Change of use

(c) An increase in numbers of people living in, working in or travelling through an area.

In dealing with the attitudes towards intensification, it is suggested that there is a clear distinction between the forms that it takes. Over half of local residents believe that building development either makes no difference or has actually improved their area. This is in stark contrast to increased activity, where the majority felt things had become worse. Those affected by intensification were also shown to have perceived benefits (common themes cited were better public transport and shopping facilities, and improvements to the area's appearance through well-designed buildings and general upgrading). However, common problems were said to relate to traffic conges-

tion, air pollution and noise, as well as concern over the loss of green space within settlements. In general terms, the research contests the view that intensification of the urban landscape will be unpopular. The research findings highlight a strong preference for development that is in keeping with the character of the local area, particularly as intensification tends to be unpopular when it is badly designed and out of keeping with the existing development. Forms of intensification that are well designed and predominantly residential are said to be viewed positively overall.[3] Small-scale and incremental intensification is also seen as acceptable. Conversely, large-scale, non-residential development, and the loss of amenity land, are viewed negatively.

In established high status areas, which are said to have more to lose from changes to the status quo, intensification tends to be less readily accepted (these are areas with a high proportion of home and car owners, and are perhaps more susceptible to 'NIMBYism'). By contrast, residents in the centralised, mixed-use urban areas appear to be more tolerant of change through development. Jenks (2000) concluded that residents seem to be more concerned that increases in density may destroy valued characteristics of an area rather than making the area more built up, and so it appears that density *per se* is less important than the form and quality of development. In addition, a promising finding was that the younger and more mobile residents (who rent rather than own their dwellings) hold more positive views about intensification. This may have beneficial repercussions for the predicted increases in single-person and small households in Ireland.

Understanding and responding to local differences is emphasised as a core element of future strategy. The concept of social capacity suggests that there are limits in terms of types and amounts of intensification, beyond which the progress will become unacceptable, and therefore, in the long-term, unsustainable. These limits can only be locally determined, and those managing the process will need to balance these limits against their broader, strategic aims for sustainable development (Jenks, 2000). This view was reinforced by Williams (2000), who claimed that far more attention will need to be paid to the sustainability implications of different types (and amounts) of intensification in particular localities.

3. Acceptance is enhanced if previously derelict or vacant land is developed.

3.3.3 Land use

Reshaping the environmental profile of resource use in cities (flows) through the reordering of land uses, the layout of areas, and building design, is suggested as the dominant discourse in urban sustainability debates (Guy and Marvin, 2000). It is argued that land-use mix influences the physical separation of activities and, therefore, impacts on travel demand, although there is some contradictory evidence to suggest that the influence is not as strong as that imposed by density. Nevertheless, the level of mixed use may contribute to travel demand, particularly through the decentralisation of less specialised employment (Stead *et al.*, 2000). Alternative urban forms can be categorised as: Dispersed city, Compact city, Edge city, Corridor city, and Fringe city (Newton, 2000).

Although alternative views stress a range of influences on accessibility, the importance of population density remains. Research by Reneland (2000) on Swedish towns suggested that although the smaller towns do have advantages, they do not offer good accessibility to all services in comparison with larger towns. During the 3-year duration of the research project, accessibility to the following services was investigated:

(a) food shops and supermarkets (facilities controlled by several private or co-operative interests);

(b) post offices and chemists (services controlled by the State);

(c) public transport, schools and libraries (services controlled by local authorities).

The measure of accessibility used in the research was the proportion of population of a town living within a theoretical distance zone of 400 m from particular services and facilities:

(a) within 400 m of the nearest chemist;

(b) within 400 m of the nearest library;

(c) within 400 m of the nearest post office;

(d) within 200 m of a public transport route;

(e) within 200 m of a public transport route with 20 min frequency.

This zone corresponds to a walking trip of roughly 5 min or less at 5 km/h, and is used in Sweden to define a good standard for walking distance from the home to a bus stop.

For new housing developments, evidence of the greater commuting distances by residents of these large new estates raises the question of whether there is something intrinsic to the planning and marketing of these estates, which encourages such 'unsustainable' behaviour (Headicar, 2000). This is of particular relevance to the urban expansion currently being experienced in Ireland. The author (*op. cit.*) suggests that it is the behaviour of people moving to the new estates that should be the basis for assessing the effects of proposed developments and not the less travel-intensive habits of a towns' indigenous populations. Critically, new residential development should be located close to the major employment concentrations, and should take the form of peripheral expansion of the principal city and/or smaller new settlements and settlement expansions on transport corridors linking it with nearby freestanding towns.

3.3.4 Spatial development issues

This section reviews the context of the National Spatial Strategy (NSS), in light of the previous sections:

(a) General discussion on spatial development

(b) Key environmental themes: evidence from case studies and from the literature.

3.3.4.1 Key issues in the National Spatial Strategy

The NSS is being constructed in a period of high economic growth and urban development activity. The influence of the EU Structural funds on urban infrastructure is also very strong (£43 billion in the next round). Generally, Ireland's spatial structure is characterised by one very dominant centre with four secondary cities. The remit of the NSS focuses on the theme of 'balanced regional development' as a means of maximising the potential and minimising the problems/impacts caused by this spatial structure. In particular, this focuses on the issues of transport, urban development, and to some extent rural economies and land use.

Transport connections between the four secondary cities are seen as crucial in the economic–urban growth strategy of the National Development Plan. The intention is to achieve the critical mass between them, to act as a counterbalance to the dominance and over-heating problems of the Greater Dublin region:

(a) Road connections are being upgraded towards motorway standards.

(b) Rail: public owned infrastructure: partnerships for improvements: franchising under discussion.

(c) Primary route: Dublin–Cork 35% target for rail passengers.

(d) Suburban rail to be developed in Cork and Limerick, under consideration by the Land-Use/Transport Studies (LUTS).

Strategic planning is one of the main tools available to steer development away from Greater Dublin, and towards the secondary cities. The main intention is to cascade such development down through the urban hierarchy to achieve 'sustainable' capacities at each level, either through restrictions, or through incentives. Under some development scenarios, the population of key settlements could double, and the trend of rural depopulation could be reversed. Therefore, the identification (where possible) of 'thresholds' for physical infrastructure and environmental performance is crucial.

3.3.4.2 National Spatial Strategy: regional issues

The NSS broadly classifies the Irish spatial structure into four types of dynamic. The overall pattern is characterised by the dominant field of Greater Dublin and the counterbalance of the other four key cities, the new growth on the west coast, and the intervening midlands and border areas.

The North and South Midlands area is in some ways the most problematic, with an existing weak and diffused urban structure. This area is subject to the competing pressures of agricultural restructuring and depopulation, the under-provision and under efficiency of local services,

and new commuting pressures from the Greater Dublin region.

Each of these regional types is identified within a selection of the case-study settlements, as summarised in Table 3.4.

If the current trends in population and economic growth persist to the year 2020 (National Spatial Strategy, 2000):

(a) The population of the Greater Dublin Area (GDA) will rise by more than 900,000 people, to ~2.4 million.

(b) Most other regions will grow marginally; by 2020, the largest, the S-W Region focused on Cork, will increase by 126,000, with Cork City accounting for 86,000 of the total.

(c) The Midlands will continue to lose population.

(d) Moderate growth will occur in other main cities.

(e) Rural population drift to the GDA can be expected to continue.

However, there are ranges of other scenarios that challenge the current trends. One of the most significant scenarios assumes that 8% of employment growth in Greater Dublin is channelled to secondary cities and towns; on that basis it projects that the population in some urban centres could double. Several questions remain regarding the possible spatial structure that could result in such growth scenarios:

(a) How far this kind of countervailing growth could or should cascade down to smaller settlements?

(b) How far the spatial structure under such growth conditions should concentrate in existing urbanised areas to reinforce critical mass?

(c) How far the development should concentrate in county towns and villages, in order to underpin the rural economy and urban structure?

3.3.4.3 National Spatial Strategy options

Several different approaches can be taken towards developing a national spatial structure, and a larger number of variations on their themes could probably be derived. The most significant of these different approaches could be described as:

(a) To continue with present trends

(b) To slightly adjust present trends

(c) The traditional solution (Approach (b) + new town)

(d) Complete dispersal.

Each of these has benefits and disadvantages, either for national, regional or local concerns. Therefore, a combination of these is suggested as the preferred spatial approach for the NSS, with its main features as follows (National Spatial Strategy, 2000):

(a) Build on and consolidate the strengths of Dublin as a capital city with a population tending towards 2 mil-

Table 3.4. Key issues in the National Spatial Strategy.

Key issues in the national spatial strategy	Case study settlements (satellite villages in parentheses)
The increasing economic dominance of the Greater Dublin area	Portlaoise (+ Freshford)
Increasing influence and emerging interaction between the other four existing gateway cities and their catchments	Limerick (+ Pallasgreen) Waterford
Areas on the west coast, on the Border, in the South-East and South Midlands where relationships between different towns are emerging	Killarney, Westport, Sligo
Other, largely rural areas in the North-West, through parts of the Midlands and into the South-West, where the agricultural employment base is declining and where the urban structure is quite broken with no dominant element	Roscrea (+ Shinrone) Athlone

lion, emphasising the areas of activity to which it is particularly suited.

(b) Other existing gateway cities could be brought to a level, probably by effective interconnection, where, in combination, they would be able to play a national role in counterbalancing Dublin. Individual cities could end up with populations in the 200,000–300,000 range, with a potential combined population of 1 million. The benefits that accrue from this would be associated with as wide a 'sphere of influence' as possible, such as neighbouring 'county towns' or local economic hubs but without urban sprawl.

(c) Develop the potential of regional centres with emerging strong links to adjacent towns and associated hinterlands as the new development opportunities best guaranteed of success, particularly in the Midlands and North-West and parts of the South and South-East.

3.3.4.4 Key factors in the urban structure of Ireland

Ireland has made a rapid transition from a primarily rural-agricultural society, to one that is now 66% urban, and it appears that the trends will continue for the near future. The *Urban Structures* study (Brady Shipman Martin, 2001) summarised this structure:

(a) There is a good size distribution of urban centres below 40,000 in population. However, there is a bias in their geographical distribution towards the East and the South-East. In particular, there is strong clustering of urban centres in the 10,000–39,999 category in the East and South-East of the country. Some of these centres, such as Bray, Swords, Malahide, Leixlip, Celbridge and Greystones, have grown very rapidly in recent years and are now part of the Dublin Metropolitan Area. Other centres in this size category have also been influenced by the economic and employment growth of the Dublin region, including Dundalk, Drogheda, Naas, Droichead Nua, Navan, Mullingar, Tullamore, Carlow and, probably to a lesser extent, Athlone.

(b) Four of the centres in the 10,000–39,000 population category (Tralee, Sligo, Killarney and Letterkenny) are located in relatively isolated parts of the country, where they are the most important towns and act as 'sub-regional' centres.

(c) The relatively well-developed urban structure of the East, South and South-East is contrasted to the less developed structure to the west and north-west of a line that runs approximately from Limerick to Dundalk. Here, urbanisation levels are lower than for the rest of the country and there are fewer large towns. As a consequence, many smaller centres provide a level of function far greater than their population would indicate.

(d) Centres with populations below 10,000 are more evenly distributed across the country, but there is a greater density of all urban settlement sizes in the East and South.

(e) Nearly half of all urban centres with populations of 5000 and over are located on or near the coast.

This provides a context for the question of 'sustainable settlement size'.

3.3.4.5 Urban development options

The remit of this project is to establish 'methodologies for the estimation of sustainable settlement size'. This involves the consideration of how such settlement sizes may be generated over a period of time, in light of the rapid growth in population, numbers of dwellings and also sizes of dwellings. There is a limited range of options available (Breheny and Rockwood, 1993):

(a) New freestanding settlements

(b) Enlargement of freestanding settlements

(c) Urban extensions (in the sense of planned medium- to large-scale developments)

(d) Corridor development (particularly related to the transportation strategy)

(e) Large-scale urban infill (this will be rare anywhere outside the Dublin conurbation)

(f) Small-scale urban infill (this constitutes the majority of development on the ground).

The implication is that such 'sustainable settlement size' is not necessarily an ideal target to be created on a blank slate, but a process of ongoing development which will apply to the growth of existing settlements probably more than to new settlements. Therefore, the case study settlements are investigated, not only for their current profile, but for their prospects and potential for growth and restructuring.

3.4 Relating urban form to environmental performance

3.4.1 Air pollution and transport

The importance of transport as a contributor to environmental problems (both global and local), and the perceived ability to influence behaviour, is reflected in the amount of research dedicated to assessing the relationship between urban form and travel characteristics. This section of the report provides a short background to the transport and air quality situation in Ireland, summarises some of the latest academic thinking with regards to empirical relationships between travel patterns and settlement parameters, and provides links to the relevant indicators compiled for Section 2.

Ireland has over 95,000 km of roads, equivalent to over 27 km per 1000 persons, a figure considered high by European standards (EPA, 2000). The recent growth in the economy has also led to an increase in car ownership, with the total number of vehicles increasing by over 50% between 1988 and 1998. Private cars accounted for the major part of this increase (though heavy goods vehicles also experienced large increases). As well as increases in the number of vehicles on the road, travel patterns have also experienced change. Between 1986 and 1996, the number of persons travelling to work, college or school in private vehicles increased by 44%, while the number of persons travelling by public transport, bicycle or foot decreased by nearly 6%.

