National Development Plan 2007 - 2013

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

STRIVE
Report Series 1

Island Limits – A Material Flow Analysis and Ecological Footprint Analysis of Ireland

STRIVE

Environmental Protection Agency Programme

2007-2013

SSTI Strategy for Science, Technology and Innovation

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

Environmental Protection Agency

The Environmental Protection Agency (EPA) is a statutory body responsible for protecting the environment in Ireland. We regulate and police activities that might otherwise cause pollution. We ensure there is solid information on environmental trends so that necessary actions are taken. Our priorities are protecting the Irish environment and ensuring that development is sustainable.

The EPA is an independent public body established in July 1993 under the Environmental Protection Agency Act, 1992. Its sponsor in Government is the Department of the Environment, Heritage and Local Government.

OUR RESPONSIBILITIES

LICENSING

We license the following to ensure that their emissions do not endanger human health or harm the environment:

- waste facilities (e.g., landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g., pharmaceutical manufacturing, cement manufacturing, power plants);
- intensive agriculture;
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- large petrol storage facilities.

NATIONAL ENVIRONMENTAL ENFORCEMENT

- Conducting over 2,000 audits and inspections of EPA licensed facilities every year.
- Overseeing local authorities' environmental protection responsibilities in the areas of - air, noise, waste, waste-water and water quality.
- Working with local authorities and the Gardaí to stamp out illegal waste activity by co-ordinating a national enforcement network, targeting offenders, conducting investigations and overseeing remediation.
- Prosecuting those who flout environmental law and damage the environment as a result of their actions.

MONITORING, ANALYSING AND REPORTING ON THE ENVIRONMENT

- Monitoring air quality and the quality of rivers, lakes, tidal waters and ground waters; measuring water levels and river flows.
- Independent reporting to inform decision making by national and local government.

REGULATING IRELAND'S GREENHOUSE GAS EMISSIONS

- Quantifying Ireland's emissions of greenhouse gases in the context of our Kyoto commitments.
- Implementing the Emissions Trading Directive, involving over 100 companies who are major generators of carbon dioxide in Ireland.

ENVIRONMENTAL RESEARCH AND DEVELOPMENT

- Co-ordinating research on environmental issues (including air and water quality, climate change, biodiversity, environmental technologies).

STRATEGIC ENVIRONMENTAL ASSESSMENT

- Assessing the impact of plans and programmes on the Irish environment (such as waste management and development plans).

ENVIRONMENTAL PLANNING, EDUCATION AND GUIDANCE

- Providing guidance to the public and to industry on various environmental topics (including licence applications, waste prevention and environmental regulations).
- Generating greater environmental awareness (through environmental television programmes and primary and secondary schools' resource packs).

PROACTIVE WASTE MANAGEMENT

- Promoting waste prevention and minimisation projects through the co-ordination of the National Waste Prevention Programme, including input into the implementation of Producer Responsibility Initiatives.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

MANAGEMENT AND STRUCTURE OF THE EPA

The organisation is managed by a full time Board, consisting of a Director General and four Directors.

The work of the EPA is carried out across four offices:

- Office of Climate, Licensing and Resource Use
- Office of Environmental Enforcement
- Office of Environmental Assessment
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet several times a year to discuss issues of concern and offer advice to the Board.

An Ghníomhaireacht um Chaomhnú Comhshaoil

Is í an Gníomhaireacht um Chaomhnú Comhshaoil (EPA) comhlachta reachtúil a chosnaíonn an comhshaol do mhuintir na tíre go léir. Rialaímid agus déanaimid maoirsiú ar ghníomhaíochtaí a d'fhéadfadh truailliú a chruthú murach sin. Cinntímid go bhfuil eolas cruinn ann ar threochtaí comhshaoil ionas go nglactar aon chéim is gá. Is iad na príomh-nithe a bhfuilimid gníomhach leo ná comhshaol na hÉireann a chosaint agus cinntiú go bhfuil forbairt inbhuanaithe.

Is comhlacht poiblí neamhspleách í an Ghníomhaireacht um Chaomhnú Comhshaoil (EPA) a bunaíodh i mí Iúil 1993 faoin Acht fán nGníomhaireacht um Chaomhnú Comhshaoil 1992. Ó thaobh an Rialtais, is í an Roinn Comhshaoil agus Rialtais Áitiúil a dhéanann urraíocht uirthi.

ÁR bhFREAGRACHTAÍ

CEADÚNÚ

Bíonn ceadúnais á n-eisiúint againn i gcomhair na nithe seo a leanas chun a chinntiú nach mbíonn astuithe uathu ag cur sláinte an phobail ná an comhshaol i mbaol:

- áiseanna dramhaíola (m.sh., líonadh talún, loisceoirí, stáisiúin aistrithe dramhaíola);
- gníomhaíochtaí tionsclaíocha ar scála mór (m.sh., déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta);
- diantalmhaíocht;
- úsáid faoi shrian agus scaoileadh smachtaithe Orgánach Géinathraithe (GMO);
- mór-áiseanna stórais peitreail.

FEIDHMIÚ COMHSHAOIL NÁISIÚNTA

- Stiúradh os cionn 2,000 iniúchadh agus cigireacht de áiseanna a fuair ceadúnas ón nGníomhaireacht gach bliain.
- Maoirsiú freagrachtaí cosanta comhshaoil údarás áitiúla thar sé earnáil - aer, fuaim, dramhaíl, dramhuisce agus caighdeán uisce.
- Obair le húdaráis áitiúla agus leis na Gardaí chun stop a chur le gníomhaíocht mhídhleathach dramhaíola trí comhordú a dhéanamh ar líonra forfheidhmithe náisiúnta, díriú isteach ar chiontóirí, stiúradh fiosrúcháin agus maoirsiú leigheas na bhfadhbanna.
- An dlí a chur orthu siúd a bhriseann dlí comhshaoil agus a dhéanann dochar don chomhshaol mar thoradh ar a ngníomhaíochtaí.

MONATÓIREACHT, ANAILÍS AGUS TUAIRISCIÚ AR AN GCOMHSHAOL

- Monatóireacht ar chaighdeán aeir agus caighdeáin aibhneacha, locha, uiscí taoide agus uiscí talaimh; leibhéil agus sruth aibhneacha a thomhas.
- Tuairisciú neamhspleách chun cabhrú le rialtais náisiúnta agus áitiúla cinntí a dhéanamh.

RIALÚ ASTUITHE GÁIS CEAPTHA TEASA NA HÉIREANN

- Cainníochtú astuithe gáis ceaptha teasa na hÉireann i gcomhthéacs ár dtiomantas Kyoto.
- Cur i bhfeidhm na Treorach um Thrádáil Astuithe, a bhfuil baint aige le hos cionn 100 cuideachta atá ina mór-ghineadóirí dé-ocsaíd charbóin in Éirinn.

TAIGHDE AGUS FORBAIRT COMHSHAOIL

- Taighde ar shaincheisteanna comhshaoil a chomhordú (cosúil le caighdéan aeir agus uisce, athrú aeráide, bithéagsúlacht, teicneolaíochtaí comhshaoil).

MEASÚNÚ STRAITÉISEACH COMHSHAOIL

- Ag déanamh measúnú ar thionchar phleananna agus chláracha ar chomhshaol na hÉireann (cosúil le pleananna bainistíochta dramhaíola agus forbartha).

PLEANÁIL, OIDEACHAS AGUS TREOIR CHOMHSHAOIL

- Treoir a thabhairt don phobal agus do thionscal ar cheisteanna comhshaoil éagsúla (m.sh., iarratais ar cheadúnais, seachaint dramhaíola agus rialacháin chomhshaoil).
- Eolas níos fearr ar an gcomhshaol a scaipeadh (trí cláracha teilifíse comhshaoil agus pacáistí acmhainne do bhunscoileanna agus do mheánscoileanna).

BAINISTÍOCHT DRAMHAÍOLA FHORGHNÍOMHACH

- Cur chun cinn seachaint agus laghdú dramhaíola trí chomhordú An Chláir Náisiúnta um Chosc Dramhaíola, lena n-áirítear cur i bhfeidhm na dTionscnamh Freagrachta Táirgeoirí.
- Cur i bhfeidhm Rialachán ar nós na treoracha maidir le Trealamh Leictreach agus Leictreonach Caite agus le Srianadh Substaintí Guaiseacha agus substaintí a dhéanann ídiú ar an gcrios ózóin.
- Plean Náisiúnta Bainistíochta um Dramhaíl Ghuaiseach a fhorbairt chun dramhaíl ghuaiseach a sheachaint agus a bhainistiú.

STRUCHTÚR NA GNÍOMHAIREACHTA

Bunaíodh an Ghníomhaireacht i 1993 chun comhshaol na hÉireann a chosaint. Tá an eagraíocht á bhainistiú ag Bord lánaimseartha, ar a bhfuil Príomhstiúrthóir agus ceithre Stiúrthóir.

Tá obair na Gníomhaireachta ar siúl trí ceithre Oifig:

- An Oifig Aeráide, Ceadúnaithe agus Úsáide Acmhainní
- An Oifig um Fhorfheidhmiúchán Comhshaoil
- An Oifig um Measúnacht Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáide

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag ball air agus tagann siad le chéile cúpla uair in aghaidh na bliana le plé a dhéanamh ar cheisteanna ar ábhar imní iad agus le comhairle a thabhairt don Bhord.

EPA STRIVE Programme 2007–2013

Island Limits – A Material Flow Analysis and Ecological Footprint Analysis of Ireland

(2004-SD-MS-22-M2)

STRIVE Report

End of Project Report available for download on http://erc.epa.ie/safer/reports

Prepared for the Environmental Protection Agency

by

EnviroCentre

Authors:

Cathy Maguire and Robin Curry

ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhú Comhshaoil

PO Box 3000, Johnstown Castle Estate, County Wexford, Ireland

Telephone: +353 53 916 0600 Fax +353 53 916 0699

Email: info@epa.ie Website: http//www.epa.ie/

ACKNOWLEDGEMENTS

This report is published as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013. The programme is financed by the Irish Government under the National Development Plan 2007–2013. It is administered on behalf of the Department of the Environment, Heritage and Local Government by the Environmental Protection Agency which has the statutory function of coordinating and promoting environmental research.

Island Limits represents the outputs of almost two years of intensive research into the interactions between the physical environment and the economy of Ireland, and the environmental impacts associated with these interactions. The authors wish to acknowledge the support of the Environmental Protection Agency in the completion of the research, in particular the help provided by Kevin Woods and Dr Shane Colgan. Further thanks are extended to Pat Fanning, Patrick Quill and George Hussey of the Central Statistics Office. The Advisory Group played a key role in supporting the research, and our thanks go to Pat Gilheaney of the Department of the Environment, Heritage and Local Government and Tim Irwin of the Environmental Policy Group. The research would not have been possible without the help and support of the people mentioned above and the research team - thanks all of them.

