An Ecological Footprint of Liverpool: Developing Sustainable Scenarios

A Detailed Examination of Ecological Sustainability

Authors:

John Barrett
Stockholm Environment Institute

Anthony Scott
Sustainable Steps Consultants

February 2001

northwest development agency

The City of Liverpool

Environment Agency

Government Office for the North West

North West Water a United Utilities company

Foreword

The Stockholm Environment Institute in collaboration with Sustainable Steps Consultants has prepared the following report. It is built on a wealth of experience within the field of developing sustainable indicators for communities, cities and regions.

This report acts as a pilot study to explore the potential use of the ecological footprint as a tool for helping to plan regional sustainability. The study investigates the ecological sustainability of Liverpool, examining what activities have the highest impact and exploring ways to reduce their impacts. The ecological footprint accounting tool is employed to undertake this task.

The principal researcher at SEI was John Barrett. From Sustainable Steps Environmental Consultants the principal consultant was Anthony Scott (contact details can be found overleaf).

Steve Lindfield from Liverpool City Council gave staff-time for the collection of data. Steve was also responsible for drawing the funders together and the work conducted by Steve Lindfield in the Sustainable Development Team at LCC was greatly appreciated.

Contacts

Dr. John Barrett
Stockholm Environment Institute – York
Biology Department, Box 373
University of York
York
YO10 5YW

Tel: 01904 43 4744
Fax: 01904 43 2898
E-mail: jrb8@york.ac.uk

Mr. Anthony Scott
Sustainable Steps Environmental Consultants

Tel: 0151 220 5161
E-mail: tonyscott@uk.packardbell.org

Mr. Steve Lindfield
Sustainable Development Team
Liverpool City Council

Tel: 0151 233 4580
E-mail: steve.lindfield@liverpool.gov.uk

Acknowledgements

First and foremost the authors would like to thank the sponsors of this project. Without their contribution this project would not have been possible. The sponsors were Northwest Development Agency, Government Office for the North West, United Utilities, Environment Agency and Liverpool City Council.

Many organisations and companies provided data for this project. The authors would like to thank the following in particular: -

- The Clean Merseyside Centre
- United Utilities
- Liverpool City Council
- The London Research Centre
- Environment Agency
- Merseytravel
- Merseyside Waste Disposal Authority
- Manweb Electricity
- Dingle SRB Partnership

We would also like to thank Erik Willis for his assistance in the production of this report, as well as the other members of SEI-Y for their thoughts and advice. The authors would like to particularly thank Joe Luckhurst for spending the time and effort in correcting errors and mis-information. Finally, the authors would like to thank Best Foot Forward for their advice and support. Their research into the component ecological footprint approach has been invaluable and many of the algorithms (entitled the 'Eco-Index Methodology)[1] used in this report are based on their initial research. Without this support, such a comprehensive analysis would not have been possible.

[1] The Stockholm Environment Institute has returned to each algorithm that has been used for this report. This has been done by revisiting the original sources of information and re-calculating the algorithms. New sources have also been used, some specific to Liverpool and some generic, which means that many of the algorithms are different to the ones used by Best Foot Forward even though the approach is very similar.

Executive Summary

The project explores the ecological footprint of Liverpool, providing an understanding into the ecological sustainability of the city. Liverpool was selected as the pilot study to examine whether the ecological footprint is an effective measurement of sustainability. The ecological footprint of a designated population is the area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth the land and water is located.

Firstly, an intensive data collection exercise was employed, with the help of Liverpool City Council, to understand the necessary components that make up the footprint calculation. Information was collected concerning transport (both freight and passenger), waste (commercial, domestic and industrial), materials (food, paper and timber), water (domestic and industrial), housing stock and built land, energy use (domestic, Service sector and industrial) and biodiversity protection. All the data helped to establish an ecological footprint of Liverpool.

Liverpool has a total ecological footprint of 4.15-hectares/per capita, compared to the UK average of 4.9 hectares/per capita. This means that the average Liverpool resident requires approximately 4 hectares of land to supply them with all their necessary resources, their transportation needs and the use and disposal of those resources. Of the world's population, 80.3% has an ecological footprint smaller than 4 hectares, and their total share of humanity's footprint is 38.3%. Their average footprint is 1.36 hectares. The other 19.7% of the population occupy 61.7% of humanity's footprint, which in itself is already at least 20% larger than the available capacity of the biosphere. To be considered sustainable, Liverpool would have to reduce its ecological footprint by 130%.

Waste has the highest ecological impact (1.6 Ha./per cap), followed by the provision of bio-resources (1.1 Ha./per cap), then transport (0.7 Ha./per cap) (both passenger and freight), utilities (0.63 Ha./per cap), biodiversity protection (0.3 Ha./per cap) and finally buildings and land (0.1 Ha./per cap).

A sustainable ecological footprint, taking into account the protection of biodiversity, is 2-hectares/per capita. Sustainable scenarios, suggesting how Liverpool could achieve this within three key areas have been developed; these being energy, domestic waste and water.

In the energy scenario three specific areas are highlighted for analysis – the City Council, home energy efficiency and commercial offices. In 1999, LCC consumed 72.4 GWh of electricity, which equated to 6,115 hectares. Several options are available to LCC, which would assist a reduction in energy consumption and its ecological footprint. Firstly, LCC could meet the UK government's targets for energy from renewable resources (5% by 2005 and 10% by 2010). Alternatively, it could set its own target of 20% renewable energy, which would reduce energy consumption by 35%. Furthermore, sufficient installation of Combined Heat and Power systems could reduce costs by 40% and result in energy consumption being reduced to less than 50GWh by 2010. However, by doing nothing, energy consumption will increase to 82 GWh by 2010.

Liverpool has more than 50% of households, which can be considered as being in 'fuel poverty'. Should the full installation of energy efficiency measures be achieved then energy consumption could be reduced by up to 89% with a significant reduction of 53,813 hectares to the ecological

footprint too. Energy consumption in the service sector tends to be ignored because it is assumed that it is a relatively small aspect of company business. However, ignorance could affect company competitiveness. The energy scenario for commercial offices is based on the DETR good office practice, which highlights the need to reduce energy consumption by 57%. Achieving this target by 2010 would result in a reduction of 71.19 GWh. Should the targets that are set in the energy scenarios be attained then the overall reduction of electricity consumption across the city would be approximately 70%.

The waste scenario provides a detailed analysis of domestic waste in Liverpool if a ‘business as usual approach’ is adopted, and the potential reduction with either recycling or composting of materials such as paper, aluminium, steel, plastic and organics. The research illustrates that Liverpool will need to recycle 93% of domestic waste by 2021 just to counteract the projected increase in domestic waste in the city. Therefore, waste minimisation schemes are essential. The scenario indicates the reduction in the ecological footprint with the introduction of various de-materialisation programmes.

The water scenario highlights the reduction in the ecological footprint with a reduction in leakage, as well as considering domestic water consumption. The scenario demonstrates the ecological footprint of key areas within United Utilities such as commercial vehicle use. A programme of toilet cistern replacement would not only conserve water (a saving of one third), it would also save energy (spent supplying the water), which would have a significant impact on the emission of CO_2 and the ecological footprint

Finally, the report examines further uses for the ecological footprint and highlights future research. The report suggests that the ecological footprint is the best available indicator for understanding regional sustainability and that this pilot study has demonstrated this. Therefore, any sustainability appraisal of a city or a region would benefit from the valuable insights that the ecological footprint offers.

Contents

Tables and Figures

Chapter 1

Sustainability, Liverpool and indicators

1.1 Introduction

Globally, probably the greatest challenge to the successful implementation of sustainable development is to change the present unsustainable trend in the consumption of resources and the equally unsustainable production of waste. One way to meet this challenge is to measure and monitor the rate of consumption and the impact of waste production of human activity and its relationship with nature's ability to provide and assimilate.

For many years, economic development and growth have been advocated as the primary solution for achieving societal well-being. Some economists (Lecomber, 1979; Harrison, 1992; Simon, 1994 and Simon and Khan, 1998) have argued that economic growth has been a success and that in general, people have never been wealthier, healthier or lived longer than their ancestors. As a result, people have been able to utilise their acquired knowledge, innovation and entrepreneurial skills to increase well-being and to overcome many of the associated environmental problems thus far. The general assumption by economists is that economic growth is good for the environment because of the relationship between income and some measures of environmental quality.

However, this relationship does not take into account the affect of the depletion of natural resources, which are ultimately finite. In essence, economic evaluation tends to ignore the biological and physical limits of the planet (Daly, 1992). Despite an elevenfold increase in World trade and a fivefold increase in economic development in the past fifty years, other increases include poverty, unemployment and environmental damage (Goldsmith, 1997. Brown, et al, 1998). In reality, only a small proportion of the global population have attained prosperity whilst the remainder endure the negative by-products of development – global warming, deforestation, soil erosion, resource depletion, displacement, poverty and inequality.

1.2 The growth of Liverpool

The development of Liverpool as a major city truly began in the seventeenth century when it's port became the main connection between England and Ireland. The first dock in the World was opened in 1719, which assisted the co-ordination of water-based traffic. Further expansion occurred with the onset of industrialisation when the city was pivotal for colonial trade and central to the slave trade with Africa, Europe and North America. To hasten the processes of trade, the River Mersey and associated docks were strategically linked with the manufacturing regions of Lancashire and Yorkshire via the Manchester and Leeds shipping canals. As a result, Liverpool rapidly became the second busiest port in the world. By 1914, a third of all UK exports and 25% of all imports, were dealt with by the port. In addition, 9 million people left Liverpool for America between 1830 and 1930. The Port of Liverpool, the first 'Freeport' of its type in the UK, is located on the Northeast shore of the river.

Due to continuing economic growth for the best part of two centuries, the population of the city of Liverpool had reached 868,000 by 1937. Since then, the effect of slum clearance, war damage and a migration to the suburbs and beyond has reduced the population to 468,000 at present. Other instances have also had significant impacts on the vibrancy of the city, such as the reduction in employment opportunities, economic decline, physical decay and derelict land and buildings. Nevertheless, the economic legacy of the past has provided Liverpool with a wealth of fine buildings, monuments and parks and the largest collection of museums and galleries outside of London (Liverpool City Council, 1999; Merseyguide, 2000a; Merseyguide, 2000b and GONW, 2000).

1.3 Liverpool today

Despite its past legacy of wealth creation, such has been the decline of economic activity in recent years that Liverpool and the wider region of Merseyside as a whole have been recognised by the European Union as one of the poorest regions in Europe. Since 1994 and up until 1999, Merseyside was the subject of Objective One Funding for the purpose of economic regeneration. A considerable amount of the funding is allocated to the city of Liverpool, as it is the economic focal point of the area. For example, a third of Merseyside's population resides in Liverpool but the city accounts for 40% of employment. This is not surprising as 1.93 million people live within a thirty-minute drive of the city centre. In contrast to those travelling into the city to work, unemployment in 1999, in some parts of the inner city was running at 40% whilst the general unemployment rate for Liverpool was 16.4%, which is more than double the national average (GONW, 2000). The Regional Competitiveness Indicators (Department of Trade and Industry, cited in GONW, 2000) have identified the region as having the lowest GDP per head, the highest unemployment in the UK, the lowest rate for business survival and that social deprivation is more acute than elsewhere in the UK. The resulting effect of Objective One funding has been to stabilise the rate of decline in Liverpool and of Merseyside in general. Objective One Funding is set to continue in 2000, as the region still meets the criteria for economic development and regeneration.

A key goal of the second round of European funding for 2000-2006 is to ensure that economic regeneration is implemented in a sustainable manner. This means "the programme [of regeneration] must have regard to the protection and improvement of the physical environment and the prudent use of resources" (GONW, 2000: 124). It will also important that the activities and environmental impacts of employment creation and economic regeneration are taken into account so as to mitigate for any negative outcomes that may occur against both the physical and natural environment of Liverpool. It is highlighted by GONW (2000: 124) that "The environment represents a key opportunity for business development and improved competitiveness through improved resource efficiency". At present waste management is a serious issue due to the recent reduction in landfill space availability. Moreover, there is still a high level of dependency on fossil fuels for energy, despite Liverpool's favourable geographical location. Having stabilised the downward spiral of decline, Liverpool is in a unique position to ensure that future economic development is implemented in a manner that is sustainable. However, before this can happen the city must measure its present level of sustainability. Only then can it ensure that policies and actions are built around the concept of sustainable development.

1.4 What is sustainable development?

A prospective solution to the global environmental problems that were causing initial concern and which may potentially lay ahead, was first highlighted in 1972, at the United Nations Conference on the Human Environment (UNCHE), in Stockholm. The conference suggested sustainable development as the only way for humans to proceed. Principle 2 states:

> "The natural resources of the Earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems,

> must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate" (UNCHE, 1972, cited in Sunkin, et al, 1999:39).

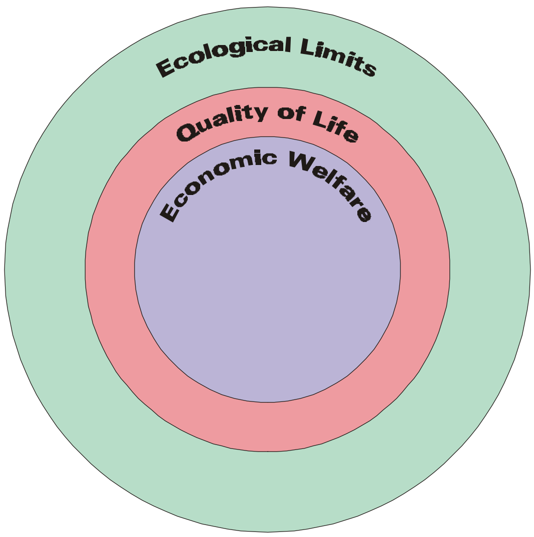
The significance of the Stockholm conference was that for the first time, environmental degradation and its effect upon the human populace were identified as a global issue. Since Stockholm, the notions of protecting and securing the Earth's resources have climbed the political ladder.

In 1987, the World Commission on Environment and Development (WCED) responded to the question of human wants and nature's ability to provide, by re-iterating that such a future could be reached by sustainable means. However, to attain prosperity, justness and security, society would have to adopt different lifestyles, especially the developed countries. The WCED (1987: 43) define sustainable development as

> "development that meets the needs of the present without compromising the ability of future generations to meet their needs
> - the concept of 'needs' of the world's poor to which overriding priority should be given: and
> - the idea of limitations imposed by the state of technology and social organisation on the environments ability to meet present and future needs"

The WCED report reiterated that there was interdependence between the environment, development, inequality and world poverty. Macnaghten and Jacobs (1997) suggest that economic and social systems are bounded by nature and not combined with it. In effect, they are ultimately constrained by nature's ability to provide resources that are ultimately finite (see Figure 1).

Figure 1.1: The natural limits of social and economic systems



Source: Based on Macnaghten and Jacobs, 1997: 9

Within this model, economic growth is not seen as an entity in itself and should not exist outside of society and economic welfare. It is now recognised as only one component of quality of life but if society is to achieve sustainability, quality of life should take precedence over economic growth. The model also provides a new dimension to the idea of ecological limits whereby society must live within ecological limits to be regarded as sustainable, society is imposed upon by the capacity of the biosphere to provide society with all its resources.

This model also helps to reach a more common sense definition of sustainable development. It helps remove the ambiguity of sustainable development that can now be defined as, achieving the highest possible quality of life for everybody within the means of nature. By understanding the Earth's ecological limits, it is possible to improve the quality of life of the most disadvantaged communities whilst always remembering that we live in a world with a finite resource base.

Another dimension of sustainable development is the method by which society moves from the unsustainable present to the sustainable future. The transition must be a democratic process to be regarded as sustainable, with action being taken by the government, businesses and the general public.

1.5 Local Agenda 21

One of the key features of the United Nations Conference on Environment and Development (1992), in Brazil, was Agenda 21. Agenda 21 promotes new forms of collective action with the involvement and co-operation of relevant social actors. Chapter 28 of Agenda 21 identifies local authorities as pivotal actors. Under the auspices of Agenda 21, local authorities are to "take responsibility for introducing, interpreting, adapting and eventually implementing the most relevant aspects of Agenda 21 for their local communities" (Lafferty and Eckerberg, 1998: 2). However, according to Alistair Scott (1999), effective citizen participation is dependent on the willingness of central government and local authorities to delegate real power to people. Participation does not just happen, such barriers as apathy, perceived impotence, suspicion and the lack of information have to be addressed and overcome.

Young (1998) proposes that in order to achieve sustainability there should be a bottom-up strategy (as opposed to the current situation whereby policies are generally dictated from above) with a two-way dialogue between the community and the local authority, which is based on information sharing. Furthermore, greater empowerment should be given to the local people. Macnaghten and Jacobs (1997) suggest that public involvement can result in at least two positive outcomes. The general public can *directly* involve themselves in proactive activities such as energy conservation or waste minimisation. Secondly, taking part in consultation exercises on matters such as policy can *indirectly* influence political decision-making. Therefore, it is imperative that a city like Liverpool seeks to begin this new era in a positive and sustainable manner.

At present, the Environmental Strategy Team of Liverpool City Council is responsible for "encouraging sustainable development and protecting and enhancing the environment" (Liverpool City Council, 1999: 18). The role of the team is to

- Manage and control the Council's environmental performance
- Integrate sustainable development into the Council's policies and activities
- Introduce awareness raising and education within the Council

- Raise the profile of sustainable development amongst the community and the business sector by forming partnerships
- Measure progress towards sustainable development

The Indicators of Sustainable Development (ISDs) devised by the Environmental Strategy Team for the purpose of measuring progress will be evaluated and discussed later.

1.6 Sustainable cities

Although many governments around the world have agreed to aim for achieving sustainable development, it is only likely to be attained with the commitment of local authorities that see a sustainable city as the ultimate goal. Wackernagel (1998) believes that the battle for sustainability will occur in cities and in cities for four main reasons:

1. People power: 45% of humans are currently concentrated in cities and it is likely that this figure will rise to 61% by 2025.

2. Political power: much of the political and economic decisions are administered in cities. The business sector, the educational establishments, middle classes and political activists are also to be found in cities.

3. Economic power: cities are the largest contributors to Gross World Product. For example, 34% of the national population of Chile live in the city of Santiago de Chile and generate 42% of that country's national income.

4. Ecological impact: cities are the hub of consumption and waste production. However, they are becoming more and more dependent on a much wider area for their needs thus having a greater ecological impact.

Since 1990, much has been done by the European Community to promote sustainability, especially in cities. For example, the Green Paper on the Urban Environment (COM (90) 218 final) offers four guiding principles for sustainable urban development (see Table 1.1).

Table 1.1: The four guiding principles for sustainable urban development identified by the European Community

1	Co-ordination/integration – of policy and decision-making for economic development, social policy, transport and the environment.
2	Responsibility – by accepting the consequences of activities at all levels.
3	Sustainability – through long-term environmental and economic objectives, as well as short-term environmental quality.
4	Subsidiarity – of the actions of the European Community by defining the responsibilities between different levels of government.

Source: based on Heathcoat-Amory, 1990: 13.

In 1991, an Expert Group on the Urban Environment was formulated and two years later the European Sustainable Cities Project began. In 1994, the European Cities and Towns campaign was launched. Thus far, the Expert Group has published *European Sustainable Cities*. Part One (1994), and *European Sustainable Cities Final Report* (1996). Nevertheless, the debate continues

(*Towards an Urban Agenda in the European Union,* CEC, 1997). Thus far, the problem of degradation throughout the EU has not been alleviated. In their review of the Fifth Environmental Action Programme, the European Environment Agency, (1995) identified 16 areas within the urban environment that required action. For example, of the 16 identified areas, 14 were related to transport (See Table 1.2). The probable cause of failure is that the measures taken to offset environmental damage are not related to reducing energy use but making energy more efficient (Maclaren, 1996).

Table 1.2: Identified target sectors in the urban environment that require action

	Action required of target sectors identified in the programme					
Action areas	**Industry**	**Energy**	**Transport**	**Agri**	**Tourism**	**Other**
Urban waste water treatment	*				*	*
Air quality – smoke and sulphur dioxide	*					
Air quality – nitrogen dioxide	*	*	*			*
Air quality – lead	*		*			*
Emissions from vehicles			*			
Passenger cars			*			
Commercial vehicles			*			
Diesel engines for tractors			*			
Vehicle emission tests			*			
Air quality - ozone			*			*
Noise – cars, buses & lorries	*		*			
Environmental Impact Assessment	*	*	*	*	*	*
LIFE finance	*		*	*	*	*
URBAN initiative – structural funds	*		*		*	*
Article 10 – ERDF Regulation	*		*		*	*
Structural funds	*		*		*	*

Source: based on European Environment Agency, 1995: 145.

In their final report the Expert Group on Urban Environment conclude:

> ”Sustainable development will only happen if it is explicitly planned for. Market forces or other unconscious and undirected phenomena cannot solve the serious problems of sustainability. Agenda 21 specifies a thorough process of considering a wide range of issues together, making explicit decisions about priorities, and creating long-term frameworks of control, incentives and motivation, combined with specified targets in order to achieve stated aims” (Expert Group, 1996: 239.).

Sustainable urban management should be based on the above process. Many of the examples and guidelines for sustainable urban development produced by the Expert Group on the Urban Environment and the 5th EAP, illustrate that a sustainable city could be achieved. However, in order to achieve a sustainable city, authorities “must have the capacity to manage production and consumption patterns, transport and waste disposal systems with appropriate consideration for their environmental impacts” (Leach, et al, 1997. p705). Using Indicators of Sustainable Development (ISDs) is one method that could enable local authorities to manage production and consumption patterns.

1.7 What are indicators of sustainable development?

As part of the sustainable development agenda, it is essential to monitor Liverpool's 'distance' from sustainability. Where the city is now and where does it want to be in the future?

At a global level it is possible to define limits that should not be crossed. For example, we know that if we chop down all the world's rainforests, there is likely to be some unpleasant global consequences. However, what does this mean within the context of a region? What must a region do (or not do) to be regarded as sustainable?

For a region or city to be sustainable it should not draw more than its fair share of the Earth’s resources. It is not only the internal functions of the city that need to embrace sustainable ideals, but also the city's relationship with the outside world. The impact of transport, waste, energy, water and supplying a city with all its bio-resources and minerals are all sustainability issues. The metabolism of the city gives us a key insight into its affect on the world as a whole. We need to understand the footprint that a city places on the rest of the world. This report goes some way to answering these questions.

Every individual, city or country is a contributor to global unsustainability. Western countries must shoulder a substantial amount of the blame, as they are responsible for the high levels of consumption, a high use of energy and producing large amounts of waste. It is unlikely that the planet can accommodate an urbanised humanity that routinely draws resources from ever more distant hinterlands or continues to use the biosphere and oceans as sinks for waste. Wackernagel and Rees (1996: 40) echo this statement by suggesting that,

> "Gaining acceptance for strong sustainability hinges on finding a meaningful unit to measure the natural capital requirements of the economy,"

How can a region assess whether it is living within the global capacity? What resources are available to that region without appropriating more than their share of the Earth’s resources? It is one thing to understand global carrying capacity, but quite another to understand whether the United Kingdom, or in this study, whether Liverpool is sustainable.

Indicators are an essential component in the overall assessment of the progress towards sustainable development. Given that indicators are dependent on available data and cost, they are invariably biased but this is inevitable. Table 1.3 highlights some specific definitions of indicators.

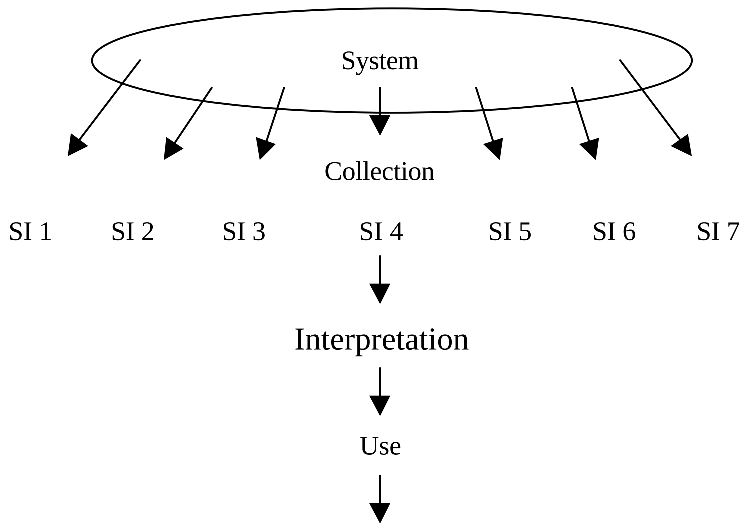
Table 1.3: Specific definitions of Indicators

Authors	Definition
Holling, et al 1978	'A measure of system behaviour in terms of meaningful and perceptible attributes'
McQueen & Noak, 1988	A 'measure that summarizes information relevant to a particular phenomenon, or a reasonable proxy for such a measure'
Chevalier, et al 1992	A variable 'hypothetically linked to the variable studied which itself cannot be directly observed'
OECD, 1993	'A parameter or a value derived from parameters, which points to/provides information about/describes that state of a phenomenon/environment/area with significance beyond that directly associated with a parameter value'

Source: based on Gallopin, 1997: 13

In essence, "Desirable indicators are variables that summarise or otherwise simplify relevant information, make visible or perceptible phenomena of interest, and quantify, measure and communicate relevant information" (Gallopin, 1997: 15). Figure 1.2 illustrates the application and use of suitable indicators.

Fig 1.2: The application and use of suitable indicators (SI 1 etc) of sustainable development



Usages

- To assess conditions and trends
- To compare across places and situations
- To assess conditions and trends in relation to goals and targets
- To provide early warning information
- To anticipate future conditions and trends

Sources: based on graphic adapted from Bell and Morse, 1999: 23. Usages adapted from Gallopin, 1997: 15

The fundamental use of indicators is to reinforce and advance policy and decision-making. However, in a global perspective, the different uses of indicators by individual countries can pose serious constraints to the meaningful use of the same indicator. Therefore, experts and policy-makers have suggested that the development of indicators should be encouraged for use at the sub national level, or preferably, at the community or local level (Gallopin, 1997). “An important and often neglected prerequisite for the usefulness (and acceptance) of indicators is that the users must understand them” (Gallopin, 1997: 25). In other words, they should relate to concepts that people can easily and readily comprehend (Morrey, 1997). A significant attribute of a suitable indicator is that it must communicate relevant information to those (at all levels) that are involved in the process towards sustainable development. Therefore, they must be fully transparent, must enable empowerment and be accepted politically, both at the national and local level. Table 1.4 highlights a list of the more desirable aspects and general requirements of suitable indicators.

Table 1.4 Requirement for suitable indicators of sustainable development

1	The value of the indicators must be measurable (or at least observable)
2	Data must be either already available or they should be obtainable (through special measuring or monitoring activities)
3	The methodology for data gathering, data processing, and construction of indicators must be clear, transparent and standardized.
4	Means for building and monitoring the indicators should be available. This includes financial, human, and technical capacities.
5	The indicators or sets of indicators should be cost effective, an issue often overlooked.
6	Political acceptability at the appropriate level (local, national, international) must be fostered (indicators that are not acceptable by decision-makers are unlikely to influence decisions).
7	Participation of, and support by, the public in the use of indicators is highly desirable, as one element of the general requirement of participation of the broader society in the quest of sustainable development.

Source: based on Gallopin, 1997: 25

Sustainable indicators can be key mechanisms for encouraging progress in the right direction. Such indicators provide a measuring tool that gives a clear understanding as to whether a level of sustainability is being attained. According to Pearce (1995; Krotscheck, 1997; Khanna, et al, 1999 and Mittler, 1999), the only way to translate sustainability is to measure the ecological capacity of a society. Put simply, the first step is to measure society’s present impact on nature, or else sustainability cannot be planned for. The next step is to monitor progress towards sustainability over time.

1.8 Liverpool’s indicators of sustainable development

The Local Agenda 21 team of the City Council produced a set of indicators of sustainable development in 1998. The publication ‘*Liverpool the changing environment*’ comprises of 56 indicators and 13 headline indicators. Table 1.5 consists of the headline indicators whilst all 56 indicators can be found in appendix 1.

Table 1.5: The headline indicators of sustainable development for Liverpool, 1998.

1	Built environment
2	Natural environment
3	Air quality
4	Water
5	Waste
6	Energy
7	Transport
8	Health
9	Housing
10	Economy and work
11	Education
12	Crime
13	Community involvement

Source: based on LA 21 team, 1998

The purposes of the indicators are to "reflect the concept of sustainable development regarding the issues and concerns facing Liverpool today" (LA 21 team, 1998: 1). The terminology used to identify indicator movements are characterised either by a tick (positive change), a question mark (no change) and a cross (negative change). The indicators tell us such things as the number and area of conservation areas (Built environment), area of vacant land (Natural environment), carbon monoxide levels (Air quality) and household refuse per property (Waste). However, none of the indicators show what the Council's aims are in respect of indicator movement. For example, the headline indicator *Air quality* has 10 supporting indicators (CO_2, SO_2, NO_2, Benzene, 1,3-Butadiene, Pb, O_3, PM10, Smoke and SO_2 and Indoor air quality), which are potentially hazardous when the standards set by the DETR's Expert Panel on Air Quality Standards (cited in publication) are exceeded. In this instance what would be the overall impact on air quality should 50% of the indicators exceed the set standard and the remainder do not? To some it may appear obvious that standards should not be exceeded but a prerequisite of an indicator is that it must be clearly understood by users, including the general public.

In comparison, the UK government sets actions and commitments in respect of all its indicators of sustainable development (DETR, 1999). For instance, on matters of air quality, the government's key actions and commitments are:

- Consulting on proposals to tighten objectives in National Air Quality Strategy
- Move towards long-term European goal of not exceeding critical loads for acidification
- Reduce acid emissions so that the UK area at risk from acid rain is significantly reduced by 2010
- Tighten controls on ozone depleting substances

The government firmly believes that local authorities have a duty to assess air quality in their regions and should it be found that standards are being exceeded they should "designate air quality management areas and produce management plans" (DETR, 1999. paragraph 8.23).

Generally, Liverpool's indicators of sustainable development can be described as almost meeting Gallopin's definition of a suitable indicator in that they convey information on the condition and state of an attribute or attributes of a system. For example, the headline indicator *Air quality* and its supporting indicators explain the state of air quality in Liverpool. However, the headline indicators do not summarise the situation either individually or collectively. In addition, the publication does not simplify the information or have a set of measurable targets so that it can be used as a communicator that makes sustainable development more comprehensible for the general public.

1.9 The problems of existing indicators

In summary, there are a number of problems that exist with the sustainability indicators selected for Liverpool. These being: -

- It is not possible to compare the effect of the indicators on a parallel scale. For example, does domestic waste production have a greater ecological impact than industrial energy consumption? The indicators in place do not have the ability to answer this question. This problem is not exclusive to Liverpool's indicators; it is also a problem with indicators used from the government to the local level.
- The indicators provide no suggestion as to when a particular activity is sustainable. What is a sustainable level of waste production or water consumption?
- The indicators cannot be understood easily.

The ecological footprint can provide some of the answers to these problems. The next chapter introduces the ecological footprint and explains why it has the ability to solve many of the problems surrounding local sustainability indicators.

Chapter 2

Comparing nature's supply with human needs: Introducing the ecological footprint

2.1 What is meant by a finite world?

When looking at the world as a whole, it is easy to visualise the finitude of the planet. When, for the first time in July 1969, humanity saw the image of the Earth as a whole, never had the finiteness of our planet been more real.

Everything that we need must be provided from the finite resources of the Earth. We must be able to provide all the necessary food, timber and minerals to provide nourishment and shelter. Sustainability adds another unique element to this. We must be able to provide everyone with these basic human needs. This is becoming a more and more difficult task, because as more and more people inhabit the Earth and less land is available, their equal share diminishes.

2.2 How much land have we got?

Given that the amount of land available for humanity is essentially finite, and thus its productivity ultimately bounded, issues of equity cannot be ignored. Indeed, few would disagree that there are currently considerable inequities in the global economy, with 20% of the planet's population currently consuming 83% of its resources.

An 'Earthshare' is the average amount of ecologically productive land (and/or sea) available globally per capita. This has been calculated on the premise that every individual in the entire world has an equal right to land. By adding up all the various productive land types (see Table 2.1), 2.3 hectares of biologically productive space is available per person (Wackernagel et al, 2000a).

Table 2.1: The ecological benchmark for sustainability

Productive Land Type	Hectares available per capita
Arable Land	0.25
Pasture	0.6
Forest	0.9
Built-up land	0.06
Sea Space	0.5
Total	**2.3**

Source: based on Wackernagel et al, 2000a

However, it is important to protect some of this land for biodiversity. With a planet of over 30 million other species, not all this land can be considered purely for human use. The World Commission on Environment and Development has suggested that 12% of productive land should be preserved for biodiversity protection. However, this has been criticised as being insufficient but may be a politically feasible target (Noss & Cooperrider, 1994). Meadows & Meadows (1992) highlight the importance of biodiversity protection believing that the annual rate of species loss is 1,000 times higher than the natural rate of extinction.