These changes in transport activity, although signifying an underlying increase in prosperity, have significant implications for air quality. Now that air pollution problems associated with coal burning have been significantly reduced, road traffic has replaced stationary sources as the greatest threat to Ireland's quality of air. "Emissions from road traffic have now become the greatest threat to air quality in Ireland, especially in urban areas" (EPA, 2000). The steady increase in car use has considerable implications for air quality in the country, with evidence showing that the ambient levels of some transport-related pollutants are likely to exceed EU standards for the protection of human health. Increasing traffic congestion is also cited as an economic disadvantage.

Road traffic is a major contributor to emissions of CO, CO_2, NO_x, VOC, and PM10s, with NO_x and particulate matter considered the major problem pollutants for local residents. However, in addition to the local air quality and climate change issues, transport pollutants can also result in acidification of soils and surface waters, increased levels of tropospheric ozone, and damage to ecosystems and materials.

In Ireland, greater emphasis is to be placed on data dissemination and the need to keep the public fully informed on the state of air quality. For example, 98-percentile smoke concentrations (large particulate matter) have now been collected for various urban areas: Dundalk, Drogheda, Bray, Arklow, Waterford, Wexford, Dungarvan, Limerick, Galway, and Ennis. In a promising light, there are said to be some encouraging developments linked to new urban development, including the establishment of suburban office parks and increasing prospects for the practice of teleworking.

3.4.1.1 Functional characteristics

Socio–economic variables are said to be important influences on the level of provision of facilities and services in a settlement (Williams and Banister, 1999). This is turn can influence both modal split and total distances travelled in a settlement (Stead *et al.*, 2000). In planning terms, Banister (1996) suggests that an ideal balance can be achieved through a hierarchy of functions, with each locality within a settlement offering the diversity needed to meet daily needs. This will act to both reduce distance travelled and encourage a modal shift. A crucial element is that higher-order functions are accessible by public transport.

Locating near major transport routes and their access points, or in proximity to existing settlement areas, can alter distances travelled, trip lengths and modal split. However, it is stressed that car ownership is not influ-

enced in this way. Car ownership tends to be directly affected by socio–economic factors rather than land-use policies (Williams and Banister, 1999). For new developments, Winter *et al.* (1995) highlight the necessity for eight different types of facility for large residential developments: food shop, newsagent, open space, post office, primary schools, public house, supermarket and secondary school. Figure 3.1 sums up the key factors in the economic/functional geography.

1. Access to urban and intermediate functions, in the 'urban effect'. This characterises the physical location of the settlement in relation to the nearest higher-order centres, such as retail, health and education. This complex question is summarised very simply here. Such locational factors include the following possibilities, where physical distance is moderated by proximity to transport infrastructure:

   (i) from peripheral (villages) to freestanding settlements (towns);

   (ii) from freestanding to district centres with various degrees of independence;

   (iii) from district centres to main urban centres.

2. Access to national and global functions, via socio–economic networks, image and profile, in the 'network effect' (Capello and Camagni, 2000). This is more independent of physical distance and territory, as in neo-classical spatial interaction analysis. The 'network' effect focuses on the benefits of higher-order functions in incomes, employment, cultural amenities, producer services and other public services.

Both the urban and the network effect are instrumental in shifting the balance of 'optimal' or 'efficient' urban size and location, in the sense that the benefits of higher-order functions shift the net welfare and externality curves towards larger settlements. In other words, dynamic gateway cities compensate for their congestion by wealth creation and by serving as hubs for other settlements.

Although evidence indicates that the provision of local facilities reduces the average journey distance by car, the reality is much more complicated. Variations in socio–economic characteristics act to increase the difficulty in establishing precise empirical relationships between land-use characteristics and travel patterns, and can also complicate the comparison of travel patterns in different areas (Stead *et al.*, 2000). The peripheral location of country towns means that the function of a settlement will be heavily influenced by the housing and job opportuni-

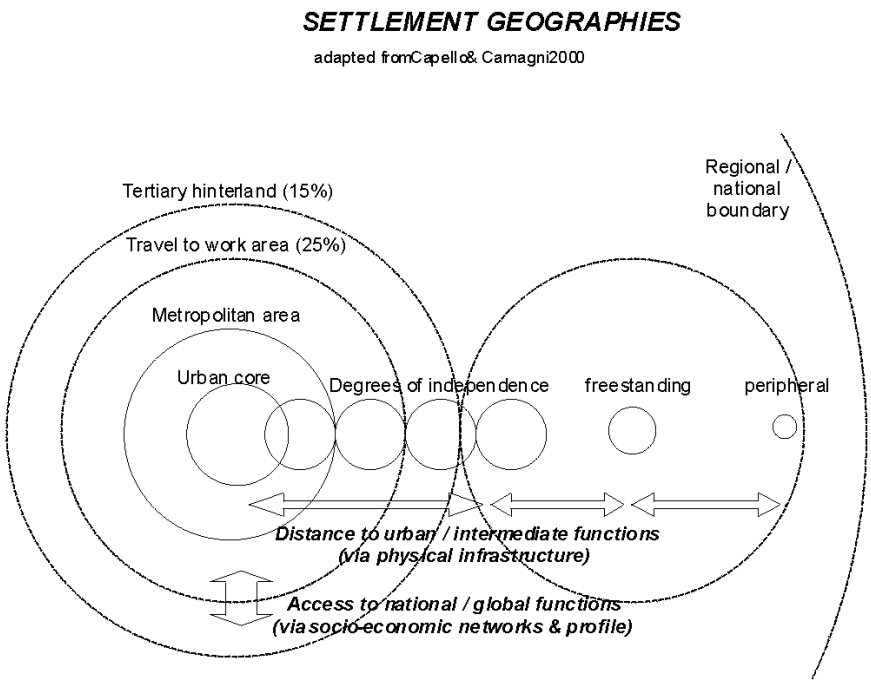

Figure 3.1. Settlement geographies.

ties in adjacent sub-regions. Attracting additional employment in order to avoid the situation where these settlements assume a solely dormitory role is likely to depend on adequate road accessibility. However, the existence of such a network also provides the means for residents to choose to live in these towns, yet commute elsewhere (Headicar, 2000).

Proximity to transport networks is likely to influence travel patterns, and consequently travel distance, by both increasing travel speeds and extending the distance that can be covered in a fixed time. Research by Headicar and Curtis (1994) concluded that proximity to major transport networks has a substantial effect on work travel distance, indicated by longer travel distances and a higher proportion of car journeys. They also found that proximity to a railway station will lead to long-distance commuting behaviour, but fewer journeys made by car.

3.4.1.2 Population size

Settlements can be relatively self-contained and perform well environmentally, when the size, job/worker ratio, and geographical location are favourable. However, when residents work out of town, commuting distances are necessarily long and this greatly reduces the settlements performance in terms of travel generation overall (Headicar, 2000). An early and commonly referenced piece of research on the influence of settlement size on travel patterns was the work by ECOTEC (1993). Their results highlighted a surprisingly weak link between population size and either distance travelled or the proportion of journeys by car, for settlements of 3000–250,000 people (Fig. 3.2). Statistical analysis suggested that car ownership levels played a more significant role in explaining differences in travel behaviour.

In more recent work on settlement size and travel patterns, Williams (1999b) found a negative relationship between settlement size and distance travelled, indicating that the smaller the settlement's resident population, the greater the total distance travelled was likely to be. For the research, a four-way relationship was defined (Fig. 3.3).

To break down modal split and its relationship with settlement size, Williams used data previously collated by Stead (1996) in his publication *Density, Settlement Size and Travel Patterns*. The settlements under investigation ranged from the large conurbation of London down to those with under 3000 inhabitants (see Table 3.5).

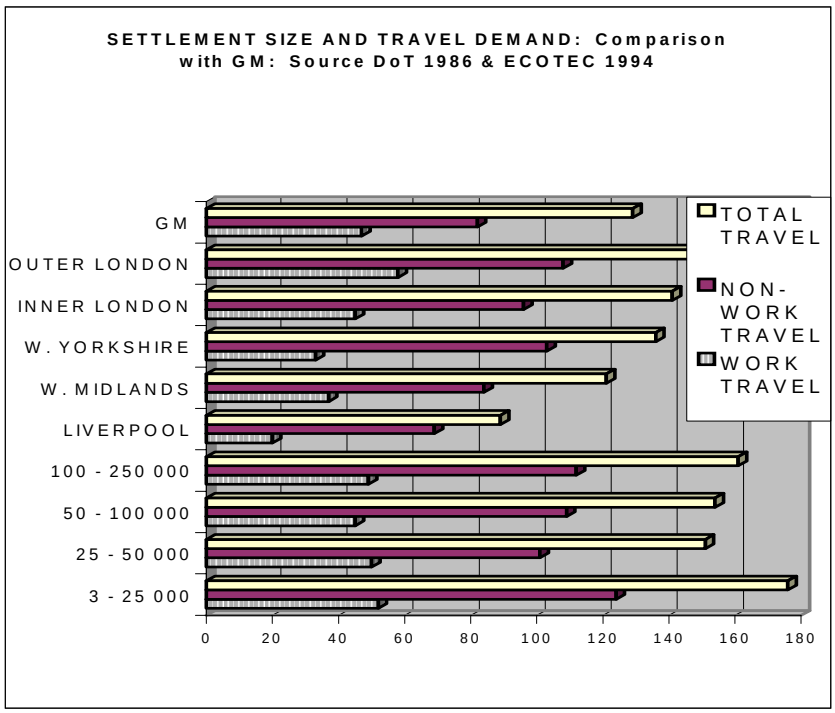

Figure 3.2. Settlement size and travel demand. Source: DoT and ECOTEC as cited in Williams 1999(b).

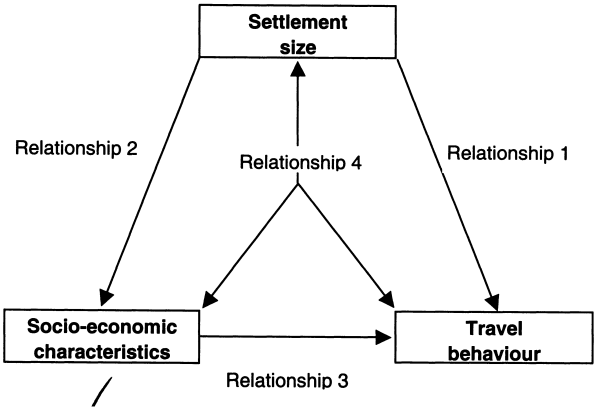

Figure 3.3. Settlement size and distance travelled.

An important finding of this work was the fact that the objective of a journey was also an important variable. The greatest increases in distance travelled between 1985 and 1994 were found to be day trips, business, shopping, and visiting friends at private homes. Increases in travelling for commuting, shopping and visiting friends purposes were estimated to be greatest in settlements with a 3000–25,000 resident population. For business, the biggest increase was in the 25,000–50,000 category.

Williams (1999b) summarised the analysis as:

(a) London: decrease in the use of non-car modes for all journey purposes, especially for commuting, suggesting an increase in car use for business, shopping and other purposes;

(b) 250k+: decline in the use of non-car modes for all journey purposes, with the exception of shopping, suggesting an increase in car use for all purposes;

(c) 100k–250k: large decline in the use of non-car modes for all journey purposes, increase in car use for all journeys;

(d) 50k–100k: decline in the use of non-car modes for all journey purposes, with the exception of shopping, suggesting an increase in car use for all purposes, excluding shopping and other purposes;

(e) 25k–50k: decline in the use of non-car modes for all journey purposes, with the exception of shopping and other categories, suggesting an increase in car use for all purposes, excluding shopping and other purposes;

(f) 3k–25k: large increase in the use of non-car modes for all journey purposes, except commuting, suggesting an increase in car use for commuting;

(g) less than 3k: decline in the use of non-car modes for all journey purposes, with the exception of shopping and other purposes, suggesting an increase in car use for all purposes.

However, the author (*op cit.*) also sought to qualify these results by emphasising that settlement size was only one variable affecting total distance travelled. Other factors were suggested, such as:

(a) quality of public transport;

(b) accessibility to local facilities;

(c) availability of local employment;

(d) socio–economic characteristics of the population;

(e) land-use and development policies.

In terms of socio–economic characteristics, one significant finding from the Williams research project was that

Table 3.5. Modal split and settlement size (from Stead, 1996).

Settlement size	London	>250k	100k–250k	50k–100k	25k–50k	3k–25k	<3k
Walking (km/person/year)	381 (max.)	328	323	365	317	303	246 (min.)
Car	5481 (min.)	6445	8483	8291	7657	9498	11,003 (max.)
Van	217 (min.)	391	451	393	332	531	813 (max.)
Bus	700	949 (max.)	509 (min.)	660	666	695	764
Rail	1207 (max.)	431	558	550	538	457	332 (min.)
Cycle	48 (min.)	56	90 (max.)	61	69	63	55
Other	206	200	253	180 (min.)	183	396 (max.)	272

settlement size has discernible links with both age and car ownership (Table 3.6). Other relationships are clarified in Fig. 3.4.

