Zukunftsrat Hamburg

An ecological footprint analysis of Hamburg

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BESTFOOTFORWARD
The Sustainability Consultants

Zukunftsrat Hamburg

This report was sponsored by Norddeutsche Stiftung für Umwelt und Entwicklung, Behoerde fuer Stadtentwicklung und Umwelt Hamburg and Stadtreinigung Hamburg.

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12 July 2012

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Client comments incorporated:
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Best Foot Forward

Best Foot Forward is a world leader in carbon and ecological footprinting, helping organisations to do business in a resource constrained world. Our consulting services include advice on policy and strategy, footprinting and tools development, supply chain sustainability and training and communication.

Best Foot Forward has been developing footprint methodologies and tools since 1997. The core textbook on ecological footprinting, 'Sharing Nature's Interest', was co-written by the company's founders and our team advised on the development of PAS2050, as well as several protocols from the World Resources Institute and the World Business Council for Sustainable Development.

Best Foot Forward has unrivalled experience, having helped over three hundred organisations to **measure, manage and reduce their environmental impact and to tell the world about their achievements. We have calculated thousands of footprints for products, organisations, regions and events**, from carrots to county councils, from wine bottles to Wimbledon.

Our multinational team of analysts and consultants is based in Oxford, England. We also draw on a network of global partners and associates offering local knowledge and additional sectoral expertise when required.

Best Foot Forward's mission is to help organisations, regions and communities to reduce their footprint. In 2005, the company was given the Queen's Award for Enterprise in Sustainable Development for its contribution to corporate sustainability.

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Executive Summary

In 2007 Hamburg residents' total ecological footprint was calculated to be **9,110,565 gha** or **5.17 gha per capita**. This is marginally higher than the ecological footprint of the average German resident of **5.08 gha per capita** in the same year.

The breakdown of the ecological footprint into components enables a better understanding of the size of resource demands associated with various aspects of consumption. The components analysed for this ecological footprint were:

- Nourishment (household food and drink consumption and food waste);
- Shelter (direct household energy);
- Mobility (personal transport);
- Services; and
- Goods (all other material and product consumption including Government and industry).

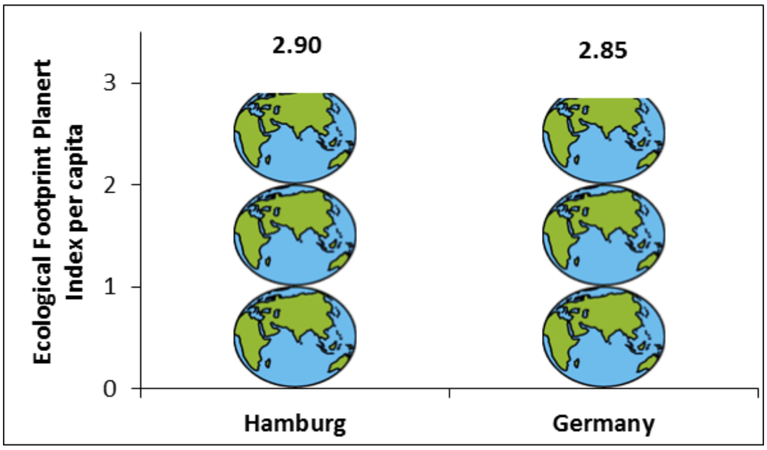
The table below shows this breakdown of both the Hamburg and the German ecological footprints.

Component	**Hamburg**		**Germany**	
	gha/capita	**% of total**	**gha/capita**	**% of total**
Nourishment	1.72	33%	1.71	34%
Shelter	0.78	15%	0.75	15%
Mobility	1.23	24%	1.14	22%
Goods	1.12	22%	1.20	24%
Services	0.32	6%	0.29	6%
Total	**5.17**	**100%**	**5.08**	**100%**

Nourishment was the largest component of the Hamburg ecological footprint, with a footprint of 1.72 gha per capita (33%). This is based on a diet of 39% animal-based food in Hamburg. Mobility and Goods were the next largest components of the Hamburg ecological footprint with 1.23 gha per capita (24%) and 1.12 gha per capita (22%) respectively.

By dividing the Hamburg ecological footprint by the earthshare, the question "*How many planets would be needed to support the global population, if everyone lived like an average Hamburg resident?*" can be addressed. In the case of Hamburg the Planet Index answer was **2.90**. This is marginally more than the German average of **2.85**. To be environmentally sustainable Hamburg's Planet Index should be equal to or less than one planet's worth of resources – 'One Planet Hamburg'.

The figure below shows a comparison of a German resident's and Hamburg resident's Planet Index.



Next Steps

This study provides a sound basis upon which to evaluate further the impact of existing municipal policies and/or develop new ideas.

Ecological footprints have been widely used for scenario planning, monitoring, policy development, options appraisal and communications. They are particularly well suited for use in behavior change campaigns, land use planning and for anticipating future resource demands.

This study highlights the significance of nourishment and mobility. Together these are responsible for over half of Hamburg's ecological footprint. These components of the footprint therefore warrant further investigation and modeling to determine opportunities (behavioral and technological) for reductions.

This analysis and Regional Stepwise™ tool provide the ability to plan and assess different options for reduction of the Hamburg ecological footprint. For example, are there any Hamburg initiatives or future actions which are easily achievable which address and reduce the ecological footprint 'big hitters'? Any reduction in the ecological footprint must address two basic drivers:

- the quantity consumed; and
- the "technology" used to supply that consumption.

If Hamburg residents are to reduce their personal ecological footprint from 2.90 global hectares to a sustainable level then all elements of the components of the footprint will need to be fully explored with a view to reducing consumption.

The concept of a "sustainable" resident[1] was the result of a number of scenarios addressing each component of the ecological footprint. Together, these may or may not reach the earthshare. The Regional Stepwise™ tool enables you to investigate what is necessary and/or possible to achieve this goal.

This is the start of a journey towards a One Planet Hamburg.

[1] As referred to in Best Foot Forward and Imperial College of Science and Technology (2000).

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1 Hamburg’s ecological footprint

In this section we explain what an ecological footprint actually is, the reasons for using it and how you measure it at local government level. We then summarise ecological footprint results for Hamburg residents and allocate the total ecological footprint to sub components (e.g. nourishment, shelter (domestic energy use), mobility (personal transport), goods and services).

1.1 What is an ecological footprint?

The ecological footprint is a tool for measuring and communicating the environmental intensity of human resource use by examining the relationship between current human demand for natural resources and the Earth’s biocapacity (i.e. the amount of natural resources the Earth can sustainably supply).

Comparing the ecological footprint (that is, the natural resource demand) with the Earth’s biocapacity provides an indicator of environmental sustainability, which if monitored over time provides guidance on the extent to which a society is moving towards or away from environmental sustainability.

If more bioproductive land and sea are required than are available, then it can be said that the rate of consumption is not sustainable. In contrast, if humanity consumes only as much as the planet is able to provide in the long term, then this would indicate that humanity’s demand for resources is sustainable: a base requirement for *Living on One World*.

The analogy of a bank account is often used – for our use of the Earth’s resources to be sustainable we need to live off nature’s interest, as opposed to depleting the capital, as we are at the moment.

Calculating the ecological footprint requires collection of data from a variety of sources about a wide range of activities such as transport, energy consumption, waste production and land use. The resource demands of these activities are converted and aggregated into the area-based ‘currency’ *global hectares* (gha), which are used to quantify both the ecological footprint and the biocapacity. The gha is a normalised unit, and its use allows global comparisons of national footprints (WWF, 2010). WWF’s Living Planet Report (2010) compares the ecological footprints and biocapacity of nations and the world as a whole and provides further explanation of the concept.

In addition to the world, nations and regions, the ecological footprint has also been used to compare products, individual lifestyles, processes, and organisations.

1.2 Why use the ecological footprint?

The ecological footprint addresses a particular research question:

How can we all live well within the means of one planet?

The ecological footprint addresses this research question by measuring “how much land and water area a human population requires to produce the resource it consumes and to absorb its carbon dioxide emissions, using prevailing technology” (Global Footprint Network, 2011).