It is almost impossible to derive one figure that is necessary for biodiversity protection. Each region or country will need to understand the distinctive nature of biodiversity for their region, making an overall figure inconsequential. Moreover, Noss and Cooperrider (1994) believe that the minimum percentage of bio-productive land that needs protecting is 25%. Therefore, the following figures can be calculated for a sustainable Earthshare per capita: -

- If the view is adopted that no land needs to be preserved for biodiversity protection = 2.3 ha./per capita
- If the WCED figure of 12% is adopted = 2 ha./per capita
- Finally, if Noss and Cooperrider minimum figure of 25% is accepted = 1.6 ha./per capita

These figures are constantly changing due to the rapid rise in world population and the erosion of soil; therefore less land has to be divided between more people. Wackernagel et al (2000) suggest that within the next 30 years the bio-productive land per capita could decline to 1.2 hectares with a world population of 10 billion.

Accepting that the figure for biodiversity preservation is at least 12 percent, it becomes apparent that humanity must learn to live equitably within a land footprint of around 1.3 hectares or 3.2 acres. Assuming that the population increases to 9.8 billion, the above figure will drop to just over 0.8 of a hectare.

2.3 How much land do we need? Introducing the ecological footprint

Land provides us with all our resources from minerals for building and food for living. Not only does land do this; it also absorbs the waste we produce, both solid waste and atmospheric emissions. Land also provides important life-functions without which, the human species would not survive. For example, land activities regulate ecological systems and climate.

With a diminishing amount of land available due to erosion, sea level rise, desertification and an increase in the world's population, land is becoming a very valuable and scarce resource. It is important to measure the amount of land we require and compare this with how much is actually available. It is essential to start monitoring whether we are living within the means of nature.

The ecological footprint has received a lot of attention recently as a potential aggregated indicator for sustainable development. It has the ability to answer the question, "How much land do we need?" and compares this with how much land we have. It has grown in popularity having now been applied to countries, regions, industry, product evaluation and individual case studies (Rees, 1992; Wackernagel and Rees, 1996; Simmons and Chambers, 1998; Wackernagel et al, 2000). Each year the ecological footprint has become more refined, portraying a more and more accurate figure of the land appropriated by humans.

The ecological footprint is a measurement of ecological sustainability, illustrating the reality of living in a world with finite resources. It provides a final figure in land area (hectares) that is required to support an individual, city, region, country or the entire world population. It provides a visual picture of the Earth's carrying capacity. This is one of the most important reasons for its popularity: individuals can resonate with a land area. It has many important features that have close connections with one of the central themes of sustainable development: ecological limits.

Wackernagel (1994: 68) provided the first definition of the ecological footprint and defined the concept as: -

> "The aggregate land (and water) area in various categories required by the people in a defined region
>
> a) to provide continuously all the resources and services they presently consume, and
> b) to absorb all the waste they presently discharge
>
> Using prevailing technology."

In other words, the ecological footprint is the total land area required to support a given population with the resources they consume and absorb all the waste they produce. It provides a valuable insight into the carrying capacity of the Earth and human appropriation of resources. Through the ecological footprint it is possible to compare 'human demand and nature's supply'.

The ecological footprint confirms Ehrlich and Holdren's definition of human impact on the environment. This being:

$$I = PAT$$

Where I is Impact, P is population, A is affluence, and T is technology (Ehrlich & Holdren, 1971).

In the Ehrlich-Holdren formulation the impact (I) corresponds to a population's ecological footprint and is a function of population size and consumption (converted into a land area) (Rees, 2000). Consumption is a function of affluence (A) and the state of technology, therefore presenting a land-based analogue of PAT (Rees, 2000).

2.4 The appealing nature of the ecological footprint

Van Vuuren, Smeets & de Kruijf (1999) have suggested six reasons why they believe the ecological footprint has attracted so much attention as a potential indicator for sustainable development. This list acts as a summary explaining its popularity.

1.The Consequences of Consumption
In the past, the approach of environmental policy has been towards the reduction in pollution levels and achieving safe standards for emissions (considering environmental and human health consequences). Increasing levels of consumption were, and still are, partly ignored. The ecological footprint has the ability to highlight the true consequences of consumption (such as global warming) and is proposed as the indicator that demonstrates this more clearly than any other.

Van Vuuren, Smeets & de Kruijf (1999:19) believe that the ecological footprint has the ability to focus on three key issues associated with consumption. These being: -

- The squandering of resources;
- Impacts of the size and composition of consumption patterns;
- Geographic re-allocation of environmental pressures.

2. Renewable resources
The ecological footprint identifies key resources for achieving sustainable development that are included in the calculation procedure, these being land and carbon dioxide levels. UNEP (1999) have highlighted the importance of land as a resource believing land is becoming increasingly

scarce. Lester Brown (1999) sees land as a finite resource believing this to be one of the major challenges for sustainable development.

> "The effects of the acute cropland scarcity emerging in some countries could affect many other areas of human activity." (Worldwatch Institute, 1999: 123)

3. Distribution of environmental resources and ecological limits
The ecological footprint establishes an ecological 'bottom line' that should not be crossed if a sustainable society is to be achieved. This places the issues of rapid population growth and the development of poorer countries in perspective. During this century, rapid growth in population has occurred in the poorer countries, thus placing increasing pressure on resources. The ecological footprint raises the question as to how we are going to distribute our environmental space to cope with the proposed increase in the use of resources. A key point raised by Lester Brown.

> "This impressive century of growth unfortunately has not translated into adequate food supplies for the Earth's inhabitants. An estimated 841 million people remain hungry and undernourished…" (Worldwatch Institute, 1999:116)

4. Environmental consequences of trade
The ecological footprint has been criticised for promoting regional self-sufficiency over global interdependence. However, Wackernagel and Rees (1996) have stated that it is not anti-trade per se, but is examining trade from an ecological perspective. It is clear that the aim of trade is to increase the flow of resources across the world; this is evident in the opening up of new markets that did not even exist at the beginning of this century. The ecological footprint is making the link between environmental impact and human consumption.

5. *The ecological footprint as a communication tool*
The ecological footprint is both a powerful and visual tool, which explains its popularity among many groups. It can be calculated on all levels from the individual to the entire Earth, thus helping to relate the issue of individual's lifestyle to global environmental problems, such as global warming. Each individual has the potential, through the eyes of the ecological footprint, to understand their contribution to global environmental crises.

6. Aggregation
The aggregation process within the ecological footprint has been criticised for only being able to provide a rough indication of sustainability. However, this does provide a means to compare the impact of various activities on the same level. This is seen as a powerful element of the tool.

2.5 The component ecological footprint approach

The component-based approach, first documented by Simmons and Chambers (1998) and then Simmons, Lewis and Barrett (2000) is a different approach to ecological footprinting. Instead of considering the consumption of raw materials, it considers the effect of transport, energy, water and waste. It has a more simplistic and educative structure with more significance to the regional level. This is mainly because it is built around activities that people can resonate with and participate in (i.e. we all produce waste and consume electricity). Simmons and Chambers (1998) calculated the first series of algorithms capable of converting resource use to land-area equivalents, entitled the 'Eco-Index Methodology™'[2]. Since then, the Stockholm Environment Institute has adopted and expanded Simmons and Chambers pioneering approach.

In the component-based model, the ecological footprint values for certain activities are pre-calculated using data appropriate to the region under consideration (Simmons, Lewis & Barrett, 2000). Within Wackernagel's approach (known as the compound ecological footprint) six major land types of productive space are used: fossil energy land, arable land, pasture, forest, built land, and sea space. The compound approach considers the human demand on each of those land types for a given population, wherever that land may be. The component approach retains the original philosophy behind footprinting but converts these into activities. By understanding the 29 components used by the Stockholm Environment Institute, it is possible to understand most of the ecological impact of a community. No model can ever claim to have incorporated the total land requirement of all human activity, but early research conducted by the Stockholm Environment Institute and Best Foot Forward suggests that the component approach considers most of the impacts (between 80 and 90%)[3]. The main categories are listed below (Table 2.2). It is important to note that many of these categories are divided even further in the actual study. For example, the waste data has been divided into 18 different categories, while the water data has considered the ecological footprint of water supply and wastewater treatment. This highlights the importance of the provision of sufficient data so that a more accurate footprint can be undertaken.

Table 2.2: The components used in the Liverpool project

COMPONENTS	
Electricity (Domestic)	Recycled Waste (Domestic)
Electricity (Service sector)	Commercial Waste
Electricity (Industrial)	Commercial Recycled
Electricity (Council Services)	Composted Waste
Gas (Domestic)	Inert waste
Gas (Industrial)	Food
Coal (Domestic)	Timber
Oil (Domestic)	Water
Travel by car	Waste water
Travel by bus	Road Freight
Travel by train	Sea Freight
Travel by air	Air Freight
Travel by ferry	Rail Freight
Built Land	Housing Stock
Household Waste	

A further explanation of the component ecological footprint model has been given below.

2.6 Life cycle approach to footprinting

Even though the component approach has the added advantage of providing a detailed breakdown of the footprint, allocation problems do exist. What the component model of footprinting is

[2] The Eco-index methodology is a trademark of Best Foot Forward (an environmental consultancy based in Oxford who pioneered the component approach). Please visit their website for further details on other publications concerning the ecological footprint. (www.bestfootforward.com)
[3] For further information on this study please contact the author (John Barrett)

attempting to do is capture all human consumption for a particular given population. This can be seen in figure 2.1 below.

Figure 2.1: The life cycle of human consumption and waste

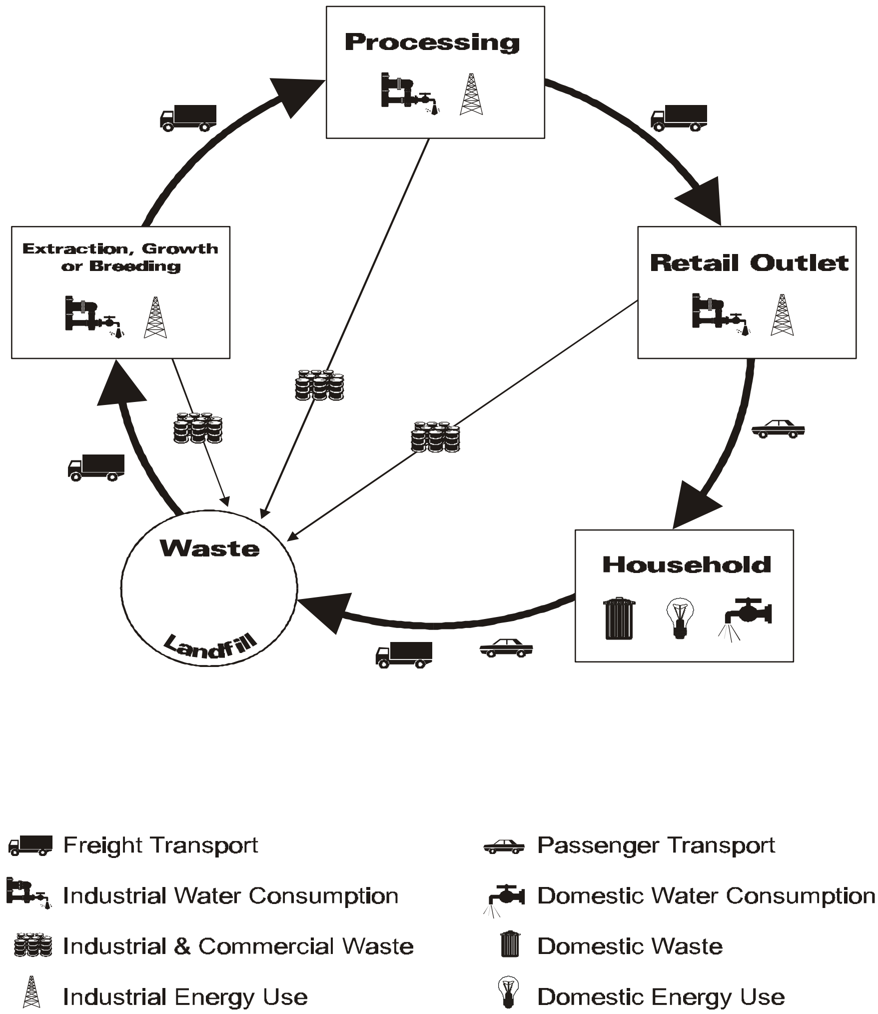


Figure 2.1 provides an understanding of what can be calculated. Firstly, the model starts with the extraction (minerals), growth (trees) or the breeding of an animal for human consumption. Both energy and water use are associated with this procedure. Freight transport is then required to move the produce to the factory for processing. At this stage, there is a large demand on industrial energy and freight transport to bring the many different products to the factory. An excellent of example of this is Boge's 'Strawberry Yoghurt Pot'. The yoghurt and its ingredients and the materials used for the glass cup made journeys totalling 3,500 km. The strawberries for example, came from Poland to be processed in Germany, the corn/wheat starch came from Amsterdam, via Cologne and then finally to Stuttgart. The aluminium sheeting came from Australia, via Norway and Neuburg (southern Germany) before reaching Stuttgart (Weizsacker et al, 1998).

Boge's calculations of the strawberry yoghurt not only demonstrated the substantial impact of freight transport but also the difficulty in collecting data like this. It is near impossible to find this much data for every product. The component footprint does provide part of the answer. It can calculate both the impact of freight transport (air, sea or road) and industrial energy use. It would be a major achievement to have a footprint figure on every product, however at present this is unrealistic.

Following further freight transportation to deliver the final product to the retail outlet, the footprint now attempts to include all the domestic impacts. These include passenger transport (car, bus, train and air) as well as domestic energy consumption and water use. After the product has been brought into the domestic environment it is disposed of (often as packaging) and will leave as waste. At this stage the footprint can distinguish between the final disposal methods. If the item is disposed of to landfill the embodied energy in that item is lost; therefore it has a footprint of the embodied energy of the item. If the item is recycled the embodied energy is saved, so the footprint is merely the energy required to recycle the product.

2.7 Conclusions

The component approach offers a unique opportunity to understand the ecological impact using comparative data and is much more personal to the region that is being studied. The next chapter explains the specific methodology employed for each separate calculation in the ecological footprint of Liverpool. To make the data more specific to Liverpool, new algorithms have been devised, which use the latest available data.

Chapter 3

The ecological footprint of Liverpool

3.1 The calculation procedure

This chapter presents the ecological footprint of Liverpool, the calculations employed for both the algorithms and consumption data, and the assumptions required.

The founders of the component approach are willing to accept that there is insufficient data to provide a truly accurate picture of human appropriation. The accuracy of the footprint is totally dependent on data availability. The footprint is flexible enough to cope with a diverse range of data, however assumptions need to be made. The better the data, the less assumptions and the more credible the final result becomes. In the case of the Liverpool project over 85% of the data collected is specific to Liverpool and gained from reputable sources. This does not mean that the remaining 15% is inaccurate. It just means that certain assumptions have been made. For example, the original data may have been specific to Merseyside and not Liverpool, meaning that the figure has had to be proportioned to Liverpool. The project has attempted to use specific data to Liverpool as much as possible within the constraints of time and resources.

3.2 The ecological footprint of passenger transport

To calculate the impact of car travel, fuel consumption, manufacturing and maintenance energy, land-take and distance travelled are derived. From this, an average ecological footprint estimate is derived for a single passenger-km. This can then be used to calculate the impact of vehicle use at the individual, organisational or regional level as required. Table 3.1 explains the calculation.

Table 3.1: An example analysis for the footprint of UK car travel per passenger-km.

Component	Additional Information	CO_2 Emissions	Built-Upon Land	Footprint
[1]Petrol		0.201 Kg/km		0.00003932 Ha/Car Km
[2]Maintenance & Manufacture		0.091 Kg/km		0.00001769 Ha/Car Km
[3]Road Space			3,047,145 Ha	
[4]Car Road Share	86%			
[5]Car Kms (000's)	6,160,000,000			
[6]Car Occupancy	1.6 persons			
CO^2 Sequestration Rate (CO^2/Ha.)	0.0001954			
Footprint			0.00000004 Ha/Car Km	0.0000364 Ha/passenger-km

[1] The UK Emission Factors Database (2000)
[2] Wackernagel and Rees (1996)
[3] DETR (1999) with an estimated average road width of 8.2m.
[4] DETR (1999, page 39)
[5] British Road Federation (BRF, 1999)
[6] DETR (1999) National Travel Survey (Figure 5.2)

Source: Updated from Simmons, Lewis & Barrett (2000)

To calculate the car transport figure, built land is included in the total. This includes the amount of built-on land for roads. The total figure of 2,571,747 hectares represents the total road space in the UK. This figure is divided by the occupancy of cars on the road (i.e. the car road space). The final calculation is the total kms travelled by cars in the UK to provide a Ha/per car km figure of built-upon land for cars. The final Ha./passenger-km figure for a car is calculated by adding the footprint of petrol, maintenance and manufacture and the built-upon land (i.e. roads), which is then divided by the average car occupancy.

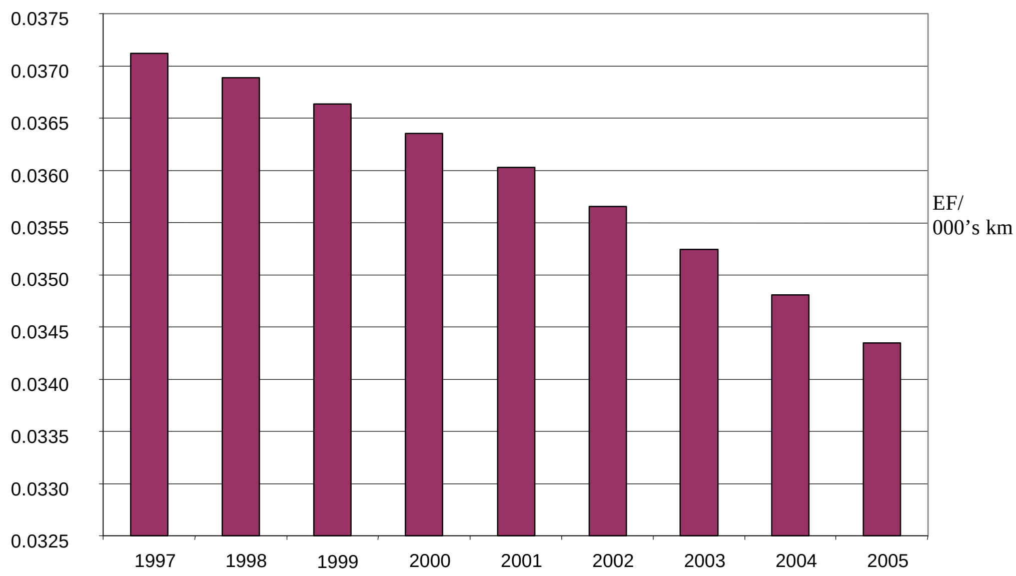
3.2.1 Change in efficiency over time

While this calculation procedure for the ecological footprint of a car passenger km may only point to reducing the distance travelled in cars to reduce the ecological footprint, this is not necessarily the case. The actual algorithm will change over time, representing increases in the efficiency of cars, which produce less carbon emissions. An increase in car occupancy and even the speed with which the car travels are other factors that change the algorithm.

3.2.2 Increase in fuel efficient engines

Over the last few years there has been a significant increase in engine efficiency meaning that less carbon dioxide is produced for every km travelled. This increase in efficiency can be documented by using the ecological footprint. Figure 3.1 below highlights what will happen to the ecological footprint of car travel with a projected increase in eco-efficiency until 2005.

Figure 3.1: Decrease in the ecological footprint of cars with an increase in efficiency



Sources: UK Emissions Database, 2000; The London Research Centre, 2000

3.2.3 Increase in car occupancy

At present, there is only an average of 1.57 occupants for an average car journey in the UK. This, obviously, can increase and therefore can decrease the passenger car footprint/per km. The ecological footprint at present for every km travelled is 0.0000364 ha./per km. If the average car occupancy was 2.5 this figure would reduce to 0.0000228 ha./per km, a reduction of 37% for every kilometre travelled.

3.2.4 Increase in road space

Over the last ten years the total road space has increased by 4.3 %, meaning an average increase of 0.43% per year. By applying this figure over the next ten years, it is possible to calculate the total road space occupied by cars, and must be added to the total footprint calculation for passenger transport by cars.

3.2.5 The transport footprint model

The model can now be put into a calculator, where it is easy to develop scenarios. For example, in 2005 what will the ecological footprint of passenger transport be when taking into account the inevitable increase in fuel efficiency, an increase in car occupancy to 2 passengers per car and if drivers travel at the most energy efficient speed? The ecological footprint can easily predict this. What it can also do is incorporate other aspects such as what will the ecological footprint be if a more efficient and reliable bus service is introduced? What will the ecological footprint be with the introduction of new train stations into urban areas? The model is flexible enough to deal with changes in behavioural patterns and technological advances. It can combine as many aspects as is required to demonstrate the effect of passenger transport into the future.

The same process can be undertaken for other forms of travel. Table 3.2 below explains the other forms of transport within the calculation. By using these calculations it is possible to compare the ecological footprint of bus, car, train, motorcycle and air travel.

As with the final figure for the ecological footprint of a passenger car km, the ecological footprint of bus will vary with efficiency and occupancy. In the UK the average bus occupancy is 12-passengers/per bus. However, specific local data supplied by Merseytravel indicates that the average occupancy for a bus in Liverpool is 9 passengers[4]. This will have an effect on the footprint per passenger using the bus. It also offers an opportunity to compare the ecological footprint of bus travel between the national average and Liverpool.

[4] The above figure for Liverpool bus occupancy (9 passengers) is a generic figure for Merseyside. Merserytravel suggest that the figure could be potentially higher because Liverpool is a densely populated urban area.

Table 3.2: The ecological footprint of various forms of travel

Transport Type	**Footprint (Ha./per year)**	**Assumptions**
Car	0.0000364 Ha./ Passenger km	• Average petrol car fuel consumption • (Source: UK Emissions Database) • Road space & average car occupancy • Embodied energy
Bus	0.0000293 Ha./ Passenger km	• Carbon dioxide emissions from fuel • (Source: UK Emissions Database) • Carbon dioxide emissions from maintenance and manufacture • Apportioned road space
Motorcycle	0.0000207 Ha./ Passenger/km	• Carbon dioxide from fuel • (Source: UK Emissions Database) • Carbon dioxide emissions from maintenance and manufacture • Apportioned road space
Train	0.00000241 Ha./ Passenger/km	• Carbon dioxide from fuel • (Source: UK Emissions Database) • Carbon dioxide emissions from maintenance and manufacture • Apportioned road space
Air	0. 0000735 Ha./ Passenger km	• Based on data from UK Domestic Flight • (Source, DETR) • Energy land • Degraded land

3.2.6 Consumption data for Liverpool

All the consumption data for Liverpool, concerning passenger transport was provided by Merseytravel and Liverpool Airport and cross-referenced with national comparisons. Every year Merseytravel re-calculates their key indicators providing up-to-date consumption figures. This also makes it possible to compare year on year, the changes in the ecological impact of passenger transport. Table 3.3 below provides the data supplied by Merseytravel converted into an ecological footprint figure.

Table 3.3: The ecological footprint of passenger transport in Liverpool

Component	Consumption Pass/km/yr (000'S)	Conversion	Footprint	Reference
Travel by car	4,105,751	0.036	149,269	Merseytravel
Travel by Bus	702,198	0.029	20,574	Merseytravel
Travel by Train	333,656	0.024	8,022	Merseytravel
Travel by Motorbike	661,538	0.020	8,600	Regional Trends/ BRF
Travel by air	10,140,169	0.073	69,134	Peel Holdings

The figures above demonstrate that the ecological footprint of car travel is substantial compared to all the other forms of transport put together. There is also the concern of the growing amount of air travel. Air travel does have the highest ecological footprint per passenger km and is a fast growing industry. With a predicted doubling of passenger kilometres by air in the next 12 years, the effect of air travel will be similar to that of car travel. These figures clearly add support to the promotion of more forms of sustainable transport (such as cycling, the train and bus). The ecological footprint of travel also questions the need to travel in the first place as all forms of travel have some impact, as can be seen from the conversion factors in table 3.2 (i.e. all forms of travel have some impact, apart from walking).

By placing these figures into a per capita footprint it is possible to compare Liverpool's situation with the UK, or other cities in the UK. Table 3.4 provides a comparison of the UK ecological footprint for the different modes of travel with that of Liverpool.

Table 3.4: A comparison of the ecological footprint of passenger travel between Liverpool and the UK

Component	**Liverpool (Ha./per capita)**	**UK (Ha./per capita)**
Travel by car	0.35	0.39
Travel by bus	0.05	0.02
Travel by train	0.02	0.02
Travel by taxi[5]	0.01	N/A
Travel by motorbike	0.02	0.02
Travel by air	0.16	0.18
TOTAL[6]	**0.60**	**0.63**

It can be seen that for bus travel, the ecological footprint algorithm is lower on a national scale than Liverpool. The residents of Liverpool travel further by bus. This means that the ecological footprint of bus travel in Liverpool is over double the national average. It is important to remember that the ecological footprint of bus travel is nearly half as low as travelling by car. It demonstrates a higher percentage of residents in Liverpool use the bus as opposed to car travel. One of the possible explanations is a low car ownership within the city. It is estimated that car ownership in Liverpool is 0.250 per person, which is the lowest ownership of all Merseyside boroughs (MerITS, 2000). There would also be a decrease in the ecological footprint per passenger-km if passenger occupancy were higher per bus.

Liverpool is starting from a point that is lower than the national average. With a total ecological footprint of 249,400 hectares the ecological impact of passenger travel is still substantial. Basically, an area the size of Luxembourg is required to provide the needed road space and for sequestration of all of Liverpool's carbon emissions.

[5] The data on distance travelled by taxis was obtained by approaching taxi drivers and findings out how far they travel in one year. Many taxis in Liverpool are run 24 hours a day and the estimated distance of one taxi in Liverpool is 128,000 km. There are also 1470 taxis in operation within the city second only to London. To calculate the ecological footprint of the taxis it was assumed that they are diesel driven.

[6] In figure 3.4, the final figure for Liverpool does not include the taxi footprint as there was no national comparison available.

3.3 the ecological footprint of freight transport

The ecological footprint of freight transport considers air, sea, road and rail. It is calculated by considering the total tonnage of goods delivered to Liverpool and how it was carried. A recently conducted Freight Survey (Atkins, 2000) provided all the necessary figures. A comparison of the ecological footprint of the different forms of transport has been given below (Figure 3.2). All the figures are based on the carbon dioxide emissions from the different forms of transporting freight.

Figure 3.2: Carbon dioxide emissions per tonne km for different forms of transport

Sources: DETR, 1999; London Research Centre, 2000

The most damaging method of moving freight is by short air journeys, followed by road freight. Both train and sea freight has substantially lower emissions than the other forms of transport. As with all of the ecological footprint calculations, every form of transport (both passenger and freight) will have some impact. This is addressed in the calculations below (Table 3.5). The other factor that is considered within the freight transport calculations is the road space for road transport.

Table 3.5: The Ecological Footprint of Freight Transport

Transport	Tonne Kms (000's km)	Ecological Footprint (Ha/ per year)
Road Freight	773,808	58,036
Air Freight	24,000	7,560
Rail Freight	39,042	547
Sea Freight	585,600	3,514
Total	**1,422,450**	**69,656**

Sources: Atkins, 2000; Peel Holdings, 2000.

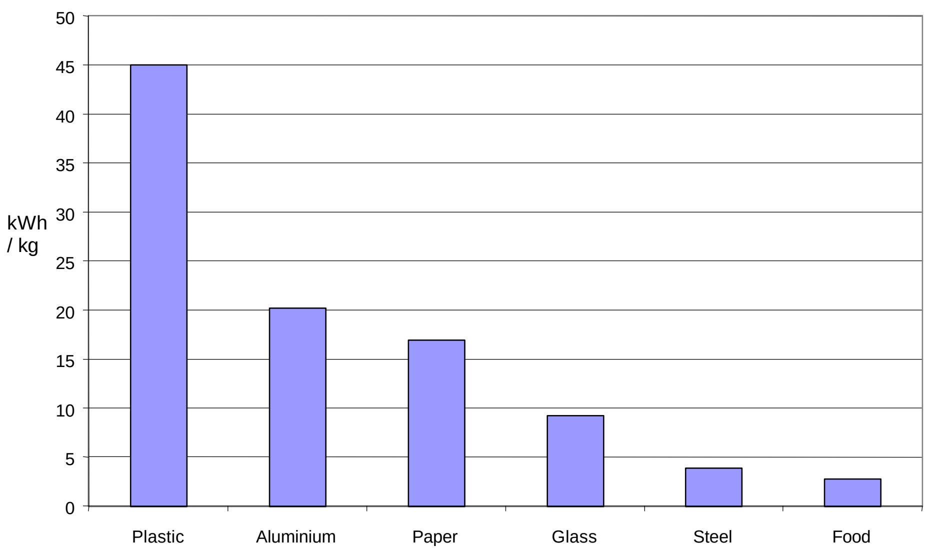
Not surprisingly, road freight has the highest ecological footprint. Over half of Liverpool's freight is delivered by road as well as road freight having a higher impact per tonne km than both sea and rail. While fewer goods are carried by air than any other form, air has the second highest ecological footprint. Finally, the proportion of goods carried by rail is very low (not even 3% of the total tonnage of goods).

3.4 The ecological footprint of waste

The waste footprint is based on the loss of embodied energy through its disposal (Chambers, Simmons and Wackernagel, 2000). If a waste item is disposed of by landfill the embodied energy is lost. The waste footprint also combines the transport requirements for waste (i.e. transporting the waste from domestic households to landfill).

The statistics concerning the embodied energy of waste came from a wide range of sources. The details and the calculations can be found in appendix 2 (page 102). It is possible to convert the energy lost from a product by understanding the contents of the average domestic bin. Recent research by the Clean Merseyside Centre (2000) has provided data specific to Liverpool. It is essential to understand the components that make up domestic waste so as to explore the possibilities for reducing the waste and for an accurate footprint calculation. This provided the necessary baseline data to calculate the embodied energy of waste and convert these figures into an ecological footprint. Figure 3.3 below highlights the embodied energy of different waste materials.

Figure 3.3: The embodied energy of waste products

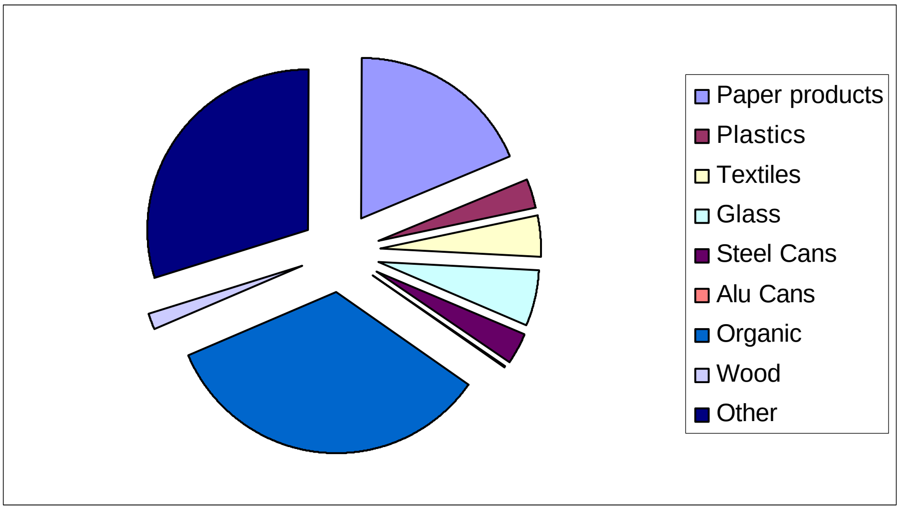


Sources: See Appendix 2. Page 102

Figure 3.3 indicates that the energy required to produce plastic is substantial compared to steel and food. Therefore, the more plastic that appears in the waste stream, the higher the conversion factor will be for waste. Aluminium also has high-embodied energy, however this is a resource that is considered to be very valuable within the context of recycling. By knowing the contents of an average Liverpool bin it is possible to establish the embodied energy of Liverpool's waste per kg.

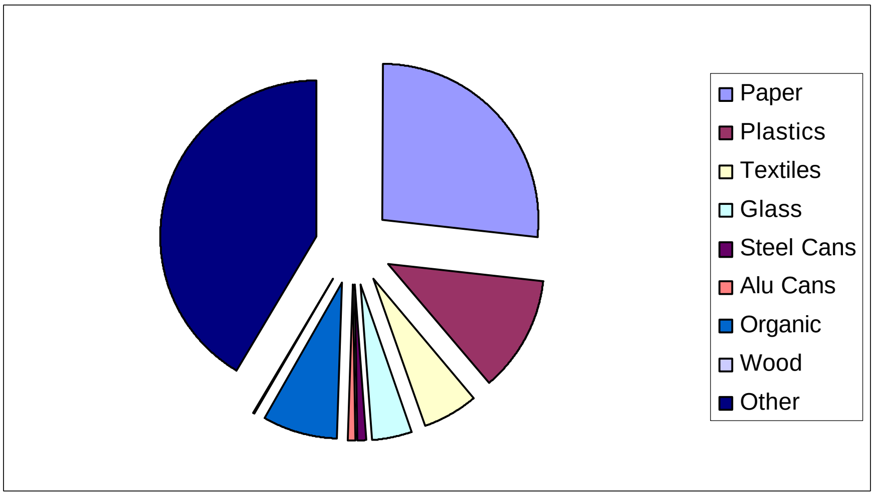
The Clean Merseyside Centre has conducted research on the breakdown of a typical Liverpool household bin. Figure 3.4 shows this breakdown.

