



WWF

REPORT

CHINA

2010

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# China Ecological Footprint Report 2010

Biocapacity, cities and development 

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WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global Network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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The China Council for International Cooperation on Environment and Development (CCICED) is a high level international advisory body established upon the approval of the Chinese Government in 1992. CCICED conducts research on major issues in the field of environment and development in China, to put forward policy recommendations to the government and to contribute to decision making on China's environment and development.

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The Global Footprint Network (GFN) promotes the science of sustainability by advancing the Ecological Footprint, a resource accounting tool that makes sustainability measurable. Together with its partners, the Network works to further improve and implement this science by coordinating research, developing methodological standards, and providing decision-makers with robust resource accounts to help the human economy operate within the Earth's ecological limits.

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# FOREWORD

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Our natural environment is the basis for life and human development. However, due to rapid social and economic development in recent years, the environment and the availability of natural resources are increasingly becoming a bottleneck for further economic growth. How to bring about a harmonious relationship between socio-economic and ecological systems is the key issue for the long term development of China and human society as a whole.

China is experiencing rapid urbanization and economic growth, and the next twenty years are a critical period for China to realize sustainable development. The patterns of development, economic growth and consumption that China adopts will determine whether China can develop sustainably within the limitations of the natural environment. With this in mind, it has been the goal of the Chinese government to accelerate the formation of a resource efficient, environmentally-friendly society.

Ecological footprint is an effective tool to measure human demand for natural resources. It can raise awareness of governments at all levels about natural resource conservation by quantifying the supply and demand of local resources. It can also support environmental and economic policymaking, as well as the optimization of local production and consumption patterns. In essence, it can provide guidance in developing an 'ecological civilization'.

After the publication of the first "Report on Ecological Footprint in China" in 2008, the China Council for International Cooperation on Environment and Development is collaborating with WWF once again to co-issue the second China Ecological Footprint Report. The goal is to explore the changes and updated situation of China's Ecological Footprint, re-examine the relationship between China's Ecological Footprint and biocapacity and contribute towards the development of an 'ecological civilization'.

The image shows the Chinese characters '祝光耀' (Zhu Guangyao) written in a traditional, expressive calligraphic style. The characters are black and set against a white background.

Zhu Guangyao  
Secretary General

China Council for International Cooperation on Environment and Development

# FOREWORD

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Our planet is our common home and its fate will define the destiny of all of us. Around the world, changing patterns of consumption combined with a growing population are increasing pressure on nature more than ever before. The Ecological Footprint helps us measure the human demand being placed on the planet's natural resources.

In this second report on China's Ecological Footprint, international and national data are combined to analyze how demand on land and water resources has changed in the 31 provinces of mainland China. Changing lifestyles and migration to cities associated with new economic opportunities are contributing to improved standards of living across the country while, at the same time, demanding more resources and increasing impacts on the natural environment. The average Ecological Footprint per capita in China has recently crossed the threshold that is considered sustainable on an average global level.

As the demand placed upon ecosystems exceeds their capacity to regenerate, China - like many other countries - is starting to draw on ecological reserves, with profound implications for ecosystem health, for food and ecological security, and for human well-being as well.

In the face of a global 'ecological credit crunch', this report points to opportunities to change direction and to increase both China's economic competitiveness and ecological security so that China can decouple its economic growth from Ecological Footprint while leaving space for nature.



James P. Leape  
Director General  
WWF International

# 1. EXECUTIVE SUMMARY

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The Ecological Footprint measures whether a country, region or the world as a whole is living within its ecological means. This report looks at China's Ecological Footprint in relation to its biocapacity. It also examines some of the challenges and opportunities the country faces in decreasing its Ecological Footprint intensity in order to strengthen its ecological security and reduce its risks in a world facing growing constraints on resources. Reflecting China's growing influence and leadership in an increasingly interconnected world, the report further highlights the role that China can play in helping to sustain the global environment.

This study updates the methods and data from the "Report on Ecological Footprint in China" published in 2008 (which used data from 2003). The current edition is based on 2007 data for China, Asia and the rest of the world, and 2008 data for China's provinces.

Improvements in the calculation of Ecological Footprint are giving us a clearer picture than ever before of the demand that humanity is placing on the Earth's renewable resources. The recent global estimates released in the WWF's Living Planet Report 2010, reveal that we now need one and a half planets to keep up with humanity's demand for resources. Alongside development of the global economy and improvements in human well-being, we have seen relentless growth in global Ecological Footprint as a result of excessive use of resources and escalating carbon dioxide emissions. Research shows that in 2007, per person Ecological Footprint was 2.7 global hectares (gha) while available biological capacity per capita was just 1.8 gha. The demand for resources exceeded that year's supply by 50 percent. This means that global ecosystems would need one and half years to regenerate the natural resources consumed and absorb the carbon dioxide emitted in 2007. Meanwhile, as human activities are affecting the environment in profound and sometimes irreversible ways, the ecosystems that provide fundamental support to the global economy are facing serious challenges.

## **This report finds that:**

- In 2007, the per capita Ecological Footprint of the average Chinese was 2.2 gha, 18 percent lower than the global average level of 2.7 gha. On a per capita basis, however, China's biocapacity – the area actually available to produce renewable resources and absorb CO<sub>2</sub> emissions – is among the world's lowest. China's total biocapacity has increased since 1961 (the first year for which estimates are available), largely due to increases in crop yields and in overall bioproductive area. Even though the annual rate of increase of China's Ecological Footprint slowed between 2005 and 2008, the country's Ecological Footprint is still increasing more quickly than biocapacity. By 2007, China's per capita Footprint was two times greater than its available biocapacity, and its ecological overshoot is continuing to increase year by year.
- Carbon footprint – the amount of land area required to sequester carbon emissions – is the largest and most

rapidly growing component of Ecological Footprint both globally and in China. In 2007, carbon footprint accounted for 54 percent of China's Ecological Footprint. The analyses in this report show that changes in individual consumption patterns have overtaken population to become the principal driver in the growth of China's total Ecological Footprint. Household consumption data indicate that demand for buildings, transportation, goods and provision of public services are the major drivers of growth in carbon footprint.

- China is at a stage of rapid urbanization and clear differences have emerged in the per capita Ecological Footprint of urban and rural areas. The per capita Ecological Footprint of urban areas is 0.9–1.8 gha higher or 1.4 to 2.5 times greater than rural areas, primarily due to the urban-rural income gap and consequent differences in consumption and energy utilization. Research shows a positive correlation between per capita Ecological Footprint and degree of urbanization, with the latter associated with an increase in Ecological Footprint and especially carbon footprint. The ongoing process of urbanization in China presents challenges and opportunities for decoupling economic development from growth in Ecological Footprint.
- Ecological Footprint and biocapacity are unevenly distributed both globally and in China. Countries can maintain biocapacity deficits through international trade, as well as by depleting domestic stocks and accumulating CO<sub>2</sub> in the global commons of the atmosphere and oceans. China is a net importer in terms of its Footprint of resource use (total Ecological Footprint excluding the carbon and built-up land components). This means its consumption is reliant on the biocapacity of other countries in the form of imported raw materials and other goods. At the same time, part of China's carbon emissions are due to its manufacturing exports to the rest of the world, making the country a net exporter of biocapacity. 20 percent of China's imported biocapacity is used for direct consumption, 35 percent in manufacture of products for domestic trade, and 45 percent in products for international trade. Trade within China results in biocapacity flows from western to eastern areas and from rural to urban areas. Excessive extraction in biocapacity export areas has led to ecological degradation.
- Water resource availability is as important for humankind as biocapacity but cannot be described using the measure of global hectares. Hence, demand for water is measured with a separate indicator, the Water Footprint. Water Footprint can be used to track human demand on water resources, which differs markedly across China and around the world. Per capita Water Footprint in China, a country with scarce water resources, is less than half of the global average. Water stress is most serious in northern China, central China, and in downstream areas of the Yellow and Yangtze rivers.

