Ecological and Carbon Footprints of Wales
Update to 2011

Stockholm Environment Institute and GHD

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Executive Summary

This report provides a new estimate of the ecological and carbon footprints of Wales for 2011. It builds on previous ecological and carbon footprint studies for Wales and should be read in conjunction with the original report by SEI, entitled *The Ecological Footprint of Wales: Scenarios to 2020*[1] (2008) and subsequent updates by Welsh Government.

Wales' ecological footprint is estimated at 10.05 million global hectares (gha), roughly 5 times the size of Wales, or 3.28 global hectares per capita (gha/c). Wales' carbon footprint is estimated at 34 Mt CO_2e, or 11 t CO_2e per capita. These figures are not directly comparable to previous estimates due to changes in the methodology by which the footprints were calculated.

At the current level of consumption, a number of key natural resources are being depleted faster than they can be replenished, and the planet's capacity to absorb our wastes is exceeded. In other words it is not sustainable in the long term, because we are exceeding the world's *biocapacity*. That is to say in order to sustain our current consumption in the long term we would require more than one planet Earth to provide the resources and absorb the wastes.

In common with other developed countries, Wales has a much higher consumption rate than the global average. Previous comparative studies have found that the ecological footprint for Wales is marginally lower than the UK average, and we do not expect this to have changed. Estimates provided by the Global Footprint Network indicate that the biocapacity of 2.7 planets would be required, if everyone in the world were to consume the same as the average UK citizen. Therefore, if everyone in the world were to consume the same as the average Welsh citizen, we estimate that just over 2.5 planets would be required.

Figure 1: Current Welsh consumption equates to 2½ planet living

Whilst currently unsustainable, consumption patterns change and resource and energy efficiency can improve and it is Welsh Government's role to develop and implement policies that facilitate the transition to One Planet Living in Wales. Foremost in this respect are its greenhouse gas reduction policies, aligned to its commitment to reduce greenhouse gas emissions from sources under devolved administration by 3% year on year

The top three local authorities with the highest ecological footprint are Ceredigion, Vale of Glamorgan and Powys. Those with the lowest ecological footprint are Merthyr Tydfil, Blaenau Gwent and Torfaen.

The primary land type dominating the footprint is the land required to sequester emissions of carbon dioxide, which arise from the burning of fossil fuels. The consumption of food, housing, transport, consumer items, private services and public services together accounts for 85% of

[1] *The Ecological Footprint of Wales: Scenarios to 2020,* SEI for the Welsh Assembly Government, 2008, www.webaddress.co.uk

the ecological footprint. The specific consumption categories that contribute the most to the ecological and carbon footprints are household energy use, transport, construction and consumption of meat, fruit and vegetables.

Previous studies identified that Wales' footprint was on an increasing trend up until 2008 (the most recent previous data). It is likely that this trend will have been either slowed or reversed as a result of the economic recession, and that it will return as the economy recovers. Whilst in previous years there has been a close correlation between economic activity and both greenhouse gas and ecological footprints, in future this correlation must be removed by de-coupling economic growth from environmental impact if government carbon and One Planet Living targets are to be achieved

This will need all sectors and stakeholders to contribute. This report highlights the consumption categories with the biggest impact, signposting the areas in which impact reduction could have the greatest overall benefit.

Specifically these are:

Ecological footprint	Carbon footprint
Domestic fuel and land use	Domestic fuel and land use
Electricity, gas and other fuels	Private transport, direct emissions and land use
Meat and meat products	Electricity, gas and other fuels
Catering services	Construction
Private transport, direct emissions and land use	Retail trade services (excl.motor trade)
Construction	Health services
Fruit and vegetables	Operation of personal transport equipment
Bread, rusks and biscuits, pastry goods and cakes	Catering services
Health services	Meat and meat products (excl. poultry)
Dairy products	Other recreational equipment etc.

Approximately 75% of the greenhouse gas emissions associated with Wales' carbon footprint are from products purchased domestically, with the remaining 25% from the final consumption of imported goods. Consequently, any improvement in the efficiency of production in the UK (e.g. by decarbonising the grid) can influence about three quarters of the global impact. On the other hand, minimizing and reducing the amount of carbon intensive products that are consumed can influence 100% of the impact. It is also important to directly address international impacts via measures targeting the international supply chain.

Table of contents

1. Introduction 1
   - 1.1 About this report 1
   - 1.2 Background 2
2. Results 6
   - 2.1 Ecological footprint 6
   - 2.2 Carbon footprint 10
3. Methodology 14
   - 3.1 Choice of methodology 14
   - 3.2 Overview of method 14
   - 3.3 Comparison to previous methodology 16
4. The transition to One Planet Living 18
   - 4.1 Trajectory for One Planet Living 18
   - 4.2 Decoupling economic growth and carbon 18
   - 4.3 Current policy measures 19
   - 4.4 Delivering change: Stakeholder roles 23
5. Conclusion 25
   - 5.1 Key messages 25
   - 5.2 Recommendations 25
6. References 27

1. Introduction

1.1 About this report

1.1.1 Scope

This report provides an estimate of the ecological and carbon footprint of Wales for 2011. It builds on and updates footprint assessments conducted by the Stockholm Environment Institute (SEI) for 1992-2006, and Welsh Government for 2008. It also reviews and updates the methodology to reflect recent developments in assessment techniques. The report describes the national (Welsh) footprints, as well as disaggregated footprints for each of the 22 local authority areas in Wales. It should be read in conjunction with the previous report produced by SEI, entitled *The Ecological Footprint of Wales: Scenarios to 2020*. Whilst the principles used are the same as for the earlier report, the calculation methodology used in this update is different. Therefore, the results cannot be directly compared.

The results presented here are not directly comparable to footprints calculated in previous years because the model developed for the assessment and the availability and scope of source data – on which the results depend – have changed. In order to compare the 2011 footprint with previous years, a time series analysis, using the same model, would be required. That is beyond the scope of this report.

This report was written by GHD[2] in collaboration with the Stockholm Environment Institute (SEI). The calculations and methodological development behind the results presented in this report were conducted by SEI.

1.1.2 Limitations

This report is an update to the national and local authority level footprint figures for Wales. It does not provide an assessment of scenarios or policies in order to achieve any reduction targets, and it does not make historical or international comparisons other than those presented briefly within for narrative purposes.

1.1.3 Structure

This report is presented in five sections:

1. **Introduction** – setting the context, scope and limitations of the report
2. **Results** – presenting the outcomes of SEI's analysis
3. **Methodology** – describing the choice of methodology, its advantages and disadvantages, and summarising the method applied by SEI
4. **The transition to One Planet Living** – discussing the scale of change required and trajectory to One Planet Living within a generation, the roles of stakeholders, and the Welsh Government policies currently in place
5. **Conclusion** – summarising the key messages and providing recommendations

[2] http://www.ghd.com/global/

1.2 Background

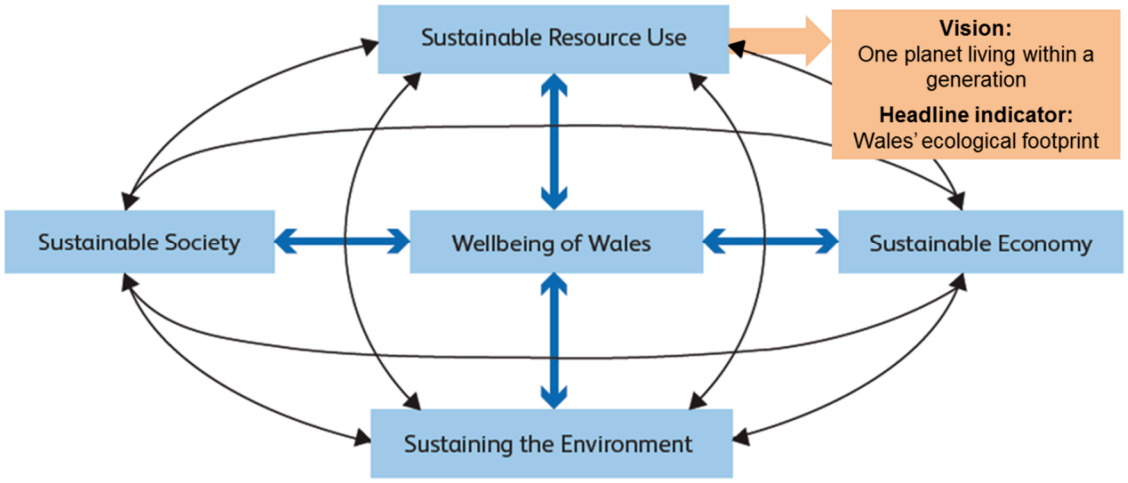
1.2.1 Welsh Government vision

The Welsh Government is one of the few administrations in the world to have enshrined a statutory duty to promote sustainable development, as defined in the Government of Wales Act 2006. In 2009 it set out its scheme for sustainable development entitled *One Wales: One Planet*, which sets out its vision of a sustainable Wales. This includes:

> "Within the lifetime of a generation we want to see Wales using only its fair share of the earth's resources"

It adopts the ecological footprint of Wales as one of five headline indicators of sustainable development. The vision for sustainable development in Wales consists of five inter-related themes, illustrated in Figure 2.

