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Quantitative Evaluation of Settlement Sustainability Policy

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Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

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Quantitative Evaluation of Settlement Sustainability Policy

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EPA Synthesis Report

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Executive Summary

A major challenge facing the world is the urgent need to enhance sustainability, as we face the interrelated challenges of climate change, dependence on fossil fuels, food shortages and an increasing population. While technological development is crucial, significant gains may also be made by the wider adoption of proven technologies through improved planning and behavioural change. It is, however, unclear to policy-makers which technologies should be prioritised. There is a strong political desire for methods to assess the impact of policy implementation on overall sustainability targets, but this has proved in the past to be very challenging, as views on the meaning of sustainability vary, and the methods that have been developed which satisfy scientists' needs for rigour have been deemed too complex and inadequately transparent by decision makers.

It is vital that we are able to measure sustainability in order to check whether or not a new policy, decision or technical innovation is having a positive impact. There are a number of existing methods for the evaluation of sustainability policies, such as the environmental impact assessment (EIA), the strategic environmental assessment (SEA) and the sustainability impact assessment (SIA). These methods are project based, in the case of EIA, or evaluate policy impacts in a more high-level/ strategic manner, in the cases of SEA and SIA. There is a need for a standardised method to quantify policy impact on settlement sustainability, which is why the Quantitative Evaluation of Settlement Sustainability Policy (QESSP) project is described here. It aimed to address these knowledge gaps by developing a metric based in multiple indices, with the ability to evaluate urban sustainability policies to provide an evidence base for policymaking. The metric named Sustainability Evaluation Metric for Policy Recommendation (SEMPRe) was designed to be both scientifically robust and policy-relevant, in that it is both quantitative and readily usable by decision makers. Quantitative data on more than 300 economic, social and environmental attributes of 79 small, medium-sized and large urban Irish settlements were assembled into a database. This provided a baseline against which projected impacts of fresh policy implementation were evaluated. SEMPRe assigns each candidate policy a numeric value indicating its projected effectiveness in enhancing settlement sustainability, using peer-reviewed published analyses and direct experience from Ireland. The most cited studies and Ireland-relevant policies were identified in the policy arenas of transport, food, housing and urban form, energy, waste and water. A novel method using multi-criteria decision analysis was developed for feasibility testing of policy initiatives.

The method was trialled with Cork County Council to develop a workable, robust and transparent indicator set designed to both expedite, and provide a clear evidence base for, the adoption and review of policies that support sustainable development in Irish development plans. In addition, the trial provided evidence supporting the formation of a core strategy for the revised County Cork development plan.

QESSP adds to our knowledge of the extent to which Irish settlements are sustainable. In general, settlements with higher populations achieved greater sustainability scores. As further quantitative assessments of policy impacts are published in future, the range of policies that can be evaluated through SEMPRe will increase. The method has been developed for Irish urban areas, but may have relevance for policy prioritisation in other comparable states.

1 Introduction

At a national level, the concept of sustainable development came to the fore following the publication of the 1987 World Commission on Environment and Development (WCED) report, which defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). Published definitions of sustainable development such as that are somewhat vague and offer no clear policy guidance other than striving for general improvement for a wide audience. This allows stakeholders to cherry-pick those aspects that best suit their sectoral or policy agendas.

Addressing a lack of policy co-ordination is a major concern in Ireland. Many authors (for example, Scott, 2010) propose testing a wide range of policy initiatives to see which initiative achieves its objectives, so that over time we learn from experience. Focused environmental policies at the urban level are now required as economic and social activities are concentrated in urban areas, and transport and levels of urbanisation are increasing. The issue of monitoring and evaluation of planning policy is an important current concern in Ireland, against a backdrop of increased emphasis on evidence-based planning and changes to legislation. Most studies cover a narrow geographical area with little policy variability and heterogeneous households. In addition, studies generally focus on one aspect of household consumption and do not permit policy evaluation across sectors (OECD, 2008).

There is increasing acceptance in Irish policymaking of the need for robust evidence to support policymaking. It is the aim of Quantitative Evaluation of Settlement Sustainability Policy (QESSP) to provide a rational, rigorous and methodological basis to assist planning practitioners and policymakers with sustainability assessment. Evidence-based policymaking has been adopted as part of QESSP to facilitate a more rational and systematic policymaking process. In particular, the QESSP methodology can help identify mitigating measures in order to maximise the sustainability of particular strategies and to develop a framework and a standardised set of environmental indicators. These will lead to a more consistent approach to the evaluation of likely significant environmental effects of plans and programmes.

During 1995–2007, there was high economic growth in Ireland and the economic pillar of sustainable development was given priority over social and environmental concerns. Development in Ireland became more fragmented and scattered, and distances between where people lived and worked increased, resulting in greater greenhouse gas (GHG) emissions from transport (DEHLG, 2010). The Irish policy response to economic recession thus far has focused almost exclusively on the banking system and austerity measures, while the immediate and important issue of global warming has been sidelined (Scott, 2012). The research described in this report was developed in the context of the 2008–2013 Irish economic and social climate, when economic growth, new house building and tax revenue fell sharply and unemployment levels rose. In this economic climate there are few financial resources available for development of new technologies. However, significant reductions in energy use can be made through the wider adoption of existing proven technologies by better planning and behaviour change. For example, adoption of the regional planning guidelines (RPGs) has ensured that local authorities need to identity excess areas of zoned lands from previous planning periods, and ensure that the re-zoning/de-zoning/phasing or reserving of these lands is carried out in a co-ordinated and consistent way.

2 Data Analysis and Policy Selection

This research builds upon previous studies at the Centre for Environmental Research (CER), University of Limerick, Ireland. The project Methodologies for the Estimation of Sustainable Settlement Size (MESSS) developed indicators for the estimation of sustainable settlement size (Moles *et al.,* 2002; O'Regan *et al.,* 2002). University researchers, senior EPA and National Spatial Strategy (NSS) practitioners collaborated in a participatory process of selecting indicators that satisfied both the researchers' need for rigour and the practitioners' need for policy relevance. Following on from this, a 4-year study titled "Sustainability and Future Settlement Patterns in Ireland" (SFSPI) was established to fill data gaps (Moles *et al.,* 2008b). SFSPI ranked settlements in Ireland according to their sustainability. Analyses were carried out on a sample of 79 Irish settlements, located in three regional clusters in western and central Ireland. A total of 40 indicators as agreed in the MESSS project were selected and indicators were aggregated into environment, socio-economics, quality of life and transport indices, 10 per index to balance inclusion of sustainability pillars. SFSPI is the most comprehensive study that has been undertaken to date in the field of sustainability and settlement patterns in Ireland. Data were collected from published sources and through a questionnaire, which was administered to about 4000 households and assembled into a database of over 300 economic, social and environmental attributes of 79 Irish settlements (Moles *et al.,* 2008a). Settlements varied in size from villages to small cities. Metrics developed during SFSPI ranked settlements according to their relative sustainability, but did not provide a method for evaluating the likely impacts of additional policy implementation designed to overcome barriers to greater sustainability. Building upon previous research, the QESSP project set out to develop the SEMPRe policy-testing method.

The overall aim of QESSP is to build on the previous projects, to identify and evaluate possible policy interventions that would be expected to enhance settlement sustainability (Figure 2.1). The QESSP project commenced on 1 July 2009 and concluded on 31 October 2013. The research team co-ordinated project management and delivery, with input from the Project Steering Committee. Settlements were agreed with the Project Steering Committee, which consisted of academics, senior local authority planners and senior policy advisors within the EPA and NSS Planning Unit. Ten steering committee meetings took place over the course of the research (approximately every 5 months), ensuring that the research was both scientifically rigorous and capable of immediate use by the planning departments of local authorities. The active participation of the Steering Committee facilitated a free flow of ideas and information among all project partners, progress reviews, identification of opportunities and resolution of issues. The composition of the Steering Committee was designed to maximise the policy relevance of project outcomes.

2.1 Settlement Selection

Almost three-quarters of European citizens live in urban areas, and this is predicted to rise to 80% by 2020 (EEA, 2010). In Ireland in 2011, cities, towns and rural areas accounted for approximately 33.3%, 28.7% and 38% of the national population, respectively (CSO, 2011). The rationale for this research is based on the recognised role of urban areas in securing balanced regional development for Ireland. Local authority development plans and Irish Government-funded research into the promotion of sustainable development have tended to ignore settlements and concentrate on larger cities. This is because of the perceived disadvantages of smaller settlements, such as fewer employment and educational opportunities, and higher costs of infrastructure and service provision. Regional planning guidelines, which identify hubs and gateways as prime locations for development, may have attracted attention away from the development needs of smaller communities (Scott, 2010). Studies on smaller settlements are needed to achieve balanced regional development (O'Regan *et al.,* 2009). In this report, policies for small, medium-sized and large settlements in Ireland are analysed; Ireland's overall sustainability depends in part on the sustainability level they achieve and they play a key role in securing balanced regional development (Table 2.1). For the purpose of this study, small settlements have been classified as urban areas with a population

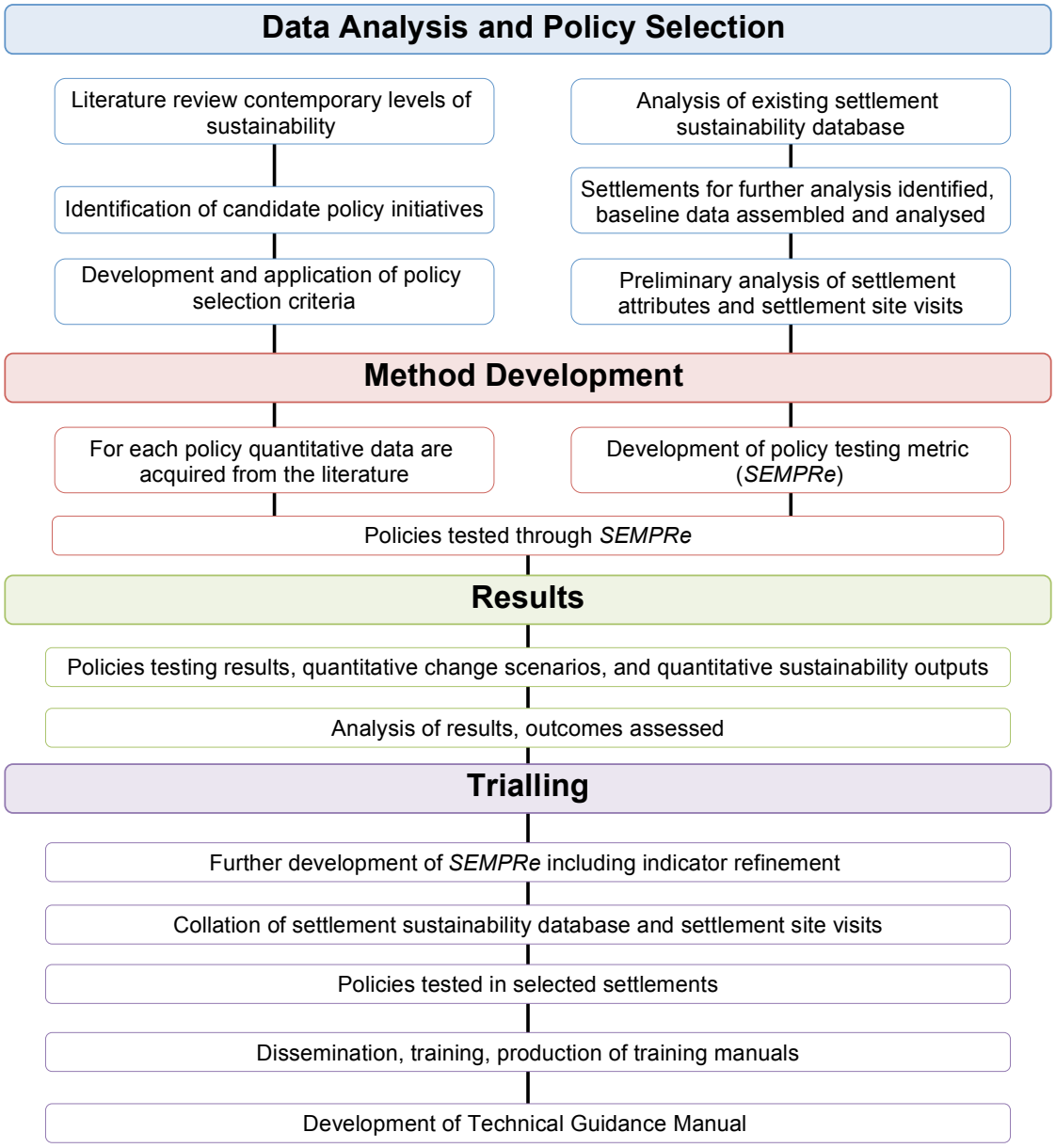


Figure 2.1. Research path.

Table 2.1. National settlement distribution

Settlement type	Population (no. of persons)	No. of settlements	Total population	% of national population
Small	≤ 1000	550	234,655	5
Medium	1001–9999	227	679,116	15
Large	10,000–30,000	34	585,225	13

Source: CSO, 2011.

of 500–1000 persons; medium settlements 1001–9999 persons, and large settlements 10,000–30,000 persons.

In selecting which settlements to test and use to validate the methods developed here, four main factors were considered: sustainability ranking, population size, geographic location and functionality.

Various types of settlement were chosen with a variety of settlement attributes: for example, coastal settlements;

inland settlements; small, medium and large sizes; satellite settlements; and settlements a large distance from Gateways (i.e. medium-sized towns identified as appropriate centres for growth through economic and social development and likely to foster regional development). This was to assess how sustainability could be improved for different types of settlement.

Settlement analysis was undertaken for 18 study settlements (Table 2.2). In keeping with the aims of the NSS, settlements were selected from the Sligo (settlements in counties Sligo, Leitrim, Roscommon, Mayo and Donegal), Midlands (settlements in counties Offaly, Laois, Roscommon, Westmeath and Galway) and Limerick (settlements in counties Limerick, Clare and Tipperary) regional clusters, in order to examine settlements in the Border, Midlands and Mid-West regions of Ireland. Clusters are centred on important Gateway towns, as identified in the NSS, and, as a guideline, a radius of 50 km from the focal point of the cluster was chosen as the catchment area. Clusters are divided into 10 bands each of 5-km distance as shown in Figure 2.2. Clusters are monocentric in the case of Sligo and Limerick, and polycentric in the case of the Midlands cluster, which is centred on the settlements of Athlone, Tullamore and Mullingar.