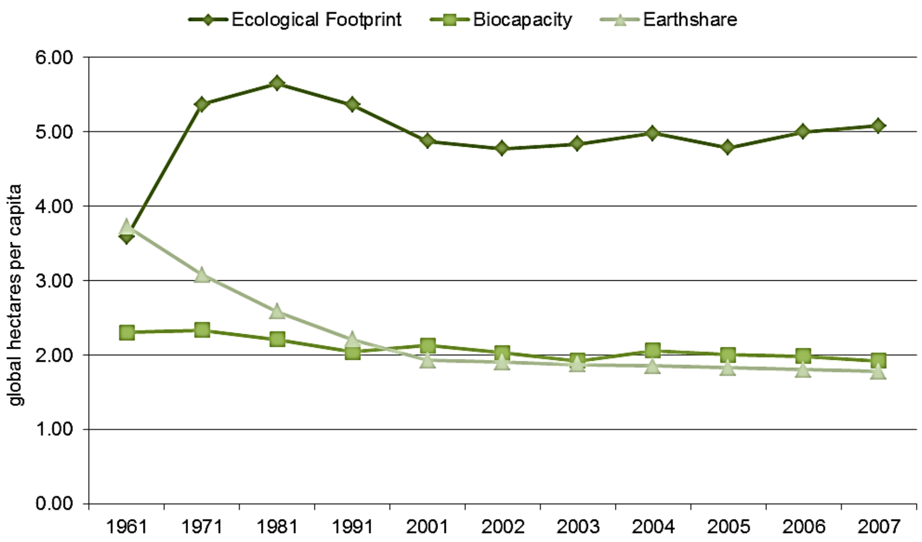
A review of the ecological footprint methodology was commissioned by the European Commission, Directorate-General for the Environment in 2007 (Best et al., 2008). This review assessed the ecological footprint and other sustainability indicators for their ability to indicate and monitor the ‘sustainable use of natural resources’ (Best et al., 2008). The ecological footprint conclusions included:

- “The Ecological Footprint could be an effective indicator for assessing and communicating progress toward the policy objectives of the EU’s Resource Strategy. National data can be aggregated at EU scales, disaggregated to understand key drivers, and used to track long-term changes in how resource use relates to carrying capacity.” (Best et al., 2008, p.7)

- “The Ecological Footprint should not be expected to measure all aspects of resource use, but should be considered within a ‘basket of indicators’ to ensure sustainability at multiple scales and across multiple dimensions.” (Best et al., 2008, p.77)
- “In addition to its role in the basket of indicators as a measurement of the EU’s progress toward sustainability, the Ecological Footprint has the potential to guide policy-making or outreach activities. It is the only indicator that can measure the relationship between a nation’s use of global renewable resources and biological carrying capacity at the global levels. It is an intuitive concept that highlights the overuse of renewable resources, and its detailed system of accounts can provide data for various subaggregations and particular activities that could be useful for policy development.” (Best et al., 2008, p.77)

An example of the unique aspect of the ecological footprint is shown in Figure 1, which compares Germany’s ecological footprint, biocapacity and global earthshare from 1961-2007 (Global Footprint Network, 2010(a)).

Figure 1: Germany’s ecological footprint, biocapacity and global earthshare per capita (1961-2007)



Data year: 2007

Due to the use of various international data sources, the National Footprint Accounts are three years behind. The latest National Footprint Accounts available at the time of this project was NFA 2010, which reports 2007 data. To align Regional Stepwise™ with National Footprint Accounts 2010, it was necessary to use 2007 data for Hamburg and Germany.

Some common Ecological Footprint terms

Bioproductivity

The capacity to produce biomass such as crops, grass or timber.

Biocapacity

The total bioproductive area of a country or region.

Earthshare

The total bioproductive area of the world divided equally among the global human population.

Equivalence factors

The ecological footprint (as measured using global average yields) is normalised by applying equivalence factors. These are multipliers that adjust different area and sea types according to their relative bioproductivity.

Global Hectare (gha)

A world average bioproductive hectare. A normalised area-based measure that permits comparisons between countries and regions with varying natural resource consumption levels and biocapacities.

Yield factors

When calculating the biocapacity of an area, the land types and sea available are normalised to world average equivalents using locally derived yield factors. These are multipliers which express the extent to which local bioproductivity is more or less than the world average for that land/sea type.

2 Ecological footprint results

2.1 Total ecological footprint results summary

The ecological footprint of Hamburg was calculated using Best Foot Forward's Regional Stepwise™ model (a standardised methodology according to the Global Footprint Network (2006, 2009)). This method uses national and international data sources and 'conversion factors'.

In 2007 Hamburg residents' total ecological footprint was calculated to be **9,110,565 gha** or **5.17 gha per capita**. This is marginally higher than the ecological footprint of the average German resident of **5.08 gha per capita** in the same year.

The average Hamburg resident has an ecological footprint which is 2% higher than the average German resident. In the UK, a similar comparison showed London residents to have an ecological footprint per capita 5% higher than the UK average (Best Foot Forward, 2002). Details of where the ecological footprint differs between Hamburg and Germany are given in Table 1 below.

The total ecological footprint can be broken down into more detailed components for further analysis. This breakdown enables a better understanding of the size of resource demands associated with various aspects of consumption.

The components analysed for this ecological footprint were:

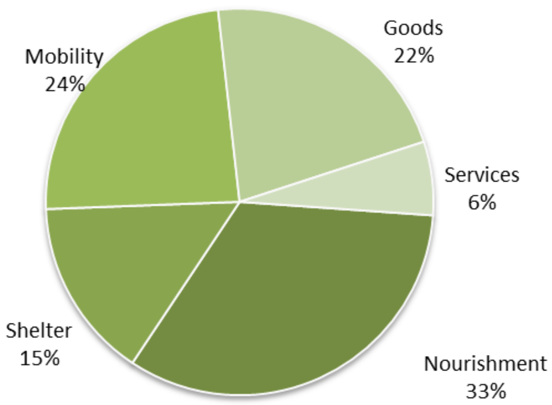
- Nourishment (household food and drink consumption and food waste);
- Shelter (direct household energy);
- Mobility (personal transport);
- Services; and
- Goods (all other material and product consumption including Government and industry).

Table 1: Ecological footprint per capita of Hamburg and Germany residents split by component, in 2007

Component	Hamburg		Germany	
	gha/capita	% of total	gha/capita	% of total
Nourishment	1.72	33%	1.71	34%
Shelter	0.78	15%	0.75	15%
Mobility	1.23	24%	1.14	22%
Goods	1.12	22%	1.20	24%
Services	0.32	6%	0.29	6%
Total	**5.17**	**100%**	**5.08**	**100%**

Figure 2 shows the breakdown of the per capita ecological footprint of Hamburg residents, split by component, in 2007. Nourishment was the largest component of the footprint, with a footprint of **1.72 gha per capita** (33%) – based on a diet of 39% animal-based food. Mobility and Goods were the next largest components of the footprint with **1.23 gha per capita** (24%) and **1.12 gha per capita** (22%) respectively.

Figure 2: Ecological footprint per capita of Hamburg residents split by component, in 2007



One More Step: Different area types

It is possible to subdivide an ecological footprint in a variety of ways. One obvious way is by policy-relevant components – such as energy, food and transport (as shown in Table 1). It is also possible to disaggregate the ecological footprint by land types required to provide the resources needed to support Hamburg.

The tables below show a breakdown of the Hamburg residents' ecological footprint, by different area types, in 2007. Energy land ("new" forest required for the absorption of carbon emissions to stabilise CO_2 levels in the atmosphere) was the largest area type, at 2.70 gha per capita. This illustrates the key role that energy use plays in Germany.