Figure 2: Welsh Government's vision for sustainable development in Wales



Source: One Wales: One Planet

Welsh Government has also set the following targets for the reduction of greenhouse gases, in its Climate Change Strategy for Wales (2010):

- A 3% year-on-year absolute reduction in greenhouse gas emissions in areas of devolved competence, starting in 2011.
- Reducing all the greenhouse gas emissions in Wales by 40% by 2020 against a 1990 baseline.

Wales' contribution to climate change extends beyond its geographical boundaries. While the national targets relate to emissions occurring physically within Wales (known as production-based or territorial emissions), it is also important to reduce the emissions associated with supply chains that extend beyond Wales' borders for goods and services consumed in Wales (known as consumption-based emissions). Therefore Welsh Government has also committed to monitoring and reducing Wales' consumption-based emissions.

1.2.2 Climate change

It is widely agreed that human emissions of greenhouse gases are contributing to global warming, and this presents a major threat to society and ecosystems over the coming decades. The degree of climate change and the severity of its consequences are uncertain, but the scientific consensus is that some degree of anthropogenic warming is now inevitable. The Intergovernmental Panel on Climate Change (IPCC)'s 5th Assessment Report, published in 2013, concluded that the probability of human emissions of greenhouse gases being responsible for global warming is now in excess of 95%.

The ability to maintain a stable concentration of greenhouse gases in the atmosphere, and therefore a stable climate, can be seen as one of the Earth's natural resources, from which we derive benefit. Therefore, by emitting greenhouse gases in sufficient quantity to irreversibly change the atmospheric concentration, we are depleting that common resource, leaving future generations with an impoverished natural environment.

In addition to its direct impacts (e.g. rising sea levels and an increased likelihood of more extreme weather events) climate change threatens a great number of other environmental resources on which we depend, like biodiversity, agricultural land, ecosystems and potable water supplies.

The ecological footprint takes account of carbon dioxide emissions (CO_2) associated with Welsh consumption activities and expresses them as an area of land.

The burning of fossil fuels contributes to the 'CO_2 area' component of the ecological footprint. This is the biocapacity required to sequester (through photosynthesis) the carbon dioxide emissions from fossil fuel combustion. This is the largest component of the ecological footprint in Wales.

1.2.3 About ecological footprinting

The ecological footprint is an indicator of the total environmental burden that society places on the planet. It represents the area of land needed to provide raw materials, energy and food, as well as absorb pollution and waste created and is measured in global hectares. A global hectare is a common unit that encompasses the average productivity of all the biologically productive land and sea area in the world in a given year. Biologically productive areas include cropland, forest and fishing grounds, and do not include deserts, glaciers and the open ocean (Global Footprint Network, 2013)[3].

The ecological footprint for a particular population is defined as: "the total area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that production produces, wherever on Earth that land and water may be located" (Rees, 2000).

This does not suggest that a region should source all its natural resources from within its own boundaries, or even from a land area comparable to its own. Instead, it highlights the extent to which current consumption is consistent with the concept of One Planet Living (refer to Section 1.2.5).

[3] Using a common unit, i.e., global hectares, allows for different types of land to be compared using a common denominator. Equivalence factors are used to convert physical hectares of different types of land, such as cropland and pasture, into the common unit of global hectares. Ecological footprints are usually calculated at national and regional levels – in this case for Wales and each of its local authorities (Global Footprint Network, 2013).

1.2.4 Consumption-based accounting

Wales' contribution to the global environmental burden extends beyond its geographical boundaries. While some of its environmental impacts occur physically within Wales, it is also important to assess the impact of supply chains that extend beyond Wales' borders. Accounting for the full supply chain impacts, irrespective of the location of the source of impact, is known as consumption-based accounting. This is in contrast to production-based or territorial accounting, which accounts only for those sources of impact within a boundary. Both the ecological and carbon footprints presented in this report are consumption-based indicators.

When considering impacts that are global in nature, e.g. climate change or consumption of world resources, it is important to use the consumption-based approach in order to identify the full scale of the impact. Consumption in one country may put pressure on resources and emit pollutants in another. With ever more complex global supply chains, it is becoming increasingly important to understand the burden that lifestyles and demand for goods and services put on the world's resources, regardless of where they are made.

Welsh Government has recognised the importance of consumption-based accounting in its Climate Change Strategy, which commits to reporting on consumption-based emissions in the annual Climate Change Strategy progress reports.

1.2.5 One Planet Living

One Planet Living describes a situation in which the region in question consumes no more than its fair share of the Earth's resources, i.e. an area of bioproductive land and sea proportional to of the global resources available and the global population.

This approach is useful because it provides an objective, quantifiable vision of environmental sustainability, a concept which otherwise can be so broad and inclusive as to lack focus when discussed amongst diverse stakeholders, particularly those who demand an evidence-based analysis. In particular, for government, whose remit includes all of society's groups and stakeholders, it provides a framework which can be agreed on – in principle – by all: that we should aim to live within the environmental constraints of the planet, and conserve the planet's capacity to provide for future generations.

To achieve One Planet Living, the share of the world's natural resources consumed by a nation should be proportional to its share of the global population. The people of Wales currently represent approximately 0.04% of the world population (assuming Welsh and World populations of 3 million and 7 billion respectively). Therefore, Wales should aim to live off 0.04% of the resources that the world can sustainably provide; currently it consumes around 0.1[4]%.

In 2050, the global population is forecast to grow to 9 billion[5], an increase of close to 30%, whereas Wales' will remain relatively stable. Therefore, in 2050, to achieve One Planet Living, Wales will need to live off a correspondingly smaller share of the world's resources. This means reducing the environmental burden of its consumption by approximately two thirds.

One Planet Living need not mean reducing quality of life and could deliver the opposite with improvements in many different aspects of well-being. In principle it can be achieved through a number of actions which would have further additional benefits, such as more reduction in the use of energy, lowering food waste and healthier diets, minimising water use and material inputs, a transition to renewable energy sources, and widespread adoption of whole life cycle

[4] Estimate based on the ratio of the ecological footprint of the UK to global biocapacity as estimated by the Global Footprint Network.
[5] UN 2010 projections, medium scenario

design, where products do not become waste, but are disassembled and reused or recycled as raw materials.

1.2.6 Self sufficiency

The ecological footprint of Wales is represented by an area calculated to be approximately 4.8 times the size of Wales. This comparison is illustrative, and does not relate to the One Planet Living goal. If Wales were seeking to be self-sufficient, however, its footprint would need to be no more than its biocapacity (the area of land and sea capable of sustaining crops, housing, forest and fish stocks and absorbing greenhouse gas emissions). Wales' biocapacity is likely to be significantly larger than its land footprint, allowing for its share of UK fishing grounds, but this report has made no assessment of its biocapacity.

1.2.7 Carbon footprint

The carbon footprint describes the physical quantity of greenhouse gases emitted to atmosphere. This study includes all six greenhouse gases subject to the Kyoto Protocol[6] are included, expressed as tonnes of carbon dioxide equivalent (t CO_2e). This is where the emissions of non-CO_2 greenhouse gases are adjusted to the equivalent emissions of CO_2 that produce the same global warming potential. SEI has included emissions made directly by sources located within Wales, as well as within its international supply chains. In other words, it is a consumption-based carbon footprint, consistent with the method used to calculate the ecological footprint.

[6] These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF_6)

2. Results

2.1 Ecological footprint

2.1.1 Total ecological footprint of Wales

The total ecological footprint of Wales is estimated at 10,05 million global hectares (gha), or 100,500 square kilometres (approximately 4.8 times the land area of Wales). Based on current population levels, this equates to about 3.28 gha per capita. This is estimates to be roughly 1.2-1.8 times the global average[7].