Table 2.2. Type and characteristics of settlements chosen for study

Settlement	Population (census 2011)	SDI	Gateway	Size	Unique attributes of chosen study settlement
Abbeyfeale	2007	55.2	Limerick	Medium	A market town located a large distance from the nearest Gateway, serving a sizeable rural catchment
Annacotty	2856	60.4	Limerick	Medium	Satellite settlement, absorbed as an exurb within the nearest Gateway settlement of Limerick
Athlone	20,153	65.4	Athlone	Large	Large inland settlement located on the River Shannon; an important employment, retail and education centre
Ballymahon	1563	48.5	Athlone	Medium	Inland settlement almost equidistant between two Gateways of Athlone and Mullingar
Ballyshannon	2503	50.9	Sligo	Medium	Coastal settlement located north-east of the Gateway of Sligo in an area of great natural beauty
Boyle	2588	55.3	Sligo	Medium	Inland settlement with good transport infrastructure located in a scenic area close to the Gateway of Sligo
Bundoran	2140	54.1	Sligo	Medium	Coastal settlement located north-east of the Gateway of Sligo, heavily dependent on tourism
Carrick-on-Shannon	3980	57.8	Sligo	Medium	Inland settlement located at a crossing point of the River Shannon. An important employment centre with good transport links to nearby Gateways
Castleconnell	1917	51.6	Limerick	Medium	Satellite settlement located close to Limerick
Ennis	25,360	63.7	Limerick	Large	Large inland settlement, an important regional centre with well-developed transport links to nearby Gateways
Glin	577	51.0	Limerick	Small	Coastal settlement, a long distance from nearest Gateway settlement of Limerick
Kinnegad	2662	47.1	Mullingar	Medium	Inland settlement located close to Mullingar with motorway access to Dublin
Mountmellick	4735	56.9	Tullamore	Medium	Inland settlement located close to Portarlington. It may be possible for both settlements to work together to improve sustainability
Mullingar	20,103	62.0	Mullingar	Large	A large inland market town, with an important commercial and industrial function, serving a large rural catchment
Portarlington	7788	53.7	Tullamore	Medium	Inland settlement located close to Mountmellick
Sixmilebridge	2507	54.2	Limerick	Medium	Medium-sized satellite settlement near the Gateway of Limerick
Sligo	19,452	63.5	Sligo	Large	Large coastal settlement in the North West Region with an important educational function
Templemore	2071	59.3	Limerick	Medium	Inland settlement with well-developed transport infrastructure. Traditionally a market town that currently has an important educational function

SDI, sustainable development index.

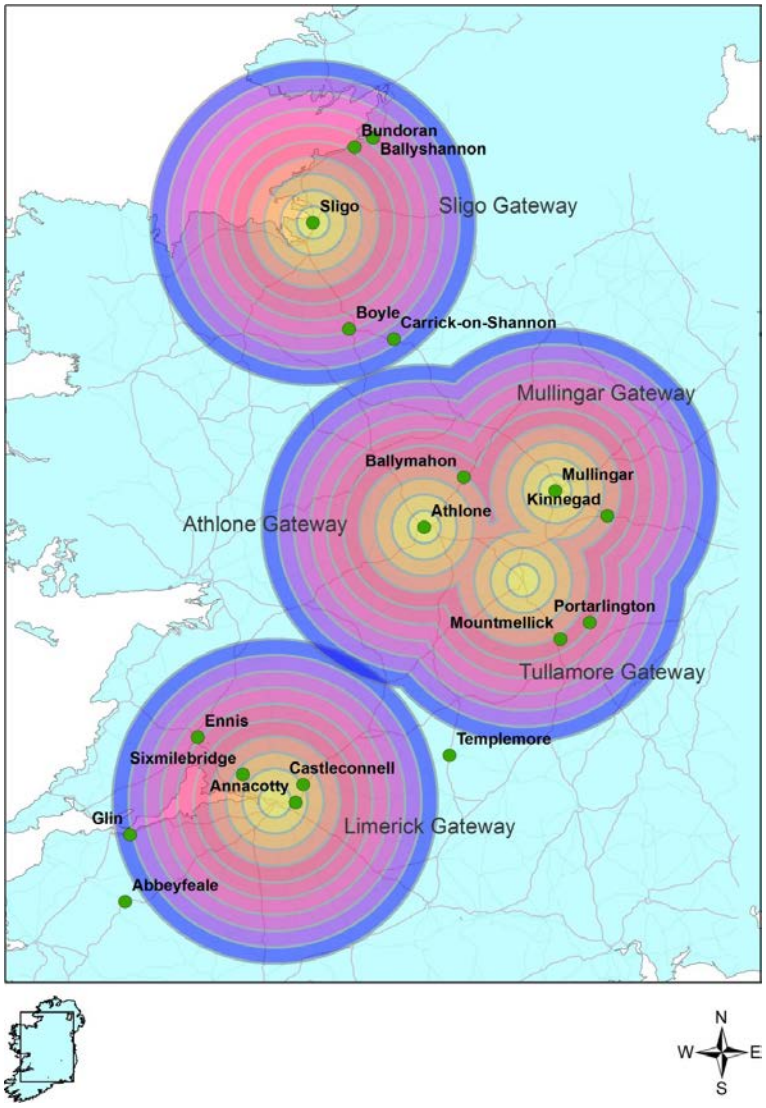


Figure 2.2. Map of study settlements (including Gateway buffers).

For the purpose of this research, emphasis is given to environmental sustainability, as energy and CO_2 emissions are integral issues of policy importance in Ireland. The residential sector in Ireland is responsible for over one-quarter of energy use, which is second only to transport. The transport and household consumption sectors are central to national-level and European Union (EU) policy development targeted at reducing non-renewable resource consumption to sustainable levels and at minimising GHG emissions. Therefore, these sectors are major concerns of national and EU policies.

A systematic literature search established current levels of sustainability in Ireland and identified important arenas in policymaking for enhancing environmental sustainability of settlements: energy, housing and urban form, transport, waste, water, and food and agriculture. These arenas were chosen because they are considered most likely to result in negative environmental impacts and showed clear policy relevance. Within these arenas, candidate policies were identified that were considered likely to increase sustainability in urban settlements in Ireland. Site visits were conducted to study settlements, and analysis of the existing settlement sustainability database identified the most and least sustainable attributes of settlements. Analysis of demonstration projects both in Ireland and abroad revealed current best practice in terms of urban sustainability policy. A candidate list of policies was collated by bringing these sources together.

It was necessary to develop policy selection criteria in order to find the most appropriate policies for Irish urban settlements. This approach forms part of the evidence-based policymaking process, which attempts to

provide evidence for policymakers, avoid duplication of research and identify research gaps. Published cases describing implementation of relevant policies were identified and policy selection criteria were developed in order to assess the evidence base and discern the policies most applicable to Irish urban settlements. The policies selected satisfied the criteria of being:

- described in quantitative terms;
- where possible evaluated more than once;
- supported by evidence on policy impacts from reliable sources;
- relevant to aspects of urban sustainability, and relatively easily understood and explained;
- suitable in an Irish town context;
- capable of implementation over relatively short timescales.

Application of these criteria resulted in a total of 40 policies being identified for further analysis (Table 2.3). Journal papers and reports provided evidence on policy implementation. Both qualitative and quantitative evidence is drawn together for each policy. Transport and domestic consumption are major concerns within these policies, as these two sectors are crucial to urban sustainability, and are strongly related to lifestyle routines and behaviour which can be addressed through policy implementation. A distinction is drawn between policies more suited to (i) national level, or (ii) local level implementation.

The policies included are diverse, and seek to influence a variety of indicators and span a range of contexts and scales. Policy validation records were compiled in order to provide a coherent policy comparison structure, an example of which is shown in Table 2.4. For full validation records for all policies please refer to EPA Technical Reports 1 and 2 (www.epa.ie). Validation records consist of:

- a policy description, which defines the scope and objectives of the policy;
- an outline of supporting evidence, both qualitative and quantitative, documenting where the policy was implemented elsewhere;
- assumptions regarding policy implementation;
- indicators the policy affects;
- the proposed policy sustainability increase that may be expected following policy implementation.

Where Irish data were available, these were used; where they were not available, examples from other countries were used as proxies. Sustainability improvements contained herein represent an average sustainability increase based upon a broad assessment of the evidence base. Although the majority of policies can be achieved over relatively short timescales, there are certain policies, such as higher urban density, congestion charging and passively heated homes, that require longer timescales. Such policies have been included because they are prominent in the literature and may afford substantial sustainability gains. Policies range from broad policies that incorporate many initiatives, such as smart growth programmes and commuter travel plans, to single policies such as water harvesting and teleworking from home.

Table 2.3. Policies that fulfilled the selection criteria

Policy arena	Policy name
Transport	*National-level policy initiatives*
	1. Driver training in economical driving techniques (driver education)
	2. Strict speed limit enforcement and speed limit reduction (enforcement)
	3. National road pricing scheme (economic aspects)
	4. Support for public transport (economic aspects)
	5. Low rolling resistance tyres (technological advancement)
	Local-level policy initiatives
	6. Urban freight distribution centres
	7. Bicycle sharing system
	8. Charging points for electric vehicles
	9. Short term car rental scheme
	10. Congestion charge for travel in urban centres
	11. Provision of bicycle lanes
	12. Payment for cycling to work
	13. Parking and showering facilities for cyclists
	14. Integrated public transport fare system
	15. Safe school routes
	16. Commuter workplace travel plans
	17. Parking cash out
Food	*Local-level policy initiatives*
	18. Communal allotments
	19. Farmers markets
Housing and urban form	*Local-level policy initiatives*
	20. Smart growth programme
	21. Passively heated buildings
	22. Teleworking from home
	23. Higher urban density
	24. Green mortgages
	25. Green roofs
Energy	*National-level policy initiatives*
	26. Education campaign to reduce standby power use
	27. Use of energy crops as home heating fuel
	28. Wind energy
	29. Smart electricity meters
	30. Prepaid electricity meters
	31. Demand side management programme
	32. Mandatory home energy audits
	Local-level policy initiatives
	33. Solar water heating
	34. Energy recovery from waste through anaerobic digestion
	35. Radiation barriers to reduce heat losses from buildings
Waste	*National-level policy initiatives*
	36. Waste prevention campaign
	37. Regulating for reduced packaging
Water	*National-level policy initiatives*
	38. Low water use fixtures
	39. Water harvesting
	Local-level policy initiatives
	40. Constructed wetlands for tertiary wastewater treatment

Table 2.4. Policy validation record for policy no. 17, *Parking cash out*

Description	The cost and availability of parking at the workplace is of critical importance in influencing travel patterns. The literature indicates that there is a link between workplace car-parking restrictions and a modal shift away from private car use. The decision whether or not to use a car for travel is determined largely by the availability and cost of parking at the destination. Roads and parking spaces are never free; the choice is whether to pay directly or indirectly for such services. Subsidies for parking represent a significant portion of vehicle operating costs; Watters *et al.* (2006) calculated that the subsidy for free parking at work in Dublin was 1.5 times the vehicle-operating costs for driving to work. The average cost of maintaining a typical parking space in the UK is £300 to £500 per year (DfT, 2002) ***Parking cash out*** is a scheme whereby commuters and house owners who receive a subsidised parking space may choose an alternative. Employees or residents could, for example, choose a parking space, a monthly travel pass or a cash alternative (Litman, 2010). Paying directly for parking is more efficient, as it gives commuters an incentive to use more sustainable modes of transport and provides savings to commuters who drive less. Organisations that address car parking can achieve significant reductions in car travel (DfT, 2002). There are a number of possible ways of implementing a parking cash out scheme. Watters *et al.* (2006) conducted a survey of employees in Ireland; respondents were asked if they would prefer giving up their parking space permanently for a one-off lump sum, yearly for a sum of €1300, monthly for a sum of €100 or daily for a sum of €4. Over 30% indicated a preference for giving up their parking space on a yearly basis, indicating some acceptance of this policy in Ireland
Evidence	***Parking cash out*** schemes typically decrease employee distance travelled by private car by 10–30%, and result in a total decrease in distance travelled by private car of 2–6% (Litman, 2010). A study of eight firms in California, USA, covering 1694 employees offering cash payouts for parking resulted in, on average, a 50% increase in the number of trips made by public transport and a 12% decrease in vehicle distance travelled (Shoup, 1997)
Assumptions	Assuming that commuting to work accounts for approximately 20% of all road traffic, a decrease of 4% in transport CO_2 emissions by weight, a decrease of 4% in traffic congestion (km/min), a decrease of 4% in percentage relative car use and a 10% increase in public transport use are realistic targets based on available evidence
Indicators affected	Transport CO_2 emissions Relative car use (%) Index of traffic congestion Public transport use (%)
Sustainability improvement	4% decrease in transport CO_2 emissions 4% decrease in % relative car use 4% decrease in index of traffic congestion 10% increase in % public transport use

3 Method Development

This chapter describes the development of the SEMPRe metric, which has been described in part by Fitzgerald *et al.* (2012).

At a national level, in an effort to integrate the principles of sustainable development into policies and programmes, Agenda 21 was agreed in 1992 (UNDESA, 1992). Since Agenda 21, a suite of methods for measuring sustainability have emerged. This diversity is itself a reason why policymakers find it hard to use these metrics in policy prioritisation. Sustainability indicators are one of the methods most frequently used for sustainability assessment. A standardised set of indicators for sustainable development needed to be developed to provide solid bases for decision-making. There is a need to define sustainable development in scientific terms and to make evaluation of sustainability a quantitative process. It is argued that indicators are not useful when considered in isolation: their value comes from using combinations of indicators to measure progress towards sustainability. A composite indicator or index is an aggregation of indicators using a predetermined methodology. Composite indicators are seen as useful tools for informing policymaking and public communication.

Previous approaches to sustainability measurement have focused on ranking entities such as states and settlements in terms of their relative sustainability. These approaches can be used to compare sustainability of settlements or regions over time. However, they were not designed to evaluate the likely sustainability impacts of additional policy implementation. There are a number of existing methods for the evaluation of sustainability policy, such as environmental impact assessment (EIA), strategic environmental assessment (SEA) and sustainability impact assessment (SIA). EIA is project based rather than area based, and SEA and SIA, in the past, have infrequently been adopted for assessments at single settlement scale, but have the capacity to be used at local scale.

3.1 Introduction to SEMPRe

SEMPRe adopts a method based on multiple indicators, with the ability to evaluate sustainability policies and inform policy decisions made not only at settlement specific level, but also, if required, at regional and national scales. It utilises 40 settlement sustainability indicators (Table 3.1). Data sources were the database generated during SFSPI, augmented by primary data collection. Environment, transport, socio-economic and quality of life indices were developed, representing key areas of sustainable development that are important concerns for urban development in Ireland. These indices were further aggregated to an overall sustainable development index (SDI) for each settlement to give a score out of 100. The indicators and indices listed in Table 3.1 were developed from data gathered as part of SFSPI and serve as a database for SEMPRe in evaluating policy impacts on study settlements.

SEMPRe was developed to satisfy the following criteria:

- to be based on the available database;
- to be able to allow testing in 40 indicators of sustainability;
- to provide a single numerical value for the projected gains in sustainability;
- to provide quantified outputs in terms of tangible policy effects;
- to provide an interface for use by non-technical practitioners.

Development of SEMPRe took place from March 2010 to June 2011, with improvements being introduced incrementally over this period.

- Initially, it was examined whether or not SEMPRe should consider individual pillars of sustainability for which developed indicator data were available: environment, quality of life, socio-economic and transport. It was decided that study of these pillars individually would not result in a general sustainability metric, but might rather lead to a compartmentalised view of sustainability. To avoid this, the pillars of sustainability were aggregated into one measurement.
- The next improvement of SEMPRe involved the recognition that it was not sufficient to provide a numeric result for sustainability improvement due to policy, but that it was also important to provide a quantified improvement due to policy implementation such as kilograms of CO_2 saved or percentage

Table 3.1. SDI component indices and indicators

Indices and indicators adopted in calculating SDI scores for settlements	
Environment index	*Quality of life index*
% recycling	% health insurance cover
Per capita waste volume	Distance to nearest hospital
% sewerage connection	% community involvement
Forest area in a 10-km radius	% odour problems
National heritage area in a 5-km radius	% noise problems
% green energy interest	% sports area satisfaction
Transport CO_2 emissions	% green area satisfaction
Drinking water NO_3	% 45+ hours employment
Electricity CO_2 emissions	General practitioners per 1000 persons
Level of wastewater treatment	% quality of life satisfaction
Socio-economic index	*Transport index*
Services index	% relative car use
Population density	% work in same town
Annual income	% households with two or more cars
% households in whole houses	% work distance < 8 km
% rented from local authority	% work distance > 24 km
% households with central heating	% public transport use
% primary education as highest level	Distance to nearest train station
% cert./dipl. as highest level of education	Index of traffic flow
House price:income ratio	Monthly distance travelled to shops
% home internet access	Distance to work

of public transport use for each of the 40 indicators. Providing tangible measurements of policy benefits is important for communicating outputs to a non-technical audience.