Table 2: Ecological footprint of Hamburg residents split by area type, in 2007

Component	Hamburg	Germany
	gha/capita	gha/capita
Ecological Footprint	5.17	5.08
Of which…		
Energy land	2.70	2.70
Crop land	1.26	1.25
Grazing Land	0.25	0.21
Forest	0.69	0.61
Built land	0.14	0.19
Fishing grounds	0.13	0.13

Table 3: Ecological footprint of Hamburg residents split by component and area type, in 2007

Component	Energy land	Crop land	Grazing Land	Forest	Built land	Fishing grounds	Total
Nourishment	0.26	1.22	0.10			0.13	1.72
Shelter	0.65			0.04	0.09		0.78
Mobility	1.20				0.03		1.23
Goods	0.27	0.04	0.14	0.65	0.03	0.00	1.12
Services	0.32						0.32
Total	**2.70**	**1.26**	**0.25**	**0.69**	**0.14**	**0.13**	**5.17**

Figure 3: Ecological footprint of Hamburg residents split by area type, in 2007

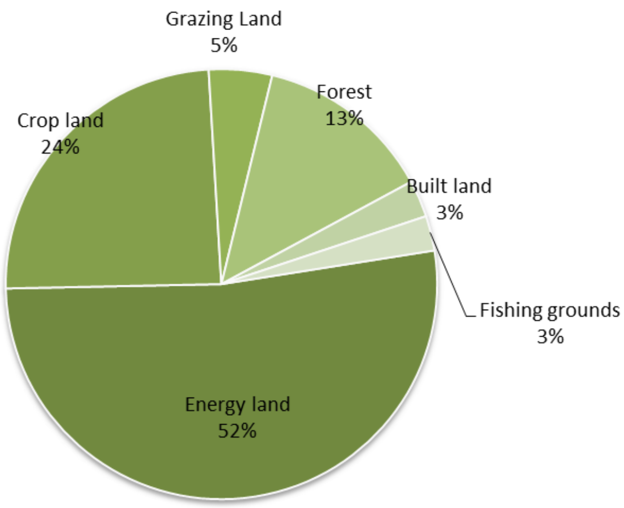
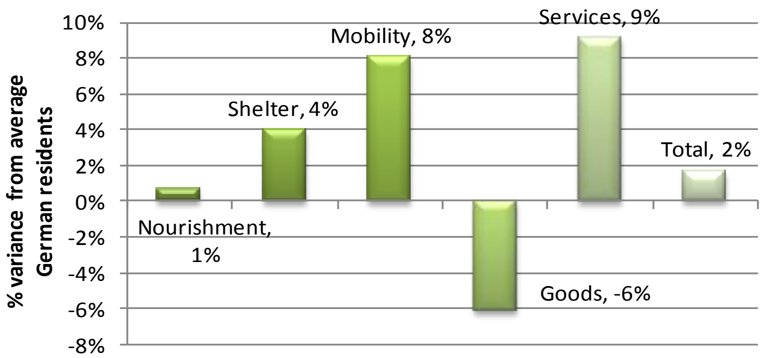


Figure 4: Ecological footprint of Hamburg residents in comparison to Germany



2.2 The ecological sustainability of Hamburg

As explained in Section 1.1 (*What is an ecological footprint?*) an ecological footprint measures the demand for natural resources. By comparing this demand with biocapacity (the available supply of natural resources) it is possible to estimate ecological sustainability.

Biocapacity can be derived at any geographical scale – it just depends on the boundaries chosen. For the purposes of sustainability assessments, biocapacity is expressed in global hectares (gha) to ensure consistency with the ecological footprint.

Hamburg's biocapacity was **0.19 gha per capita**, compared to the average Germany biocapacity of **1.92 gha per capita**. If the same principles are applied to the whole world, the biocapacity per capita, referred to as the 'earthshare', was **1.78 gha per capita** (Global Footprint Network, 2010(a)).

The ecological footprint can be compared with biocapacity derived at either the global, national or local level. Comparing a Hamburg resident's ecological footprint (**5.17 gha**) with the local biocapacity per capita (**0.19 gha**) indicates whether the population is living within the means of its local boundaries – or not. The figures show that at a local level, demand for natural resources is greater than the available local supply.

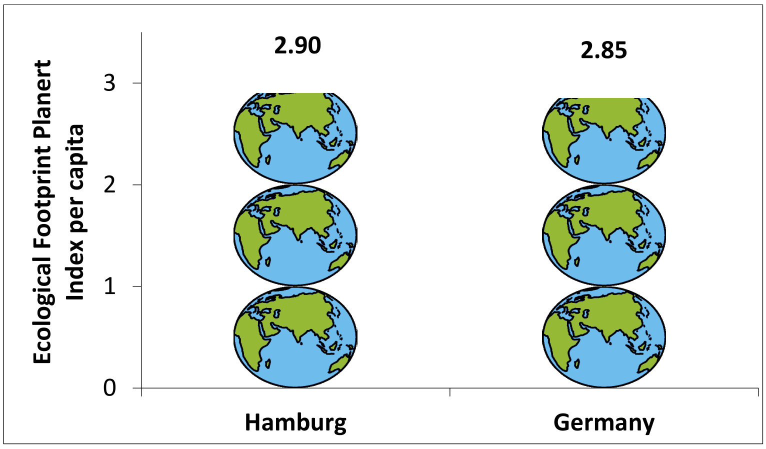
Alternatively, it is possible, and some would argue more reasonable, to compare the ecological footprint with globally available biocapacity as an indication of whether the Hamburg population is living within the environmental and equitable means of our planet. This comparison is shown in Table 4 and Figure 5.

Table 4: Comparison of a Hamburg resident's ecological footprint with regional, national and global biocapacity

	gha per capita
Hamburg ecological footprint	5.17
Hamburg biocapacity	0.19
Germany biocapacity	1.92
World biocapacity (earthshare)	1.78

By dividing the Hamburg ecological footprint by the earthshare, the question "*How many planets would be needed to support the global population, if everyone lived like an average Hamburg resident?*" can be addressed. In the case of Hamburg the Planet Index answer was **2.90**. This is marginally more than the German average of **2.85**. To be environmentally sustainable Hamburg's Planet Index should be equal to or less than one planet's worth of resources – 'One Planet Hamburg'.

Figure 5: Comparison of German resident's and Hamburg resident's Planet Index

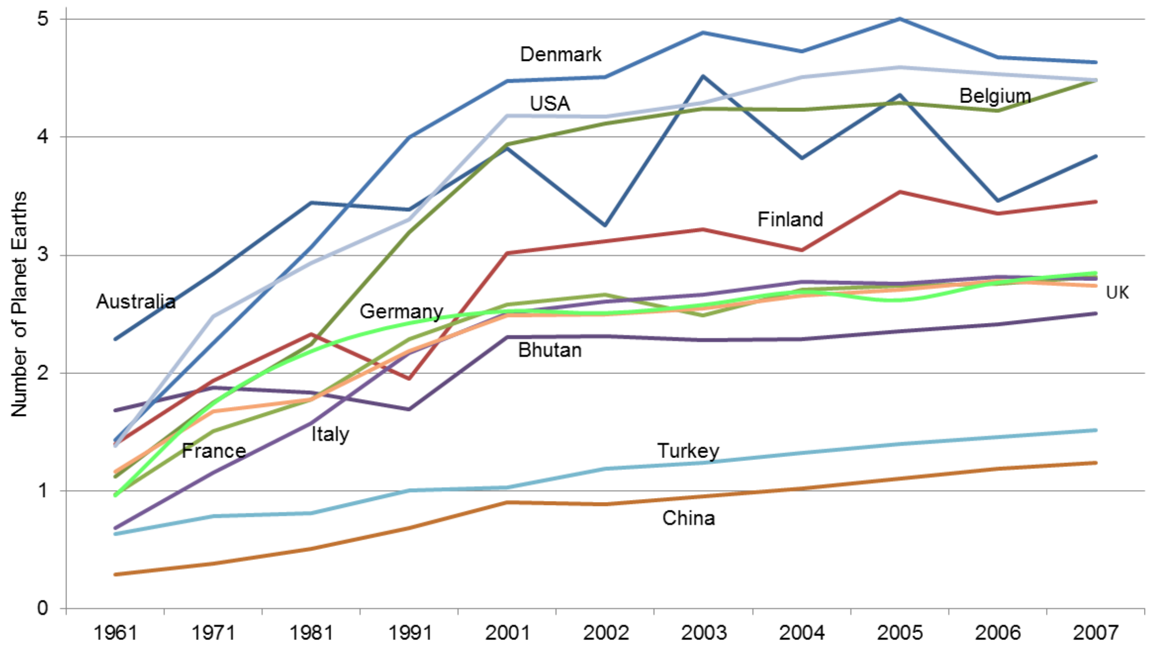


Local authorities have used the ecological footprint as a broader measure of sustainability: one clear benefit is that a sustainable level of consumption can be aimed for.

2.2.1 Germany Planet Index Comparisons

Wider comparisons with the Hamburg ecological footprint are not available as no other analyses have been completed by Best Foot Forward or others using the Regional Stepwise™ methodology. However, it is possible to compare the average German resident's Planet Index to the average resident's Planet Index of other nations with the 2010 National Footprint Accounts.