These trends place China at a crossroads in terms of sustainable development. The challenge facing China today is that of decoupling economic development from growth in Ecological Footprint while leaving space for nature. How can China continue to achieve gains in human well-being without costing the Earth? Based on the findings of this report the following policy suggestions are made:

### **1. Use the relationship between Ecological Footprint and biocapacity as one of the key indicators of progress towards an 'ecological civilization'.**

The term 'ecological civilization' is commonly used in official discourse in China. China aspires towards the development of an 'ecological civilization' as its path towards sustainability following earlier agricultural and industrial stages. Reducing Ecological Footprint and increasing biocapacity are both important pathways towards achieving an 'ecological civilization'. By comparing human demand on the environment, represented by Ecological Footprint, with the capacity of natural ecological systems, represented by biocapacity, in order to determine whether the demand creates an ecological surplus (where biocapacity exceeds Ecological Footprint) or an ecological deficit (where Ecological Footprint exceeds biocapacity), we can assess the environmental impact of development. It is recommended to use these measures for determining whether or not a society is on track to better manage natural resources. This can be monitored by establishing a national Ecological Footprint and biocapacity accounting system to track utilization of, and changes in, local ecological resources. This system, together with other indicators, can be used to support economic policy-making and local development plans by offering straightforward scientific analyses.

### **2. Strengthen ecosystem management and improve biocapacity.**

China has limited natural resources on a per capita basis, and improving this ecological base is a key strategy to ensure national ecological security. Hence, China should strengthen ecosystem management and increase biocapacity through the following measures:

(1) Maintain a healthy natural environment and preserve biologically productive forests, grassland, etc. As a country with scarce ecological resources on a per capita basis, it is vital that China preserves its existing natural ecosystems for future generations. This can be accomplished by (a) enforcing strict land use planning policies; (b) implementing ecological restoration and nature conservation policies; (c) increasing the area of ecologically productive land and optimizing the use of land according to local geographical and climatic conditions; (d) compensating net biocapacity exporting regions through a variety of economic and administrative measures; and (e) restoring ecologically degraded regions, thereby improving their productivity and pollution absorption capacity.

(2) Increase land productivity, promote increases in biocapacity while conserving biodiversity. Unlike some other countries, the biocapacity of China has continuously increased; for example, forest coverage has expanded over the last 30 years and the scale of production of aquaculture and agriculture has increased – in recent years, one fifth of the world's grain, half of its vegetables and one third of its meat products were produced in China. It is recommended that the government work to reinforce this trend by (a) investing in sustainable agriculture, forestry, animal husbandry and fisheries; (b) optimizing the distribution of agricultural production, developing high-efficiency and sustainable agriculture while promoting inter-cropping; (c) increasing agricultural productivity and the degree of mechanization; (d) encouraging comprehensive utilization of crop residues; and (e) increasing land productivity and quality.

### **3. Reduce carbon footprint as a primary focus for decreasing biocapacity deficits.**

Carbon footprint has become the primary force driving the increase in China's Ecological Footprint and any effort to reduce Ecological Footprint must therefore focus on reducing carbon footprint. China can reduce carbon footprint through the following measures:

(1) Establish and promote a low carbon economy by (a) adjusting and optimising industry structures according to local biocapacity; (b) restricting and prohibiting certain industries while encouraging energy conservation and production



patterns that are environmentally friendly and resource efficient; (c) increasing the utility and conversion efficiency of fossil fuels throughout their life cycles; and (d) increasing the proportion of renewable energy in the energy portfolio. For regions where per capita Gross Domestic Product (GDP) is less than 30,000 RMB (US\$ 4,500) – the amount above which Ecological Footprint shows a positive association with per capita GDP – the focus should be on investment and development patterns that do not also cause a rapid rise in Ecological Footprint.

(2) Focus on building low carbon cities / eco-cities in China's urbanization. Although urbanization is associated with higher Ecological Footprint, there are ways this relationship can be optimised. To that end, the urbanization process in China should follow a low carbon, environmentally friendly approach to urban planning that includes controlling the expansion of cities and towns, deploying appropriate transportation systems, promoting residences with locally available facilities and decreasing carbon footprint in buildings and transportation.

(3) Promote sustainable consumption by: (a) encouraging low carbon and resource efficient consumption patterns and selection of environmentally friendly goods and services, (b) having government set an example through establishing green procurement policies and low carbon offices; and (c) improving the lifespan of public facilities and optimizing their design in order to avoid waste and poor construction quality. It is important to account for regional development and consumption levels when formulating plans for encouraging changes in carbon footprint. In provinces where per capita GDP is above 30,000 RMB, the plan should focus on changes in consumption patterns to slow down or freeze the increase in Ecological Footprint.

#### **4. Reduce biocapacity deficits through resource allocation.**

Biocapacity and water resources are unevenly distributed both globally and in China. There is often limited correlation between resource availability and population distribution, thus it is often impossible to meet consumption demand within local limits. Trade is one means to redress this imbalance, but poorly planned and irresponsible trade practices can lead to overexploitation of natural resources and weakening of local natural capital. Accordingly, special attention should be given to biocapacity, water and other resources embedded in international and domestic trade through measures that promote sustainable natural resource flows as a basis for long term economic development. This can be achieved through the following measures:

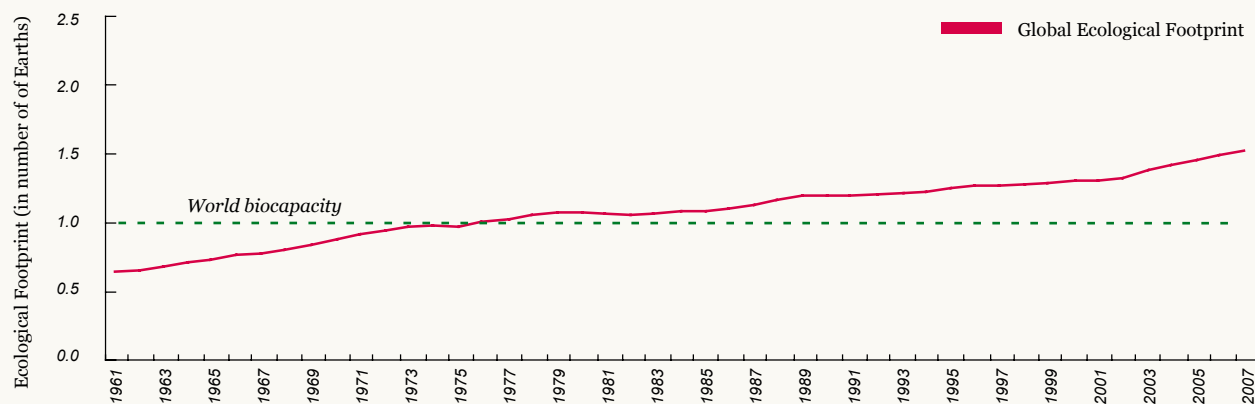
(1) Formulate a domestic trade policy that encourages appropriate biocapacity flows. China should adopt a range of economic and administrative measures that promote efficient allocation of ecological resources and minimize inappropriate exportation and inter-provincial transfers of biocapacity and water resources through (a) innovative tax systems such as an energy resource tax and a carbon tax which encourages enterprises to invest in new technologies that conserve energy and reduce emissions; and (b) development of trade policies that encourage sustainable flows of biocapacity, minimize the export of resources from degraded areas, and curtail irresponsible trade practices.

(2) Encourage international cooperation in order to promote sustainable trade flows. Global trade reflects the ecological interdependency among countries and highlights that environmental problems are global in nature. It is recommended to pay attention to unsustainable imports and exports of biocapacity in order to lessen the ecological impact of trade on China and other countries.

## 2. INTRODUCTION

Over the past three decades China has seen per capita incomes increase by more than 50 times and hundreds of millions of people have been lifted out of poverty as a result of development. However, rapid industrialization, urbanization and agricultural intensification have increased the pressure on natural resources and created serious environmental problems. Accordingly, scientists and policy makers are jointly exploring new approaches to development that are more sustainable.

This report analyzes the relationship between China's biocapacity and Ecological Footprint to assess the current state of demand for biological capacity in China and to place China's situation in the context of a resource constrained world. Compared with the first "Report on Ecological Footprint in China" published in 2008 (with data from 2003), accounting methods have been improved, giving a clearer picture of the demand that humans are placing on the planet. In this report, the region "China" covers 31 provinces, autonomous regions and municipalities in mainland China (hereinafter referred to as "provinces") and does not include Hong Kong, Taiwan or Macao. Figures for Asia and China are from the Global Footprint Network and reflect calculations from the year 2007, while those related to Chinese provinces are from the Institute of Geographic Sciences and Natural Resources Research (IGSNRR) in China and reflect 2008 data. The trade analyses have also been improved, increasing the analyzed product items from 43 to 132.