Williams based her research on Gloucestershire in the S-W of England, and Table 3.7 details total distances and modal choices for both urban and non-urban settlements in the county. These are compared to the national averages for 1991.

An important feature that complicates the relationship between settlement size and distance travelled is the objective of the travel undertaken. For the UK, the distance travelled per person per year to and from work increased by 18% between 1985 and 1995, whilst the distance travelled per person per year for shopping and personal business purposes increased by 38% (Titheridge *et al.*, 2000). It is, therefore, likely that as the balance between commuting and other travel objectives changes, so too will the form and location of the most sustainable settlements.

Research in Norway has identified a statistical relationship between the distance from the urban centre and total travel distance per person in Oslo (Naess and Sandberg, 1996). The authors found that the distance between home and the centre of the settlement is an important determinant of total travel distance (in combination with factors such as car ownership and accessibility to local facilities). Car ownership was found to be an influential variable for transport energy consumption, followed by the distance between home and the settlement centre, accessibility to local facilities, and various socio–economic factors.

Table 3.6. The relationship between socio–economic characteristics and travel patterns (Williams, 1999b: p. 17).

	Total distance travelled	Total distance travelled by car	Total distance travelled by non-car modes	Car ownership
Car ownership	• Positive relationship between total distance travelled and car ownership	• Positive relationship between distance travelled by car and car ownership	• Negative relationship between distance travelled by non-car modes and car ownership	–
Age	• Children and elderly age groups travel the least • Age group 16–59 travel the most	• Positive relationship between distance travelled by car drivers and % of population in age categories 30–59 • Positive relationship between distance travelled by car drivers and passengers and % of population in 16–29 age categories	• Positive relationship between distance travelled by non-car modes and % of population in 16–29 age category	• Positive relationship between car ownership and % of population in the 30–59 age category
Income	• No information available	–	• Positive relationship between distance travelled by rail and income • Negative relationship between distance travelled by bus and income	• Positive relationship between car ownership and income
Employment	• No information available	–	• Positive relationship between distance travelled by rail and % of population employed full-time	–

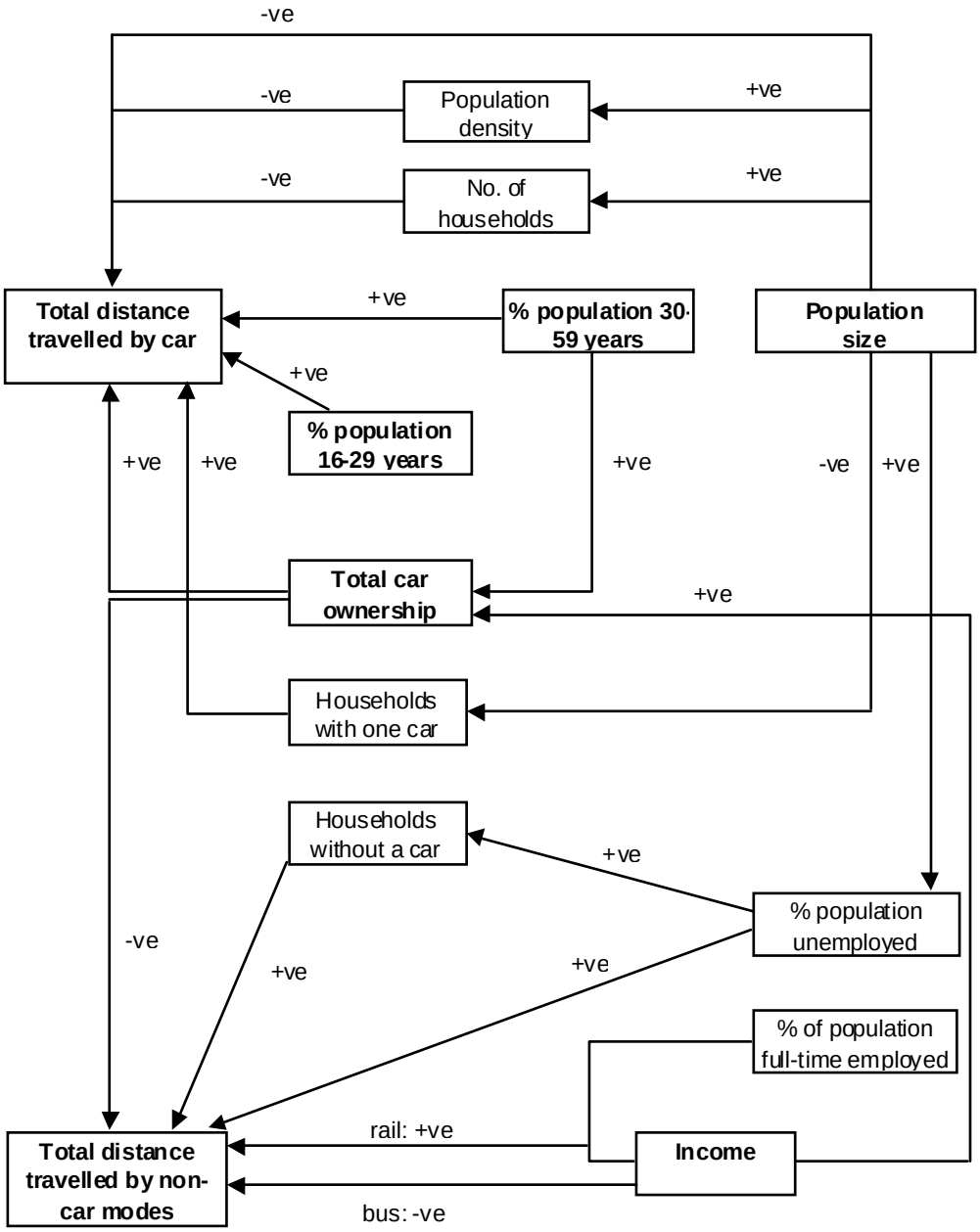

Figure 3.4. Relationship between travel, socio–economic and population characteristics.

Table 3.7. Travel characteristics for Gloucestershire (Williams, 1999b).

	Total distance travelled per worker per year (km/person/year)	% of total distance travelled to work by car	% by public transport	% by foot	% by other modes	Car ownership
Gloucestershire urban districts	1204.5	64	7.5	13	15.5	71.5
Gloucestershire non-urban districts	2044	69	5	10	16	80
National average 1991						Urban = 69 Non-urban = 77

Their study of six different companies in Greater Oslo uncovered a relationship between modal split, energy use for journeys, and the geographical location of the workplace. Results indicated that workers in peripheral, low-density parts of the urban area use car travel to a much greater extent, and use considerably more energy than employees of workplaces located in central areas. Several other Norwegian studies have also shown that modal split is significantly affected by the location of workplaces within the urban area. Therefore, both modal split and distance travelled are considered important variables influencing energy use for work-related travel.

Some of the detailed findings (Naess and Sandberg, 1996) are of relevance to thinking in the Irish context:

(a) Both of the two centrally located workplaces that were investigated had commuting distances above the total average of the case study firms.

(b) Among the employees of the two workplaces located in the urban fringe, the proportions of those travelling by car are high and the public transport figures very low. Both businesses are also located in low-density areas with poor public transport but ample parking facilities.

(c) The proportion of commuting distance travelled by car correlates strongly with the distance from downtown Oslo. The range of variation in the proportion of those travelling by car matches the variations in distance from downtown Oslo, the density of development, and the availability of public transport facilities near the workplace.

In their conclusions, the authors listed public transport facilities and parking conditions as the planning factors most directly influencing the amount of car travel, whilst a firm's distance to the downtown area, and density of buildings near the workplace, have indirect influences on modal split. They also cite distance to the central area as the variable most strongly associated with the energy-use levels of the workplace. Their results suggest that short travel distances to central areas, and high densities, contribute indirectly to energy-use improvements by increasing the viability of good public transport facilities near the workplace. Hence, a non-car modal split is encouraged. As a result, the location of the workplace relative to the centre of the settlement has a greater influence on modal split than actual commuting distances.

Other salient points derived from the Norwegian study suggest that commuting distances are shorter for those workplaces within settlements rather than on the urban fringe (which are also dominated by the private car). Furthermore, the more specialised the business's function is (and the larger hinterland from which visitors come), the more favourable a central location becomes. For visitor-attracting, non-specialised functions with a primarily local catchment area, a decentralised location interspersed with residential areas scores well in terms of energy use. For other workplaces targeting a local catchment area, a central location would appear to be the best choice for low energy use. In general terms, an inner-area, high-density location with good public transport facilities seems to be preferential from an energy perspective. If a workplace needs to locate peripherally, the next best solution is the selection of a site close to existing public transport nodes.

3.4.1.3 Density

The compact city has become synonymous with policies that emphasise the merits of urban containment (Breheny, 1995). The density parameter is thought to influence travel patterns (Fig. 3.5) for a number of reasons. In the first instance, high densities increase the opportunities for local contact and activities that are maintainable without the use of a car. Secondly, higher densities ensure the viability of service provision by a locality (and hence reduce the need to travel longer distances). Thirdly, high densities tend to reduce average distances between homes, services, and employment. Finally, high densities influence modal choice, with average distance by car, bus and rail decreasing with increasing population density, and average distance on foot remaining constant, regardless of population density (Stead *et al.*, 2000).

One of the key early studies, adopting multiple regression analysis, showed density as the dominant explanatory variable for the levels of energy use related to the transport sector[4] (Newman and Kenworthy, 1989). Their

4. They defended their focus on density on the basis that economic determinants (price and incomes) are unlikely to be used seriously as policy tools by politicians.

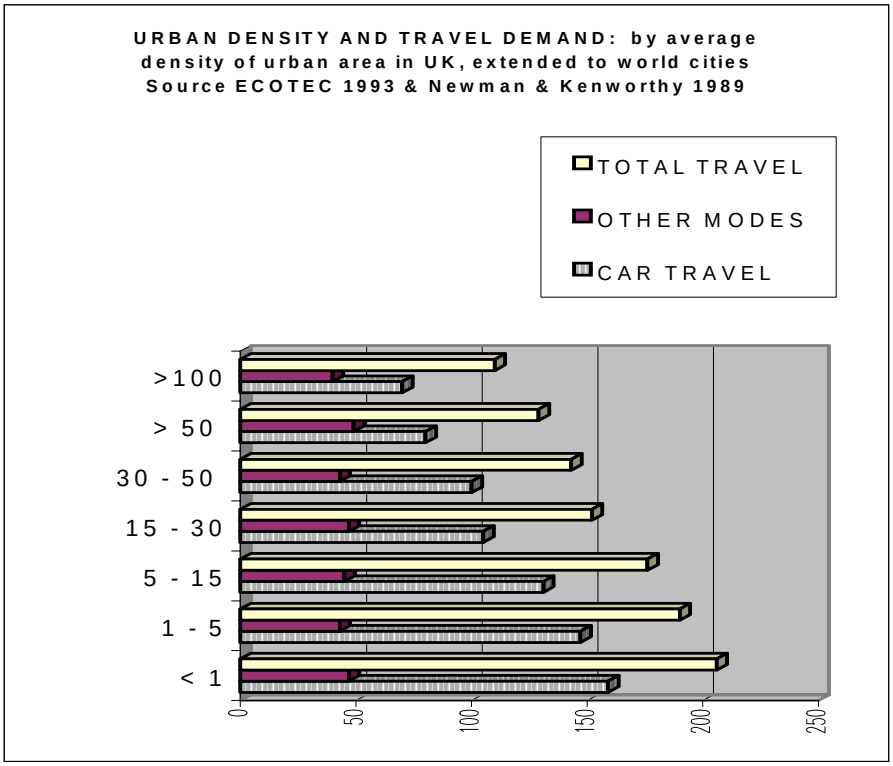

Figure 3.5. Urban density and travel demands.

methodology involved measuring petroleum consumption and population densities for a selection of large cities around the world, with the evidence illustrating a clear negative relationship between density and fuel consumption. Other dominant influences were found to be job density and the dominance of the city centre area. In particular, important features that were emphasised by the work were employment decentralisation, increased suburb-to-suburb work trips, and the growth in travel from non-work trips.

Their findings have since been reinforced by additional research which has shown that as population density increases transport energy use falls (Table 3.8). In the UK, ECOTEC (1993) suggested that with increasing density, the proportion of trips by car decreases, whilst non-car modes increase. Their results show an inverse correlation between total distances travelled per week and population density. Car travel is the dominant feature. People living at the lowest densities travel approximately twice as far by car as those living at the highest densities. Specifically, car journeys account for 72% of trips in the low-density areas, but only 51% in high-density areas. Their conclusions state that large urban areas (due to high urban densities, shorter travel distances, and public transport facilities) are inherently much more sustainable than their smaller or rural counterparts.

However, the influence of density is not without debate. Common criticisms are that socio–economic characteristics such as income, car ownership, and fuel price are not given adequate consideration when determining private vehicle use (Buxton, 2000). Furthermore, Owens (1991) argues that the relationship between densities should not be viewed as linear. The suggestion is that although the relationship between public transport and density is linear, as is the relationship between public transport and car usage, thresholds exist. In this case, as densities increase, there is a shift towards increased public transportation, with distinct threshold densities needed for a viable public transport system. Buxton (2000) also cites substantial research that indicates that both density and land-use mix are related to modal choice and as these increase the levels of non-car travel also rises, while single-occupant vehicle use falls.