Figure 3.4: The breakdown of a Liverpool household bin



The majority of Liverpool's domestic waste is made up of organic material (i.e. foodstuffs, garden rubbish). Paper, particularly newspapers products, is the second highest component. Thirty percent of the waste was described as ‘other’. National data was applied to give some understanding as to what this could be. On average, nappies make up 10% of the waste explaining a significant percentage of the ‘other’ category. The remainder was considered to be materials with a low embodied energy. It is often better to underestimate human appropriation than face the criticism of being alarmist. Figure 3.5 provides the details of the embodied energy of Liverpool's waste.

Figure 3.5 kWh/kg of Liverpool waste



Source: Clean Merseyside Centre, 2000

From this analysis, it is possible to calculate the embodied energy of Liverpool's domestic waste. This translates into an ecological footprint of 2.85 hectares per tonne of municipal waste landfilled. This figure is specific to Liverpool and will vary from region to region.

By recycling waste instead of producing goods from raw materials, a substantial amount of energy can be saved. It is important to remember however, that there is still an energy requirement associated with recycling and that all forms of waste disposal have some impact. Therefore, the ecological footprint of recyclable products is the energy required within the recycling process.

3.4.1 Waste data collection

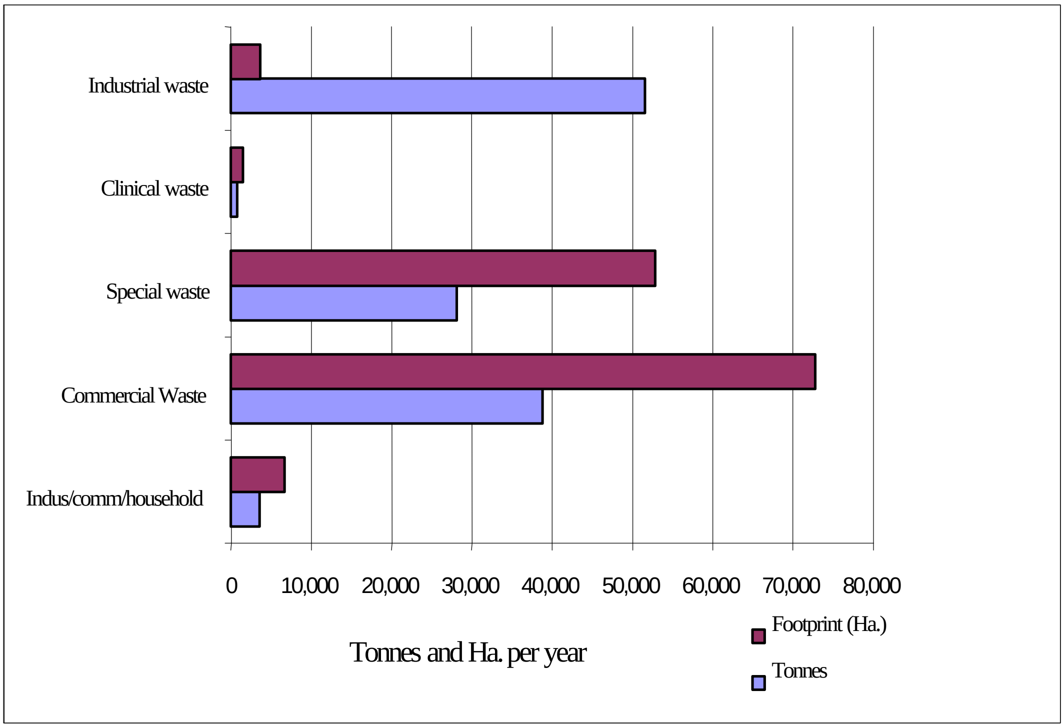
Liverpool City Council, the Environment Agency and the Clean Merseyside Centre provided the data concerning the production of waste in Liverpool. Comprehensive information on domestic, commercial and aggregate waste was provided along with the disposal method for the waste. The necessary data has been listed next to the footprint calculation.

1. Household Waste to Landfill
In 1999, each resident of Liverpool produced 0.45 tonnes of domestic waste. This equates to 212,126 tonnes of domestic waste, of which only 2.3% is recycled. This is one of the lowest recycling rates in the country, where the national average stands at 9% (DETR, 2000a). Of the 212,126 tonnes collected, 174,913 tonnes is collected from household dustbins, 21,063 tonnes comes from street cleansing and 16,150 tonnes is derived from civic amenity sites. This represents a total ecological footprint for municipal waste of 517,093 hectares. Household waste has one of the largest ecological footprints out of all the components and raises major concerns for the future (addressed in the scenarios).

Even though Liverpool only recycles 6,521 tonnes of its domestic waste stream this still has an ecological footprint. As previously explained, the footprint of recycled products is the energy required to recycle the product. Therefore, Liverpool has a total recycling footprint of 5,869 hectares. This is predominately made up of glass and paper recycling.

2. The Commercial Waste Ecological Footprint
Nearly all of Liverpool's commercial and industrial waste is disposed of in landfill. This provides a significant ecological footprint to dispose of the waste. Figure 3.6 displays the tonnage of different waste categories, and the ecological footprint of the waste categories.

Figure 3.6: The ecological footprint of commercial and industrial waste



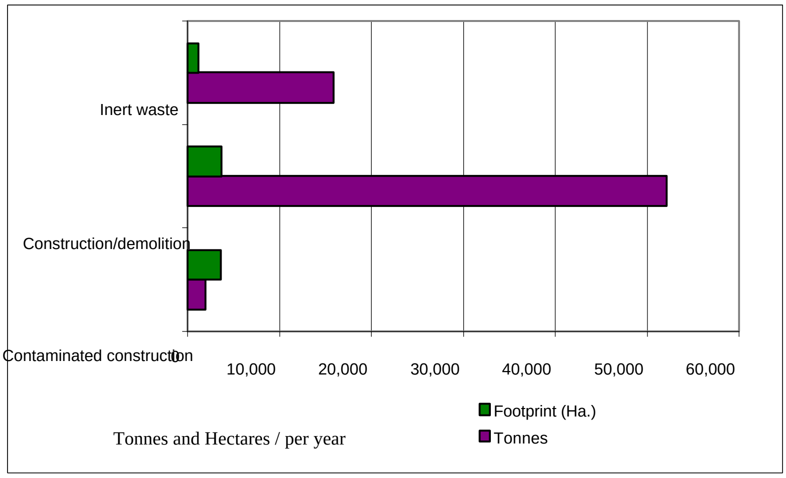
Source: Environment Agency, 2000

Commercial waste clearly has the highest ecological footprint within this comparison. However, it is still domestic waste that has the greatest impact of all. This does not mean that commercial and industrial waste is not important and any strategies to reduce the ecological footprint of these waste streams are welcomed.

3. The Ecological Footprint of Construction Waste

In 1998, Liverpool produced 70,000 tonnes of inert and aggregate waste. This figure does seem slightly low due to the numerous amounts of regeneration projects within the city. However, lots of this material will be used for covering at landfill sites and has a low amount of embodied energy compared to domestic waste. Figure 3.7 provides the findings for construction waste.

Figure 3.7: The ecological footprint of construction material



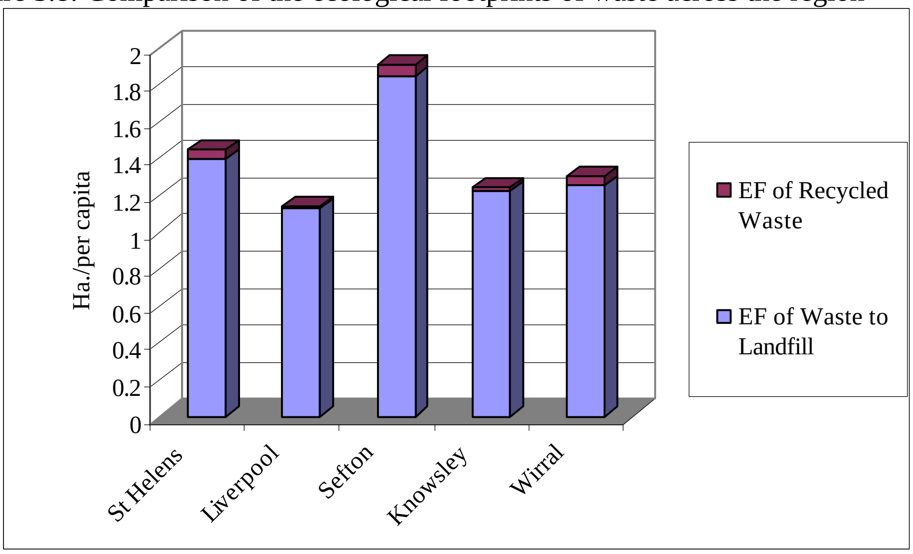
Source: Environment Agency, 2000

The total ecological footprint of construction waste is 8,322 hectares. Construction waste is responsible for the majority of the ecological footprint.

Overall, waste has the largest impact of all the sectors. With a total ecological footprint of 656,808 hectares, this means a footprint 1.64 hectares per capita just for waste. Referring back to what can be regarded as sustainable, i.e. 2 hectares; the ecological footprint of waste alone has nearly exceeded Liverpool's Earthshare.

With the use of the ecological footprint, it is possible to compare the impact of waste between different regions. The example below provides a comparative analysis of the ecological footprint of waste for Liverpool, Sefton, Knowsley, St Helens and Wirral. The ecological footprint of waste going to landfill and of recycled products has also been calculated.

Figure 3.8: Comparison of the ecological footprints of waste across the region

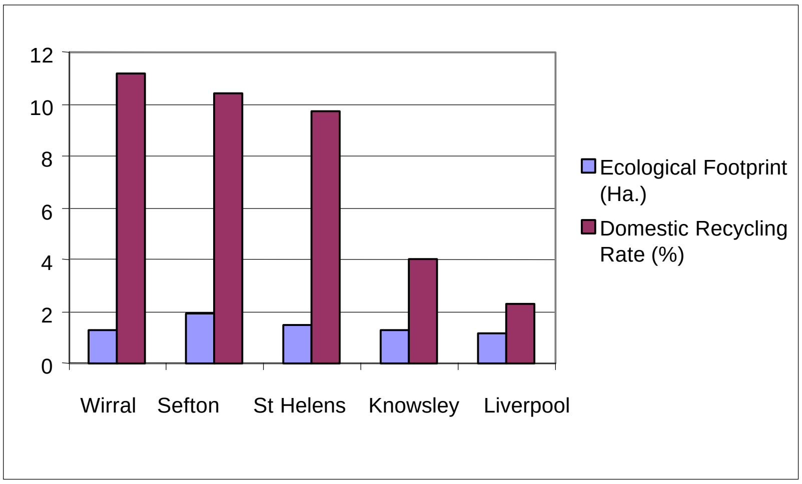


Source: MWDA, 2000

Figure 3.8 considers the municipal waste from refuse collection, street cleansing and civic amenity sites. The amount of recycled waste has also been included within the example.

Liverpool clearly has the lowest ecological footprint (1.14 Ha./per capita) for domestic waste out of all the other areas. Sefton clearly has the largest ecological footprint on a per capita basis of 1.9 hectares. This may surprise many people when these figures are compared with the recycling rate of all these regions with the ecological footprint for domestic waste, shown is figure 3.9 below.

Figure 3.9: Comparison of the ecological footprint of waste and the recycling rate



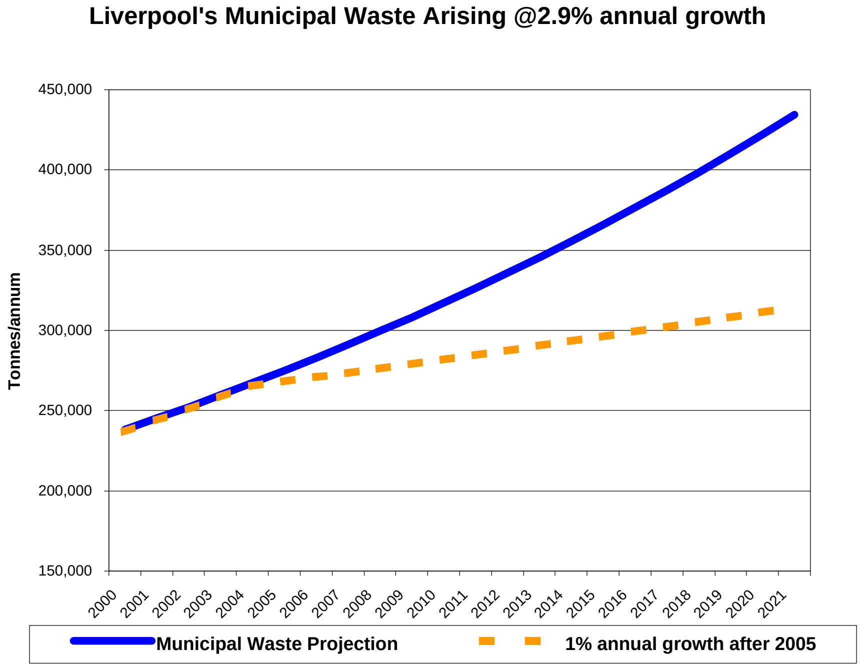
Source: MWDA, 2000

Wirral has the highest recycling rate of 11.2%, followed by Sefton. The most interesting finding from this comparative study is that Sefton has a recycling rate of 10.4% and the highest ecological footprint for domestic waste. Why is this the case? In simple words, Sefton produces too much waste. It may have an excellent recycling rate compared to Liverpool (2.3%) but by producing a substantially greater amount of waste, it therefore has a higher ecological footprint. This demonstrates the need for a balanced approach to tackling waste issues. While recycling is important, if the issue of waste minimisation is not considered, then the effect of recycling can be lost. In the development of a sustainable waste strategy, sustainability can only be achieved through intelligent rationisation of means and prudent moderation of ends.

It is also possible to suggest reasons why this is the case. Sefton can be considered to be a more affluent area than Liverpool. Research has demonstrated that more affluent areas usually have a higher rate of recycling. There is often a higher level of public concern for the environment and people feel that they are 'doing their bit' by recycling. At the same time, they have a higher disposable income, which usually means that they are likely to purchase more. This results in higher levels of waste and counteracts the benefits of recycling. Until the issue of consumption is placed firmly in the minds of the general public this paradox will continue.

This issue is taken further by considering the potential growth of domestic waste in Liverpool. Research by the Clean Merseyside Centre (see Fig 3.10) has provided comprehensive data that demonstrates an annual increase of 2.9% in Liverpool's municipal waste. This demonstrates quite clearly that any strategy to deal with Liverpool's waste must concentrate on the issue of waste minimisation.

Figure 3.10 : The estimated rise in household waste consumption for Liverpool



Source: The Clean Merseyside Centre, 2000

With this data available, it is possible to understand what the increase in the ecological footprint will be in 2010 and 2020. This issue has been considered in the scenarios for waste under the heading of 'Business as Usual'.

The next analysis for waste looks at where the waste ends up and who is responsible for receiving Liverpool's waste. The proximity principle is one of the main aims of Government Policy concerning waste. It suggests that a local authority should be responsible for dealing with their own waste within their local authority. This means that waste should not be transported across the country, increasing the emissions of transport. Table 3.6 below, demonstrates that where waste is produced and where it is disposed of, are two totally different places.

Table 3.6: Comparative analysis of the ecological footprint and landfill

County Data	Total to landfill 000's	Waste footprint 000's	Population 000's	Landfill Footprint per cap
Cumbria	978.6	2475.858	492.88	5.02
Lancashire	2649.4	6702.982	1100	6.09
Merseyside	637.1	1611.863	1434.18	1.12
G Manchester	1871.2	4734.136	2527	1.87
Cheshire	3086.2	7808.086	677	11.5

Source: Environment Agency, 2000

None of the waste produced by Liverpool is disposed of in Liverpool. Cheshire has the largest responsibility for receiving waste from other areas within the North West and also has the lowest population. An estimate of the ecological footprint of waste production in Cheshire is about 2.5 Ha./per capita, while the county actually disposes 11.5 Ha./per capita of waste. This clearly questions the successfulness of the proximity principle within local government policy. Cheshire is clearly bearing the responsibility for the waste of other counties.

In conclusion, the issue of waste requires immediate attention within Liverpool. While it may have a lower ecological footprint for waste than surrounding areas it is still substantial. The potential growth in waste in Liverpool is higher than that of Merseyside. Unless strategies to reduce the ecological footprint of waste are taken on board, Liverpool will soon have an equivalent footprint to its surrounding areas. Issues to reduce this impact are considered within the scenarios.

3.5 The ecological footprint of water and water treatment

The ecological footprint of water is calculated by considering the energy required to supply the water. Domestic, commercial and industrial uses, are all taken into consideration. All the necessary data was provided by United Utilities and cross-referenced with data from the Environment Agency. Not only is supply taken into consideration but also leakage.

Data provided by United Utilities suggests that Liverpool requires approximately 79 Mega-litres of water a day. There is also a significant amount of leakage (35 Ml/per day). This calculates to a total consumption of 114 Ml/per day or 41,610 Ml annually. The calculation below explains how this has been converted into an ecological footprint.

41,610 Ml x Energy Requirement per Ml = 10.4 GWh

This energy requirement to supply all the water can now be converted into a footprint value by considering the carbon dioxide emissions of supplying this energy.

10.4 GWh x Footprint Conversion Factor for UK Energy Mix (84.47 Ha./per GWh)

= 879 Hectares.

This figure can also be desegregated by sector. Therefore, the ecological footprint of the sectors is as followed: -

- Domestic Water Supply = 494 Hectares
- Commercial and Industrial = 270 Hectares
- Leakage = 339 Hectares

Leakages represent 31% of the ecological footprint of supplying Liverpool with all its water. Future projections provided by United Utilities demonstrate how they intend to reduce this figure over the coming years. On a per capita basis the ecological impact of water supply is very low at 0.002 ha./per capita.

The ecological footprint of water supply is relatively low when compared to the ecological footprint of supplying Liverpool with all its newspapers and magazines, which has an impact nearly 30 times greater.

To strengthen the analysis of water, it was decided, after discussions with United Utilities, to conduct an ecological footprint of the wastewater produced by Liverpool as well as considering water supply. United Utilities provided the necessary information concerning the energy use of wastewater. The calculation has been explained below. Liverpool is responsible for producing 188 million litres of wastewater each year. For every million litres of wastewater that is treated, an average of 268.7 kWh is required. This equates to an ecological footprint of 4.26 hectares.

3.6 The ecological footprint of bio-resources

Food and timber make up this section. Due to the size of this project this area utilises proxy data as opposed to all the other categories (i.e. waste, energy, transport, water, housing stock etc.) Data from the National Food Survey has been used to assess the land area required to provide Liverpool with all its food. An analysis of timber demand has also been conducted. This has been converted into the land area required to supply all of Liverpool's timber.

In many ways, the ecological footprint of food is probably the most simplistic. All that is required is knowledge of the amount of kg/ha./per year for the different food types (available from the United Nations Food and Agriculture Organisation) and the consumption data for the particular region or city. Table 3.7 below provides the estimated consumption of Liverpool concerning food, the amount of kg/ha./per year and the ecological footprint. Ten of the main food consumption categories have been considered.

Table 3.7: The ecological footprint of food within Liverpool

Food category	Average Consumption per individual (kg)	Total consumption for Liverpool (tonnes)	Kg/Ha./ Per year	Footprint
Milk and Cream	0.25	117.00	336	348.21
Cheese	5.4	2,530.94	34	74439.53
Meat and meat products	48.9	22,900.2	734	31199.15
Fish	7.6	3,553.06	29	122519.17
Eggs	0.09	42.3446	556	76.16
Fats and Oils	10.1	4,721.18	596	7921.45
Sugar and preserves	8.1	3,796.42	3,229	1175.72
Vegetables and vegetable products	104.3	48,793.7	12,120	4025.88
Fruit and fruit products	56.7	26,526.2	12,120	2188.63
Cereal products	78.9	35,968.6	2,641	13619.31
Total		150,361.14		257,513
Footprint (per capita/ year)				**0.64**

Source: based on National Food survey, 1999

The ecological footprint of food consumption in Liverpool is estimated to be 0.64 ha,/per capita. Included within this figure is the embodied energy of the product. The packaging in which the products will be wrapped has not been included within this figure. This has been associated to the waste stream of Liverpool, thus avoiding the issue of double counting.

The consumption data for Liverpool was obtained from the Ministry of Food and Fisheries. It has been adjusted to the specific circumstances within Liverpool (i.e. adjusted by socio-economic status, which is based around income).

As well as supplying Liverpool with all its food, timber is another major resource consumed by the city. Considering the use of the timber on a national scale, and adjusting this with local data has provided the consumption data for Liverpool. It is estimated that Liverpool is responsible for consuming 378,200 tonnes of timber a year. This equates to approximately 0.6 tonnes per capita. The ecological footprint of timber is calculated by considering the amount of land required to grow the timber that is consumed. Therefore, the ecological footprint of timber consumption in Liverpool is estimated at 250,000 hectares, which is approximately 0.62 hectares/per capita.

The final figure for Liverpool does not include the ecological footprint of papers and magazines consumed by the city for reasons of double counting. Liverpool consumes nearly 19,000 tonnes of paper and magazines each year. This has an ecological footprint of 30,000 hectares (0.07 Ha./per capita).

Therefore, the total ecological footprint of providing Liverpool with all its necessary bio-resources is 1.14 Ha./per capita, or 537,000 hectares.

3.7 The ecological footprint of energy

All the energy component footprints are based on a relatively simple calculation; the amount of carbon dioxide produced by the forms of energy, multiplied by the carbon sequestration rate for forests. For the component approach the same sequestration as Wackernagel (1997) is applied (100GJ/per Ha./per yr.). For example, the burning of coal emits more carbon than oil burning and oil burning emits more carbon than the burning of gas. Table 3.8 below has selected some examples of the ecological footprint of different forms of energy production including any assumptions made.

Table 3.8: Energy footprints

Energy Type	Kg of CO_2/kWh	Ecological Footprint per GWh (Ha./per yr.)	Source
UK Grid Electricity	0.44	84.47	• Digest of UK Energy Statistics (2000), published by the DTI
Natural Gas	GWh	36.48	
Oil	GWh	80	
Coal	GWh	129	• DETR Guidelines

3.7.1 Energy consumption data

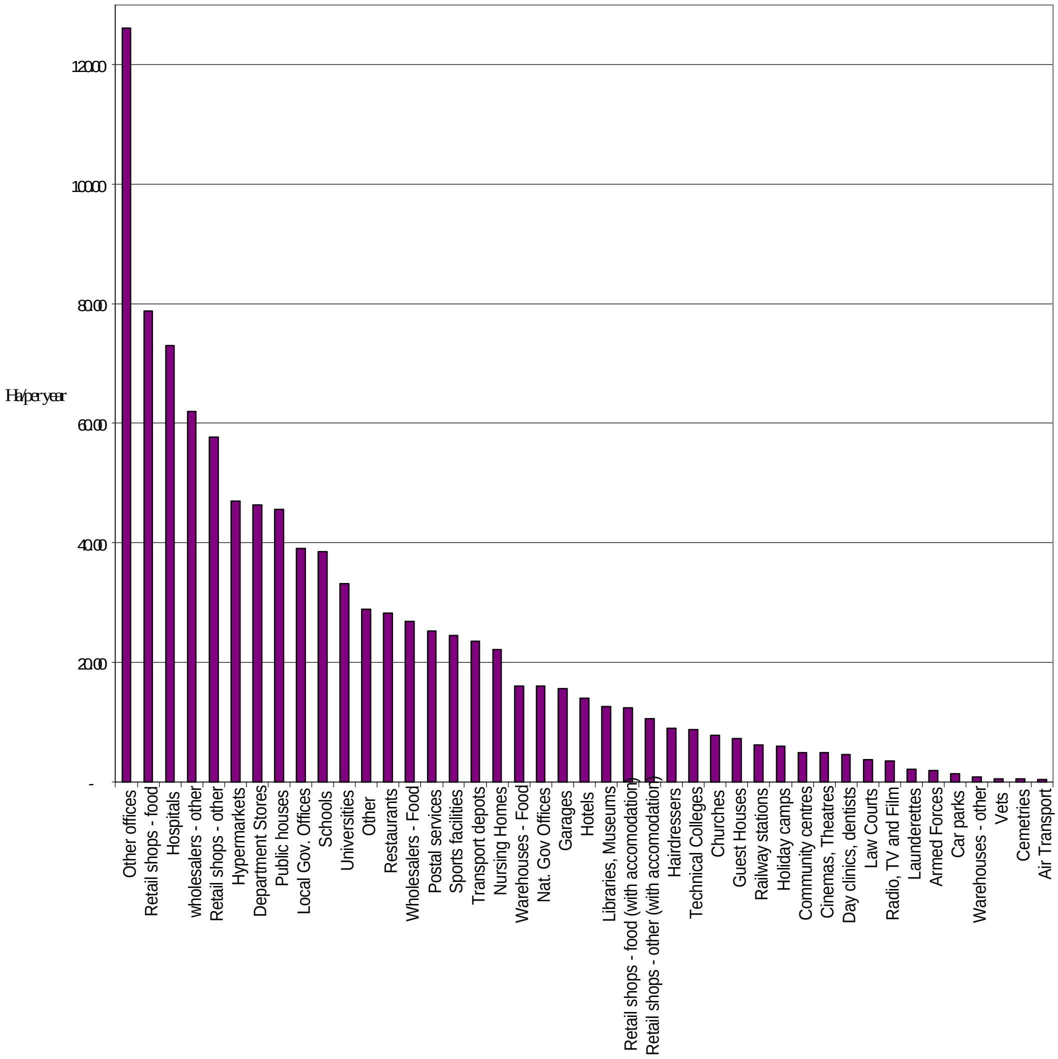
All the consumption data was obtained from local sources, including Manweb and Transco (gas). Data concerning domestic, commercial and council energy use was gained. Particularly detailed data concerning the electricity for commercial use was available. The ecological footprint of electricity, gas, domestic oil and coal was calculated. Table 3.9 shows the results.

Table 3.9: The ecological footprint of energy supply in Liverpool

Energy Source	**Consumption**	**Footprint (Ha)**
Electricity (Domestic)	712.9 GWh	60,219
Electricity (Service sector)	997.8 GWh	84,281
Electricity (Council)	72.4 GWh	6,116
Gas (Council)	228 GWh	8,317
Gas (Domestic)	3,019 GWh	110,133
Oil	265.8 tonnes	13,266
Coal	236.8 tonnes	13,638
	Total	**298,783**

The total ecological footprint of energy consumption n Liverpool is 0.63 hectares per capita. The largest component of this figure is gas. Following gas, service sector electricity usage has the second highest impact, which has been separated into 20 different categories to demonstrate how much each sub-sector consumes in relation to their footprints (see Figure 3.11).

Figure 3.11: The ecological footprint of electricity (Service sector) supply in Liverpool



The ecological footprint of supplying the City Council has been separated from the electricity (Service sector) figure. This is because of key demonstrations concerning the energy scenarios in the next chapter. As well as this, it demonstrates that the electricity consumed by the Council is responsible for an ecological footprint equivalent to over 19,000 domestic households. This figure includes the energy requirements for all the City Council's buildings, street lighting and traffic lights.

None of the figures above include industrial energy use. This is to avoid the issue of double counting. Embodied energy within other products has already been included in the calculation procedure. Also, Liverpool would be held responsible for the energy required supplying products to other consumers, outside Liverpool. For these reasons, industrial energy is extracted from the final figure.

3.8 The ecological footprint of built land and buildings

This section considers the amount of land occupied by buildings and roads as well as the materials stored within the buildings. The built land includes the city of Liverpool, the land occupied by rail, unproductive land and road space. Table 3.10 displays the findings.

Table 3.10: Built land in Liverpool

Demand Category	Consumption (Liverpool)
Built Land:	10074
...Cities	5200
...Roads[7]	3906
...Rail	5
...Unproductive	759
...Other	1430
Built Land Footprint of Liverpool (ha) 11,300	

There is also a substantial amount of embodied energy within the materials used within the buildings. This has to be divided over the lifetime of the buildings, as the footprint measurement is for one year. Many organisations have attempted to establish the embodied energy of buildings and have provided a range of figures. The Centre of Alternative Technology has conducted research to establish the energy embodied within the materials for four different house types (Flat, Terrace, Semi-detached, Detached). BRE have also published information on the average embodied energy of houses. Distributing the embodied energy over the average lifespan of a house gives some indication into the ecological footprint of properties within Liverpool. The other data that is required concerns the quantity of the different house types within Liverpool. Liverpool City Council provided this information.

[7] To avoid double-counting roads are subtracted from the final figure as they have already been accounted of within transport.

Table 3.11: The Ecological Footprint of Liverpool's Housing Stock

House type	Houses (No's)	Ecological Footprint (ha)
Flats	35,415	1,503
Terraced	31,082	2,426
Semi-Detached	51,804	6,354
Detached	69,699	12,279
Total	**188,000**	**22,562**

The embodied energy of the different houses is distributed over a 70-year lifespan. This is the average lifespan of a property built in the UK and was obtained from the Department of Environment, Transport and Regions. The results indicate that the ecological footprint of detached houses has the highest ecological footprint out of all of Liverpool's housing stock (see Table 3.11).

3.9 The total ecological footprint of Liverpool – analysing the results

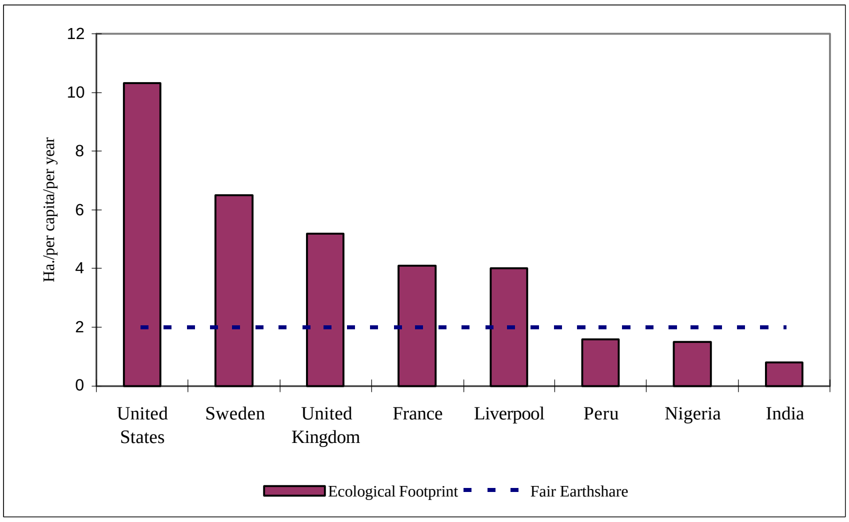
The results for each of the separate components have been analysed within their specific sections. This section presents the overall findings and some of the key points that apply to all the separate components.

Liverpool has a total ecological footprint of 4.15 hectares. This means that the average Liverpool resident requires just over 4 hectares of land to supply them with all their necessary resources, the transportation and use of those resources and the disposal of those resources. How does this compare with other countries, including the UK?

Currently, the ecological footprint of the UK is estimated at 4.9 hectares per person. Therefore, the average Liverpool resident is closer to achieving ecological sustainability than the average UK resident. However, this does not mean that Liverpool can be regarded as sustainable on two grounds.

Firstly, the ecological footprint of Liverpool raises some key equity issues. 80.3% of the world population has an Ecological Footprint smaller than 4.0 hectares, and their total share of humanity's footprint is 38.3%. Their average footprint is 1.36 hectares. The other 19.7% of the population occupy 61.7% of humanity's Footprint, which in itself is already at least 20% larger than the available capacity of the biosphere. Figure 3.12 below, provides a comparison of the ecological footprints of various countries and Liverpool.

Figure 3.12: A comparison of ecological footprints per capita by country

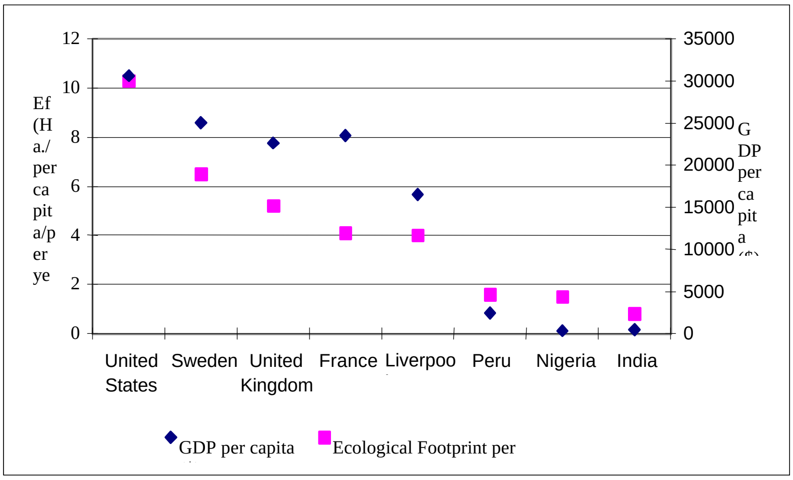


Source: Author and WFF (2000)

The Unites States has the largest ecological footprint on a per capita basis in the world. Liverpool's footprint is similar to France's per capita. It is clear that all the industrialised countries in the world have an ecological footprint above their fair Earthshare, of which the city of Liverpool is no exception.