- The final development of SEMPRe involved the introduction of a weighting system. This was to allow for sustainability policies having greater projected impacts on aspects of settlements that were identified as having lower relative sustainability, on the assumption that these areas would have greater room for improvement.

Figure 3.1 refers to the stages in the application of SEMPRe.

3.2 Worked Example of SEMPRe

SEMPRe was constructed on a Microsoft Excel 2003 platform (later upgraded to a Microsoft Excel 2007 platform) and based on the settlement attribute database linked to interface data on separate spreadsheets. SEMPRe was programmed with the use of simple logic gates and algebraic formulae; it was constructed to be as user-friendly as possible (for example, settlement attribute data cannot be lost or corrupted) and was programmed separately for each of the 18 settlements, as values for their sustainability indicators varied. A unique SEMPRe interface was created for each settlement.

Indicators are organised into environment, quality of life, socio-economic and transport indices, with 10 indicators per index. SEMPRe extracts data from the 24,000-piece SFSPI dataset located on other spreadsheets running in the background of the model, to quantify the impact of selected policies on settlements. Figure 3.2 shows the 10 indicators that constitute the Transport index for Abbeyfeale.

A normalising equation was required in order to aggregate baseline data of differing units. In the absence of the normalising equation, it would not be possible to compare or aggregate differing units of measurement. Two equations were developed: Equation 3.1 and Equation 3.2.

$$1 - \frac{\text{optimum value} - x}{\text{optimum value} - \text{lowest value}} \qquad \text{Equation 3.1}$$

$$1 - \frac{x - \text{optimum value}}{\text{lowest value} - \text{optimum value}} \qquad \text{Equation 3.2}$$

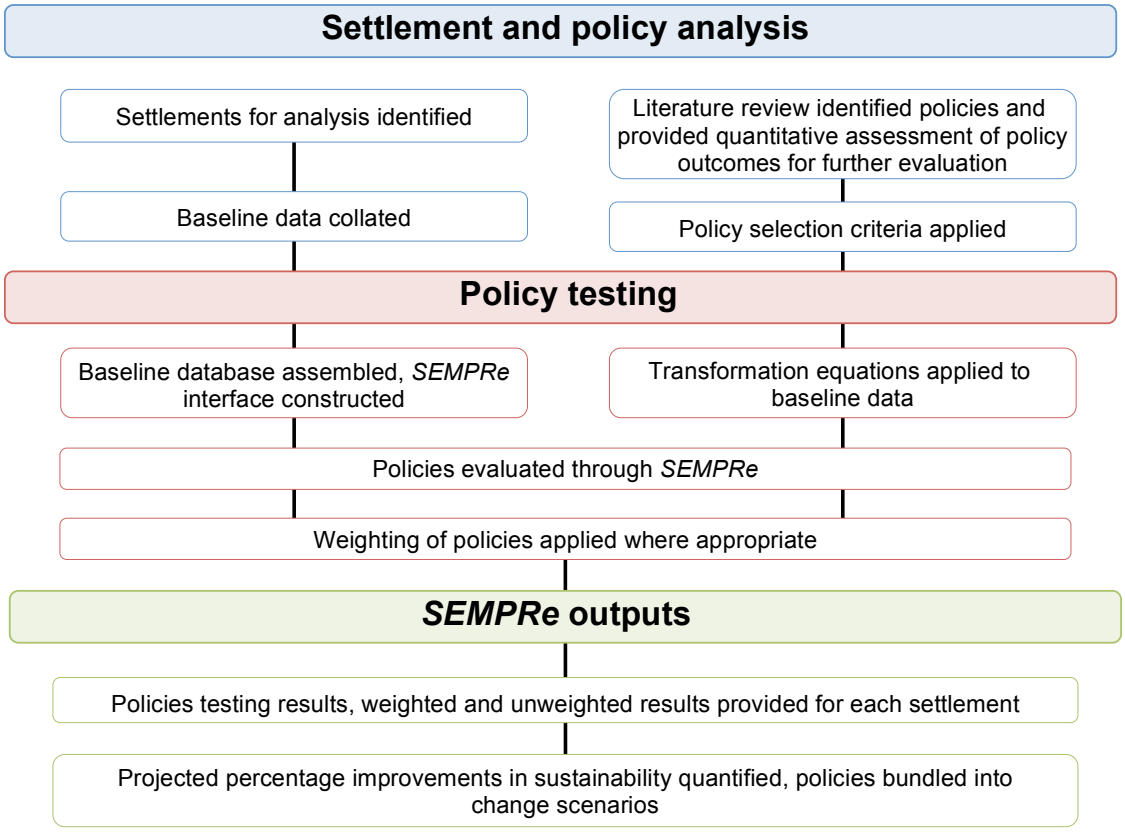
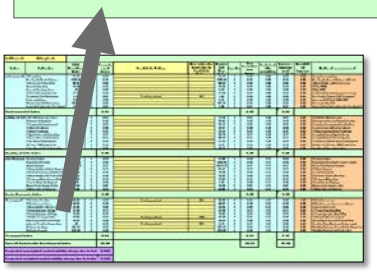


Figure 3.1. Description of stages in the methodological development of SEMPRe.

Settlement:	Abbeyfeale			
Index	Indicator	2006 Baseline data	Equation	Transformed score
Transport	% Relative car use	30.00	2	0.63
	% Work in same town	68.97	1	0.70
	% Households with >2 cars	24.96	2	0.89
	% Work distance <8 km	55.90	1	0.72
	% Work distance >24 km	15.36	2	0.78
	% Public transport use	14.89	1	0.31
	Km to nearest train station	28.49	2	0.38
	Index of traffic congestion	.83	2	0.70
	Distance to shops	205.31	2	0.64
	Distance to work	693.90	2	0.90
Transport Index				6.64



- Baseline data
- Normalising equation
- Transformed score

Figure 3.2. SEMPRe transport baseline data for Abbeyfeale.

One of two transformation equations is applied to each indicator. Equation 3.1 is applied to indicators where an increase in value leads to increased settlement sustainability, such as percentage of recycling and percentage of public transport use, and Equation 3.2 is applied to indicators where a decrease in value leads to increased settlement sustainability, such as per capita waste volume and percentage of car use. The transformed scores for each indicator are summed to give a score out of 10 for each index. The index scores are added and multiplied by 2.5 to give an overall SDI score out of 100. The normalising equations used here access the SFSPI datasets for each indicator in each of the 79 settlements and score each indicator for a specific settlement by ranking it between 0 and 1 depending on how relatively high or low it is within the wider context of the 79 settlements.

The projected impacts of a candidate policy on an indicator are quantified in the unit of that indicator, by an amount representing a conservative estimate derived from published sources. To demonstrate the modelling of policy impact through SEMPRe, an example policy, policy no. 17, *Parking cash out,* is chosen to be modelled in the settlement of Abbeyfeale, Co. Limerick. *Parking cash out* is a policy whereby commuters who receive a subsidised parking space may choose an alternative. Employees or residents could, for example, choose a parking space, a monthly travel pass or a cash alternative. In this example the new indicator levels of a 4% decrease in relative car use, transport CO_2 emissions and index of traffic congestion and a 10% increase in public transport use are input into SEMPRe (Figure 3.3).

The projected changes in indicator data due to the policy being modelled are applied to the baseline data (Figure 3.4). The model applies normalising equations to the new data to give new transformed scores. A policy is likely to impact on several indicators, including the possibility of cumulative impacts, some possibly negative. A strength of SEMPRe is that it facilitates the modelling of a policy that impacts on multiple indicators simultaneously. The projected changes for all relevant indicators are input into SEMPRe, which then recalculates the score for that settlement.

Once the policy impacts on multiple indicators have been quantified and it has been noted how the policy changes the normalised data, the baseline data are aggregated before and after modelling. The difference in aggregated baseline data prior to and following modelling is calculated and expressed as a percentage, which is taken to represent the change in sustainability associated with the implementation of that policy in that settlement. SEMPRe produces weighted and unweighted figures for overall percentage sustainability increase (Figure 3.5). In addition to providing

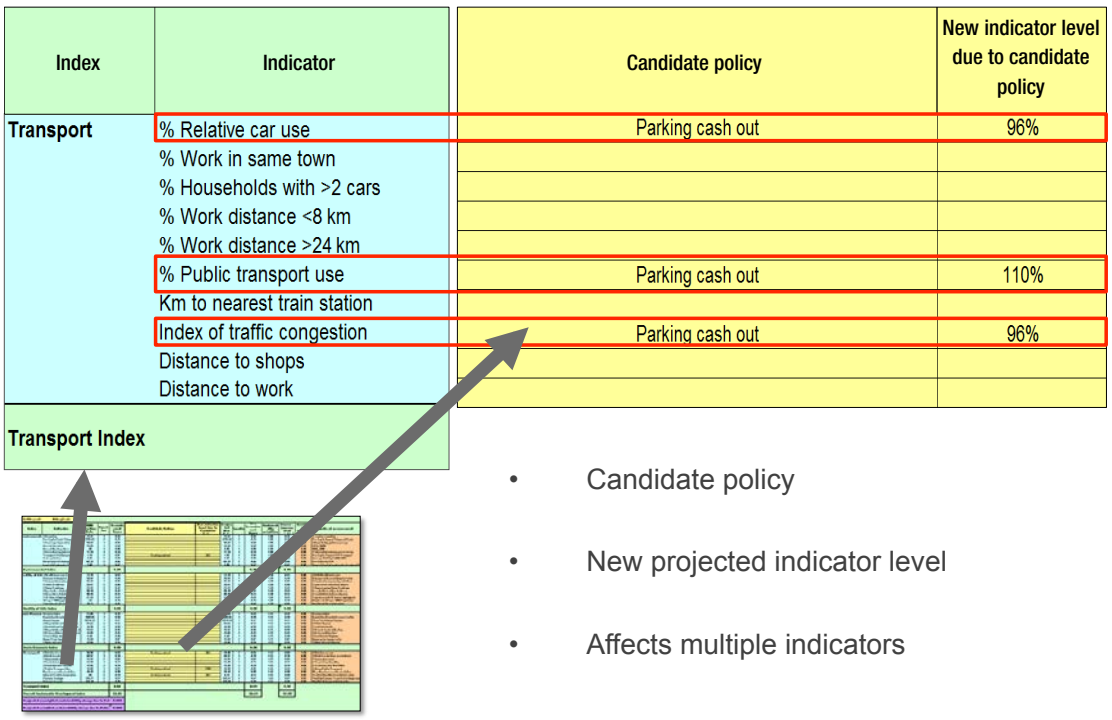
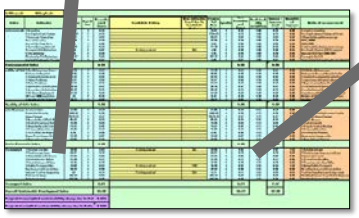


Figure 3.3. SEMPRe expected policy impact.

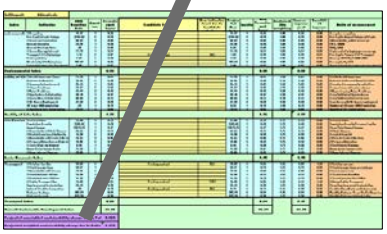
Index	Indicator	Projected new data	Equation	New transformed score	Sustainability weighting	Scores – improvement weighted
Transport	% Relative car use	28.80	2	0.66	1.25	0.83
	% Work in same town	68.97	1	0.70	1.25	0.70
	% Households with >2 cars	24.96	2	0.89	1.25	0.89
	% Work distance <8 km	55.90	1	0.72	1.25	0.72
	% Work distance >24 km	15.36	2	0.78	1.25	0.78
	% Public transport use	16.38	1	0.35	1.25	0.44
	Km to nearest train station	28.49	2	0.38	1.25	0.38
	Index of traffic congestion	0.79	2	0.72	1.25	0.90
	Distance to shops	205.31	2	0.64	1.25	0.64
	Distance to work	693.90	2	0.90	1.25	0.90
Transport Index				6.74		7.17



- Projected new data
- Weighting applied

Figure 3.4. SEMPRe new projected data.

Projected unweighted sustainability change due to policy	0.56%
Projected weighted sustainability change due to policy	0.56%



- Sustainability change modelled by aggregating indicators
- Weighted and unweighted results

Figure 3.5. SEMPRe outputs.

a sustainability impact associated with policy implementation, SEMPRe provides a bundle of quantified impacts associated with each policy. Providing quantified results in addition to percentage sustainability gains in SEMPRe is useful to aid the communication of policy impacts in a non-technical way.

A simple and transparent weighting system was most appropriate to enable understanding by non-technical personnel and a variety of stakeholders. A possible basis for weighting arises from the finding that the attributes of settlements play a major role in determining the outcome of policy implementation. If the greatest weaknesses in the attributes of a settlement are identified, in terms of environmental, socio-economic, transport or quality of life indicators, then it may be argued that policies that target the weakest aspects of sustainability

through policy implementation provide the greatest scope for improvement, such that indicators affected by these policies should be weighted more heavily. Here, a weighting system was adopted based on the analysis of the attributes of settlements. Indices for a settlement were ranked from highest to lowest, and a weighting of 1.75 attributed to the lowest-scoring index, 1.5 to the second lowest, 1.25 to the third lowest and 1 to the highest-scoring index.

A total of 40 policies were tested through SEMPRe for each of the 18 settlements (on the basis of that settlement's score on each indicator). Further information is available in EPA Technical Reports 1 and 2 (available at www.epa.ie).

3.3 Policy Feasibility Testing

It is acknowledged that not all policies are applicable in every settlement. Feasibility testing determines the viability and practicality of policy implementation in each settlement (O'Doherty *et al.,* 2013). Policies found to have positive impacts on sustainability through application of the SEMPRe metric were then subjected to feasibility testing. The feasibility testing process is described by O'Doherty *et al.* (2013).

Feasibility testing aims to inform policymakers about the feasibility of policy implementation in an Irish urban context. This process intends to find the best choice for the decision maker by transforming a complex problem into a single-criterion problem and ranking alternatives according to their feasibility. It considers whether or not policies are suitable in an Irish urban context and in which type of settlements a policy is most applicable. Additionally, feasibility testing provides a clear plan of action and identifies policy stakeholders, either at local or national level, in order to determine who is responsible for the work involved. In addition to its usefulness to policymakers, the method is sufficiently simple to be interpreted by non-technical users.

