Geo Factsheet

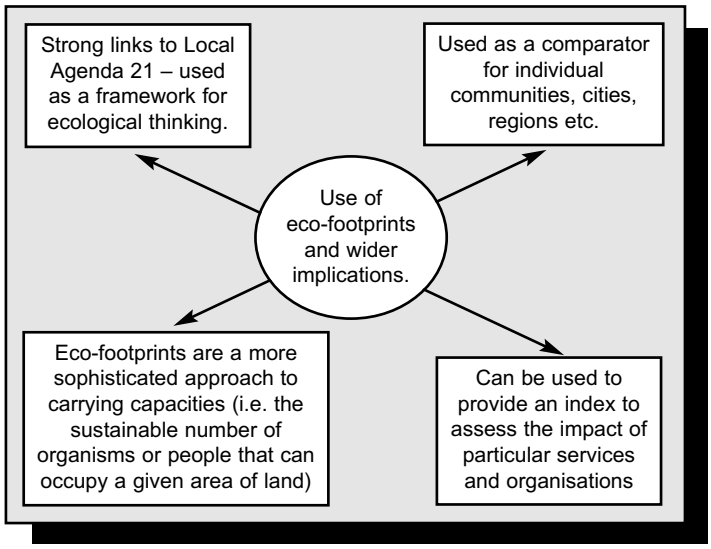
April 2005 Number 183

Eco-Footprints

Introducing the eco-footprint concept

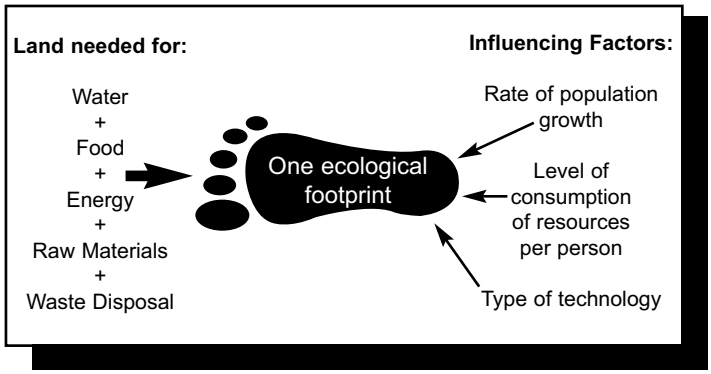
The ecological footprint (EF) provides an aggregated indicator of natural resource consumption, including energy and materials, in much the same way that economic indicators such as Gross Domestic Product (GDP) or the Retail Prices Index (RPI) have been adopted as a way of representing the financial economy. Co-originated in the early 1990s by Professor Rees and Dr. Wackernagel, ecological footprint analysis has rapidly taken hold and is now in common use in many countries at national and local levels. Its application includes analysis of policy, benchmarking performance, education and awareness raising and scenario development. The European Commission's Common Indicators Programme has adopted the EF as an indicator of regional environmental sustainability and the methodology has support from many in the public, private and civil sectors worldwide.

Fig. 1



Ecological footprints measure people's natural resource consumption. The footprint deals only with demands placed on the environment, as shown in *Fig. 2*. A country's footprint is the total area required to produce the food and fibre that it consumes, absorb the waste from its energy consumption, and provide space for its infrastructure. People consume resources and ecological services from all over the world, so their footprint is the sum of these areas, wherever they are on the planet.

Fig. 2 The ecological footprint



It does not attempt to include the social or economic dimensions of sustainability. The footprint is a 'snapshot' estimate of bio-capacity demand and supply usually based on data from a single year.

Ecological footprint calculations are based on two assumptions:

1) That we are able to estimate the resources we consume and wastes generated
2) That these resource / waste flows can be converted to an equivalent area of land needed to provide such functions.

Included in the Ecofootprint calculations:

- ***Materials and waste***
- ***Passenger / personal transport***
- ***Water***
- ***Direct energy use***
- ***Freight transport***
- ***Built land***

The total footprint is determined by adding the individual resource and waste footprints.