**Figure 2.1. Global Ecological Footprint and biocapacity (1961-2007).**

Since 1961, growing human population and per capita consumption in most parts of the world have led to a more than doubling of global Ecological Footprint. Humanity's Ecological Footprint overtook global biocapacity in the mid-1970s and has remained above this threshold ever since.

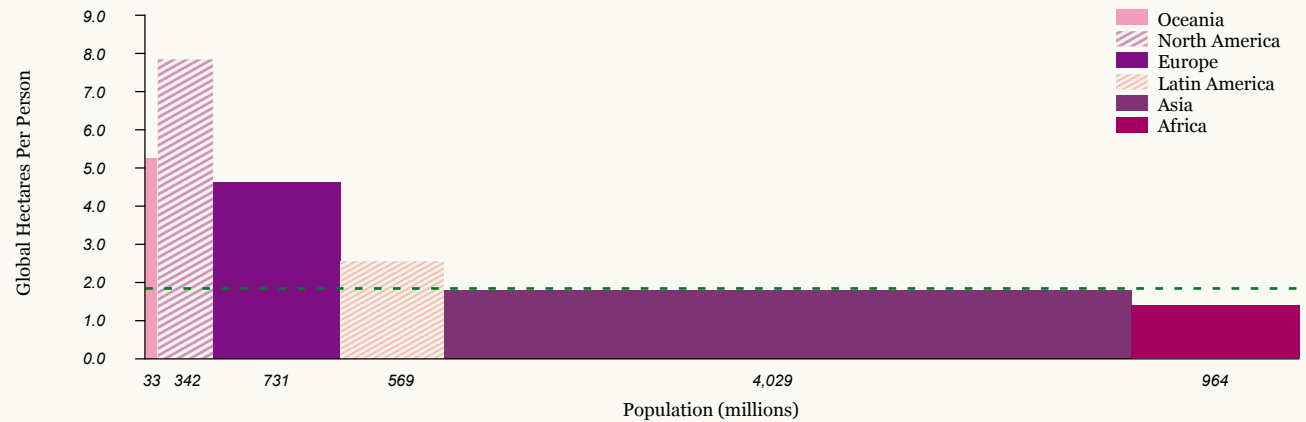
Data source: Global Footprint Network, 2010

In 2007, global human demand for ecological resources, as measured by Ecological Footprint, exceeded the planet's regenerative capacity or biocapacity by 50 per cent (Figure 2.1). This means that people are no longer relying exclusively on the annual regeneration of natural resources, but are depleting resource stocks and accumulating CO<sub>2</sub> waste in order to support their lifestyles. The excessive demand for ecological resources creates global ecological overshoot, the consequences of which can include increasing CO<sub>2</sub> concentrations in the atmosphere and oceans, expansion of deserts, degradation of grasslands, depletion of fish stocks, reduction in forest cover and loss of biodiversity. We need to bring an end to ecological overshoot in order to ensure a sufficient supply of renewable resources and sustain the ecosystem services that provide these resources, while leaving room for other species.

There are large differences in the Ecological Footprint of different countries, reflecting differences in population and per capita consumption levels. For example, the US and UAE's average per person Ecological Footprint is about 3-4 times

**Figure 2.2. Average per person Ecological Footprint by region (2007).**  
The dotted line represents global average biocapacity available per person.

Data source: Global Footprint Network, 2010



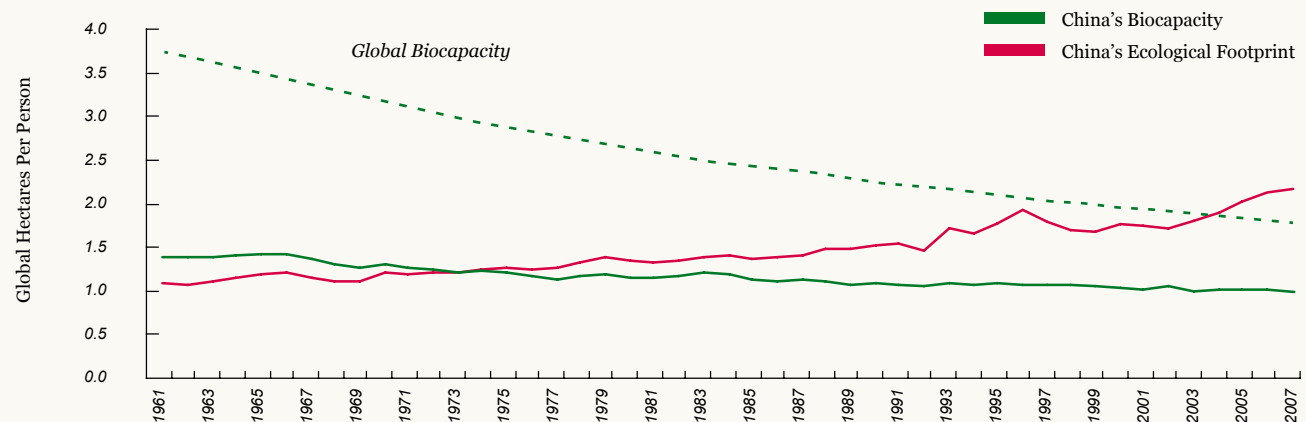
**Figure 2.3. Decline in per person biocapacity at the global scale (1961-2007).**

The dotted line represents global average biocapacity available per person. China's overall Ecological Footprint began to exceed its biocapacity in the 1970s, as was the case in many other parts of the world.

China's average per capita consumption exceeded a level that would be sustainable at a global level in 2004, some 30 years after the global sustainability threshold was breached.

In 2007, China required 2.2 times its own biocapacity to support consumption of natural resources and to absorb CO<sub>2</sub> emissions.

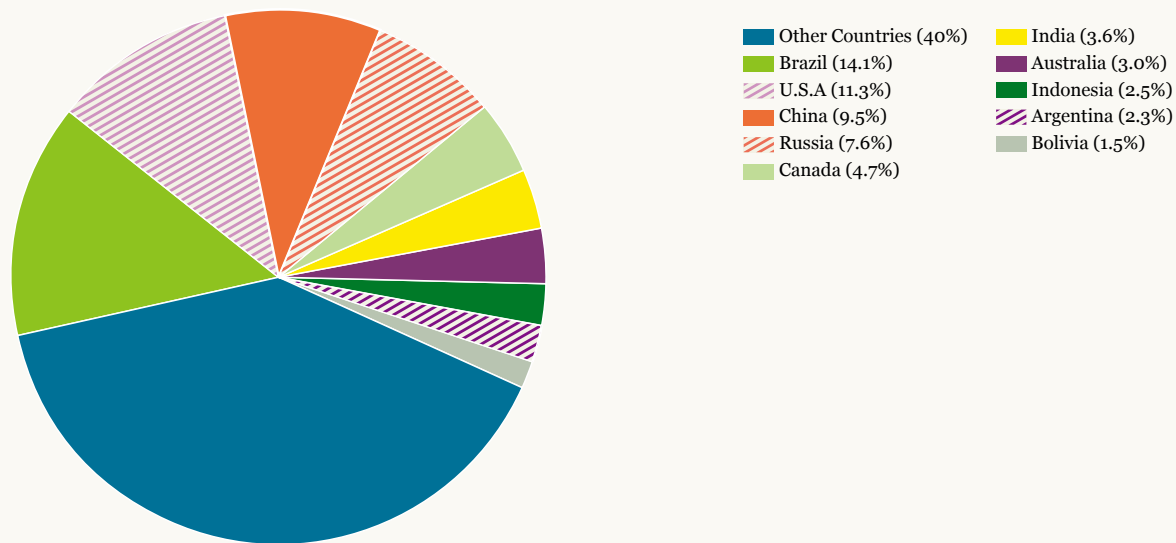
Data source: Global Footprint Network, 2010



higher than the global average, while India's average per person Ecological Footprint is only one-third of the world's average. If global consumption patterns were the same as those of the US or UAE, we would need 4.5 Earths to meet resource needs, while if the global consumption patterns were the same as that of India, we would only need 0.5 Earths.