Policy validation involves defining issues, solutions and evaluation criteria. Feasibility testing begins with a description of the policy and its aims. Secondly, an assessment is made of the likelihood of the policy initiative meeting its objectives when implemented; ambiguities in the evidence and obstacles to implementation are documented based on effects achieved elsewhere. Thirdly, the possibility of unintended consequences such as rebound and backfire effects are considered. Fourthly, a plan of action is designed to assist decision makers with policy implementation. Policy cost-effectiveness, a timeline for implementation, uptake rates and applicability in an Irish context are estimated on the basis of previous experience elsewhere. In addition, the scale of policy implementation is examined, as some policies are better suited to national-level implementation by a government or other national body, while others better suit local-level implementation by a local authority or community organisation, and some policies may require a mixture of national- and local-level implementation.

Because of the rebound effect (Sorrell *et al.,* 2009), only a proportion of the potential energy and material savings may be achieved in practice. This feasibility-testing method has attempted to take rebound and backfire effects into consideration through the use of quantitative data based on previous experiences elsewhere and inclusion, where available, of quantitative evidence on rebound and backfire effects.

Policies aimed at increasing urban sustainability that can be implemented at a low cost and over short timescales were targeted. In order to find the most beneficial of the 40 policies, multi-criteria analysis was used to compare alternatives in a consistent way. A weighting system was developed to take into account the project aims and objectives, and the priorities of the project Steering Committee. Objectives and criteria for policy selection may be changed to suit other national requirements. In determining the overall level of feasibility of implementation, three criteria were assessed: length of timeline for policy implementation, cost of policy implementation and improvement in per capita sustainability. The percentage improvement in per capita sustainability was calculated using SEMPRe for each policy in each of the study settlements. For these three criteria, the expected consequence for the implementation of each policy was assigned a numerical score on a scale of 0–10 (Table 3.2), with more desirable outcomes given higher scores. The criteria were weighted, in line with the assumed importance of each one. A weighting of 1 was attributed to (i) length of timeline for policy implementation and (ii) cost of policy implementation. A weighting of 2 was assigned to improvement in SEMPRe per capita sustainability score, as this is a fundamental criterion that determines policy effectiveness.

The three scores were weighted, aggregated and expressed as a percentage of maximum value, which effectively transforms the problem into a single-criterion problem for ease of comparison between policies. It is

Table 3.2. Policy feasibility scores

Criterion	Score
Length of timeline (years)	
<1	10
1–2	8
2–3	6
3–4	4
>5	2
Cost	
Low	10
Medium	5
High	1
Improvement in per capita sustainability (%)	
>4	10
3–4	8
2–3	6
1–2	4
<1	2

acknowledged that there is an inherent subjectivity in establishing weighting and scoring systems. A different ranking system might be adopted depending on the needs of the decision maker.

Four other possible alternative weighting systems were developed:

- a weighting system that favours high-sustainability policies;
- a weighting system that favours low-cost policies;
- a weighting system that favours short-timeline policies;
- a weighting system that favours policies that reduce CO_2 emissions.

Policies were ranked from highest to lowest in terms of feasibility of implementation and, where two or more policies had equal feasibility scores, policies were ranked according to their SEMPRe sustainability impact.

3.4 Policy Ranking and Development of Quantitative Change Scenarios

To attempt to identify policy options with greater overall impact, individual candidate policies were grouped into bundles, with the idea that, instead of introducing one new policy, decision makers might introduce a bundle of policies at the same time. Three bundles were assembled, each representing a policy intervention scenario (here called a "change scenario"), ranging from conservative to innovatory. For each scenario a target was set for a percentage improvement in sustainability, calculated on the basis of SDI scores for settlement sustainability ranking (see Table 3.3).

Policies contained herein are not mutually independent and may interact; indeed, because of the substantial numbers of policies in this study, there are a large number of potential interactions between policies. These interactions can be positive and mutually

Table 3.3. Change scenario impact targets and criteria

Name	Target	Required change criteria
Primary change scenario	23% increase in SEMPRe score	Takes settlements with lowest SDI score to average Takes settlements with average SDI scores to high
Significant change scenario	32% increase in SEMPRe score	Takes settlements with low SDI score to above average Takes settlements with average SDI score to highest
Extensive change scenario	41% increase in SEMPRe score	Takes all settlements' SDI score to above highest

reinforcing, or negative where policies counteract each other's effectiveness; therefore, a full assessment of interactions between all policies contained herein is difficult to achieve. It is acknowledged that the true effect of policy implementation can be fully evaluated only through trialling of the method.

3.5 Development of a Method to Address Double Counting

The policy mix contained herein as far as possible makes use of synergies and avoids contradictions in the effects of policies. Overlap between policies, termed "double counting", may overestimate the impacts of proposed policies. Through careful examination of the scope, objectives and operation of policies double counting is minimised. Potential overlaps of data are avoided as much as possible through the use of empirical evidence from cases in which multiple policies have been implemented together and the effects evaluated.

A method was developed to overcome the issue of double counting of policies when constructing quantitative change scenarios. When constructing policy bundles, the first time an indicator is affected by a policy, the full quantified improvement is attributed. If more than one policy affects an indicator, then, subsequent to the first policy, quantified improvements were added on a sliding scale. Initially, 100% of the change is accounted for, and each time an indicator is acted upon by more than one policy, the quantified change is halved. For example, in the primary change scenario the first time an indicator is acted upon 100% of the change is counted, the second time 50%, the third time 25%, and so on. This process is identical for the significant and extensive change scenarios.

4 Results

Policies were tested for each of the 18 study settlements. For demonstration purposes, results for examples of small, medium-sized and large settlements are described here. SEMPRe and feasibility results are provided for the small settlement of Ballymahon, the medium-sized settlement of Templemore and the large settlement of Athlone. For results for all settlements, please refer to EPA Technical Reports 1 and 2 (www.epa.ie).

4.1 SEMPRe Results

4.1.1 Athlone

The results of testing the 40 policies through SEMPRe for Athlone are shown in Figure 4.1.

The average unweighted sustainability improvement calculated for Athlone was 0.7%; results varied from 0.1% for policy no. 5, *Low rolling resistance tyres,* to 3.5% for policy no. 23, *Higher urban density*. The addition of a weighting resulted in higher calculated SEMPRe scores. The average weighted sustainability improvement was 1.5%; results varied from 0.1% for policy no. 9, *Short term car rental scheme,* to 5.4% for policy no. 23, *Higher urban density*. In general, in Athlone, both weighted and unweighted calculated scores for local-level transport policies were below average whereas calculated scores for national- and local-level water policies and housing and urban form policies were above average.

4.1.2 Templemore

The results of testing the 40 policies through SEMPRe for Templemore are shown in Figure 4.2.

Calculated SEMPRe scores for Templemore showed large variability. The average unweighted sustainability improvement was 0.6%; results varied from 0.04% for policy no. 25, *Green roofs,* to 3.7% for policy no. 23, *Higher urban density*. The addition of a weighting resulted in higher calculated SEMPRe scores. The average weighted sustainability improvement was 2.4%; results varied from 0.1% for policy no. 9, *Short term car rental scheme,* to 8.0% for policy no. 23, *Higher urban density*. Both weighted and unweighted calculated scores for local-level transport policies were below average, whereas calculated scores for waste policies and housing and urban form policies in Templemore were above average.

4.1.3 Ballymahon

The results of testing the 40 policies through SEMPRe for Ballymahon are shown in Figure 4.3.

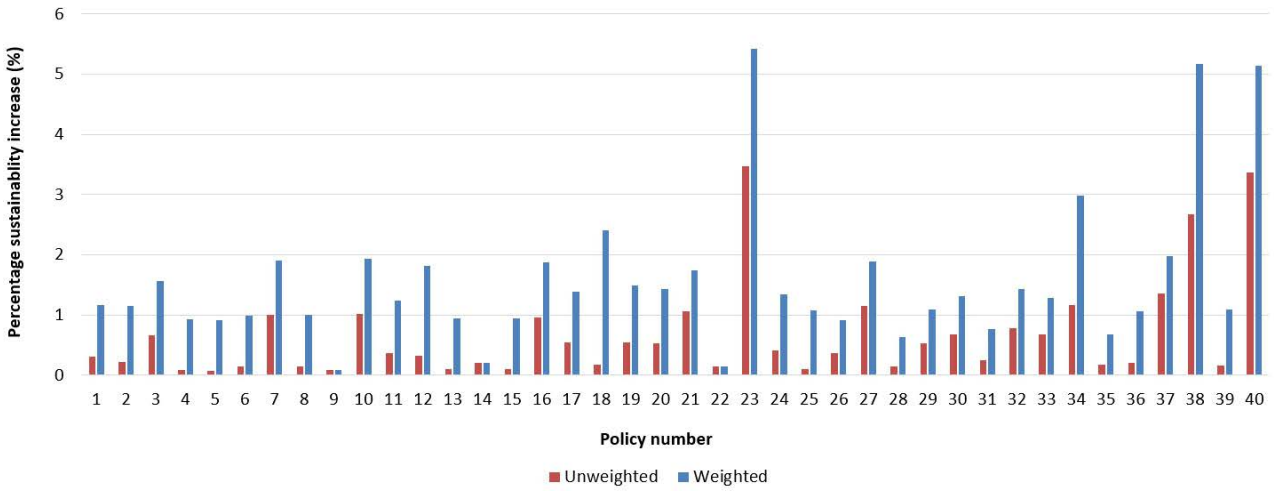


Figure 4.1. Weighted and unweighted SEMPRe results for Athlone.

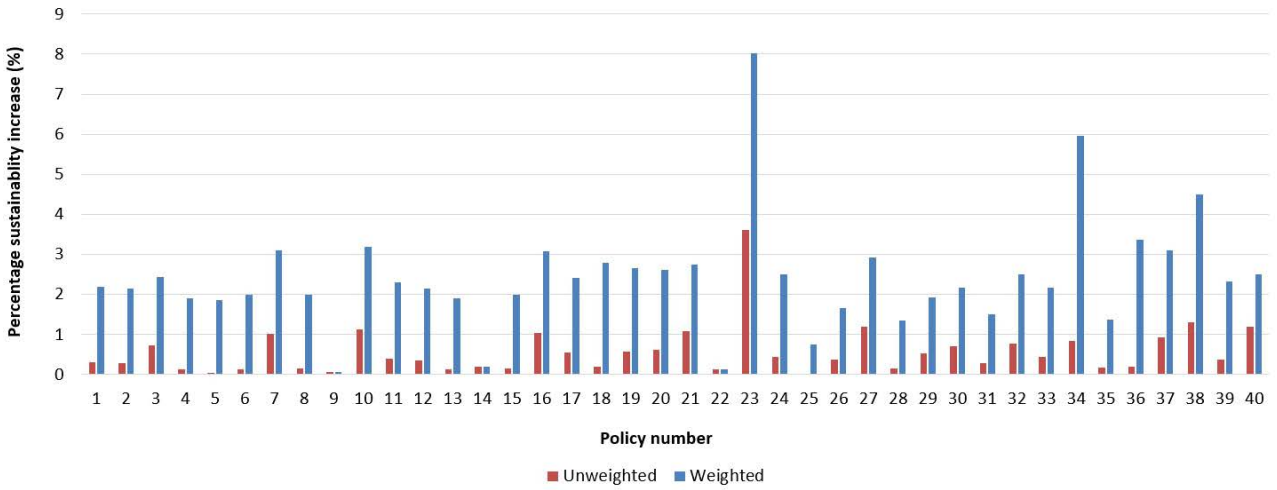


Figure 4.2. Weighted and unweighted SEMPRe results for Templemore.

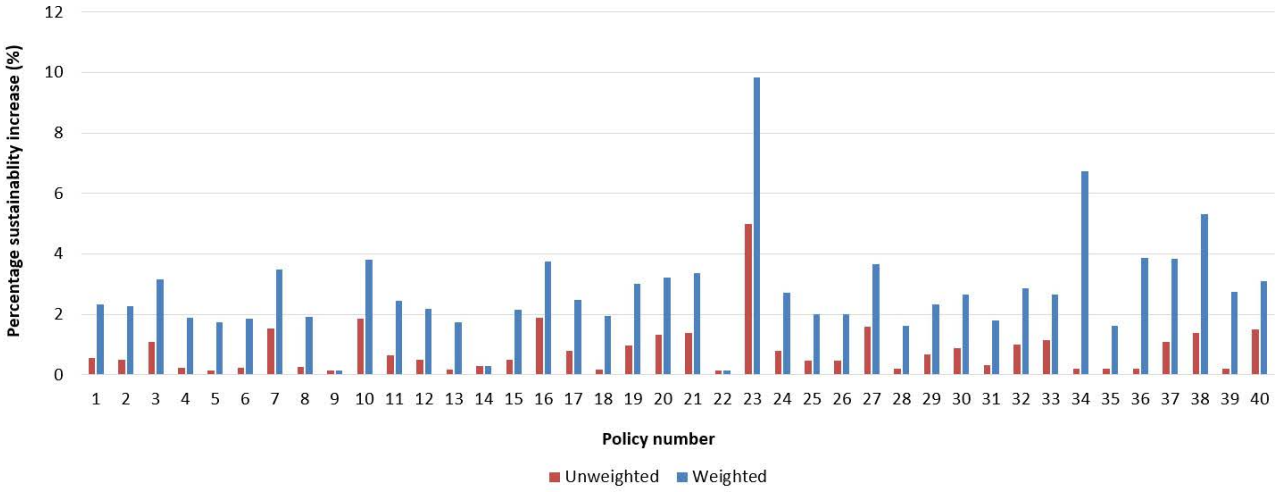


Figure 4.3. Weighted and unweighted SEMPRe results for Ballymahon.

Policies tested for Ballymahon recorded a wide range of SEMPRe results. The average unweighted sustainability improvement was 0.9%; results varied from 0.2% for policy no. 5, *Low rolling resistance tyres,* to 5.0% for policy no. 23, *Higher urban density*. The addition of a weighting resulted in higher calculated SEMPRe scores. The average weighted sustainability improvement was 2.8%; results varied from 0.2% for policy no. 9, *Short term car rental scheme,* to 9.8% for policy no. 23, *Higher urban density*. In general, in Ballymahon, both weighted and unweighted calculated scores for transport and national-level energy policies were below average, whereas calculated scores for housing and urban form policies and national-level waste policies were above average.

4.2 Feasibility Testing Results

Following policy testing through SEMPRe, policies were feasibility tested in all settlements according to the method described earlier. Results for the settlements of Athlone, Templemore and Ballymahon are provided here. Feasibility testing found that 40 policies were applicable in large settlements, 36 in medium-sized settlements and 30 in small settlements.

4.2.1 Athlone

The results of policy feasibility testing in Athlone are shown in Table 4.1. Where two or more policies had equal feasibility scores, policies were ranked according to their SEMPRe weighted sustainability increase (%).