If everyone in the world lived a similar lifestyle to the average Liverpool resident, then we would require a total of 2.5 planet Earths to supply all the necessary resources. While there are major inequalities on a global scale, concerning the distribution of resources, there are also major inequalities between UK residents and even Liverpool residents. Figure 3.13 below considers the inter-relationship between economic growth and the ecological footprint.

Figure 3.13: Relationship between GDP and the ecological footprint



Sources: World Bank Database, 2000; Wackernagel et al, 2000

What figure 3.13 demonstrates is a clear link between economic growth and ecological impact. This may explain why Liverpool has a smaller ecological footprint than the UK average. However, it is still possible to have a large ecological footprint and a poor quality of life. If for example, your house was badly insulated and you were at home on a regular basis because of unemployment, it is likely that the heating would be on quite regularly, which would create a high ecological footprint for energy use. You may also have poor links to key shopping areas, therefore needing to use a taxi, which has a higher ecological footprint than a bus or train.

These two simple examples show that there is not always a relationship between the most affluent in the community and a high ecological footprint. However, if someone can afford a powerful car, goes go on regular long-haul flights and generally consumes at a higher rate, they will have a substantial ecological footprint.

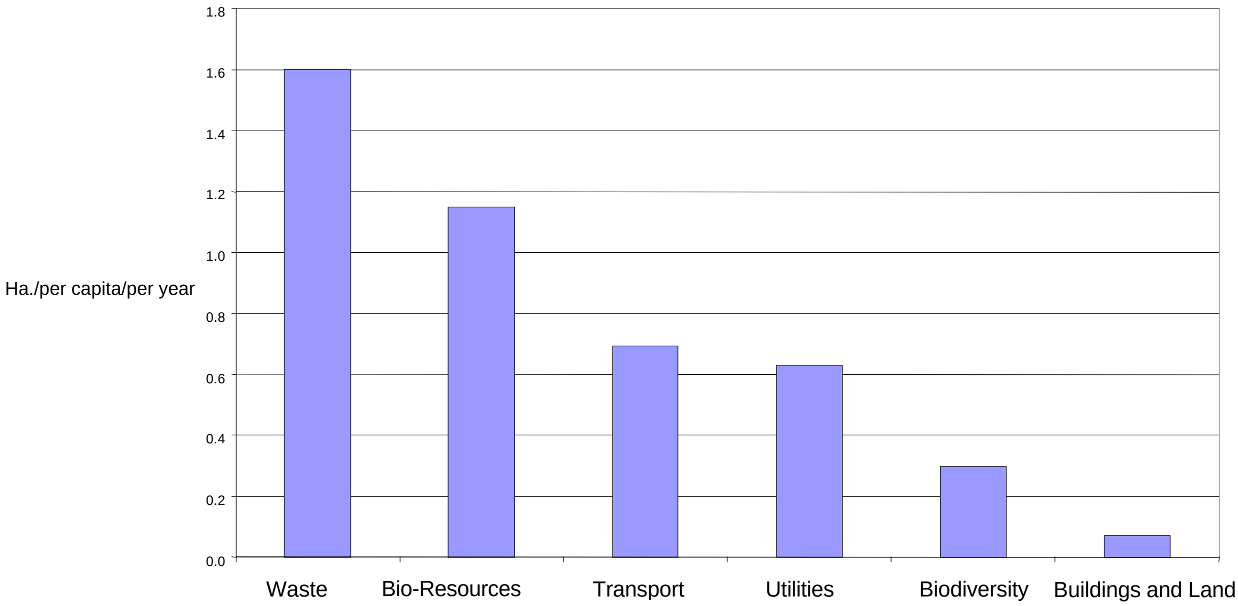
The other important point to recognise is that a low ecological footprint and a high quality of life are achievable. The scenarios (Chapter 4) go someway in demonstrating how this is possible. What the sustainability concept informs us, is the necessity to de-couple quality of life and resource use. How can we achieve a decent quality of life for everyone whilst only using our fair share of the Earth's resources?

A powerful visual demonstration of the area required for providing Liverpool with all its resources and absorbing all its waste, is that it requires an area approximately the size of Wales. To be considered sustainable, Liverpool would have to reduce its ecological footprint by 130%.

3.10 The largest impacts

The ecological footprint is sufficient to suggest approximately how much we must reduce our consumption, improve out technology, redistribute wealth, or change behaviour to achieve sustainability. All these issues are addressed within the scenarios. To understand this in relation to particular issues, figure 3.14 provides a breakdown of the ecological footprint of Liverpool into the main sections. This gives an insight into the main impacts in relation to ecological sustainability.

Figure 3.14: The Ecological Footprint of Liverpool by activities



Waste clearly has the highest ecological impact, followed by the provision of bio-resources, then transport (both passenger and freight), utilities, biodiversity protection and finally buildings and land.

As well as considering our human needs for resources, the ecological footprint of Liverpool has included a responsibility for Liverpool to protect land for the other 30 million species on the planet. The footprint measurement suggests that everyone on the planet is responsible for protecting 0.3 hectares of 'biodiversity land'. This does not mean that every individual has to personally take care of 0.3 hectares, but it does mean that Liverpool should attempt to protect an area of 120,000 hectares in order to guard wildlife and maintain (or even increase) biodiversity. This area does not have to be solely within the Liverpool boundary. At present Liverpool is responsible for protecting 1,296 hectares. To fulfil the remainder, Liverpool could be involved in projects and initiatives to protect some of the worlds most important and vulnerable ecosystems. The initiatives are not necessarily the responsibility of the council, but the responsibility of all the Liverpool residents, as an acceptance of global stewardship.

It is also possible to consider the components in a more dis-aggregated form, providing an insight into the key areas requiring attention concerning ecological sustainability. Table 3.12 (and illustrated in Figure 3.15 overleaf) divides the ecological footprint of Liverpool into 24 separate components. One of the advantages of the ecological footprint is that it is possible to compare all these issues on the same scale. By considering the eight components with the largest ecological footprint it is clear to see the main drivers of unsustainability.

Table 3.12 The component ecological footprint of Liverpool

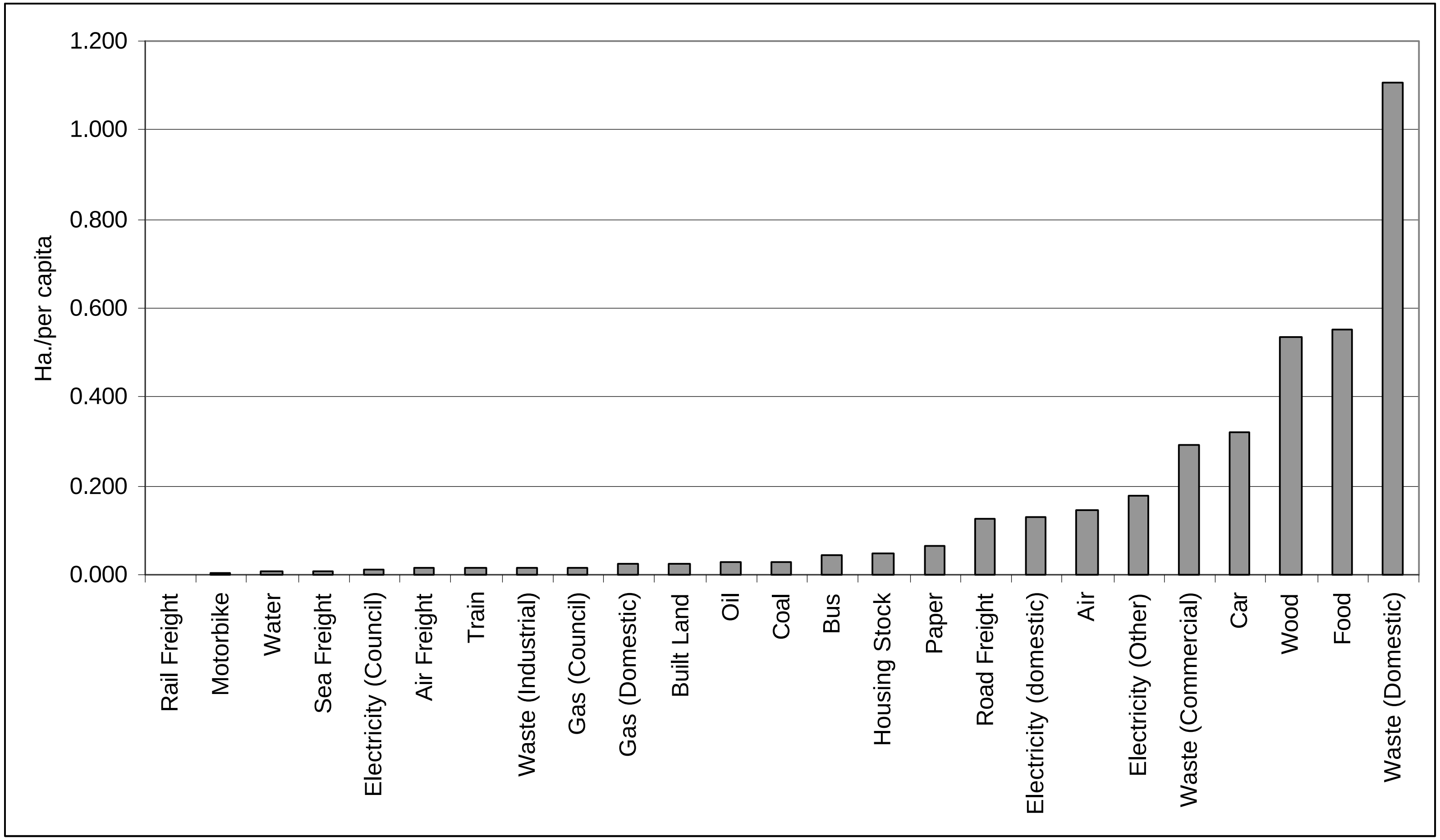
Component	**(Ha)**	**Component**	**(Ha)**
Rail freight		Bus	
Motorbike		Housing stock	
Water		Paper	
Sea freight		Road freight	
Electricity (LCC)		Electricity (domestic)	
Air freight		Air	
Train		Electricity (other)	
Waste (industrial)		Waste (commercial)	
Gas		Car	
Built land		Wood	
Oil		Food	
Coal		Waste (domestic)	
	Ecological footprint of Liverpool		

Four main areas appear, these being: -

- Waste issues – especially the impact of domestic waste, followed by commercial waste;
- Resources issues – supplying Liverpool with all its food, wood and other bio-resources;
- Passenger transport – both car and air transport have ~~a~~ significant footprints;
- Electricity – especially commercial electricity use, however domestic use is still an important factor

The above main areas of unsustainable activity provide a clear and comprehensive insight into the global impact of Liverpool. Firstly and importantly, the ecological footprint has demonstrated which activities are responsible for the greatest impact and therefore suggest which should be the objectives of the political decision-making process. Secondly, and probably more important, it has been shown that all activities (some greater than others) have an impact on nature and equity and hence a holistic approach should be the mainstay of the goal of sustainability. The next chapter develops some solutions to these problems and addresses the issues of waste, energy and water use. Sustainable scenarios have been developed to highlight what Liverpool could potentially achieve by 2020.

Fig 3.15 The component ecological footprint of Liverpool



Chapter 4

Developing a sustainable scenario

4.1 The sustainable model for Liverpool

One of the key uses of the ecological footprint is its ability to develop scenarios. The ecological footprint also provides an insight into the ecological bottom-line. With these two important aspects, a sustainable model for Liverpool can be generated.

At present the ecological footprint of Liverpool is 4.15 hectares per person. A sustainable ecological footprint, taking into account the protection of biodiversity, is 2 hectares per person. How this reduction in the ecological footprint is achieved is very important. The sustainable development agenda informs us that the transition to a sustainable society must be achieved with the participation of the general public. This process must also improve the Liverpool residents' quality of life. Therefore, the challenge for the scenarios below is to develop suggestions that reduce the ecological footprint to a more sustainable level while at the same time improving the quality of life of Liverpool residents.

The scenarios suggest possible reductions in the ecological footprint in three important areas: energy, waste and water. The energy scenario takes a detailed look at a range of sectors (Service sector, domestic and the City Council). It provides very detailed calculations on the potential reductions that can be made for the domestic sector. Overall, the scenario demonstrates that a 70% reduction in the ecological footprint of energy is possible over a 10-year time scale.

The waste scenario addresses the domestic waste sector as this has the largest impact of all the components. Detailed examinations of recycling and composting options have been explored, providing a detailed account of the reduction that can be gained in the ecological footprint. The scenario also highlights the importance of a waste minimisation scheme, and provides a detailed calculation of this.

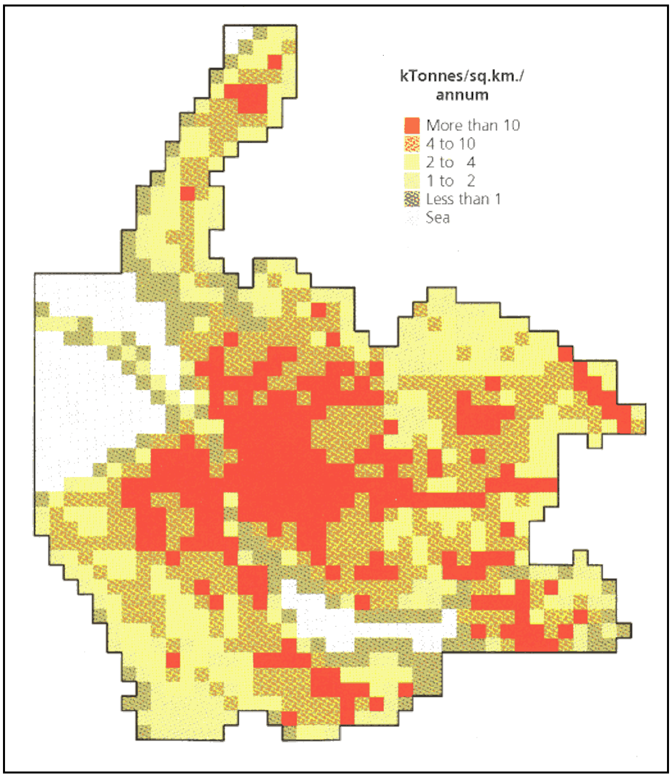
Finally, the water scenario highlights what United Utilities is doing to reduce the ecological footprint of water through the control of leakage. As an example, it also highlights sustainable targets that can be reached through the introduction of water saving devices in the domestic sector.

4.1.1 Liverpool and CO_2 emissions

Since their discovery, the central feature of economic growth has always been fossil fuels for energy. As economic growth intensifies around the world, the demand for energy will double and more than likely treble from its 1990 level by 2050. Both national and personal consumption of oil has risen year on year to a level whereby today, the average American and European annually consume 5 and 3 tonnes of oil equivalent respectively (Fells, 1999). The argument against both the continuing use and increasing consumption of fossil fuels is evident in the relationship between emissions and the effects on human health and the environment. In particular, the emission of Carbon dioxide from the burning of fossil fuels, which has been identified as “the single most important man-made gas associated with the greenhouse effect” (Bloyd, 1996: 1047).

Recent reports have shown that regionally, Merseyside was responsible for the emission of 12,973 ktonnes of CO_2 (LRC and RSK Ltd, 1997) or 8.1 tonnes of CO_2 per capita (Mander, et al, 1999). In total, Merseyside is responsible for 14% of the emissions of greenhouse gases in the Northwest region of the UK (Mander, et al, 1999). Figure 4.1 illustrates that the area of Liverpool (predominantly shaded red) is responsible for a significantly higher proportion of CO_2 than that of Merseyside as whole.

Fig 4.1: Concentrations of CO_2 emissions within Liverpool compared with the area of Merseyside, 1997



Source: LRC and RSK Ltd, 1997: 19.

In order to reduce the emission levels of CO_2, it is important that policies are implemented, which encourage alternative energy resources and efficient technologies that are less damaging to the health of its citizens and the fabric of the city.

Liverpool is in a strong position whereby it could move forward with an energy policy that would aim for a level of sustainable consumption. Such a policy would not only be important for the environment but would be of benefit to its citizens especially those trapped by fuel poverty. In addition, the economy would benefit from an increase in jobs, which would be associated with the sustainable technology industry.

4.2 Liverpool's energy consumption

The result of the ecological footprint analysis of energy consumption shows that in 1999, Liverpool's total energy consumption equated to an area of 298,783 hectares (Electricity

=150,680.9ha; Gas = 118,450ha; Oil = 13,263.4ha and Coal = 13,639.7ha). On a per capita basis, each person in Liverpool requires 0.63 hectares of land to provide for their energy needs. When each person's equitable share of global bio-productive land is taken into consideration (2 ha), it is clear that approximately 32% or almost one third of their share of the land had been consumed by an energy supply that is, in the majority of instances, used to excess and in many cases; wasted. Table 4.1 highlights the sources of energy, sector consumption and their ecological footprints.

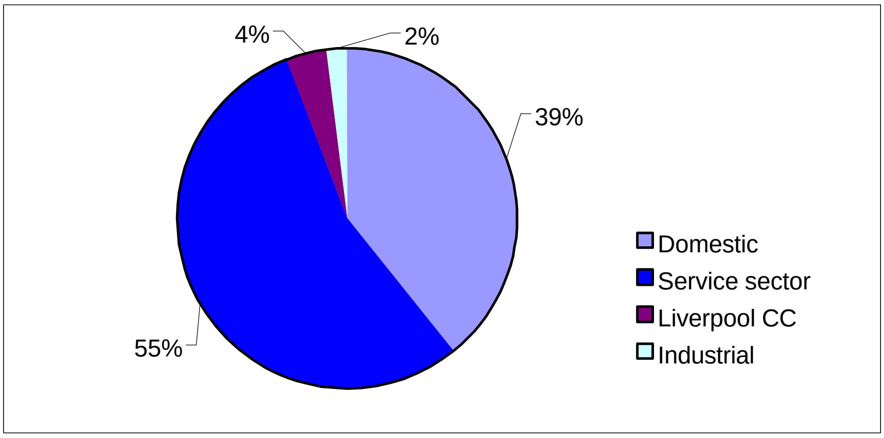
Table 4.1: The ecological footprint of energy consumption by source and sector, 1999.

Source	**Sector**	**Consumption**	**Unit**	**Ecological Footprint** (Ha)
Electricity	Service sector	997.8	GWh	84,346.67
	Domestic	712.9	GWh	60,218.66
	Liverpool CC	72.4	GWh	6,115.63
	Total electricity	*1,783.1*	*GWh*	*150,680.96*
Gas	City	3,019	GWh	110,133.12
Gas	Liverpool CC	228.0	GWh	8,317.44
	Total gas	*3,247*	*GWh*	*118,450*
Oil	All supplies	265.8	Tonnes	13,263.42
Coal	All supplies	236.8	Tonnes	13,639.68
			Ecological Footprint	**298,783**

Due to the lack of data for a further breakdown of gas consumption (other than for the Council and the city as a whole), scenarios for gas reduction have not been considered in this study. From this point, the term energy consumption, in the main, applies to electricity consumption only.

Compared to the previous year, electricity consumption increased by 1.2% or 2,264.5 hectares. The service sector (55%) is accountable for the greatest consumption of energy (998.54 GWh or 84,346.67 hectares). Interestingly, Liverpool City Council has an electricity footprint of 6115.63 hectares, which is equivalent to 7.25% of commercial consumption. Figure 4.2 illustrates the percentage of electricity consumed by each sector.

Figure 4.2: The percentage of electricity consumed by sector



Given that the economic situation within Liverpool has been stabilised by an injection of European led funding, Liverpool City Council is in a strong position to adhere to the sustainable goals set out in the Merseyside Objective One Single Programme Document. The first step would be for the Council to lead by example.

4.3 Liverpool City Council And Energy Consumption

Liverpool CC was responsible for the consumption of 72.4 GWh of electricity in 1999, which was provided by fossil fuels. The breakdown of electricity consumption by the Council is shown in Table 4.2.

Table 4.2 Liverpool City Council's electricrity consumption.

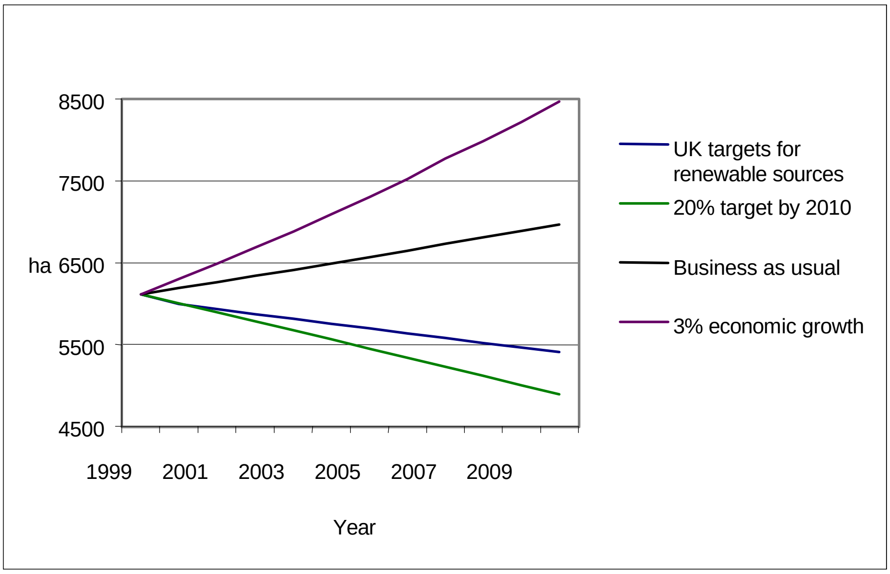
Energy consumables	**Consumption (GWh)**	**Ecological Footprint (ha)**
Buildings	45	3,801.15
Street lighting	24	2,027.28
Traffic lighting	2.4	202.72
Other	1	84.47
Total	**72.4**	**6,115.63**

In order to reach a sustainable level the aim must be to reduce the reliance on fossil fuels as a source of energy. Although the Council's consumption of energy represents only 4% (see Fig 4.2) of the total energy consumed by the city in general, the Council must be at the forefront of change.

Since the liberalisation of the energy supply industry, consumers are now able to buy their electricity from anywhere in the UK. Not only can they purchase electricity freely they can also insist that their electricity is derived from renewable sources (Jones, 2000). In response to the latter, the UK government has recently set national targets for the inclusion of renewable energy as part of the overall supply of energy to the UK. The targets set are 5% by 2003 and 10% by

2010 (DETR, 2000b). Using the same targets, the Council could reduce it's ecological footprint by 305.79ha to 5,809.84ha by 2003 and by 2010, the Council's ecological footprint for energy would be 5,504.06ha, which would be an overall reduction of 611.57ha on 1999 consumption levels. In comparison, a 'business as usual' scenario based on either the 1.2% growth in electricity consumption from 1998 to 1999 or the present rate of national economic growth, which is currently 3%, would see the ecological footprint increase by 13.29% and 856.52ha to 6,972.15ha or 27.64% and 2,349.73ha to 8,464.73ha respectively. The significant difference between the renewable resources option and for example, permitting the impact of economic growth to continue unabated is a considerable 2,960.67 hectares or 34.98%. The UK targets for renewable energy are not the only options. For example, the Council could set its own of target of 20% by 2010, which would see its ecological footprint fall by 1,223.13ha to 4,892.5ha. Figure 4.3 illustrates the impact of the above scenarios.

Figure 4.3: Options available to Liverpool City Council concerning its consumption of energy and their relative ecological footprints (electricity supply only)



In addition to switching some of the current electricity supply to renewable sources, the Council could also invest in renewable energy technologies such as Combined Heat and Power (CHP), Photovoltaic panels or offshore wind turbines/wind farms. For the latter option, Liverpool is geographically well placed. Below are examples where new technologies have lessened the burden on the environment and have been economically viable.

4.3.1 The Whitehall district energy scheme and CHP

In 1999, a Combined Heat and Power system was installed in Whitehall, which will provide sustainable energy to over 20 government buildings. It is estimated that the CHP will save over £500,000 annually in energy bills and reduce the emission of 5,000 tonnes of carbon (Walker, 2000). Not only is this important on both counts of saving money and emissions to the atmosphere, the government has ensured that good quality CHP will be exempt from the Climate Change Levy, which begins in April 2001. There is also a proposal to introduce a system of 100% first year capital allowance for energy efficient projects (DTI, 1999). The Climate Change Levy is expected to add 10% to energy bills (excluding domestic customers) but could be neutralised as an exemption applies to the electricity produced on site or sold directly to other businesses (Walker, 2000).

Theoretically, the Council could install sufficient CHP capacity to meets its needs whilst cutting its energy costs by 40%, reducing carbon emissions by 50% and increasing energy efficiency by 20% (Vidal, 2000). Thus, recouping over time the costs of installation and helping the city towards the goal of sustainability. Figure 4.4 compares energy cost savings of CHP against the annual increase of 1.2% for energy consumption from 1998-1999 (the same annual increase is added to subsequent years). Figure 4.5 shows the effect of CHP upon the ecological footprint. It is clear that at the present rate of increase of energy consumption, the Council would require some 82 GWh (6972ha) of electricity in order to operate in 2010. However, a CHP system would require less than 50 GWh to meet energy needs in 2010. Importantly, the Council's ecological footprint would be 31.6% (4182.95ha) less in 2010 than at present (6,115.65ha).

Fig 4.4: Potential energy cost savings to the Council of CHP compared to an increase in the use of fossil fuels.

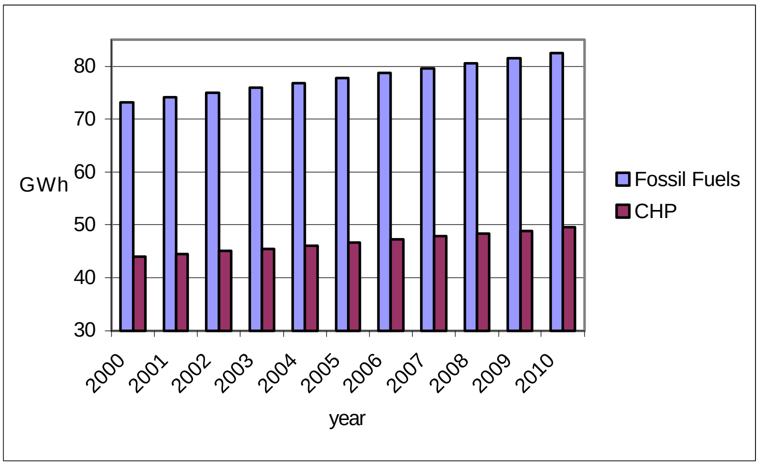
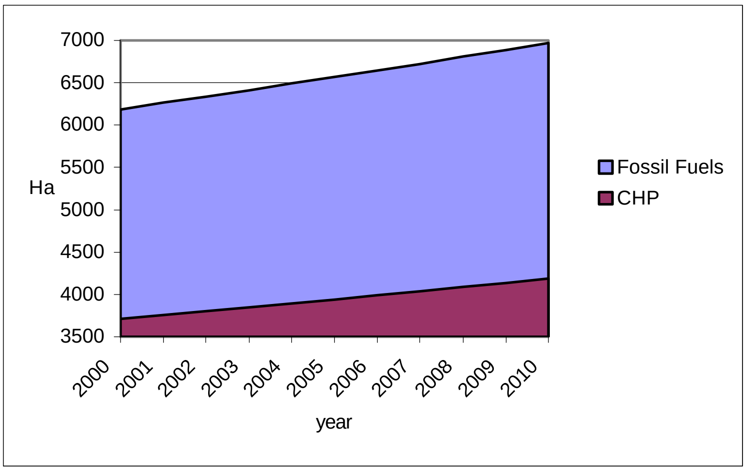


Fig 4.5: The reduction in the ecological footprint for the Council by installing CHP



Below is an example where the authorities in Barcelona have set themselves the task of supplying much of the city's hot water needs from thermal solar panels. They will achieve their reduction in fossil fuel-use with the aid financial incentives and making it compulsory for new developments to install thermal solar panels for the generation of hot water.

4.3.2 Barcelona and thermal solar panels

The city authorities of Barcelona are campaigning to get all its hot water from thermal solar panels. The authorities have set themselves the target of 50,000 square metres of solar panels by 2004. In order to meet this target, they are offering financial incentives and making it compulsory that all new buildings must be fitted with thermal solar panels. In addition, all schools will get special priority so that children can be educated in the values of renewable energy. The Local Education Authority should also consider the issue of education and renewable energy as Liverpool schools consumed 38.51 GWh of electricity in 1999, which is equivalent to a land area of 3, 253 hectares.

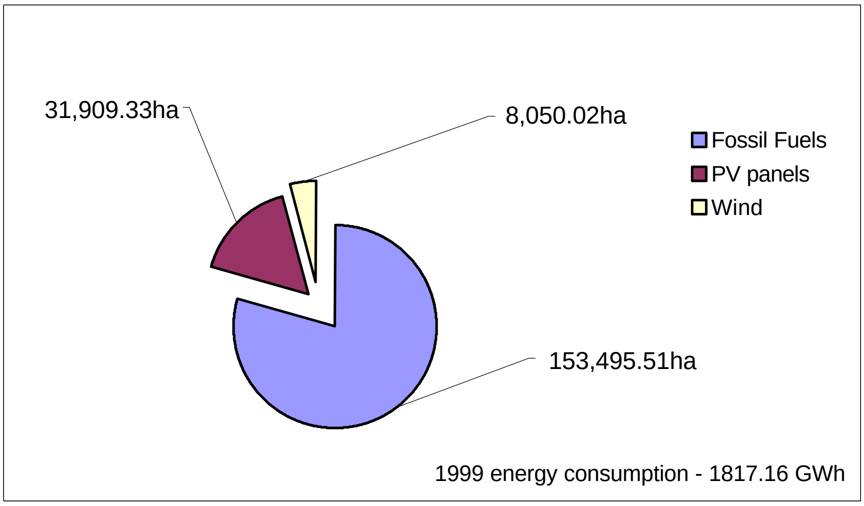
In order to lead by example, the authorities in Barcelona have guaranteed that all municipal buildings will be fitted with the panels by 2004. To encourage the use of solar panels, financial incentives are offered by the authority, regional government and from EU Funds. Recent changes in local planning rules insist that thermal solar panels are fitted on all new buildings, which includes commercial and industrial premises. The criteria for installation is that any premises that require hot water that exceeds the amount of hot water needed by 20 housing units must have thermal solar panels. This threshold is to be cut to 15 housing units in 2001 (Anon. 2000). Such decision-making and foresight also makes economic sense.

Since 1994, 352 sites in Liverpool have been developed (either as new builds or as refurbishments) for such purposes as housing, hotels, supermarkets, shops, offices and others. The total area of the sites is 2,570,600 square metres. Not a square metre of these sites is used to produce renewable energy. In the future, 6,620,000 square metres are earmarked for development.

In 1999, the average consumption of electricity per hectare of land in Liverpool was 160,810.6 kWh. On the same basis, future developments may add 106.45 GWh to the energy consumed by the city (based on 1999 consumption) or 8,827.11ha to the ecological footprint. Although future developments will be considered vital to the economy and for job prospects, they should not be unsustainable. In essence, the Council should be looking towards new technologies, which will assist the city to prosper without causing environmental concern.

By taking a similar stance to that of the authorities of Barcelona, Liverpool could significantly reduce the ecological impact of 662 hectares of potential new development. For example, it has been demonstrated (Solarcentury.co.uk, 2000) that 30m^2 of PV panels produce 1,200 kWh over a period of one year. By this calculation, 25ha of PV panels will produce 1 GWh of electricity in a year. The ecological footprint demonstrates clearly that PV panels are more sustainable than fossil fuels. For instance, the generation of a GWh of electricity from fossil fuels is the equivalent of 84.47 hectares whilst the same amount of energy derived from Photovoltaic panels equates to 17.56 hectares, a saving of 69.91 hectares. Liverpool is also geographically well placed to consider the utilisation of offshore wind farms, which have an ecological footprint of 4.4ha per GWh (Simmons, Lewis and Barrett, 2000). Figure 4.6 illustrates the comparative ecological footprints of the above methods of energy production based on the energy consumed in1999.

Fig 4.6 Ecological Footprints and energy production, applied to total energy consumed in 1999



4.4 Energy conservation in the home

It has been recognised that Liverpool is a city in much need of economic regeneration. This recognition is supported by the fact that 50.38% of households claim Housing and/or Council Tax benefit. "These benefits are a good indication of levels of poverty" (Anti Poverty Unit, 1999: 2). Since 1996, the indicators show that the level of poverty has increased by 2%.