As for China, 2007 was the fourth year in which average Ecological Footprint per person was higher than the global average biocapacity available per person (Figure 2.3). Yet during this time, China's average per capita Ecological Footprint was 2.2 global hectares, 0.5 gha lower than the average Footprint worldwide.

Significant regional and national differences in environmental conditions and land use practices are reflected in important differences in biological capacity between countries and regions (Figure 2.4). Despite low levels of natural resources per person, China is home to 9.5 percent of the world's total biological capacity, a level exceeded only by Brazil and the US and is responsible for 15 percent of global demand on biocapacity.



**Figure 2.4. Top ten biocapacity rich countries (2007).**

Data source: Global Footprint Network, 2010

We only have one Earth. In a context of limited resources and regeneration capacity, our current patterns of development and consumption are unsustainable. If humanity is to prosper, we need to live and to manage our development in a way that is ecologically sound. Sustainable development requires facing tough choices and accepting difficult truths, but the consequences of not implementing sustainable development - ecological degradation, loss of ecosystem services and even societal collapse - are much more perilous.

China's influence today is greater than at any time in recent history. This report aims to strengthen China's position by exploring ways to improve consumption patterns, reduce China's ecological risk, manage its biocapacity as a key asset to the continued wellbeing of its people and, in an increasingly interconnected world, point to the role that China can play in helping to sustain global ecosystem services.

**Ecological Footprint:**

The Ecological Footprint tracks human demand on ecosystems by adding together the equivalent areas of world average biologically productive land and water required to provide the renewable resources that people use, provide space for infrastructure, and absorb the CO<sub>2</sub> waste that human activities produce. The Ecological Footprint tracks demand in the following categories: cropland, grazing land, forest land, fishing grounds, built-up land and carbon. The first five types of Footprint are defined in this report as Footprint of resource use.

The term 'Ecological Footprint', when not further qualified, refers to the Ecological Footprint of Consumption: the Footprint associated with the entire supply chain serving the consumption of a given population or region. The Ecological Footprint of Production, on the other hand, measures direct demand for biocapacity, regardless of whether the end products of this demand are consumed locally or are exported. Footprint of resource use in this report refers to Ecological Footprint exclusive of carbon footprint.

**Biocapacity:**

Biocapacity measures the area of biologically productive land and water actually available to provide renewable natural resources and absorb CO<sub>2</sub> waste.

**Biocapacity deficit/surplus:**

Biocapacity deficit is when Ecological Footprint exceeds biocapacity; biocapacity surplus is when biocapacity exceeds Ecological Footprint.

**Ecological overshoot:**

During the 1970s, humanity as a whole passed the point at which the annual Ecological Footprint matched the Earth's annual biocapacity – that is, the Earth's human population began consuming renewable resources faster than ecosystems can regenerate them and releasing more CO<sub>2</sub> than ecosystems can absorb. This situation on a global level is called "ecological overshoot", and has continued since then.

**Global hectare (gha):**

Both the Ecological Footprint (which represents demand for resources) and biocapacity (which represents the availability of resources) are expressed in units called global hectares (gha), with 1 gha representing the productive capacity of 1 hectare of land at world average productivity.

**Illustration 2.1: Components of Ecological Footprint.**

As this image suggests, we can understand the concept of ecological footprint in terms of the total human impact on the Earth, including built up land (our cities, factories, railways, etc.), crop land (farms), grazing lands, fishing grounds and forests.



<b>CROPLAND FOOTPRINT:</b>	Calculated from the area used to produce food and fiber for human consumption, feed for livestock, oil crops and rubber.
<b>GRAZING LAND FOOTPRINT:</b>	Calculated from the area used to raise livestock for meat, dairy, hide and wool products.
<b>FOREST LAND FOOTPRINT:</b>	Calculated from the amount of lumber, pulp, timber products and fuel wood consumed by a country each year.
<b>FISHING GROUNDS FOOTPRINT:</b>	Calculated from the estimated primary production required to support the fish and seafood caught, based on catch data for more than 1,400 different marine species and more than 260 freshwater species.
<b>BUILT UP LAND FOOTPRINT:</b>	Calculated from the area of land covered by human infrastructure, including transportation, housing, industrial structures, and reservoirs for hydropower.
<b>CARBON FOOTPRINT:</b>	Calculated as the amount of forest land required to absorb CO <sub>2</sub> emissions, primarily from burning fossil fuels, other than the portion absorbed by oceans. These emissions are the only waste product included in the Ecological Footprint.

# 3. ECOLOGICAL FOOTPRINT: GLOBAL AND ASIAN CONTEXT

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## **The global context**

In 2007, global Ecological Footprint was 18 billion gha or 2.7 gha per person while the Earth's biocapacity was only 11.9 billion gha, or 1.8 gha per person representing an ecological overshoot of 50 percent. This means it would take 1.5 years for the Earth to regenerate the renewable resources that humanity used in 2007 and to absorb the CO<sub>2</sub> emissions released. Put another way, in 2007 we used the equivalent of 1.5 planets to support our activities.

People in different countries place very different demands on ecological systems (Figure 3.1). In 2007, the average Ecological Footprint per person in China was 2.2 gha, 0.5 gha lower than the global average. This places China 74th amongst the 153 countries for which Ecological Footprint data were published in WWF's Living Planet Report 2010.

## **The Asian context**

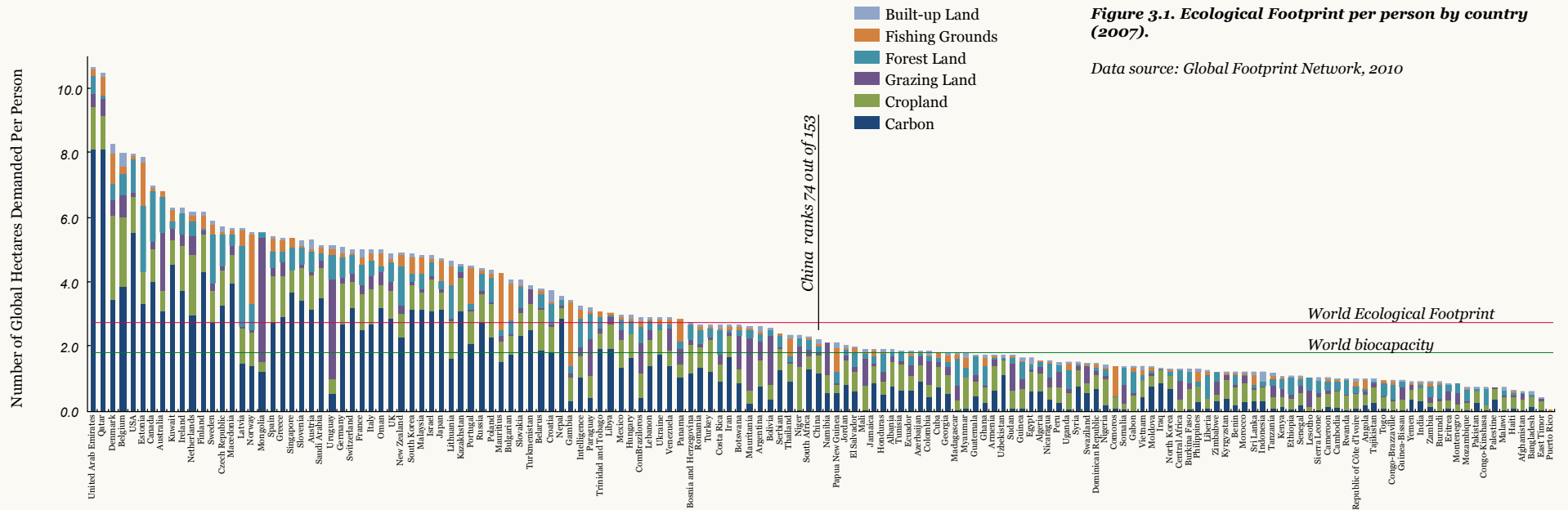
Asia's average per person Ecological Footprint was 1.78 gha, equivalent to the global average biocapacity and well below the global average Ecological Footprint of 2.7 gha per person. However, Asia's overall consumption accounted for 40 percent of humanity's Ecological Footprint, equal to 60 percent of global biocapacity. This is due to the region's large population, which accounts for 60 percent of the world's total (Figure 3.2).