Table 4.1. Impacts and feasibility of policy implementation in Athlone

Rank	Policy no.	Policy	SEMPRe weighted sustainability increase (%)	Level of feasibility (%)
1	38	Low water use fixtures	5.2	95
2	40	Constructed wetlands for tertiary wastewater treatment	5.1	95
3	19	Farmers markets	1.5	70
4	33	Solar water heating	1.3	70
5	1	Driver training in economical driving techniques	1.2	70
6	36	Waste prevention campaign	1.1	70
7	37	Regulating for reduced packaging	2.0	60
8	5	Low rolling resistance tyres	0.9	60
9	26	Education campaign to reduce standby power use	0.9	60
10	35	Radiation barriers to reduce heat losses from buildings	0.7	60
11	23	Higher urban density	5.4	57.5
12	12	Payment for cycling to work	1.2	57.5
13	22	Teleworking from home	0.1	55
14	34	Energy recovery from waste through anaerobic digestion	3.0	52.5
15	18	Communal allotments	2.4	52.5
16	27	Use of energy crops as home heating fuel	1.9	52.5
17	32	Mandatory home energy audits	1.4	52.5
18	17	Parking cash out	1.4	52.5
19	30	Prepaid electricity meters	1.3	52.5
20	2	Strict speed limit enforcement and speed limit reduction	1.2	52.5
21	29	Smart electricity meters	1.1	52.5
22	6	Urban freight distribution centres	1.0	52.5
23	7	Bicycle sharing system	1.9	47.5
24	11	Provision of bicycle lanes	1.2	47.5
25	8	Charging points for electric vehicles	1.0	47.5
26	15	Safe school routes	1.0	47.5
27	4	Support for public transport	0.9	47.5
28	13	Parking and showering facilities for cyclists	0.9	47.5
29	16	Commuter workplace travel plans	1.9	42.5
30	21	Passively heated buildings	1.8	42.5
31	39	Water harvesting	1.1	42.5
32	25	Green roofs	1.1	42.5
33	31	Demand side management programme	0.8	42.5
34	14	Integrated public transport fare system	0.2	42.5
35	9	Short term car rental scheme	0.1	42.5
36	3	National road pricing scheme	1.6	37.5
37	24	Green mortgages	1.4	37.5
38	10	Congestion charge for travel in urban centres	1.9	32.5
39	20	Smart growth programme	1.4	27.5
40	28	Wind energy	0.6	22.5
Average			1.6	52

4.2.2 Templemore

Thirty-six policies were feasibility tested in the medium-sized settlement of Templemore. The results are presented in Table 4.2.

4.2.3 Ballymahon

Thirty policies were feasibility tested in the small settlement of Ballymahon. The results are presented in Table 4.3.

Table 4.2. Impacts and feasibility of policy implementation in Templemore

Rank	Policy no.	Policy	SEMPRe sustainability increase (%)	Level of feasibility (%)
1	38	Low water use fixtures	4.5	95
2	36	Waste prevention campaign	3.4	90
3	19	Farmers markets	2.7	80
4	1	Driver training in economical driving techniques	2.3	80
5	33	Solar water heating	2.2	80
6	40	Constructed wetlands for tertiary wastewater treatment	2.5	75
7	37	Regulating for reduced packaging	3.1	70
8	5	Low rolling resistance tyres	1.9	70
9	26	Education campaign to reduce standby power use	1.7	70
10	35	Radiation barriers to reduce heat losses from buildings	1.4	70
11	12	Payment for cycling to work	2.2	67.5
12	4	Support for public transport	2.0	67.5
13	34	Energy recovery from waste through anaerobic digestion	6.0	62.5
14	16	Commuter workplace travel plans	3.1	62.5
15	27	Use of energy crops as home heating fuel	2.9	62.5
16	32	Mandatory home energy audits	2.5	62.5
17	17	Parking cash out	2.4	62.5
18	2	Strict speed limit enforcement and speed limit reduction	2.2	62.5
19	30	Prepaid electricity meters	2.2	62.5
20	23	Higher urban density	8.0	57.5
21	11	Provision of bicycle lanes	2.3	57.5
22	8	Charging points for electric vehicles	2.0	57.5
23	15	Safe school routes	2.0	57.5
24	13	Parking and showering facilities for cyclists	1.9	57.5
25	22	Teleworking from home	0.1	55
26	18	Communal allotments	2.8	52.5
27	21	Passively heated buildings	2.8	52.5
28	39	Water harvesting	2.4	52.5
29	29	Smart electricity meters	1.9	52.5
30	31	Demand side management programme	1.5	52.5
31	3	National road pricing scheme	2.8	47.5
32	24	Green mortgages	2.5	47.5
33	14	Integrated public transport fare system	0.2	42.5
34	20	Smart growth programme	2.6	37.5
35	28	Wind energy	1.4	32.5
36	25	Green roofs	0.8	32.5
Average			2.5	61.0

The highest- and lowest-ranking policies for the 18 settlements are based upon the chosen ranking method, which combines the priorities of significant improvement in sustainability, low cost and short implementation timescale. The chosen ranking system favours policies that are easy to implement in the short term and are low cost. Results for alternative ranking systems are contained in EPA Technical Reports 1 and 2.

Policies tested for Athlone (Table 4.1) recorded a wide range of feasibility percentage scores, from 22.5% to 95%, with an average feasibility of 52% and average

Table 4.3. Impacts and feasibility of policy implementation in Ballymahon

Rank	Policy no.	Policy	SEMPRe sustainability increase (%)	Level of feasibility (%)
1	38	Low water use fixtures	5.3	95.0
2	36	Waste prevention campaign	3.9	90.0
3	19	Farmers markets	3.1	90.0
4	33	Solar water heating	2.7	80.0
5	1	Driver training in economical driving techniques	2.4	80.0
6	26	Education campaign to reduce standby energy use	2.0	80.0
7	27	Use of energy crops as home heating fuel	3.7	72.5
8	37	Regulating for reduced packaging	3.9	70.0
9	5	Low rolling resistance tyres	1.8	70.0
10	35	Radiation barriers to reduce heat losses from buildings	1.7	70.0
11	12	Payment for cycling to work	2.2	67.5
12	34	Energy recovery from waste through anaerobic digestion	6.7	62.5
13	21	Passively heated buildings	3.4	62.5
14	40	Constructed wetlands for tertiary wastewater treatment	3.1	62.5
15	32	Mandatory home energy audits	2.9	62.5
16	30	Prepaid electricity meters	2.7	62.5
17	29	Smart electricity meters	2.4	62.5
18	2	Strict speed limit enforcement and speed limit reduction	2.3	62.5
19	18	Communal allotments	2.0	55.0
20	22	Teleworking from home	0.2	55.0
21	39	Water harvesting	2.8	52.5
22	31	Demand side management programme	1.8	52.5
23	20	Smart growth programme	3.2	47.5
24	24	Green mortgages	2.7	47.5
25	15	Safe school routes	2.1	47.5
26	8	Charging points for electric vehicles	1.9	47.5
27	14	Integrated public transport fare system	0.3	42.5
28	9	Short term car rental scheme	0.2	42.5
29	28	Wind energy	1.6	32.5
30	25	Green roofs	0.9	32.5
Average			2.5	61.9

weighted SEMPRe score of 1.6%. Policy no. 38, *Low water use fixtures,* ranked highest (95%), followed by policy no. 40, *Constructed wetlands for tertiary waste-water treatment* (95%). On average, water and waste policies recorded the highest feasibility scores whereas energy and transport policies recorded the lowest.

Policies tested for Templemore (Table 4.2) recorded feasibility percentage scores ranging from 32.5% to 95%, with an average feasibility of 61% and average weighted SEMPRe score of 2.5%. Policy no. 38, *Low water use fixtures,* ranked highest (95%), followed by policy no. 36, *Waste prevention campaign* (90%). On average, water, waste and food policies recorded the highest feasibility scores, whereas housing and urban form, and energy recorded the lowest.

Policies tested for Ballymahon (Table 4.3) recorded feasibility percentage scores ranging from 32.5% to 95%, with an average feasibility of 62% and average weighted SEMPRe score of 2.5%. Policy no. 38, *Low water use fixtures,* ranked highest (95%), followed by policy no. 36, *Waste prevention campaign* (90%). On average, water and waste policies recorded the highest feasibility scores, whereas energy and transport policies recorded the lowest.

4.3 Quantitative Change Scenarios

Evaluation of 40 policies in 18 settlements showed that, in order to meet the change scenario targets, it was necessary to bundle policies together into change scenarios. For each of the study settlements three quantitative change scenarios were assembled. Results for Athlone, Templemore and Ballymahon are shown in Tables 4.4–4.6.

Analysis of change scenarios for the study settlements reveals that each settlement requires different policies and different numbers of policies to achieve each of the required change scenarios. It appears that small settlements may generally require fewer policies than medium-sized and large settlements to satisfy change scenarios. This may be because small settlements are less sustainable, allowing greater policy impact.

An additional output of SEMPRe is quantified sustainability outputs for each change scenario. This permits the evaluation of change scenarios in a more tangible way, to communicate outputs more effectively to a non-technical audience and stakeholders. Tables 4.7–4.9 provide results of quantified sustainability outputs for the three quantitative change scenarios described earlier.

Table 4.4. Quantitative change scenarios for Athlone

Scenario	Policy no.	Policy	SEMPRe sustainability increase (%)
Primary change scenario	38	Low water use fixtures	5.2
	40	Constructed wetlands for tertiary wastewater treatment	5.1
	19	Farmers markets	1.5
	33	Solar water heating	1.3
	1	Driver training in economical driving techniques	1.2
	36	Waste prevention campaign	1.1
	37	Regulating for reduced packaging	2.0
	5	Low rolling resistance tyres	0.9
	26	Education campaign to reduce standby power use	0.9
	35	Radiation barriers to reduce heat losses from buildings	0.7
	23	Higher urban density	5.4
		Total	*25.3*
Significant change scenario	Primary change scenario plus:		
	12	Payment for cycling to work	1.2
	22	Teleworking from home	0.1
	34	Energy recovery from waste through anaerobic digestion	3.0
	18	Communal allotments	2.4
	27	Use of energy crops as home heating fuel	1.9
		Total	*33.9*
Extensive change scenario	Significant change scenario plus:		
	32	Mandatory home energy audits	1.4
	17	Parking cash out	1.4
	30	Prepaid electricity meters	1.3
	2	Strict speed limit enforcement and speed limit reduction	1.2
	29	Smart electricity meters	1.1
	6	Urban freight distribution centres	1.0
		Total	*41.3*

Table 4.5. Quantitative change scenarios for Templemore

Scenario	Policy no.	Policy	SEMPRe sustainability increase (%)
Primary change scenario	38	Low water use fixtures	4.5
	36	Waste prevention campaign	3.4
	19	Farmers markets	2.7
	1	Driver training in economical driving techniques	2.3
	33	Solar water heating	2.2
	40	Constructed wetlands for tertiary wastewater treatment	2.5
	37	Regulating for reduced packaging	3.1
	5	Low rolling resistance tyres	1.9
	26	Education campaign to reduce standby power use	1.7
		Total	*24.3*
Significant change scenario	Primary change scenario plus:		
	35	Radiation barriers to reduce heat losses from buildings	1.4
	12	Payment for cycling to work	2.2
	4	Support for public transport	2.0
	34	Energy recovery from waste through anaerobic digestion	6.0
		Total	*35.9*
Extensive change scenario	Significant change scenario plus:		
	16	Commuter workplace travel plans	3.1
	27	Use of energy crops as home heating fuel	2.9
		Total	*41.9*

Table 4.6. Quantitative change scenarios for Ballymahon

Scenario	Policy no.	Policy	SEMPRe sustainability increase (%)
Primary change scenario	38	Low water use fixtures	5.3
	36	Waste prevention campaign	3.9
	19	Farmers markets	3.1
	33	Solar water heating	2.7
	1	Driver training in economical driving techniques	2.4
	26	Reduction in standby energy use	2.0
	27	Use of energy crops as home heating fuel	3.7
		Total	*23.1*
Significant change scenario	Primary change scenario plus:		
	37	Regulation for reduced packaging	3.9
	5	Low rolling resistance tyres	1.8
	35	Radiation barriers to reduce heat losses from buildings	1.7
	12	Payment for cycling to work	2.2
		Total	*32.5*
Extensive change scenario	Significant change scenario plus:		
	34	Energy recovery from waste	6.7
	21	Passively heated buildings	3.4
		Total	*42.6*

Table 4.7. Quantitative change scenarios sustainability outputs for Athlone

Scenario	Quantified sustainability outputs SEMPRe
Primary change scenario	1.4-mg/L decrease in NO_3 in drinking water
	0.3-tonne decrease in per capita CO_2 from transport emissions
	26.5-kg decrease in per capita CO_2
	0.01-km/min increase in speed of traffic flow
	1.5% increase in regular recycling
	596-kg decrease in per capita annual volume of waste
	7.4% decrease in relative car use
Significant change scenario	*Primary change scenario plus:*
	0.1-tonne decrease in per capita CO_2 from transport emissions
	2.1% decrease in relative car use
	0.9% increase in work in same town as residence
	0.7% increase in travel less than 8 km to work
	0.1% decrease in travel greater than 24 km to work
	3.9-km decrease in monthly distance travelled to work
	699-kg decrease in per capita annual volume of waste
	2.5-kg decrease in per capita CO_2
	1.6% increase in quality of life satisfaction
Extensive change scenario	*Significant change scenario plus:*
	29.5-kg decrease in per capita CO_2
	0.1-tonne decrease in per capita of CO_2 from transport
	1.3% decrease in relative car use
	2.5% increase in public transport use
	0.02-km/min increase in speed of traffic flow

Table 4.8. Quantitative change scenarios sustainability outputs for Templemore

Scenario	Quantified sustainability outputs SEMPRe
Primary change scenario	3.0-mg/L decrease in NO_3 in drinking water
	66% increase in general level of wastewater treatment
	1.6% increase in regular recycling
	375-kg decrease in per capita annual volume of waste
	0.1-tonne decrease in per capita CO_2 from transport emissions
	0.01-km/min increase in speed of traffic flow
	19.4-kg decrease in per capita kg CO_2
Significant change scenario	*Primary change scenario plus:*
	5.3-kg decrease in per capita kg CO_2
	0.1-tonne decrease in per capita CO_2 from transport emissions
	1.7% decrease in relative car use
	439-kg decrease in per capita annual volume of waste
Extensive change scenario	*Significant change scenario plus:*
	0.2-tonne decrease in per capita CO_2 from transport emissions
	4.7% decrease in relative car use
	25.8-kg decrease in per capita CO_2
	95.7-km decrease in monthly distance travelled to work

Table 4.9. Quantitative change scenarios sustainability outputs for Ballymahon

Scenario	Quantified sustainability outputs SEMPRe
Primary change scenario	1.5 % increase in regular recycling
	50.3-kg reduction in annual volume of waste
	345-kg reduction in CO_2 emissions
	67 % increase in wastewater treatment
	0.02-km/min increase in traffic flow
	1.5 mg/L reduction in NO_3 in water courses
Significant change scenario	*Primary change scenario plus:*
	31-kg decrease in CO_2 emissions
	1.8 % decrease in relative car use
	314-kg reduction in per capita annual volume of waste
Extensive change scenario	*Significant change scenario plus:*
	23.6-kg decrease in CO_2 emissions
	107-kg reduction in per capita annual volume of waste

5 Trial of QESSP in Cork County Council

The issue of monitoring and evaluation of sustainability is timely in Ireland, against a backdrop of increased emphasis on evidence-based planning and changes to legislation. The aim of linking the Cork County Council Development Plan Review with the QESSP trial project was to develop a workable, robust and transparent urban sustainability appraisal method. The trial involved testing the usefulness of the methods in a real-life working environment to allow further validation and improved calibration of the methods within the Irish context. The trial identified an indicator set that satisfied the Department of Environment, Community and Local Government requirement that the indicators were generally applicable within Irish local authorities. Indicators were designed to both expedite, and provide a clear evidence base for, adoption and review of policies. The SEMPRe framework was revised to account for the new indicator suite. Outputs were used for incorporating environmental and sustainability considerations within development plans, leading to a more standardised approach to the evaluation of likely significant effects of plans and programmes.