Figure 6: Comparison of resident's Planet Index for a selection of nations



3 Ecological footprint component results

The Hamburg component ecological footprint results are reported and analysed by component. Each component analysis includes a breakdown of the ecological footprint into two generic contributing factors:

The ecological footprint is a result of the following formula[2]:

$$EF = ct$$

Where:

c = consumption of natural resources by a population

t = technology used to supply the consumed natural resources.

3.1 Shelter and Services

Shelter (domestic energy and land use by residents at home) and Services (energy use by residents outside of the home) consumed amounted to 21% of the total Hamburg resident's ecological footprint, with domestic energy being the larger component of the two. Looking at the domestic supply, electricity produced the largest footprint (45%), followed by natural gas & LPG (23%). Table 5 provides a breakdown of the shelter footprint by energy and land use.

Table 5: Breakdown of Hamburg's shelter and services ecological footprint component, in 2007

Component	**Total**	**Per capita footprint**	
	gha	**gha**	**%**
Shelter	**1,373,419**	**0.78**	**15%**
Of which…			
Electricity	612,297	0.35	45%
Natural gas & LPG	319,388	0.18	23%
Heating Oil, Kerosene & Gas Oil	120,715	0.07	9%
District heating	92,555	0.05	7%
Coal	2,630	0.00	<1%
Wood fuel	74,259	0.04	5%
Built land	151,576	0.09	11%
Services	**559,915**	**0.32**	**6%**
Of which…			
Hotels & Restaurants	119,655	0.07	21%
Health & Education	68,952	0.04	12%
Community, Social, Personal	17,150	0.01	3%

[2] Note the ecological footprint is an implementation of the I=PAT equation, as set out by Ehrlich and Holdren (1971).

Office & Administration	209,869	0.12	37%
Commerce	144,289	0.08	26%
Total	**1,933,334**	**1.10**	**21%**

For shelter, consumption relates to the kWh of different energy sources consumed and ha of built land used (***c***) and technology relates to the $kgCO_2/kWh$ of each energy source and gha/ha of built land use in Germany (***t***). A comparison of domestic energy and land ***ct*** for Hamburg and Germany is shown in Table 6*.*

Table 6: Comparison of Germany's and Hamburg's consumption and technology factors for shelter component, in 2007

Component	**Consumption c**		**Technology t**	
	Hamburg	**Germany**	**Hamburg**	**Germany**
	kWh/capita		**$kgCO_2/kWh$**	
Shelter	**8,272**	**8,598**		
Of which…				
Electricity	2,185	1,701	0.58	0.61
Natural gas & LPG	3,273	3,978	0.20	0.20
District heating	1,157	524	0.17	0.21
Heating Oil, Kerosene & Gas Oil	938	1,564	0.27	0.26
Coal	16	129	0.34	0.35
Wood fuel	702	702	0.00	0.00
	ha/capita		**gha/ha**	
Built land*	0.02	0.01	5.41	5.41

Notes: *Built land is aligned to the NFA 2010. Germany data submitted was found to be 63% larger than that used in the NFA 2010 (CORINE).

Consumption of domestic energy in Hamburg was overall lower than the average German resident, yet consumption of electricity was higher. Electricity was also the most intense energy source.

Table 7 compares the shelter ecological footprints of Hamburg and Germany.

Table 7: Comparison of Germany's and Hamburg's shelter ecological footprint, in 2007

Component	Ecological Footprint	
	Hamburg	Germany
	gha/capita	
Shelter	**0.78**	**0.75**
Of which…		
Electricity	0.35	0.28
Natural gas & LPG	0.18	0.22
District heating	0.05	0.03
Heating Oil, Kerosene & Gas Oil	0.07	0.11
Coal	0.00	0.01
Wood fuel*	0.04	0.04
Built land**	0.09	0.05

Notes: *Forest land to provide wood fuel. ** Housing.

Table 7 shows that Hamburg residents consume 28% more electricity but this is partially offset by the electricity CO_2 intensity being 5% less than the average for Germany. A similar situation exists for District heating – consumption is 220% of the German average but the CO_2 intensity is 19% lower than the German average. Whilst Natural Gas and LPG, Heating Oil, Kerosene and Gas Oil and Coal have lower energy consumption, the effect of the higher consumption for Electricity and District heating is that overall the shelter ecological footprint for Hamburg is marginally higher than the German average.

For services, BFF's Regional Stepwise™ methodology uses the same ***t*** factor for Hamburg as for Germany. Education and health services are also assumed to be constant. Table 8 therefore shows consumption (***c***) data only (represented by spend), which accounts for the difference between Hamburg and Germany services ecological footprints.

Table 8: Comparison of Germany's and Hamburg's services spending (c) and ecological footprint, in 2007

Component	Consumption c	
	Hamburg	Germany
	€/capita	
Services	3,474	3,144

Component	Ecological Footprint	
	Hamburg	Germany
	gha/capita	
Services	0.318	0.291

3.2 Nourishment

The nourishment ecological footprint for Hamburg residents was **3,026,747 gha** (or **1.72 gha per capita**). At 33%, nourishment was the largest component of the overall ecological footprint. Table 9 shows the breakdown of the nourishment ecological footprint between animal-based and plant-based food. Plant-based food was the marginally larger component of the nourishment ecological footprint (53%).

Table 9: Breakdown of Hamburg's nourishment ecological footprint component, in 2007

Component	Total	Per capita footprint	
	gha	gha	%
Nourishment	**3,026,747**	**1.72**	**33%**
Of which…			
Animal-based	1,422,907	0.81	47%
Plant-based*	1,603,840	0.91	53%

Notes: *Includes unharvested crop land.

For nourishment, consumption relates to the mass of different foodstuffs consumed in kg (***c***) and technology relates to the gha/tonne of each foodstuff (***t***).

Table 10 shows nourishment ***c*** and ***t*** for Hamburg and Germany.

Table 10: Comparison of Germany's and Hamburg's consumption and technology factors for nourishment component, in 2007

	Consumption c		Technology t	
	Hamburg	Germany	Hamburg	Germany
	kg/capita		gha/tonne	
Nourishment	**1,005**	**975**	**0.0017**	**0.0018**
Of which…				
Animal-based	394	384	0.0015	0.0015
Plant-based	611	591	0.0020*	0.0021*

Notes: *Includes unharvested crop land.

Total nourishment consumption in Hamburg is 3% higher than the average German resident, although the relative weighting of animal-based and plant-based foodstuffs is slightly different (the proportions of animal-based foodstuffs is 0.4% lower and plant-based foodstuffs 0.3% higher). Animal-based foodstuffs were also the most gha-intense nourishment source, but the overall gha intensity of total nourishment consumption is 2% less than for the average German resident. Table 11 compares the nourishment ecological footprint of Hamburg and Germany.

Table 11: Comparison of Germany's and Hamburg's nourishment ecological footprint, in 2007

	Ecological Footprint	
	Hamburg	**Germany**
	gha/capita	
Nourishment	**1.72**	**1.71**
Of which…		
Animal-based	0.81	0.80
Plant-based	0.91	0.91

3.3 Mobility

The mobility ecological footprint in Hamburg was **2,169,617 gha**, or **1.23 gha** per capita. Mobility constituted 24% of the total ecological footprint. Table 12 shows the breakdown of the mobility ecological footprint. The largest component of which was air travel (49%), followed by car travel (38%).

Table 12: Breakdown of Hamburg's mobility ecological footprint component, in 2007

Component	**Total**	**Per capita footprint**	
	gha	**gha**	**%**
Mobility	**2,169,617**	**1.23**	**24%**
Of which…			
Car	823,120	0.47	38%
Bus & coach	32,310	0.02	1%
Rail, tram & metro	158,886	0.09	7%
Waterborne	92,318	0.05	4%
Air	1,062,983	0.60	49%
Motorbikes & scooters	-	-	-

For mobility, consumption relates to the pass-km[3] travelled by different travel modes (***c***) and technology relates to the CO_2/pass-km and built land gha/pass-km of each travel mode (***t***). A comparison of mobility energy and land ***c*** and ***t*** for Hamburg and Germany is shown in Table 13.

[3] 1 pass-km = 1 passenger travelling 1 kilometre.