An important aspect of poverty is the ability to maintain warmth in the home. A satisfactory heating regime is considered to be one where the main living room is heated to 21^0C and other occupied rooms to 18^0C (DTI, 1999). People who are unable to maintain warmth in their home are considered to be in 'fuel poverty' and many of those people on benefit are recognised as being in fuel poverty. Fuel poverty is defined as a household that "needs to spend 10% or more of its income to provide adequate heat and energy provision" (DTI, 1999: 72). However, the DTI notes that although a household would need to spend 10% of its income to keep warm, many cannot afford to. According to the DTI, 1 in 5 households in the UK are in fuel poverty. Liverpool, in comparison, has 1in 2 households in fuel poverty (based on those claiming a benefit).

Under the Home Energy Conservation Act 1995, "Local authorities have an important role to play in promoting energy efficiency at a local level" (DTI, 1999: 55). Although energy efficiency has generally improved (2-2.5% across England), local authorities need "to do more" (DTI, 1999: 55). To encourage further uptake of energy efficient initiatives, the government has increased the funding of the Home Energy Efficiency Scheme (HEES) and widened the number of improvement measures provided for properties. Previously, 100% grants were available to households where the occupier was in receipt of a qualifying benefit however HEES only offered the option of one main improvement measure (loft insulation, cavity wall fill, draught-proofing, or heating control upgrades) and a number of supplementary measures (2 energy efficient light bulbs, a hot water tank jacket or advice on energy). Despite the measures available the DTI (1999) have recognised that fuel poverty is likely to continue as HEES was limited in that only one measure could be undertaken and that the grant ceiling was inadequate to address the problem of maintaining warmth in the home.

As of April 2000, a New Home Energy Efficiency Scheme has been introduced, which has a wider remit than its predecessor. The major differences of the New HEES are that it will have 2 tiers, some additional measures and a substantial increase in the grants available per household. The first tier has a grant maximum of £1000 and can draw from a list of the previous measures with addition improvements (see Table 4.3). Tier 2 (New HEES Plus) draws from the same list but has a maximum grant of £2000, which is targeted at low-income and over 60s households. The aim of the new packages is to reduce the amount of fuel that is required to heat each home, which could save households £300-1000 a year.

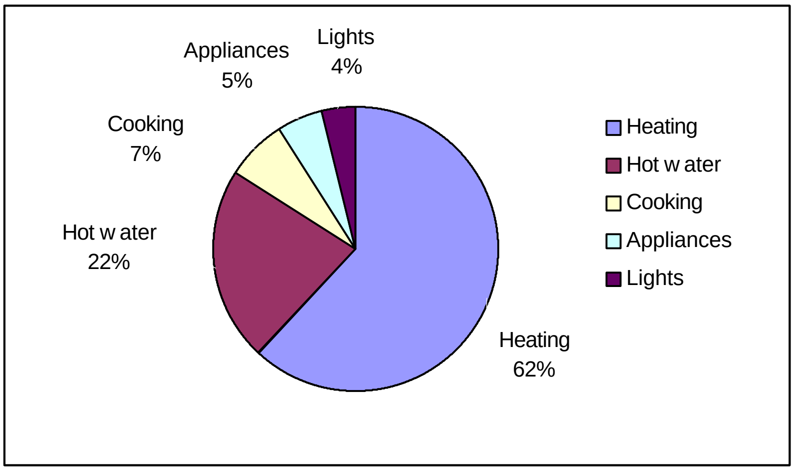
Table 4.3: Measures available under the New Home Energy Efficiency Scheme

Measures
Loft insulation
Draught-proofing of doors and windows
Cavity wall insulation
Hot water tank insulation
Compact fluorescent lamps
Heating system measures
Gas room heaters with thermostat controls
Electric storage heaters
Closed solid fuel fire cassette
Electric dual immersion water heater with foam insulated tank
Timer controls for electric space and water heaters

Source: DTI, 1999

In a study by The Association for Environment Conscious Building (1995) they calculated that hot water and space heating (84%) accounted for most of the energy consumed by a household. Lights, appliances and cooking were responsible for the remainder of energy consumption (see Fig 4.7).

Fig 4.7: The percent of energy consumed in a home by source



It is also estimated that electricity consumption in homes across the UK produce between 66-70 Mt of CO_2 annually (DETR, 2000c). Besides relieving fuel poverty, energy efficiency is also necessary to reduce harmful emissions into the atmosphere. This is why it is important that local authorities should do more to conserve energy in homes. For example, by raising awareness, consumers could be influenced to purchase a gas cooker rather an electric one and save 360kgs of CO_2 a year (DETR, 2000c). Table 4.4 highlights the potential savings for carbon emission for UK households.

Table 4.4: Potential domestic energy savings of CO_2

Measure	Potential saving Mt-CO_2/yr	Measure	Potential saving Mt-CO_2/yr
Loft insulation (150mm)	1.87	Condensing boilers	6.64
Cavity wall insulation	8.58	Low energy lights	6.78
Solid wall insulation	9.75	Efficient dishwashers	0.26
Full double glazing	3.34	Efficient refrigerators	2.53
Extra double glazing	1.32	Efficient fridge/ freezers	5.32
Full draught-proofing	1.10	Efficient freezers	4.77
Extra draught-proofing	0.40	Efficient televisions	1.69
Cylinder insulation	0.66	Efficient electric cookers	5.57
Extra cylinder insulation	0.84	Efficient gas cookers	1.06
		Total potential saving	**62.48**

Source: based on BRE, 1995

It is shown in the Good Practice Guide (DETR, 2000c) that there are potentially high-energy savings to be gained from the undertaking of remedial work to prevent heat loss from domestic premises. In the guide, potential energy savings are highlighted individually for detached, semi-detached and terraced properties. For the purpose of this study, a mean saving in kWh is applied to the energy conserving measures based on the potential energy saving of all property types. This method is applied to data from an energy efficiency survey undertaken by Liverpool CC in 1996, as the property types surveyed were not defined. The same mean will be adopted for home energy saving scenarios. Assumptions are made that no further remedial work has been carried out, energy consumption is based on 1999 data and the potential energy and cost savings are based on DETR (2000c) data.

In 1999, Liverpool's domestic energy consumption was 712.9 GWh. The mean consumption for households (188,000) was 3,792 kWh and the ecological footprint per property was 0.32 hectares. Compared to the national average for domestic energy consumption (5,281.5 kWh) the average Liverpool property consumes (28.2%) less. The probable reason for this is that more than half of the properties in Liverpool can be defined as being in fuel poverty, which is reflected in the actual amount of energy that is consumed generally. Table 4.5 illustrates the results of the 1996 energy efficiency survey, which is combined with the annual cost savings of remedial work, the payback time and the potential energy savings (kWh). Added to the 1996 survey are energy efficient lights and replacement boilers, which can have potentially significant savings in energy and costs. Data from table 4.5 is also used to establish energy savings scenarios and a reduction in the ecological footprint for domestic energy.

Table 4.5 Results of a 1996 energy efficiency survey and potential cost and energy savings

1996 Energy Survey		Benefits		
Measure	(%)	Savings £/year	Pay back Time (years)	Savings kWh/year
Cylinder insulation	93	20	2	169
Central heating	82	90	3	915
Loft insulation	72	55	5	556
Draught stripping	50	22	6-7	248
Cavity wall insulation	27	112	3-4	1156
Double glazing	26	37	4	345
Energy saving lights	Not surveyed	40	2	421
Boiler replacement	Not surveyed	150	2	1443
	Potential savings	**528**		**5,253**
Sources: LCC, 1996. DETR, 2000c				

Table 4.5 identifies significant areas where potential savings in cost and energy can be achieved. For example, the replacement of a boiler would result in the savings of £150 a year whilst reducing energy consumption by 1,443 kWh over the same period. Should the remaining hot water tanks be insulated then the consumption of energy would be reduced by 2.22 GWh across the city and reduce the ecological footprint by 187.5 hectares. Table 4.6 highlights the results of the energy efficiency survey and the savings made thus far. For example, remedial work has saved 334.65 GWh and 27,143.3 hectares respectively. Table 4.7 demonstrates how energy could be further conserved should targets for the completion of remedial work be achieved.

Table 4.6 Results of 1996 energy efficiency survey by LCC and the resulting savings in energy and hectares

1996 Energy Efficiency Survey			
Measure	Completed (%)	Saved Gwh	Saved EF (ha)
Cylinder insulation	93	29.54	2,495.2
Central heating	82	141	11,910.2
Loft insulation	72	75.26	6,357.2
Draught stripping	50	23.31	1,800
Cavity wall insulation	27	58.68	4,956.6
Double glazing	26	16.86	1,424.1
Total saved		**334.65**	**27,143.3**

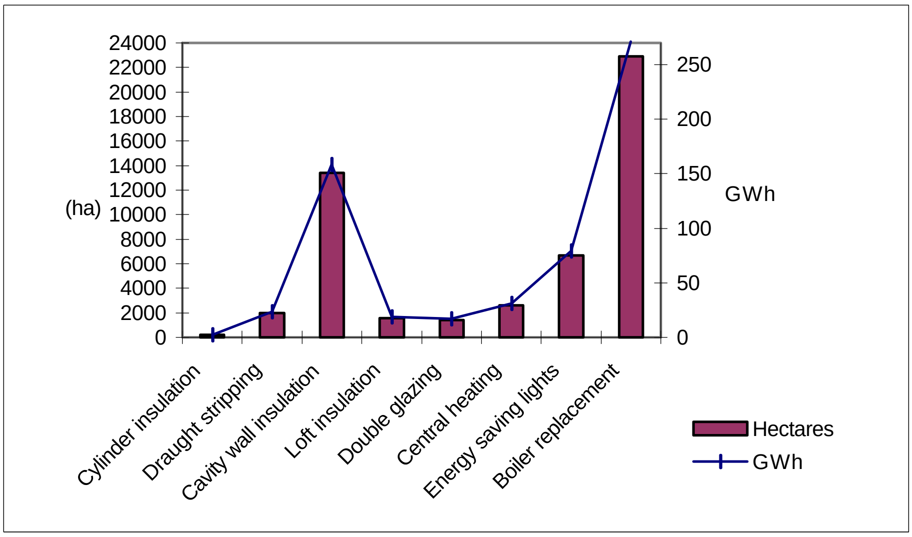
Table 4.7 Targets for achieving significant reductions in domestic energy consumption

Measure	1996 (%)	Target 50% Annual savings GWh	Year 2005 EF (ha)	Target 60% Annual savings GWh	Year 2006 EF (ha)	Target 70% Annual savings GWh	Year 2007 EF (ha)	Target 80% Annual savings GWh	Year 2008 EF (ha)	Target 90% Annual savings GWh	Year 2009 EF (ha)	Target 100% Annual savings GWh	Year 2010 EF (ha)
Cylinder insulation	93											2.22	187.5
Central heating	82									13.76	1,162.3	17.2	1,452.8
Loft insulation	72							8.36	706.1	10.45	882.7	10.45	882.7
Draught stripping	50			4.66	396.6	4.66	396.6	4.66	396.6	4.66	396.6	4.66	396.6
Cavity wall insulation	27	49.98	4,222	21.73	1,835.5	21.73	1,835.5	21.73	1,835.5	21.73	1,835.5	21.73	1,835.5
Double glazing	26	15.56	1,314	6.48	547.3	6.48	547.3	6.48	547.3	6.48	547.3	6.48	547.3
Energy saving lights	0	39.57	3,342	7.91	668.1	7.91	668.1	7.91	668.1	7.91	668.1	7.91	668.1
Boiler replacement	0	129.87	10,970	27.12	2,290.8	27.12	2,290.8	27.12	2,290.8	27.12	2,290.8	27.12	2,290.8
Potential savings		**234.98**	**19,848**	**67.9**	**5,726.2**	**67.9**	**5,726.2**	**76.26**	**6,444.4**	**92.11**	**7,783.3**	**97.77**	**8,261.3**

The first point to note is that had no energy efficiency measures been undertaken, then domestic energy consumption would have been 48% higher and as a result, 29,115ha would have been added to the ecological footprint for domestic energy. Therefore, it is important for those charged with implementing energy efficiency in homes and in a sense relieving fuel poverty, to continue to build on the relative success thus far and ensure that the grants that are currently available from New HEES Plus are put to effective use.

The long-term objective should be the implementation of all energy efficiency measures into all homes by 2010. This includes those homes that have yet to be built. The net savings of reaching this objective would be an 89% reduction in overall energy consumption or a fall of 53,789ha, based on the 1996 survey (see Fig 4.8).

Fig 4.8: Net savings of full energy efficiency measures in all homes



In the short-term the aim should be to increase the numbers of households where measures are fitted. For example, achieving 50% installation of cavity wall insulation, double-glazing, energy-saving lights and replacing boilers would by 2005 show potential savings of 234.98 GWh and 19,848ha. Figures 4.9 and 4.10 highlight the potential savings for energy and hectares year on year until 2010. Initially, there is a tendency for high savings in relation to GWh and hectares because of the significant impact that energy saving lights and boiler replacement has on energy efficiency. As more energy saving measures is implemented the trend is for greater savings as year 2010 approaches.

Fig 4.9: The potential savings of GWh to 2010

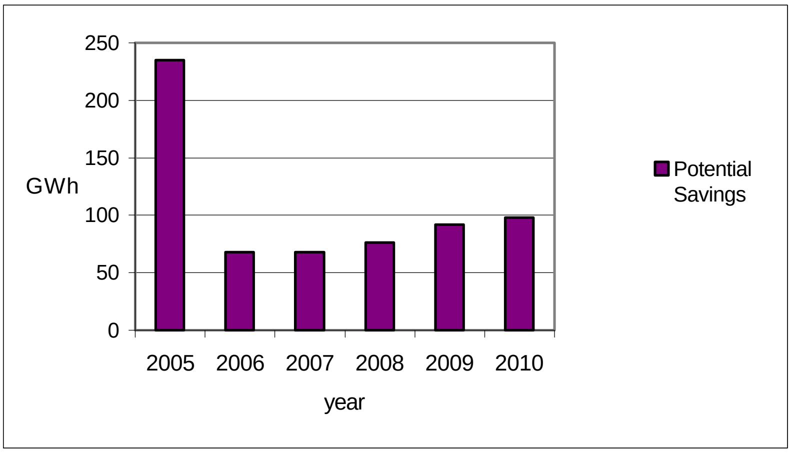
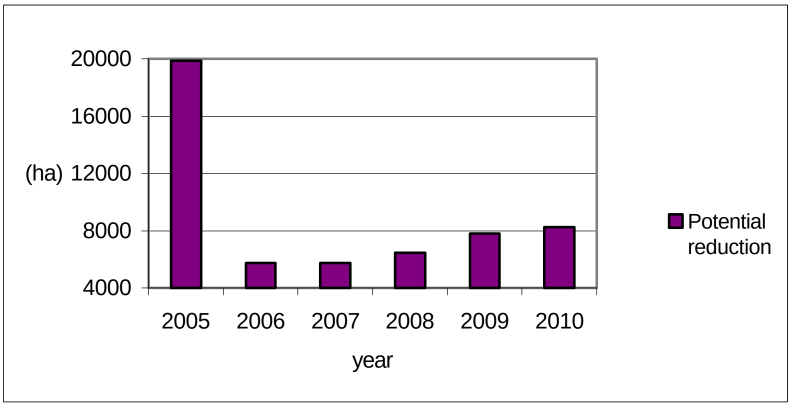


Fig 4.10: The potential for reducing the ecological footprint by 2010



The suggested targets in Table 4.7 are not set in stone but are there for guidance to enable domestic energy consumption and the ecological footprint to be reduced over time. How this is achieved relies very much on funding and the order in which measures are implemented. For example, an obvious target would be the complete installation of cylinder insulation because a 93% success rate has already been achieved. Completing this installation would be good for moral and show commitment, it would also save energy and land, even though the impacts would be relatively small to begin with.

4.5 The service sector and the ecological footprint

The service sector is very varied and is comprised of private commercial services such as shops and offices and the public sector, which consists of central and local government offices, Education and Health. Since 1970, electricity consumption in the service sector of the UK has increased by 133%. This is mainly due to an increase in the use of electrical equipment (IT), heating, cooling, lighting and more recently air conditioning (DTI, 1999). However, during the same period, energy intensity (delivered energy consumption divided by contribution to GDP) has decreased by 37%.

Businesses are coming under increasing pressure concerning their environmental performance. For instance, legislation is becoming more stringent, regulatory bodies are acting tougher and insurance cover is diminishing. Furthermore, greater public awareness and the purchasing power of consumers are having a significant effect on the goods and services sold by companies (Hilary, 1994).

Since 1992, the World Business Council on Sustainable Development has advocated the concept of eco-efficiency to businesses around the world. Although the aim of business is to satisfy human needs and for that they are rewarded with profits but responsible business should also aim to improve peoples' quality of life. Eco-efficiency can help business as well as individuals, governments and other organisations to become more sustainable. Eco-efficiency is defined as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity" (Cowe 2000: 7). In essence, the concept outlines the sustainable targets for business – achieving more value from lower inputs of material and energy, with a reduction in emissions to land, air and water.

The performance of the public sector nationally, is generally measured in terms of 'value added output', which has grown 90% since 1970 but this contradicts its environmental performance (e.g. 133% increase in electricity consumption). According to a survey by the Building Research Establishment (cited in DTI, 1999) the public sector consumes more energy on heating its offices than any other sub-section, including Education, Retail, Hotels and catering and the Health service.

However, this is not the trend in Liverpool where public sector offices (National/Local government) consume 88.41 GWh and are surpassed by Commercial offices (126.16 GWh) and Retail shops (collectively, 159.77 GWh) in their use of energy. Retail shops probably top the table for energy consumption because nationally, lighting accounts for 31% of retail use (DTI, 1999) and there is a tendency to have all-night illumination. Table 4.8 displays the energy consumption (electricity) of the service sector in Liverpool. In total, energy consumption by the service sector in 1999 was 1,031.9 GWh or 87,167.12ha. The area required to provide the service sector with it energy is almost 7.5 times greater than the area of Liverpool.

Table 4.8: Service sector electricity consumption, 1999

Service sub-sectors	GWh	Ha	Service sub-sectors	GWh	Ha
Retail shops - food	78.85	6652.0	Nat gov offices	16.01	1352.3
Retail shops - other	58.00	4899.2	Garages	15.56	1314.3
Retail shops - food (+ accom)	12.38	1045.7	Hotels	13.96	1179.2
Retail shops - other (+ accom)	10.54	890.3	Libraries, museums	12.59	1063.4
Sub-total	**159.77**	**13646.97**	Hairdressers	8.95	756.0
Other offices	126.16	10656.7	Technical colleges	8.76	739.9
Hospitals	72.95	6162.0	Churches	7.78	657.1
Wholesalers - other	61.98	5235.4	Guest houses	7.23	610.7
Hypermarkets	47.00	3970.0	Railway stations	6.15	519.4
Department stores	46.4	3919.4	Holiday camps	5.99	505.9
Public houses	45.62	3853.5	Community centres	4.94	417.2
Local gov	72.4	6115.6	Cinemas, theatres	4.90	413.9
Schools	38.51	3252.9	Day clinics, dentists	4.62	390.2
Universities	33.14	2799.3	Law courts	3.74	315.9
Others	28.83	2435.2	Radio, TV and film	3.51	296.4
Restaurants	28.18	2380.3	Launderettes	2.13	179.9
Wholesalers - food	26.88	2270.5	Armed forces	1.90	160.4
Postal services	25.24	2132.0	Car parks	1.30	110.6
Sports facilities	24.45	2065.2	Warehouses – other	0.82	69.2
Transport depots	23.57	1990.9	Vets	0.53	44.7
Nursing homes	22.09	1865.9	Cemetries	0.52	43.9
Warehouses - food	16.02	1353.2	Air transport	0.36	30.4
			Totals	**1031.9**	**87,167.12**

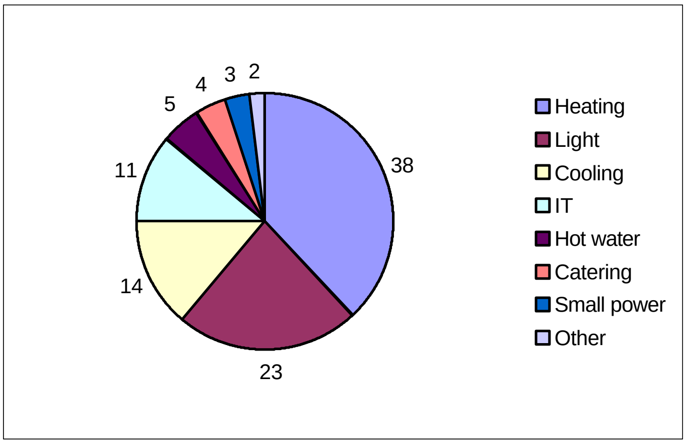
The impact of energy consumption in the public sector has been discussed earlier in this chapter therefore the focus of further scenarios within the service sector will be commercial offices as there appears to be several barriers to investing in energy efficiency in this particular sub-sector (Scrase, 2000). For example, institutional investors own approximately half of commercial office stock (Callender and Key, 1997. Cited in Scrase, 2000), 70% of the stock is multi-tenanted (Scott, 1996) and office service charges are incorporated into the total occupancy costs (Jones, Lang and LaSalle, 2000). Hence, there is “a classic landlord/tenant barrier to improving energy efficiency: tenants are unable or unwilling to invest in improving energy efficiency of buildings owned by another party, and the owners are happy to pass on the fuel costs to the tenant” (Scrase, 2000: 13). Therefore, It is probable that with the introduction of the Climate Change Levy in 2001, tenants are likely to be burdened with the additional 10% that will inevitably be added to their energy costs.

The largest investors in commercial property stock are long-term insurance companies, UK quoted property companies, foreign investors, pension funds, property unit trusts and investment trusts. Importantly, freeholders occupy only 10% of commercial offices. According to Scrase (2000), this vested interest rarely demands energy efficiency in properties because it is assumed that energy costs are relatively low compared to the occupants annual turnover. Using the example of air-conditioning, which can be highly inefficient (over half of new offices and a third of retail outlets were fitted with air-conditioning in the 1990s), research by Jones, Lang and Lasalle (2000) suggests that this may not be the case. For example, in 1998, the average service charge (excluding maintenance) for an air-conditioned office building was £57.36 per m^2 but in comparison, the service charge for a non air-conditioned building was £40.26 therefore air-conditioning amounts to 18% of the service charge. Furthermore, when maintenance is added, the proportion of the service charge for air-conditioning increases to 35%, which may be a significant reason for a tenant to consider reducing its energy costs.

Tenants in a multi-tenanted building may also find it difficult to make use of renewable technologies because their energy supply (gas and electricity) is invariably shared with the other occupants (although it is metered separately). Therefore, the only options are switching lights and equipment off when not in use, which should not be dismissed as they do conserve energy and save on costs. However, there is the opportunity for occupants to insist that the owners of a building install an energy saving system or possibly sharing the costs of the installation of a new technology such as CHP.

In a study by Pout, et al (1998) it was shown that UK commercial offices emit over 9.5 million tonnes of CO_2 annually. Heating and lighting are responsible for the greatest percentage share of CO_2 by end use (see Fig 4.11). Using the same percentage split for end use as Figure 4.11, Liverpool's commercial offices emitted 55,495.79 tonnes of CO_2 in 1999. Heating and lighting consumed 76.9 GWh of energy, emitted 33,842.8 tonnes of CO_2 and required 6,495.7ha of land (see Table 4.9). In order to function at present, commercial offices required 126.16 GWh of energy and 10,656.73ha of land, which is almost the area of Liverpool (11,300ha).

Fig 4.11: Per cent CO_2 emissions by end use in commercial buildings



Source: based on Pout, et al (1998)

Table 4.9: The impact of Liverpool commercial office energy consumables

Consumables	**%**	**GWh**	**Ha**	**CO_2 tonnes**
Heating	38	47.94	4,049.49	21,097.85
Light	23	29.01	2,450.47	12,766.97
Cooling	14	17.66	1,491.74	7,771.97
IT	11	13.87	1,171.60	6,104.03
Hot water	5	6.30	532.16	2,772.56
Catering	4	5.04	425.73	2,218.05
Small power	3	3.78	319.30	1,663.54
Other	2	2.52	212.86	1,109.02
Total	**100**	**126.12**	**10,653.36**	**55,503.99**

In a recent DETR (2000d) publication 'Energy use in offices', typical offices are defined as 1; Naturally ventilated cellular, 2; Naturally ventilated open-plan, 3; A/C standard and 4; A/C prestige. Typical and good practice energy consumption is based on kWh/m^2 of treated area. The differences between typical and good practice for each office type is shown in Table 4.10. For this study, the mean difference (56.98%, rounded to 57%) between office types is applied to a commercial office scenario.

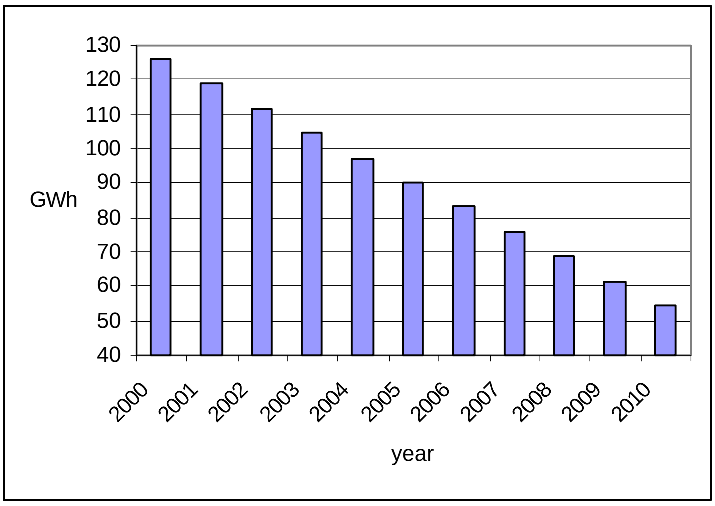
Table 4.10: Typical and good practice energy consumption in offices in the UK

KWh/m2 treated floor area								
	Type 1		Type 2		Type 3		Type 4	
	Good practice	Typical	Good Practice	Typical	Good practice	Typical	Good practice	Typical
Totals	112	205	133	236	225	404	348	568
%	54.63		56.35		55.69		61.26	
Mean % difference (56.98) 57								

Source: based on DETR, 2000d

In order for commercial offices to achieve a good practice regime, energy consumption must be reduced by 57% against the present consumption of 126.16 GWh. To attain this reduction in energy consumption, it is suggested that an annual 10% reduction target of 7.19 GWh be set. Over a ten-year period the result will be a 57% reduction in energy consumption, thus reaching a level of energy use that is compatible with commercial office good practice. Figure 4.12 illustrates that by 2010 the energy required by commercial offices to function will be 54.26GWh, a saving of 71.91 GWh.

Fig 4.12: The reduction of energy consumption with the achievement of commercial office good practice by 2010



Not only will energy consumption be reduced, there will be simultaneous reductions in the ecological footprint from 10,656.73ha to 4,582ha and CO_2 emissions, which will fall from 55,521.59 tonnes to 23,874.29 tonnes. However, this target will only be met if new office developments are designed to meet commercial office good practice or better. A similar target could also be set for the remaining sub-sectors of the service sector, which could result in an overall ecological footprint reduction of 48, 077.6ha.

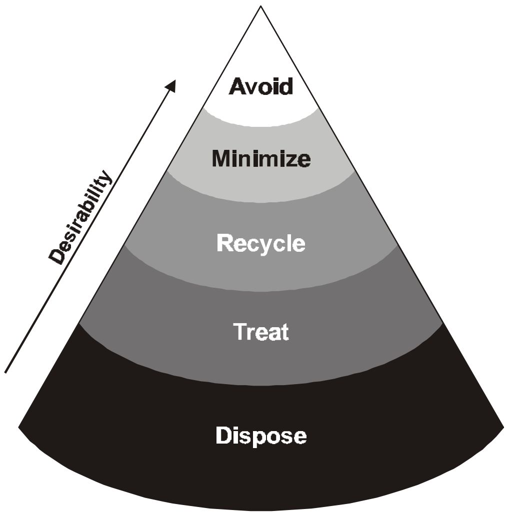
To some extent these targets are most likely to be out of the reach of many of the occupants of commercial office buildings because of the present barrier of ownership, which hinders progress towards sustainable energy consumption. However, with the introduction of the Climate Change Levy in 2001 there is a strong incentive for businesses to take heed of their impacts upon the city and persuade property owners to 'do their bit'. There are many, currently available technologies besides the suggestions given to the local authority in this chapter (CHP, solar energy, wind power), which can assist in meeting the targets that have been set such as condensing natural boilers, compact fluorescent lights, low energy computing equipment and accessories, improved design and use of air-conditioning, loft and cavity wall insulation and hot water insulation, In addition, the results, scenarios and the message that permeates from an ecological footprint analysis of energy should enable the local authority to aim towards encouraging partnerships with suppliers and consumers of energy.

Should the targets set for a reduction in energy consumption be attained by 2010 then the ecological footprint for electricity consumption will be reduced from 153,495.5ha to 45,213.77ha, a reduction of 70.55%.

4.6 Domestic waste scenario

A systematic shift in waste management away from disposal and towards waste prevention and recycling, requires the use of an integrated set of policy measures to change the behaviour of the waste generators - industry, commerce and consumers. The following scenarios for waste have attempted to take all these aspects into consideration. The scenarios are based on the waste hierarchy (see Figure 4.13). Different scenarios employ different aspects of the waste hierarchy in an attempt to demonstrate the most sustainable and realistic waste strategy.

Fig 4.13: The waste hierarchy



Before introducing the scenarios it is important to define a sustainable amount of waste production for Liverpool. Potentially, the ideal position for waste in Liverpool is to reach a situation of zero waste. This may sound absurd under the present climate but this should undoubtedly be the final target. The scenario for waste does not attempt to suggest such a target as it is based around a 10 and 21-year realistic plan for the city.

The waste hierarchy demonstrates the need to firstly avoid producing the waste, then minimising the waste. Both these categories address the primary use of resources as opposed to the end use of waste (i.e. recycling, treatment and disposal). The scenarios will address all these issues.

It is important to have some idea as to what a sustainable level of waste would be in terms of the ecological footprint. At present, the ecological footprint of waste is 1.6 hectares/per capita. Depending on the other components (such as energy, transport etc.) a sustainable ecological footprint for waste is 0.6 hectares/ per capita. Therefore, domestic waste must achieve a target of 0.39 hectares/ per capita. It would be an excellent achievement to reach this level. However, under the present situation the scenarios suggest a possible ecological footprint of domestic waste of 0.82 by 2021 from 1.1 hectares/ per capita.

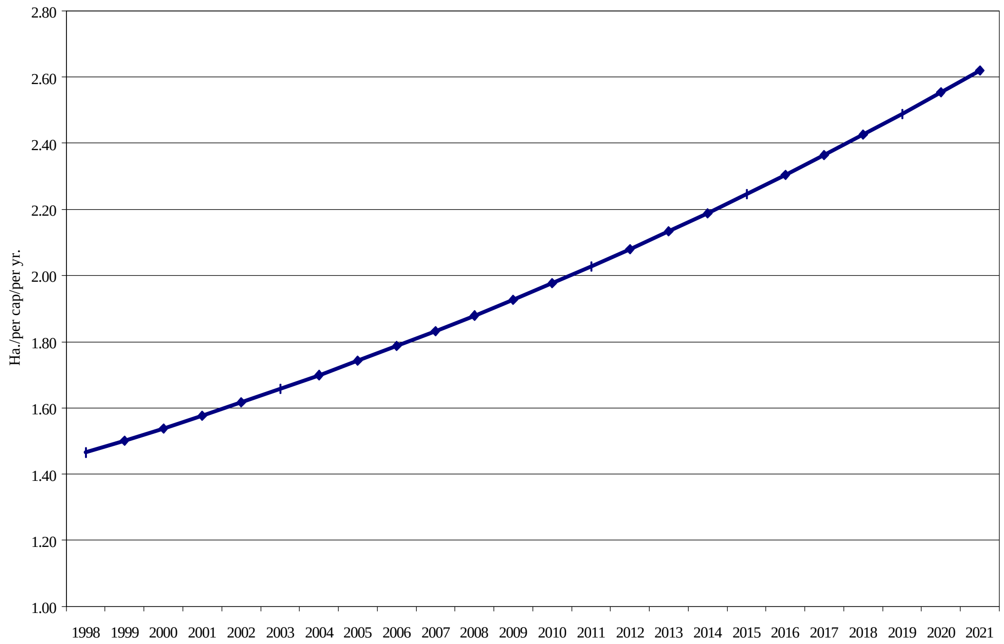
Five scenarios have been applied to domestic waste.