The modelling of urban form with a focus on energy-consuming characteristics tends to conclude that two types of

Table 3.8. Primary energy consumed per person per week, by mode and urban size (MJs). (Breheny, 1995: derived from ECOTEC data, 1993).

	Car	Bus	Rail	Walk	Other	Total
Inner London	99.7	7.0	20.1	-	13.6	140.4
Outer London	148.4	5.2	13.7	-	15.2	182.5
Metropolitan areas	92.5	9.8	2.8	-	14.0	119.1
Other urban area (over 250,000)	122.6	9.8	4.9	-	19.6	156.9
100,000–250,000	150.4	5.0	6.7	-	18.5	180.6
50,000–100,000	144.6	4.2	7.7	-	16.6	173.1
25,000–50,000	145.2	3.3	7.4	-	14.9	170.8
3000–25,000	174.7	4.2	4.7	-	19.8	203.4
Rural	214.6	3.3	6.4	-	23.7	248.0
All areas	149.1	5.4	6.7	-	18.0	179.2

growth are more sustainable: in the core of the settlement or in a 'decentralised concentration' form (the development of sub-centres that maintain overall densities) (Breheny, 1995). With the prime focus of the environmental debate centred on energy, it is clear that the greater dependence of rural and small-town dwellers on the car is the major source of their energy consumption and unsustainable behaviour. However, aside from energy efficiency benefits, Breheny also suggested that there may be other wider impacts linked to containment policies, including economic, social and cultural benefits.

3.4.1.4 Land use

Land-use characteristics can have an influence on travel patterns, impacting at scales from strategic to local (Stead *et al.*, 2000). Land-use characteristics affecting travel patterns include:

(a) location with respect to existing towns, cities and infrastructure;

(b) structure of development – size and shape;

(c) land-use type and overall mix;

(d) clustering/concentration of development;

(e) land-use mix – level and scale of mix;

(f) density of development (population and employment density);

(g) layout of development (movement networks, neighbourhood type).

Car use for commuting is said to decline as land-use mix increases, though the gradient of this relationship is not considered steep (Van and Senior, 2000). In their research, Van and Senior found that there were strong contrasts between areas for car use and walking/cycling for light food trips. Their results indicate that mixed land uses tend to encourage walking and cycling, and deter car use, for frequent, regular purposes such as light food shopping trips. Consequently, new development should be designed to encourage less travel, especially car-based journeys. It is suggested that to counter suburbanisation, land-use planning should encourage compact, mixed-use, and accessible developments (Williams and Banister, 1999).

It has long been recognised that an interdependent relationship exists between land-use mix, socio–economic characteristics, and travel patterns. Burnett and Hanson (1982) reported a link between income and land-use patterns, which was thought to explain some of the variation in travel patterns in different locations. One of the main findings was that frequency of travel was linked to household income, with those on higher incomes travelling more than those on lower incomes. The complexity of interactions between land use, socio–economic characteristics and travel patterns is heightened by interrelationships between varying land-use characteristics. For example, settlement size may be linked to population density, the distance to settlement centre, or the availability of residential parking (Stead *et al.*, 2000).

Possible interactions between land-use characteristics are considered to be (*ibid.*):

(a) Population size

(b) Local facilities

(c) Population density

(d) Employment density

(e) Job ratio

(f) Distance to urban centre

(g) Availability of parking

(h) Public transport accessibility

(i) Pedestrian network

(j) Road network

(k) Neighbourhood type

Possible interactions between socio–economic factors:

(a) Income

(b) Car ownership

(c) Household size and type

(d) Attitudes

(e) Personality type

(f) Driver's license

(g) Gender

(h) Age

(i) Education

(j) Employment type

(k) Work status.

In earlier work, Stead (1996) estimated that socio–economic characteristics were the dominant variables for explaining travel patterns, typically explaining half of the variation in travel distance per person according to locality. On the other hand, land-use characteristics account for one-third of the variation. The author identified a number of 'key' socio–economic determinants: household car ownership, household socio–economic group, and the proportion of working residents. Williams and Banister (1999) reported similar socio–economic determinants, though they added income as another important characteristic. In the work by Stead *et al.* (2000), three studies were compared (see Table 3.9). Analysis shows that although socio–economic characteristics explain the greatest amount of variation in travel patterns, there are also important land-use characteristics that need to be accounted for. The most important land-use characteristics linked with car ownership are considered to be proximity to a railway station and the frequency of the local bus service. On a final note, there may be a correlation between the availability of residential parking and the proportion of short journeys made on foot (assuming that car owners wanted to retain their parking spaces). As well as reduced parking, other measures that may create a better living environment for the local community include traffic calming and pedestrianisation. For example, Copenhagen has been involved in a 30-year programme of reducing central and inner-area parking by 3% each year. These actions, together with upgraded bicycle and pedestrian infrastructure and activities, have ensured that the city has combined a reduction in traffic growth with a thriving central area (Newman and Kenworthy, 2000).

3.4.1.5 Summary

Transport is the largest and fastest growing user of energy in Ireland, accounting for over one-third of total energy demand. Increases in the number of vehicles, combined with a trend towards larger vehicles are cited as the main contributors (EPA, 2000). In the UK, national planning guidance (PPG13) has been initiated with the aim of reducing the impact of car travel by increasing settlement densities and mixed-use development in public transport corridors and nodes. Elsewhere, the Dutch have also been proactive, with their ABC policy framework. It specifies the need to develop in existing transport corridors, particularly public transport corridors, and at transport nodes.

However, research findings have also shown that travel patterns can be extremely complex. For example, Williams (1999a) highlighted the example of three London Boroughs that had experienced intensification over 10 years, with analysis showing no reductions in car use during this period. Travel patterns were considered so complex, due to lifestyle shifts such as cross-London

Table 3.9. Relationships between travel patterns, land-use and socio–economic characteristics (Stead *et al.*, 2000: p. 184).

	Total travel		Travel-to-work distance	Travel-to-work mode	
	Stead, 1996	Williams and Banister, 1999	Titheridge *et al.*, 2000	Williams and Banister, 1999	Titheridge *et al.*, 2000
Socio–economic					
Socio–economic group	√	x	√	x	√
Car ownership	√	√	√	√	√
Employment status	√	√	x	√	√
Age	x	√	x	√	√
Household structure	√	n.a.	x	n.a.	x
Income	√	√	n.a.	n.a.	n.a.
Land use					
Distance from the urban centre	x	n.a.	√	n.a.	x
Settlement size	√	√	x	√	x
Mixing of land uses	√		√		√
Provision of local facilities	√	√	√	√	x
Density of development	√	√	x	x	x
Frequency of nearest bus service	√	n.a.	x	n.a.	x
Proximity to nearest railway station	x	n.a.	√	n.a.	√
Availability of residential parking	√	n.a.	n.a.	n.a.	n.a.

commuting for work and increased journeys for leisure, that no relationship could be identified. As a consequence, it is suggested that the growth in car ownership and diffuse life patterns are influential trends that are difficult to influence through land-use planning alone (Williams and Banister, 1999), with socio–economic factors and societal aspirations playing significant roles in the positive relationship between provision and trip frequency (Williams and Banister, 1999). However, although there are limits to planning, the presence of local facilities is a necessary condition for local use. From the evidence to date, key actions to become less car dependent, and hence more sustainable, are (Newman and Kenworthy, 2000):

(a) revitalise the inner city;

(b) focus development around the existing rail system;

(c) discourage further urban sprawl;

(d) extend the public transport system and build new urban villages in the suburbs.

In the international arena, an Australian Urban and Regional Development Review concluded that changes to urban form (including compactness, concentration around a strong central city, increased density, public transport-supportive development, and localised employment and services) could impact significantly on transport energy savings and, in the medium-term, improve the sustainability of cities (Buxton, 2000).

It is likely that the role of settlement size in influencing travel patterns is limited. However, in combination with location, density, provision of services and facilities, and employment opportunities, its importance will be enhanced. From the evidence detailed earlier, analysis suggests that there is a relationship between service provision and the size of settlement. Once this relationship has been reliably quantified, settlement size has the potential to be a useful benchmark for predicting and controlling travel patterns (Williams and Banister, 1999). A simplified diagram depicting a planning framework for transport sustainability is shown in Fig. 3.6. Although size, location and density influence travel patterns within

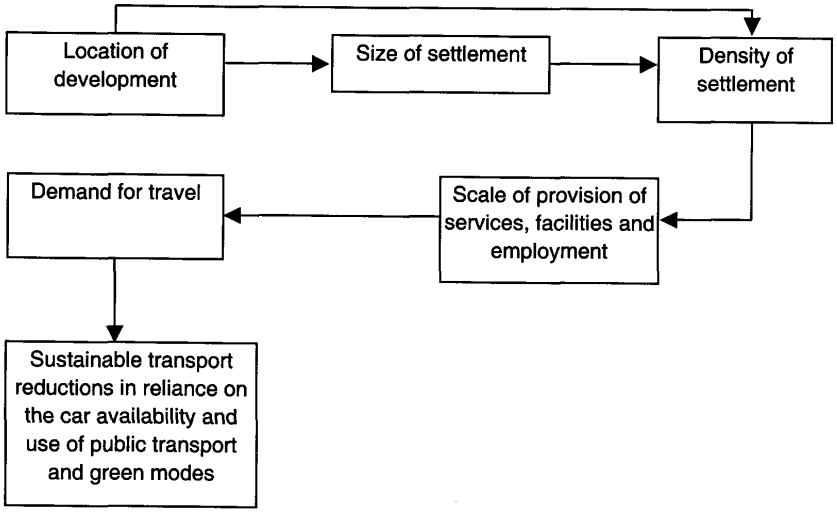

Figure 3.6. Planning for transport sustainability (Banister, 1996).

and between settlements, the number of trips and distance travelled within a settlement are also influenced by the provision and accessibility of services and facilities (*ibid.*). The authors argue that sufficient size is necessary to ensure the viability of employment, service and leisure activities, with the facilities grouped in close proximity to encourage the use of greener modes of transport, as car dependence is seen to increase with distance between services/facilities.[5]

For new housing it appears that larger, well-serviced and high-density settlements are best at reducing the need to travel. This can be applied to a single large settlement or several smaller, dense, clustered settlements. Owens (1991) advocates the development of a cluster of smaller settlements, which in combination have a total resident population of 250,000, linked by a public transport network. Basic facilities, services and employment would need to be located in each individual settlement.

3.4.1.6 Indicators and the Irish case studies

From the empirical evidence collated for Section 2, initial analysis suggests that evidence of sensitivity to settlement size is extremely patchy. The purpose of these concluding sections for each of the environmental issues is to evaluate the significance of Section 2 indicators, and to arrive at an overall assessment of the relationship between settlement size and sustainability. Evaluation is based solely on empirical data collected for Section 2, and it should be noted that, due to time constraints, settlement sample size was very small, with limited data availability. As such, the findings and conclusions reported here need to be interpreted in an indicative fashion only.

From the evidence, it is clear that the transport parameter is an extremely complex issue for determining sustainable settlement size, with a range of interdependent relationships existing between the many variables. However, from the diverse and often contradictory evidence (heavily influenced by socio–economic and societal aspirations), there are some general points that can be highlighted and used to guide and refine indicator frameworks.

Overall, it would appear that larger, high-density, and well-serviced settlements would perform best in limiting car-based travel. However, socio–economic characteristics are an extremely important variable and one on which planning can only have minimal impact. In terms of settlement size, it is apparent that a reasonable size of settlement is required to ensure accessibility to local facilities, availability of local employment, as well as having an indirect influence on car ownership levels. It is suggested that settlements need a minimal size to ensure an adequate diversity to meet the needs of the community, including the presence of shops, schools, open space, etc. It is also important that higher-order functions are accessible by public transport. Empirical evidence remains patchy but a crude estimate derived from the literature

5. Diversity of services and facilities is also considered important in the encouragement of self-sufficiency.

would be a target minimal population size of around 25,000.

Closely linked to the size parameter is that of density. At population sizes of less than 25,000, densities tend to be low and hence encourage a much more prolific use of the car. There would also appear to be a density threshold for increased bus travel, with settlements with over 250,000 inhabitants ensuring adequate density for the provision of a high quality bus service. In planning terms, this would point to the development of existing urbanised areas or the development of sub-centres that maintain density levels.

Urban shape and land use is another important variable. Of most benefit is the promotion of mixed land-use development, in particular the favourable location of the workplace in relation to the home (though shopping and leisure are becoming increasingly important). Other issues include presence of a railway station, frequency of the local bus service, limited parking spaces, and pedestrianisation initiatives.

(a) Travel mode to work: contrary to most other studies, there is little change in the percentage of car drivers according to settlement size. Other issues, particularly relating to density and land-use mix, may be of more relevance in explaining car-based activity.