Table 13: Comparison of Germany's and Hamburg's mobility consumption and technology factors, in 2007

	Consumption c		Technology t			
	Hamburg	Germany	Hamburg	Germany	Hamburg	Germany
	pass-km/capita		$kgCO_2$/pass-km		built land gha/million-pass-km	
Mobility	**15,401**	**14,764**	**-**	**-**	**-**	**-**
Of which…						
Car	7,769	10,728	0.14	0.14	2.77	5.17
Bus & coach	519	447	0.07	0.07	5.96	7.41
Rail	2,247	961	0.08	0.08	1.28	4.31
Tram & metro	631	193	0.07	0.07	1.28	4.31
Air	4,235	2,435	0.37	0.37	0.37	3.33
Motorbikes & scooters	-	-	-	-	-	-
	tonne-km/capita		**$kgCO_2$/tonne-km**		**built land gha/million-pass-km**	
Waterborne[4]	3,700	3,700	0.04	0.04	0.22	0.22

Except for car travel, consumption of mobility by Hamburg residents was higher for each mode than the average German resident. The lower consumption of car travel is to be expected due to the fact that Hamburg is an urban environment. Nevertheless, car travel remained the most consumed travel mode, followed by air, whereas the most CO_2 intense travel mode was air, followed by car. Table 14 compares the mobility ecological footprints of Hamburg and Germany.

Table 14: Comparison of Germany's and Hamburg's mobility ecological footprint, in 2007

Component	Ecological Footprint	
	Hamburg	Germany
	gha/capita	
Mobility	**1.23**	**1.14**
Of which…		
Car	0.47	0.67
Bus & coach	0.02	0.02
Rail, tram & metro	0.09	0.04
Waterborne	0.05	0.05

[4] Waterborne data was only available in tonne-km (1 tonne travelling 1 kilometre). This is possibly an over-estimate as this unit normally describes freight travel, not passenger travel.

Air	0.60	0.36
Motorbikes & scooters	-	-

Table 14 shows that whilst Hamburg residents travel by car 30% less than the average German resident, they travel by air 66% more than the average German resident. This key difference results in a higher mobility ecological footprint for Hamburg.

3.4 Goods

The total goods footprint for Hamburg residents was **1.12 gha per capita**, accounting for 22% of the total ecological footprint.

See Table 15 for a breakdown of the Hamburg goods ecological footprint.

Table 15: Breakdown of Hamburg's goods ecological footprint component, in 2007

Component	Total	Per capita footprint	
	gha	gha	%
Goods	**1,980,866**	**1.12**	**22%**
Of which …			
Construction*	697,645	0.40	35%
Net traded goods +	470,132	0.27	24%
Plant-based (excl. wood products)**	63,189	0.04	3%
Animal-based***	253,827	0.14	13%
Other wood and paper products	448,988	0.25	23%
Built land	47,086	0.03	2%

Notes: *Energy & construction timber. +Energy only. **Includes crop land. ***Includes pasture and fishing.

For goods, consumption relates to the production of municipal waste (***c***) and technology relates to the management options for the waste produced (***t***). A comparison of municipal waste production and management ***ct*** for Hamburg and Germany is shown in Table 16.

Table 16: Comparison of Germany's and Hamburg's goods consumption and technology factors, in 2007

Component	Consumption *c*		Component	Technology *t*	
	Hamburg	Germany		Hamburg	Germany
	kg/capita			Management %	
Goods	**-**	**-**	**Goods**	**-**	**-**
Of which…			*Of which…*		
Total domestic waste	474	454	Waste-to-energy	66%	42%
Of which…					
Recycled/ composted	161	263	Recycled/ composted	34%	58%
	ha/capita			**gha/ha**	
Built land*	0.005	0.013	Built land	5.41	5.41

Notes: *Built land is aligned to the NFA 2010. Germany data submitted was found to be 63% larger than that used in the NFA 2010 (see Appendix A for details).

Production of municipal waste by Hamburg residents was higher than the average German resident, yet the portion sent for recycling or composting was lower. The municipal waste not sent for recycling or composting was assumed to be sent to waste-to-energy. Municipal waste sent for recycling or composting has a lower gha-intensity than waste-to-energy. Table 17 compares the goods ecological footprints of Hamburg and Germany.

Table 17: Comparison of Germany's and Hamburg's goods ecological footprint, in 2007

Component	**Ecological Footprint**	
	Hamburg	**Germany**
	gha/capita	
Goods	**1.12**	**1.20**
Of which…		
Construction*	0.40	0.39
Net traded goods +	0.27	0.43
Plant-based (excl. wood products)**	0.04	0.03
Animal-based***	0.14	0.10
Other wood and paper products	0.25	0.18
Built land	0.027	0.071

Notes: *Energy & construction timber. $^{+}$Energy only. **Includes crop land. ***Includes pasture and fishing.

Tables 16 and 17 show that whilst Hamburg residents produce more municipal waste, of which less is sent for recycling or composting, the impact of the difference in "net traded goods" actually resulted in a lower goods ecological footprint for Hamburg.

3.4.1 Waste

Regional Stepwise™ does not provide a specific waste ecological footprint. Instead waste data is used to estimate the ecological footprint of goods consumed by Hamburg residents (including waste).

However, waste is the sole driver behind the ecological footprint of the goods component – therefore reducing the ecological footprint of waste will also reduce the ecological footprint of the goods component. For Hamburg, the goods component was significant and accounted for 22% of the total ecological footprint.

Action to reduce the ecological footprint of the goods component should be designed around the following issues:

- how much waste is produced (kg/capita); and
- waste management policies such as recycling, composting etc. (kg/capita).

In addition for this analysis, waste sent to energy recovery also contributes to the shelter component by providing energy classified as renewable.

4 Ecological footprint analysis methodology

This section includes an abridged version of the methodology described in An Ecological Footprint of the UK (Barrett & Simmons, 2003). The methodology used for Regional Stepwise™ further develops this general approach, and is wholly compatible with the National Footprint Standards (Global Footprint Network, 2009).

4.1 What is an ecological footprint?

An ecological footprint is the area required to provide the goods and services consumed by individuals, communities or organisations. It can also be derived for products or for particular activities. Using an 'area equivalence' expressed as 'global hectares', the ecological footprint expresses how much of nature's *renewable* bioproductive capacity (or 'interest') we are currently appropriating. If more of nature's interest is consumed than is available (i.e. nature's 'capital' is being reduced), then it is possible to assume that the rate of consumption is not sustainable (Chambers et al., 2000).

4.2 A snapshot approach

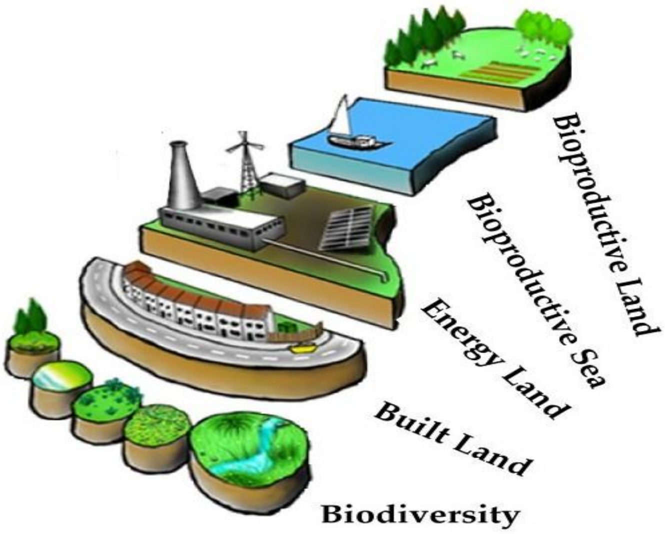
An ecological footprint is a 'snapshot' methodology. It is based on a year-specific data set – 2007 for Hamburg. An ecological footprint tells us how much bioproductive area would be required to support current consumption, and does not attempt to predict future impacts or measure past impacts. It is likely that, due to technological changes and variations in material flows through the economy (consumption of resources), the ecological footprint (and biocapacity) will change over time, hence the need to focus on one year.