Worrying Trends

The global ecological footprint was 13.5 billion global hectares in 2001, or 2.2 global hectares per person (a global hectare is a hectare whose biological productivity equals the global average). This demand on nature can be compared with the Earth's biocapacity, based on its biologically productive area - approximately 11.3 billion global hectares, which is a quarter of the Earth's surface. The productive area of the biosphere translates into an average of 1.8 global hectares per person in 2001.

What is a hectare?: *A hectare is an area of land which measures 100m x 100m (equivalent to 10,000m^2). In terms of monetary worth, the value will be dependent on the land use. For example a hectare of forested land in an upland region may be worth £1,000 - 3,000 whilst an area of prime real estate within an urban are may fetch £1 million.*

The global Ecological Footprint changes with population size, average consumption per person, and resource efficiency. The Earth's biocapacity changes with the amount of biologically productive area and its average productivity. In 2001, humanity's Ecological Footprint exceeded global biocapacity by 0.4 global hectares per person, or 21%. This global overshoot began in the 1980s and has been growing ever since *(see Fig. 3)*. In effect, overshoot means spending nature's capital faster than it is being regenerated.

Fig. 3 Humanity's ecological footprint, 1961 - 2001.

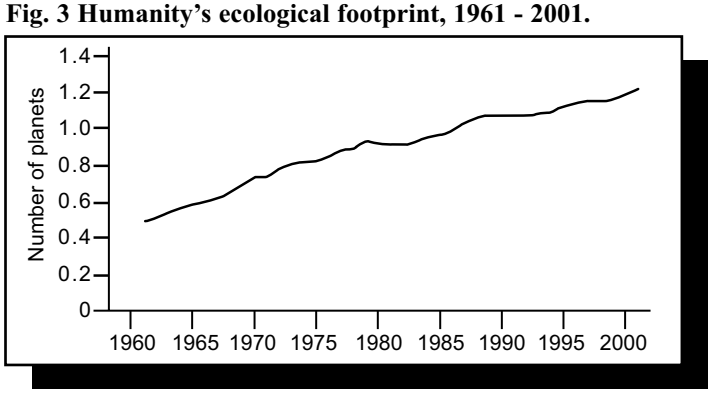


Table 1 The Ecological Footprints of Nations, 1995.

Nation	*Population (1995)*	*Nation's average ecological footprint (ha per cap)*	*Nation's available biocapacity (ha per cap)*	*Nation's ecological deficit (if negative) (ha per cap)*	*Total eco-footprint of nation (km^2)*	*Total available biocapacity of nation (km^2)*
Australia	17,862,000	9.4	12.9	3.5	1,672,000	2,305,000
Bangladesh	118,229,000	0.6	0.2	-0.3	659,000	275,000
China	1,220,224,000	1.4	0.6	-0.8	17,311,000	7,323,000
Costa Rica	3,424,000	2.8	2.0	-0.8	96,000	68,000
Ethiopia	56,404,000	0.7	0.5	-0.2	389,000	274,000
Germany	81,594,000	4.6	1.9	-2.8	3,788,000	1,540,000
Hong Kong	6,123,000	6.1	0.0	-6.1	375,000	2,400
Japan	125,068,000	4.2	0.7	-3.5	5,252,000	873,000
New Zealand	3,561,000	6.5	15.9	9.4	230,000	565,000
Pakistan	136,257,000	0.9	0.4	-0.5	1,278,000	552,000
Russian Federation	148,460,000	4.6	4.3	-0.4	6,839,000	6,314,000
Singapore	3,327,000	6.6	0.0	-6.5	219,000	1,000
United Kingdom	58,301,000	4.6	1.5	-3.0	2,667,000	903,000
United States	267,115,000	9.6	5.5	-4.1	25,532,000	14,697,000
World	5,687,114,000	2.2	1.9	-0.3	126,080,000	110,091,000