- Business as usual scenario
- Eco-efficiency scenario
- De-materialisation scenario
- Government Aims and Objectives
- Sustainable scenario

4.6.1 The business as usual scenario

Before considering what the ecological footprint of waste will be with the introduction of different schemes, it is important to understand what the ecological footprint of waste would be if nothing were done. At present, in ecological terms, waste has the largest impact of all the components. Even though the ecological footprint of waste was lower for Liverpool than other areas in Merseyside it is set to increase at a faster rate, according to research conducted by the Clean Merseyside Centre (2000). Figure 4.14 provides an insight into the projected increase into the ecological footprint of domestic waste if nothing is done.

Figure 4.14: Projected Increase in the Ecological Footprint of Waste produced by Liverpool



This projection is based on five assumptions: -

- The rise in municipal waste will be 2.9%
- The rise in commercial waste will be 1%
- The rise in industrial waste will be 1.2%
- The components that make up domestic waste in Liverpool will not change significantly (i.e. the proportion of plastic, cardboard etc.)
- Recycling rates will not increase to above 10%

The projected rise of the ecological footprint of waste is most likely to be a conservative estimate. The rise in construction waste is also likely to be higher. The figure for municipal waste has been derived from comprehensive research and is both the most significant and accurate figure. By 2010, if no efforts are made to stem the growth of waste, the ecological footprint of domestic waste will be 2 hectares per person. This is a substantial increase of 30% from 2000. Not only have policies attempting to reduce the ecological footprint got to deal with a current unsustainable level of waste, but they must also deal with a potential growth of 30%. All the scenarios for waste have taken this growth rate into account.

- *The Eco-efficiency scenario*

Eco-efficiency is often described as 'getting more from less'. In terms of waste, it is about a better end use for the waste involving the introduction of recycling schemes, and composting schemes. This scenario does not question the amount of waste produced but themes in solely on eco-efficiency measures.

Recycling is a major component of the eco-efficiency scenario. The most successful household recycling schemes involve a door-to-door collection service. Examples of local authorities who have introduced such schemes demonstrate that a 40% recycling rate is a realistic target to achieve. Assuming that this could be achieved in Liverpool over a ten-year period may be slightly unrealistic because of the present attitude to recycling in the city. Past studies have shown that many areas in Liverpool see recycling as a low priority (Barrett and Scott, 2000). However, this target has been achieved in other areas of the country.

The amount of waste that can be collected from a kerbside scheme relates to waste quantities and waste composition. At present, not all of Liverpool’s domestic waste is suitable for recycling. It is estimated that 70.13% of Liverpool’s domestic waste can either be recycled or composted. Therefore, of the 175,000 tonnes collected at the moment, 122,727.5 tonnes could be recycled or composted. Breaking this figure down even further, 35.5% of household waste could be composted and 34.6% could be recycled. The average household in Liverpool produces 930kg of waste, of which 330.15kg could potentially be composted and 321.78kg could be recycled.

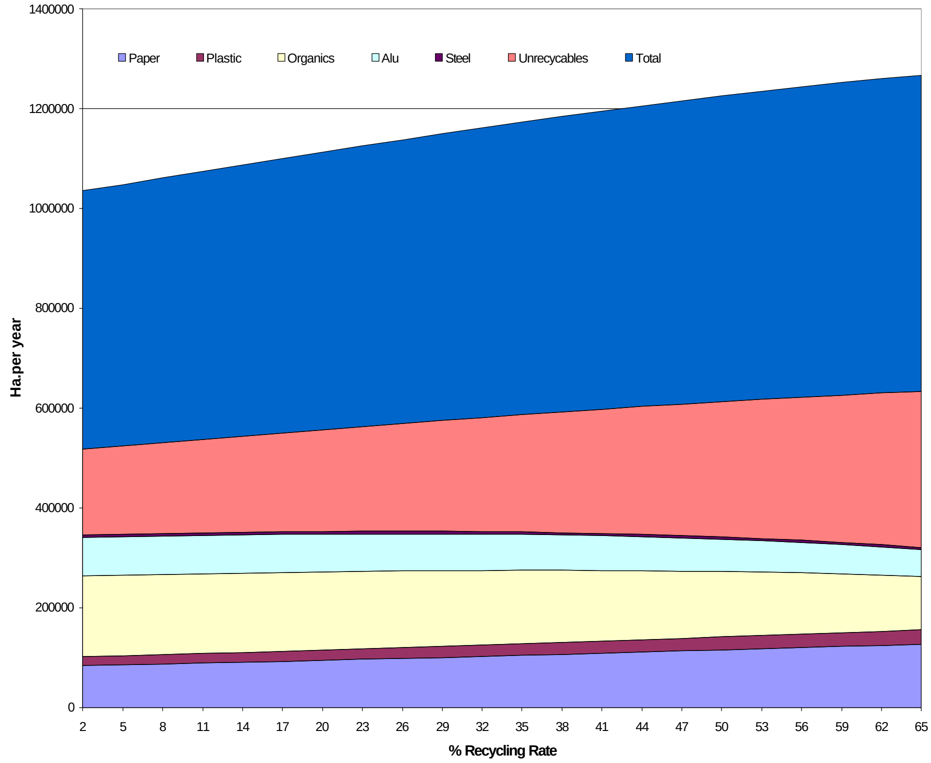
By applying these figures, and taking into account the increase in waste over the next ten years, it is possible to develop scenarios relevant to Liverpool.

4.6.2 The kerbside collection scheme for dry recyclables

The kerbside scheme would mean a weekly collection of mixed recyclables, which would include the collection of paper (magazines and newspapers mainly), glass of all different colours, plastics and both steel and aluminium. All houses would be covered in the scheme in an effort to gain the maximum amount of recyclable goods. Materials are put out in boxes and collected in purpose built trucks that can carry 4 tonne loads. It is assumed that everyone who participates in the scheme will recycle all their materials. For example, they will recycle all their newspapers, plastic and glass. At present the average household disposes of 930kg of waste to landfill and only 33kg per annum is recycled. For a household participating in the scheme that had not previously recycled this would change to 322kg per annum being recycled. Figure 4.15 shows the footprint with the continuing success of the recycling scheme. The model has taken two other factors into account: -

- The transportation of waste: A recycling scheme does have an extra transport burden associated with it. Estimates, taking into account similar schemes in other areas of the country, have been applied.
- The growth in Liverpool’s municipal waste will be 2.9% per year (taken from research conducted by the Clean Merseyside Centre).

Figure 4.15: The ecological footprint of domestic waste in Liverpool



If Liverpool is able to achieve a recycling rate of 65% by 2021 and does not attempt to minimise domestic waste over this time period, then the ecological footprint will increase by 212,020 hectares (0.45 hectares per capita). To counteract the growth in waste, a recycling rate of 95% would have to be achieved. The 65% recycling rate by 2021 would mean an ecological footprint of 1.85 Ha./per capita, as opposed to the business as usual footprint of 2 Ha./per capita. The separate materials in the waste stream have been discussed below.

4.6.3 Achieving 100% recycling and composting

100% participation may seem totally unrealistic. This scenario is not suggesting that Liverpool can achieve this in the near future. However, it does demonstrate what can ultimately be achieved. In some European countries this has been accomplished (composting in the Netherlands, Austria and Germany).

Therefore, in ecological footprint terms the following applies: -

- The ecological footprint of waste to landfill: 312,928 hectares (0.27 hectares/per capita)
- The ecological footprint of recycling: 146,091 hectares (0.13 hectares/per capita)
- The ecological footprint of composting: 3,075 hectares (0.007hectares/per capita)

The total of all three (i.e. landfill, composting and recycling) is an ecological footprint of 462,094 hectares (0.99 hectares/per capita).

One of the most striking aspects of the ecological footprint of a 100% recycling and composting scheme is that it is not a substantial reduction from the present footprint of domestic waste; 0.99 hectares/per capita compared to 1.16 hectares/per capita. The sole reason for this is the projected growth of domestic waste in Liverpool.

To obtain the ecological footprint of domestic waste and considering the effect of recycling schemes, detailed analyses of paper, organics, aluminium, steel and plastics were undertaken. The reduction in the ecological footprint of an increased recycling rate of the different materials varies considerably. An analysis of each material has been illustrated below.

- *Paper and Magazines*

Table 4.11 demonstrates the necessary calculations that produced the scenario for Liverpool, concerning the ecological footprint of waste paper. The same calculations have been conducted for all the materials. As the amount of waste is expected to increase every year, a separate calculation is required combining the suggested recycling rate for that year along with the waste arising. After establishing the tonnage of material that will either go to landfill or be recycled, two different conversion factors are applied. This has been explained in the calculation below.

Table 4.11: The projected ecological footprint for waste paper in Liverpool with the introduction of a recycling scheme.

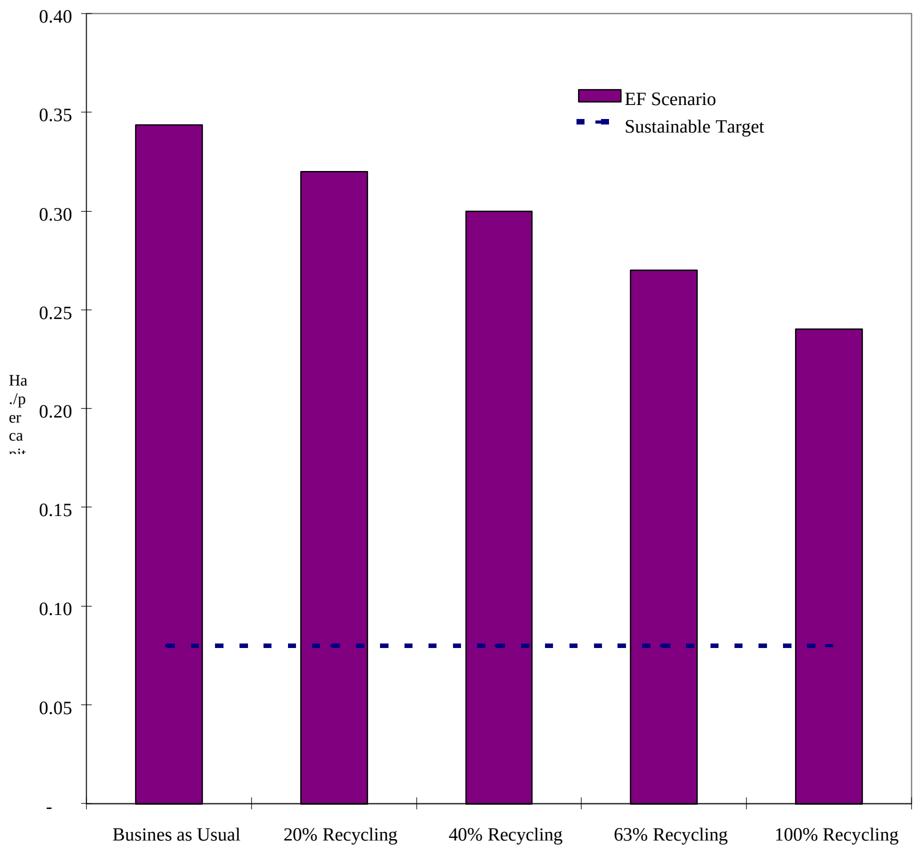
Year	Recycle Rate (%)	Landfill (tonnage)	Recycling (tonnage)	Landfill Footprint (Ha)	Recycling Footprint (Ha)	Total Footprint (Ha)	Footprint Per Capita (Ha)
2000	2	44,553	160	83,760	222	83,982	0.18
2001	5	43,552	2,292	81,879	3,186	85,065	0.18
2002	8	43,400	3,774	81,593	5,246	86,838	0.19
2003	11	43,203	5,340	81,221	7,422	88,643	0.19
2004	14	42,957	6,993	80,759	9,720	90,479	0.19
2005	17	42,661	8,738	80,202	12,145	92,348	0.20
2006	20	42,311	10,578	79,545	14,703	94,249	0.20
2007	23	41,906	12,517	78,783	17,399	96,182	0.21
2008	26	41,441	14,560	77,909	20,239	98,148	0.21
2009	29	40,914	16,711	76,918	23,229	100,147	0.21
2010	32	40,322	18,975	75,805	26,375	102,180	0.22
2011	35	39,660	21,356	74,562	29,684	104,246	0.22
2012	38	38,927	23,858	73,183	33,163	106,346	0.23
2013	41	38,118	26,489	71,661	36,819	108,480	0.23
2014	44	37,229	29,251	69,990	40,659	110,649	0.24
2015	47	36,256	32,152	68,162	44,691	112,852	0.24
2016	50	35,196	35,196	66,168	48,922	115,090	0.25
2017	53	34,043	38,389	64,002	53,361	117,363	0.25
2018	56	32,795	41,739	61,654	58,017	119,671	0.26
2019	59	31,445	45,250	59,116	62,897	122,014	0.26
2020	62	29,989	48,930	56,380	68,012	124,392	0.27
2021	65	28,423	52,785	53,435	73,371	126,806	0.27

(N.B. Even though all the other materials have undergone the same calculation procedure they will not all be illustrated in this way. The paper scenario is merely to demonstrate how the calculations were conducted).

For ‘Year 2005,’ it is suggested that a 17% recycling rate can be achieved. Therefore, 42,957 tonnes will go to landfill and 6,993 tonnes will be recycled. The 42,957 tonnes is multiplied by the ecological footprint factor for landfill (1.9 Ha./per tonne) while the 6,993 tonnes is multiplied by the paper recycling conversion factor of 1.4 Ha./per tonne). The conversion factor for recycling paper is the amount of energy required per tonne to recycle to paper. The two final columns represent the total ecological footprint of paper for that year, at that recycling rate and the figure in a per capita form.

It is assumed that an increase in the recycling rate of 3% is a feasible target. While the ecological footprint of paper is higher in 2021 if a 65% recycling target is achieved, this does not mean that recycling paper will not have any benefits. Figure 4.16 demonstrates what the ecological footprint of paper would be if the recycling rate did not increase along with some other possible outcomes.

Figure 4.16: Comparison of options for recycling paper

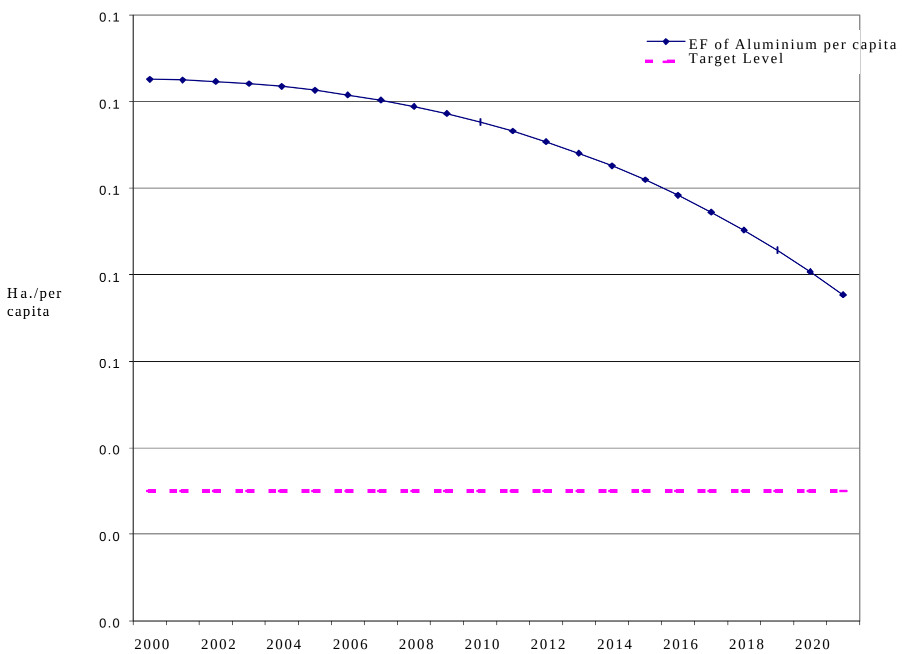


The first and most striking element of these findings is how far away a 100% recycling rate for paper is from the sustainable target. It demonstrates that the reduction obtained through recycling is not sufficient to bring about a sustainable level of waste paper generation. This does not mean that recycling paper has not been beneficial. Within the scenario for paper a 65% recycling rate is suggested as a feasible target. This would bring about a 22% reduction in the ecological footprint if recycling rates did not increase from the present figure. By far the worst situation is the ‘business as usual’ approach where the ecological footprint of waste paper is 4.3 times higher than the sustainable level. If a 100% recycling rate were achieved for paper then the ecological footprint of paper would still be higher in 2021 than in 2000. The issue of the volume of waste that is produced is discussed in the 'De-Materialisation' Scenario.

- *Aluminium*

Liverpool disposes of quite a small amount of aluminium (0.41% of the domestic waste stream). Despite this, disposing of aluminium to landfill has a high ecological footprint due to the high level of embodied energy within the material. The benefits in reducing the ecological footprint of aluminium are a lot greater than paper. This can be seen in figure 4.17. The same scenario has been applied, i.e. an increase of 3% in recycling until 2021 combined with the projected growth of Liverpool's domestic waste. Figure 4.17 also compares Liverpool's aluminium footprint with a sustainable level.

Figure 4.17 The projected reduction in the ecological footprint of recycling in Liverpool



Unlike paper, there is still a reduction in the ecological footprint of aluminium even though the projected growth in the disposal of aluminium is 17,805 tonnes in 2021 compared to 9,768 tonnes in 2000. Aluminium is one of only a few materials that could potentially reach a sustainable level if a 100% recycling rate was achieved. The reduction that could be made with the introduction of a waste minimisation scheme could be substantial.

- *Organics*

A large proportion of domestic waste can be classified as being organic (35.5%). This includes food and garden waste and it can only be potentially composted. This equates to an ecological footprint of 159,350 hectares (0.34 hectares/per capita). The reductions that can be gained from introducing a composting scheme are substantial.

Composting has by far the lowest ecological footprint compared to any recycling method and the calculation has been explained below. The majority of central composting schemes use the turned windrow method, a process in which piles of shredded and mixed organic waste approximately 3 metres high, 4 metres wide, and any length, are constructed. The windrows are turned regularly to ensure an even mixture, to provide aeration and to control temperature and moisture. The ecological footprint of composting is the energy required to carry out this process as well as the transport requirements for collecting the composting material.

A recent US EPA report (Juniper Consultancy Services Ltd, 1999) on greenhouse gas emissions from MSW management concluded that large scale centralised composting will produce virtually no greenhouse gas emissions: they concluded that no methane would be produced and CO_2 emissions would be negligible. However, composting systems typically require a power input of 35 kWh/tonne to turn the windrow or aerate the piles. There is also the process of anaerobic digestion, with a typical energy demand of 150 kWh/tonne. Composting also has a transport requirement that has been estimated at 6km/tonne. Converting these figures to an ecological footprint is demonstrated as thus;

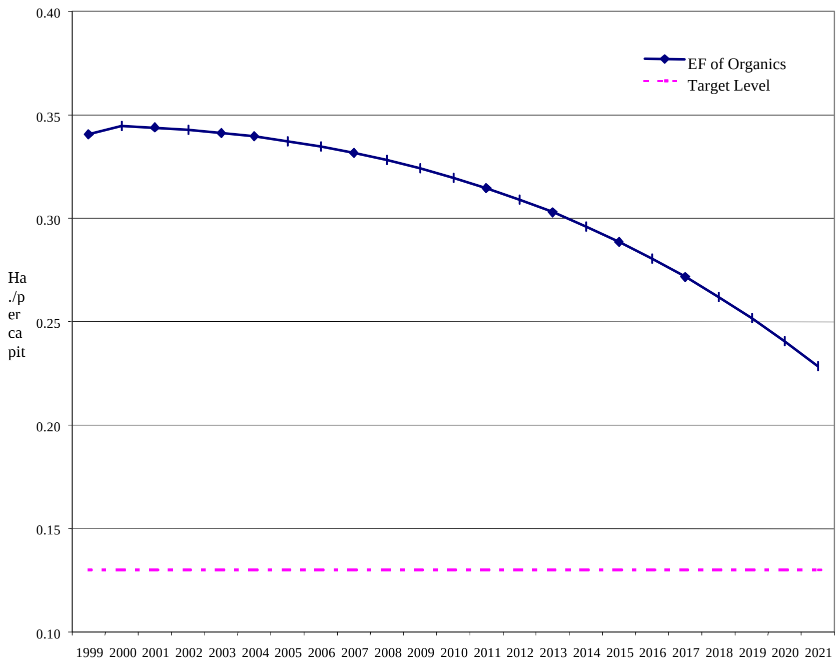
Total energy requirement per tonne:	185 kWh
Total transport requirement per tonne:	6 kilometres

Footprint per kWh (0.000084 hectares) x 185 = 0.016 hectares per tonne
Footprint per kilometre (0.00023 hectares) x 6 = 0.001 hectares per tonne

Therefore, the total ecological footprint of composting is 0.02 hectares/per tonne. This is compared to the ecological footprint of disposing of organic material to landfill (2 hectares/per tonne). Hence, if a scheme is introduced to collect organic waste the reduction in the ecological footprint can be considerable. There is also the opportunity to turn the by-product into a commercially viable product and create employment.

The average household in Liverpool produces 330kg of organic waste per year, or 6.35kg per week. Organic waste could be collected on a fortnightly basis, as the volume per household is not substantial. Householders could put out their organic waste in special paper sacks, which can be shredded along with the contents by the refuse truck. This makes the collection process efficient and more cost effective. A calendar can be issued to each household as to when the collections are. The composting bags can also be delivered during the waste collection process. The composting plant could either be run by the local authority or by a private firm. The potential reduction with the introduction of the scheme is shown in Figure 4.18. Again, it is suggested that the scheme could grow by a rate of 3% per year and takes into account the projected growth of waste.

Figure 4.18: The ecological footprint of introducing a composting scheme



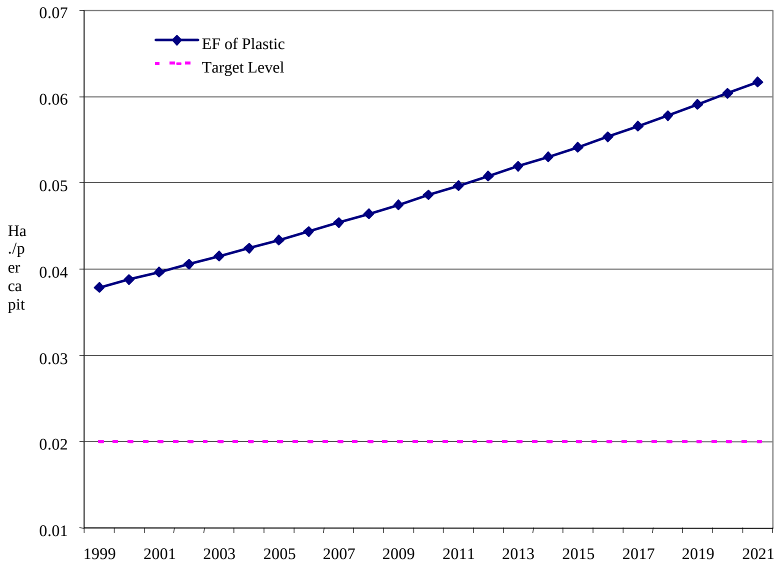
The success of a composting scheme could bring about a substantial reduction of 52,431 hectares. By recycling 80.5% of organic waste the sustainable target can be reached. The sustainable level is not the cut-off point where further reductions are not required. It merely highlights that measures taken to reduce the ecological footprint of some materials have a more favourable return than others do. It may be necessary to reduce the ecological footprint of composting further to compensate the growth in other materials, or where the gains are less apparent.

In pricing the composting scheme, examples from other local authorities suggest a price of £52 per tonne. This is the equivalent of approximately £17.50 per household per year. How this is funded is very much down to the local authority in question. Some authorities have been willing to meet this cost while others have made the householder buy into the scheme. There is also the possibility of commercial sponsorship on the composting bags provided.

- *Plastics*

Chapter 3 highlighted that plastic has a very high-embodied energy and a high ecological footprint. The process for recycling plastic is also very energy intensive, meaning that gains through recycling are minimal compared to aluminium or composting. Figure 4.19 demonstrates that the growth in plastic within the domestic waste stream over the next 25 years will easily outweigh the reduction in the ecological footprint through recycling.

Figure 4.19: The ecological footprint of plastic in the domestic waste stream



This poses the question as to whether plastic should appear in the waste stream at all. The most effective method to reduce the ecological footprint of plastic is to remove it from the waste stream and use materials that can be more effectively recycled. Even a 100% recycling rate by 2021 would not reduce plastic to a sustainable level.

- *Glass and Steel*

The gains in recycling glass are not as advantageous as aluminium as there is not a substantial saving between landfill and recycling. Glass is set to increase from having a small impact at the moment to a marginally higher impact in 2021 (from 0.02 to 0.03 hectares/per capita). As with many other materials, the growth in glass will counteract the gains made through recycling. With steel, the benefits do outweigh the growth in waste, but again this is marginal. Steel has a low impact in the first instance because it has a low embodied energy and is only responsible for 2.94% of the Liverpool waste stream. At present the ecological footprint of steel is 0.011 Ha./per capita. This would reduce to 0.09 Ha./per capita by 2021 if the target of recycling 65% is achieved.

4.6.4 De-materialisation scenario

With all forms of waste disposal, be it landfill or recycling, there is some form of impact. The ecological footprint has the ability to assess this, which can be seen in the eco-efficiency scenario. What is interesting about this is that even if Liverpool obtains a 95% participation in both recycling and composting, this would only counteract the potential growth in the ecological footprint of domestic waste. This highlights a most important fact; Liverpool must produce less waste in the first place and attempt to curb the potential growth in municipal waste highlighted by the Clean Merseyside Centre. This is one of the key objectives within the 'Waste Hierarchy' (see figure 4.13); avoid producing waste. If Liverpool were to curb the potential growth and even reduce municipal waste, along with a fully functional recycling scheme the effect on the ecological footprint would be substantial. The largest reduction in ecological impact can be gained through such schemes. They are also cost effective as less waste appears in the waste stream. The initiatives theme in on changing the culture and attitude toward waste and makes individuals aware of the consequences of waste disposal.

Waste prevention at the household level starts at the point of consumption by choosing products and services with the least environmental impact. This requires individuals to make decisions based upon the amount of raw material and energy used to manufacture these products. Waste prevention is defined as the prevention of waste at source or as eliminating waste before it is created, and the term is now often inter-changed with 'waste minimisation' or 'waste reduction'. A good way of looking at waste prevention is as an overall waste management strategy that seeks to reduce the amount of waste generated at each stage of a product's life span. For instance a company may change the design of a product or a process so that less raw material, energy and water are employed in its manufacture. A householder, on the other hand, can prevent waste by using their purchasing power to buy a product that uses fewer resources in its manufacture or working life than a substitute product.

The other area of this scenario is concerned with removing key materials from the waste stream that have a particularly high ecological footprint. Plastic is an excellent example of this.

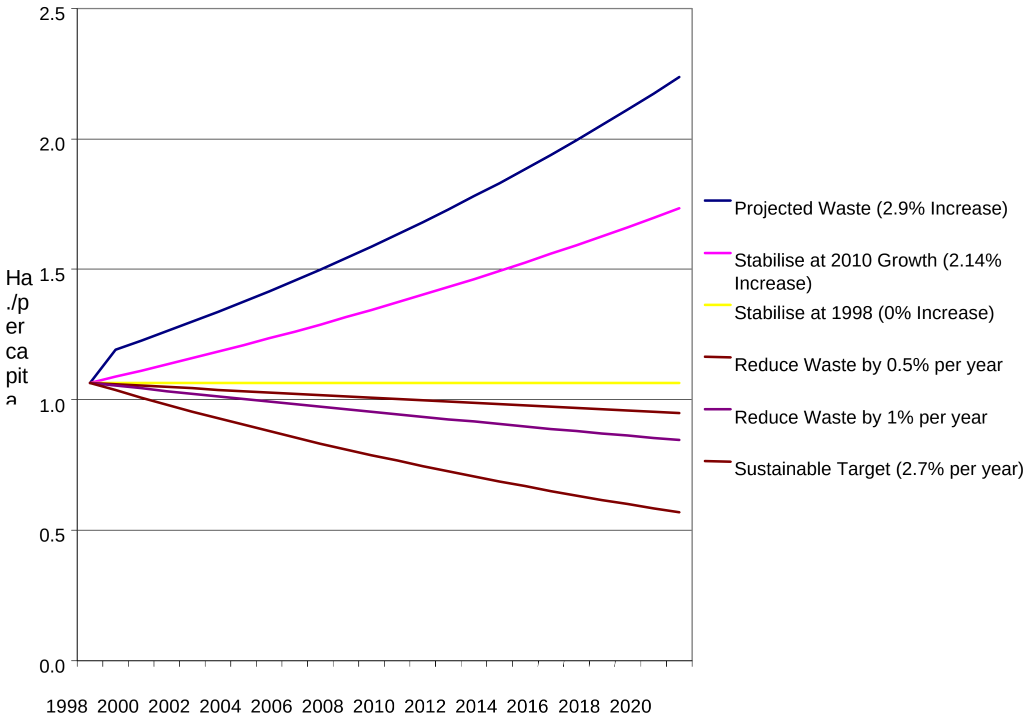
4.6.5 Waste prevention

Below are a number of themes that focus on the concept of changing people’s attitude toward waste. This list of 14 waste reduction ideas is not exhaustible. The list merely serves as suggestions that could be incorporated into a public education campaign.

- Take your own shopping bag to the shops.
- Purchase refillable containers for cleaners, washing solutions and detergents whenever possible.
- Purchase rechargeable batteries rather than disposable batteries.
- Avoid disposable products e.g. nappies, tissues, face wipes, razors, paper and plastic cups, plates and cutlery, kitchen towels, serviettes, computer cartridges, cameras.
- Avoid over packaged products and try to buy unpackaged goods.
- Use a milk delivery service.
- Buy products in returnable containers wherever possible.
- Pass on unwanted clothes and furniture to friends or charities and second-hand shops.
- Buy products such as washing up liquid in large containers to help minimise packaging waste.
- Reuse envelopes - purchase re-use labels.
- Use and refill your own durable drinks bottle.
- Contact the Mailing Preference Service to discourage unsolicited mailshots.
- Place a note on the door stating no unsolicited mail.
- For brown and white goods check whether spare parts are available locally, and when items break, try to repair them rather than replacing them.

It is impossible to predict, without extensive research, whether the public would carry out many of the suggestions, thus making it very difficult to know the reduction in the ecological footprint. However, if Liverpool were to set a target to at least curb the growth of domestic waste by encouraging many of these ideas, the benefits of recycling would be more noticeable. It is the responsibility of every citizen in Liverpool to question the amount of waste they produce and the responsibility of the local authority to provide the information and guidance to encourage individuals to use less. Figure 4.20 demonstrates the reduction in the ecological footprint with the introduction of a waste prevention scheme with varying success rates.

Figure 4.20: The ecological footprint of waste minimisation



To achieve a sustainable level of domestic waste in Liverpool it is necessary to reduce waste by 2.7% per year. This does not include the potential increase in recycling. Obviously, schemes of recycling and waste reduction would work in parallel. The combination of options is considered in the final waste scenario.

4.6.6 Removing particular materials from the waste stream

Within the projections for Liverpool's waste it was shown that plastic was set to have the highest increase in impact, even if a 65% recycling rate was achieved. Therefore, another strategy to reduce the ecological footprint is to produce less of the most unwanted materials. Plastic is the most unwanted material as it contains a high level of embodied energy and recycling plastic has marginally beneficial effects. By 2021, if half of the projected plastic was removed from the waste stream and glass was used instead, there would be a noticeable reduction in the ecological footprint.

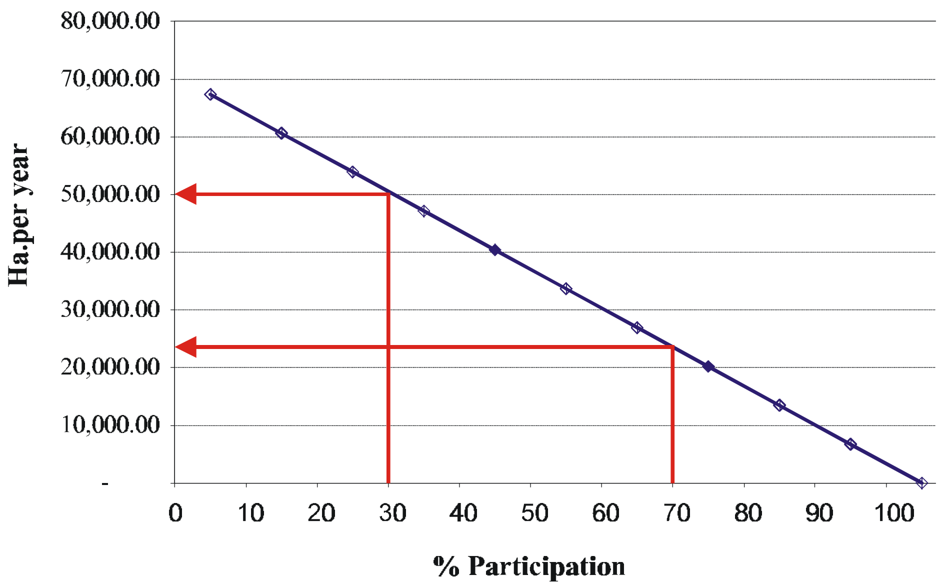
This would mean a reduction in the tonnage of plastic by 7,000 tonnes and an increase in glass by at least 10,000 tonnes. This equates to a reduction in the ecological footprint of 10,214 hectares (0.02 Ha./per capita).