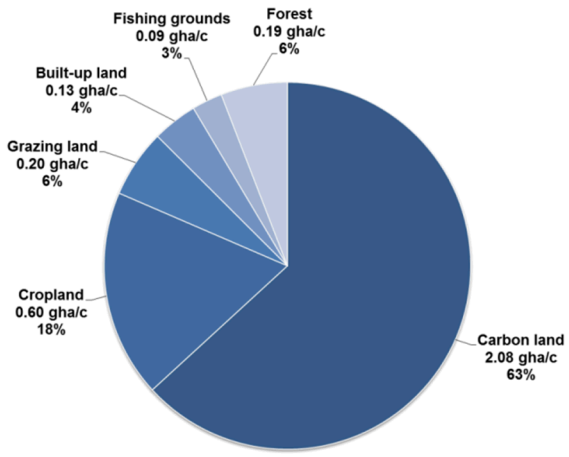
2.1.2 Breakdown by land type

The ecological footprint is made up of six land types:

- Carbon land – land and sea required to sequester CO_2 emissions, by photosynthesis
- Cropland – land required to produce crops
- Grazing land – land required to raise animals and animal products
- Built-up land – land required for housing, buildings and other infrastructure
- Fishing grounds – sea area required to produce fish
- Forest – land required to sustain biodiversity

Figure 3 shows the relative contribution of each land type. Carbon land is the most important component, accounting for 63% of the overall ecological footprint of Wales. In other words, the emission of carbon dioxide resulting from burning fossil fuels is the most important factor determining the overall environmental burden (refer to Section 2.2).

Figure 3: Ecological footprint of Wales by land type



[7] Global average figure of 2.7 gha/c in 2007 published by the Global Footprint Network (GFN). Note that the GFN methodology is different to the one we have used, so the results cannot be directly compared. GFN's figure for the UK in 2007 is 4.9 gha/c.

2.1.3 Breakdown by consumption theme

The ecological footprint is influenced by the food people eat, the way they travel and the energy they use in the home. It also accounts for the purchase of products and services from insurance to televisions to items of clothing. Finally, it also includes impacts from construction activity and investment in infrastructure.

By grouping the ecological footprint by final demand theme it is possible to identify six broad areas that contribute significantly to the ecological footprint.

- **Housing** – fuel emissions from direct household energy use for heat, hot water, lighting and electrical appliances as well as the impact from household maintenance and from household construction.
- **Food** – food and drink consumed by households and at restaurants and takeaways.
- **Transport** – fuel emissions from personal travel in public and private vehicles as well as the impact from maintaining vehicles, buying new vehicles and building the transport infrastructure.
- **Consumer items** – production of all products bought by households, from newspapers to appliances.
- **Private services** – all private sector services ranging from entertainment to financial.
- **Public services** – all services provided by the public sector ranging from education and healthcare to sewage and waste disposal.
- **Other** – this includes other aspects of purchasing or expenditure included in national accounts, such as gross fixed capital formation or not-for-profit institutes serving households. For more information about components of final demand in national accounting see the UK Blue Book from the Office for National Statistics[8].

Figure 4 shows the relative contributions of each theme to the ecological footprint of Wales. A list of dominant categories is given in Table 1, which includes all the categories contributing to the ecological footprint by more than 2.5 gha/c. The top ten are ranked and highlighted in bold. These provide some insight to the areas in which the Welsh Government could develop targeted reduction policies to the greatest effect.

[8] Source: http://www.ons.gov.uk/ons/rel/naa1-rd/united-kingdom-national-accounts/the-blue-book--2013-edition/index.html, accessed 5 Decmeber 2013

Figure 4: Ecological footprint of Wales by consumption theme

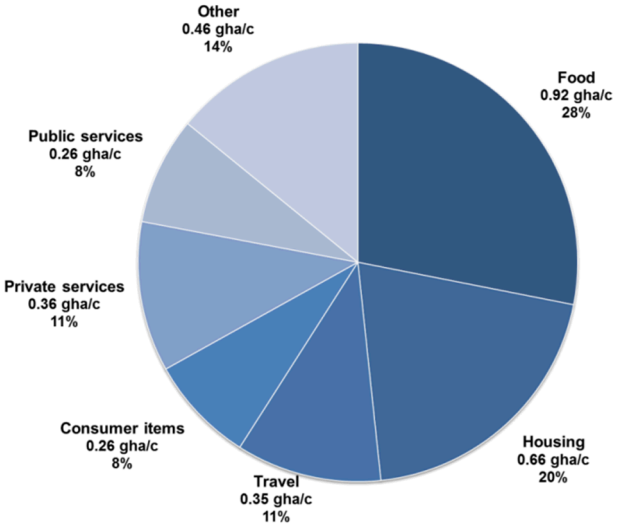


Table 1: Ecological footprint of Wales: Dominant categories

Rank	Theme/category	gha/c	% of theme
	Food	**0.92**	
3	**Meat and meat products (excl. poultry)**	**0.20**	**22%**
7	**Fruit and vegetables**	**0.16**	**17%**
8	**Bread; rusks and biscuits; pastry goods and cakes**	**0.13**	**14%**
10	**Dairy products**	**0.10**	**11%**
	Meat and meat products (poultry)	0.08	8%
	Other food products (incl. sugar)	0.06	7%
	Cocoa, chocolate and sugar confectionery	0.05	5%
	Grain mill products; starches and starch products	0.05	5%
	Wild fish and fish products from catch	0.04	4%
	Non-alcoholic beverages	0.03	3%
	Housing	**0.66**	
1	**Domestic fuel and land use**	**0.29**	**44%**
2	**Electricity, gas and other fuels**	**0.21**	**33%**
	Imputed rentals for housing	0.03	5%
	Travel	**0.35**	
5	**Private transport, direct emissions and land use**	**0.18**	**50%**
	Operation of personal transport equipment	0.07	21%
	Road transport services	0.03	8%
	Air transport services	0.03	8%
	Consumer items	**0.26**	
	Other recreational equipment etc.	0.15	56%
	Clothing	0.03	12%
	Private services	**0.36**	
4	**Catering services**	**0.18**	**50%**
	Recreational and cultural services	0.03	9%
	Accommodation services	0.03	7%
	Public services	**0.26**	
9	**Health services**	**0.11**	**43%**
	Education services	0.05	20%
	Public administration and defence services; compulsory social security services	0.04	17%
	Other final demand	**0.46**	
6	**Construction**	**0.17**	**37%**
	Products of agriculture, hunting and related services	0.05	11%
	Coke and refined petroleum products	0.03	5%

2.1.4 Breakdown by local authority

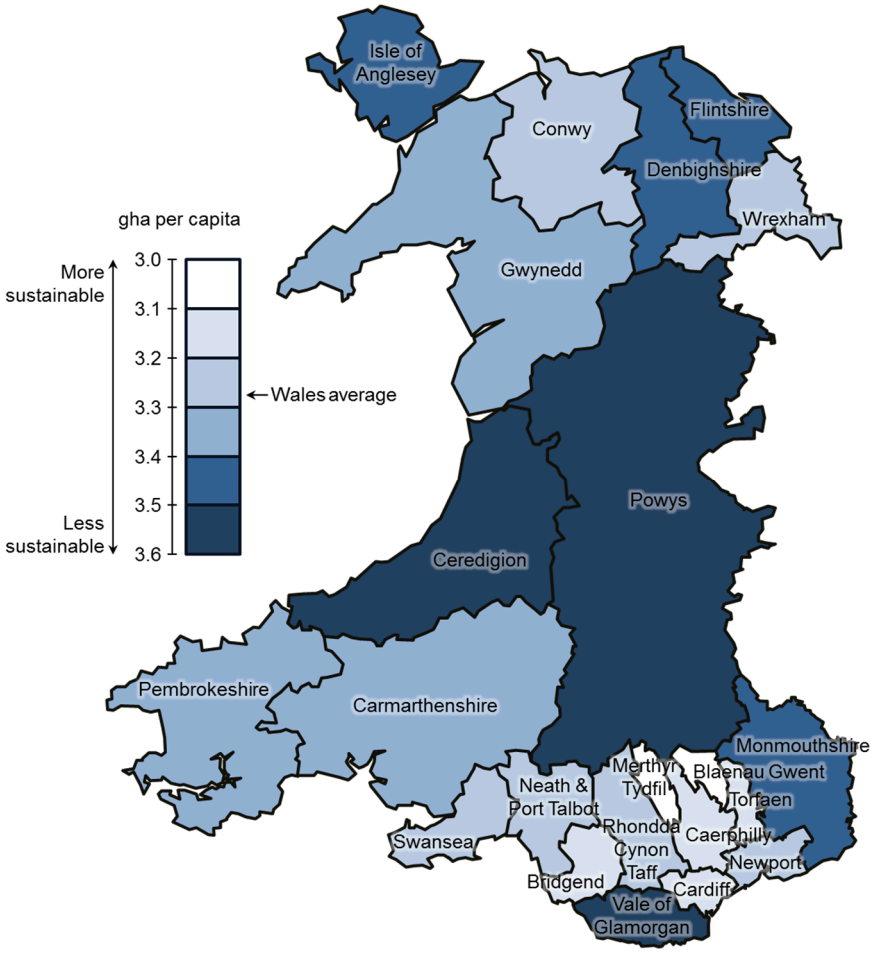
Table 2 and Figure 5 show the ecological footprint for each of the 22 local authorities in Wales.