DISCLAIMER

EPA STRIVE PROGRAMME 2007–2013

Published by the Environmental Protection Agency

PRINTED ON RECYCLED PAPER

ISBN: 1-84095-258-X

Price: Free 03/08/300

Details of Project Partners

Robin Curry (Project Coordinator)
EnviroCentre
10 Upper Crescent
Belfast
BT7 1NG
Tel.: +44 (0) 28 278330
Email: rcurry@envirocentre.co.uk

Cathy Maguire
EnviroCentre
10 Upper Crescent
Belfast
BT7 1NG
Tel.: +44 (0) 28 278330
Email: cmaguire@envirocentre.co.uk

Richard Moles
The Centre for Environmental Research
University of Limerick
Limerick
Ireland
Tel.: +353 (0) 61 202700
Email: richard.moles@ul.ie

Bernadette O'Regan
The Centre for Environmental Research
University of Limerick
Limerick
Ireland
Tel.: +353 (0) 61 202700
Email: bernadette.oregan@ul.ie

Conor Walsh
The Centre for Environmental Research
University of Limerick
Limerick
Ireland
Tel.: +353 (0) 61 202700
Email: conor.walsh@ul.ie

Craig Simmons
Best Foot Forward
The Future Centre
115 Magdalen Road
Oxford
OX4 1RQ
Tel.: +44 (0) 1865 250818
Email: craig@bestfootforward.com

Kevin Lewis
Best Foot Forward
The Future Centre
115 Magdalen Road
Oxford
OX4 1RQ
Tel.: +44 (0) 1865 250818
Email: kevin@bestfootforward.com

Table of Contents

Executive Summary

The *Island Limits* project delivers the first Material Flow Analysis (MFA) and Ecological Footprint (EF) of Ireland. It underlines the vital contribution that the modelling and measurement of material flows and the Ecological Footprint (EF) make to developing a robust evidence base to support policy and decision making for sustainable development. The authors hope that the completion of the first Material Flow Analysis and EF of Ireland will make a vital contribution to the development of targeted, evidence-based policies, the communication of our current consumption impacts and the prioritisation of actions and options for reducing these impacts.

Major world economies such as the European Union now recognise that continued economic growth can only be sustained if this growth is 'decoupled' from resource use and the associated impacts upon the environment. Policy initiatives include the Thematic Strategy on the Sustainable Use of Resources and the adoption of a renewed Sustainable Development Strategy in 2006. In Ireland, the review of the Sustainable Development Strategy refers specifically to the importance of decoupling economic growth from consumption of environmental resources. The strategy is currently under revision, and with resource consumption at the heart of EU policy, sustainable consumption and production is the key challenge for the next generation of Irish sustainable development policy.

The MFA has quantified the material flows within the Irish economy and on an all-island basis; the footprint has provided a measure of the environmental sustainability of current levels of consumption by the population. The MFA demonstrated that Ireland has a higher material input and consumption than some other European countries and below average resource productivity. Ireland would need to increase its resource productivity by 25% to reach the EU-15 average. The updating of the Northern Ireland MFA, which has enabled the creation of an all-island model, has also allowed a comparison of resource use and the resource productivity and intensity of both economies on an all-island basis.

The Ecological Footprint analysis established that if everyone on the planet consumed as much as an Irish resident three earths would be needed to support current global resource consumption. The scenarios have demonstrated the outcome of 'business as usual' and how meeting some current policy targets will not achieve the reduction in the Footprint that is required to live within current global capacity. The all-island EF showed Irish residents to have a lower EF than both Northern Ireland and UK residents.

It is anticipated that the Island Limits project will contribute to the evidence base for policy development and decision making for sustainable development; research findings are presented in a way that should facilitate their uptake and use. The outputs of the programme can provide an evidence base for decision making for a range of stakeholders – including policy-makers, industry, local authorities, householders and the research community.

The evidence base produced by the research can help to underpin the policy and decision making process necessary for transforming the Irish economy towards a sustainable footing. The management of this process will require ongoing research and development in order to build Ireland's capacity to support policy development and implementation; a particular focus is required in the data, measurement and modelling and capacity-building areas.

The outputs of the research programme include: wide-ranging recommendations on a framework for integrating ecological sustainability into policy; improvements to data to facilitate and improve the application of MFA and ecological footprinting to underpin sustainable development decision making; and building research capacity in resource accounting in Ireland. Recommendations for further research that would complement and build on the work in the Island Limits project include the development of an integrated EF/carbon dioxide/material flow Input-Output (I-O) model and a basic physical I-O table for Ireland.

1 Introduction

1.1 Resource Management and Sustainable Development

It could be argued that the ‘sustainable development’ debate began with the realisation that increasing economic growth and the related consumption of resources could not be sustained, and that the world was running up against environmental limits in terms of the carrying capacity of the planet (as outlined in Meadows et al., 1972).

The growing recognition of the importance of depletion of non-renewable resources, a deteriorating environment, accelerating industrialisation, rapid population growth and widespread malnutrition culminated in 1987 with the publication of *Our Common Future.* This set out the following definition of sustainable development (World Council on Environment and Development, 1987):

> Humanity has the ability to make development sustainable – development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Major world economies such as the European Union (EU) now acknowledge that continued economic growth can only be sustained if this growth is ‘decoupled’ from resource use and the associated impacts upon the environment. Policy initiatives include the Thematic Strategy on the Sustainable Use of Resources and the adoption of a renewed sustainable development strategy in 2006 with a key objective: ‘to promote sustainable consumption and production to break the link between economic growth and environmental degradation’ (European Council, 2006, p. 3).

At a national level, the review of Ireland’s Sustainable Development Strategy, published in 2002, refers specifically to the ‘importance of decoupling economic growth from consumption of environmental resources’ (DOEHLG, 2002, p. 9). The sustainable development strategy will be revised in the near future and, with resource consumption at the heart of EU policy, sustainable consumption and production is the key challenge for the next generation of Irish sustainable development policy.

1.2 Sustainable Consumption and Production Evidence Base

The process of moving towards sustainable consumption of resources and sustainable development can be addressed only through more effective integration of environmental concerns into other policy areas – in particular, economic development. The ultimate goal must be the integration of measurement and accounting methods for materials and the environment with those for the economy and society, to enable indicators of resource use and environmental sustainability to be incorporated routinely into national and European policy development, in the way that GDP and other economic indicators are currently.

Acknowledging the scale of the changes required to move the economy towards a more sustainable footing also underlines the necessity to bolster the management and decision making process with key methodologies, tools and techniques. These will provide a knowledge and evidence base about the interactions between our economies and the environment and the impacts of these interactions.

A wide range of such methodologies (with differing strengths and weaknesses) exists, Material Flow Analysis (MFA) and Ecological Footprint Analysis (EFA) having received particular attention in recent years. The application of MFA and EFA can be seen as an *iterative process* that aims to provide a robust evidence base for policy development and decision making. This can support all stages of the process – from measurement, assessment and benchmarking through to policy development, implementation and action and monitoring and evaluation. Figure 1 illustrates the role of MFA and EFA in supporting this process:

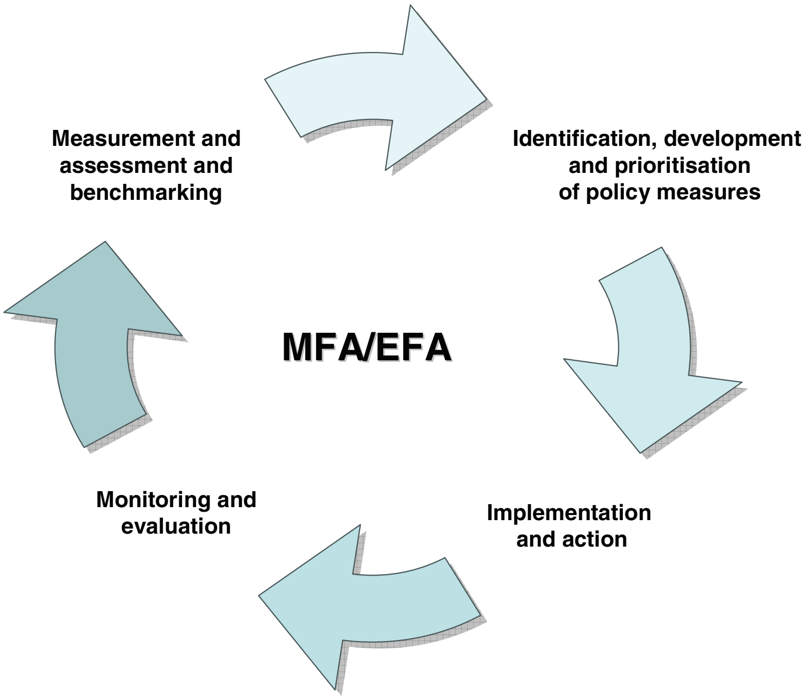


Figure 1: The MFA/EFA decision support process

1.3 Why Combine Material Flow Analysis and Ecological Footprint Analysis?

The MFA methodology can be used to measure resource flows both through countries and regions, and through industries at both national and regional levels. This in turn allows the calculation of a range of indicators relating to resource consumption and resource efficiency, such as 'direct material input' (DMI), 'domestic material consumption' (DMC), 'resource productivity' and 'resource intensity' of the economy. Material Flow Analysis (or mass balance) studies have been carried out recently at European, national and regional levels and the methodology is increasingly recognised as an important part of the 'toolkit' of methodologies for measuring progress towards sustainable development.

While MFA provides very valuable information, and offers a vital contribution to our understanding of the material throughputs of economies, EF adds further value to this process. Developed in the early 1990s by William Rees and Mathis Wackernagel at the University of British Columbia, the Ecological Footprint has risen to prominence as an indicator of environmental sustainability (Wackernagel and Rees, 1996) and has been applied at global, European, national and regional levels. The footprint has been adopted as an indicator for the European Common Indicators Programme, the Greater London Assembly and the National Assembly of Wales. In addition, following the completion of *Northern Limits: A Resource Flow Analysis and Ecological Footprint of Northern Ireland* (Curry et al., 2004) and the publication of the Sustainable Development Strategy for Northern Ireland, the footprint has been adopted as one of the sustainable development indicators for Northern Ireland.

The distinction between the methodologies can be set out as:

- **Material Flow Analysis:** a quantification of material flows within an economy.
- **Ecological footprinting:** an analysis of material impacts related to consumption.

Therefore, while MFA *quantifies* the flows, the EF *sets these flows in the context of sustainability* and provides a measure of the ecological pressure associated with these flows. In other words, the ecological footprinting approach

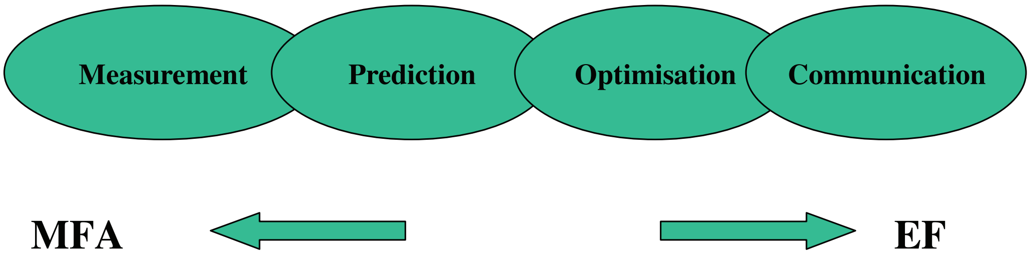


Figure 2: Synergies between MFA and EF

adds value to and complements the MFA approach by setting resource consumption into a sustainability context and communicating this information in a way that is understood easily by decision makers and the general public. Therefore, combining MFA and EF analysis encourages the development of synergies between the very different strengths and weaknesses of the two methodologies, as set out in Figure 2.

1.4 The Island Limits Programme – Objectives and Targets

The objectives and targets relate to four main areas, which are set out below. Since the inception of the Island Limits project in January 2005, additional work elements were identified, an Input-Output (I-O) analysis (funded by the EPA) was carried out, and the Northern Limits data year (co-funded by the Department of the Environment for Northern Ireland Environmental Policy Group) was updated. All added value to the aims and objectives of the programme by extending the range of analyses that could be carried out and improving the data quality for the all-island approach.