Biocapacity and earthshares

One of the most powerful uses of the ecological footprint approach is in the assessment of sustainability. By comparing the ecological footprint (demand) with biocapacity (supply) it is possible to assess the ecological sustainability of current consumption - see Table 1. 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 average 'earthshare'. If everyone lived within their earthshare, this would attain the notion of "One Planet Living", i.e. an environmentally sustainable earth. The earthshare is calculated by dividing the total amount of bioproductive land and water on the planet by the current population. This gives the average amount of bioproductive land and sea available globally per capita. The latest calculations estimate the earthshare to be 2 ha per person.

There are significant differences in patterns of consumption and EFs across the globe - see *Table 1*. The US for instance is commonly recognised as having the largest footprint of any region, with an average EF per head of population at 9.6 ha. In comparison, Ethiopia and India have a footprint of 0.7 and 1.0 respectively. *Fig. 2* shows how EF varies by region. In general there is an inverse relationship between level of development and size of eco-footprint.

The total area of a country, however is also important in terms of measured EF. Australia has an EF of 9.4 ha per person, but the nation's available biocapacity is 12.9 ha per person. As a result Australia, even with a high degree of consumption, still has biocapacity "space" capacity based on its land area. Bangladesh however has a low EF per head at 0.6 ha, but the countries available biocapacity is extremely low at 0.2 ha per person. As a result the total eco-footprint of the nation exceeds its biocapacity by around 250%. See *Fig. 4* below.

The UK's Footprint in Context

Latest figures suggest the total ecological footprint of the UK is 321,621,000 global hectares. This represents a per capita footprint of 5.45 hectares. 86% of the world population has an ecological footprint smaller than 5.45 hectares. This 86% has a total share of 52% of humanity's footprint, while the remaining 14%, within which the UK lies, occupy 48% of humanity's footprint. This means that the residents of the UK are within the top 14% of the World's population in terms of the size of their impact on the global environment.

The UK's ecological footprint is 3 times the land area of the UK. This land is actually located in various countries around the world. When compared with the fair Earthshare (which is 2 hectares each) the UK's ecological footprint would have to be reduced by 70% in order to be ecologically sustainable *(see Fig. 5)*. Other footprint studies, for example, indicate that there will be a large variation among the residents in the UK, where some will have an ecological footprint nearer 2 ha and others a footprint that exceeds 10 ha.

Fig. 4 Ecological footprint by region.

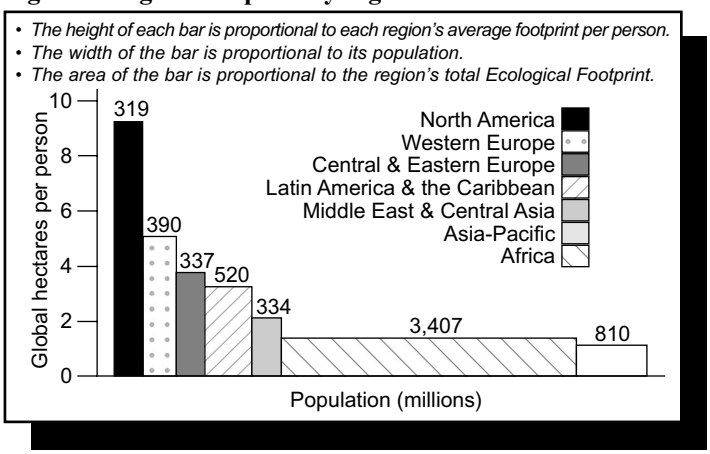
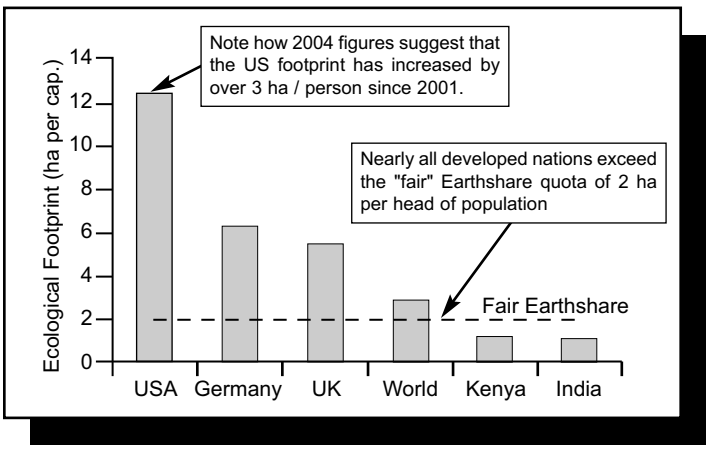