Asia's total biocapacity was 3.3 billion gha, representing 28 percent of global biocapacity. This translates to 0.8 gha of biocapacity per person, less than half the global average and the lowest biocapacity relative to population of any of the world's regions. Asia's total Ecological Footprint is 2.2 times its biocapacity. Asia as a whole is an importer of biocapacity. Thus Asia meets its biocapacity deficit partly by drawing on other regions' biocapacity, as well as by using the global commons to absorb its CO<sub>2</sub> emissions.

Asia has the largest Ecological Footprint growth among all the world's regions: between 1961 and 2007, the region's total Ecological Footprint increased by about 3.4 times or about 5,100 million gha. This increase is a result of a population that more than doubled in combination with a 30 percent increase in per person Ecological Footprint during the same time period.

The carbon footprint is the fastest-growing Ecological Footprint component in Asia, just as in other regions. In 2007, the carbon footprint accounted for 50 per cent of Asia's Ecological Footprint, compared to just 5 per cent in 1961. Since the per person Ecological Footprint in Asia is smaller than the global average, the per person carbon footprint is also lower.

The disparity in Ecological Footprint per person amongst Asian countries is larger than any other region (Figure 3.3). This is due primarily to differences in affluence and consumption patterns. At 10.7 gha per person, residents of the United Arab Emirates (UAE) have the world's highest Footprint per person, while the Ecological Footprint per person in Pakistan is only 0.8 gha. Due to their large populations, China and India are the two countries with the largest total Ecological Footprint.

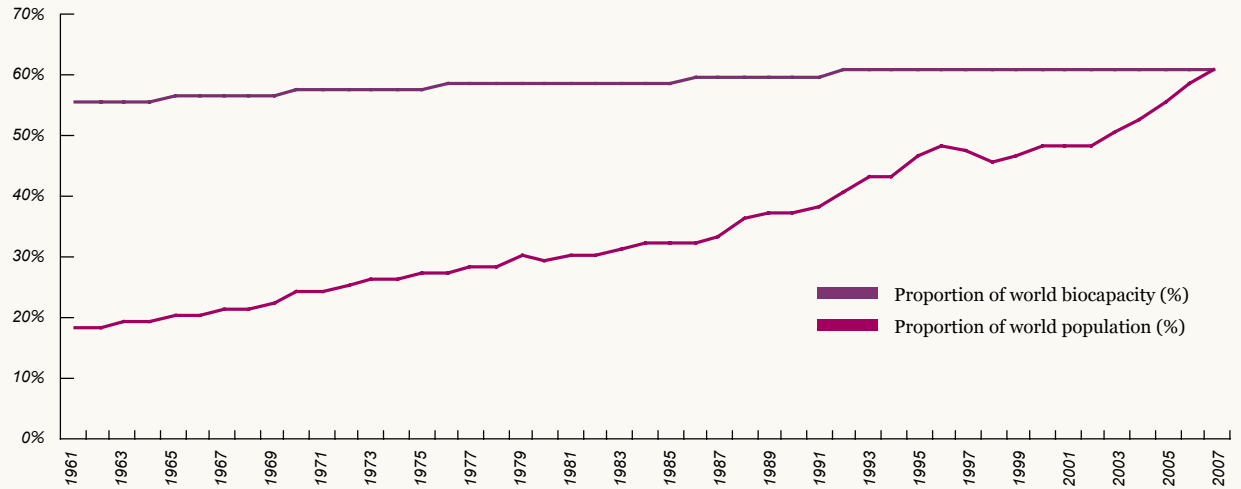




**Figure 3.2. Asia's population and use of biocapacity over time (1961-2007).**

In 2007, Asia accounted for about 60 percent of the world's population, and used about the same amount of the world's available biocapacity.

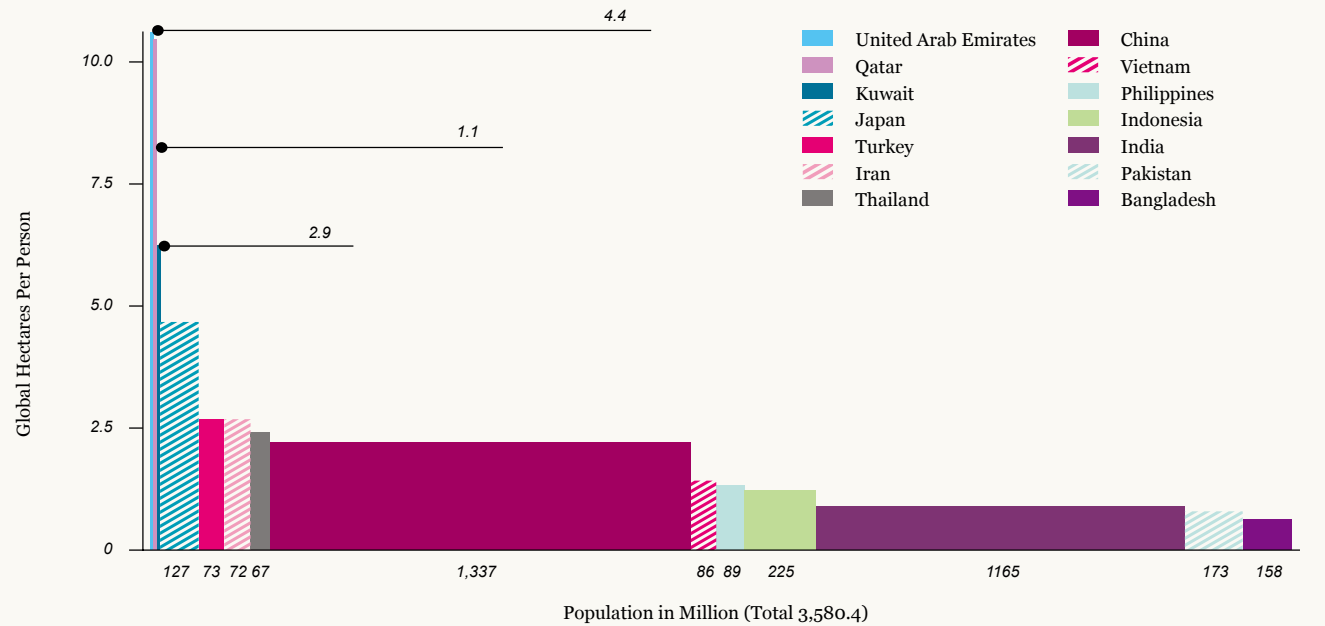
Data source: Global Footprint Network, 2010



**Figure 3.3. Ecological Footprint by country in Asia (2007).**

The area of each box represents the total Ecological Footprint of that country (per person Ecological Footprint x total national population). Population in millions is shown under or beside the bars. UAE and Qatar have the highest per person Ecological Footprint while China and India have the largest total Ecological Footprints.

Data source: Global Footprint Network, 2010

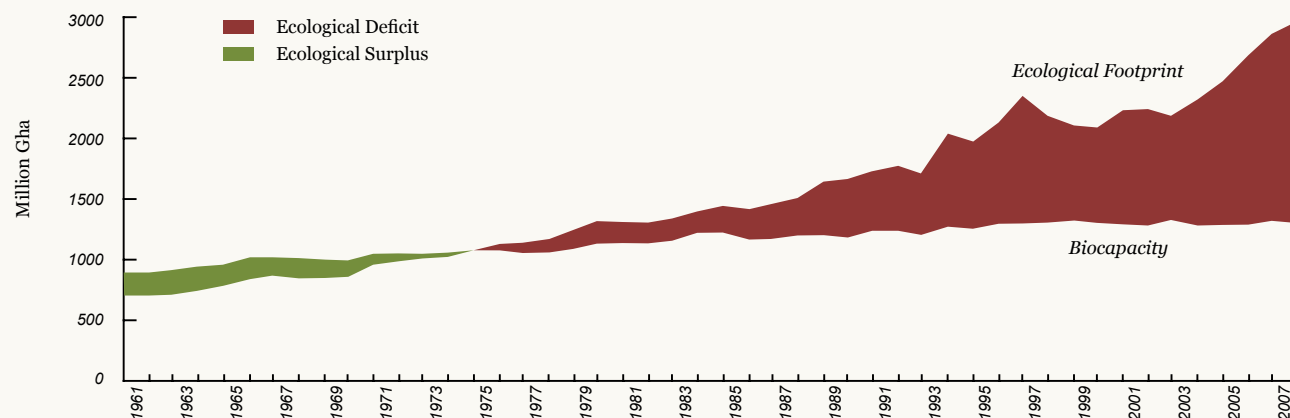


# 4. CHINA'S ECOLOGICAL FOOTPRINT AND BIOCAPACITY

China has experienced comprehensive social and economic development during the past half century and its Ecological Footprint has shown an upward trend during most of this period. China is endowed with significant biocapacity, behind only Brazil and the United States, although its per capita biocapacity is low.