4.3 Area types

For the purposes of calculating an ecological footprint, bioproductive land and sea is categorised into four basic types (see Figure 7):

- **Bioproductive land** is the land required to produce crops, grazing, timber (forest) etc. Use of these land types is usually calculated separately.
- **Bioproductive sea** is the sea area required to provide fish and seafood.
- **Energy land** is 'new' forest required for the absorption of carbon emissions to stabilise CO_2 levels in the atmosphere. Calculations take into account the absorptive capacity of the oceans and discount it (WWF, 2010).
- **Built land** refers to buildings and infrastructure. Once built on, land is no longer bioproductive in any year.

Figure 7: Area types used to calculate an ecological footprint[5]



The following examples illustrate the relationship between the four main types of bioproductivity when an ecological footprint is calculated.

Example 1

A cooked meal of fish and rice would require bioproductive land for the rice, bioproductive sea for the fish, and forested 'energy' land to re-absorb the carbon emitted during processing and cooking.

Example 2

Driving a car requires built land for roads, parking and so on, as well as a large amount of forested 'energy' land to re-absorb the carbon emissions generated from petrol use. In addition, energy and materials are used for construction and maintenance of the vehicle.

4.4 Biocapacity and earthshare

One of the most powerful uses of the ecological footprint is in the assessment of sustainability. By comparing the ecological footprint (demand on natural resources) with biocapacity (the available supply of natural resources) it is possible to assess the ecological sustainability of current consumption - if demand is greater than supply, the level of consumption is not sustainable.

Biocapacity can be expressed as local biocapacity or as global average biocapacity – the latter is referred to as the earthshare. If everyone lived within their earthshare, this would give an environmentally sustainable human existence on earth. Earthshare is calculated by dividing the total amount of bioproductive land and sea on Earth by the current global population. This gives the average amount of bioproductive land and sea available globally per capita.

[5] "While not a direct measure of species populations, the ecological footprint provides an indicator of the pressure on ecosystems and biodiversity by measuring the competing level of ecological demand that humans place upon the biosphere." (Global Footprint Network, 2012a) The ecological footprint has been officially adopted by the Convention on Biological Diversity to be included among its biodiversity indicators.

4.5 The common reporting unit: National Footprint Accounts

The National Footprint Accounts (Global Footprint Network, 2010) are a series of ecological footprint calculations for over 100 countries.

The National Footprint Accounts use an ecological footprint methodology known as the 'compound' or 'top-down' approach. The compound approach captures all resource use (including trade) within a geographical boundary, and is measured at a national level. To calculate the per capita ecological footprint of a nation using the compound methodology, the following national data is used:

- Production, import and export of materials, such as crops, animals, fish and wood;
- Energy consumption, including the net balance of embodied energy through traded products including minerals; and
- National land use.

International bodies, such as the United Nations Food and Agriculture Organisation and the International Energy Agency, regularly publish this type of data. Data for Hamburg was not represented in any of these publications, and not being a nation, it is not included in the National Footprint Accounts.

To enable comparisons between regions with different bioproductive capabilities, the ecological footprint is presented in global hectares (gha).

One global hectare is equivalent to one hectare of biologically productive space with world average productivity.

To convert different areas with different productivities into standardised global hectares, two conversion stages are required:

1. For each area type, the local area is converted to a 'global average' equivalent area using yield factors – so if one hectare of land is twice as productive as the global average, it becomes two 'global average hectares' of that area type. The National Footprint Accounts give 'yield factors' for each nation to enable this conversion. These results are presented in specific area types, for example 'global average crop area' or 'global average forest area'. However 'global average hectares' for different area types represent different amounts of bioproductivity.
2. 'Global average' areas for each area type (crop, grazing, forest, built land etc.) are converted into standardised units of area by applying equivalence factors. The equivalence factors, from the National Footprint Accounts, are subject to change due to both data availability and variability in the bioproductivity of the planet over time. This international, standardised unit of area is the global hectare (gha).

The results of the National Footprint Accounts are reported in ecological footprint per capita for each country, as totals and split between the different area types. Table 18 shows the results for an average German in 2007 (Global Footprint Network, 2010).

Table 18: The 2010 National Footprint Account for Germany, 2007 data

Demand Type	Production	Imports	Exports	Consumption	Biocapacity
	gha person-1	*gha person-1*	*gha person-1*	*gha person-1*	*gha person-1*
Carbon Footprint	2.85	2.01	2.16	2.70	0.00
Cropland	0.92	0.83	0.50	1.25	0.92

Grazing Land	0.01	0.21	0.01	0.21	0.09
Fishing Grounds	0.14	0.16	0.16	0.13	0.08
Forest Land	0.62	0.76	0.77	0.61	0.65
Built-up Land	0.19	-	-	0.19	0.19
TOTAL	**4.72**	**3.97**	**3.60**	**5.08**	**1.92**

Geographical and responsibility accounting principles

Before a regional ecological footprint, such as Hamburg, can be calculated, a fundamental boundary decision needs to be made - should it calculate Hamburg's footprint (geographical principle) or consumption associated with Hamburg residents (responsibility principle)?

These two approaches can give very different results. Taking the complex issue of airports as an example: it is theoretically possible to include all regional airport activities as part of the Hamburg footprint (geographical principle), or to estimate the impact attributable to Hamburg residents using airports anywhere (responsibility principle).

However, sufficiently precise air travel data is particularly difficult to obtain. Where non-residents are included in air travel data this would align better with the geographical principle, but where air travel abroad is included, this would align better with the responsibility principle. The air travel data for this study included aspects of both the geographical principle and the responsibility principle.

Despite these difficulties with air travel data, overall this study calculated Hamburg residents' ecological footprint using the responsibility principle, as this is most compatible with other global, regional and city studies. Sustainability assessments using the average earthshare are only valid when using the responsibility principle. See Lewan & Simmons (2001) for further discussion on the responsibility versus geographical principle.

4.6 Disaggregating the National Footprint Accounts: Regional Stepwise™

While the National Footprint Accounts represent the global ecological footprint 'gold standard', the results are not immediately relevant to national or regional policy-makers or individuals, as they do not relate to policy areas or activities such as waste or transport.

However it is possible, using a 'component' methodology, to provide a policy-relevant disaggregation of the National Footprint Accounts. Components relate to key activity and policy areas, such as the production and consumption of food, domestic energy, personal transport and the materials, products and services traded and consumed.

Best Foot Forward use a component-based methodology called Regional Stepwise™ to re-analyse the National Footprint Accounts. See Barrett & Simmons (2003) for a comprehensive account of the general approach. The results derived using the Regional Stepwise™ methodology are wholly compatible with the Ecological Footprint Standards (Global Footprint Network, 2012), and with the methodology used by the European Common Indicators Programme (ECIP), which allows for benchmarking of cities and regions across Europe. For further information on the ECIP methodology see Lewan and Simmons (2001).

The Regional Stepwise™ methodology combines resource consumption, life cycle, and trade data to calculate a range of smaller, more detailed ecological footprint components.

This is a two-step process:

Step 1

The National Footprint Account for Germany is disaggregated into Regional Stepwise™ components: shelter, goods, nourishment, mobility, and services. For a detailed description of the disaggregation process, see Barrett and Simmons (2003). In essence it involves factoring consumption data with the ecological footprint conversion factors used in the National Footprint Accounts, supplemented by life cycle data when required, to derive ecological footprint results for each component. This is more complex for some components than others.

For example, deriving a component ecological footprint for a car passenger travelling one kilometre (1 pass-km), requires analysis of data on fuel use, materials and energy for manufacture and maintenance of the vehicle, and the share of German road space appropriated by the car (Table 19). The associated conversion factors are then applied to the number of passenger-kilometres (pass-km) travelled, and used as a breakdown of the energy and built land categories of the National Footprint Accounts.

To derive a similar conversion factor for a material is considerably more complex, particularly where imports and exports, and differing national production efficiencies are taken into account.

Table 19: An example ecological footprint of average German car travel, per pass-km

	Energy land	**Built land**	**Total**
CO_2 per pass-km (kg)	0.14		
Uplift factor*	145%		
Carbon responsibility**	78%		
World carbon absorption (tonnes C/ha/yr)**	0.97		
Direct car land use (total ha)		844,911	
Land use (ha/car km)		1.47E-06	
Equivalence factor	1.26	2.51	
Yield factor		2.15	
Average occupancy (persons/car)		1.54	
Total (gha/pass-km)	**0.000057**	**0.000005**	**0.000063**

Notes: * The uplift factor represents the fuel equivalent used for manufacturing and maintenance, and comes from Wackernagel & Rees (1996). ** See glossary.