Fig. 5 The ecological footprint of various countries.



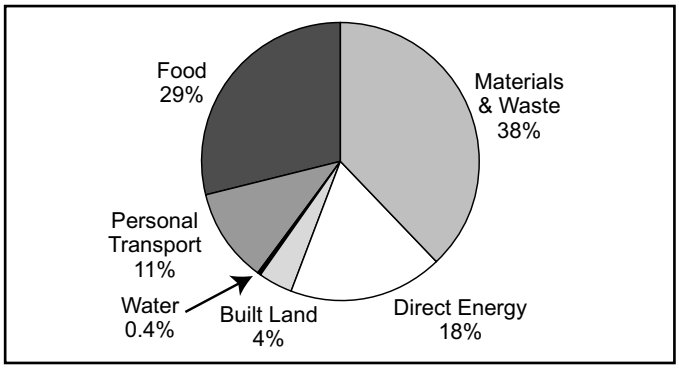
Case Study 1: Scotland's Footprint in Detail

In 2001, Scotland residents' ecological footprint was 27,082,915 ha or 5.35 ha per capita:

- *Direct energy was 0.97 gha per capita (18% of total ecological footprint)*
- *Domestic energy use was the largest component, responsible for 68% of the direct energy ecological footprint.*
- *Materials & waste was the most significant component, with a per capita footprint of 2.01 ha (38% of the total ecological footprint).*
- *Food was the second largest component, with a per capita footprint of 1.55 ha (29% of the total ecological footprint).*
- *Animal-based food products were responsible for 77% of the food ecological footprint.*
- *Personal transport was 0.6 ha per capita (11% of the total ecological footprint).*
- *Scotland's residents travelled 67,000 million passenger-kilometres.*
- *Car travel was the largest component of passenger transport - responsible for 78% of the personal transport ecological footprint.*
- *Built land was 0.21 ha per capita (4% of total ecological footprint).*

The figure of 5.35 ha per person, is slightly less than the 2002 UK average of 5.45 ha / capita. Fig. 6 shows the EF of Scottish residents.

Fig. 6 The ecological footprint of Scotland's residents, by component in 2001.



The full details of Scotland's footprint are available from: www.scotlands-footprint.com

Local scale success: Santa Monica reduces its footprint

The City of Santa Monica, located near Los Angeles in California, has a well deserved reputation as a leader in the sustainable development. For decades, the city's progressive population has elected representatives to the local and state government that are willing to be leaders on environmental, social, and economic issues - the three pillars of sustainability. The commitment to sustainability combined with the political will and leadership helped lay the ground work for the City of Santa Monica's Sustainable City Program's official adoption in 1994. A recently published study indicate that Santa Monica's dedication to sustainability has helped significantly reduce its Ecological Footprint - this is against a background of continued footprint increases in the US and many other parts of the world.

Reasons for success?

- Since 1990 there has been an overall reduction in the energy component of the Santa Monica's Footprint. In part this is explained by the City's procurement of renewable (geothermal) energy in 1999, and the reduction in overall natural gas and diesel fuel use.