4.6.7 Targeting the 30% un-recyclables

Of all the domestic waste produced in Liverpool it was estimated that 30% was unsuitable for recycling, of which 35% are disposal nappies. This would correspond with the waste stream of other UK authorities. Therefore, the ecological footprint of nappies in the domestic waste stream is approximately 52,138 hectares and by 2021 this could potentially rise to 109,525 hectares (0.23 hectares/per capita). This is a higher impact than most of the materials discussed within the eco-efficiency scenario. This highlights the considerable impact of disposal nappies. In 2004, disposal nappies will cost the City Council nearly £400,000 in Landfill Tax. In 2021, if the landfill tax continues to increase at its current rate and the projected 2.9% rise in Liverpool waste, the Landfill Tax for nappies could cost the Council over £1.4 million. There is both an economic and ecological incentive to reduce the volume of disposal nappies being sent to landfill.

One method to reduce nappies within the waste stream would be to promote the use of re-usable nappies. There is a scheme in Wirral that will provide you with a weekly supply of terry-towelling nappies and clean them for you. Through promotion or even subsidising such schemes, could reduce the ecological footprint of Liverpool's domestic waste and reduce the burden of Landfill Tax. Figure 4.21 illustrates the potential saving that can be made.

Figure 4.21: The potential reduction in the ecological footprint of nappies



It is very difficult to assess the uptake of such a scheme and market research is needed to assess the success of the scheme. Figure 4.21 provides the opportunity to see the reduction in the ecological footprint at all levels of participation. For example, it could answer the question: What will be the reduction in the ecological footprint if there is a 30% participation in the scheme, or 70% participated in the scheme?

- *Government Aims and Objectives*

Within the Government's report entitled 'Waste Strategy 2000', targets have been set for local government, businesses and households. The overall aim to is 'to manage waste and resources better'.

By 2005, the Government objective is to reduce the amount of industrial and commercial waste, which is sent to landfill to 85% of 1998 levels. In meeting this target, the strategy suggests that it is important to focus on recovering value and reducing environmental impacts.

At present 9% of household waste is recycled and a further 8% has energy recovered from it, however Liverpool has only achieved the target of 2.5%. The Government and the National Assembly have set challenging targets to increase the recycling of municipal waste.

- To recycle or compost at least 25% of household waste by 2005
- To recycle or compost at least 30% of household waste by 2010
- To recycle or compost at least 33% of household waste by 2015

If Liverpool were to achieve these targets, taking into account the potential increase in waste, it would reduce it’s the ecological footprint of waste. This has previously been demonstrated by calculating that a 95% recycling rate was required to counteract the growth in waste.

- *Sustainable Scenario*

The sustainable scenario draws from a number of the other scenarios demonstrating the effect of implementing a range of strategies to tackle the domestic waste footprint. One of the key points to be learnt from the waste scenario is that a recycling and composting scheme will not be sufficient. Strategies put forward in the ‘De-Materialisation’ Scenario must also be considered and combined with the recycling and composting scheme (see Table 4.12).

The following aspects have been adopted and show what the ecological footprint could be in 2010 and 2021.

- By 2010 a 32% recycling rate has been achieved and by 2021 a 65% recycling rate has been achieved for plastic, glass, aluminium, steel and paper.
- Liverpool has managed to stabilise its waste by 2010 after a 2.9% increase for 10 years and between 2010 and 2021 it has managed to reduce its waste by 0.5% per year by volume from the 2010 figure.
- By 2021 the amount of plastic within the waste stream has been halved and alternative materials have replaced it (i.e. glass). By 2010, 25% of the plastic has been removed from the waste stream.
- A successful re-usable nappy scheme is in place and has achieved a participation rate of 30% by 2010 and a 70% participation rate by 2021.
- A composting scheme is introduced that removes 32% of all domestic organic material by 2010, and 65% by 2020.

Table 4.12: Sustainable waste scenario for Liverpool

Note:All figures are in hectares or hectares/per capita	**2000**	**2010**	**2021**	**Sustainable Target ?**
De-materialisation	526,232	642,342	607,884	**?**
Recycling				
…Paper	3,186	26,093	50,158	23,715
...Plastics	291	4,651	5,998	2,836
...Glass	133	3,152	6,262	2,961
...Aluminium	63	133	256	121
...Steel	11	227	396	187
Composting				
…Organics	34	718	1,420	671
Landfill				
…Paper	81,879	68,377	36,529	17,271
...Plastics	17,857	12,368	5,773	2,730
...Glass	7,440	7,485	3,769	1,782
...Aluminium	77,253	71,343	3,475	1,643
...Steel	5,230	4,830	2,132	1,008
…Organics	161,175	151,031	75,696	35,789
...Unrecyclables	171,681	204,502	194,179	91,807
Total EF	526,232	554,910	386,044	182,520
Per Capita	**1.12**	**1.19**	**0.82**	**0.39**

All these figures have combined all five of the scenarios listed above. This made some of the calculations very complex. The calculation for glass has been shown below as an example.

For the ‘Glass to be landfilled in 2021’ figure, initially it was important to know the total amount of domestic waste that will be produced in that year. This takes into account the de-materialisation figure 0.5% from 2010 to 2021. At the moment, glass represents 5.49% of the domestic waste stream. As well as this figure, within the scenario, glass is set to increase at a higher rate than other materials because of the reduction in the use of plastic. Therefore, as well as the projected 16,474 tonnes an extra 2,417 tonnes is added, which represents a 50% reduction in plastic. The success of the recycling scheme is estimated at 65% by 2021 therefore only 35% of the total tonnage will go to landfill. The figure is multiplied by the footprint conversion factor for glass disposed in landfill.

For 2010, the scenario demonstrates that the ecological footprint will still increase even though many measures have been introduced. Within the first 10 years, to curb the growth in the ecological footprint of waste is an achievement. It is not until 2021 when the real benefits can be seen. The biggest gains are made from de-materialisation, recycling aluminium and composting organic material. Increasing the composting rate even further will have an even more substantial reduction on the ecological footprint. Establishing a comprehensive strategy for composting (be it a centralised system or community composting), must be one of the priorities. Within the 'Eco-Efficiency' Scenario the growth in plastic outweighed any of the benefits from recycling. However, the sustainable scenario shows a clear reduction in plastic with the introduction of the waste removal scheme. The benefits of recycling have now become apparent.

By introducing the nappy scheme into the sustainable scenario, the growth of un-recyclables going to landfill has been contained. The more this section is reduced in the future by tonnage, the easier it will be to achieve the sustainable target in the final column.

The sustainable target in the final column has deliberately not been given a date. It is impossible to pinpoint a time scale when it will be achieved. In 20 years the material content of waste may have changed dramatically as well as recycling processes. However, this figure provides an insight into how far Liverpool has to go. If Liverpool does manage to achieve the 2021 target this would be sizeable achievement, even though a sustainable domestic waste system will still be elusive.

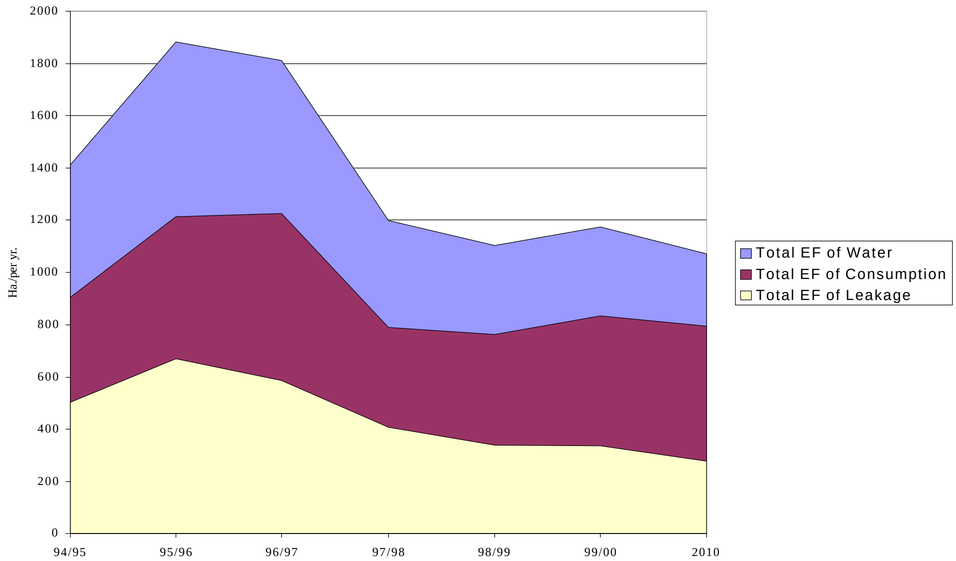
4.7 Water scenario

The water scenario has taken a slightly different approach to the other two scenarios on energy and domestic waste. Not only does it consider methods for reducing the ecological footprint of water, it also demonstrates the value of the ecological footprint as a sustainability indicator for the water industry. This is done by footprinting different elements of United Utilities' (UU) operations such as transport and waste, as well as water supply and wastewater. The scenario also highlights the change in the ecological footprint over time and demonstrates the reduction in the ecological footprint with the introduction of UU' future policy objectives. In addition, the scenario will look at the outcome of introducing a cistern replacement programme and what effect this would have on water conservation, energy and CO_2 emissions.

4.7.1. Future predictions

UU has provided the necessary data for Liverpool and the Northwest region to predict what the ecological footprint of water could be, up to 2010. Below is an example of what will happen to the ecological footprint of water for Liverpool by 2010 (Figure 4.22).

Figure 4.22: Future prediction of ecological footprint of water



In comparison with the average UK ecological footprint for water supply, UU is 33% more efficient[8], meaning a substantially lower footprint than the national average. Where UU will achieve most of its reduction in the ecological footprint is from reducing leakage. They have already made substantial progress on this matter thus far and if their 2010 target is achieved the reduction in the ecological footprint becomes even more noticeable. A reduction in leakage is not the only factor that will reduce the ecological footprint by 2010. Two other factors play an important role; further energy efficiency and consumption. Over the time scale, the amount of energy to supply the water per unit has been reduced.

In recent years, UU have increased the usage of off-peak energy rather than peak-time energy and improved pump efficiency. Most of the energy consumption for water supplied to Liverpool is from large pumping stations and some of the main treatment processes. There may be some limited scope for improving pumping efficiency and process efficiency. However, the main factors that affect energy consumption are water demand and weather. During dry weather UU has to reduce usage of some of their normal water sources and we, as consumers, must make greater use of water sources requiring higher energy consumption. Some of the major reductions in the ecological footprint can be gained through the conservation of water, which is the responsibility of every individual company and household, as well as UU.

An understanding into the energy requirements of different domestic water uses has been given below. Chambers, Simmons and Wackernagel (2000) have calculated the ecological footprint of various different household uses of water. However, as before, this is the ecological footprint of the energy required supplying the water and nothing more. The assumptions are based on data from UK water companies (see Table 4.13).

[8] This is based on UU's ability to provide water by more efficient means

Table 4.13: Domestic water use

Water Use	Unit	Footprint (m2/per yr.)
Cold tap water	Per 100 litres	0.08
Washing machine	Per 100 washes	255
Dishwasher	Per 100 washes	167
Bath	Per 100 baths	98
Shower	Per 100 showers	27
Toilet	Per 100 flushes	1.24

Source: Chambers, Simmons and Wackernagel (2000)

The calculations above could be placed into a model to help individuals understand their water use and the subsequent impact this has in energy terms.

Acknowledging that the rate of water use is ultimately a measure of its sustainability, the metric of per capita footprint of water use per day is applicable. One target for environmental efficiency is 150 litres per person per day, which is suggested by Shane and Graedel (2000). This suggestion is slightly less than the water consumed by the people living in Amsterdam (159 ltr/hd/day), which is one of the lowest consumption rates by an industrialised country. In comparison, water consumption by those living in New York City is 466 ltr/hd/day and in Kampala, Uganda, 25 ltr/hd/day (United Nations Centre for Human Settlements, 1997).

The target above is based on the assumption that industrial countries tend to use more water than necessary and that the application of basic water conservation techniques would make 150 ltr/hd/day a feasible target. At present, Liverpool’s water consumption is 252 ltr/hd/day. This means a reduction in water use of 40%.

A potentially preferable water measure would be to compare the water used with the sustainable draw from an area's watershed. Such a measure would be a much more accurate way to make sure that urban areas had sustainable water consumption rates over the long term. Presently, there is not an available figure for most urban areas, but it may be possible to derive it in the future (Shane and Graedel 2000). Although it is known how much water is available, the major issue to overcome is how much is needed for humans, flora and fauna, and how this can be supplied. For example, should more reservoirs be built (which is a somewhat contentious issue), or should more use be made of the rain that falls on concrete, rooves and farmland. There are a number of examples that could be applied to conserve water such as; permeable surfaces, which would help to replenish stocks of groundwater, the recycling of greywater in homes, or to alter agricultural practices whereby fields are ploughed transversely to increase water retention and reduce runoff?

4.7.2. Footprinting United Utilities

It is also possible to conduct an ecological footprint of the total supply by United Utilities, as well as some of their activities (such as the footprint of commercial vehicles).

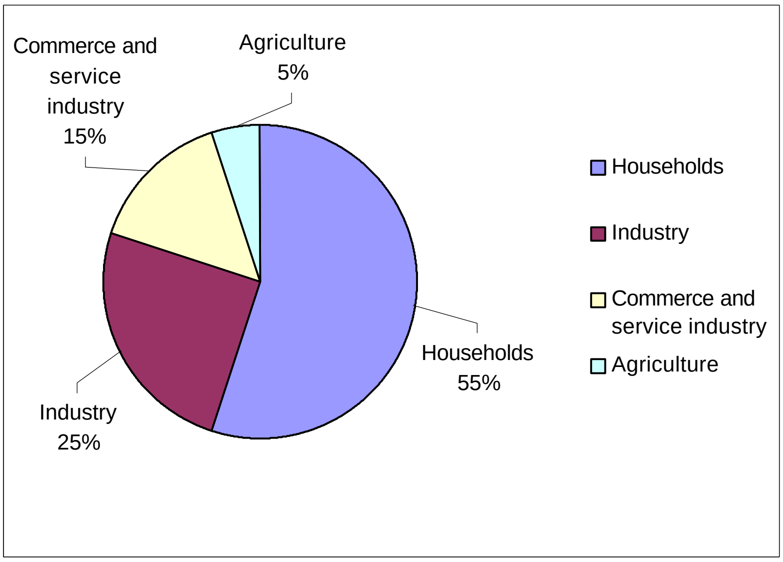
UU, supplies 1,947 Megalitres (Ml) of water per day, giving an annual supply of 710,100 Ml. This has a subsequent energy requirement of 229.1 GWh and an ecological footprint of 19,353 hectares, which is required to absorb the carbon dioxide produced in this process. This is an area 6 times greater than the amount of woodland that UU own. This is not the total impact of UU operations as there are also the issue of waste and transport, to mention a few. The calculations below show the ecological footprint of commercial travel within the organisation.

In 1999/00 UU consumed 3.97 million litres of diesel, 78,000 litres of petrol and 1,800 litres of LPG for use by commercial vehicles. This equates to an ecological footprint of 2,055 hectares for commercial activity. This is an increase of 3.8% from 1997/98, which had an ecological footprint of 1,997.4 hectares. The transport section in Chapter 3 indicated how it was possible to reduce the ecological footprint of transport using a number of methods. One, which is being employed by UU, is to instruct their drivers to drive in a more sensibly and conservative manner; this has enabled UU to reduce the environmental impact of CO_2 emissions from their essential needs of transportation. The ecological footprint could act as an indicator for the company so that they could monitor the impact of commercial transportation year on year.

4.7.3 Water conservation

In an analysis of public water supply in England and Wales, it is possible to show where the volume of water is supplied (see Fig 4.23).

Figure 4.23: Breakdown of public water supply in England and Wales



Hodges, 1998a, p2

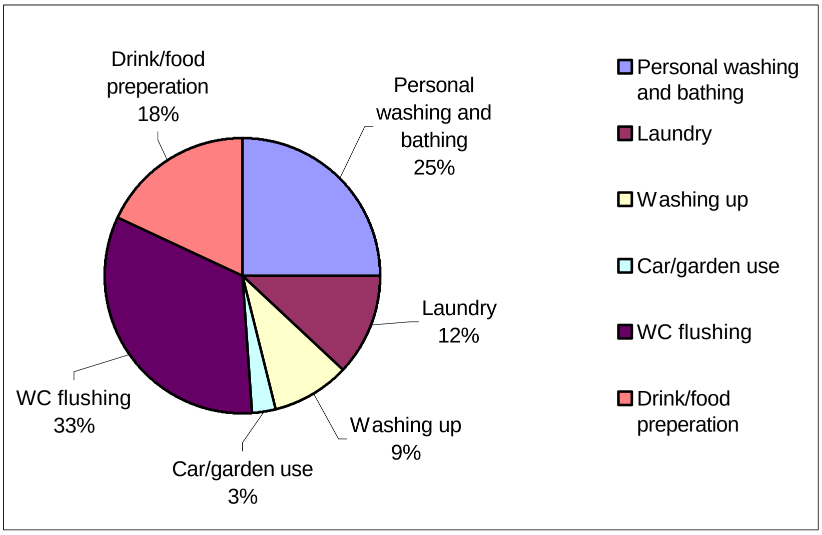
For comparative purposes, the proportion of water that is supplied to Northwest domestic premises (65%) is 10% greater than in other parts of England and Wales. In contrast, the trend for the commercial and industrial sectors (35%) is the reverse whereby the proportion of water supplied is 10% less. A likely reason why this may be the case is that in general, those industries in the Northwest that consumed great quantities of water in the past have suffered from the impact of an economic turndown and are unlikely to return to similar levels of consumption in the future. However, there is the possibility that the service sector will increase its consumption of water in the future, as the focus of economic regeneration will centre on leisure, tourism and other related services, especially on Merseyside (GONW, 2000).

By applying a national proportional breakdown to UU data, the commercial and industrial sector (35%) is broken down further, which offers opportunities to identify, firstly, significant areas where water conservation measures are most needed although the long-term objective would be to attain water conservation in all areas of consumption. Table 4.14 highlights where water is mostly consumed and how the ecological footprint is distributed on a per capita basis, which will enable closer scrutiny of the methods implemented to conserve water and reduce wastefulness. For demonstrative purposes, Figures 4.24 and 4.25 identify national average household and commercial/service water use patterns.

Table 4.14: Relationships between sector water consumption in the NW and their footprints

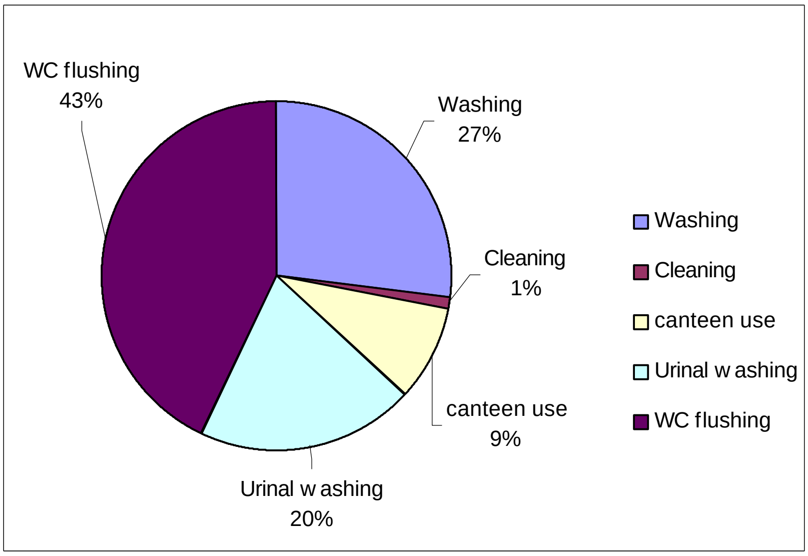
Sector	**Sub-total %**	**Total %**	**Volume Ml/yr**	**Footprint (ha/yr)**	**Footprint Per/cap m^2/yr**
Industry	*55*		136,801.5	3,725.5	0.53
Commerce and service industry	*33*	35	82,080.9	2,235.3	0.31
Agriculture	*12*		29,847.6	812.8	0.11
Sub-totals	*100*		*248,730.0*	*6,733.6*	*0.96*
Households		65	461,925.0	12,579.6	1.79
	Total	**100**	**710,655**	**19,353**	**2.74**

Fig 4.24: Household water use patterns



Hodges, 1998a, p3

Fig 4.25: Office water use patterns



Hodges, 1998a, p3

In both instances, toilets and bathrooms are the greatest consumers of water (office toilets [urinal washing, WC flushing] – 63%), bathrooms [Personal washing/bathing, WC flushing] – 58%). In terms of the ecological footprint, office toilets have a footprint of 1,408.23 hectares however home bathrooms have a much greater footprint (4,151.26 ha) because of the greater amount of water that is consumed (+66%) in the home.

According to the Water Supply (Water Fittings) Regulations 1999, it is insisted that the maximum size of cistern flushes must be 6 litres. Therefore, it is assumed that all WC's in homes and offices (pre-1999) currently have a 9 litre capacity cistern installed. On this basis, it is possible to reduce water consumption by one third with the installation of a 6 litre capacity cistern, which is just as effective. For example, WC flushing in the home accounts for 33% of water consumption (see Fig 4.24), this could be reduced by 11% and result in the conservation of 50,811.7 Ml of water and reduce the ecological footprint by 1,383.75 hectares.

4.7.4 Conserving water in Liverpool

UU currently supplies Liverpool with 41,610 Ml of water per year. Using the data from UU, Liverpool homes consume 27,046.5 Ml of water, which is 65% of the total supplied[9]. Within the home, WC's (33%) consume 8,925.34 Ml of water per year. For the purpose of a scenario for reducing the water consumed by WC's, an assumption is made that all homes have one WC, which is fitted with a 9 litre capacity cistern. In order to achieve a third reduction in WC water consumption, all 9 litre capacity cisterns must be replaced with 6 litre capacity cisterns. This would mean that the present WC consumption in Liverpool (8,925.34 Ml) would fall by 2,945.36 Ml by 2010. In addition 736,340 kWh of energy would also be saved. Importantly, the on going savings by 2010 would be 16,204 Ml of water, over 4 GWh of energy, 342.11 hectares and a reduction of 2,126.72 tonnes of CO_2 emissions (see Table 4.15).

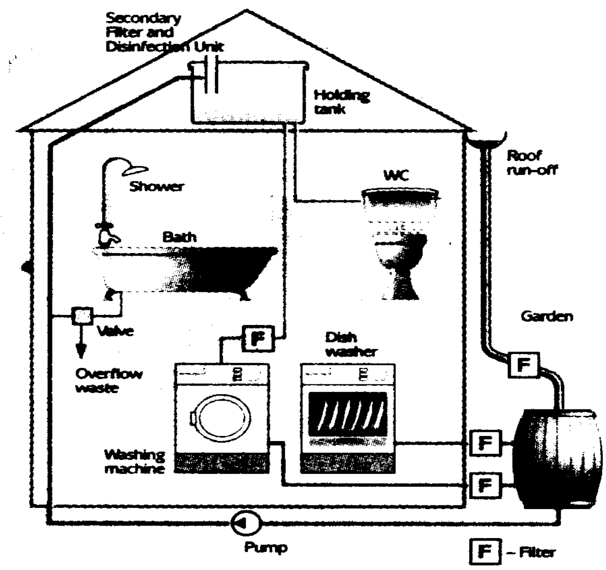
[9] This is based on the regional proportion of water supplied (65%), which is divided by the total number of houses – 188,000 and is an estimate of water consumption for Liverpool.

Table 4.15: The positive impacts of a cistern replacement programme in Liverpool.

Year	Target %	Water conserved (Ml)	Energy saved (kWh)	EF saved (ha)	Emissions saved (CO_2 tonnes)
2001	10	294.5	73,625	6.21	34.26
2002	20	589.12	147,280	12.44	64.81
2003	30	883.6	220,900	18.65	97.21
2004	40	1,178.14	294,535	24.87	129.62
2005	50	1,477.18	369,295	31.19	162.52
2006	60	1,767.21	441,802	37.31	194.43
2007	70	2,061.75	515,437	43.53	226.83
2008	80	2,356.28	589,070	49.75	259.24
2009	90	2,650.82	662,705	55.97	291.64
2010	100	2,945.36	736,340	62.19	324.05
Total savings		16,203.96	4,050,989	342.11	2,126.72

Despite this potential to conserve water, save energy and reduce CO_2 emissions, there is a major obstacle to achieving these targets – cost. Although UU 'do their bit' by sending out and giving away 'sava-a-flush' devices (which save on average 8 litres of water per device), should the onus be on UU to meet this cost or should there be some commitment from Liverpool CC or the government? For example, the Council could be proactive by undertaking a replacement programme on the properties currently under their ownership. Alternatively, the planning department within the Council could play a leading role by insisting that all new developments must be fitted with the smaller cistern. They could also promote the use of recycled greywater/rainwater within the design element of a building. Figure 4.26 illustrates how a greywater recycling system works.

Fig 4.26. A greywater household



Hodges, 1998b p15

Given that the government considers it right and proper to provide funds to alleviate ‘fuel poverty’ they should also consider the importance of conserving water, energy and the emissions of CO_2. Not only could they provide funds for a cistern replacement programme they could also provide funding so that standard taps could be replaced with spray taps, which use 75% less water per minute (standard tap – 8 litres/per minute, spray taps – 2 litres/per minute Hodges, 1998b) for example. Besides conserving water, energy and emissions the examples above would also provide much-needed jobs in the manufacturing and installation industries.

Chapter 5

The Ecological Footprint and other uses

In this study thus far, the ecological footprint has shown to be an excellent tool for demonstrating whether a city and its citizens are near to the objective of sustainability. Clearly, those charged with the management of the city of Liverpool have some important decisions to make in relation to its ecological performance if they want their city to achieve the goal of sustainability in the future. The results show that Liverpool requires an area many times greater than itself in order to provide it with all its present consumption needs and to absorb the resulting waste that is produced. Much of the city's ecological expansion can be attributed to past development that did not consider the implications of growth in terms of the global damage that may subsequently occur. In essence, this additional land acquisition has accumulated over the years but in effect, it belongs to other inhabitants elsewhere on the planet. Therefore, the city should consider ways in which appropriated land could be returned to the global community. The scenarios within this study have shown that this can be done to good effect.

To ensure that the message of what needs to be done gets across to a wider audience, the methodology of the ecological footprint can be put to further use. For example, it can be used as an educational tool for local communities and schools, it can assist in identifying potential solutions to sustainable living within the planning system, local industries and the service sector could use the ecological footprint as a 'stand alone' environmental management system or in conjunction with environmental management systems such as the European Eco-management and Audit Scheme (EMAS, EC Regulation 1836/93) and the International Organisation for Standards environmental management system (ISO 14001: 1996).

5.1 The ecological footprint: an environmental education and awareness-raising tool

In a recent study into public perceptions of sustainable development (Barrett and Scott, 2000), it was found that people were generally aware of environmental problems (mainly through the media) but little was known or understood of the concept of sustainable development.

> *"I've heard of it but I don't know what it means"* (Group 2 Participant)

In fact, many members of the focus groups were taken aback by the immense burden that humans place upon the environment, as a group participant stated:

> *"I was quite shocked that we needed three more planets"* (Group 3 Participant)

With the aid of the ecological footprint many people were able to understand and identify with the notion of global equity and an even distribution of the resources of nature. Links were also made between human activity, poor health and environmental degradation. For example, on the issue of transport one participant blamed traffic congestion for causing ill-health whilst others put the blame on inadequate public transport for the increase in car use.

1. *"But we've also got to look at the state of public transport, the buses and how they've gone down, some are really grotty.*

2. *Especially in Liverpool where they buy 30 year-old west-Midlands buses. I'd like to see the older dirty buses taken off the road.*
1. *Yeah.*
2. *I've been on the bus once when the fumes were inside the bus".*

(Group 7 participants)

It was also realised that by doing something for themselves, people could actually help the environment. Group 5 participants gave such an example were their actions to improve their quality of life also benefited the environment.

1. *"When you talked about putting new windows in your houses; you would reduce your footprint and improve your quality of life?*
2. *Yeah we will. So maybe you can do both together.*
3. *We didn't think of that. If we save on our bills we're not using so much energy and helping stop global warming".*

(Group 5 participants)

1."It's made a difference in my life because my bills have gone down and my house is warm" (Group 1 participant)

From the resulting discussions, a discernable pattern emerged in that many of the older participants recalled that the recycling of materials was common practice in the past, practically nothing was ever wasted. However, today, a throwaway society has become apparent. Younger participants (teenagers) view the notion of protecting the environment as abstract and far removed from their daily lives and needs. In effect, there was the sense that they had been ostracised and therefore there was little they could do to change the situation because teenagers were rarely asked their opinion. Despite this negative response, there was a genuine concern for future generations. A concurrent theme throughout the discussions was the need for education.

1. *"I think it would be important to educate because I have never considered any of this having any effect on the way I live or anyone else throughout the world.*
2. *They should educate everyone then it wouldn't be a waste, because everyone would know*
3. *If we knew, we wouldn't be sitting here and you wouldn't be explaining, we'd be saying to you, oh yeah, oh yeah, but we don't know"*

(Group 3 participants)

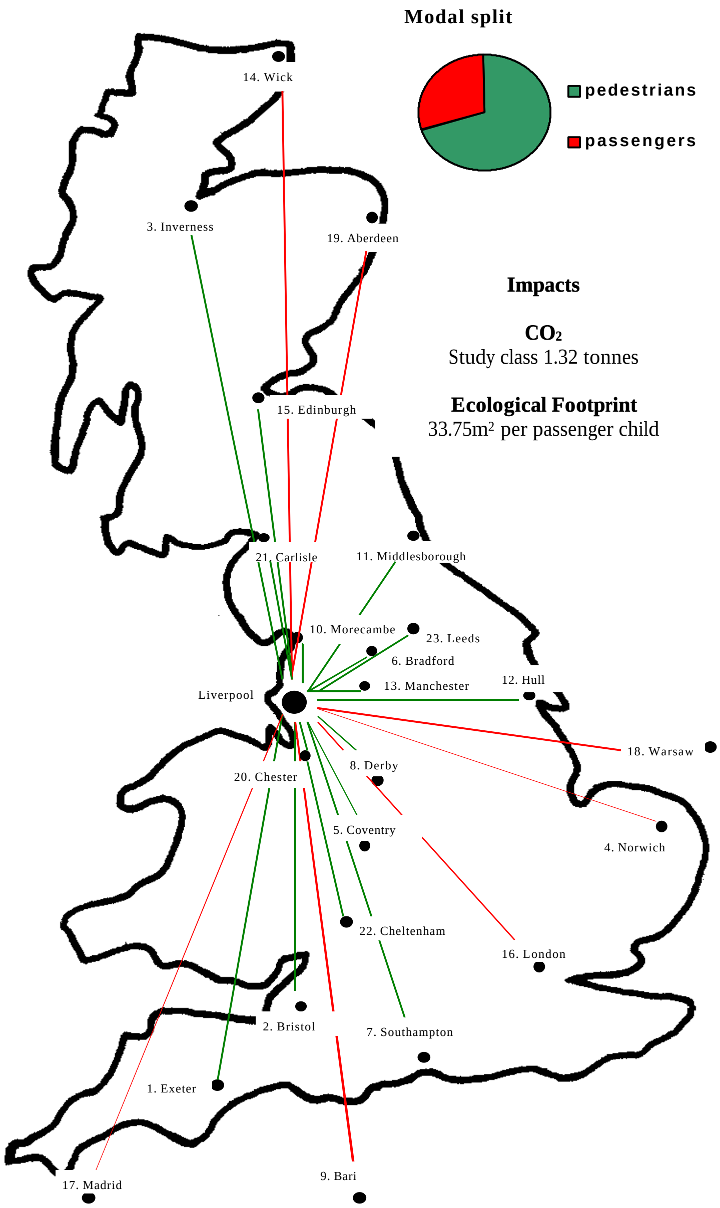
The groups promoted education on many occasions and for the younger participants, environmental education was seen as an essential requirement for schoolchildren.

Aaland and Caplan (1999) suggest that educating children about their environment through lessons in school is an effective way of making sure that the message about sustainability reaches them. To demonstrate that the ecological footprint can be used as an educational tool, a study was undertaken to measure the amount of CO_2 that was released into the atmosphere as a result of taking children to school by car. In addition, the ecological footprint required for the 'school run' was also measured.

The study class (Primary school) consisted of 23 children, of which 16 were pedestrians and 7 were passengers in cars. The aggregate annual journey to school for all children in the study class was 10,133km with 3,567km apportioned to walkers and 6,566km for car passengers. The modal split was 70/30% for pedestrians and passengers respectively.