Prior to the mid-1970s, China enjoyed an ecological surplus (Figure 4.1) - an excess of biocapacity over Ecological Footprint - and the grazing land, forest land and fisheries components of its biocapacity were able to meet demand (Figure 4.2). However, these surpluses have been continually shrinking and deficits have started to appear, and demand for fishing grounds has recently exceeded supply, contributing to China's overall biocapacity deficit.

Growth in carbon emissions has become the primary driver of China's growth in Ecological Footprint (Figure 4.3). In 2007, carbon footprint accounted for 54 percent of China's Ecological Footprint. Transportation, production and consumption of goods, housing and services are the main drivers of carbon footprint and the increasing per person carbon footprint is largely the result of expanded demand in these areas. The growth in carbon footprint is particularly associated with lifestyle changes in wealthier provinces.

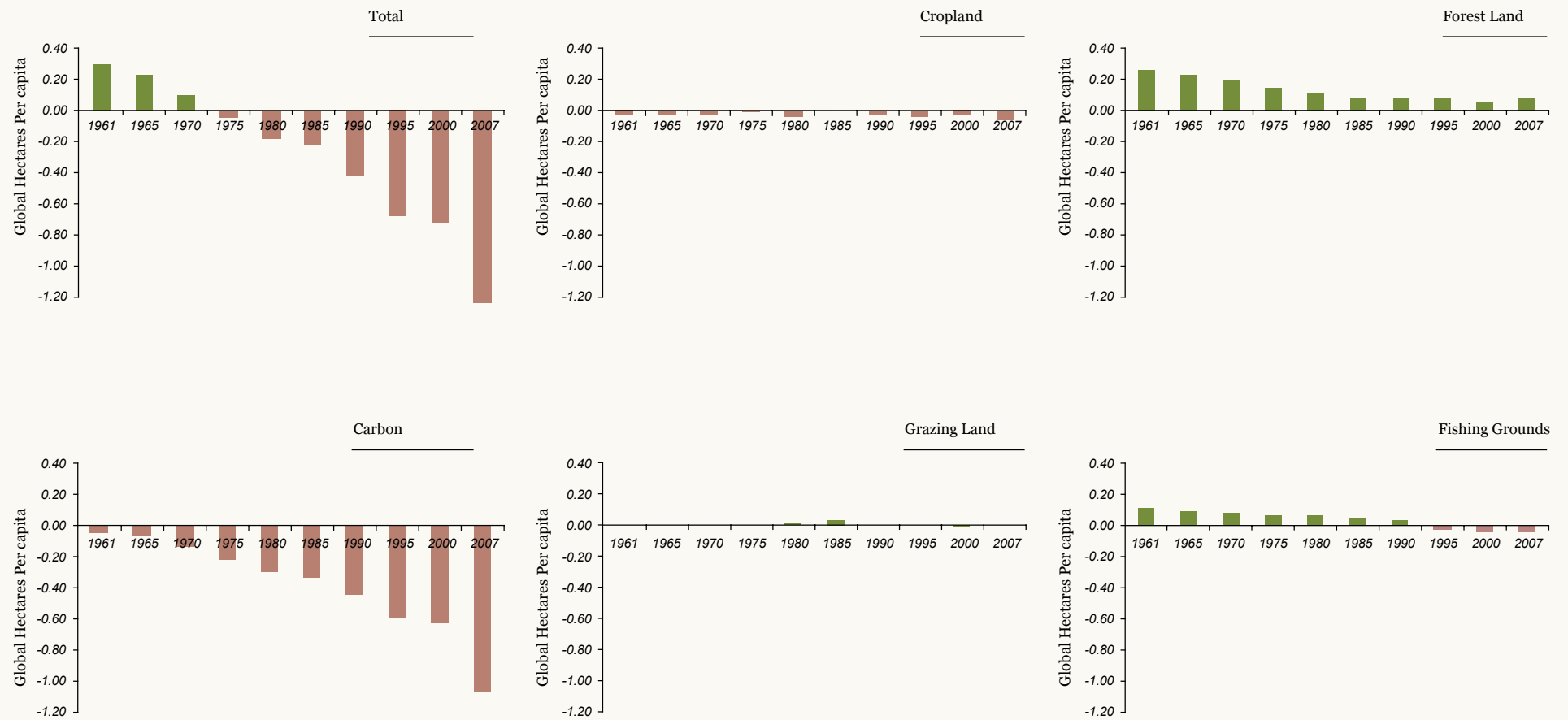


**Figure 4.1. Changes in China's biocapacity and Ecological Footprint (1961-2007).**

China needs 2.2 times the country's own biologically productive land area to meet its requirements for resources and to absorb CO<sub>2</sub> emissions.

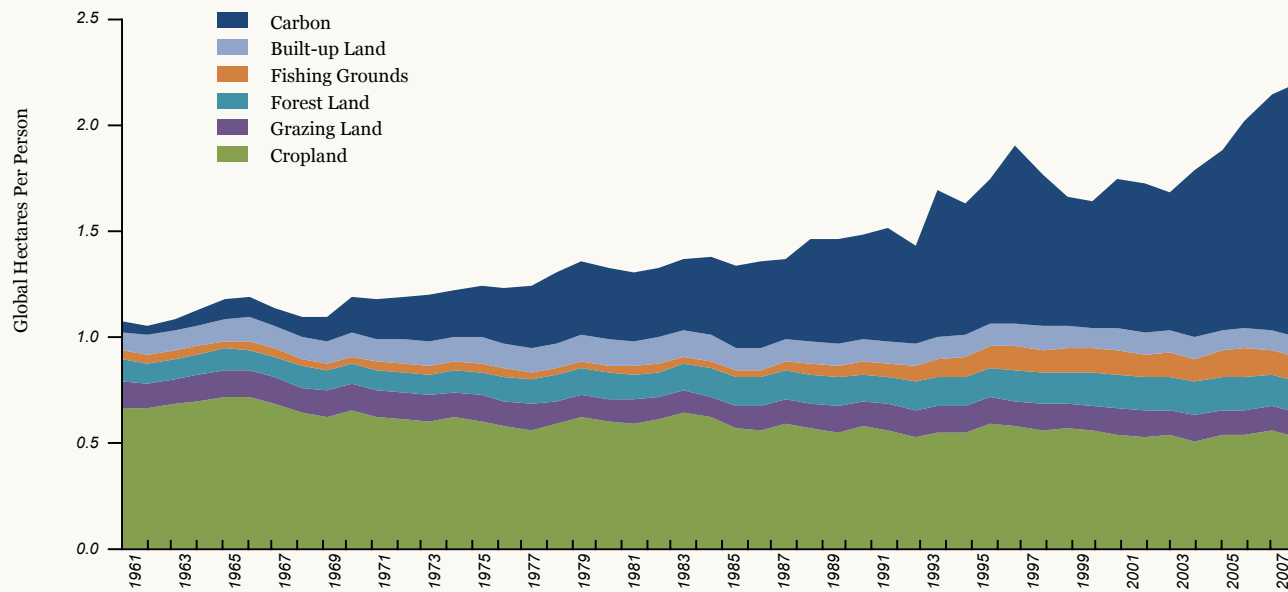
China's per capita Ecological Footprint is currently 81 percent of the global average. If all the world's inhabitants lived like an average resident of China, then a biocapacity equivalent of 1.2 Earths would be required to keep up with humanity's consumption and CO<sub>2</sub> emissions. Meanwhile, humanity as a whole requires the equivalent of 1.5 Earths to meet its current level of consumption.