The local authorities with the highest ecological footprints are Ceredigion, Vale of Glamorgan and Powys. Those with the lowest are Merthyr Tydfil and Blaenau Gwent. The variation in footprint at a local level is influenced by a number of factors including income, demographics, patterns of household expenditure and the energy performance of housing stock.

Table 2: Ecological footprint of Wales and Local Authorities

Local Authority	gha/c	Local Authority	gha/c
Merthyr Tydfil	3.06	Conwy	3.28
Blaenau Gwent	3.10	Pembrokeshire	3.36
Torfaen	3.13	Carmarthenshire	3.36
Caerphilly	3.14	Gwynedd	3.38
Cardiff	3.16	Flintshire	3.41
Bridgend	3.20	Monmouthshire	3.42
Rhondda Cynon Taff	3.20	Denbighshire	3.44
Newport	3.20	Isle of Anglesey	3.46
Neath Port Talbot	3.20	Powys	3.53
Swansea	3.25	Vale of Glamorgan	3.53
Wrexham	3.27	Ceredigion	3.59
		Wales average	**3.28**

Figure 5: Ecological footprint of Wales by region



The local authorities with the lowest environmental burden per capita are shown in lighter colours. These tend to be the areas with relatively high population density, particularly the valleys and the area stretching from Swansea and Newport. Those with a higher burden per capita are shown in darker colours. These tend to be the areas with relatively sparse rural populations.

The data used to calculate the footprints only allows limited distinction between the counties. Some of the categories making large contributions to the footprint were calculated from national-level data, for example private (household) transport and government capital expenditure on construction. These were calculated at a national level and, in the absence of county-level data, then attributed equally between the counties on a per capita basis. Of the data that were available at the county level, the most important category driving the difference between counties is 'electricity, gas and other fuels' consumed by households.

2.2 Carbon footprint

2.2.1 Total carbon footprint of Wales

The total carbon footprint of Wales is estimated at just over 34 million tonnes of carbon dioxide equivalent (t CO_2e). At current population levels, this equates to 11.11 t CO_2e per capita.

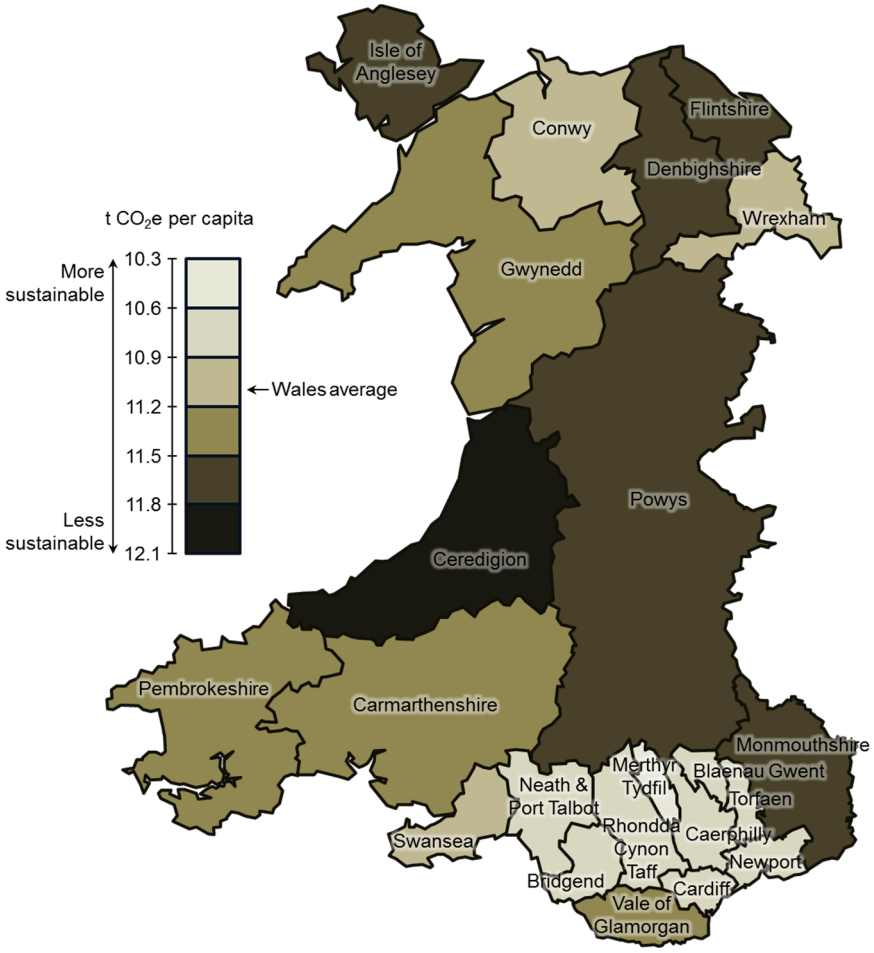
2.2.2 Breakdown by Local Authorities

The carbon footprint for each of the local authorities is shown in Table 3 and Figure 6. In general the local authorities with a high carbon footprint are also those with a high ecological footprint. However, there are some exceptions, for example Vale of Glamorgan which has the 7th highest carbon footprint but the 2nd highest ecological footprint. This is because of slight differences in the make-up of the ecological footprint between regions. For example, carbon land accounts for a slightly higher proportion of the ecological footprint of the Vale of Glamorgan (64%) than the national average (63%).

Table 3: Carbon footprint of Wales and Local Authorities

Local Authority	t CO2e per capita	Local Authority	t CO2e per capita
Merthyr Tydfil	10.52	Conwy	11.18
Blaenau Gwent	10.64	Carmarthenshire	11.36
Caerphilly	10.64	Pembrokeshire	11.40
Cardiff	10.66	Gwynedd	11.48
Newport	10.77	Vale of Glamorgan	11.48
Torfaen	10.77	Monmouthshire	11.50
Bridgend	10.82	Flintshire	11.54
Neath Port Talbot	10.85	Denbighshire	11.60
Rhondda Cynon Taff	10.86	Isle of Anglesey	11.76
Swansea	11.02	Powys	11.90
Wrexham	11.04	Ceredigion	12.01
		Wales average	**11.11**

Figure 6: Carbon footprint of Wales by region



The local authorities with the lowest carbon footprint tend to be those with the lowest overall environmental burden per capita, i.e. the valleys and more densely populated areas in South Wales. The inherent limitations in the data described in Section 2.1.4 prevent a detailed analysis of the difference between counties.

2.2.3 Breakdown by Consumption theme

Figure 7 shows the carbon footprint broken down by the consumption themes listed in Section 2.1.3. A list of dominant categories is given in Table 4, which includes all the categories contributing to the carbon footprint by more than 85 kg CO_2e per capita. The top ten are ranked and highlighted in bold. These provide some insight to the areas in which the Welsh Government could develop targeted reduction policies to the greatest effect.