On average, a car emits 0.2012 kg of CO_2 per kilometre therefore the annual emission of CO_2 for 7 passenger/children was 1.321 tonnes. However, it is difficult to expect children to visualise a tonne of Carbon dioxide therefore data for the distances walked or driven to school were converted into the equivalent distances to cities around the UK and Europe (See Fig 5.1) and into an ecological footprint, which was more easily understood. For example, in a school year 3 children were driven the equivalent distances to Madrid, Bari and Warsaw in Europe whilst some children walked as far as Inverness, Exeter and London in order to get to school.

Fig 5.1. The ecological impact of the 'school run'



Source: Author

The ecological footprint required for sequestrating the CO_2 emitted by 7 passenger/children amounts to 236.3 square metres or 33.75 m^2 per passenger/child. In effect, the area of 7 classrooms would need to be planted with trees in order to absorb the CO_2 that is emitted during the ‘school run’ by the study class.

The same methodology was also applied to the total number attending the school (599 children) using the modal split above and the mean distance travelled by car of the study class (938km). In total, 168,746km are driven to (am) and from (pm) the school annually and as a result, 33.9 tonnes of CO_2 are emitted. The ecological footprint for the school run amounted to 6,075.5ha. However, if the drivers return directly home then the figures above could conceivably be doubled? Such evidence could be promoted alongside other issues concerned with the school run such as health, safety and congestion (London and Romieu, 2000; DETR, 2000e). It was found that for educational purposes and for raising awareness of the problems associated with the ‘school run’, the ecological footprint proved more than useful.

5.2 The ecological footprint and planning

The planning system within any local authority determines, how a city is and will be developed. It is also vital to the implementation of sustainable development. Planning deals with a wide range of technical subjects from forecasting population change, housing predictions, formal design and layout to mineral extraction. The skill of the planner is the ability to bring together a number of considerations in terms of a particular proposal. For instance, the technical consideration for a new development must be aligned with policies concerning the landscape, wildlife, noise and access. However, according to Smith (2000) in the case of renewable energy, the response from planning authorities has, with a few exceptions, been mainly reactive. In the main planners have responded to other people’s proposals rather than putting forward their own ideas and offering advice.

Smith (2000) believes that planners should be more informed about the potential benefits a city has to offer. For example does the topography or location lend itself to the harnessing of wind-speed, does derelict/vacant land offer the option for biomass fuels, is there the potential for hydro development or does environmental designation prevent development. In order to inform themselves of their region, Smith suggests the development of databases, which can help establish targets, gain consensus and set more site-specific proposals. The ecological footprint can form the basis of such a database and any subsequent targets. The next logical step for planners is to put proposals into plans. This will raise awareness amongst developers, local people and interest groups. Public consultation is vital to this process, however, if proposals are informative and well founded, adjustments can be made.

Given that interests such as technicalities and policies tend to conflict, the ecological footprint could assist the planning system. For example, the ecological footprint has shown that the city of Liverpool exceeds its ‘fairshare’ of land and natural resources, therefore the planning system can utilise the results to tackle the subject of how is the city to achieve a reduction in its impact in global terms. Liverpool has a significant amount of derelict land, which can be unsightly and a possible deterrent to potential investors in the city. Some of this land (excluding contaminated land) could be planted with a bio-crop that could be harvested to provide a fuel for energy. This would have several potential benefits such as increased biodiversity, provide an economic incentive (Levett, 1998) or significantly reduce the consumption of fossil fuels. Liverpool has many urban trees but they are nearing maturity. As trees age their potential to lock-up CO_2 diminishes, in order to combat this important environmental loss some of the derelict land within the city could be suitable for urban woodland creation. This would be a low-risk, low-cost option with a high value to local people and the environment (Forestry Commission, 2000) and provide an attractive environment for investors and visitors (Environment Agency, 1999).

Other important aspects that are locked up in the urban environment are the resources and embodied energy in existing buildings (Vale and Vale, 1996). Hence, if buildings are demolished and replaced these aspects will be lost and the replacement materials would certainly add to the footprint. The re-using of existing buildings will prevent the ecological footprint from escalating further.

In addition, the ecological footprint could be used to measure the impact of new developments from the extraction of minerals and aggregates, processing, manufacture and transportation of materials and finally the environmental impact of the location. In order to create a sustainable environment, existing buildings should be considered first and adapted to meet changing needs. The requirements for new developments for example, should be designed to maximise solar gain, minimise heat loss, conserve energy, use recycled materials whenever possible and sourced locally, which would enhance job prospects and the economy in general. The layout should also be strategically planned to minimise the impact of cars and travel. The importance of the ecological footprint is that it could aid the processes of developments before they leave the drawing board.

Environmental Impact Assessment (EC Directive 97/11), which assesses the effects of certain projects on the environment, is well established within town and country planning. Although, an assessment of a project invariable seeks to uncover the negative impacts on a site-specific environment, the positive impacts of new technologies for example, are mainly overlooked and need only comply with building regulations. This is despite their environmental impact being considerably less than conventional technologies. An example of this has been highlighted in this study where there is no record of new technologies being installed during the recent physical regeneration of Liverpool. However, this type of response to development may have to change in the near future, as the wider implications of development will need to be considered. Pauli (1998) states that

> “the most ecologically devastating environmental impacts may not result from the direct effects of an individual project, but from the combination of existing stresses on the environment together with the steady accumulation of individual minor effects over time” (Pauli, 1998: 77).

According to Rees (1995) cumulative environmental effects (CEA) will be the next step in the EIA process. In the near future planners will need to address local or regional cumulative effects of environmental activities and assess the impact from a global perspective. Fundamentally, any development will need to take into consideration no net loss of essential natural capital and advocate zero-impact growth for new developments. The ecological footprint approach taken in this study clearly demonstrates the cumulative effect of development and growth. On the other hand, the ecological footprint could also be used to assist in a reversal of the present trend of expansion.

5.3 The ecological footprint and environmental management

The move towards the integration of environmental issues in the general business framework of companies has been relatively slow. For example, of the 22,000 VAT registered companies on Merseyside, only 19 have achieved ISO 14001 accreditation (GONW, 2000). In the main, companies have been prompted towards environmental management by a regulatory ‘stick’ rather than the ‘carrot’ of profitability. A timely reminder is the Climate Change Levy, which will be introduced in 2001 and will add almost £5million to the energy costs of the service sector of Liverpool. Put another way, the Levy will remove £5million from Liverpool’s economy. In the energy scenario it has been shown how energy savings can be achieved, which subsequently result in a reduction of the ecological footprint and a move towards the target of sustainability.

At present, companies can choose between EMAS or ISO 14001 should they wish to implement an environmental management system. The ecological footprint could easily be incorporated into either system or be employed independently. Both EMAS and ISO 14001 require that significant aspects or effects, which a company may have on the environment, should be identified and be subjected to control and improvement where practicable. In addition, a company may wish to build in improvement programmes. Importantly, neither management systems consider the holistic impact of a company and refer specifically to significant impacts and compliance with regulations. Basically, the aim of both systems is to achieve regulatory compliance and potentially improve performance. Improving performance and taking a holistic approach are not essential elements of these environmental management systems.

The ecological footprint can, with sufficient, detailed data, review and calculate all aspects and effects of a company’s input and output, which would strengthen the role of EMAS and ISO 14001. As a ‘stand alone’ environmental management system (EMS), the end result of an ecological footprint analysis would be the identification of how near or far a company is in terms of operating in a sustainable manner. It can set targets that not only attain a level of regulatory compliance but also enable a company to take the equally important step beyond the minimum requirement by law. For example, the energy required for lighting and IT equipment in an office environment may not be considered as a significant impact of a company’s operation or represent a high proportion of its turnover but it does signify a controllable cost. Therefore, the opportunity arises whereby this cost can be reduced and hence improve competitiveness. Similar controllable costs are likely to be available for waste and water.

5.4 Local solutions through local supplies

One particular way in which the city of Liverpool could reduce its global impact would be to seek ways and means of providing solutions locally. Many of the products and goods that the city currently consumes are brought into the city from other parts of the region or the UK or from across the world. In order to reduce their impact on the city’s ecological footprint, attempts should be made to bring together businesses and local people to formulate ways in which these consumables could be provided nearer to home. Food is a typical consumable that can travel huge distances before it is eaten and inevitably sent to a landfill site somewhere outside of the boundaries of the city. More should be done to promote locally grown food produce, which can be consumed and the residue composted rather than sent to landfill. In the first instance, where possible, residents should be educated in the benefits of home-grown produce and where this is not possible (because of the type of accommodation, flats etc), partnerships should be encouraged between local growers and retailers. This could be achieved with a local food directory. Alternatively, regular markets should be permitted where local goods with an emphasis on organic produce, local sustainable timber or re-used products for example, could be sold.

Below is a list of other local initiatives that could be supported and facilitated by the local authority:

- Waste exchanges – where organisations can advertise waste for use by others
- Working with local companies to reduce the number of empty lorry trips
- Door to door recycling
- Re-use schemes such as furniture, white goods and IT equipment
- Database of initiatives that could be accessed by local people and businesses
- Encourage green businesses and technology

Education

- The issue of sustainability and what this means for the city
- Waste reduction – aimed at schools, business clubs, shops and offices
- Renewable energy options for service sector and domestic premises
- Promotion of energy efficiency
- Promotion of organic agriculture, low energy farming and allotment use
- Purchasing local organic produce
- Walk to school schemes

Chapter 6

Potential research using the ecological footprint

This section identifies five key areas where further research could potentially be conducted. The aim of this section is to provide an understanding into the uses of the ecological footprint and how they apply to Liverpool and the Northwest region.

- *An Ecological Footprint of the Northwest*

As more and more power is given to regions in the United Kingdom, an understanding of the ecological impact of a region is becoming apparent. Regional strategies for the Northwest have been published and the ecological footprint could act as a benchmark for ecological sustainability. Such a project could also identify best practise within the region by comparing cities and towns.

- *Transport Scenarios*

The ecological footprint of Liverpool provided some detailed information concerning transport in Liverpool. However, there was no scenario on transport and an assessment of future policy objectives. As Liverpool is to receive a substantial amount of funding for public transport in the near future, the ecological footprint could help guide the spending of this money so as to achieve the largest modal shift.

- *Business Case Studies*

Businesses can benefit by understanding their ecological impact through the ecological footprint and develop scenarios to reduce their impact. This has the added bonus of reducing costs for many businesses. Research into the potential savings highlighted by the ecological footprint would be invaluable.

- *Footprinting Future Development*

With the regeneration of Liverpool comes a potential increase in the ecological impact of the city. The ecological footprint can be used to assess the impact of different developments and possible methods to reduce that impact.

- *Footprinting for Communication and Education*

The ecological footprint is a valuable tool for highlighting the unsustainability of individual's lives and linking these to the larger global problems. The transition to a sustainable society will not occur until people understand why it is important to change. The ecological footprint could be used in workshops as a tool for helping people understand how they can change and the effect that they can have.

Chapter 7

Conclusions

The ecological footprint has provided an understanding of Liverpool's demands from nature and its distance from achieving ecological sustainability. It is important to remember that the ecological footprint is merely an accounting tool. It is now the decision of politicians and the residents of Liverpool whether they wish to pursue sustainable development. The ecological footprint has provided the necessary information to know where Liverpool is now. It is now up to Liverpool to decide where it wishes to be in the future. The ecological footprint can also help with this stage by indicating how effective potential schemes may be through the development of scenarios.

The scenarios are suggestions, which would bring Liverpool closer to ecological sustainability. These are not the only options and the ecological footprint takes nothing away from the democratic process of decision-making. The scenarios provide two things. Firstly, they demonstrate the value of the ecological footprint in assessing future projects. Secondly, they act as a reminder that innovation combined with a growing concern in environmental issues, can bring about positive change.

The final chapter provides an insight into the flexibility of the ecological footprint as it can be used for many different purposes. Within Liverpool, the ecological footprint can be a valuable tool for education at all ages, for businesses to understand their all impacts and as a comparative tool with other cities and local authorities.

The ecological footprint of Liverpool provides a robust measurement of Liverpool's demand of nature. This is not the only aspect of the sustainable development debate. It is also important to consider social sustainability issues, such as poverty, exclusion, health and education. This is something that the ecological footprint does not do or has ever claimed to do. When any decision is made the ecological footprint should never be the sole indicator employed to make that decision. However, what the ecological footprint does do is frame the debate. What is the highest quality of life that can be achieved within our fair earthshare? This is the key question concerning sustainability and the ecological footprint has provided a valuable contribution to answering this question.

Appendix 1. The complete set of indicators of sustainable development for Liverpool

	Headline indicator	Supporting indicators
1	**Built environment**	Number/% of listed buildings in need of repair
		Number and quality of listed buildings
		Number/area of conservation areas
2	**Natural environment**	Number/area of municipal parks
		% of population living within 400m of a municipal park
		Number/area of Sites of Nature Conservation Value (SNCVs)
		% of population living within 1km of a SNCVs
		Area of vacant land
		Number of usable allotments
3	**Air quality**	Carbon monoxide
		Sulphur dioxide
		Nitrogen oxide
		Benzene
		1,3 Butadiene
		Lead
		Ozone
		Particulate matter
		Smoke/Sulphur dioxide
		Indoor air quality
4	**Water**	Drinking water quality at the customers tap
		Water consumption
		Hosepipe ban
		Rivers meeting the Environment Agency water quality
5	**Waste**	Domestic waste production per property per year
		Waste recycled per year
		% of population living within 1km of a recycling bank
6	**Energy**	Reduction of CO^2 emissions in estate action properties per annum
		Grants for energy saving improvements
		Number of Buildings measured for energy efficiency
		Total fuel saved per improve property in the estate action programme per annum
		Installed renewable energy capacity
7	**Transport**	Car ownership
		Transport by mode to workplace
		% of population living within 400m of a bus route/railway station
		Length of dedicated cycle routes
		Length of street converted to pedestrianisation in the city centre
8	**Health**	% of low births per 100 births
		Number of premature deaths and deaths in infancy per 1000 population
		% of population living within 2km of a municipally run sports/leisure centre
9	**Housing**	Number of houses and average house size
		% of dwellings that are empty
		The condition of the housing stock
		Number of homeless households
10	**Economy and work**	Total population usually resident
		Citizens in full/part time/self employment as a percentage of the working population
		Unemployment
		% of the population below the poverty line

11	**Education**	Destination of school leavers into education and training after year eleven
		% of the population who are members of a municipal library
12	**Crime**	Recorded crime per 1000 population
		Number of developments attaining “secured by design” standard
13	**Community involvement**	Membership of the Liverpool Local Agenda 21 network
		Numbers and membership of voluntary environmental groups present in Liverpool with local roles
		Number of schools actively involved in the LA 21 process
		Membership of the Liverpool environmental forum
		Development of Local Agenda 21 plans

Appendix 2: The Embodied Energy of Waste and Energy Requirement of Recycling

Waste Stream Material	**KWh/kg Production**	**Sources**	**Year**	**Energy Recycling Requirement (kWh/kg)**	**Source**	**Year**
Paper						
…Newspaper	10.17	Tellus Institute	1999	6.05	Tellus Institute	1999
…Corrugated Cardboard	9.72	Tellus Institute	1999	8.39	Tellus Institute	1999
…Office paper	10.67	Tellus Institute	1999	6.64	Tellus Institute	1999
…Tissue paper	10.09	Tellus Institute	1999	0.28	Tellus Institute	1999
Plastic						
…PET	29.94[10]	Boustead	1999	8.62	Tellus Institute	1999
…HDPE	21.58[11]	Boustead	1999	5.48	Tellus Institute	1999
…LDPE	27.22	Tellus Institute	1999	7.28	Tellus Institute	1999
Glass						
…Bottle	12.46	Grant et al	1999	3.24	Swiss Agency for the Environment	1999
…Sheet	6.11	Building Research Establishment	1999	3.24	Swiss Agency for the Environment	

[10] This figure has been derived from the database supplied by APME. The total figure can be broken down as follows: a) Fuel production and delivery energy 6.52 kWh/kg; b) Energy constant of delivered fuel 12.26 kWh/kg; c) Energy use in transport 0.124 kWh/kg; d) Feedstock energy 11.03 kWh/kg.

[11] This figure has be derived from the database supplied by APME. The total figure can be broken down as follows: a) Fuel production and delivery energy 2.29 kWh/kg; b) Energy constant of delivered fuel 6.1 kWh/kg; c) Energy use in transport 0.09 kWh/kg; d) Feedstock energy 13.1 kWh/kg.

Metal						
…Aluminium can	16.83[12]	Swiss Agency for the Environment	1999	1.12[13]	Swiss Agency for the Environment	1999
…Tin can	12.6	Tellus Institute	1999	5.23	Tellus Institute	1999
Organics						
…Food waste	2.7	Friends of the Earth	1991	0.185	Juniper Consultancy Services Ltd	1998
…Garden waste	2.7	Friends of the Earth	1991	0.185	Juniper Consultancy Services Ltd	1998

[12] This figure includes two different processes. 1) The energy requirement for the production of aluminum can (16.80 kWh/kg), 2) The transport requirement of the aluminum can (0.026 kWh/kg)
[13] This figure includes two different processes. 1) The energy requirement for the recycling of aluminum can (1.1 kWh/kg), 2) the transport requirement of the aluminum can (0.014 kWh/kg)

Appendix 3: Doubling Counting and Global Equivalence Factors

Double Counting

There are some possibilities of counting the same area twice within the component ecological footprint process. While it may not be possible to remove them all some steps have been taken to try and counteract this problem.

Doubling Counting Built land – Included within the passenger car footprint is the land area occupied by roads. Therefore, to avoid counting road land twice it is removed from the total built land (which included houses, offices and degraded land).

Industrial energy – Many of the products considered within the calculation include an embodied energy figure. The waste data is the industrial energy requirement to produce the waste. Therefore, to count the energy requirements of these products and industrial energy use within Liverpool would be double counting. To avoid this industrial energy is not included in the footprint calculation.

Global Equivalence Factors

This report has not used global equivalence factors. Many of the other reports on ecological footprinting have done so. The equivalence factor compares the biomass of all the different land types to assess the amount of productive area that is being appropriated. More precisely, these factors inform us about the category's relative yield as compared to world average land. Some respects comparisons used in this study may differ slightly. For example, with the application of global equivalence factors Liverpool's footprint would increase closer to 4.7 hectares/per capita. This is still below the national average but not as significant as 4.1 hectares/per capita. If more information to required concerning global equivalence factors, please contact the author.

References

Aaland, D.M. and Capland, A.J. 1999. Household valuation of curbside recycling. Journal of Environmental Planning. Vol 42. N^o 6. Glasgow. pp781-799.

Anon, 2000. Place in the sun for thermal solar. Green Futures. No 24. Sept/Oct. London. Forum for the Future. p13.

Anti Poverty Unit, 1999. Poverty Digest. The extent of poverty in Liverpool. Issue 2. Anti Poverty Unit, Liverpool CC.

Association for Environment Conscious Building, 1995. Greener Building. Coaley. Green Building Press.

Atkins, W.S. 2000. Liverpool freight transport study. Unpublished report for Liverpool CC.

Barrett, J. and Scott, A. 2000. Public perception of sustainable development within Dingle, Liverpool and a guide to developing a successful Local Agenda 21 strategy. Unpublished report for Dingle SRB Partnership. February 2000.

Barrett J., 2001. The Component Ecological Footprint: The Development of Sustainable Scenarios, Impact Assessment of Project Appraisal, in press.

Bell, S. and Morse, S. 1999. Sustainability indicators. Measuring the unmeasurable. London. Earthscan.

Bloyd, C. 1996. Energy and the environment. Energy. Vol 21. N^o 11. Oxford. Elsevier. pp1047-1050.

British Road Federation, 1999. Road Facts 1999.

British Research Establishment, 1995. Potential carbon emission savings from energy efficiency in housing. Information Paper IP 15/95. Garston. BRE.

Brown, L.R.; Flavin, C. & French, H. 1998. State of the World 1998. London, Earthscan. p3.

Callender, M. and Key, T. 1997. Value of the UK commercial property stock. Cited in Scrase, I, 2000.

Chambers N., Simmons C., Wackernagel M. 2000. Sharing Nature's Interest, Earthscan.

Clean Merseyside Centre, 2000. Projected Increase in Waste in Liverpool and Merseyside.

Clean Merseyside Centre, 2000a. A Breakdown of the Domestic Waste Stream in Liverpool and Merseyside by Material.

Commission of the European Communities, 1990. Green paper on the urban environment. Communication from the Commission to the Council and Parliament. COM (90) 218 Final. 27/June/1990.

Commission of the European Communities, 1997. Towards an urban agenda in the European Union. COM (97) 197. Commission Of The European Communities. Brussels.

Cowe, R. 2000. Measuring eco-efficiency: a guide to reporting company performance. World Business Council for Sustainable Development. wwwWBCSD.org

Daly, H.E. 1992. The economic growth debate: what some economists have learnt but but have not. Eds Markandya, A, and Richardson, J. Environmental economics. London, Earthscan. pp36-49.

Department of the Environment Transport and the Regions, 1999. A better quality of life. a strategy for sustainable development in the UK. Norwich. HMSO.

Department of the Environment, Transport and the Regions, 1999a. Transport Statistics Great Britain. Government Statistical Service.

Department of the Environment, Transport and the Regions, 1999b. Digest of environmental statistics No.18. Government Statistical Service.

Department of the Environment, Transport and the Regions, 1999c. CO2 Emissions Inventory. Government Statistical Service.

Department of the Environment, Transport and the Regions. 2000a. Waste Strategy 2000: England and Wales Part 1. HMSO.

Department of the Environment Transport and the Regions, 2000b. Energy efficiency and local well-being. A corporate priority for local authorities. Discussion Paper. London. HMSO.

Department of the Environment Transport and the Regions, 2000c. Energy Efficiency Primer: Good practice Guide 171. HMSO.

Department of the Environment Transport and the Regions, 2000d. Energy use in offices. Energy consumption guide 19. Energy Efficiency Best Practice Programme. London. HMSO.

Department of the Environment, Transport and the Regions, 2000e. School travel. www.local-transport.detr.gov.uk/schooltravel/index.htm

Department of Trade and Industry, 1999. The Energy Report. www.detr.gov.uk

Ehrlich P. & Holdren J., 1971. Impact of Population Growth, Science 171, pp 1212-1217

Environment Agency, 1999. Merseyside Objective 1 Single Programming Document, 2000-2006. Environmental Profile. Environment Agency.

European Environment Agency, 1995. Environment in the European Union 1995. Report for the review of the fifth environment action programme. European Environment Agency. Copenhagen. p146.

Expert Group On The Urban Environment. 1994. European sustainable cities. Part one. Commission Of The European Communities. Brussels.

Expert Group On The Urban Environment. 1996. European sustainable cities. Final report. Commission Of The European Communities. Brussels.

Fells, I. 1999. On the brink? Energy in the next millennium. Energy World. N^o 269. Oxford. Elsevier. pp16-19.

Forestry Commission, 2000. The potential for woodland on urban and industrial wasteland. www.forestrycommission.uk

Friends of the Earth, 1991. The Recycling Officers Handbook, Friends of the Earth Publications.

Gallopin, G.C. 1997. Indicators and their use: Information for decision-making. Eds Moldan, B & Billharz, S. Sustainable Indicators. Report of the project on indicators of sustainable development. Chichester. Wiley. pp13-27.

Goldsmith, E. 1997. Can the environment survive the global economy? The Ecologist. Vol 27. N^o 6. London. pp242-248.

Government Office North West, 2000. Merseyside Objective 1 Programme 2000-2006. Single Programming Document. CCI No. 1999 GB 161 DO 002.

Ibid. p7

Ibid, p124
Harrison, P. 1992. The third revolution. Environment, population and a sustainable world. London. IB Tauris and St Martins Press. pp39-41.

Heathcoat-Amory, D. 1990. Explanatory memorandum on the European Community document. Green Paper on the urban environment. Department Of The Environment [UK].

Hilary, R. 1994. The Eco-Management and Audit Scheme. Cheltenham. Stanley Thornes.

Hodges, D. 1998a. Water Conservation – a need but how do we achieve it? Water and Environment Manager. Vol 12 N^{o}2. London. pp2-3.

Hodges, D. 1998b. Safe use of household greywater. Water and Environment Manager. Vol 13 N^{o}6. London. pp15-17.

Jones, S. 2000. Switching the sparks. Green Futures. No 24. Sept/Oct. London. Forum for the Future. pp50-54.

Jones, Lang and Lasalle, 2000. Office service charge analysis research. www.joneslanglasalle.com

Juniper Consultancy Services Ltd 1999. Trends in Waste Management Methods and Technologies: A Review of Best Practice from an international perspective.

Khanna, P.: Ram Babu, P. and George, Suji. M. 1999. Carrying capacity as a basis for sustainable development. A case study of national capital region in India. Eds Diamond, D and Massam, B>H> Progress in Planning. Vol 52. Part 2. Oxford Elsevier. pp101-166.
Krotscheck, C. 1997. measuring eco-sustainability: comparison of mass and/or energy flow based aggregated indicators. Environmentrics. Vol 8. Chichester. Wiley. Pp661-668.

Lafferty, W.M. & Eckerberg, K. 1998. The nature and purpose of Agenda 21. Eds Lafferty, W.M. & Eckerberg, K. From the Earth Summit to Local Agenda 21. Working towards sustainable development. London. Earthscan.

Leach, A.M. Bauen, A. and Lucus, N.J.D. 1997. A systems approach to materials flow in sustainable cities: A case study of paper. Journal of environmental planning and management. Vol 40. N^{o}6. Abingdon, Oxfordshire. pp705-723.

Lecomber, R. 1979. The economics of natural resources. London. MacMillan. p14.

Levett, R. 1998. Footprinting: a great step forward, but tread carefully – A response to Mathis Wackernage. Local Environment. Glasgow. pp67-74.

Liverpool City Council, 1999. Liverpool Planning and Transportation handbook. Development and Environmental Services Directorate. Place. The Publishing Company. p8.

Local Agenda 21 Team. 1998. Liverpool the changing Environment. Liverpool. Public Relations & Information Services Graphic Design Unit. Liverpool City Council.

London Research Centre and RSK Environment Ltd, 1997. Atmospheric emissions inventories for four urban areas. London. London Research Centre. p20.

London Research Council, 2000. UK Emissions Factor Database, available from: http://www.london-research.gov.uk/

Maclaren, D. 1996. Achieving sustainability through the concept of 'environmental space': a Trans-European project. European Environment. Vol 6. p74. Wiley.

Macnaghten, P. & Jacobs, M. 1997. Public identification with sustainable development. Global Environmental change. Vol 7. N^{o} 1. GB. Elsevier Science. pp5-24.

Mander, S. Buchdahl, J. Shackley, S. and Conner, S. 2000. Carbon Counting. Northwest England's first inventory of greenhouse gas emissions. Manchester. Manchester Metropolitan University's Atmospheric Research and Information Centre, UMIST and Northwest Climate Group.p7.

Merseyguide, 2000. History, the city of Liverpool. www.merseyguide.ndo.co.uk/origin.htm.

Merseyguide, 2000. Liverpool Firsts. www.merseyguide.ndo.co.uk/firsts.htm.

Ministry of Agriculture, Food and Fisheries, 1999. National Food Survey 1999, Office of National Statistics.

Mittler, D. 1999. Environmental Space and barriers to local sustainability: evidence from Edin burgh, Scotland. Local Environment. Vol 3. No 4. Taylor & Francis. pp353-365.

Noss, R. & Cooperrider, S., 1994. Monitoring and Assessing Biodiversity, in Lykke, E., Achieving Environmental Goals, Belhaven, London.

United Utilities, 1999. Drinking Water Compliance Report 1999, UU.

United Utilities, 1999. Social and Environmental Impact Report 1999-2000, UU.

Pauli, S. 1998. Beyond standard assessment tests. Town and Country Planning. Vol 3 No 6. March 1998. pp77-78.

Pearce, D. 1995. Sustainable development: the political and institutional challenge. Eds. Kirkby, J. O'Keefe, P. and Timberlake, L. The earthscan reader in sustainable development. London. Earthscan. pp287-289.

Pout, C.H.; Moss, S.A. and Davidson, P.J. 1998. Non-Domestic building fact file. Garston. BRE.

Rees, J. 1985. Natural resources. Allocation, economics and policy. London. Methuen. p37.

Rees W.E., 1992. Ecological footprints and appropriated carrying capacity: what urban economics leaves out. Environment and Urbanisation 1992, 4(2), pp 121-130

Rees, W. E. 1995. Cumulative environmental assessment and global change. Environmental Impact Assessment Review. Pp295-309.

Rees W.E. (2000) Eco-Footprint analysis: merits and brickbats, Ecological Economics 2000, 32(3), pp 371-374

Scott, A. 1999. Whose futures? A comparative study of Local Agenda 21 in Mid Wales. Planning practice and research. Vol 14. N° 4. Abingdon, Oxfordshire. Carfax. pp401-421.

Scott, P. 1996. The property masters: A history of the British commercial property sector. London. E & EF Spon.

Shane, A.M. and Graedel, T.E. 2000. Urban environmental sustainability Metrics: A provisional set. Journal of Environmental Planning and management. Vol 43. No 5. pp643-663)

Simmons C. and Chambers N., 1998. Footprinting UK Households: how big is your ecological garden? Local Environment 1998, 3(3), pp 355-362

Simmons C., Lewis K. & Barrett J., 2000. Two feet – two approaches: a component-based model of ecological footprinting. Ecological Economics. Oxford. Elsevier Science. pp. 375-380.

Simon, J.L. 1994. More people, greater wealth, more resources, healthier environment. Economic

Affairs. Institute of Economic Affairs. Oxford. Blackwell. April. pp22-29.

Simon, J.L. and Kahn, H. 1998. Introduction to the resourceful Earth. Eds Drysek, J.S. and Schlosberg, D. Debating the Earth. The environmental politics reader. Oxford. Oxford University Press. p53.

Scrase, I. 2000. White collar CO_2. Energy consumption in the service sector. The Association for the Conservation of Energy. www.ace.co.uk

Shane, A.M. and Greadel, T.E. 2000. Urban environmental sustainability metrics: a provisional set. Journal of environmental planning and management. Vol 43. N^o 5. Oxfordshire. Pp643-663.

Smith, A. 2000. Can the planning system deliver renewable energy? Green Government. April 2000. Manchester. Partnership Media Group Ltd. pp25-26.

Solarcentury. 2000. www.solarcentury.co.uk

Sunkin, M. Ong, D. M. & Wight, R. 1998. Sourcebook on environmental law. London. Cavendish. p39.

UNCED.1992. Earth Summit Agenda 21: the United Nations Programme of Action from Rio, Oxford University Press.

United Nations Environment Programme, 1999. *Global Environment Outlook*, U.N.E.P.

Vale, B. and Vale, R. 1996. Urban design: the challenge of sustainability. Journal of urban design. Vol 1. N^{o}2. Abingdon, Oxford. Carfax. pp141-143.

Van Vuuren, Smeets & de Kruijf, 1999. The Ecological Footprint of Benin, Bhutan, Costa Rica and the Netherlands, RIVM: National Institute of Public Health and the Environment, report 807005 004.

Vidal, J. 2000. Blyth spirit can lead to a greener Britain. The Guardian. 17/11/2000. London. p17.

von Weizsacker E., Lovins A., Lovins L., 1998. Factor Four: Doubling Wealth, Halving Resource Use, Earthscan, London.

Wackernagel M., 1994. Ecological Footprint and Appropriated Carrying Capacity: A Tool for Planning Toward Sustainability. PhD Thesis. Vancouver: University of British Columbia, School of Community and Regional Planning.

Wackernagel, M. and Rees, W. 1996. Our ecological footprint. Reducing human impact on the earth. Gabriolla Island. B.C. Canada. New Society Publishing.

Wackernagel, M. 1998. Footprints: recent steps and possible traps. The author's reply to Roger Levett's response. Local Environment. Glasgow. Carfax Publishing. pp221-225.

Wackernagel, M.; Onisto, L.; Bello, P.; Linares, A.C.; Falfan, I.S.L.; Garcia, J.M.; Guerrero, A.I.S. & Guerrero, G.S. 1999. National natural capital accounting with the ecological footprint concept. Ecological Economics. Oxford. Elsevier Science. pp375-390.

Wackernagel, M. 2000. Big things first: focusing on the scale imperative with the Ecological Footprint. Ecological Economics. Vol 32. Nº3. Oxford. Elsevier Science. pp391-394.

Wackernagel M., 2000a. Living Planet Report 2000, World Wildlife Fund for Nature.

Walker, A. 2000. Developing CHP in the public sector and beyond. Green Government. April 2000. Manchester. pp21-22.

White P.R., Franke M. & Hindle P., 1994. Integrated Solid Waste Management: A Life Cycle Inventory

World Commission on Environment and Development. 1987. Our Common Future. Oxford. Oxford University Press.

Worldwatch Institute, 1999. State of the World 1999, Earthscan Publications Ltd, London.

Young, S. 1998. The United Kingdom: A mirage beyond the participation hurdle? Eds Lafferty, W.M. & Eckerberg, K. From the Earth Summit to Local Agenda 21. Working towards sustainable development. London. Earthscan.