The development plan is a document detailing the overall strategy for the proper planning and sustainable development of an area. The Planning and Development Acts 2000 and 2010 (www.environ.ie/planning/legislation/planning-acts) define the mandatory objectives that should be included in the development plan, including objectives for the sustainable development of an area. Amendments to the Planning and Development Act in 2010 introduced a statutory requirement for development plans to contain a core strategy. This requires local authorities to provide, among other things, details of the quantum and distribution of population in accordance with the provisions of the RPGs. The purpose of the core strategy is to show that the general distribution of population and new development proposed in the development plan is consistent with the NSS and relevant RPGs, taking into consideration statutory obligations of planning authorities under the Habitats Directive Assessment and Flood Risk Assessment. In preparing proposals for a draft core strategy, planning authorities must give consideration to any significant environmental effects arising from the implementation of the core strategy as part of the new development plan. It is the aim of the trial project to provide evidence to support the formation of a core strategy including the evaluation of population growth scenarios. It is intended that SEMPRe will provide a methodological basis to assist in the evaluation of the environmental effects of new development plans, providing evidence to align, co-ordinate and distribute resources to the most sustainable settlements.

Since the introduction of the Planning and Development (Strategic Environmental Assessment) Regulations 2004 (www.epa.ie/monitoringassessment/assessment/sea), planning authorities have been required to carry out a strategic environmental assessment (SEA) in relation to their development plans in order to improve the environmental sustainability of the new plan, raise awareness of environmental issues and compare alternative scenarios. Under the SEA directive, there is an obligation to monitor and assess strengths and weaknesses in the preparation of plans and programmes. The SEA directive is not prescriptive in relation to methods to be adopted, and authorities have adopted different methodologies, some carrying the SEA process themselves, others employing external consultants. In either case, the extent to which the SEA process has been integrated into the development plan decision-making process has been variable. The view is emerging among planning practitioners that, to be effective in influencing the decisions made as part of creating a development plan, authorities need to adopt methodologies that secure the full and rigorous integration of the SEA process with that of creating the development plan. This implies that, to improve the effectiveness of SEA, planning practitioners themselves will need to apply standardised methodologies for SEA at all levels of the plan-making process. Planning authorities must give consideration to any significant environmental effects arising from the implementation of the core strategy as part of the new development plan. The planning authority is required to demonstrate that, in arriving at its preferred core strategy, the environmental effects were considered. The trial of QESSP in Cork County Council aims to provide evidence to show that environmental considerations were taken into account during the formation of the core strategy of the development plans and assisted in the identification of mitigating

measures to help maximise the sustainability of particular strategies. Crucial to this process is the requirement that environmental criteria identified within the SEA Directive are fully reflected in the indicators selected for the SEMPRe analysis.

5.1 Settlement Selection

On 7 January 2013, Cork County Council gave formal notice under section 11 of the Planning and Development Act 2000 of its intention to review the existing development plan and prepare a new plan for its area. Cork County Council was selected to partner the QESSP extension because of the timing of the development plan review and because it was a forward-looking local authority that contained a large variety of different-sized settlements with different functions (26 main towns, each influenced by a diverse spectrum of both environmental sensitivities and development pressures). The Planning Policy Unit at Cork County Council brought to the project significant experience in the collection and analysis of relevant data and in the development and implementation of new planning and environmental methodologies. Cork County Council had won the Irish Planning Institute award for overall planning achievement on three occasions. Although trialled in Cork, the techniques and methodologies developed in the QESSP extension are transferable to other planning authorities.

Trialling of the QESSP project began on 3 September 2012. Initially, an assessment of data availability was conducted and researchers were embedded in the Cork County Council Planning Policy Unit team. A scoping exercise was undertaken by planners to determine the settlements to be analysed. The method is best suited to the analysis of small, medium-sized and large settlements; therefore, for the purpose of sustainability analysis in Cork, the 26 main settlements were selected. These main settlements in Cork collectively accounted for approximately 46% of the population of County Cork and had an important role in securing balanced regional development. Selected settlements were located in four strategic planning areas (SPAs) in County Cork as shown in Figure 5.1.

Selected settlements varied in terms of function, and ranged in population size from 658 persons (Schull) to 17,368 persons (Ballincollig). In terms of distance to Cork City, the furthest settlement was Castletownbere (125 km) and the nearest was Glanmire (7 km). The following 26 main settlements in Cork (Table 5.1) were selected to be analysed as part of the study.

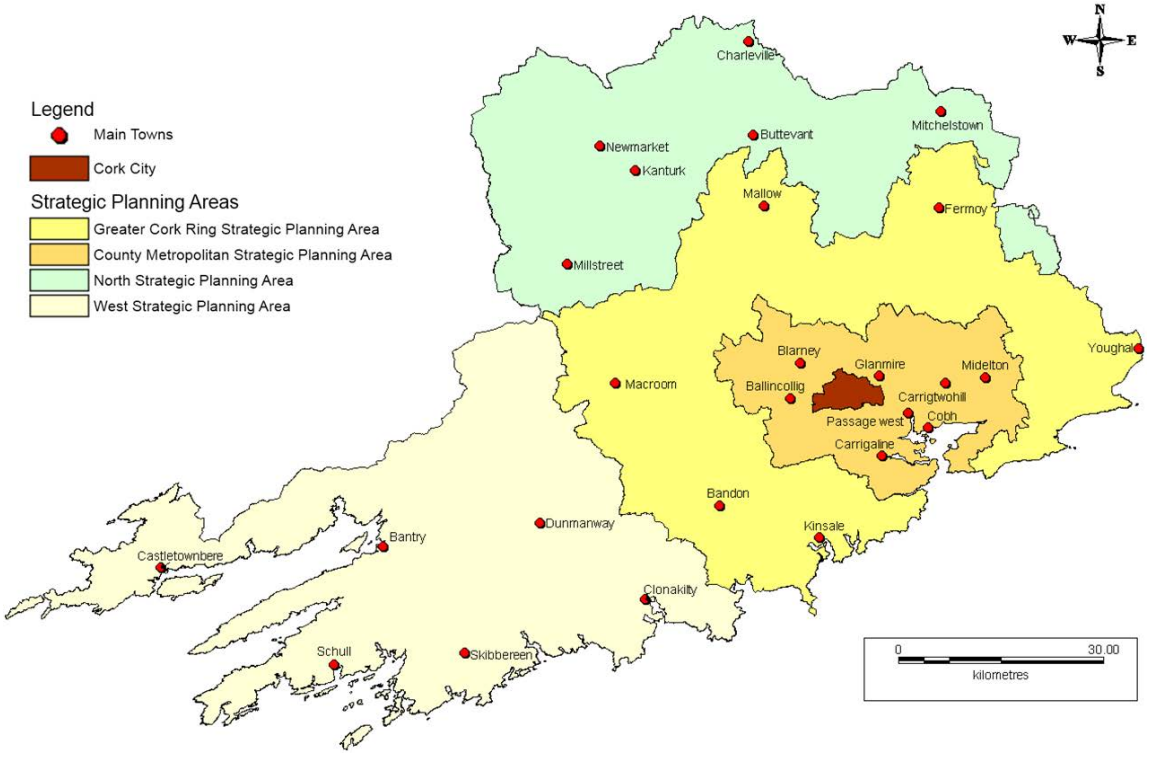


Figure 5.1. Strategic planning areas and main settlements in County Cork.

Table 5.1. Twenty-six main settlements in County Cork

Strategic planning area	Settlements	Population 2011	Distance to Cork City (km)
Metropolitan Cork SPA	Ballincollig	17,368	9
	Blarney	2437	10
	Carrigaline	14,775	13
	Carrigtwohill	4551	16
	Cobh	12,347	23
	Glanmire	8924	7
	Midleton	12,001	23
	Passage West	5709	14
Greater Cork Ring SPA	Bandon	6640	31
	Fermoy	6489	36
	Kinsale	4893	27
	Macroom	3879	41
	Mallow	11,605	34
	Youghal	7794	51
West SPA	Bantry	3348	85
	Castletownbere	912	125
	Clonakilty	4721	52
	Dunmanway	1585	60
	Schull	658	107
	Skibbereen	2670	85
North SPA	Buttevant	945	45
	Charleville	3672	40
	Kanturk	2263	57
	Millstreet	1574	63
	Mitchelstown	3677	50
	Newmarket	988	62

5.2 Sustainable Development Indicators

Analysis commenced with a vision of a sustainable settlement. The sustainability indicators in this study were identified through stakeholder workshops with university researchers, senior planners and policymakers working in a participatory process, selecting indicators that satisfied both the researchers' need for rigour and the practitioners' need for policy relevance. A series of stakeholder workshops identified five broad policy themes in settlement sustainability enhancement: infrastructure and location, water and wastewater, population and urban form, transport and energy, and liveability. These arenas were selected with cognisance of data availability and applicability to Irish settlements. A list of 80 possible sustainable development indicators within these arenas were compiled using 40 indicators from the previous QESSP study, indicators from RPGs, and indicators as suggested by a literature review and the Steering Committee.

It was necessary to develop selection criteria in order to produce a concise set of indicators. Using the following selection criteria, a suitable suite of environmental sustainability indicators was compiled that could be populated using data readily available in local authorities:

- indicators used were relevant and not duplicated;
- both trend and condition (not just snapshots in time) could be measured for each indicator;
- indicators were policy-relevant and complementary to RPGs and development plans;
- indicators covered pertinent aspects of settlement sustainability;
- data were available at a settlement level.

Using these criteria, the potential list of 80 possible indicators was refined to 30. Subsequent meetings with local authority planners resulted in agreement on a more concise set of 25 indicators, which reduced the potential for overlap. In selecting indicators, four main filters were used to ensure that (i) indicators used were

relevant and not duplicated; (ii) both trend and condition (not just snapshots in time) could be measured for each indicator; (iii) indicators were policy-relevant; and (iv) indicators covered pertinent aspects of settlement sustainability.

Application of indicator selection criteria resulted in a diverse suite of 25 sustainable development indicators. A literature review established that there was no universally accepted method for weighting indicators: here, priorities were identified through discussion and agreement with planners. An advantage of SEMPRe is that weightings may be applied according to the needs of the user. A number of alternative weighting scenarios were examined. The scenario deemed most appropriate was weighting of key indicators. A simple and transparent weighting system was developed to facilitate ease of understanding by non-technical personnel and stakeholders. The five key indicators selected were:

- infrastructural capacity for settlement expansion;
- populated area at risk of flooding;
- planned population density;
- number of public transport services per 1000 persons;
- distance to nearest acute hospital.

A weighting of 2 was attributed to key indicators and all other indicators were allocated a weighting of 1. The indicators chosen (Table 5.2) in this study are presented not as a definitive set of settlement sustainability indicators, but rather as a comprehensive set of indicators developed deliberately to provide a holistic view of settlement sustainability in an Irish context, taking into account data availability.

Once indicators were identified, the next stage involved the compilation of a sustainability database. An extensive sustainability database was collated; quantitative data on the economic, social and environmental

Table 5.2. Twenty-five settlement sustainable development indicators

Group	Indicator
Infrastructure and location	Infrastructural capacity for settlement expansion
	Connected to gas distribution network
	Index of recycling facilities
	Proportion of households with broadband
	Presence of farmers markets
Water and wastewater	Water quality of water bodies
	Wastewater treatment spare capacity
	Unaccounted-for water
	Populated area at risk of flooding
	Urban wastewater treatment status
Population and urban form	Planned population density
	Proportion of population unemployed
	Proportion of population with tertiary education
	Housing vacancy rate
	Distance to nearest large retail centre
Transport and energy	Average transport CO_2
	Settlement walkability
	Number of public transport services/1000 persons
	Average household heating CO_2
	Proportion of population travelling to work by private car
Liveability	Distance to nearest acute hospital
	Tidy Towns points score
	Special Areas of Conservation, Special Protection Areas or Natural Heritage Areas within 5 km of settlement
	Distance to nearest park, nature reserve or wildlife park
	Presence of 24-hour Garda station

attributes of the 26 study settlements in Cork were assembled into a 1100-piece database. Researchers, in collaboration with Cork County Council, identified, collated and evaluated relevant environmental data using internal sources within Cork County Council, e.g. water services, environmental department and external data sources (e.g. Bord Gáis, EPA, Coillte, etc.). SEMPRe was restructured to accommodate the new indicators, and a unique interface was created for each of the 26 main settlements in Cork. A new database was populated for 25 SDIs in each of the 26 study settlements.

One of two normalising equations was then applied to the baseline data to produce a transformed score. Normalisation is a powerful technique that permits comparison and aggregation of indicator data allowing for the identification of relative strengths or weaknesses within settlements. The transformed scores for each of the 25 indicators in each settlement were aggregated in order to provide an overall sustainability score out of a maximum of 100, enabling settlements to be ranked in terms of relative sustainability. Table 5.3 shows the ranking of settlements in Cork according to their SDI scores.

These sustainability rankings give us new insights into settlement sustainability. Overall SDI scores range from 35 to 63; while no settlement had an exceptionally low or high SDI score, considerable differences were identified. In addition, analysis enabled the creation of a benchmark against which the rate of progress towards European, national, regional and local sustainability targets could be measured over time. This allowed settlements to be categorised according to their sustainability and for the evaluation of future population growth scenarios.

Inputting settlement sustainability results into ArcGIS software (ArcGIS: www.esri.com/software/arcgis) allows the development of a thematic map of settlement sustainability. ArcGIS allows settlement SDI results to be divided into a number of separate classes based on natural groupings inherent in the data. Divisions of values based on natural breaks, as in the Jenks classification system, will identify the class breaks that best group similar values. Jenks may be employed to divide SDI results into any number of sustainability categories. For the purpose of this study, in order to keep analysis as succinct as possible, three categories were developed as follows: category 1 settlements have the highest SDI results, category 2 have intermediate SDI results and category 3 have the lowest SDI results. Figure 5.2 displays a thematic map of settlement SDI scores divided into the three categories.