(b) Distance travelled to work: evidence from the Irish case studies would appear to be contrary to what would normally be expected. Distance travelled tends to be highest for the largest settlements, with travel of less than 2 miles also low in comparison to the smaller settlements (urban shape/land use may better account for these results). Data presented on distance to workplace/education and the mode of transport to workplace/education do not present a clear picture of differences between settlements of varying size.

3.4.2 Climate change and energy consumption

Due to recent economic growth, limited capacity for hydropower development, and a policy not to develop nuclear power capacity, Ireland now has one of the highest emissions of greenhouse gases per capita in the EU. This reliance on fossil fuels ensures that energy generation, agriculture, and traffic account for over 70% of greenhouse gas emissions nationally. Of most concern are the projections for 2010. Under a business-as-usual scenario it is likely that emissions will be at least 30% higher than in 1990 (EPA, 2000), more than twice that allowed by Ireland's legally binding commitments under the Kyoto Protocol. The concession to Ireland of a further increase in emissions, combined with a considerably improved economic situation, means that "little sympathy can be expected from other Member States if the allowed target is not respected" (EPA, 2000: p. 195). There is limited activity in the renewable field in Ireland. Until very recently, renewable energy was largely confined to wood burning in open fires and hydro-electricity production. However, independent hydropower producers, wood-processing plants, and wind-energy developers have begun to increase renewable capacity in Ireland.

Industrial energy demand will be a result of varying types of industrial activity, including (EPA, 2000):

(a) 40% employed in metals and engineering;

(b) 16% in food;

(c) 9% in chemicals;

(d) 7% in paper and printing;

(e) 22% in other manufacturing;

(f) 4% in electricity, gas and water;

(g) 2% in mining, quarrying and peat.

3.4.2.1 Urban form

In contrast to the abundant research on the urban form and the transport issue, there is little in the way of academic studies relating to other types of energy use. The work that does exist would appear to suggest that on the basis of emissions, the more concentrated or 'directed' forms of urban development generate superior outcomes compared to the business-as-usual scenario (Newton, 2000). Higher densities have been cited as a prerequisite for the increased take-up of energy-efficient technologies[6] (Williams, 2000), though the author did add the proviso that further research is needed to determine the specific influence of density.

6. It has been estimated that as much as 70% of delivered energy is subject to the influence of land-use planning (Williams, 2000).

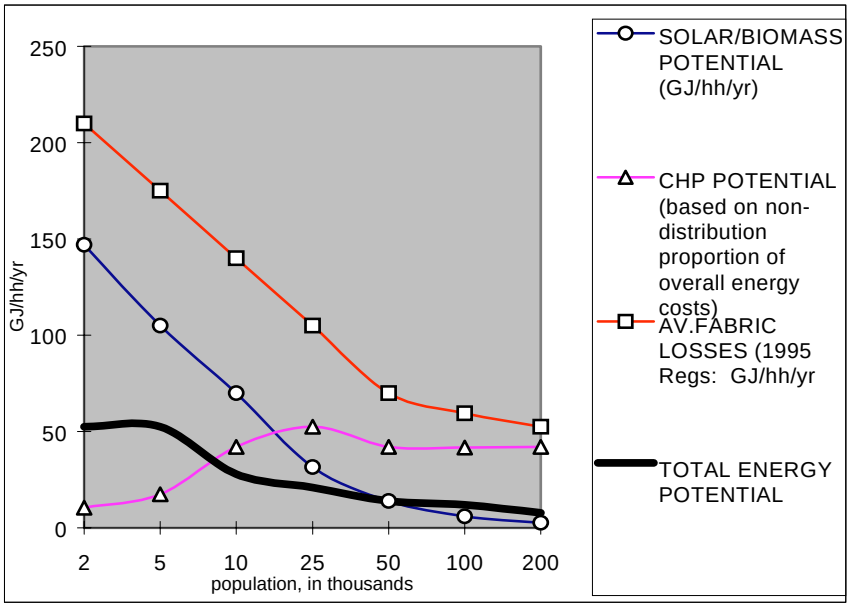

Figure 3.7. Energy potential.

For the renewable technologies, particularly solar power, it is layout rather than size and density that are important, and careful design is necessary to ensure that no overshadowing occurs (Fig. 3.7). In terms of Combined Heat and Power (CHP), both layout and density influence the viability of successful operation. Systems tend to operate to a baseload for domestic hot water, and hence viability will depend on a minimum number of units. Sub-100-kW systems are available but are not commonly used, as they are vulnerable to a lack of load diversity.

As a benchmark, a minimum of 60 housing units is usually taken as the threshold for viability (Building Research Establishment, personal communication).

However, as there are many variables influencing the viability of individual systems, assessment should ideally be made on a case-by-case study.

A study that has attempted to relate urban density to energy use was undertaken by Larivière and Lafrance (1999) for the 45 most populous cities of Quebec, Canada. Their work focused on electricity consumption, and they concluded that their modelling results could explain 85% of urban electricity consumption. The authors put forward a subset of six predictors as significant in explaining the annual energy consumption per inhabitant of the 45 most populous cities of Quebec:

AVGAGE: average inhabitant age;
DEGDAY: the annual degree-days below 18°C;
DENSITY: the urban density (inhabitant per km^2);
ELECTRIC: the share of homes heated by electricity;
LANDWEAL: the standardised land wealth per inhabitant;
PLANLEAS: Planning, leisure and culture expenditure per inhabitant.

They describe the best model by:

$$\mathbf{Y = -16964 + 389.47 \times AVGAGE + 1.016 \times DEGDAY - 0.498 \times DENSITY + 86.47 \times ELECTRIC + 0.1159 \times LANDWEAL}$$

In their concluding remarks, they suggest that the increased level of services in larger cities will tend to cancel the energy gains associated with higher densities.

3.4.3 Water quality (waste water)

One of the major environmental problems in Ireland is the eutrophication of fresh water, and it has been officially acknowledged that water quality management planning has not succeeded in preventing the deterioration of surface water quality[7] (EPA, 1999c). The upward trend in slight and moderate pollution classification for water-

7. The more densely populated and intensively farmed regions of the country are worst affected by water pollution.

courses is attributed to eutrophication by both fertilisers and point source (sewage) discharges. The increase in seriously polluted rivers is attributed to suspected sewage discharges and, to a lesser degree, to agricultural activity. Remedial action for point-source pollution can involve (1) the provision of adequate waste treatment facilities where these are lacking, (2) improved management of existing sewage and industrial waste treatment facilities, or (3) large, 'industrial' farmers adopting more sustainable practices (EPA, 1999d).

Population density is low in the rural areas of Ireland. Consequently, it is likely that the waste water from many communities will continue to be treated in small-scale wastewater treatment systems[8], many of which need to be upgraded to meet the requirements of new EU-derived regulations and standards (EPA, 1998a). Full implementation of the Urban Wastewater Treatment Directive will result in 89% of the EU population being served by secondary treatment, as well as around 45% with nutrient removal. With increasing levels of both tourism and prosperity there are likely to be new demands on the rural fabric of Ireland, with holiday homes and hotels, leisure facilities, and small businesses becoming much more widespread. Wastewater treatment facilities will have to be updated accordingly.

3.4.3.1 Urban form

International experience strongly suggests that population size is a key variable in relation to provision of wastewater treatment plants. A crude benchmark is the 1000 population equivalent (p.e.) threshold. Up to this limit, systems tend to be smaller, more environmentally friendly operations (little or no energy requirements); above this limit, conventional engineering sewage treatment works tend to be the most effective choice of operation (Scottish Agricultural College, personal communication). Population equivalent is based on flow measurement and varies across Europe (between 120 and 250 litres per person). The 1000 p.e. is also the figure used by the UK Legislation BS 6297: 1983, which deals with installations suitable for the disposal of domestic sewage from communities ranging from single households. Summary details were compiled by the EPA (1998a).

In their literature review of small-scale wastewater treatment (EPA, 1998b), the Irish EPA summarised activity from other areas, including the following:

> Dakers and Cockburn (1990): discussed Thames Water operation of 400 works, with over half of these serving populations of less than 2000. Biological filters are most commonly used but oxidation ditches and reed beds are also used.
>
> Boller and Deplazes (1990): in Switzerland, more than 900 wastewater treatment plants serve 90% of the population. Of these, 30% are designed for less than 1000 inhabitants. Local pollution problems with small, untreated discharges have been reported. Generally, rotating biological contactors (RBCs) and trickling filters are used for smaller installations, with activated sludge being used for plants of approximately 1000 p.e. upwards. In the size range of 100–1000 p.e., biofilm and suspended growth systems are chosen with equal frequency.
>
> Jansen *et al*. (1994): data were collected from 119 treatment plants in the population range 100–2000 p.e.[9] Mechanical/biological plants make up 29 of the 119 plants (mostly activated sludge systems, but also including rotating disc and trickling filters). Constructed wetlands, classified as low technology, make up 19 of the plants.

Other examples of innovative small-scale treatment plants that were discussed include:

(a) The WRC in Great Britain has developed designs for packaged activated sludge systems to serve populations in the range of 100–1000 persons. Target effluent quality is 15:20:5 mg/l of BOD, suspended solids and ammonia nitrogen, respectively, on a 95-percentile basis.

(b) In South Africa, a compact, intermittently aerated activated sludge package plant was developed in which all the treatment processes were housed within a 12-m shipping container.

8. The waste water from over one-third of the population is treated in small-scale treatment systems.

9. Requirements for wastewater treatment plants serving less than 5000 p.e. in Denmark are decided by the local authority.

(c) Biological wastewater treatment, with simultaneous aerobic sludge stabilisation, can operate as a charge process for a range of 300–2000 p.e.

In their work on economic and engineering approaches to wastewater management, Carmichael and Strzepek (undated) utilised optimisation and water quality models to assess alternative treatment options. Using the modelling package GAMS, the authors selected alternative point-source abatement at each discharge site, with the aim of combining treatment options to minimise the combined treatment costs necessary to achieve ambient quality standards. The production of oxygen by algae is determined in part by nitrogen (N) and phosphorus (P) availability, and is defined as:

$$\mathbf{P_a = a_{op}G_{max}(1.066)_{T\text{-}20}G(I)_{aj}\ [min(f_k(E_{N,i})\ /\ k_{s,N} + f_k(E_{N,i}),\ (f_k(E_{P,i})\ /\ k_{s,P} + f_k(E_{N,i})]}$$

where:

$\mathbf{a_{op}}$ is the ratio of DO produced per unit of algal photosynthesis, mg O / mg chl *a*,

$\mathbf{G_{max}}$ is the maximum growth rate of algae, l/day,

T is the temperature in °C, dimensionless,

G(I) is the light limitation factor, dimensionless,

$\boldsymbol{a_j}$ is the algal biomass concentration, mg chl *a*/l, and

$\mathbf{K_{s,k}}$ is the half-saturation constant, mg/l.

The general form of the optimisation model minimises the combined annualised cost (C_i,$year) of treatment plant choices over the set X_i = {No treatment (NONE), Mechanical (M), Chemically enhanced mechanical (CM), Biological (B), Biological with chemical treatment (BC), Biological with denitrification (BCN)} at each of the emitting sites so that dissolved oxygen (DO) standards are maintained. For this situation, abatement choices were discrete and lumped, with each option including prescribed abatement levels of BOD, P, and N. Each treatment plant choice also has a discrete set of pollution abatement percentages. Treatment plant choices are presumed to be built to a designed maximum capacity flow, due to economies of scale in wastewater treatment technology.

Figure 3.8 illustrates the discrete treatment plant cost estimates for different treatment options and the cubic cost function for a particular site.

Of the two types of modelling techniques used, continuous modelling relies on the total cost curve, whereas the integer model uses actual uneven changes in technology and cost. Therefore, continuous function-based approximations are best suited for economic policy at a broad policy scale, with integer modelling most appropriate for identifying specific priority locations for wastewater abatement or for choosing specific technologies for these priority sites.

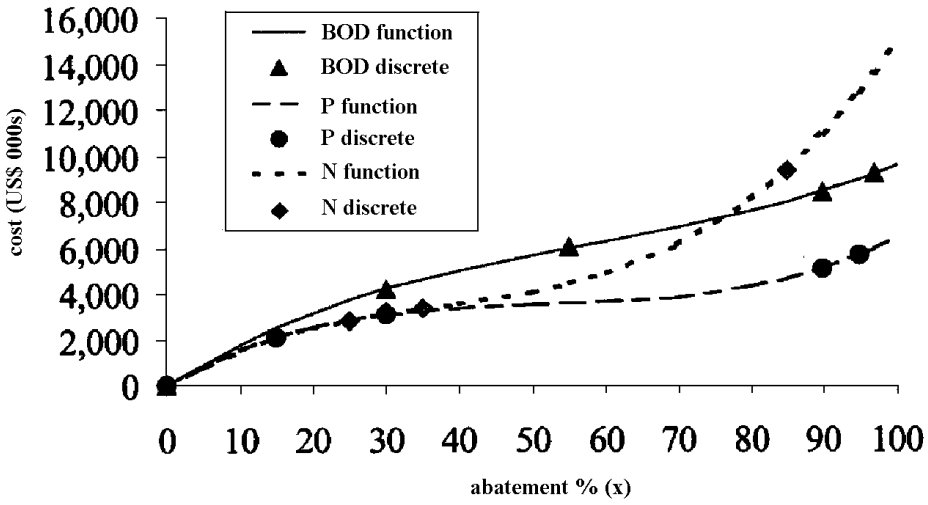

Figure 3.8. Total cost curve.