1.4.1 Material Flow Analysis (MFA)

- Carry out an MFA of Ireland using two approaches: (i) the 'economy-wide material flow accounts' methodology and (ii) an environmentally extended I-O analysis.
- Carry out a comparison of the strengths and weaknesses of both MFA approaches.
- Create an MFA model of the Irish economy classified by industrial sector and geographical region.
- Carry out a data quality assessment and data-gaps and needs analysis.
- Calculate the resource efficiency of the Irish economy via the application of MFA derived indicators such as direct material input (DMI) and domestic material consumption (DMC).

1.4.2 Ecological Footprint Analysis

- Calculate the Ecological Footprint (EF) of Ireland using the Best Foot Forward (BFF) Regional Stepwise™ methodology.
- Compare the EF of Ireland with other countries.
- Measure the ecological sustainability of Ireland.
- Model a number of improvement scenarios in key areas of the economy such as food, energy and waste management.
- Develop an EF model based on the existing University of Limerick (UL) model.

1.4.3 The All-Island Approach

- Integrate the outputs of the analyses for Ireland with the outputs of the Northern Ireland Material Flow Analysis and Ecological Footprint to produce an all-island MFA and EF.

1.4.4 Dissemination

- Disseminate the outputs of the research via conferences, refereed journals, and research networks, for example, ConAccount, ENSURE, Ecological Economics and Industrial Ecology Networks.
- Publish all findings available via a website and through an EPA report on completion of the project.

1.5 Why were Two Different Methods Used?

The Ecological Footprint of Ireland was calculated on the basis of (a) the Best Foot Forward (BFF) Regional Stepwise™ model (a standardised methodology) and (b) the University of Limerick's (UL) model (created uniquely for this project). The models differ in that the UL model relies more on data captured from national sources, while the BFF method is based on the National Footprint Account (NFA) of Ireland. The NFA uses international data sources such as those from various United Nations departments and the International Energy Agency. This is then integrated with, and re-analysed using, national consumption data sources. Calculating the EF using two different methods in parallel was undertaken because:

- Using two separate methods undertaken by independent research teams allowed validation of the EF as an indicator of sustainability. If both methods arrived at similar conclusions, this would be a clear indication that the underlying methods and assumptions in the calculation of an EF are credible, and that the final result provides a scientifically robust and reliable indicator, relevant to policy choice and development.
- A comparison of the two datasets allowed the research team to satisfy itself that the most reliable data were included in both calculations.
- A comparison of the methods adopted in both calculations provided opportunities for the revision and strengthening of methods. One example is the implementation of changes to the 2006 release of the NFAs.
- Sub-national scale footprint calculations (for regions, towns and individual companies) may be calculated using both BFF and UL methods. However, the UL method may be more flexible in reflecting local conditions (through the inclusion of location-specific conversion factors) more strongly.

The full set of results, discussion and conclusions can be found in the main project report and is summarised below. Details on the methodologies, technical issues and discussions relating to each element of the project can be found in the three technical appendices of the main project report.

2 Material Flow Analysis (MFA) of Ireland

2.1 Economy-Wide MFA

The completion of the first economy-wide MFA for Ireland has provided a comprehensive description of the material flows *between* the environment and the economy and also *within* the economy itself (production and consumption). This has created a sound material accounting framework, which can be built on to enable Ireland to measure and model its consumption of resources on an ongoing basis. The economy-wide material flow model of Ireland for 2003 is shown in Figure 3.

The MFA identified those industrial sectors that are 'big hitters' in terms of resource consumption, showing that in terms of direct material consumption the 'mining and quarrying' sector consumed the greatest amount of materials, followed by the agricultural sector. The breakdown of material flows in Ireland for 2003 is shown in Table 1.

Consumption of products was also calculated and Chapter 2 of the main report contains a table showing the breakdown by sector. Tables showing a breakdown of the outputs to the environment (waste, emissions to air and dissipative outputs of products) are also given in Chapter 2 of the main report.

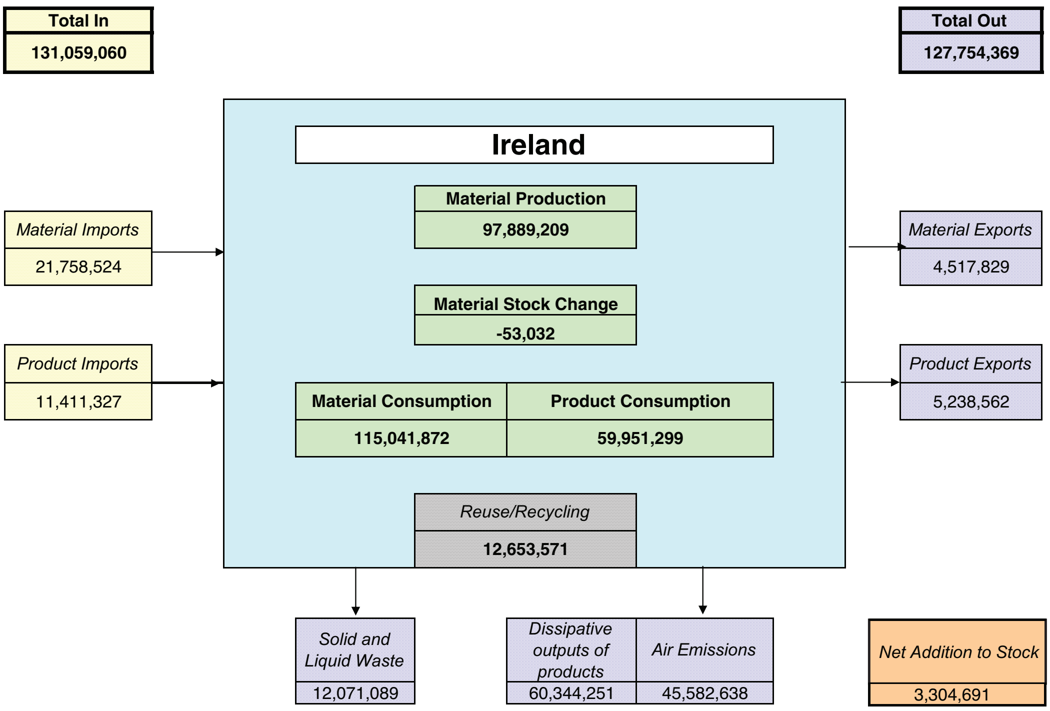


Figure 3: Material flow model of Ireland in 2003 (tonnes)

Table 1: Material flows through Ireland in 2003 (tonnes)

Description	Production	Import	Export	Net Supply	Stock change	Consumption
Total materials	97,889,209	21,758,524	4,517,829	115,129,905	-53,032	115,041,872
Of which						
Agriculture	39,956,337	2,258,366	1,342,475	40,872,228	-101,000	40,736,228
Forestry	2,736,606	170,756	349,335	2,558,027	No data	2,558,027
Fishing	338,640	6,609	106,410	238,839	No data	238,839
Coal, lignite and peat extraction	332,406	1,315,370	9,306	1,638,470	106,256	1,744,726
Oil and gas extraction	562,440	13,077,892	1,548,216	12,092,116	-58,288	12,033,827
Metal ores extraction	943,795	3,421,099	503,363	3,861,531	No data	3,861,531
Other mining and quarrying	53,018,985	1,508,432	658,723	53,868,694	No data	53,868,694

2.2 MFA Indicators

A set of indicators was derived from the MFA and material balance: these indicators provide a picture of the 'industrial metabolism' of Ireland and allow comparison in a standardised way both with other countries and over time. MFA indicators can be divided into three main categories: (i) input, (ii) output and (iii) consumption. Balancing and efficiency indicators can also be calculated. Each of these indicators below was calculated for Ireland as a whole and on a per capita basis. Efficiency indicators relate MFA indicators to economic indicators such as gross domestic product (GDP):

- **Direct material input (DMI)** measures the direct input of materials (in terms of their mass) for use into the economy, i.e. all materials that are of economic value and are used in production and consumption activities. DMI equals domestic extraction plus imports.
- **Domestic material consumption (DMC)** measures the total amount of material used directly in the economy. DMC equals DMI minus exports.
- **Domestic processed output (DPO)** is the total weight of materials extracted from the domestic environment or imported that have been used in the domestic economy before flowing to the environment. Emissions to air, waste disposed in landfills, material loads in wastewater and materials dispersed into the environment as a result of product use are included in DPO.
- **Direct material output (DMO)** represents the total quantity of material leaving the economy after use either towards the environment or outside the national boundary. DMO is the sum of DPO plus exports.
- **Physical trade balance (PTB)** measures the physical trade surplus or deficit of an economy. PTB equals imports minus exports.
- **Resource efficiency indicators** measure the resource productivity and intensity of the economy. Resource productivity is the contribution to GDP at constant prices generated per tonne of domestic extraction (DE), material input and material consumption (GDP/MFA indicator). Resource intensity is the tonnes of domestic extraction, material input and material consumption needed to generate 1 unit of GDP at constant prices (MFA indicator/GDP).

Table 2: MFA derived indicators for Ireland 2003

Indicator type	Indicator	Unit	Value
Input	DMI	Tonnes	119,647,733
	DMI per capita	Tonnes per capita	30.5
Consumption	DMC	Tonnes	115,129,904
	DMC per capita	Tonnes per capita	29.4
Output	DPO	Tonnes	117,997,978
	DPO per capita	Tonnes per capita	30.1
	DMO	Tonnes	127,137,366
	DMO per capita	Tonnes per capita	32.5
Balancing	PTB	Tonnes	17,240,695
	PTB per capita	Tonnes per capita	4.4
Resource productivity	GDP/DE	Euros per tonne	998
	GDP/DMI	Euros per tonne	817
	GDP/DMC	Euros per tonne	849
Resource intensity	DE/GDP	Tonnes per euro	0.001
	DMI/GDP	Tonnes per euro	0.00122
	DMC/GDP	Tonnes per euro	0.00118

Table 2 shows the values of the indicators derived from the Material Flow Analysis of Ireland.

2.3 Comparison of Ireland with Other European Countries

Some MFA indicators have been adopted by EuroStat (The Statistical Office of the European Communities), and studies have been carried out on resource use in European countries to support the development of the Thematic Strategy for Sustainable Use of Resources. These studies calculated a time-series of MFA indicators for the EU-15, and this data has been used to put the Irish indicators in context. Time-series comparisons with other EU-15 countries were carried out for DMI, DMI per capita, DMC, DMC per capita and series of resource productivity and intensity indicators. A time-series of DMI for Ireland is given in Figure 4(A) below.

2.4 Resource Productivity and Intensity

DMI is high in Ireland but has remained so over the course of significant economic growth, which reflects relative decoupling. Nonetheless, Ireland still has a significantly higher materials burden than other countries. At a European level, the economy has been growing steadily while at the same time resource use has remained fairly constant in terms of DMI per capita. This has led to a relative decoupling of economic growth and resource requirements, which is reflected in an increase in resource productivity (GDP/DMI) (Moll et al., 2005). Direct resource productivity of the EU's economy has increased from 1980 to 2000. The resource productivity and intensity indicators for Ireland and the EU-15 are shown in Figure 4 (B and C).

The resource intensity of Ireland's economy has decreased since the 1980s. In 1980, 2.8 kg of direct material input was required to contribute €1 to GDP; this fell to 1.2 kg in 2000 and 1.12 kg in 2003. In 1980, 2.6 kg of direct material consumption was required to contribute €1 to GDP, falling to 1.09 in 2000 with a slight rise to 1.18 in 2003. Ireland has a higher resource intensity than the EU average, and, although it is decreasing faster then the EU-15 as a whole, this decrease has levelled off from 2000 to 2003.