1990 Footprint	2,914 sq. miles
2000 Footprint	2,747 sq. miles

- Increases in recycling rates during the 1990s in Santa Monica have also helped the city reduce its Footprint. According to the Natural Resources Defense Council, for every ton of glass, paper, plastic, and metal diverted from landfills and recycled the city reduces its potential energy use by about 50%. At a recycling rate of 62% and growing, effectively reducing the size of the total waste stream would help reduce Santa Monica's Footprint..
- The City of Santa Monica is moving ahead in terms of more sustainable transport initiatives, including solar powered electric vehicle charging stations, aggressive public transportation promotions, and a city employee trip reduction program

Santa Monica's Ecological Footprint in context

The results of Santa Monica's Footprint assessment, in *Table 2*, reveal Santa Monica's in 1990 was 2914 square miles. By 2000 the city reduced its Ecological Footprint by 167 square miles (5.7%) to 2747 square miles. On a per person basis, Santa Monica's footprint went from 9.7 ha in 1990 to 9.3 in 2000. The 2000 average is about 10% smaller than the US average (approximately 11 ha) but still almost four times larger than the earthshare value of 2 ha per person.

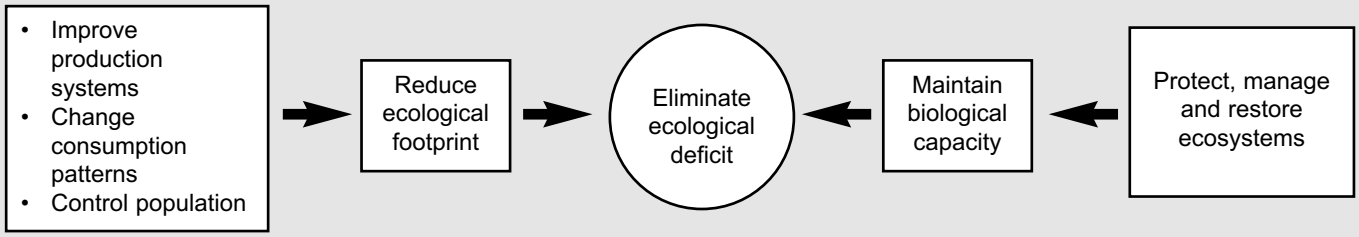
Table 2 Changes in major footprint factors, Santa Monica 1990 - 2000

Factor	Reduction	Increase	Footprint Effect (sq. miles)
Natural Gas	7.7 million therms		-45.0
Diesel Fuel	614,500 gallons		-6.5
Recycling		143,800 tons	-26.0
Electricity		97.5 million kWh	+39.0
Gasoline		927,400 gallons	+9.0
Built Space		51.7 acres	+1.13

Reductions associated with population decline and products and services, and increases in % of renewable energy and biocapacity (parks) account for much of the remaining changes in 1990 and 2000.

Fig. 7 shows a summary diagram of ways of improving an ecological deficit. This can either be done by reducing the EF or improving and maintaining biological capacity.

Fig. 7 Policies for eliminating the ecological deficit.



Some Problems with the Ecofootprint Approach

- *Footprint accounts are incomplete.*
  Ecological Footprint analysis does not claim to account for all human impacts on the environment. Instead it prefers to offer a conservative underestimate whilst acknowledging that other impacts exist. Most obviously, the accounts focus on resource consumption, with the exception of water, and underestimate the impacts of waste products.

- *Applying Carrying Capacity concepts to human populations is flawed. Evidence has shown that (a) humans can and do increase the carrying capacity of their environment to meet their needs and (b) certain regions and communities seem to be living beyond their local carrying capacity now with few ill effects.*

  * Criticism (a) the footprint is a 'snap shot' measure, reflecting the supply and demand at the time of the analysis, future effects (such as increase or decrease in biocapacity) would only become apparent in subsequent analyses.