Figure 7: Carbon Footprint of Wales by consumption theme

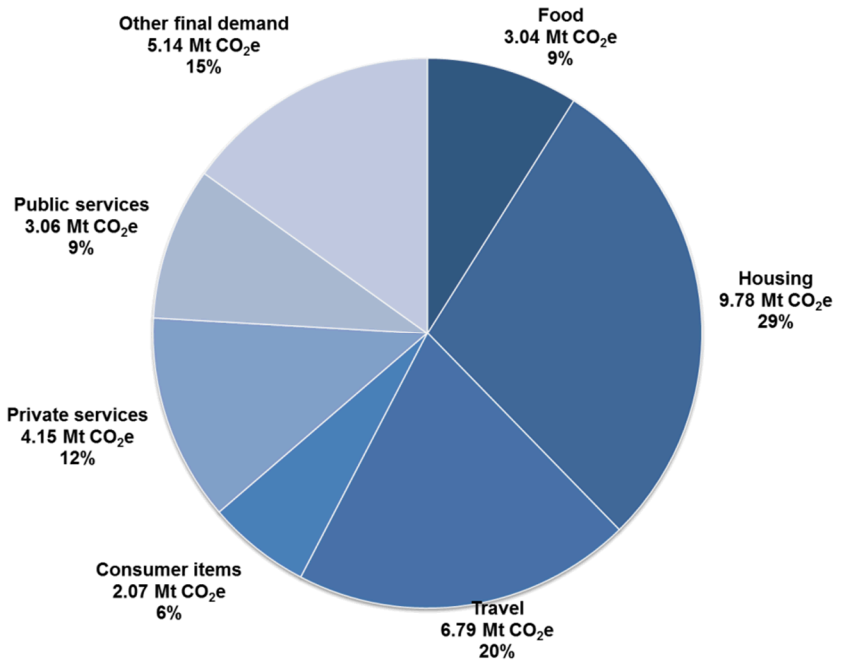


Table 4: Carbon footprint of Wales: Dominant categories

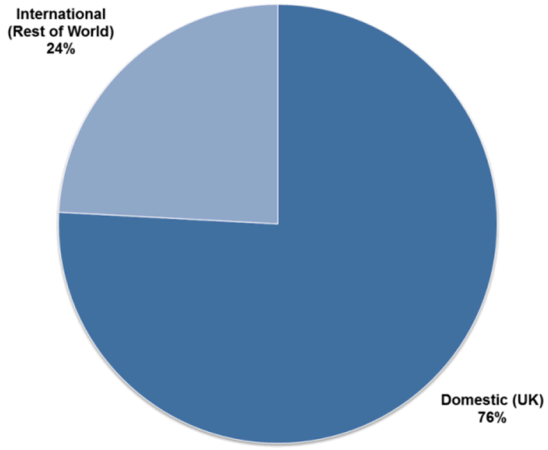
Rank	Theme/category	kt CO_2e	% of theme
	Food	**3,042**	
9	**Meat and meat products (excl. poultry)**	625	**21%**
	Fruit and vegetables	505	17%
	Housing	**9,779**	
1	**Domestic fuel and land use**	**4,157**	**43%**
3	**Electricity, gas and other fuels**	**3,740**	**38%**
	Imputed rentals for housing	472	5%
	Water supply and miscellaneous dwelling services	331	3%
	Actual rentals for housing	285	3%
	Travel	**6,782**	
2	**Private transport, direct emissions and land use**	**3,777**	**56%**
7	**Operation of personal transport equipment**	**1,219**	**18%**
	Road transport services	478	7%
	Air transport services	472	7%
	Consumer items	**2,065**	
10	**Other recreational equipment etc.**	**613**	**30%**
	Private services	**4,151**	
5	**Retail trade services (excl.motor trade)**	**1,510**	**36%**
8	**Catering services**	**836**	**20%**
	Wholesale trade services (excl. motor trade)	426	10%
	Public services	**3,054**	
6	**Health services**	1,363	**45%**
	Public administration and defence services; compulsory social security services	548	18%
	Education services	545	18%
	Waste collection, treatment and disposal	260	9%
	Other final demand	**5,140**	
4	**Construction**	**1,939**	**38%**
	Coke and refined petroleum products	389	8%

The most important categories contributing to the carbon footprint, and the rank order, are similar to the ecological footprint. A comparison is provided in Section 4.2 (Table 5).

2.2.4 Comparison of domestic vs. international emissions

The majority of emissions – approximately 75% – associated with Wales' carbon footprint are from products and services purchased domestically, with the balance associated with the demand for imported goods. Figure 8 illustrates the breakdown between emissions from domestic (UK) purchases and those associated with international (import) purchases (Rest of World). It is important to note that this disaggregation distinguishes between goods and services purchased by final consumers domestically and those purchased from abroad. It does not show where those emissions were actually released as even though goods are purchased domestically they may have emissions embedded in their supply chains which occurred abroad, prior to processing and selling domestically. Further, more detailed analysis would be required to separate emissions according to their point of release. This is beyond the scope of this report.

Figure 8: Carbon footprint of-Wales: domestic vs. international



In principle there are four ways to reduce the impacts of consumption:

1. Improving the efficiency of production (i.e. fewer emissions or land impacts per unit produced)
2. Altering the structure of production (using alternative input materials)
3. Reducing the size of consumption (i.e. fewer units consumed)
4. Altering the structure of consumption (consuming lower impact products and services)

Government strategies to improve the efficiency of production in the UK (e.g. by decarbonising the grid) can influence about three quarters of the global impact. On the other hand, minimizing and reducing the amount of carbon intensive products that are consumed can influence 100% of the impact. It is important to address both the efficiency and size of production and consumption.

3. Methodology

3.1 Choice of methodology

3.1.1 Ecological footprint

There is no internationally agreed method for national footprint calculation. However, two basic methodologies are widely accepted and have been applied in numerous studies:

- Using financial information (trade values) and multipliers derived from economic input-output analysis.
- Using physical information (trade volumes) in combination with life cycle coefficients that identify the impact of these traded goods.

Each has its advantages and limitations. In this study, and previous studies for Wales, SEI selected the first approach. The main reasons for this are that the method is based on global trade, production and consumption data for the whole economy. This means that it does not suffer from truncation errors (it captures the impacts along full supply-chains). The crucial advantage of input-output based analysis is that it is possible to attribute environmental impacts to virtually any:

- Consumption activity, such as consumption of regions, nations, governments, cities, socio-economic groups or individuals, whether domestically or abroad (imports/exports);
- Production activity, such as agriculture, manufacturing, services etc.;
- Associated economic activity such as supply chains, trade flows or recycling.

Input-output analysis has been applied to ecological footprint analyses for a decade and is now a well-established technique for the calculation of ecological footprints of nations, sub-national entities, socio-economic groups and organisations or companies. It is also accepted as an approach within the Global Footprint Network's (GFN) standards.

3.1.2 Carbon footprint

A carbon footprint can also be calculated using the same input-output method described above, and for consistency and to benefit from the advantages listed the same technique is applied. This approach is also commonly used for estimating consumption based emissions at the national level and has been applied in numerous studies for many different countries.

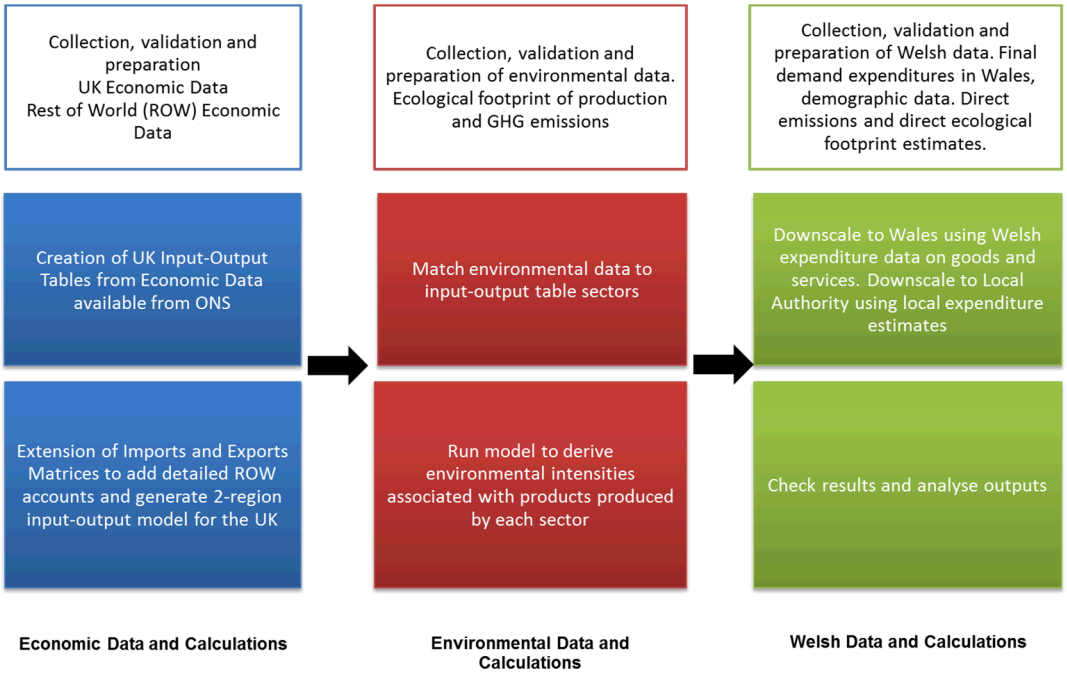
3.1.3 Limitations

The main limitation of the method is the level of product disaggregation available within the data; emission intensity factors are at the industry sector level, such as 'dairy products', rather than separated into 'milk' and 'butter'. The method is also reliant on a variety of national and international statistics, which are often not updated on a consistent regular basis.