2. 5 Input-Output Analysis

Environmental accounting is a complex and rapidly developing field, in which a range of methodologies has been developed which have different applications, strengths and weaknesses. The decision by the Environmental Protection Agency (EPA) to fund additional work to develop environmentally extended I-O tables has enabled (i) the modelling of the flows of products within the economy and (ii) the estimation of the physical amount of natural resource inputs required by domestic industry to meet the final demand of Irish households and products for export. The I-O analysis also identified which industrial

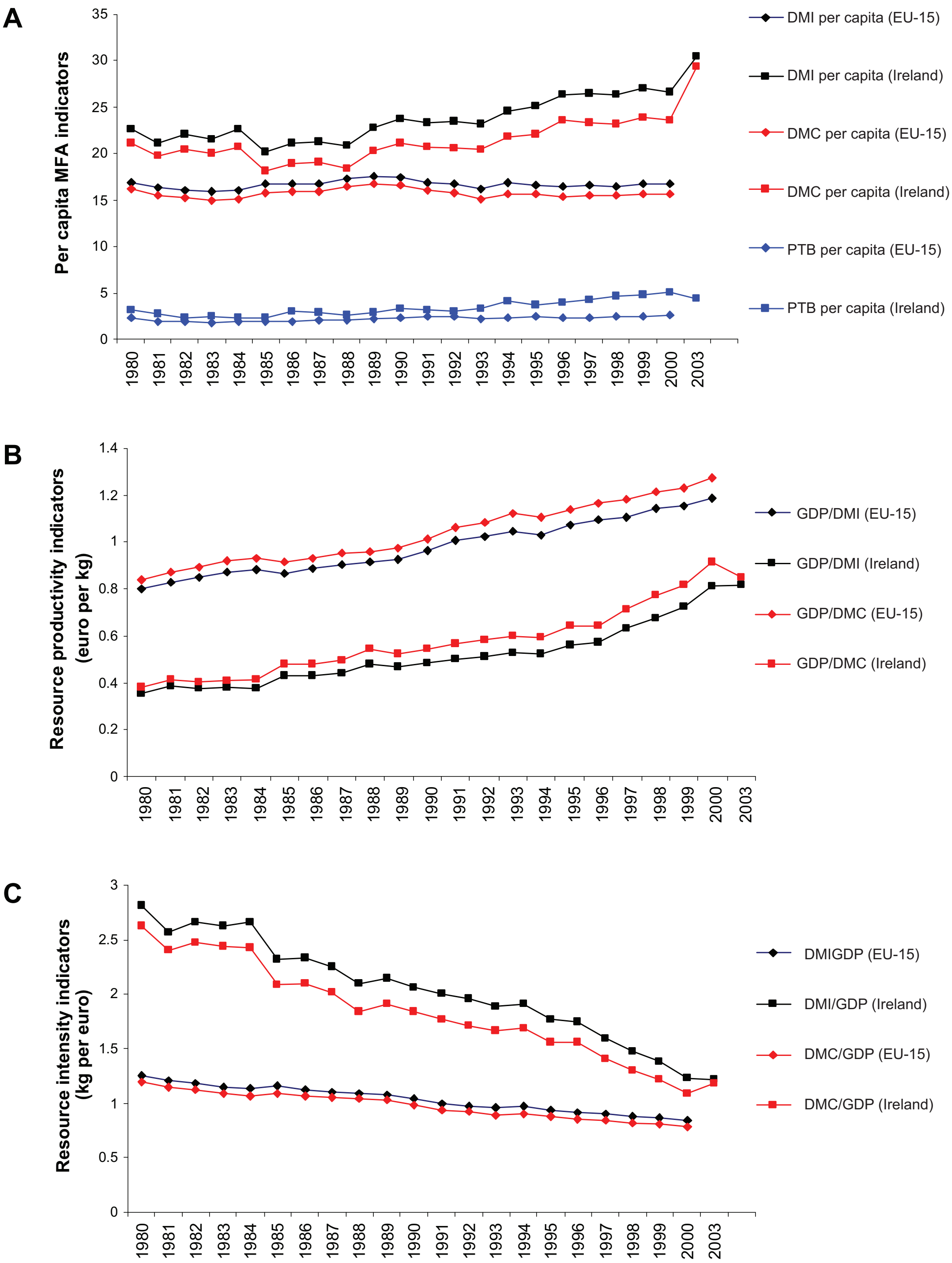


Figure 4: MFA indicators for Ireland and the EU-15 from 1980–2003 (2001 and 2002 are not included)

sectors are 'big hitters' in terms of resource consumption, although, unlike the MFA, this includes both direct and indirect consumption and incorporates the service sectors (Table 3). The I-O 'big hitters' were 'construction', followed by 'food and beverages', 'non-metallic mineral products' and 'agriculture, forestry and fishing'.

Analyses were carried out for all material inputs, biomass, metals, fossil fuels, minerals and imports separately. In each of these, the total material requirement needed to produce total final demand, final demand for households and final demand for exports was determined (see Chapter 2 of the final report for results).

Table 3: Total Material Requirements needed to meet final demand (tonnes).

	Sector	Total Material Requirements		Sector	Total Material Requirements
1-5	Agriculture, forestry and fishing	8,798,118	**45**	Construction work	41,032,023
10-14	Mining and quarrying products	3,784,691	**50**	Motor fuel and vehicle trade and repair	45,310
15	Food and beverages	26,809,805	**51**	Wholesale trade	130,574
16	Tobacco products	26,801	**52**	Retail trade and repair of household goods	443,735
17	Textiles	168,181	**55**	Hotel and restaurant services	2,562,992
18	Wearing apparel	9,999	**60**	Land transport services	72,069
19	Leather and leather products	38,546	**61**	Water transport services	17,534
20	Wood and wood products (excl furniture)	649,965	**62**	Air transport services	97,621
21	Pulp, paper and paper products	298,944	**63**	Auxiliary transport services and travel agencies	56,711
22	Printed matter and recorded media	166,022	**64**	Post and telecommunication services	236,734
23, 36	Petroleum and other manufacturing products	3,743,583	**65**	Financial intermediation services	124,591
24	Chemical products and man-made fibres	3,922,950	**66**	Insurance and pension services	91,862
25	Rubber and plastics	259,751	**67**	Services auxiliary to financial intermediation	958
26	Other non-metallic mineral products	10,194,857	**70**	Real estate services	2,402,767
27	Basic metals	1,673,541	**71**	Renting services of machinery and equipment	14,256
28	Fabricated metal products	171,633	**72**	Computer and related services	49,226
29	Machinery and equipment n.e.c.	380,024	**73**	Research and development services	27,768
30	Office machinery and computers	809,256	**74**	Other business services	286,449
31	Electrical machinery and apparatus n.e.c.	551,402	**75**	Public administration and defence	1,337,999
32	Radio, television and communications apparatus	175,264	**80**	Education	680,140
33	Medical, precision and optical instruments	186,617	**85**	Health and social work services	304,105
34	Motor vehicles and trailers	80,633	**90**	Sewage and refuse disposal services	1,539
35	Other transport equipment	28,637	**91**	Membership organisation services n.e.c.	38,599
37	Recycling	679	**92**	Recreation	123,429
40	Electricity and gas	829,720	**93**	Other services	33,320
41	Water collection and distribution	0	**95**	Private households with employed persons	77

The results of the economy-wide MFA and the I-O analysis are complementary and show the direct and indirect material requirements of the Irish economy. Both analyses identified the same areas of the economy as consuming the most materials, namely the provision of building materials and construction, the provision of food and beverages and agricultural products.

Taken together, this ground-breaking work has created a framework that can form the basis for the development of national environmental accounts, which will enable Ireland to measure its resource consumption and efficiency and to benchmark its performance against other economies. With the ongoing development of data-collection systems and indicators under the Thematic Strategy on the Sustainable Use of Resources, this will also ensure that Ireland has in place robust material accounting systems to meet its future reporting obligations within the EU. Resource use and resource efficiency are major issues for environmental policy and two main themes have been identified as policy relevant: (i) the 'total quantity used' and (ii) the 'efficiency in use'. This implies that the resource issue should be analysed in terms of resource consumption (DMC) and resource efficiency (resource intensity and productivity).

3 Ecological Footprint Analysis of Ireland

3.1 What is an Ecological Footprint?

An Ecological Footprint[1] is a tool for measuring and communicating the intensity of human resource use. It expresses the relationship between the contemporary human demand for natural resources and their sustainable supply at the global scale (that is, the earth's biocapacity).[2] Comparing the EF (the natural resource demand) with the global availability of the bioproductive area (the sustainable natural resource supply) provides an indicator of environmental sustainability. If monitored over time, the EF provides guidance on the extent to which a society is moving towards or away from sustainability. If more bioproductive land and sea are required than are available, then it is likely that the rate of consumption is not sustainable (Chambers et al., 2000). In contrast, if humanity consumes only as much as the planet is able to provide in the long term, then this indicates that humanity's demand for resources is sustainable: a base requirement for Living on One World (LOW).

Ireland's EF was calculated using (a) the Best Foot Forward (BFF) Regional Stepwise™ model (a Footprint Standards 2006 compliant re-analysis of the National Footprint Accounts for Ireland 2005 [GFN, 2005]) and (b) the University of Limerick's (UL) model (created uniquely for this project). The different methods arrived at different results for the overall EF of Ireland:

- The **BFF model** calculated a figure of 5.37 gha per person.
- The **UL model** gave a figure of 5.81 gha per person (a difference of less than 8%).

A breakdown of the results of both models is given in Parts A and B.

[1] The ecological footprint (EF) measures how much bioproductive area (whether land or water) a population would require to sustainably produce all the resources it consumes and to absorb the waste it generates, using prevailing technology. It therefore indicates the **demand** for resources.

[2] The biocapacity (BC) measures the bioproductive **supply**, i.e. the biological production in an area. It is an aggregate of the production of various ecosystems within the area, e.g. arable, pasture, forest, productive sea. Some of it is built or degraded land. Biocapacity is dependent not only on natural conditions but also on prevailing farming/forestry practices.

3.2 Part A: Regional Stepwise™ Model

3.2.1 Ecological Footprint Summary Findings

In 2002, Irish residents' total EF was calculated to be 20.9 million gha (or 5.37 gha per person). The total EF can be broken down into more detailed components for further analysis (see Chapter 3 of the main report for detailed results). This breakdown enables a better understanding of the size of resource demands associated with various aspects of consumption. The relative component breakdown is given in Figure 5.

The year 2002 was the most recent year for which the NFAs were available from the Global Footprint Network (GFN). As all consumption data were also available for this year, 2002 was chosen as the base analysis year for the Regional Stepwise™ Ecological Footprint for Island Limits. At the time of writing, not all of the consumption data were available for 2003. An estimate for the EF for Irish residents in 2003 was calculated using consumption data for 2002 and 2003. This was undertaken to facilitate a comparison of the results from the Regional Stepwise™ and UL models.

Because the EF measures apparent consumption of resources (or final demand), it is appropriate to compare the footprint with other indicators of the economy as a whole. For example, Ireland's EF can be compared with Ireland's GDP (Figure 6). It is also of interest to compare this figure with the MFA indicators as the EF considers the natural resources needed to supply consumed goods. For example, where the MFA reports 1 tonne of aluminium, the EF shows that it requires around 15 gha to supply that tonne of aluminium; and where the MFA reports 1 tonne of chalk, the EF shows that it requires around 0.003 gha to supply that tonne of chalk.