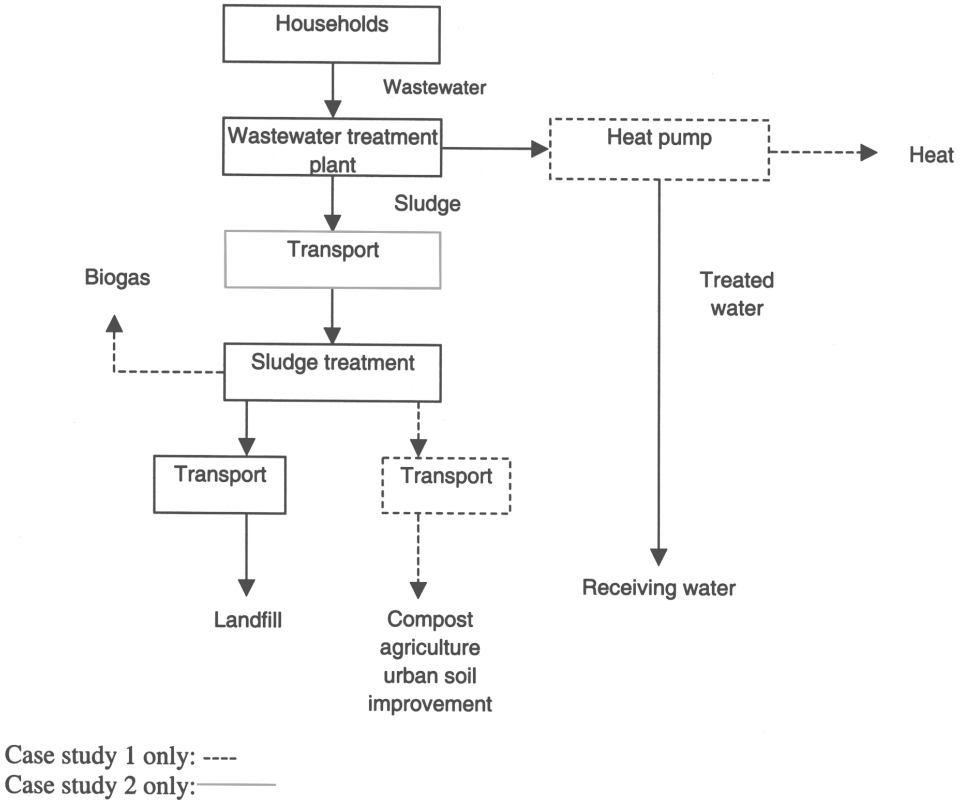

Figure 3.9. Case Studies 1 and 2.

Other important analysis was carried out by Chalmers University of Technology (1997). Their analysis involved a technical overview of wastewater treatment systems, evaluated using Environmental Impact Assessment (EIA) and Life Cycle Assessment (LCA). The study investigated two case studies.[10] Case Study 1 was a suburb of Gothenburg, where much of the population lives in rented apartment houses. Waste water is pumped to a large wastewater treatment plant in Gothenburg, where it is treated mechanically, biologically and chemically. The sludge from the biological and chemical treatments is fermented under production of biogas (most used internally).[11] Case Study 2 was a coastal village with 900 inhabitants, increasing to 1700 during the summer months. Waste water is treated mechanically, biologically and chemically before release into the sea (Fig. 3.9). Figure 3.10 presents a flow chart of pre-treatment followed by treatment on sand filter beds for the liquid part of the waste water while Figure 3.11 shows sewage and grey water separated by the introduction of 'separating' toilets and installation of additional piping in the housing stock.

10. The study excluded industrial and storm-water waste.
11. Treated sludge is used for compost (8%), agriculture (12%) and urban soil improvement (70%).

3.4.3.2 Environmental Impact Assessment (EIA)

EIA was applied to the operation of each of the systems, with the system boundaries defined as collection and transport of waste water, transport to storage or treatment, storage and treatment, production and transportation of resources needed for the operation of the system, discharge to receiving waters and improvement and the transportation of residuals. The main findings for Case Study 1 (suburban area) were that the two alternatives to BAU would both have greater local impact than the existing system with a periodic increase of flow in the local watercourses (caused by discharges from filter beds). Increased transport requirements would also exist for the collection of sludge, urine, filter sand, etc. Alternative 2 has the greatest transport requirements. Both the options would also require large areas to cater for filter beds. The location of wastewater facilities near housing would reduce playground areas and in the case of Alternative 2, there would probably be occasional occurrences of unpleasant odours.

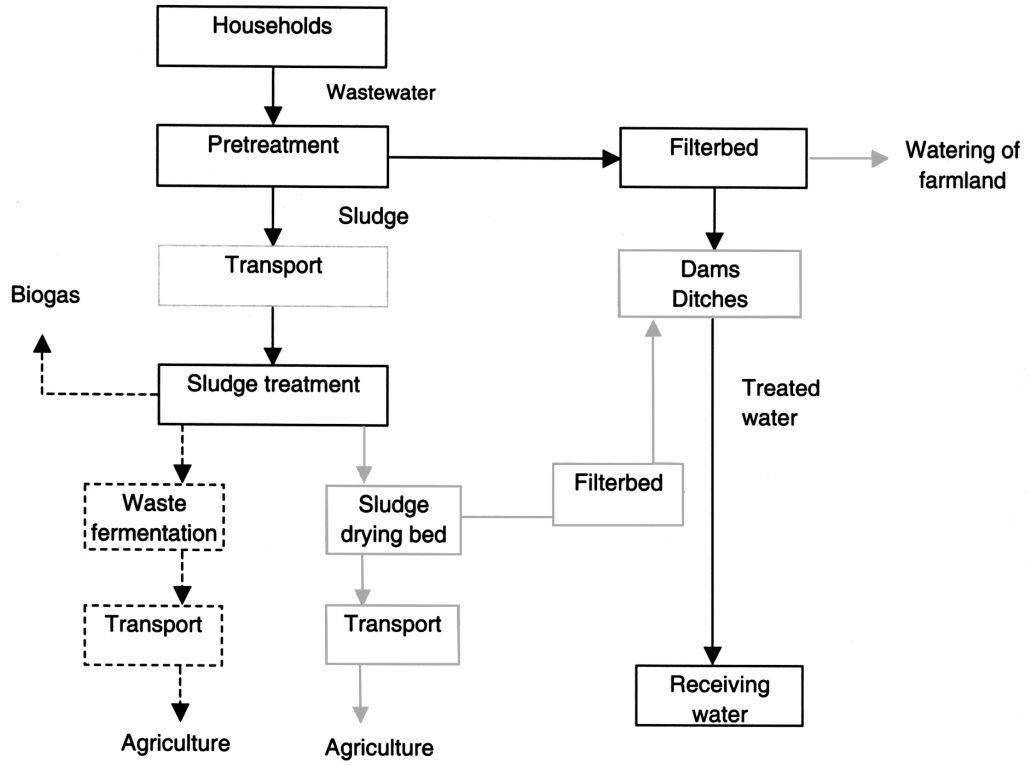

Figure 3.10. Pre-treatment followed by treatment on sand filter beds for the liquid part of the waste water.

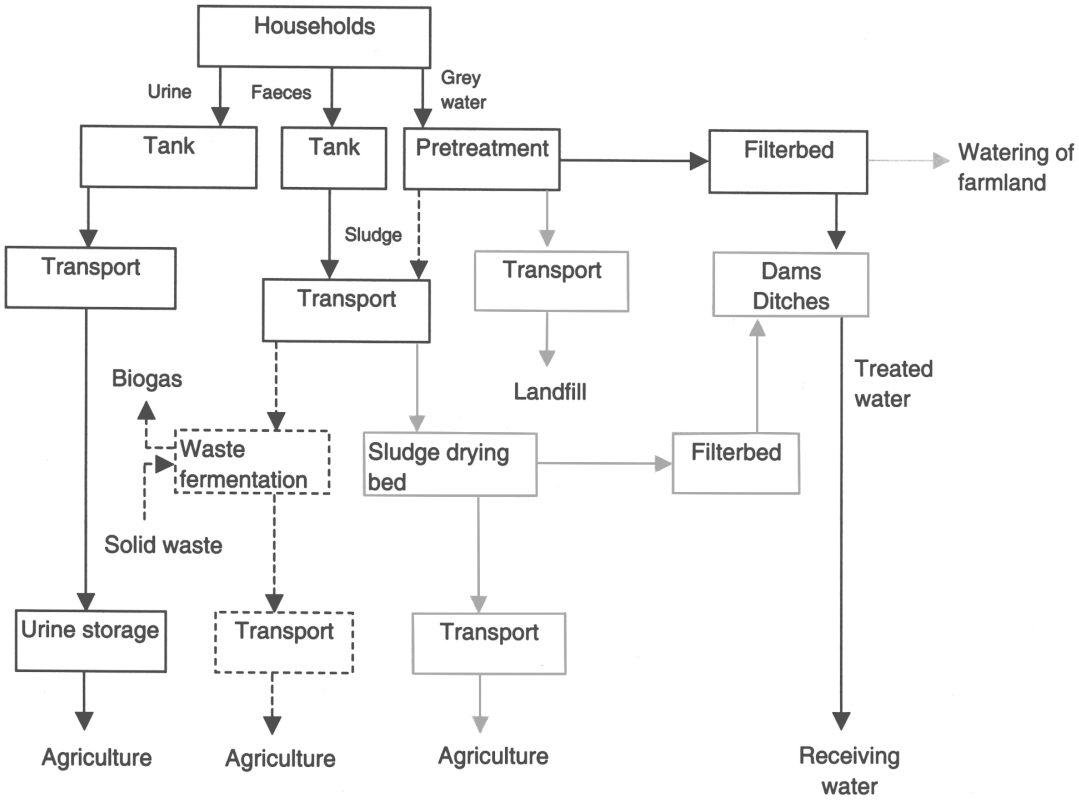

Figure 3.11. Sewage and grey water are separated by the introduction of 'separating' toilets and installation of additional piping in the housing stock.

In relation to regional effects, wastewater systems contribute to eutrophication as a result of nitrogen and phosphorus discharges. The main difference between the alternatives on offer are in terms of nitrogen discharges, an important feature as urine contains around 80% of the nitrogen from household waste water. Alternative 2 is, therefore, the most advantageous alternative when looking at the question of nutrient discharge. For the recycling of natural resources, Alternative 2 is advantageous, with the greatest recycling of nutrients and the lowest use of electricity. One exception is fossil fuel use, which is greater in Alternative 2 than in Alternative 1, though the BAU option is the most favourable. The study concludes that Alternative 2 is the most favourable option for Case Study 1, due to performance in terms of the use of natural resources and benefits for eutrophication. Alternative 2 is also most favourable with regards to energy usage.

In Case Study 2 (coastal village), the sea is the receiving water for all three alternatives. Alternative 2 has the greatest transport requirements within the residential area; however, the BAU option exhibits the greatest overall volume of transportation (between treatment plants and between treatment plants and landfill). It also causes the greatest emissions of nitrogen oxides and sulphur oxides of all the options. The existing system does not involve nitrogen reduction, so both Alternatives 1 and 2 are more advantageous with regards to eutrophication. Similarly, there is no recycling of sewage sludge in the existing system. Alternative 2 is considered the most favourable option, closely followed by Alternative 1 (mainly due to nitrogen discharge being given the highest priority). Alternative 1 is the most favourable option in terms of both energy use and emissions to the atmosphere.

3.4.3.3 LCA methodology

Assessments of activities were based on a core system and an enlarged system, with an understanding that a change in wastewater system will also affect the surrounding technical systems (for example, the recycling of nutrients will reduce the need for other types of fertiliser).

Case Study 1

(a) Alternative 2, urine separation, was assessed to be the environmentally preferable alternative.

(b) Alternative 1, filter beds, was assessed as the second best system.

(c) Alternative 0, the existing system, was assessed as the least preferable option.

Case Study 2

It was much more difficult to rank alternatives for this case study. After additional arguments it was concluded that:

(a) Alternative 2 was the environmentally preferable alternative owing to lower values for the most relevant parameters, except phosphorus emissions to water, which can probably be reduced over time.

(b) Alternative 0 was the second-best option, despite higher air emissions than Alternative 1, because emissions to water are lower, which was considered more important since the main task of a wastewater treatment system is to reduce emissions to water.

(c) Alternative 1 was the least preferable option.

3.4.3.4 Summary

The most common small-scale sewage treatment operation is the operation of a septic tank, with some form of treatment afterwards. For Ireland, facilities tend to incorporate a septic tank with soakaway; however, this form of treatment is not considered ideal, and is definitely not recommended for settlements of over 100 houses.[12] Developments in Scotland could perhaps be taken on board to benefit the Irish situation. Here, rural areas have seen a shift towards the use of septic tanks, followed by treatment in natural wetland systems (of which there are several types, with reed beds the best known). Not only can natural wetland systems cope with natural variation in load better than conventional systems, but they require low maintenance and no energy input and hence are able to 'look after themselves' (Scottish Agricultural College, personal communication).