3.2 Overview of method

A detailed description of the method used by SEI is provided in a technical report which accompanies this report. The key steps involved are summarised in Figure 9.

Figure 9: Summary of method



3.2.1 Source data

This assessment has relied on the following data:

- UK supply and use tables for 2011, derived from the National Accounts published by the Office for National Statistics (ONS). This groups commodities into 96 categories.
- UK Analytical Input-Output tables, published by ONS.
- UK greenhouse gas emissions data for each of the 96 categories. These were sourced from the UK Environmental Accounts.
- UK ecological footprint of production (land use) data, broken down into cropland, grazing land, built-up land, fisheries, forest land and land required to sequester carbon emissions. These were derived from the Global Footprint Network's ecological footprint of production data for the UK.
- Rest-of-World economic data for 2009, derived from the World Input Output Database[9] (WIOD).
- Rest-of-World environmental data for each of the import/export categories, based on the data from WIOD, the Carbon Dioxide Information Analysis Centre and Global Footprint Network's National Footprint Accounts.
- Final demand (e.g. household and government) expenditure estimates for Wales and the Welsh local authorities, derived from the ONS' Expenditure and Food Survey and Welsh Government Budgets and Accounts, 2011.
- Emissions data for Wales and the Welsh regions taken from the National Atmospheric Emissions Inventory.
- Population data for Wales and the Welsh regions from Welsh Government Statistics.

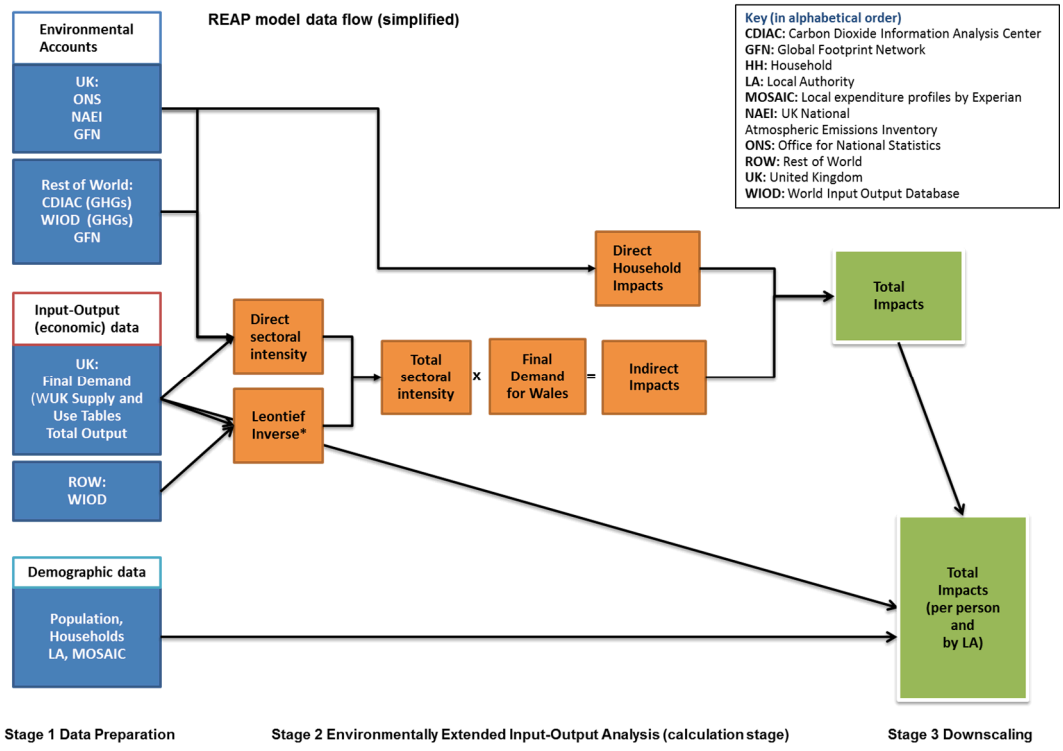
[9] www.wiod.org

3.2.2 Multi-regional input output model

SEI developed the multi-regional input-output model (MRIO) required for the footprint estimate by creating a new two-region (i.e. UK and Rest-of-World) input-output (IO) model for 2011, using the latest available economic data (supply and use tables) from the Office of National Statistics. The model uses the input-output equations (known as Leontief equations after the economist who first formulated them in the 1930s) to calculate the footprint, and reallocates emissions and land use from the point of production to the categories of consumption.

Figure 10 provides an illustration of the data flows and calculation steps involved.

Figure 10: Summary of data flows and calculation steps



3.3 Comparison to previous methodology

The general input-output methodology remains consistent with that employed for past reports and data updates. However, there are differences in the input data used, how it was utilised, and the implementation of the methods.

The most obvious change is to the input data. Where available, the most recent data sets (such as the most recent ONS SUT tables) were used to construct a new input-output table. Where more recent data has been used, the methods and techniques applied to them, whilst fundamentally the same as those used previously, in terms of broad approach and purpose, have been improved upon in order to provide the best possible accuracy. An example of this is the use of the Eurostat supply tables. These tables contain confidential entries which must be estimated for available data, and a brand new and improved algorithm was developed and implemented to achieve this (see technical report for full details).

In some instances, more recent data was not available, and in these instances improvements have still been made. A prime example of this is use of a transition matrix required to transform the IO data from purchaser's prices to basic prices. The most recent example of such a table

remains the 2005 table supplied by the ONS. Whereas in the previous work this same (2005) table was used for each year, in this work considerable effort has been made to create a new, updated table for 2011. This involves taking the 2005 data as a starting point, and systematically using and incorporating more recently available data to estimate and construct an up to date transition table (see technical report for full details).

Another significant departure from past methods is the choice of rest of world data used to construct the two-region UK/ROW MRIO model. Whereas in the past the GTAP[10] database (and subsequently derived MRIO) was used, in this work the World Input-Output Database MRIO id used. Whilst the WIOD model uses a higher level of regional and sectoral aggregation (129 regions and 57 sectors in GTAP vs 41 regions and 35 sectors in WIOD), the reasons for this choice are logical. Firstly, the relative level of regional aggregation is not as important since the models are subsequently aggregated to a two-regional (UK and ROW) level anyway. Secondly, the sectoral breakdown available is not deemed as important as the actual categorisation employed; the WIOD sector classification is much easier (and more appropriate) to disaggregate to the SIC2007 sector classification system used in the UK SUT data than the custom classification scheme employed by GTAP. The main reasons for moving to the WIOD database though are that the data is more recent (2009 vs 2007 for GTAP), and that the WIOD database incorporate more recent and useful environmental data. This makes estimation and adjustment to 2011 data more reliable, and the implementation of emissions data a more seamless and efficient process.

One effect of the change of MRIO employed is that the output data is presented in a subtly different form. Whilst the GTAP database is presented in Product by Product (PxP) form, the WIOD data is in Industry by Industry (IxI) form. This effectively means that rather than representing expenditure by manufacturers of products of a given industry for products of other industries, instead it is the expenditure by an industry in other industries. This is a subtle difference (results are fundamentally similar since products of a given industry are typically made by that industry), and more reflects assumptions made within the construction of the tables and nuances in the final output (discussed in more detail in technical report) than a significant change in the results and their interpretation.