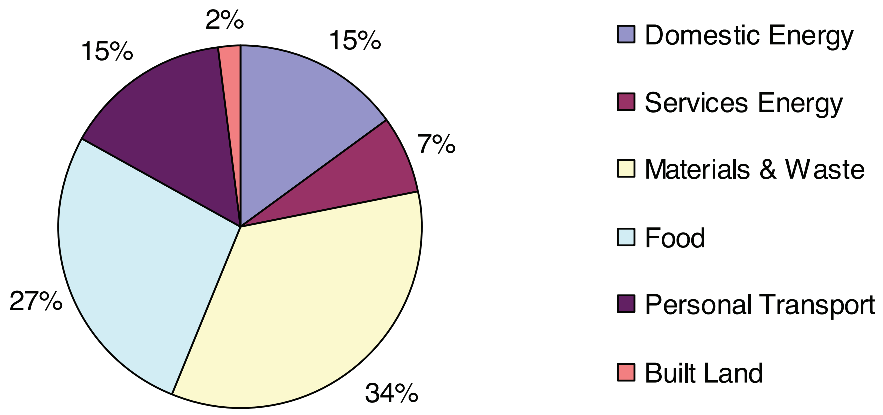


Figure 5: Ecological footprint of Irish residents by component in 2002

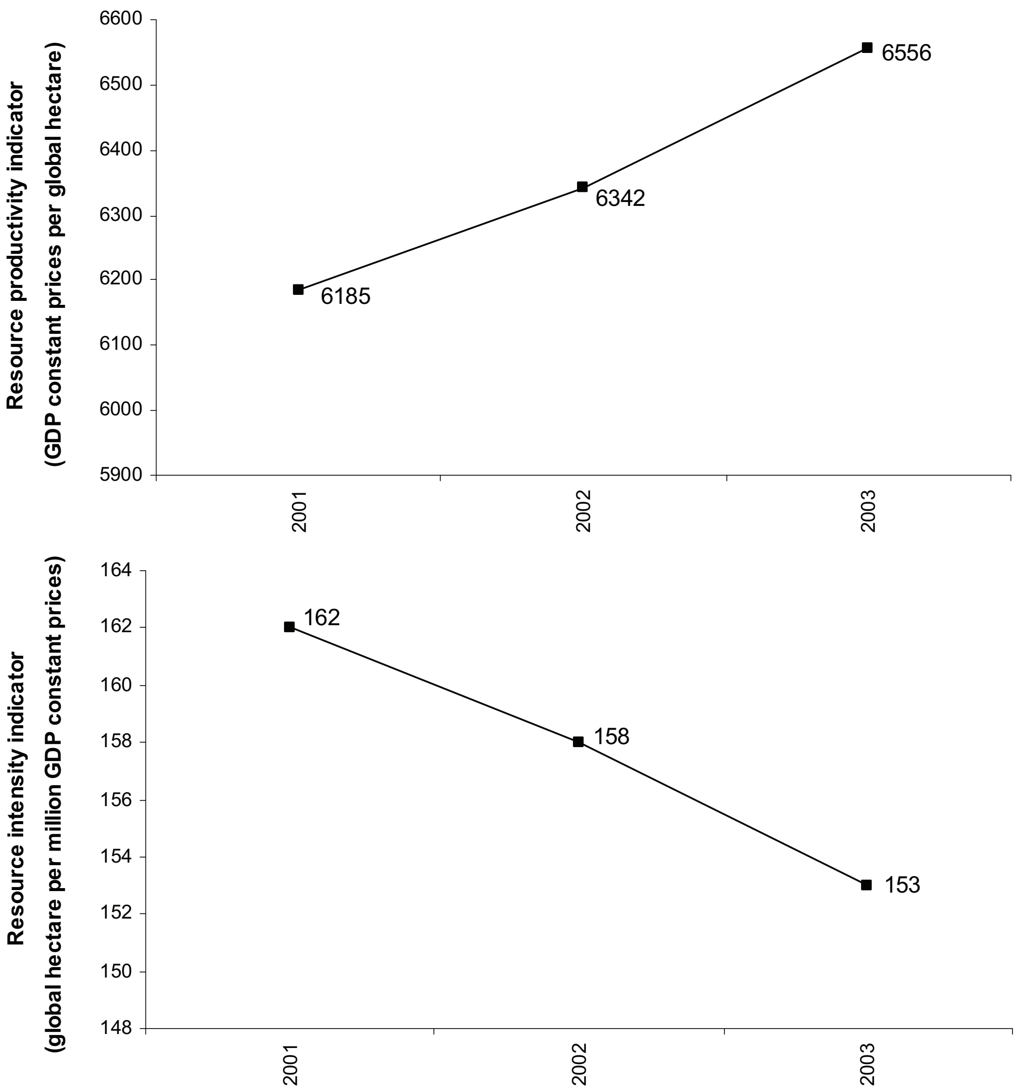


Figure 6: Resource productivity and intensity indicators for Ireland, 2001–2003

3.3 Part B: UL Footprint Calculation Model

The value of developing an Ireland-specific method for the EF is to ensure that all data, conversion factors and assumptions are specific to Irish conditions and completely transparent. Consequently, as part of this research, an Ireland-specific footprint was calculated. A variety of assumptions and conversion factors was used: selected as most representative of Irish conditions, it was anticipated that they would provide a transparent methodology to be used as a tool in environmental management. Information from Irish sources was used were possible to generate customised conversion factors.

3.3.1 UL Model Overall Results

The EF calculated here is for the 26 counties of the Republic of Ireland (RoI). These adaptations of the footprinting method to Irish specific conditions gave a result of 5.81 gha per capita for 2003. This is less than 8% higher than that arrived at with the BFF methodology. The overall results of the footprint calculation are shown in Table 4 (presented in the format adopted by the GFN). As the table shows, energy consumption contributes most to the overall footprint, and pasture use is second in significance.

Chapter 3 of the main report contains a detailed breakdown of the components with footprints for energy, transport, food and agriculture, fish, wood, waste, water and built land.

Table 4: Summary of overall Footprint results

Footprint Category	**Imported**	**Produced**	**Exported**
	Gha/cap	Gha/cap	Gha/cap
Arable Footprint	1.16	0.53	0.93
Pasture	0.51	1.23	0.91
Forest	0.64	0.39	0.52
Fish consumed		0.38	
Built land		0.20	
Energy	1.93	3.10	1.9
Total	**4.24**	**5.83**	**4.26**
Overall Consumption		**5.81**	

3.4 Comparison between the UL model and BFF's Regional Stepwise™ Footprint Calculations and Results

The methodology employed to calculate the EF has undergone rapid development in recent years and the calculation of the EF of Ireland – by both Best Foot Forward and the University of Limerick – has enabled a valuable methodological comparison to be carried out. This methodological comparison has shown the main differences between the Regional Stepwise™ and the University of Limerick's method to be:

- Varying boundaries of assessment.
- Different methodology factors.
- Accounting assumptions applied.

The UL method focused on resource production within the national territory of Ireland, whereas the Regional Stepwise™ method was based on net consumption for the study year. While there was less than 8% difference in the overall EF calculated using both methodologies, the differences in data and methodology were clear when considering individual elements of the footprint calculation. Table 5 summarises these differences:

Table 5: Summary of differences between the BFF and UL Footprint values.

Major differences between BFF and UL Ecological Footprint component calculations (values are all per capita for 2003)	Reasons for the difference	Implications of the difference
Energy Component (BFF 3.59 gha; UL 3.13 gha)	The calculation method used in both cases was similar, but data inputted differed. These differences related primarily to traded goods, such as meat products, which Ireland exports in large quantities.	Inclusion of traded goods in a Footprint calculation may be expected to be problematic as traded goods data are complex to interpret, and the embodied energy of such goods has been estimated in various ways and with differing results. The Footprint is therefore sensitive to data source and quality.
Pasture-land Component (BFF 0.30gha; UL 0.83gha)	The difference in value calculated arose from both data inputted and the study boundary selected. The BFF value reflects the pasture area required to produce the meat consumed in a year. The UL method calculated the area required to feed the entire cattle and sheep herds, including animals not consumed in the study year. The number of cattle alive at year's end is considerably greater than the number slaughtered during the year.	The difference in values calculated is large because Irish agriculture is based primarily on meat production through grazing. In this respect Ireland is unusual when compared to other countries.
Built-land Component (BFF 0.11gha; UL 0.20gha)	The difference arose because the BFF method includes data on major roads only from a European source. The UL method also includes data derived from national sources on the area covered by minor roads.	Ireland is perhaps exceptional in Europe in that minor roads cover a relatively large area, and major roads cover a relatively small area. It might be argued that minor roads should be included for all countries.
Fishing Component (BFF 0.24gha; UL 0.38gha)	The values calculated were dissimilar because both data inputted and calculation method adopted differed. The UL method calculates the biomass required to feed fish consumed within the study year, and converts this to annual net primary production and hence area of ocean required. The BFF method calculates the Footprint similarly to the UL model, but also considers the energy transfer between trophic levels and an estimate of the global sustainable fishing yield. There are also differences in the assumptions used to estimate the trophic levels of caught seafood and the treatment of fishmeal.	Converting a three dimensional ocean into a two dimensional Footprint is necessarily problematic. It is quite possible that neither method is entirely satisfactory. Data quality and availability are also significant issues. Our understanding of the metabolism of oceanic ecosystems is limited, which creates further problems for Footprint calculations.

The work undertaken in the Island Limits project also identified some problems with the treatment of traded goods in the NFAs (which in the case of Ireland were particularly problematic: see Chapter 3 of the main report). Solutions were identified and have already been fed into the NFA review process, which will lead to a more reliable and robust 2006 Ireland account. The outputs from Island Limits enhance the value and acceptability of the EF as an indicator of environmental sustainability. Therefore, the key message – that the people of Ireland consume more than the global average – may be communicated more successfully.

3.5 Examples of Footprints at Regional, Local and Company Scales

Ecological footprinting can be carried out a variety of scales: national, regional, local, for industrial sectors, for individual companies and even for individuals. The application of ecological footprinting was investigated at sub-national level and the availability of data was explored. It was concluded that ecological footprinting can provide valuable regional, local and company scale insights and is a useful management tool for policy makers. Chapter 4 of the main report contains examples of county-scale footprints for transport, cattle and water; regional-waste footprints and company-scale footprints.