Table 5.3. Weighted settlement sustainability ranking

Settlement	SDI score	Population size (2011)
Ballincollig	62.8	17,368
Blarney	61.5	2437
Carrigaline	57.2	14,775
Carrigtwohill	56.8	4551
Midleton	54.9	12,001
Cobh	54.8	12,347
Bandon	54.5	6640
Mallow	53.6	11,605
Glanmire	53.5	8924
Bantry	53.1	3348
Clonakilty	50.3	4721
Kinsale	50.3	4893
Fermoy	49.6	6489
Passage West	48.6	5709
Macroom	46.7	3879
Buttevant	46.1	945
Schull	43.8	658
Mitchelstown	42.8	3677
Charleville	41.1	3646
Newmarket	41.0	988
Skibbereen	39.2	2670
Youghal	38.2	7794
Dunmanway	37.8	1585
Castletownbere	37.7	912
Millstreet	36.7	1574
Kanturk	35.3	2263

5.2.1 Category 1 settlements: highest sustainable development index results

Category 1 settlements range in population size from Blarney (2437 persons) to Ballincollig (17,368 persons). The average SDI of category 1 settlements was 56.3. In general, category 1 settlements are relatively large in terms of population size (with an average population size of 9400 persons) and are located in relatively close proximity to Cork City. Category 1 settlements benefit from economies of scale in terms of infrastructure and services. All settlements in the County Metropolitan SPA are category 1 settlements, with the exception of Passage West. Category 1 settlements outside the

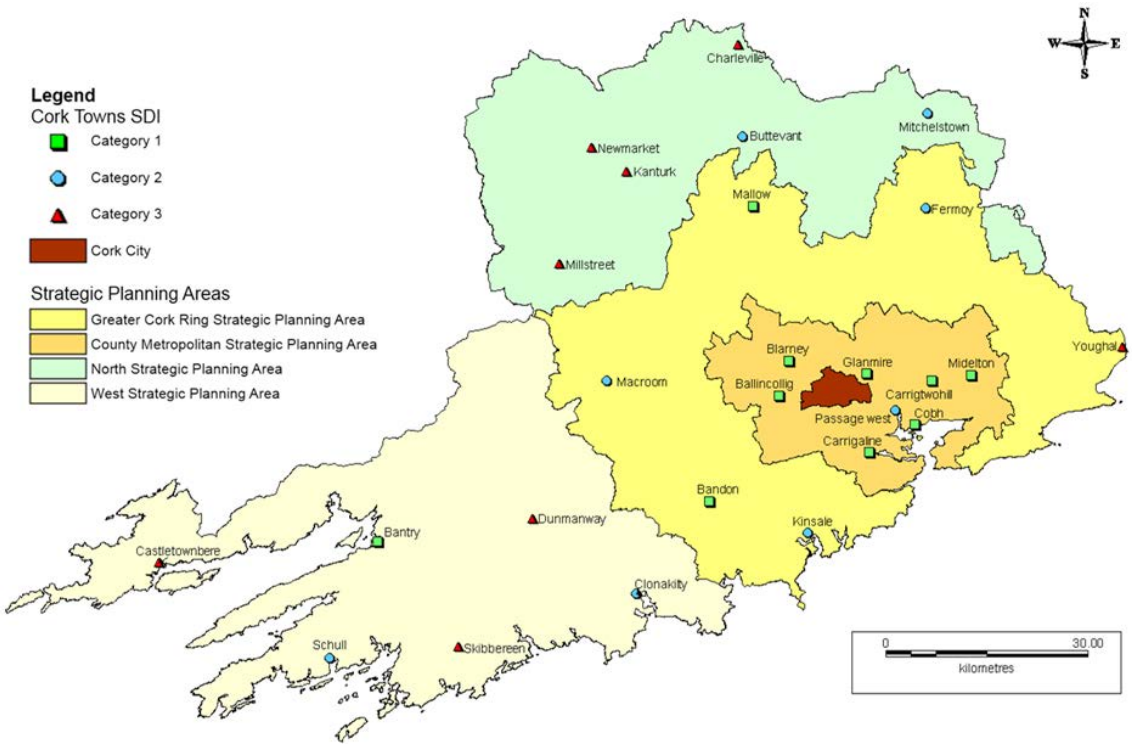


Figure 5.2. Thematic map of overall settlement sustainable development indices.

County Metropolitan SPA are Mallow, Bandon and Bantry.

5.2.2 Category 2 settlements: intermediate sustainable development index results

Category 2 settlements have intermediate levels of sustainability (with an average SDI of 47.3) and range in population size from Schull (658 persons) to Fermoy (6489 persons). In general, category 2 settlements have smaller population sizes (with an average population size of 3871 persons) and are more peripheral relative to Cork City than category 1 settlements. Certain category 2 settlements such as Schull and Buttevant have population sizes of fewer than 1000 persons and peripheral locations, yet fall into the intermediate sustainability category. Passage West is the only category 2 settlement in the County Metropolitan SPA.

5.2.3 Category 3 settlements: lowest sustainable development index results

Category 3 settlements are the least sustainable (with an average SDI of 38.4) and range in population size from Castletownbere (912 persons) to Youghal (7794 persons), with an average of 2682 persons. In general, category 3 settlements are smaller settlements sited in more peripheral locations relative to Cork City, and are mainly located in the North and West SPAs.

Given the broad view taken on sustainability in choosing SDI, settlements may be relatively more or less sustainable for a number of reasons. It can be observed in Cork that, in general, larger settlements are more sustainable and, as distance to Cork City decreases, settlement sustainability increases. Detailed analysis of settlement attributes reveals further insights into settlement sustainability and into which attributes of settlements impede or inhibit progress towards sustainability. Sustainability kite diagrams were used to communicate visually a settlement's performance in each of the themes. The total area enclosed by the blue line represents the sustainability of the settlement. The following paragraphs describe a detailed study of settlement sustainability; results for the most sustainable settlement, Ballincollig (Figure 5.3), and the least sustainable settlement, Kanturk (Figure 5.4), are shown.

Ballincollig was the largest of the 26 study settlements, with a population of 17,368 persons. An SDI of 62.8 (Figure 5.3) was recorded for Ballincollig, which was the highest of the 26 study settlements. Population and urban form was the highest-scoring index, as Ballincollig had a relatively high population density, a high proportion of population with tertiary education

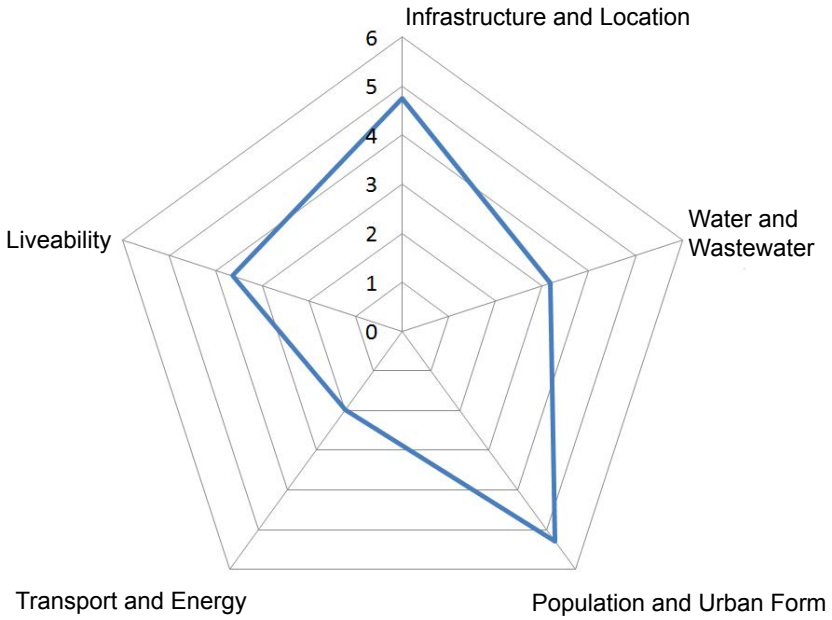


Figure 5.3. Sustainability kite diagram for Ballincollig.

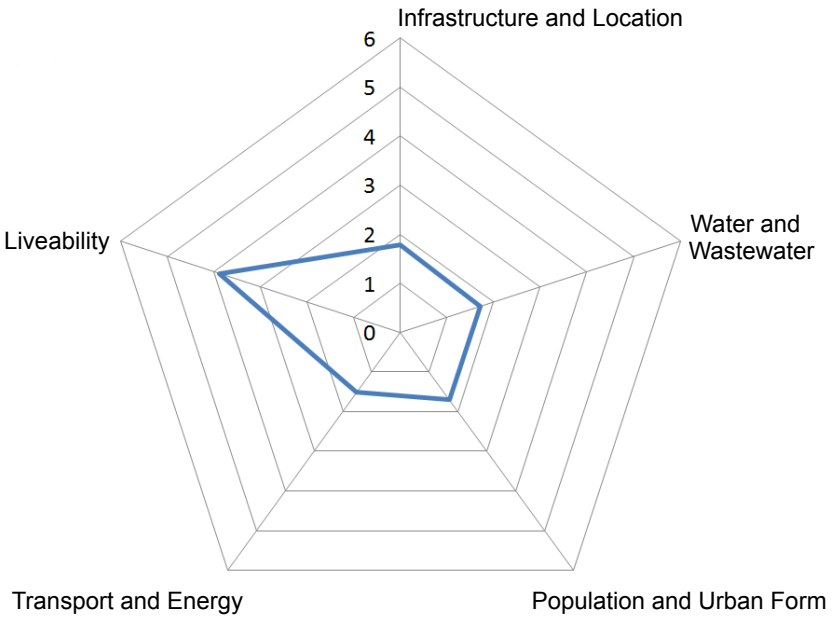


Figure 5.4. Sustainability kite diagram for Kanturk.

and relatively low unemployment levels. Infrastructure and location was the second highest-scoring index. Ballincollig benefited from a location close to an acute hospital, a regional park and a large retail centre; however, Ballincollig did not have a civic amenity site or a 24-hour Garda station. Transport and energy was the lowest-scoring index, as private car use was relatively high.

Figure 5.4 shows a kite diagram for sustainability indices in Kanturk. Kanturk (population 2263) is in the least sustainable settlement category, with an SDI of 35.3. Liveability was the highest-scoring index in Kanturk thanks to the presence of a 24-hour Garda station, a relatively high Tidy Towns points score and relatively close proximity to an acute hospital and a park. The lowest-scoring index was water and wastewater, as the wastewater treatment plant failed the urban wastewater treatment standards in 2011, unaccounted-for water was relatively high and there was a relatively large area at risk of flooding. Kanturk was located a substantial distance from the nearest large retail centre, was not

connected to the national gas distribution network and had relatively low infrastructural capacity for settlement expansion. The population density in Kanturk was relatively low, and employment levels and the proportion of population with tertiary education were low. Private car use was relatively high and public transport provision was relatively low.

5.3 Discussion of Results

Different settlements have different characteristics and differing weak and strong attributes of sustainability. In general, larger settlements recorded higher sustainability scores than smaller settlements. Sound interpretation of the results presented here should lead to prioritisation of actions that may increase settlement sustainability. To provide information on trends, this research will need to be replicated in future.

Settlements in the County Metropolitan SPA recorded the highest sustainability scores, with an average score of 56.2. On average, the County Metropolitan towns were the largest in the study sample, with an average population of 9764 persons, and were the closest settlements to Cork City. Ballincollig recorded the highest sustainability score, thanks to its relatively large population size, proximity to Cork City and well-developed amenity areas and employment opportunities. Blarney was the second highest-scoring settlement – it benefits from a location close to Cork City, a relatively compact urban form, well-developed infrastructure and amenity areas, and good water quality. Other Metropolitan towns that recorded relatively high scores included Carrigaline, Carrigtwohill, Midleton and Cobh.

The average sustainability score for Greater Cork Ring SPA Area settlements was 48.8, which is lower than the County Metropolitan SPA but higher than the North or West SPAs. Greater Cork Ring settlements are relatively large, with an average population size of 6883 persons. The most sustainable Greater Cork Ring settlement was Bandon, with an SDI of 54.5. Bandon has well-developed services and infrastructural capacity for settlement expansion. Mallow was the second highest-scoring settlement in the Greater Cork Ring; this fits with Mallow's relatively large population size and designation as a Hub town in the NSS, Hub being identified in the NSS as well suited to growth through economic and social development and likely to foster regional growth. Mallow has well-developed services and the capacity to accommodate additional population. Kinsale, Fermoy and Macroom recorded intermediate sustainability scores, while Youghal recorded a relatively low score and is in the least sustainable category. A lack of secondary wastewater treatment, high private car use, low infrastructural capacity for expansion, and a relatively isolated location contributed to the low scores observed for Youghal. Private car use was relatively high; all Greater Cork Ring settlements recorded relatively low scores for transport and energy.

The average sustainability score in the West SPA was 43.7. In general, settlements in the West SPA were relatively small, with an average population of 2316 persons and were located a relatively long distance from Cork City. Bantry was the most sustainable settlement, with a score of 53.1. The presence of an acute hospital, a 24-hour Garda station and good water quality contributed to the high calculated score for Bantry. Clonakilty was the second highest in terms of sustainability. Clonakilty has well-developed services, amenity areas and employment opportunities. Schull recorded a score of 43.8, which places Schull in the intermediate sustainability category even though Schull was the smallest settlement in the sample with a population size of 658 persons. Private car use in Schull was relatively low. Skibbereen, Dunmanway and Castletownbere were all in the lowest sustainability category. Their isolated location and relatively low scores for water and wastewater contributed to their low overall scores.

The lowest average scores were calculated for the North SPA, with an average sustainability score of 40.5. On average, the North SPA settlements were the smallest in the study sample, with an average population of 2187 persons, and were located a relatively large distance from Cork City. Buttevant was the most sustainable because of its location on the N20 between Cork and Limerick and relatively close to an acute hospital, with a high calculated score for water and wastewater. Mitchelstown was the second highest-ranking settlement, which performed above average for water and wastewater. Charleville and Newmarket recorded similar scores but were in the least sustainable settlement category. Kanturk and Millstreet had the lowest scores in the sample.

5.4 Policy and Scenario Modelling

The analysis presented here assists with the identification of more or less sustainable settlement attributes, which informs our understanding of settlement

sustainability. Following settlement sustainability analysis, policies were tested in each of the 26 study settlements. A total of 30 policies could be modelled in the units of the indicators. It appears that, because of the inherent differences between settlements, there are no universal policies that will be applicable in all settlements, and a tailored approach to sustainability enhancement is required. Table 5.4 contains the 10 highest-ranking policies according to their feasibility scores for Ballincollig. The highest-scoring policies for Ballincollig are transport and energy policies. Transport and energy is the lowest-scoring index in Ballincollig; therefore, the greatest room for improvement may be in this area.

Table 5.5 contains the 10 highest-ranking policies according to their feasibility scores for Castletownbere. The highest-ranking policies relate to energy and infrastructure. The analysis suggests that these areas may afford relatively large sustainability improvements in Castletownbere.

5.5 Evaluation of Alternative Population Scenarios

In addition to ranking and categorising settlements in terms of sustainability, the method enables quantification of the environmental effects of proposed scenarios. An important part of the SEA of the county development plan involves evaluation of the likely environmental effects of different scenarios in terms of proposals for the distribution of future populations. When evaluating scenarios, it was assumed that infrastructure and service provision increased on a pro rata basis in line with population growth. Scenarios were proposed by the Cork County Council SEA team and are realistic and capable of implementation within statutory and operational requirements of the county development plan. Three scenarios were evaluated as follows:

- Scenario 1 consolidates growth in the Wider Metropolitan Area, the Greater Cork Ring SPA, the North and West SPA, and concentrates growth

Table 5.4. Ten highest-ranking policies in terms of SEMPRe score for Ballincollig

Policy no.	Policy	Improvement in per capita sustainability (%)	Feasibility (%)
3	National road pricing scheme	4.5	67.5
7	Bicycle sharing scheme	3.1	67.5
6	Urban distribution centres	0.8	60
19	Farmers markets	0.3	60
1	Driver training in economical driving techniques	0.8	60
32	Mandatory home energy audits	0.9	60
35	Radiation barriers to reduce heat losses from buildings	0.4	60
12	Payment for cycling to work	1.0	57.5
23	Higher urban density	5.5	57.5
5	Low rolling resistance tyres	0.2	55

Table 5.5. Ten highest-ranking policies in terms of SEMPRe score for Castletownbere

Policy no.	Policy	Improvement in per capita sustainability (%)	Feasibility (%)
32	Mandatory home energy audits	4.9	100
21	Passively heated buildings	6.6	90
27	Use of energy crops as home heating fuel	7.3	82.5
29	Smart electricity meters	3.3	72.5
33	Solar water heating	3.3	72.5
35	Radiation barriers to reduce heat losses from buildings	1.1	70
3	National road pricing scheme	4.6	67.5
25	Green roofs	2.6	62.5
1	Driver training in economical driving techniques	0.5	60
5	Low rolling resistance tyres	0.1	55

along an east–west axis between Midleton, Cork City (Kent Station) and Ballincollig and along other public transport corridors.