Data source: Global Footprint Network, 2010



**Figure 4.2. China's Ecological Footprint surplus/deficit by land use type, excluding built-up land.**

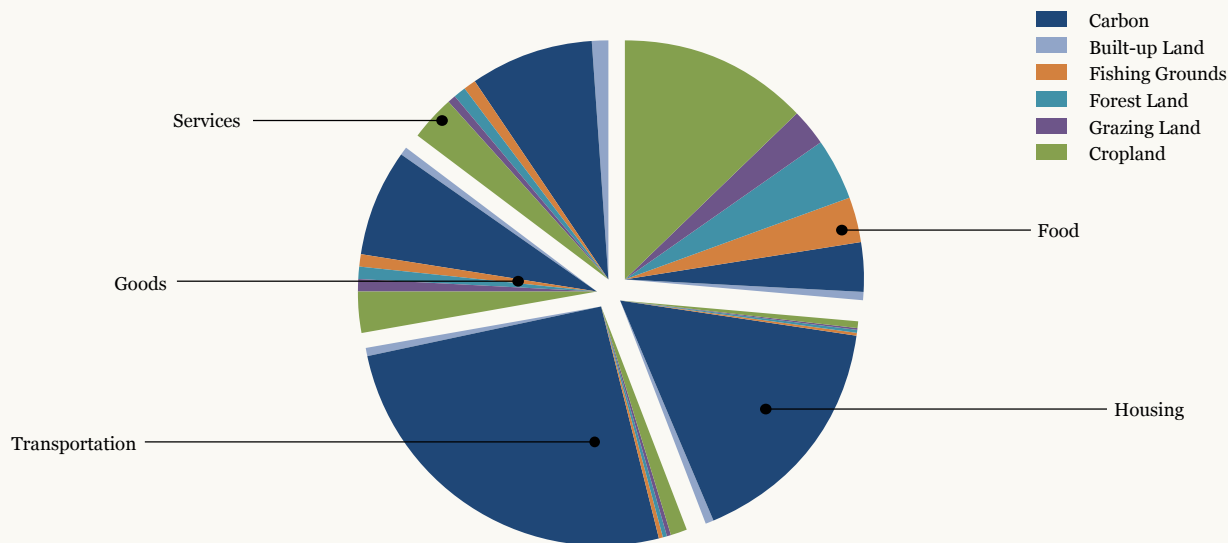
Data source: Global Footprint Network, 2010



**Figure 4.3. China's per person Ecological Footprint by component, 1961-2007.**

Note: Fishing grounds footprint measures the areas that provide humans with aquatic products. Detailed information about human demand on water and water pollution assimilation services can be found in Chapter 9 "Water Footprint".

Data source: Global Footprint Network, 2010



**Figure 4.4. Distribution of household Ecological Footprint by Footprint component among six economic sectors based on an economic input-output analysis.**

Data source: Global Footprint Network, 2010

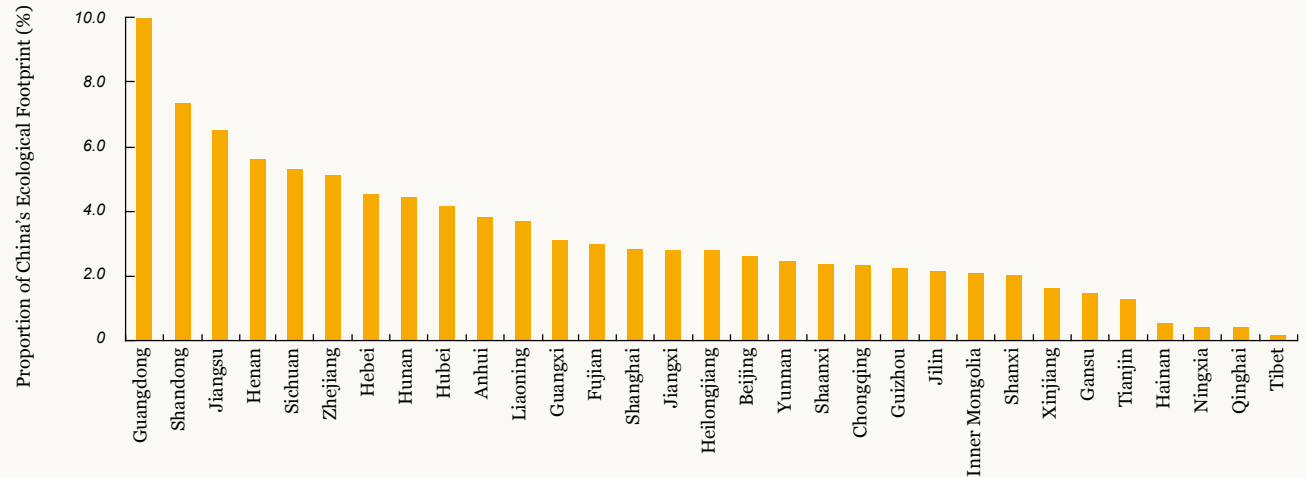
China's provinces (including provinces, municipalities and autonomous regions) vary significantly in their socio-economic and environmental contexts. Analysis of historical Ecological Footprint and biocapacity data at the provincial level provides detailed information regarding ecological stress at specific locations and changes over time.

Ecological Footprint and biocapacity are not evenly distributed across China (Figures 4.5 and 4.6). Because population density varies across China, the provincial distribution of per capita Ecological Footprint shows a very different pattern from the distribution of total provincial Ecological Footprint. In comparison with Ecological Footprint, biocapacity is more unevenly distributed across provinces.

**Figure 4.5. China's Ecological Footprint by province (2008).**

Ecological Footprint differs markedly between provinces in China. In 2008, the provinces with the largest Ecological Footprint were Guangdong, Shandong, Jiangsu, Henan, Sichuan, Zhejiang, Hebei, Hunan and Hubei. Together these provinces accounted for 53 percent of China's total Ecological Footprint. Provinces with relatively small Ecological Footprint were Xinjiang, Gansu, Tianjin, Hainan, Ningxia, Qinghai and Tibet. Together these provinces were responsible for only less than 6 percent of China's total Ecological Footprint. Tibet, Qinghai and Ningxia have the lowest populations of all of China's provinces, and together account for a mere 1 percent of the country's total Ecological Footprint.

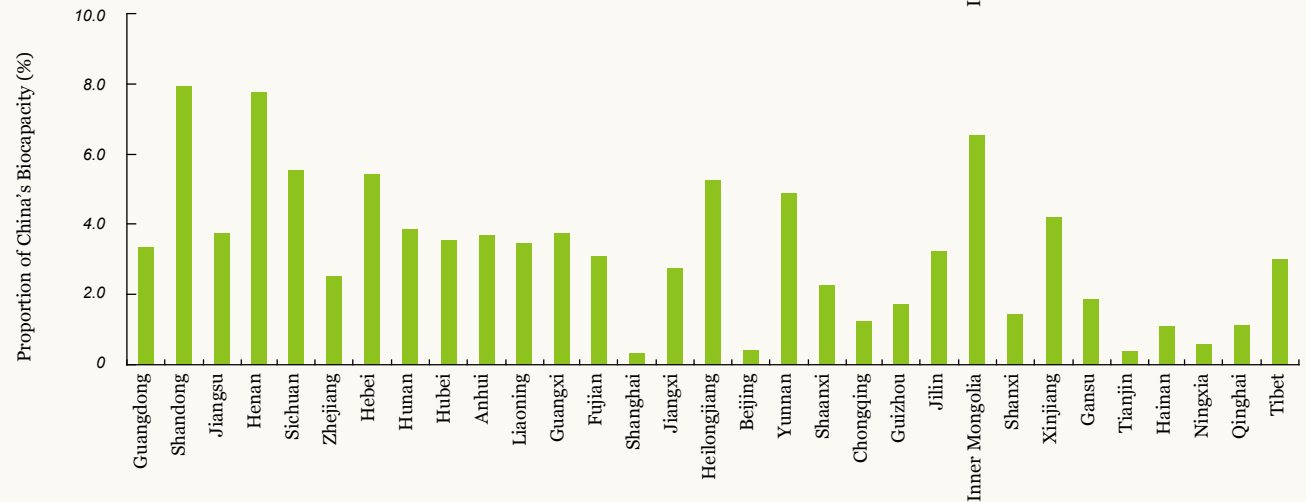
Data source: IGSNRR, 2010



**Figure 4.6. China's total biocapacity by province (2008).**

Changes in land resources and their productivity are the main sources of the uneven distribution of China's biocapacity. In 2008, Shandong, Henan, Sichuan, Hebei, Heilongjiang, Yunnan, Inner Mongolia and Xinjiang together accounted for 48 percent of total national biocapacity; while Shanghai, Beijing, Chongqing, Guizhou, Shanxi, Gansu, Tianjin, Hainan, Ningxia and Qinghai together only accounted for 10 percent of China's total biocapacity.