3.6 Ecological Sustainability Assessment of Ireland

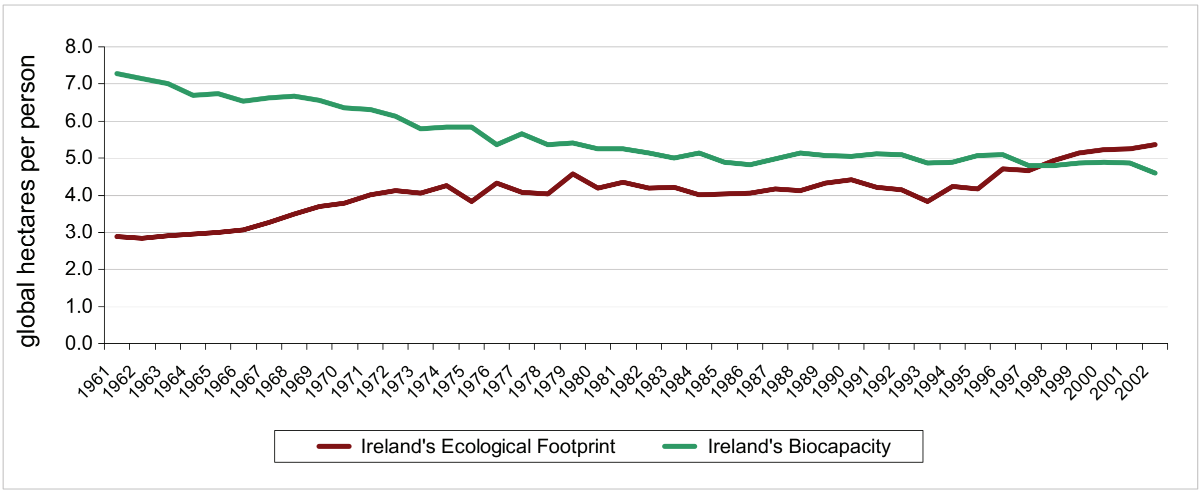
The Ecological Sustainability Assessment of Ireland is the comparison of Ireland's resource demand, the EF, with the available supply of resources (Biocapacity) at a national and global level. Definitions of the elements comprising the sustainability assessment are set out below:

- **Biocapacity** is a measure of the biological productivity in an area. It is an aggregate of the productivity of various ecosystems within the area, for example, arable or crop land, pasture, forest and bioproductive sea, built or degraded land. Biocapacity is dependent not only on natural conditions but also on prevailing farming and forestry practices.
- **Bioproductivity** is the ability of an area to produce biomass, which is the weight of organic matter, including animals, plants and micro-organisms above or below the soil surface. Different ecosystems will have different levels of bioproductivity.
- **Earthshare** is the average area of global resources available per person. To calculate earthshare, the total available bioproductive area of the planet is divided equally among the current global population. It is estimated that the current earthshare is 1.8 gha per person (GFN, 2005). If everyone lived within his or her earthshare, we would be ecologically sustainable at a global level.
- **Yield** is the rate of production, for example agricultural production (tonnes) per hectare of crop.

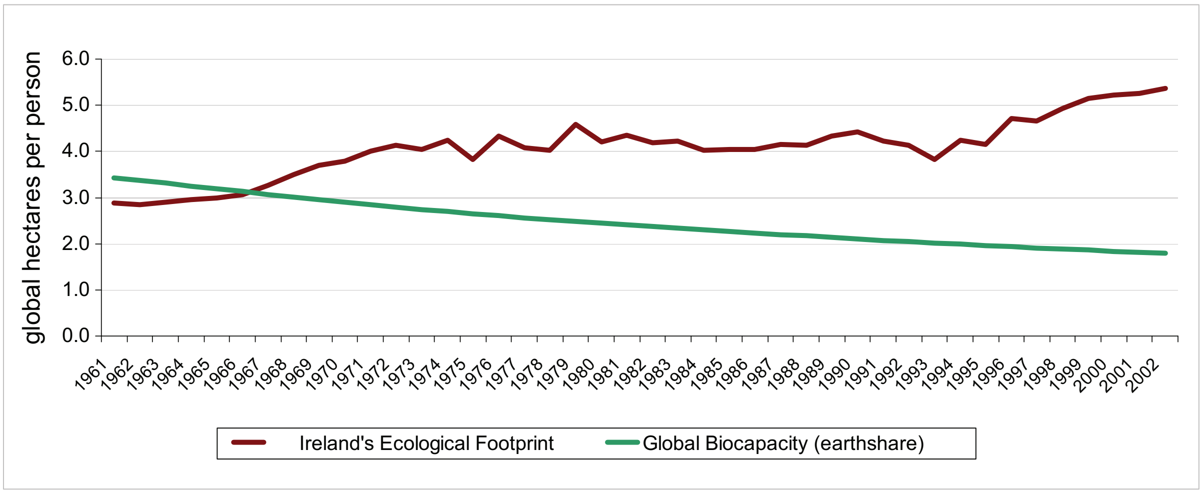
The Ecological Footprint can be compared with biocapacity derived at either the global, national or regional level. Comparing an Irish resident's Ecological Footprint (5.37 gha) with Ireland's biocapacity per person (4.61 gha) indicates whether the population is living within the means of its national boundaries. The figures show that, at a national level, demand for natural resources is more than the available supply. Figure 7(A) shows the relationship between Ireland's EF and Biocapacity from 1961-2002.

Alternatively, it is possible, and some would argue more meaningful, to compare the EF with globally available biocapacity as an indication of whether Ireland's population is living within the environmental limits of our planet. Irish residents consume resources and ecological services from all over the world: therefore, their footprint is the sum of these areas wherever they are on the planet. If national footprints are compared only with national biocapacity this does not reflect the global nature of ecological capital and environmental limits. Countries with large footprints and large biocapacity (such as the United States and Canada) would appear more environmentally sustainable than their current levels of consumption indicate, whereas countries with low per-capita biocapacities, which typically result from high population densities (such as Bangladesh or the Netherlands) or inhospitable climates (Ethiopia or Saudi Arabia for example), and which do not have the capacity to meet their resource demand would appear less sustainable environmentally. The comparison of Ireland's EF (per capita) and global biocapacity (earthshare) from 1961–2002 is shown in Figure 7(B), and illustrated in terms of a planet index in Figure 7(C).

A



B



C

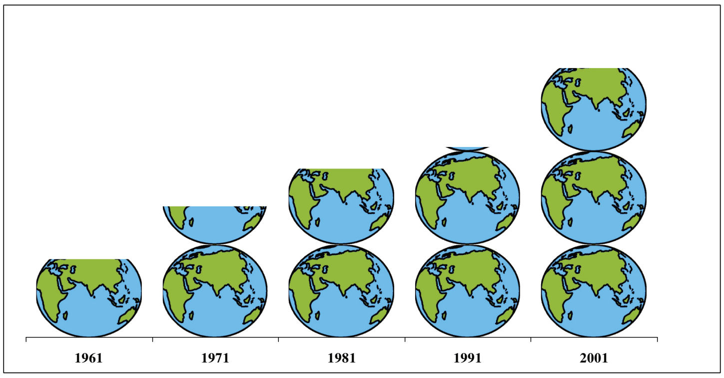


Figure 7: (a) Ireland's Ecological Footprint and biocapacity from 1961–2002, (b) Ireland's Ecological Footprint (per capita) and global biocapacity (earthshare) from 1961–2002, (c) Ireland's planet index

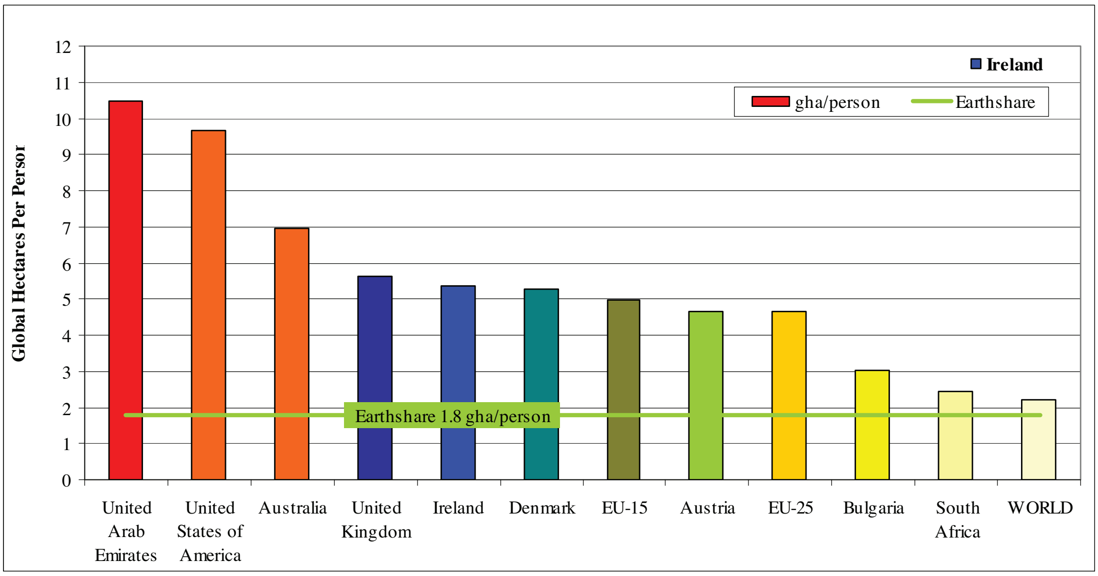


Figure 8: An Ireland resident's ecological footprint in relation to other nations

How does the EF of an Irish resident compare with residents of other parts of the world (Figure 8)? The NFAs (GFN, 2005) measure the EF of residents in 150 countries around the world, as well as the EF of an average world resident. Figure 8 also highlights the earthshare against which all EFs can be compared to measure global ecological sustainability.

3.7 Ecological Footprint Scenarios

The range of scenarios that it has been possible to model has shown that both MFA and ecological footprinting can work as powerful tools in identifying the 'big hitters' in terms of resource consumption, allowing the development of policies which are 'fine-tuned' and targeted. Chapter 6 of the main report presents scenarios for electricity, waste and food to illustrate how the EF may change over time. These scenarios were developed to illustrate the relationships between new technology, potential future consumption, the implementation of current government targets and various other factors.

Based on those from Northern Limits (Curry et al., 2004), they provided valuable insight into the impacts of existing and projected electricity consumption, waste management and food production and consumption. Examples of LOW (Living on One World) footprints are given for some scenarios, and all scenarios are summarised to illustrate one possible lifestyle of a LOW footprint Ireland resident. LOW scenarios depict the ideal goal: reaching such a target would entail a step-by-step approach and consist of a year-on-year reduction in the footprint. This highlights the scale of the challenge to reduce consumption and the footprint to within the earthshare; it also identifies how far current policies will go in achieving this. Further development of scenarios in other policy areas would inform policy making and the development of actions to reduce Ireland's Ecological Footprint.

4 All-Island Material Flow Analysis and Ecological Footprint

In order to facilitate further cooperation and management of natural resources on an all-island basis, there is a clear need for research that enables the measurement of resource consumption and associated environmental impacts on an all-island basis. Sustainable production and consumption policies need an evidence base that allows measurement and monitoring of performance. The construction of an all-island MFA and EF is the first step in building this evidence base and this has been supported by wide-ranging recommendations in Chapter 9 of the main report on further harmonisation to facilitate cooperation and management of natural resources on an all-island basis.

Resource accounting is a fast-moving field and efforts in recent years have focused on standardising the approaches taken to calculating MFAs and EFs to enable comparison between studies and over time. The Northern Limits MFA was calculated for the data year 2001 using a hybrid methodology of the economy-wide material flow accounts (EuroStat, 2001) and the methodology developed for the Mass Balance UK Programme (Linstead and Ekins, 2001). Therefore, to enable the calculation of the most up-to-date all-island model, the Northern Ireland MFA was updated to 2003 using the economy-wide MFA methodology. The results of the updated Northern Ireland MFA and EF are given in Chapter 7 of the main report. This also enabled MFA indicators to be derived for both Northern Ireland and an all-island model, thus allowing benchmarking against other countries.