- Scenario 2 is an alternative employment-led growth scenario, which focuses a higher level of growth in a number of key settlements where employment-led growth can be delivered.
- Scenario 3 focuses on public investment primarily in water and wastewater infrastructure within the main settlements, therefore providing a more efficient provision of infrastructure.

The population targets for each proposed scenario were input into SEMPRe to determine the effects on overall settlement sustainability. Figure 5.5 illustrates the proportion of population residing in each of three categories of settlement in 2011 and the projected proportion of population in 2022 according to the proposed scenario population targets when analysed using SEMPRe.

It can be seen that all three scenarios result in a more sustainable population distribution pattern than the 2011 baseline. In 2011, the proportion of the population residing in the most sustainable (category 1) settlements was 64.2%, the intermediate (category 2) settlements accounted for 21.2% and the least sustainable (category 3) settlements accounted for 14.6% of the population of the main towns. The results show that almost two-thirds of the population of the main settlements in Cork in 2011 resided in the most sustainable category of settlement as measured by SEMPRe.

In scenario 1 the proportion of the population residing in the most sustainable (category 1) settlements was predicted to rise by 2.3% compared with 2011 levels. The proportion in category 2 was predicted to decrease by 1.4% compared with 2011 levels and the proportion residing in category 3 settlements was predicted to decrease by 0.9% compared with the 2011 baseline. Compared with the baseline, the transport scenario was found to distribute a greater proportion of the population to the most sustainable settlement category when evaluated using SEMPRe.

Scenario 2 showed an increase of 3.8% in the proportion of population allocated to the most sustainable category of settlements compared with the 2011 baseline. The proportion in category 2 settlements was predicted to decrease by 1.5% compared with 2011 levels and the proportion residing in category 3 settlements was predicted to decrease by 2.3% compared with the 2011 baseline. SEMPRe analysis shows that scenario 2 impacts more positively on settlement sustainability than scenario 1.

Scenario 3 showed an increase of 4.1% in the proportion of population allocated to the most sustainable category of settlements when compared with the 2011 baseline. The proportion in category 2 settlements was predicted to decrease by 2.1% compared with 2011 levels and

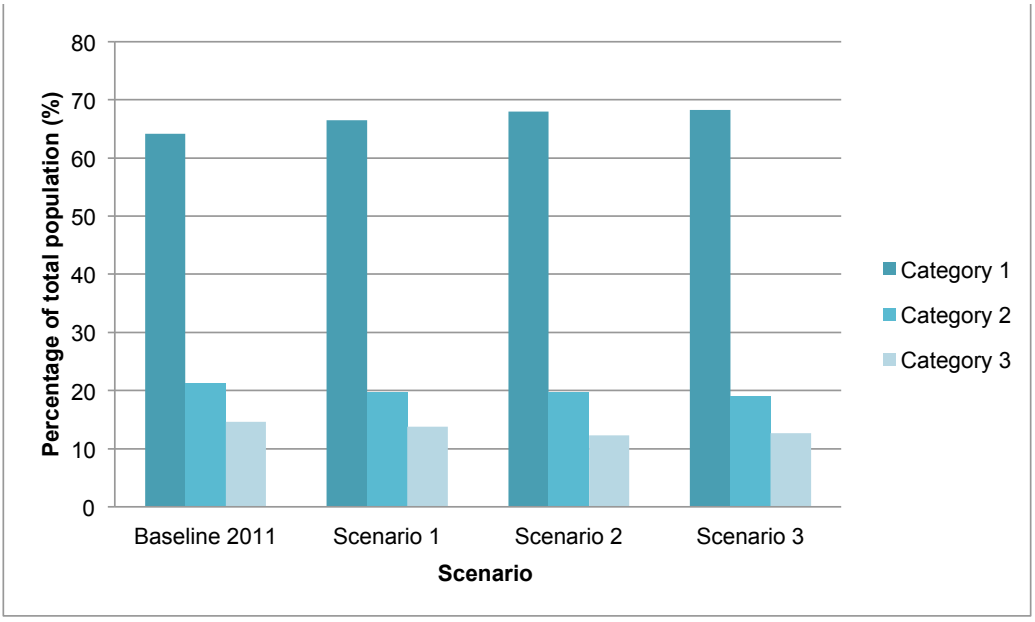


Figure 5.5. Proportion of population in each settlement category, 2011 and 2022 (projected) for three scenarios.

the proportion residing in category 3 settlements was predicted to decrease by 2.0% compared with the 2011 baseline.

From this analysis, it appears that all three scenarios impact positively on overall sustainability, with scenario 3 resulting in the greatest improvement in sustainability. In scenario 3, the number of persons residing in the most sustainable (category 1) settlements is predicted to rise by 45,408 from 64% of the total population in 2011 to 68% of the total projected population in 2022 (Figure 5.6). Conversely, the proportion of the population in the less sustainable category 2 and 3 settlements is predicted to decrease. Category 2 settlements are predicted to grow by 7967 persons but their share of total population is predicted to decrease from 21% in 2011 to 19% in 2022. The total population residing in category 3 settlements is projected to rise by 4403 persons under the proposed plan; however, the proportion of total population residing in category 3 settlements is predicted to decrease from 15% in 2011 to 13% in 2022.

This demonstrates that the projected growth targets contained in the county development plan allocate approximately 79% of future population growth to the most sustainable (category 1) settlements, 14% to category 2 settlements and 7% to the least sustainable category 3 settlements. From this analysis, it appears that the general direction of the proposed development plan is towards accommodating future population growth in the most sustainable settlements as measured by SEMPRe.

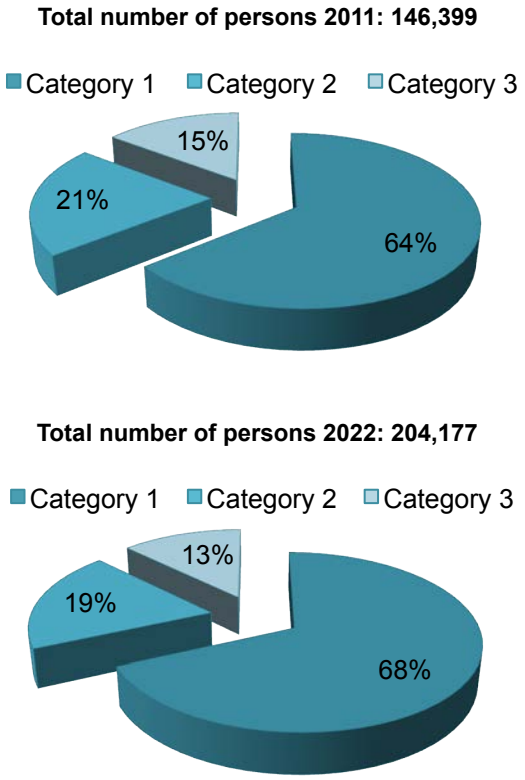


Figure 5.6. Number of persons in each settlement category, 2011 and 2022 (projected).

6 Discussion and Conclusions

Planning policies are largely focused on economic development, and it is argued here that more attention should be paid to developing urban resilience in relation to, for example, the effects of climate change. Future availability of fossil fuels is uncertain and there is a need for energy use in the transport and household sectors to become less intensive. The prospects for global climate stability will depend largely on whether or not a transition to more sustainable patterns of energy consumption can be implemented in the near future.

This research was developed in the context of the current Irish economic and social conditions, in which there has been little history of planning for sustainability, so it may not be applicable in countries with more advanced planning methods, a longer history of engagement in planning for sustainability, and larger available budgets for more expensive policies.

QESSP tackles the knowledge gap that, to date, has meant that methods were not available to quantify the impact of policies in order that policy planners could compare different policy measures, to ensure that the most effective policy is implemented, and to assess how individual policies combine to contribute to overall targets. A method was developed that was both scientifically rigorous and capable of immediate use within the planning departments of local authorities.

This research has attempted to make Irish policymaking for sustainability a more transparent and systematic process, and to assist governments in identifying the most feasible settlement sustainability policies to meet national and international environmental targets, providing planners with a stronger evidence base for policy prioritisation.

QESSP adds to our knowledge of the extent to which Irish settlements are sustainable. A key contribution of this research is that the methods developed here may be applied in other contexts and provide a framework for decision makers, with a detailed knowledge of the local area, to construct strategic sustainability strategies. The method can take snapshots of sustainability at different times to monitor progress towards greater sustainable development.

6.1 Policy Relevance of Research

An initial goal of QESSP was to “tame the few” least sustainable settlements, and subsequently bring all settlements up to a standard equivalent to or above the standard of the current most sustainable settlements nationally. This approach restricts the opportunities for those against policy change to argue that it is too risky to be the “first jumper”, or that simply it is impractical to implement such a policy.

Policy analysis here shows that a “one size fits all” approach will not be efficient in enhancing urban sustainability. All policies developed here are based on extensive data collection and all conclusions are evidence based. No one policy has a large sustainability impact, and therefore bundling of policies into change scenarios was necessary to significantly enhance settlement sustainability.

In general, settlements with higher populations achieved greater sustainability scores, indicating the current relative unsustainability of small isolated settlements. This suggests that greater sustainability increases can accrue through targeted investment in more sustainable medium-sized and large settlements. This is possibly because of economies of scale in larger settlements, for example in public transport, waste and water infrastructure. It is clear that smaller and more isolated settlements will require customised policy bundles to bring their sustainability to acceptable levels.

Multiple change scenarios are presented in this research, each representing a policy intervention scenario ranging from conservative to innovatory. The more innovatory the scenario, the more policies it contains, and the greater the cost and timescale associated with its implementation. Change scenarios progressively build upon one another in a scaled approach. Change scenarios identified a mix of local- and national-level policies, indicating that, in order to successfully enhance settlement sustainability, a “bottom up” approach should be combined with a “top down” approach. The scenarios developed during this research, as far as practicable, harness possible synergies and mitigate conflicting policy effects.

6.2 Methods

The methods have been chosen based on their ability to provide a tangible means of examining what sustainable development means in practice and to provide a comprehensive overview of sustainability. Research reported here provides a possible method for standardisation of sustainable settlement policy evaluation in an Irish context.

The SEMPRe and feasibility testing methods have been published in international journals (Fitzgerald *et al*., 2012; O'Doherty *et al*., 2013). The methods provide a mechanism for productively exploiting published evaluations of policy implementation, which are currently scattered through the literature, providing improved evaluation of policy targets and potential champions. Research findings have been presented at national and international research conferences, and have received positive responses.

A precise methodological approach was adopted and methods developed, such as SEMPRe, indicator weightings, feasibility testing and change scenario calculations. Methods to address double counting are based on a stated theoretical underpinning, and not presented as unproblematic, so that future refinements are expected.

Data availability restricts the selection of certain indicators, as sustainability data tend to be more complete at larger spatial scales, but can be difficult to source at smaller spatial scales. Given the growing interest in sustainable development, data availability may be expected to improve in future.

It is recognised that the changes in SDI scores predicted here may not be significant in the longer term. To reduce risks associated with climate change, it is expected that the method will undergo development as policy targets evolve.

While, for an increasing number of policies, implementation has occurred and quantitative assessment of impacts has been published, for many other candidate policies, no assessments have been published. As further studies are published, the range of policies that can be tested will increase, as will the rigour of analyses. Sound interpretation of the results presented here leads to prioritisation of actions that may be expected to increase settlement sustainability.

QESSP is of relevance to Ireland in the context of (i) meeting international environmental legal obligations (for example the Kyoto protocol, the Water Framework Directive and the Effort Sharing Decision) and (ii) the need to enhance transparency in policymaking.

6.3 Dissemination and Future Work

The trial of QESSP tested the usefulness of the methods in a real-life working environment. Through working closely with a local authority, QESSP was developed further into a transparent, indicator-based package for assessing plans and programmes and informing planning for future population growth. Workshops were also held with senior planners from Limerick Local Authority, Tipperary Local Authority, Clare Local Authority and Kerry Local Authority. At a regional level, invited presentations were given to the South-West and Border Regional Authorities.

It is recognised that an important part of sustainable development is that it is dynamic in nature and requires rolling innovation over longer timescales for successful implementation. A strength of this research is that the initiatives described here aim to provide a foundation on which further sustainability increases can be built beyond the timeline of the project.

These results represent an important first step for Ireland on the ladder to more sustainable urban development. The results provide a better evaluation of what and who should be targeted in terms of policy development, providing a means whereby policymakers may select policies with greater certainty of the likely outcome.

This research may be expected to improve environmental governance and lead to improvement in evidence-based decision-making by examining alternatives and consequences of decisions, generating new knowledge and reframing policy problems.

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Abbreviations

EIA	Environmental Impact Assessment
EU	European Union
GHG	Greenhouse gas
NSS	National Spatial Strategy
QESSP	Quantitative Evaluation of Settlement Sustainability Policy
RPG	Regional Planning Guidelines
SDI	Sustainable development index
SEA	Strategic Environmental Assessment
SEMPRe	Sustainability Evaluation Metric for Policy Recommendation
SFSPI	Sustainability and Future Settlement Patterns in Ireland
SIA	Sustainability Impact Assessment
SPA	Strategic Planning Area

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL

Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:

- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha);*
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
  - Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Thascairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol (*m.sh. Timpeall an Tí, léarscáileanna radóin).*
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- An Oifig um Cosaint Raideolaíoch
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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Quantitative Evaluation of Settlement Sustainability Policy

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There is now clear recognition that in future, urban communities (both Local Authorities and voluntary) must play a more active role in promoting sustainable development so as to meet national and EU environmental targets, especially in relation to greenhouse gas emissions. Governments must provide leadership, but communities have crucial knowledge on land areas in which new policies may be implemented. This report explains a method and decision support tool designed to aid Local Authorities and communities in prioritising policies which benefit the environment and are appropriate for their circumstances.

Identifying pressures

79 urban communities studied were found to have relatively low Sustainable Development Index values, with smaller settlements (population <1000) showing lowest values. Dublin was excluded from the study.

Informing policy

Communities require guidance on both the potential and appropriate policies to enhance their sustainability. Policy makers need to be reassured that implementation of appropriate policies is likely to have the intended outcomes. Some policies are more easily implemented in the short term and with limited cost, but others often with greater impact take longer and are more expensive. Communities differ in population, location and economic base: prioritising policies must take account of both community attributes and available resources.

Developing solutions

This research developed a decision support tool to enhance community sustainability which is both academically robust (all predicted policy impacts are supported by published studies) and accessible for planners and policy makers in voluntary communities. The tool is structured around a set of indicators which may be altered to suit local circumstances. The tool calculates the likely impact of introducing a new policy, taking rebound effects into account, and identifies policies required to meet set targets. The tool was trialled over six months with Cork County Council planners and adopted in the preparation of a new County Development Plan. The tool was found to be user friendly and valuable in providing evidence for more sustainable policy decisions. It is freely available to all communities and can be downloaded at goo.gl/MtMnKz

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