Additional equations are required whenever another area type is involved, for example crop land and grazing land for animal-based food products, or the sea for fish and other sea-based products. A similar approach is used to derive ecological footprint results for:

- Shelter (domestic energy and land use)
- Goods (materials and waste)
- Nourishment (food and drink)
- Mobility (personal transport)
- Services.

Details of how ecological footprints were derived for these components are shown in Section 4.7 (*Deriving the ecological footprint results: Component by component*). The components represent the main categories of impact, and each key component can be sub-divided into smaller categories. For example shelter splits into fuel types such as electricity, gas and domestic heating oil. Each of these sub-categories can be broken down further, for example into domestic and commercial sectors. The availability and reliability of data is the key limiting factor in determining the number and coverage of components.

Regional Stepwise™ components are chosen to reflect data availability at the European level, to maintain consistency and compatibility. The key component ecological footprints are added together to obtain a total ecological footprint, which is then calibrated to the National Footprint Accounts.

Step 2

Once the National Footprint Accounts have been disaggregated into the Regional Stepwise™ components, consumption data is assessed. Consumption data used in the Hamburg ecological footprint analysis was coordinated and submitted by Zukunftsrat Hamburg. The consumption data used for the ecological footprint is presented in component-specific units alongside the ecological footprint results (see Section 3 (*Ecological footprint component results*).

4.7 Deriving the ecological footprint results: Component by component

Deriving ecological footprint conversion factors is different for each component. The following sections illustrate the key data and methodology issues involved.

4.7.1 The shelter footprint

The National Footprint Accounts present total energy consumption data for a nation, and national per capita energy consumption. The Regional Stepwise™ methodology enables this total to be broken down into direct and indirect energy. Built land methodology is documented separately in Section 4.7.5 (*The built land footprint*).

Shelter includes direct domestic energy and energy for the provision of services, for example hotels and schools. Indirect energy use is accounted for in other component ecological footprints. For example, energy used to produce materials and products (known as embodied energy) is accounted for in the goods ecological footprint, and energy for personal transport is accounted for in the mobility component.

CO_2 emissions associated with direct energy usage are calculated according to energy source (see Table 20), and the ecological footprint derived by calculating the global hectares of new forest required to assimilate these emissions. The conversion factor used for German grid electricity is given in Table 21.

Table 20: CO_2 emissions from the use of different energy sources in Hamburg and Germany

Energy source	Hamburg	Germany
	kgCO_2/kWh	
Electricity	0.58	0.61
Natural gas & LPG	0.20	0.20
Heating Oil, Kerosene & Gas Oil	0.27	0.26
Coal	0.34	0.35
Wood fuel	0.00	0.00

Table 21: Calculating the Hamburg grid electricity conversion factor

Hamburg grid electricity, per GWh		Energy land
A	Carbon per GWh (tonnes)	156.30
B	Carbon responsibility*	78%
C	World carbon absorption (tonnes C/ha/yr)**	0.97
D	Equivalence factor	1.26
(A*B*D)/C	**Ecological footprint (gha/GWh)**	**158.93**

Notes: * CO_2 emissions assimilated by the sea are excluded from the ecological footprint, which leaves approximately 78% of emissions to be accounted. ** See glossary.

4.7.2 The goods footprint

The National Footprint Accounts assess the bioproductive land and energy land requirements of goods (materials and products consumed) separately. The bioproductive land requirements are all accounted for in the raw materials production, import and export data for each area type (crop, grazing, forest and built land). 'Embodied energy', which is consumed during the manufacture of goods, is not identified separately as a part of national energy consumption. The embodied energy of all imported and exported goods are calculated separately and then used to adjust the national energy consumption to derive net energy consumption.

Where waste was sent to waste-to-energy, no net embodied energy savings were assumed. Where waste was recycled or composted, it was assumed to reduce the need for virgin resource consumption: embodied energy savings of 76% for Germany and 66% for Hamburg were assumed (based on Barrett & Simmons, 2003) for recycled and composted materials. Waste sent for recycling or composting resulted in a net deduction of the goods ecological footprint.

4.7.3 The nourishment footprint

The National Footprint Accounts identify nourishment materials and products (foodstuffs) only at the raw material stage, for example wheat, potatoes and bovine meat. Nourishment products such as ice cream or soup are not identified. For this study, food was disaggregated into categories listed in the national Food Balance Sheets (FAOSTAT, 2007).

The Food Balance Sheets (FAOSTAT, 2007) convert nourishment products into the raw materials required to produce them. Thus the energy used, and biodegradable waste produced, during the production and manufacturing of nourishment products (excluding post-consumer waste, which was included in the 'goods' component), were included in the nourishment ecological footprint.

The embodied energy associated with food production was identified and accounted according to the National Footprint Accounts. The area required for growing crops and rearing animals to supply the Hamburg population with nourishment, was calculated using global yield factors from the National Footprint Accounts, and converted to global hectares (see Global Footprint Network (2008) for further information). Nourishment product embodied energy estimates are shown in Table 22. An example of calculating a nourishment ecological footprint is shown in Table 23.

Table 22: Estimates for embodied energy in nourishment

Nourishment product	MJ per kg
Cereals	4
Starchy root	26
sugar & sweeteners	15
pulses	8
treenuts	20
oil crops	7
veg. oils	21
vegetables	8
fruits	8
stimulants	30
spices	30
alcoholic beverages	24
meat	40
edible offal	15
animal fats	68
milk	5
eggs	19
fish & seafood	60
other aquatic products	58

Table 23: Calculation of the ecological footprint per tonne of cattle meat, boneless, fresh, chilled or frozen

Cattle meat, boneless, fresh, chilled or frozen* (tonne)		Energy land
A	Carbon (t per tonne	0.83
B	Carbon responsibility**	78%
C	World carbon absorption (t C/ha/yr)**	0.97
D	Equivalence factor	1.26
(AxBxD)/C	**Ecological footprint (gha/tonne)**	**0.84**
Cattle meat, boneless, fresh, chilled or frozen* (tonne)		**Grazing land**
A	Grass requirement (t/t live animal)	12.00
B	Extraction rate (t product/t live animal)	0.66
C	World average grass yield (t/wha/yr)[6]	1.30
D	Equivalence factor (gha/wha)	0.46
(A/B)*(D/C)	**Ecological footprint (gha/tonne)**	**6.45**

Notes: * Tables relate to imports only. Separate calculations are undertaken for home production and exports. ** See Glossary.

4.7.4 The mobility footprint

The National Footprint Accounts do not identify transport impacts separately; instead the energy and built land impacts are aggregated within the total ecological footprint calculations. Freight transport was accounted for in the 'nourishment' and 'goods' components, with only Hamburg resident travel data accounted for in the mobility component.

In this study, the mobility ecological footprint was disaggregated by a range of transport modes. Carbon emissions associated with each mode are given in Table 24. An example calculation for the ecological footprint of air transport is shown in Tables 25 and 26.

Table 24: Carbon dioxide emissions per passenger-kilometre for different modes of transport

Transport mode	Hamburg	Germany
	kgCO_2/pass-km	
Car	0.14	0.14
Bus & coach	0.07	0.07
Rail, tram & metro	0.08	0.08
Air	0.37	0.37
Motorbikes & scooters*	-	-

Note: * 'Motorbikes & scooters' were not available as separate data and have been included within the 'car' data.

[6] wha = world hectare

Table 25: Calculation of the shorthaul air transport conversion factors

Calculation of the shorthaul air transport conversion factor		Energy Land
A	Carbon per pass-km (kg)	0.100
B	Uplift factor*	145%
C	Carbon responsibility**	78%
D	World carbon absorption (tonnes C/ha/yr)**	0.97
E	Equivalence factor	1.26
((A/1000)*B*C*E)/D	**Ecological footprint (gha/pass-km)**	**0.00015**

Table 26: Calculation of the international air transport conversion factors (continued)

Calculation of the international air transport conversion factor		Energy Land
A	Carbon per pass-km (kg)	0.096
B	Uplift factor*	145%
C	Carbon responsibility**	78%
D	World carbon absorption (tonnes C/ha/yr)**	0.97
E	Equivalence factor	1.26
((A/1000)*B*C*E)/D	**Ecological footprint (gha/pass-km)**	**0.00014**

Notes: * The uplift factor represents the fuel equivalent used for manufacturing and maintenance, and comes from Wackernagel & Rees (1996). ** See glossary.