4.1 All-Island Material Flow Analysis

An all-island MFA was calculated for 2003 by integrating the Ireland and Northern Ireland analysis updated to the data year of 2003, and using the standardised Eurostat methodology, while discounting any inter-jurisdictional flows of materials and products. The results are set out in Figure 9:

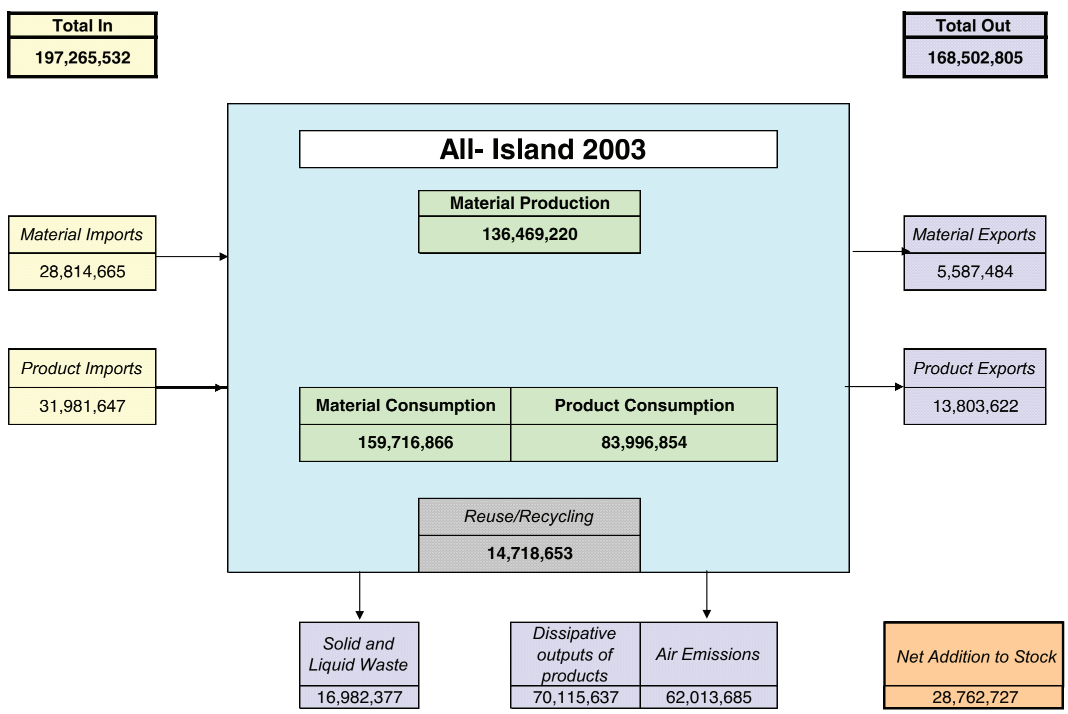


Figure 9: All-island material flow model for 2003 (tonnes)

Material and product consumption was also calculated for industrial sectors on an all-island basis (see Chapter 7 of the main report for further details.)

4.2 All-Island Ecological Footprint Analysis

To create an all-island EF, the total EF of Ireland was added to the Northern Ireland Footprint which had been recalculated for the data year of 2003, and adjusted to take methodological developments into account. The results are set out in Figure 10 and Table 6.

A similar ecological sustainability analysis was carried out on an all-island basis (see Chapter 8 of the main report for further details); as noted above, if everyone on the planet consumed as much as an average all-island resident, three earths would be needed to support current global resource consumption.

4.3 Resource Accounting and Management on an All-Island Basis

Integrating the MFA and EF models on an all-island basis can contribute to the development of a robust evidence base for resource accounting and management. Together, they form a 'basket of indicators' relating to resource use and environmental sustainability. They can underpin decision making and policy making and enable analysis, policy and scenarios to be developed on an all-island basis. If further cooperation and progress are to be made in resource accounting and management on an all-island basis, then data collection and classification systems should be harmonised. The lack of Northern Ireland specific data, leading to the use of data derived from UK sources, leads to uncertainties in the estimates of resource flows both in Northern Ireland and subsequently on an all-island basis. Collection of Northern Ireland specific data in a format that enables better integration of data would decrease these uncertainties and improve the accuracy of resource accounting on an all-island basis.

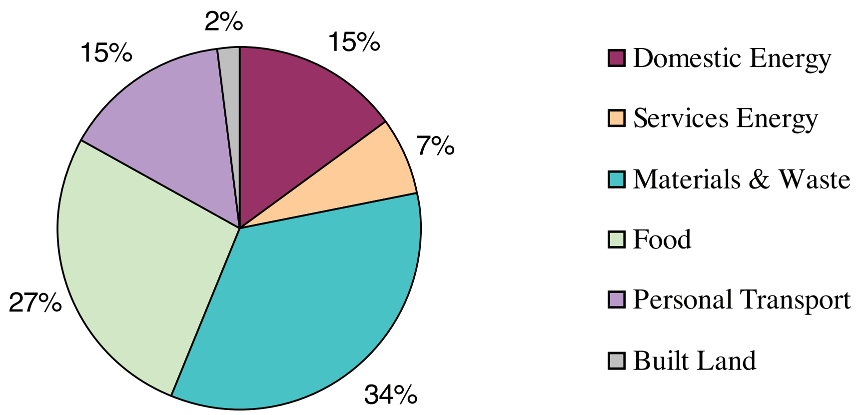


Figure 10: All-island per capita Ecological Footprint by component in 2002

Table 6: Ecological Footprint of Northern Ireland, Ireland and All-Island residents, by component, in 2002

	Ireland 2002			Northern Ireland 2002			All-island 2002		
Component	**Total Footprint (gha)**	**Footprint per capita (gha/ person)**	**% of Footprint**	**Total Footprint (gha)**	**Footprint per capita (gha/ person)**	**% of Footprint**	**Total Footprint (gha)**	**Footprint per capita (gha/ person)**	**% of Footprint**
Ecological Footprint	20,977,870	5.37	100	9,481,962	5.59	100	30,479,832	5.44	100
Of which..									
Direct energy	4,684,113	1.20	22	2,029,463	1.20	21	6,713,576	1.20	22
Of which..									
Domestic Energy	3,142,041	0.80	15	1,585,055	0.93	17	4,727,096	0.84	16
Services Energy	1,542,072	0.39	7	444,408	0.26	5	1,986,480	0.35	7
Materials & Waste	7,146,213	1.83	34	3,241,402	1.91	34	10,387,615	1.85	34
Food	5,569,109	1.42	27	2,335,267	1.38	25	7,904,376	1.41	26
Personal Transport	3,164,162	0.81	15	1,316,716	0.78	14	4,480,878	0.80	15
Built Land	434,274	0.11	2	559,114	0.33	6	993,388	0.18	3

5 Summarising Sustainability

Given the sustainability challenges highlighted by the Island Limits research, it is clear that the development of methodologies and indicators to measure and benchmark progress must always be placed within the context of the moving target of sustainability. The Material Flow Analysis and Ecological Footprint and related sustainability and resource indicators produced by Island Limits represent a contribution to the ‘basket of indicators’ required to measure progress towards sustainable development. No one indicator could possibly hope to capture the complex interplay of environmental, economic and social drivers, pressures and responses that combine to play a part in the sustainable development system.

5.1 Integrated Sustainability Appraisal

A range of approaches has been taken that attempt to summarise and synthesise sustainable development indicators in a way that captures the ‘bigger picture’ for policy and decision makers, and which allows the indicators to be integrated with economic and social indicators. A number of integration methods has been developed – such as triple bottom line accounting (TBL) and sustainability balanced scorecard – as methods of integrated sustainability appraisal.

A range of tools and techniques has been developed, which attempt to summarise the sustainability of a society, region or organisation, by capturing all of the economic, environmental and social criteria or indicators, and presenting these to policy makers in an integrated format, in order to facilitate policy development and decision making. An example of one of these approaches to facilitate integrated sustainability appraisal is set out in Figure 11.

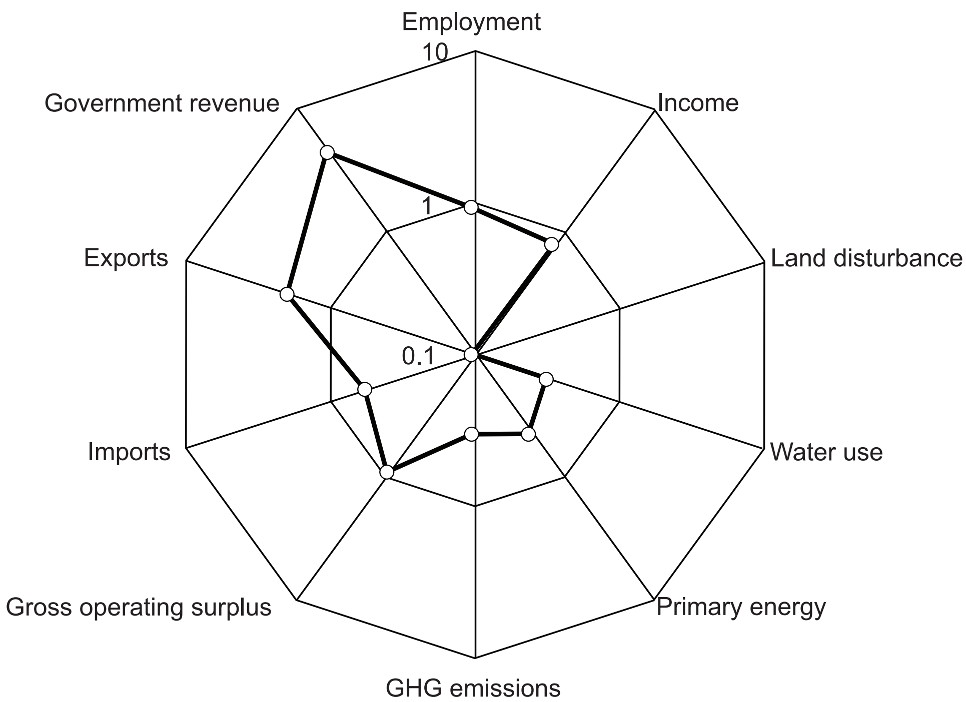


Figure 11: Integrated sustainability appraisal

5.2 Who is this Research For?

Island Limits has produced research to provide an evidence base for policy development and decision making for sustainable development and resource management in Ireland. It has aimed to present the research findings in a way that facilitates its uptake and use. As such, the outputs of the programme can provide an evidence base for decision making for a range of stakeholders, such as:

- **Policy makers:** who need a robust evidence base to underpin the development of sustainable consumption and production policies and actions.
- **Industry:** industrial sectors and businesses can use the results of the environmentally extended I-O analysis to improve their understanding of resource management and environmental impacts of their supply chains. Industry can use the Ecological Footprint to identify where changes in practice and initiatives to enhance efficiency can reduce their footprint significantly.
- **Local authorities:** can use ecological footprinting as an option within the Strategic Environmental Assessment of their development plans.
- **Householders:** can assess their consumption choices and use the EF to inform choices.
- **Non-governmental organisations and community groups:** can use the research in policy and advocacy work.
- **Research community:** has a vital role to play in ensuring that there is a robust and transparent evidence base for sustainable development and sustainable consumption and production policy and decision making.

Island Limits has provided the first step in the production of a system of environmental accounting for Ireland. The evidence base produced by the research can help to underpin the policy and decision making process which will be required for the transformation of the Irish economy towards a sustainable footing. The management of this process will require ongoing research and development in the field of sustainable development and resource use in order to build Ireland's capacity to support policy development and implementation, with a particular focus being required in the following areas:

- **Data:** improved information for environmental accounting and sustainable consumption and production.
- **Measurement and modelling:** continued development of methodologies such as MFA, ecological footprinting and environmental extended I-O analysis.
- **Capacity building:** developing networks and creating capacity building and training programmes for public, private and non-governmental sectors.