Two other important questions are pertinent to the Irish situation: tourism and phosphorus removal. In terms of tourism, systems need to be designed for the maximum number of population, as they will also operate efficient-

12. It is also now possible to have a 'mound' soakaway.

ly for lesser numbers. Ensuring that the investment in upgraded facilities is economically viable may require a more even spread of the tourist season. Where the eutrophication problem is considered severe, it will be necessary to ensure that tertiary treatment is in place for sewage works in order to reduce the phosphorus loading of watercourses.

However, it is clear that the viability of different levels of treatment is affected by settlement size. See Section 2 for ideal indicators.

3.4.4 Urban metabolism (resource use and waste)

From the official Irish literature, it would appear that analysis predominantly takes the traditional approach of tackling the different stages of resource flows as separate entities, typically the waste disposal component. However, ideally, the dynamics of resource flows should not be viewed in isolation. The industrial 'ecosystem' is made up of production, distribution and consumption networks, including the utilisation of primary materials and energy, through to final waste disposal. The first law of thermodynamics (energy and material can be transformed but not destroyed) ensures that each unit of raw material will at some point become a future waste. Society will ultimately have to reduce its dependence on primary resources; therefore, a systematic approach dealing with the full 'cradle-to-grave' flow is preferable. "When analysing the ecological significance of economic efforts, all resource and energy inputs – from the cradle to the grave – as well as the respective land use, must be taken into account" (Hinterberger *et al.*, 1997: p. 5). Although sub-national data would not appear to be available, future targeting of sectoral resource flows would be a useful addition to being able to accurately assess the sustainability of settlements.

As was discovered in a resource flow audit for the N-W region of England (McEvoy and Ravetz, 2001), there tends to be significant differences between waste arisings and disposal. For municipal waste, the composting of organic wastes is considered a viable option for the disposal of such wastes, and is an activity that could be promoted to a greater extent.

3.4.4.1 Urban form

Current industrial structures promote excessive resource consumption and associated production of wastes; therefore, a primary goal of 'industrial ecology' is seen as the creation of the conditions necessary to promote a cyclical system. Strategies to achieve this include dematerialisation, substitution, reuse/recycling and the utilisation of waste streams (Ayres and Simonis, 1997), but it will also be influenced by urban form. Modern industrial systems can be viewed as a collection of linear flows. We take materials from nature, process them for economic gain, and then dispose of the residue back into nature. Evidence indicates that the sheer scale of activity is now threatening the earth's ecological integrity (Worldwide Fund for Nature, 2000). Investigating the industrial metabolism of a locality enables the pattern of material flows to be better understood, and consequently managed.

In general terms, the demands of the modern economic system ensure that "anthropogenic flows interfere with natural flows and cycles, such as the hydrological cycle, the carbon–oxygen cycle, the nitrogen and sulphur cycles and the phosphorus cycle" (Ayres, 1998: p. 10). In addition, there have also been increasing calls for a move beyond the concept of eco-efficiency towards a wider and more holistic approach (the mantra of 'joined-up' thinking). This would involve balancing current resource 'flows' with the goals of a sustainable settlement. Crucially, societies should be acting to:

(a) reduce primary resource inputs;

(b) close material loops;

(c) advocate whole life responsibility;

(d) minimise environmental impacts;

(e) increase local self-sufficiency;

(f) promote integrated materials management.

3.4.4.2 Indicators and the Irish case studies

The deficiency in the current Irish approach to resource flows is that there is an over-emphasis on waste rather than looking at the whole life-cycle 'system'. Consequently, there are few data on resource flows at the sub-

national scale. Taking the situation as it stands, indicators should be directed towards highlighting improvements in waste management, particularly relating to recycling activity. In the longer run, it would be beneficial if more data could be collated for all stages of the resource 'flow'.

3.4.5 Urban quality

Overall, Irish planning activity should be looking towards an integrated strategy that reduces the environmental impacts of energy use, transportation, resource use, waste disposal to land and water, and maximises the use of available urban sites in order to reduce the uptake of land of agricultural or wildlife value. In response to the latter, urban renewal schemes were introduced in Ireland in 1985 to remediate the increasing problem of dereliction and dilapidation, which had affected the inner areas of Irish towns and cities. The scheme, primarily tax based, has now been extended to many of Ireland's major towns (EPA, 2000). Furthermore, the National Spatial Strategy highlights the importance of identifying the spatial development patterns that would contribute to efficient energy usage, waste minimisation, reducing the impact of traffic, and maximising opportunities for sustainable transportation. It also called for the identification of where balanced and sustainable urban growth was feasible.

3.4.5.1 Urban form

Three dimensions influence the relationships between urban patterns and ecological systems: land use, land cover (manipulation), and biophysical and ecological conditions (effects on ecosystems). Urbanisation is blamed for homogenising the landscape; therefore, enhancing the quality and diversity of the urban landscape is viewed as extremely desirable. The degree of habitat heterogeneity is considered a key factor in maintaining species diversity and can have a significant effect on species richness (the loss of heterogeneity may be more relevant for some species than others). Another important factor for ecosystems threatened by urbanisation is landscape connectivity, which is said to go some way towards mitigating the impact of urbanisation. Corridors that connect remnant patches are predicted to facilitate the movement of plants and animals, increasing their chances for survival. Current ecological studies suggest that natural patches should be maintained as large, interconnected areas (Alberti, 2000).

To conserve and enhance this biodiversity potential is a challenging task under current urban development pressures. It requires a response on the strategic levels of planning for the entire city region, with landscape ecological concepts based on habitat corridors and connectivity implemented to safeguard and restore landscape ecological coherence. Furthermore, open spaces and green spaces within urban centres provide various environmental benefits in terms of maintenance of biodiversity and improved air quality, in addition to general amenity value. They also add to the general aesthetic quality of the urban landscape.[13]

The application of landscape ecological concepts to the planning process to secure sustainable development can act to promote well-functioning green structures that simultaneously improve urban climates, reduce run-off from precipitation, and provide suitable habitats for wildlife. Changes in land cover affect biotic diversity, primary productivity, soil quality, run-off and sedimentation rates. By altering the nature of the surface and generating large amounts of heat, urbanised areas modify the microclimate and air quality. The increase in impervious land area associated with urbanisation affects both geomorphological and hydrological processes, causing changes in water and sediment fluxes (for example, the presence of urban trees can mitigate storm water run-off and provide flood control). Since ecological functions and processes are linked with the landscape, urbanisation has important implications for ecosystems dynamics at the local and global scale. Many studies show the role of urban vegetation in providing critical aesthetic values and community well-being.

Due to the limited scope of this project, it is not possible to explore the ecological processes and functions of the urban landscape; suffice to say that the application of ecological principles to urban development can have a significant role to play in promoting more sustainable activity. Of particular interest is the study by Whitford *et al.* (undated). For this research, the authors determined that the local ecological performance of settlements is

13. This is a difficult issue to standardise as opinion varies as to what may be considered green space.

strongly influenced by the proportion of green space (particularly that of tree cover). Green space is, therefore, an important indicator for sustainable settlements, and can be used to derive performance indicators for surface temperature, hydrology, carbon storage and sequestration, and biodiversity. The data needed for establishing these indicators can be obtained from aerial photography (percent of the land covered by buildings, roads, different types of vegetation and bare soil). Collating such information for Irish settlements would be extremely beneficial.

3.5 Urban form and sustainability

3.5.1 Issues for towns in the Western region

Major growth pressures from tourism-based development, i.e. seasonal, low-skilled leisure-based economy.

(a) Problems of remote location and need for indigenous economy, e.g. Westport.

(b) Restructuring of former coastal and industrial functions, e.g. Sligo.

(c) Problems of dispersed development in hinterland and outlying areas, small-scale drainage/sewage, transport congestion and lack of public transport, lack of services for residents, ecological pressures from visitors.

(d) Alternatively, centralised growth in existing towns, or large-scale tourism developments.

(e) Alternatively, decentralisation to outlying towns and villages.

(f) Major growth pressures from tourism-based development, i.e. seasonal low-skilled leisure-based economy.

3.5.1.1 Implications for 'sustainable settlement size'

(a) Tourism development and residential development need to be considered together as two sides of the same urban structure. Therefore, size and threshold effects need to look at both season/off-season profiles.

(b) The 'sustainable size' benefits/impacts balance is shifted by the locational needs of tourism development for dispersed rural/coastal development. In other words, much tourism value depends on remote locations.

(c) Threshold effects, season/off-season, viability for local services and public transport in outlying villages, viability of communal drainage sewage plants.

(d) Potentials for eco-efficiency improvements to infrastructure, intensive public transport within urban areas, low-energy construction, natural process WWT plant.

3.5.2 Issues for towns in the Midlands regions

(a) Major restructuring of agricultural and local service economy.

(b) Problems of weak and diffused urban structure and service provision.

(c) Pressure from commuter development from Greater Dublin.

(d) Weak and diffused urban structure and service provision.

(e) Uncertain future use for much marginal land.

3.5.2.1 Implications for 'sustainable settlement size'

(a) Channelling commuter-based development into more self-sustaining local economies with local jobs and services.

(b) Restructuring existing services to a clear hierarchy of provision linked to public transport.

(c) Identifying trends and potentials at the bottom end of the hierarchy, i.e. population loss from villages and small towns, to possible growth for larger towns.

(d) Threshold effects in size and density:

  (i) size/density of larger towns for viable public transport,

  (ii) size/density of larger towns for public/commercial services; natural process WWT in outlying areas.

(e) Potentials for eco-efficient infrastructure improvements:

(i) increasing attractiveness and efficiency of public transport,

(ii) low-energy rural development,

(iii) new forms of community business/services to increase viability,

(iv) new forms of distributed services in education/ health, and

(v) natural process WWT in outlying areas – no single threshold but linked to new multi-functional land use.

3.5.3 Issues for Gateway cities and city regions

(a) Reinforcement of strategic higher-order functions, in particular incentives for inward investment and sunrise industries: this affects the catchment area and travel patterns, and the intensity and type of urban development (city centre office vs. industrial estates).

(b) Enlargement of the total city-region population, up to a possible doubling of existing size: this represents a huge opportunity for improvement that cannot be wasted.

(c) Urban densification and clustering to maintain urban viability.

(d) One option: planned growth in urban satellite towns and settlements.

(e) Alternative option: redistribute growth to surrounding rural county towns and settlements.

3.5.3.1 Implications for sustainable size of Gateway cities

(a) There are questions for the NSS on the population distribution between smaller and larger settlements in the urban hierarchy.

(b) There are questions for county and local planning, on the spatial distribution between centralised and decentralised patterns.

(c) Overall, the link between size and density is crucial. In other words, increasing size while maintaining current development densities will not guarantee much improvement or potential for improvement. Increasing densities will be more viable where size is also increased, whether by urban extension or by new settlements.

(d) Threshold effects for densities of inner urban areas:

(i) to support intensive public transport, i.e. more than 10% of mode: in the region of >5000 persons/ha,

(ii) distributed heat and other infrastructure: threshold depends on finance and energy prices, and

(iii) maintenance of urban open space.

(e) Threshold effects for spatial patterns in suburban and hinterland areas:

(i) clustering effect and viability of public transport, and

(ii) eco-efficient water treatment.

(f) Potential for eco-efficient infrastructure:

(i) for low-energy building in dense urban areas,

(ii) low-impact transit-based clustered development, and

(iii) extensive biodiversity networks.

3.6 Implications for spatial development

This section summarises the issue of settlement size and its linkage to environmental impact. The key point is that size is one factor among several other linked factors (Table 3.10). Some environmental factors are most sensitive to size while some are strongly linked to density. Others are more related to function. The threshold relationship summarises, where possible, the kind of threshold effects where these are significant. Finally, the potentials represent not the current relationships but the scope for major improvements where these are related to settlement size.

Settlement size depends on where the boundary around the settlement is drawn. Therefore, up to three sizes are reported in the case studies:

(a) Urban area or UDC size,

(b) Suburban area or effective functional size for direct access, and

Table 3.10. Implications for spatial development.

	Summary of 'size' linkages					
	Urban size	**Urban density**	**Spatial patterns**	**Socio–economic function**	**Threshold effects**	**Development prospect**
Key environmental parameters						
Air emissions – transport Demand/mode energy – emissions – congestion	Correlation modal split: critical mass effect	Accessibility: local services; local trip modes	Correlation commuting/ regional travel	Correlation incomes/car ownership/job specialisation	Bus threshold: local rail threshold	Clustering around nodes: corridor patterns
Climate emissions – energy Size/form/ construction Energy – minerals	No clear linkage	Building forms, micro-climate, orientation	No clear linkage	Building quality and energy usage: commercial buildings	Micro-climates	CHP: low-energy construction: embedded generation
Water quality – sewage treatment Technology/ infrastructure Effluent/water	Critical mass for viability of tertiary WWT	Cost per unit of drainage	Viability of centralised systems	Possible presence of industry	Rural/Primary/ secondary/tertiary WWT	Upgrading of WWT under EU Directive
Urban metabolism waste arisings and disposal Technology/ infrastructure Land use – leachate – resource loss	Collection recycling, disposal methods	Viability of collection routes and access to recycling	No clear linkage	Possible presence of industry	Critical mass for incineration: composting	Recycling and re-use networks: industrial ecology networks
Urban quality Noise – congestion – biodiversity – open space	Correlation to general level of impacts: some positive	Correlation to general level of impacts: some positive	Landscape linkage – not very clear	Usage and maintenance of urban space	No clear linkage	Urban green structure and traffic calming strategy

(c) Hinterland or city-region size, which includes the settlements in a functional relationship combined for a land-use transport study.