  * Criticism (b) ignores the fact that populations can exceed local carrying capacity either temporarily, by running down natural capital, or more permanently, by importing or appropriating capacity from elsewhere. Take the example of a fishing community dependent on a local lake for their food. They can over-fish the lake, temporarily increasing supply, by catching smaller and smaller fish. This will impact on the ability of the fish population to sustain itself leading to decline in stocks.

- *Carrying capacity is irrelevant since resource yields can be increased in the case of renewable resources, and depletion rates for non-renewable resources for can be extended by technology.*

  * Indeed, carrying capacity can be altered: both eroded as in the case of desertification, and enhanced as in the case of careful management schemes. That's why ecological footprints are always compared to the biocapacity of a given year. In fact, as footprint accounts point out, technological efficiency is one possible strategy to reduce humanity's draw on nature (as long as the efficiency gains are not outpaced by an increase in consumption).

- *Certain economies that are highly urbanised (UK, Singapore, Hong Kong) can never be sustainable since they can never meet their ecological demands from their own land (which is a relatively small area).*

  * Of course, urbanised economies are more likely, by definition, to need to import resources to meet their needs. This does not mean they can never achieve sustainability, it just means that they will have a more dispersed footprint which will have a certain transportation 'overhead'.

Exam Qs

(1) Study the data in *Table 1*. Briefly identify any patterns (i.e. MEDC vs LEDC) and account for possible anomalies.

(2) What impacts might an increasing world population have in terms of biocapacity and earthshare?

(3) Looking at Scotland's footprint break-down. What strategies could you recommend to reduce the impact of the most significant waste / energy contributors?

Guidelines for answers for exam

(1) MEDCs tend to have 2-3x EF ha/per person compared with MEDCs. Some MEDCs that are surprisingly high: Australia (9.4), Canada (7.2) Singapore (6.6) - also find out about footprints for United Arab Emirates and Kuwait. Some MEDCs have comparatively low EF, e.g. Italy (4.2). Can you make a link between this and climate and energy consumption?

(2) Increased pressure of population will impact directly on the biocapacity since this is a fixed area (although technology may improve agriculture output in some areas). With more people resources are shared amongst a greater number of individuals so the earthshare figure will have to be reduced.

(3) Materials / waste, energy and food account for the majority of the Scottish footprint. Reducing personal and freight transport are important suggestions, together with a reduction in food miles.

Glossary

* **Biocapacity** - Refers to the total of the biologically productive areas.
* **Biologically productive areas** - Are those areas of a country or region with quantitatively significant plant and animal productivity. Biologically productive areas of a country or region comprise its biological capacity. Arable land is potentially the most productive area.
* **Earthshare** - The average amount of global resources available per capita. To calculate an earthshare, the total available land and sea area of the planet is divided equally among the current global population. It is estimated that the current earthshare is 1.9 - 2.0 ha / per person. If everyone lived within their earthshare, we would achieve One Planet Living.
* **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 by a region's population. 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.
* **Gross Domestic Product (GDP)** - Is a measure of the total flow of goods and services produced over a specified time period. It is obtained by valuing outputs of goods and services at market prices.
* **Primary production** - The process of extracting, growing or harvesting materials in or from their raw and/or natural state. Agriculture, fishing, forestry, hunting and mining are primary industries.
* **Recycling** - Is 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.
* **Yield factors** - When calculating the biocapacity of an area, the land types and sea available is 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 that of the world average for that land or sea type.

Research Websites

For global footprints www.wwf.panda.org has full details in the Living Planet Atlas

For looking at the schools footprints use www.ecoschools.com

www.bestfootforward.com/ecocal.htm - for exploring your own footprint use

Acknowledgements

This Factsheet was written by David Holmes who is a senior examiner and works at King Edward V1 College, Stourbridge.

Curriculum Press, Bank House, 105 King Street, Wellington, TF1 1NU. Tel. 01952 271318.

ISSN 1351-5136