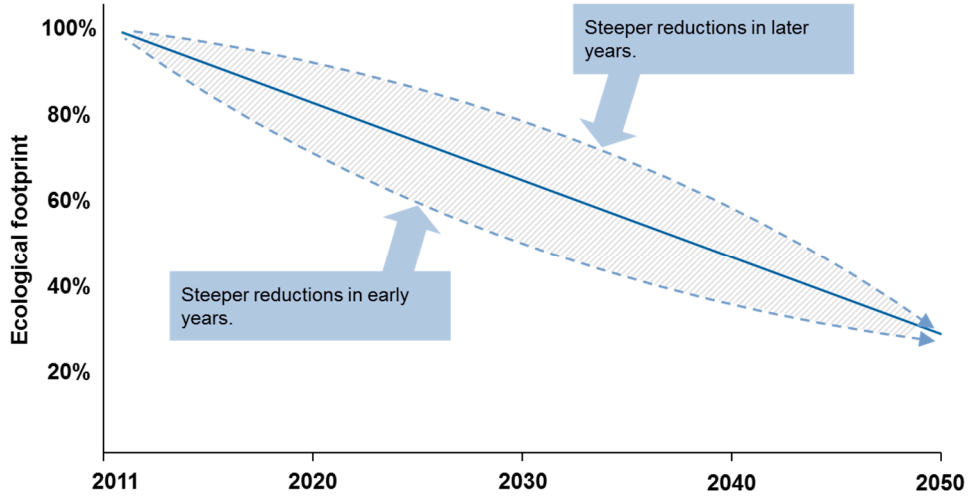
[10] Global Trade Analysis Project: https://www.gtap.agecon.purdue.edu/

4. The transition to One Planet Living

4.1 Trajectory for One Planet Living

The Welsh Government's target is to achieve 'One Planet Living' within a generation. As described in Section 1.2.5, this will require a reduction of the ecological footprint of Wales by approximately two thirds. Figure 11 shows this degree of change and example trajectories to achieve this. For the purposes of this report, the timescale of the Welsh Government's "within ageneration" is taken to be achievement by the year 2050.

Figure 11: Trajectory for One Planet Living



The trajectory that is achieved in reality is unlikely to be a straight line. Instead the Welsh Government will need to steer a course somewhere between the two dotted lines which represent the upper and lower bounds. If reductions can be made sooner rather than later, the likelihood of achieving the goal will increase. Therefore there is an urgency to deliver change over the short term. Conversely if the change achieved in the next few years is too small, the goal will become much harder to achieve in the longer term.

Whilst it is desirable to make as much progress as possible in the short term, this will require significant effort to drive new policies and influence all the stakeholders to play their part.

4.2 Decoupling economic growth and carbon

Because of differences in the methodologies, it is not possible to make comparisons between the results for 2011 and previous years. However, previous studies identified that the ecological footprint of Wales was increasing until 2008 (the most recent previous data). It is likely that this increase will have been either slowed (or even reversed) as a result of the global economic recession, but that it will increase again as the economy recovers. Whilst in previous years there has been a close correlation between economic activity and both greenhouse gas and ecological footprints, in future this correlation must be removed by de-coupling economic growth from environmental impact if government carbon and One Planet Living targets are to be achieved.

The policies likely to be most effective will be those targeting the consumption categories making the biggest contributions to the footprint. The top ten categories contributing to the ecological and carbon footprints are listed in Table 5.

Table 5: Summary of Dominant Categories

Ecological footprint	Carbon footprint
Domestic fuel and land use	Domestic fuel and land use
Electricity, gas and other fuels	Private transport, direct emissions and land use
Meat and meat products	Electricity, gas and other fuels
Catering services	Construction
Private transport, direct emissions and land use	Retail trade services (excl.motor trade)
Construction	Health services
Fruit and vegetables	Operation of personal transport equipment
Bread, rusks and biscuits, pastry goods and cakes	Catering services
Health services	Meat and meat products (excl. poultry)
Dairy products	Other recreational equipment etc.

The differences between the two lists of dominant categories are explained by the fact that the carbon footprint is only component of the ecological footprint. Categories that have significant environmental burdens in addition to the carbon land component (e.g. meat products and fruit and vegetables which require grazing land and cropland) tend to fall higher in the ranking for the ecological footprint. Conversely those with particularly high carbon intensity fall higher in the ranking for the carbon footprint (e.g. private transport and construction).

4.3 Current policy measures

A wide range of policy measures aligned to the vision are already in place, and the Welsh Government is continuing to develop legislation to promote sustainable development and the transition to One Planet Living. Notably the Future Generations Bill is currently being drafted, which will make sustainable development the central organising principle of the devolved public service in Wales and create an independent body to provide advice, guidance and expertise.

The policy measures currently in place generally fall into five key categories:

- Reducing the carbon footprint of industry
- Retrofitting buildings
- Building sustainably
- Promoting the low carbon economy
- Education and behaviour change

These Welsh Government policy measures complement a range of EU and UK policies. Tables 6-10 provide an overview of the key policies.

Table 6: Overview of existing policy measures: Reducing the carbon footprint of industry

Policy measure	Description
EU schemes	
European Emissions Trading Scheme (EU ETS)	A cap and trade scheme designed to limit and ultimately reduce greenhouse gas emissions from qualifying heavy industry facilities throughout the EU
European Renewable Energy Directive	Sets binding targets for all EU Member States, such that the EU will reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector
UK Government schemes	
The Carbon Reduction Commitment Energy Efficiency Scheme (CRCEES)	A proposed UK-wide cap and trade scheme designed to reduce CO2 emissions from qualifying businesses and organisations
Climate Change Levy (CCL)	A tax on non-renewable energy delivered to non-domestic users in the UK
The Renewables Obligation (RO)	Requires licensed UK electricity suppliers to source a specified proportion of the electricity they provide to customers from eligible renewable sources. It is scheduled to cease in 2017.

Table 7: Overview of existing policy measures: Retrofitting buildings

Policy measure	Description
UK Government schemes	
Green Deal	Helps householders and businesses increase the energy efficiency of properties by allowing them to make energy saving improvements without having to pay all the costs up front. The scheme allows people to pay back the costs over time through electricity bills.
Energy Companies Obligation (ECO)	Requires energy suppliers with more than 250,000 domestic customers to provide free or subsidised home energy efficiency measures in harder to treat homes, and pay in part or full for the installation of efficient boilers, insulation and heating improvements into the homes of lower income households.
Display Energy Certificates (DECs)	Mandatory display of a certificate rating the energy efficiency of the building at all large public buildings.
Welsh Government schemes	
Nest	Provides an advice service open to all households, and provides eligible householders with a 'whole house' package of energy efficiency improvements free of charge
Arbed	Funds home energy efficiency projects submitted by local authorities in

	some of the most deprived areas of Wales.
Ynni'r Fro	Provides enterprises grant aid, loans and free advice and information to help social enterprises develop community scale renewable energy schemes using European Structural Funding.

Table 8: Overview of existing policy measures: Building sustainably

Policy measure	Description
UK Government schemes	
National Planning Policy Framework	UK planning regime that presumes in favour of sustainable development, including Permitted Development Rights for domestic and non-domestic micro generation equipment
Building Regulations Part L	Controls the elements of new buildings relating to energy performance, including insulation, windows, doors, air permeability, heating and lighting efficiency; and requires energy ratings and carbon emission targets for dwellings.
Code for Sustainable Homes	An environmental assessment method for rating and certifying the performance of new homes.
Welsh Government schemes	
Welsh Housing Quality Standard	A standard for social housing that includes challenging energy efficiency targets, and a funding package to help Local Authorities and Registered Social Landlords to upgrade existing social housing.
21st Century Schools Programme	A standard, under development for sustainable schools, including a requirement for all new school buildings capital projects to meet the BREEAM `excellent' standard.
Government funding criteria	Criteria applied across procurement, grant funding and capital funding projects across Government in order to promote resource efficiency and the sustainability agenda.

Table 9: Overview of existing policy measures: Promoting the low carbon economy

Policy measure	Description
UK Government schemes	
Feed-in tariffs	Premium paid by government to businesses and householders generating electricity from solar photovoltaics for every unit they feed in to the national grid,
Renewable Heat Incentive (RHI)	Provides financial support to businesses that generate and use renewable heat to heat their buildings. It is expected to be extended to households in 2014.