5.3 Summary of Key Recommendations

A summary of key recommendations is set out below; the full set of recommendations is set out in Chapter 9 of the main report.

5.3.1 Policy Recommendations

Sustainable use and economy-wide management of natural resources goes far beyond environmental policies. Reducing the dependence from raw materials through more efficient use has been recognised as an option to trigger innovation and foster competitiveness. Therefore, resource efficiency also becomes a key strategy for economic, industrial and technology policies, and also for social policies through securing employment (Bringezu, 2006).

During its presidency of the EU, Finland initiated a discussion on a new generation of environmental policy based around three key objectives: (i) the sustainable use of natural resources; (ii) a 'one planet' environmental policy; and (iii) more effective decision making. The forthcoming revision of Ireland's sustainable development policy offers an opportunity to develop new environmental policies that promote and achieve ecological sustainability, of which the EF is a key indicator. Ecological sustainability should be at the core of sustainable development policy with economic and social and cultural policies aimed at achieving this. The following key recommendations provide a framework for integrating ecological sustainability into policy:

- MFA and associated indicators should be made a core element of the revised Sustainable Development Strategy for Ireland.
- The EF should be made a Headline Indicator within the revised Sustainable Development Strategy for Ireland and as an indicator in local authority policy formation.

- The MFA outputs should be used to inform the development of policies which address total resource use and efficiency of use at both national and sectoral levels.
- The ecological sustainability assessment and scenarios demonstrate the need for policies and actions to reduce the EF. They also demonstrate the challenging nature of changes needed to live within the resources of one planet. The scenarios can be further developed to identify 'win-win' synergies between different policy areas that not only reduce the footprint but contribute to meeting other targets. An example of this is demonstrated in the food scenario. Policies that encourage a move away from chemical-based agriculture would reduce the footprint of food production and also ease the environmental pressures associated with the application of chemical fertilisers in agriculture (and contribute to meeting Nitrates Directive targets).
- A Sustainable Consumption and Production (SCP) plan should be developed; this would change production and consumption patterns and also minimise the exploitation of non-renewable resources.
- The generative capacity of Ireland's renewable resources such as forests and land resources should be safeguarded through policies aimed at halting the decline of biocapacity. This is in line with the common framework of the Thematic Strategy on Soil Protection.

5.3.2 Data Recommendations

In all areas of environmental accounting, one key issue is data availability. Data requirements for the Island Limits project were complicated by the need to integrate data from two jurisdictions with differing systems and policies. The data-related recommendations have therefore been divided into (i) those that the project team believe will facilitate and improve the application of MFA and ecological footprinting to underpin sustainable development decision making in Ireland and (ii) the more problematical recommendations on the development of data systems to support the use of MFA and ecological footprinting on an all-island basis. Data recommendations have also been divided into those appropriate to MFA and ecological footprinting and further subdivided to clarify where these apply to the data gaps and needs for Ireland, or on an all-island basis. Key recommendations are:

- The main barrier to carrying out the analysis was data confidentiality. However, the Central Statistics Office (CSO) facilitated access to the data and agreed a format for publication that met confidentiality requirements and the project team's needs. This arrangement was productive and ongoing communication should be maintained with the CSO.
- Consumption of products is calculated from production and trade data. Trade data should be integrated with ProdCom[3] in Ireland to enable MFAs to be carried out more rapidly.
- Data on hidden flows associated with materials (both domestic and imported hidden flows) should be gathered to enable the calculation of Ireland's Total Material Requirement (TMR).
- There was a lack of data on key MFA and EF components at regional level. Proxy measures could be used to allocate national data on a regional basis for some aspects of the MFA and EF, but not all. Some components such as emissions to air are calculated on a national basis only. Data collection at a regional level should be explored to enable resource accounting at a sub-national level.
- The construction of environmentally extended I-O tables will enable further research which was outside the scope of this study. These tables allow the manipulation of final demand categories and the identification of the impact of this on economic sectors and the relationship between sectors, in terms of flows of materials and changes in total material requirements. The final demand category of most interest is households and further research into changes in demand of households for various consumer goods and how this affected the material requirements of the economy and individual sectors would inform policy makers and contribute to the development of sustainable consumption and production policies.

[3] ProdComm (PRODucts of the European COMmunity), a harmonised system across the EC for the collection and publication of product statistics.

5.3.3 Ecological Footprint Analysis Recommendations

Both the sensitivity of the NFA for Ireland to trade outlined in Chapter 3 of the main report and the initial research undertaken have highlighted the need for further investigation of the NFA for Ireland. This would enable the most accurate calculation of Ireland's footprint that could be compared and benchmarked against other countries. It is recommended that further research be undertaken in the specific areas of trade data and the NFA methodologies. A series of recommendations for the consideration of the GFN and the National Accounts Review Committee is given in Chapter 9 of the main report.

5.3.4 All-Island Analysis Recommendations

- The main data recommendations relating to the all-island model are the lack of Northern Ireland specific data. This necessitates using data derived from UK statistics by proxy measures. This leads to uncertainties around the accuracy of Northern Ireland estimates and therefore the all-island model.
- Northern Ireland is the only region of the UK which does not produce economic I-O tables, and this restricts the region's ability to measure and model economic impacts of policy and fine-tune these to regional conditions. It is not currently possible to carry out the type of environmentally extended I-O analysis delivered for Ireland for Northern Ireland. It is therefore recommended that Northern Ireland develop regional economic I-O tables to enable such analysis to be carried out and to allow further understanding of the industrial metabolism on an all-island basis.

5.3.5 Capacity-Building Recommendations

MFAs provide a foundation for making and evaluating environmental policy decisions at both strategic and operational levels. MFA data can offer policy-makers a sound basis for setting strategic targets and tracking the effectiveness of environmental policies. MFAs offer a common source of data that technical experts, managers and the public can use to set targets and track the effectiveness of environmental policies (WRI, 2005). The World Resources Institute has set out three practical steps that can be undertaken to institutionalise material flow accounts:

1. Develop a network of resource, environmental and economic data providers, including information and statistical offices, to expand and improve the data protocols for compiling and managing the data.
2. Identify the user communities and evaluate methods for presenting material flow data that are policy relevant and accessible to the public.
3. Assemble a broad-based partnership of data providers and users to take the lead in institutionalising material flow accounts.

This process has begun in an informal way during the Island Limits project. Discussions should be held between environmental policy makers in both the Republic of Ireland and Northern Ireland on the harmonisation of data collection and classification systems to facilitate the ongoing use of MFA and ecological footprinting on an all-island basis.

It is recommended that further research to complement and build on the work in Island Limits be undertaken. Options could include the development of an integrated EF/carbon dioxide/material flow I-O model for Ireland. This could be used as one component of an integrated sustainability appraisal of Ireland to provide a fully integrated assessment of the economic, social and environmental status of Ireland's economy. Another option could include the development of a basic physical I-O table for Ireland; the resources required would be dependent on how extensive it was and the mix of physical and monetary data used. Development of a basic physical I-O table would enable the determination of projected material requirements as they would not require projections of future prices in the way environmentally extended monetary I-O tables would (Weisz and Duchin, 2005). Compilation of a basic physical I-O table and a comparison with the environmentally extended I-O table would inform which approach would be most likely to meet policy and decision makers' needs now and into the future.

References

Bringezu, S. (2006) *Materialising Policies for Sustainable Use and Economy-wide Management of Resources: Biophysical Perspectives, Socio-economic Options and a Dual Approach for the EU*. Wuppertal Papers No. 160, Wuppertal Institute, Germany.

Chambers, N., Simmons, C. and Wackernagel, M. (2000) *Ecological Footprints: As an Indicator of Sustainability.* Earthscan, London.

Curry, R., Simmons, C., McDaid, C. and Lewis, K. (2004) *Northern Limits: A Resource Flow Analysis and Ecological Footprint of Northern Ireland.* Arena Network, Belfast.

DOEHLG (Department of Environment, Heritage and *Local Government) (2002) Making Ireland's Development Sustainable. Review, Assessment and Future Action*. DEHLG, Dublin.

European Council (2006) Renewed Sustainable Development Strategy. Document 10117/06. European Council, Luxembourg.

EuroStat (2001) *Economy-Wide Material Flow Accounts and Derived Indicators. A Methodological Guide.* European Commission, Luxembourg.

GFN (Global Footprint Network) (2005) *National Footprint Accounts, 2005 Edition*. GFN, California.

Linstead, C. and Ekins, P. (2001) *Mass Balance UK. Mapping UK Resource and Material Flows.* Forum for the Future. London.

Meadows, D.H., Meadows, D.L., Randers, J. and Behrens, W.W. (1972) *The Limits to Growth.* Universe Books.

Moll, S., Bringezu, S. and Schutz, H. (2005) *Resource Use in European Countries. An Estimate of Materials and Waste Streams in the Community, including Imports and Exports using the Instrument of Material Flow Analysis.* Wuppertal Report No.1. Wuppertal Institute, Germany.

Wackernagel, M. and Rees, W. (1996) *Our Ecological Footprint: Reducing Human Impact Upon the Earth.* New Society Publishers, Canada.

Weisz, H. and Duchin, F. (2006) Physical and monetary input-output analysis: what makes the difference? *Ecological Economics* 57(3): 534–41.

World Commission on Environment and Development. (1987) *Our Common Future. The Report of the World Commission on Environment and Development.* Oxford University Press.

WRI (World Resources Institute) (2005) *Material Flow Analysis. A Tool for Making Environmental Policy.* World Resources Institute Washington DC.

Acronyms

DMC	domestic material consumption
DMI	direct material input
DMO	direct material output
DPO	domestic processed output
EF	Ecological Footprint
EFA	ecological footprint analysis
BFF	Best Foot Forward
GDP	gross domestic product
GFN	global footprint network
I-O	Input-Output
MFA	Material Flow Analysis
NFA	National Footprint Accounts
PTB	physical trade balance
SCP	Sustainable Consumption and Production
TMR	Total Material Requirement

NDP
National Development Plan 2007 - 2013

Science, Technology, Research and Innovation for the Environment (STRIVE) 2007-2013

The Science, Technology, Research and Innovation for the Environment (STRIVE) programme covers the period 2007 to 2013.

The programme comprises three key measures: Sustainable Development, Cleaner Production and Environmental Technologies, and A Healthy Environment; together with two supporting measures: EPA Environmental Research Centre (ERC) and Capacity & Capability Building. The seven principal thematic areas for the programme are Climate Change; Waste, Resource Management and Chemicals; Water Quality and the Aquatic Environment; Air Quality, Atmospheric Deposition and Noise; Impacts on Biodiversity; Soils and Land-use; and Socio-economic Considerations. In addition, other emerging issues will be addressed as the need arises.

The funding for the programme (approximately €100 million) comes from the Environmental Research Sub-Programme of the National Development Plan (NDP), the Inter-Departmental Committee for the Strategy for Science, Technology and Innovation (IDC-SSTI); and EPA core funding and co-funding by economic sectors.

The EPA has a statutory role to co-ordinate environmental research in Ireland and is organising and administering the STRIVE programme on behalf of the Department of the Environment, Heritage and Local Government.

epa
Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

ENVIRONMENTAL PROTECTION AGENCY
PO Box 3000, Johnstown Castle Estate, Co. Wexford, Ireland
t 053 916 0600 f 053 916 0699
LoCall 1890 33 55 99
e info@epa.ie w http://www.epa.ie

SSTI
Strategy for Science, Technology and Innovation

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government