4.7.5 The built land footprint

The National Footprint Accounts include built land as a separate component, but do not distinguish different uses. Built land includes all areas that are built on, contaminated or degraded to the degree that they are rendered biologically unproductive.

Table 27: Hamburg and Germany built land allocation to different components

Built land use	Component	Hamburg		Germany	
		%	ha/capita	%	ha/capita
Rail network	Mobility	2.57%	0.0037	2.60%	0.0050
Road – bus & coach	Mobility	2.16%	0.0031	1.73%	0.0033
Road - cars/two-wheelers	Mobility	15.02%	0.0215	29.07%	0.0555
Airports	Mobility	1.09%	0.0016	4.25%	0.0081
Ports	Mobility	0.57%	0.0008	0.43%	0.0008
Housing	Shelter	59.97%	0.0860	24.99%	0.0477
Commercial/industrial land	Goods	18.63%	0.0267	36.93%	0.0705

To calculate each built land ecological footprint, a yield factor was applied to the raw data to convert it into hectares of global average crop area (National Footprint Accounts assume that most built land was once productive). A crop area equivalence factor was then applied to convert the data into global hectares. A separate calculation is used for hydro land. Table 28 shows the ecological footprint calculation for built land and hydro land.

Table 28: Calculation of the built land and hydro land conversion factor

Calculation of the built land & hydro conversion factors		Built land
A	Crop Yield factor - Germany	2.15
B	Crop Equivalence factor	2.51
A*B	**Ecological footprint (gha/hectare)**	**5.41**
C	Hydro Yield factor - Germany	1.00
D	Hydro Equivalence factor	1.00
D/C	**Ecological footprint (gha/hectare)**	**1.00**

4.8 The ecological sustainability methodology

To estimate Hamburg's biocapacity, three steps were followed:

1. The various area types within Hamburg were defined and aligned with a yield class used in the National Footprint Accounts to find the relevant yield factors.
2. The yield factors (YF) were then applied to each area type to give Hamburg bioproductivity in terms of global averages. The yield factors take into account the differences between national bioproductivity and average global bioproductivity for each resource type (see Table 29).
3. The different land types were then converted into global hectares (gha) using National Footprint Accounts equivalence factors (EQF).

Table 29: Hamburg area types, by hectares, with associated Germany yield factors and global equivalence factors

Land Cover	Area	YF	EQF	Biocapacity
[-]	**[ha person^{-1}]**	**[wha ha^{-1}]**	**[gha wha^{-1}]**	**[gha person^{-1}]**
Cropland	0.005	2.15	2.51	0.03
Grazing Land	0.01	2.23	0.46	0.01
Marine	-	2.97	0.37	-
Inland Water	0.003	1.00	0.37	0.001
Forest Land	0.003	4.08	1.26	0.01
Infrastructure	0.03	2.15	2.51	0.14
Hydro	-	1.00	1.00	-
TOTAL	**0.04**			**0.19**

5 Glossary

CO_2 intensity
The ratio of CO_2 emissions to a unit of consumption e.g. kWh of electricity.

Carbon Responsibility
The carbon footprint is calculated by estimating how much natural sequestration is necessary in the absence of sequestration by human means. After subtracting the amount of CO_2 absorbed by the oceans (25%), ecological footprint accounts calculate the area required to absorb and retain the remaining carbon based on the average sequestration rate of the world's forests (WWF, 2010).

Composting
The aerobic process by which biologically degradable wastes are broken down to form a stable material containing organic matter and plant nutrients.

Conversion factor
A co-efficient used to convert units. For example, ecological footprint conversion factors convert consumption of a resource into an ecological footprint. The ecological footprint conversion factors used in this analysis are from BFF's Regional Stepwise^{TM} methodology.

Direct energy
Energy consumed by the consumer e.g. household electricity, vehicle fuel etc. Opposed to embodied or indirect energy, which is consumed by others associated with the supply and/or disposal of the resources consumed e.g. electricity power station, car manufacture and disposal.

Earthshare
The average amount of global resources available per capita (gha). To calculate an earthshare, the total available land and sea area of the planet is divided equally among the current global population. If everyone lived within his or her earthshare, we would meet a base requirement for Living on One World.

Ecological footprint
The ecological footprint is a sustainability indicator which expresses the relationship between humans and the natural environment. The ecological footprint accounts the use of natural resources. It is a 'snapshot' measure and typically refers to average annual consumption.

Global hectares (gha)
One global hectare is equivalent to one hectare of biologically productive space with world average productivity.

Gha intensity
The ratio of global hectares to a unit of consumption e.g. tonne of animal-based food.

Passenger kilometre
One person travelling one kilometre.

Per capita
Refers to a person or resident of Hamburg or Germany.

Personal transport
Transport carrying passengers, as opposed to freight.

Recycling
The process of collecting, sorting, cleansing, treating and reconstituting materials that would otherwise become waste, and returning them to the economic stream as raw materials for new, reused or reconstituted products.

Resources
Energy, materials and products, water and land that have a useful purpose to humanity either in their original form or when embodied into a final product.

World carbon absorption
The carbon uptake rate used to convert tonnes of carbon dioxide to global hectares is derived from data on the net annual growth of forests drawn from the IPCC (2006). The uptake rate is calculated assuming that carbon comprises half of that net increase in biomass. This 'yield' for carbon uptake, combined with the forest equivalence factor, converts tonnes of carbon dioxide into a footprint in global hectares. The methodology of this approach continues to be discussed, and any changes could have a significant impact on the carbon footprint calculations (Kitzes et al., 2008).

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Appendix A – Assumptions, Consumption and Technology Data

(see Appendix_A.xls for data, sources and calculations)

1. Wood fuel – See Section 3.1 (*Shelter and Services*)

No wood fuel data was submitted for Hamburg. This data is required to calculate the ecological footprint of the wood supply – CO_2 from burning is accounted elsewhere. Therefore, wood fuel was assumed for the average Hamburg resident to be the same as submitted for the average German resident.

2. Car travel – See Section 3.3 (*Mobility*)

Car travel data was not submitted for Hamburg. The assumption for Hamburg was based on the modal split of travel within Germany and Hamburg (for which data was submitted). This data showed Hamburg's use of "individual motorised transport" – assumed for car travel – to be 72% of the same for Germany.

The car travel data submitted for Germany was then multiplied by 72% to estimate the car travel of the average Hamburg resident (7,769 pass-km/capita – Table 13).

3. Rail, bus & coach – See Section 3.3 (*Mobility*)

Rail, bus & coach data for Germany was submitted for "short-distance trips" and "long-distance trips". Only "short-distance trips" data was submitted for Hamburg. The Germany "long-distance trips" % of total travel was then assumed to estimate the missing "long-distance trips" for Hamburg. This resulted in Hamburg using rail, bus & coach 197% more than Germany. This assumption was compared to the submitted modal split travel data, which showed Hamburg public transport use to be 200% of Germany public transport use.

4. Waterborne – See Section 3.3 (*Mobility*)

No waterborne travel data was submitted for Hamburg. It was assumed that the waterborne data submitted for Germany applied to Hamburg also. No further adjustments were made.

5. International travel – See Section 3.3 (*Mobility*)

The Germany National Footprint Accounts 2010 (2007 data) used an assumption to estimate CO_2 emissions from international travel: *"Allocation of international transport emissions ("bunker fuels") according to each country's imports as a fraction of total global trade in units of mass"* (Global Footprint Network, 2010a)

This assumption is a sensitive data issue for the National Footprint Accounts 2010 and was compared to the data submitted in Germany's 2009 Inventory (2007 data) submitted under the Kyoto Protocol (UNFCCC, 2009). The National Footprint Accounts 2010 estimated 55 million tonnes CO_2, whereas the Germany Inventory 2009 reported 35 million tonnes CO_2. Further, the Germany Inventory 2009 split this total between air and waterborne travel.

The Germany 2009 Inventory data was used in this analysis for international air and water travel.

6. Services energy – See Section 3.1 (*Shelter and Services*)

Services energy consumption by energy source was submitted for Hamburg, but not broken down by service type as required in Regional Stepwise™. To estimate the Hamburg distribution across the service types, the relative distribution across the service types for Germany was also applied to Hamburg services.

To remain consistent with Germany, only electricity and gas energy sources were included.