Welsh Government schemes	
Corporate Social Responsibility Framework and Sustainable Development Charter	Voluntary charter for organisations in Wales helping them to align to the sustainable development (SD) agenda.
Business advice and support services	Advice, interest free loans and other advice to businesses to help them increase their resource efficiency, via Business Wales, the Carbon Trust, Salix Finance Ltd, Farming Connect and the Energy Saving Trust.
Skills development	Qualifications, Apprenticeship schemes and other training to develop skills that will be required in the low carbon economy
Energy Wales Programme	Government strategy setting the ambition and approach to create a sustainable, low carbon economy for Wales
Waste strategy for Wales: Towards Zero Waste	Government strategy for reducing Wales' ecological footprint through waste prevention, preparation for re-use, recycling and energy recovery of waste. Actions under this strategy include the Waste Infrastructure Procurement Programme, and a Waste Prevention Programme for Wales.
Sustainable Waste Management Grants	Government funding to support increases in local authority recycling.
Sector Priorities Fund	Provides funding for training for new low carbon industries.

Table 10: Overview of existing policy measures: Education and behaviour change

Policy measure	Description
Welsh Government schemes	
Education for Sustainable Development and Global Citizenship (ESDGC)	Embeds sustainable development within the school curriculum
EcoSchools	Part of an international initiative, EcoSchools Wales works to inspire whole-school action for sustainable development
Sustainable Travel Towns	Government funding provided to towns to inspire/encourage behaviour change by the demonstration of sustainable travel.
Active Travel Bill, Active Travel Plan and funding	Requires local authorities to continuously improve facilities and routes for pedestrians and cyclists and to prepare maps identifying current and potential future routes for their use. The Bill will also require new road schemes (including road improvement schemes) to consider the needs of pedestrians and cyclists at design stage. Welsh Government also provides substantial investment in public transport through the Regional Transport Services Grants.
Welsh Local Government Association (WLGA) Sustainable Development Framework	Provides practical guidance and information resources at both a corporate and service level on delivering sustainable development.

4.4 Delivering change: Stakeholder roles

Delivering the change required to achieve One Planet Living will require action from all stakeholders and all sectors. The roles of the key stakeholder groups are discussed below.

4.4.1 The Welsh Government

The Welsh Government's role includes the devising and implementation of policies within its areas of devolved competency that will help achieve its vision for sustainable development. It therefore has to balance the reduction of environmental impacts, whilst improving wellbeing and growing the Welsh economy. It also monitors progress towards the sustainable development goals, acts as an exemplar to other organisations, and helps others through the provision of grant funding and information resources.

The Welsh Government operates within a UK, EU and international context, and therefore has a role in supporting and enabling UK and international sustainable development policies and programmes. It has shown international leadership, being one of only a very few governments to date to have enshrined a statutory duty to promote sustainable development, and by adopting ambitious sustainable development and greenhouse gas reduction targets.

4.4.2 Local Government

Local government sets local policy and provides one of the key interfaces between government and businesses, other organisations and the people of Wales. Local authorities are responsible for the delivery of a wide range of public services as well as grant funding and can both lead and act as catalysts for local action. Local authorities also have a role to be exemplars for implementing sustainable practices as an organisation. This includes reducing their own impacts but also working with business groups, local communities and other forums to promote and achieve wider societal reductions, for example through behaviour change.

Local government must keep track of its progress towards sustainable development objectives, and ensure its own approaches and delivery is aligned with Welsh Government policy.

4.4.3 Public sector organisations

There are many public sector organisations in Wales that also provide a key interface with the public, for example the NHS, schools and colleges, and police. These organisations all have a role to act as exemplars and reduce the impacts of their own operations. Educational establishments in particular have a key role in inspiring the next generation and providing the skills, training and knowledge to support the growth of new low carbon technologies.

4.4.4 Businesses

Businesses large and small have an increasing incentive to reduce their consumption of energy to reduce costs and many are also required to monitor and report their greenhouse gas emissions. In addition, there are strong business drivers for the adoption of sustainable business models, for example where core products and strategy are aligned to meet the needs of an increasingly low carbon economy. Businesses also have an opportunity to inspire

employees and customers through ambitious and innovative approaches to sustainable development, thereby attracting and retaining better talent, new customers and business growth.

4.4.5 Communities and individuals

The role of communities and individuals is to implement grassroots solutions to the challenges of sustainable development. This includes taking measures to improve the energy efficiency of their homes, reduce the impacts of travel by travelling less or choosing greener modes of transport, reduce unnecessary consumption and waste. It also includes the adoption of small scale renewable energy and selection of occupations that are aligned to the low carbon economy. Both of these have the potential to provide benefits to both the individuals concerned and wider society.

5. Conclusion

5.1 Key messages

The ecological footprint of Wales provides an assessment of the total environmental burden associated with Welsh consumption. Current levels of consumption are considered unsustainable; if everyone in the world were to consume the same as the average Welsh citizen, the biocapacity of just over 2.5 planet Earths would be required to provide sufficient resources and absorb the wastes. The Welsh Government has a goal to achieve 'One Planet Living' within the lifetime of a generation. This will require a reduction of the impacts of Welsh consumption by approximately two thirds.

The ecological footprint for Wales has been calculated at 3.28 global hectares per capita (gha/c). This is not directly comparable to previous estimates carried by SEI and Welsh Government due to changes in the methodology by which the footprint was calculated. The top three local authorities with the highest ecological footprint are Ceredigion, Vale of Glamorgan and Powys. Those with the lowest ecological footprint are Merthyr Tydfil, Blaenau Gwent and Torfaen.

The consumption of food, housing, transport, consumer items, private services and public services together accounts for 85% of the ecological footprint. The primary land type dominating the footprint is the land required to sequester emissions of carbon dioxide, which arise from from the burning of fossil fuels.

The carbon footprint of Wales has been calculated at 11.1 tonnes of carbon dioxide equivalent per capita (t CO_2e per capita). The top three local authorities with the highest carbon footprint are Ceredigion, Powys and Isle of Anglesey. Those with the lowest carbon footprint are Merthyr Tydfil, Blaenau Gwent and Caerphilly.

In order to achieve the One Planet Living goal a significant degree of change is required. This will need all sectors and stakeholders to contribute. The Welsh Government's current policies are aimed at reducing the impacts of Welsh consumption in a number of ways; the most significant of these target reductions in greenhouse gas emissions in Wales. Further policy development and implementation will be needed, and targeting steeper reductions in early years will increase the probability of meeting both carbon and One Planet Living goals in the longer term. Policies targeting the consumption categories that contribute the most to the footprint are likely to be the most effective. These categories include household energy use, transport, construction and consumption of meat, fruit and vegetables.

Most of the greenhouse gas emissions associated with Wales' carbon footprint occurs from purchases of domestic goods and services. Therefore the priority should be to improve both the efficiency of production and size and type of consumption within Wales. It is also important to reduce emissions released outside Wales but that contribute to products consumed within Wales', along international supply chains. This can be achieved by reducing the magnitude of consumption as well as participation in international policies and driving improvements in supply chain management.

5.2 Recommendations

The following recommendations are made in relation to this ecological and carbon footprint update:

- Consider undertaking a time series analysis using the new model developed for this update. This would enable historical comparisons and identification of trends.
- In common with the majority of the Western World, current levels and patterns of consumption in Wales are unsustainable. Therefore the Welsh Government should continue to strive for change, and seek ways to promote and catalyse the transition to more sustainable levels and patterns.
- The Welsh Government should continue to develop policies to reduce the impact of consumption, taking into account that that the most effective policies are likely to be those that target the consumption categories making the largest contribution to the impact.
- The Welsh Government should strive to achieve steeper reductions in the early years of the target timescale, and not place a disproportionate burden on later years. Early reductions will increase the probability of achieving the One Planet Living goal within a generation.
- The Welsh Government should also develop policies to accelerate the process of decoupling carbon from economic growth. There is a real risk that emissions and the ecological footprint could grow over the coming years if the economy grows. The types of policy that could be effective in decoupling carbon from growth include those that stimulate growth in green technologies including renewable energy or smart technology and (coupled with grid decarbonisation), and demand management policies, such as reducing the need to travel through spatial planning. There is also a broader discussion about the role of economic growth in improving living standards and well-being, with alternative mechanisms and measurements of progress that could be consider (for example, see Beyond-GDP[11] or the OECD Better Life Index[12])
- The Welsh Government should develop policies targeting a reduction in international impacts. Examples of the type of approach that will contribute to this include participation in international environmental initiatives and raising both awareness and standards of supply chain environmental management by Welsh organisations.

[11] http://ec.europa.eu/environment/beyond_gdp/index_en.html
[12] http://www.oecdbetterlifeindex.org/

6. References

Global Footprint Network, 2013. Website text - http://www.footprintnetwork.org/en/index.php/gfn/page/frequently_asked_questions/#method2

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7. Acknowledgements

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