Settlement density is closely related but is distinct from size. The density linkage to environmental performance is often more clearly identified and covered in the literature.

Spatial pattern covers the context of functional city-region, county or other type of hinterland, which may be defined in several ways:

(a) Travel to work area,

(b) Political/administrative area, and

(c) Bioregion or water catchment.

Socio–economic function covers the above question of social structure, economic activity and the urban balance of population vs. service hierarchy.

Threshold effects identify, where possible, the evidence for particular critical boundaries or thresholds in size and density, for various levels of infrastructure provision and environmental performance.

Potentials identify, where possible, the prospects for new infrastructure and improved environmental performance, as related to urban size and density thresholds.

Appendix

Case study settlements: Gateway cities

Limerick

Situation	Medium-sized city on west coast estuary
Population: urban area and total area	52,039 / 79,137 / 230,000 (LUTS hinterland area)
Land area and gross density	9.56 km^2; 8277 people/km^2
Main function	County city: mixed economy
Socio–economic profile	Mixed: largest centre for deprived groups outside Dublin
Residential profile	Residential growth: mainly to SE on new bypass route
Industrial profile	Mixed: industrial growth
Hinterland and regional issues	County – marginal agriculture: major new water investment
Governance issues	UDC weak with conflict between two counties
Environmental issues	
Transport and accessibility issues	Land-use transport study New bypass on main Dublin route Investment in the Ennis–Shannon N18
Spatial development issues	County – weak urban structure: only one major settlement Limerick at hub of three main corridors Future strategic development deflected N towards Co. Clare
NSS region main elements	Limerick/Ennis/Shannon and the Mid-West – ‘Dynamic city region with weaker elements’ Compact metropolitan/urban area broadening on a Limerick–Ennis axis Outer components – rest of Co. Limerick, N. Tipp., East and West Clare, which are developing more slowly Lack of major urban centres in Limerick County Issue of spatial balance also emerging in Clare + Tipperary. 2000 Pop. 230,000 (Limerick LUTS area)
NSS development issues	Infrastructurally stronger than many areas Improving transport, if undetermined role for public transport Environmental Quality in Limerick City Emerging strategic role for Limerick on an ‘Atlantic Corridor’ spanning Galway–Cork Strong and multi-sectoral role of dedicated agency – SFADCo.
NSS spatial links	Very much aligned on a North (to Ennis + Galway)–South (Cork) axis (road and proposed rail) Other axes too – South-East to Waterford (road and rail) – South-West to Kerry (road) – North-East to Tipperary + Midlands (road and rail)
NSS key spatial issues	Consolidating Limerick’s Strategic role on an ‘Atlantic Corridor’ A settlement strategy that embraces public transport Building on and enhancing environmental qualities Broadening out activity levels to Counties Limerick, N. Tipp. and E/W Clare

Waterford

Situation	Small coastal city
Population: urban area and total area	42,540 / 44, 155 / 77,000 hinterland
Land area and gross density	11.53 km^2; 3830 people/km^2
Main function	Coastal and former industrial
Socio–economic profile	
Residential profile	
Industrial profile	
Hinterland and regional issues	
Governance issues	
Environmental issues	
National Spatial Strategy region	5: Waterford–South Tipperary/Wexford – ‘Unlocking the potential of the South-East’
NSS region main elements	A compact metropolitan area defined by topographical influences Outer realms of influence embracing Dungarvan (Co. Waterford) New Ross (Co. Wexford) Carrick-on-Suir (S. Tipp) 2000 Pop. 77,000
NSS development issues	Traditional weaknesses in infrastructure – road access Reliance on traditional industries exposed Emerging role in urban and rural tourism Weaker in skills base Division between counties Overtaken in urban size rankings by centres that were smaller in the 1970s North Wexford being increasingly driven by Dublin
NSS spatial links	Strategic bridging point linking Rosslare with South, Mid-West and West Weaker north–south axis from Dublin, Carlow and Kilkenny, very poor quality leading to some isolation
NSS key spatial issues	Improving connectivity between Waterford and Dublin/Cork/Limerick Establishment of good east–west axis (N25) intersecting N11 and N9 and placing Waterford–Wexford at a strategic intersection, seeing them as interrelated Consolidating improvements in environmental quality capitalising on riverside location Governance in relation to common management of divided authorities

Case study settlements: Western towns

Sligo

Situation	Large coastal town
Population: urban area and total area	17,786 / 18,509
Land area and gross density	4.74 km^2; 3905 people /km^2
Main function	
Socio–economic profile	
Residential profile	
Industrial profile	
Hinterland and regional issues	
Governance issues	
Environmental issues	
National Spatial Strategy region	7: Sligo–Leitrim – ‘Compact linkages with Potential’
NSS region main elements	Sligo dominating radial elements to Sligo/Roscommon/Leitrim – Tobbercurry, Boyle, Carrick-on-Shannon, Manorhamilton
NSS development issues	More limited topographically constrained hinterland – mountains and lakes Poor connections Major infrastructural barriers Limited size and carrying capacity of Sligo itself
NSS spatial links	To hinterland of Sligo/Leitrim/North Roscommon Also Enniskillen and West Ulster Not to Mayo but maybe due to emerging problems on N5 road corridor
NSS key spatial issues	Addressing infrastructural barriers Reconnecting to natural if not operational hinterlands – Mayo–Ulster Examining potential of Sligo itself for expansion Potential of natural resources

Killarney

Situation	Large tourism based town
Population: urban area and total area	8809 / 12,011
Land area and gross density	2.64 km^2; 4550 people/km^2
Main function	
Socio–economic profile	
Residential profile	
Industrial profile	
Hinterland and regional issues	
Governance issues	
Environmental issues	
National Spatial Strategy region	9: Kerry 'Emerging Potential – a clear region'
NSS region main elements	Tralee/Killarney – employment, retailing governance North Kerry/Listowel/Ballybunion – employment Dingle Peninsula – tourism South Kerry/Iveragh Peninsula/Kenmare – tourism
NSS development issues	Pressures in Tralee–Killarney and Dingle/Tourism areas contrasting with South and North Kerry. North Kerry, with tourism and development potential, is not on a strategic corridor South Kerry suffers difficult access, poorer than West Kerry/peninsulas, West Cork Pressure on environmentally sensitive areas Serious infrastructural barriers primarily access, also power
NSS spatial links	Two key axes To Limerick (very poor between Newcastle West and Tralee) To Cork Also to Clare and Mid-West via Shannon Estuary ferry link
NSS key spatial issues	Resolving complementary spatial roles for Tralee and Killarney Enhancing quality and value chain of tourism Responses to structural change in North Kerry Enhancing connectivity to South Kerry Reversing tendency towards a dispersed and random settlement policy Development of other towns

Westport

Situation	Small coastal town near Castlebar
Population: urban area and total area	4253
Land area and gross density	
Main function	
Socio–economic profile	
Residential profile	
Industrial profile	
Hinterland and regional issues	
Governance issues	
Environmental issues	
National Spatial Strategy region	8: Mayo – ‘Clear potential for links’
NSS region main elements	Castlebar – Westport Ballina – North-West Mayo South and East Mayo – Ballyhaunis Western coastal fringe 2000 Pop: ?
NSS development issues	Placement of Castlebar on the N5, with clear local government, retailing, residential and employment roles, is underscoring local dominance Westport tending to be largely residentially and tourism focused Ballina suffering from weakness of hinterland and lack of linkages Underutilised potential of western areas if limited carrying capacity South/East Mayo, like North Roscommon/East Galway sharing problems of serious structural decline Serious infrastructural barriers to developing what potential there is
NSS spatial links	Area is isolated and not on, but terminates, a strategic corridor Primarily an east–west axis (road and rail)
NSS key spatial issues	Better interconnection of centres as well as outward links Links to Sligo Links to Midlands/Roscommon via N60 Extracting potential of western fringe within fragile carrying capacities Infrastructural barriers Linking infrastructure to a spatial vision

Case study settlements: Midlands towns

Athlone

Situation	Large town on strategic crossroads
Population: urban area and total area	7691 / 15,544
Land area and gross density	4.32 km^2; 3598 people/km^2
Main function	Mixed
Socio–economic profile	
Residential profile	
Industrial profile	
Hinterland and regional issues	
Governance issues	
Environmental issues	
Spatial development issues	
National Spatial Strategy region	10: The North Midlands – 'Activating potential'
NSS region main elements	Five counties Mid and South Roscommon with East Galway (Ballinasloe) – some employment Longford – employment, retailing and governance roles Western part of Westmeath/Athlone – education employment and retailing, very weak agricultural hinterland West and South Offaly – strong employment, retailing and governance roles in Tullamore but with weaker rural areas and rural towns and villages – Birr 2000 Pop. (urban) 55,000; (rural) ?
NSS development issues	Under pressure from encroaching influence of Dublin to the East, and potentially Galway to the West, draining labour and resulting in dormitory-type roles Weaker if improving infrastructure, roads, rail and power – communications Strategic location on national primary roads not yet acknowledged and utilised Weakness of hinterland undergoing structural change is a factor Competition between centres to attain self-sufficiency in services Little pooling – no overlap and therefore strengthening appeal of region
NSS spatial links	At present, only definable link is between Roscommon and Athlone Other centres compete – Longford vs. Mullingar vs. Tullamore, etc. Centres see themselves along Dublin–West/North-West axes rather than interconnecting
NSS key spatial issues	Avoiding the Midlands becoming an extension of what happens on either coast Utilising and combining the strengths of the region to boost potential Attraction of water bodies – tourism Usage of tracts of boglands – renewable energy Building on the strategic advantages of Athlone whilst strengthening other urban centres as well

Roscrea

Situation	Small town on main route from Dublin
Population: urban area and total area	4170 / 4170
Land area and gross density	1.11 km^2; 3757 people/km^2
Main function	
Socio–economic profile	
Residential profile	
Industrial profile	
Hinterland and regional issues	
Governance issues	
Environmental issues	
National Spatial Strategy region	12: South Midlands – 'Competitive tension'
NSS region main elements	Four or five independent elements with a mixture of stronger and weak rural hinterlands Portlaoise Carlow Kilkenny Thurles (+Clonmel?) Each performing mix of employment, retailing administrative and cultural roles
NSS development issues	Some (Portlaoise and Carlow) are being drawn into the GDA Others (Thurles) very static Potential of Kilkenny now developing, building on quality of life, culture Attractive surrounding urban structure but an increasingly dispersed settlement pattern Service shortages in many smaller centres Moderate–poor access will enhance dramatically
NSS spatial links	None apart from physical, roads and rail Strong competitive tensions between centres
NSS key spatial issues	Like the Midlands, in danger of fragmenting under pressure from the east (GDA) and continuing structural decline in traditionally stronger areas in the south – Tipperary N and S Riding Interconnection a way forward Enhancing the attractiveness of the area, towns and country

Portlaoise

Situation	Large town on main route from Dublin
Population: urban area and total area	3531 / 9474
Land area and gross density	4.44 km^2; 2134 people/km^2
Main functions	
Socio–economic profile	
Residential profile	
Industrial profile	
Hinterland and regional issues	
Governance issues	
Environmental issues	
National Spatial Strategy region	12: South Midlands – 'Competitive tension'
NSS region main elements	Four or five independent elements, with a mixture of stronger and weaker rural hinterlands Portlaoise Carlow Kilkenny Thurles (+Clonmel?) Each performing mix of employment, retailing administrative and cultural roles
NSS development issues	Some (Portlaoise and Carlow) are being drawn into the GDA Others (Thurles) very static Potential of Kilkenny now developing, building on quality of life, culture Attractive surrounding urban structure but an increasingly dispersed settlement pattern Service shortages in many smaller centres Moderate–poor access will enhance dramatically
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Case study settlements: Satellite villages

Pallasgreen

Situation	Village near Limerick
Population: urban area and total area	303 / 303
Land area and gross density	0.15 km^2; 2020 people/km^2
Main function	Traditional village with new commuting development
Socio–economic profile	
Residential profile	
Transport and accessibility issues	In the inner travel-shed of Limerick
Environmental issues	
Spatial development issues	

Shinrone

Situation	Small village near Roscrea
Population: urban area and total area	479 / 479
Land area and gross density	0.24 km^2; 1996 people/km^2
Main function	
Socio–economic profile	
Residential profile	
Environmental issues	
Spatial development issues	

Case study settlements: Freestanding village

Freshford

Situation	Small village near Kilkenny/Portlaoise
Population: urban area and total area	632 / 632
Land area and gross density	0.17 km^2; 3718 people/km^2
Main function	
Socio–economic profile	
Residential profile	
Environmental issues	
Spatial development issues	

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