Data source: IGSNRR, 2010



In 2008 the provinces with the highest total biocapacity (more than 4 percent of national biocapacity each) were Shandong, Henan, Sichuan, Hebei, Heilongjiang, Yunnan, Inner Mongolia and Xinjiang. Together they accounted for 48 percent of national biocapacity. With 2-4 percent of national biocapacity each, Guangdong, Jiangsu, Zhejiang, Hunan, Hubei, Anhui, Liaoning, Guangxi, Fujian, Jiangxi, Shaanxi, Jilin and Tibet, together accounted for 42 percent of national biocapacity. With lowest total biocapacity (less than 2 percent of national biocapacity each), Shanghai, Beijing, Chongqing, Guizhou, Shanxi, Gansu, Tianjin, Hainan, Ningxia and Qinghai, together accounted for 10 percent of total national biocapacity.

In 2008, Guangdong, Shandong, Jiangsu, Henan, Sichuan, Zhejiang, Hebei, Hunan and Hubei, each accounted for over 4 percent of total national Footprint and their combined total Footprint accounted for 53 percent of the national total Footprint. Anhui, Liaoning, Guangxi, Fujian, Shanghai, Jiangxi, Heilongjiang, Beijing, Yunnan, Shaanxi, Chongqing, Guizhou, Jilin, Inner Mongolia and Shanxi, each accounted for 2 to 4 percent of national total Footprint, and their combined total Footprint accounted for 41.1 percent of national total Footprint. With 12.3 percent of total national Footprint, the five western provinces of Xinjiang, Gansu, Ningxia, Qinghai and Tibet, as well as Tianjin and Hainan together accounted for 5.9 per cent of China's Ecological Footprint (Figure 4.5).

The increase in Ecological Footprint has been driven in large part by carbon footprint, which has become the largest component of China's Ecological Footprint (Figure 4.7). In 2008 the carbon component accounted for over 50 percent of the Ecological Footprint in 29 of China's 31 provinces, and exceeded 65 percent in Shanghai, Beijing, Tianjin and Shandong. Between 1985 and 2008 (1990 and 2008 for Tibet) the carbon component of per person Ecological Footprint of each province rose by 0.4-2.0 gha, while all other components increased by 0.25 gha or less. The predominance of carbon as the major component of Ecological Footprint is not expected to change based on current development patterns.

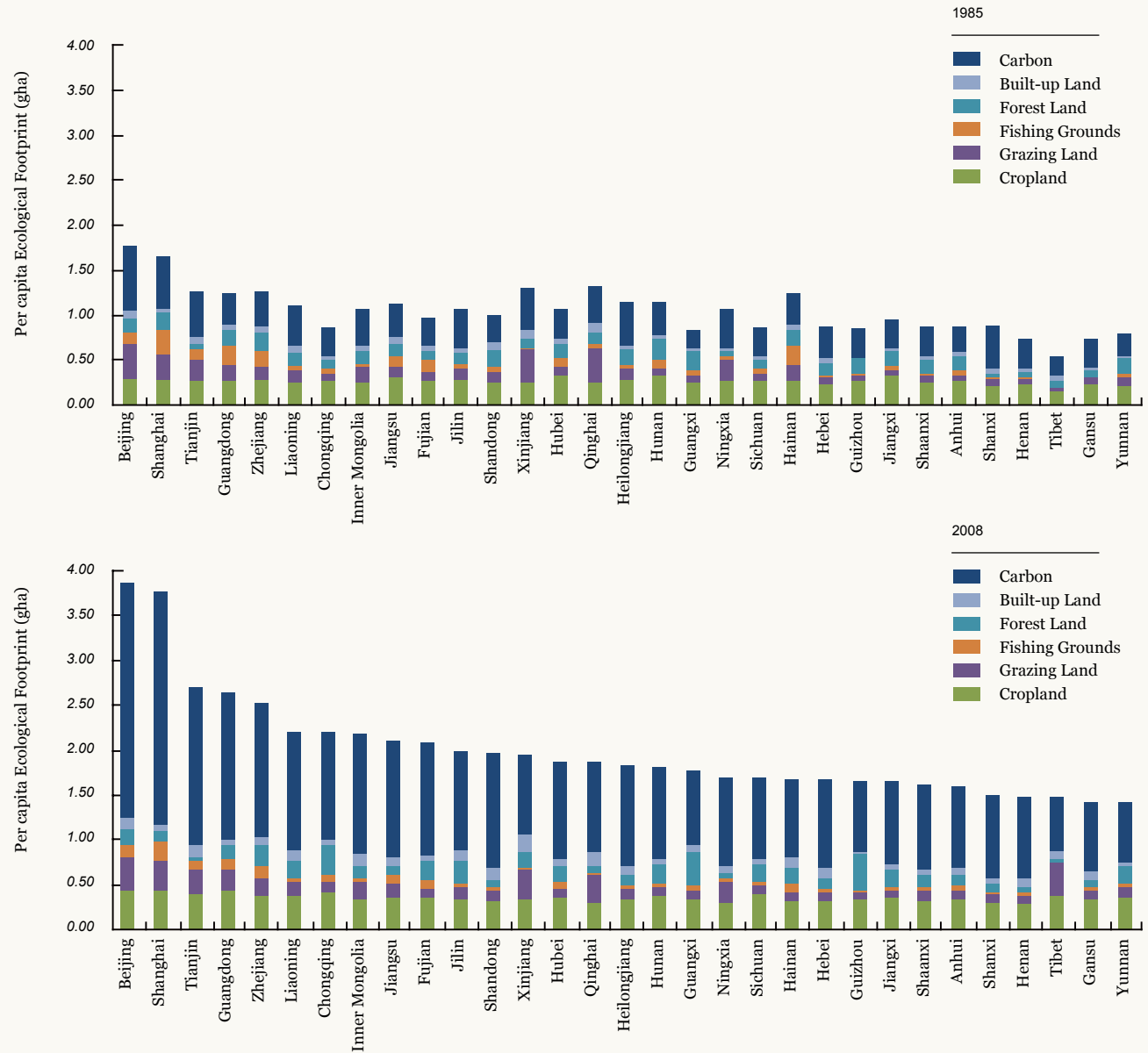
There are clear differences between provinces in per person Ecological Footprint (Figure 4.7). In 2008, Beijing had the largest per person Ecological Footprint, 2.7 times larger than that of Yunnan, the province with the smallest Footprint. Despite the variation in magnitude in total Ecological Footprint and Footprint components between provinces, growth in Footprint is a shared feature over the period 1985-2008. Eleven provinces saw their per person Ecological Footprint double in this period, ten experienced increases between 85 and 95 percent and the remaining ten experienced increases between 40 and 84 percent. Shanghai, Beijing, Tianjin, Guangdong and Chongqing have seen the greatest overall growth in their per person Ecological Footprint.

The rate of increase in per person Ecological Footprint slowed down in most provinces during 2005-2008 in comparison to the period 2000-2005. For instance, in Beijing the reduction in the rate of increase in per person Ecological Footprint can be explained by the stabilisation in the rate of urbanization together with energy conservation measures, as well as the transition from a manufacturing to a service economy. However, in some provinces such as Shandong, the rate of increase in per person Ecological Footprint continued to rise in parallel with urbanization.

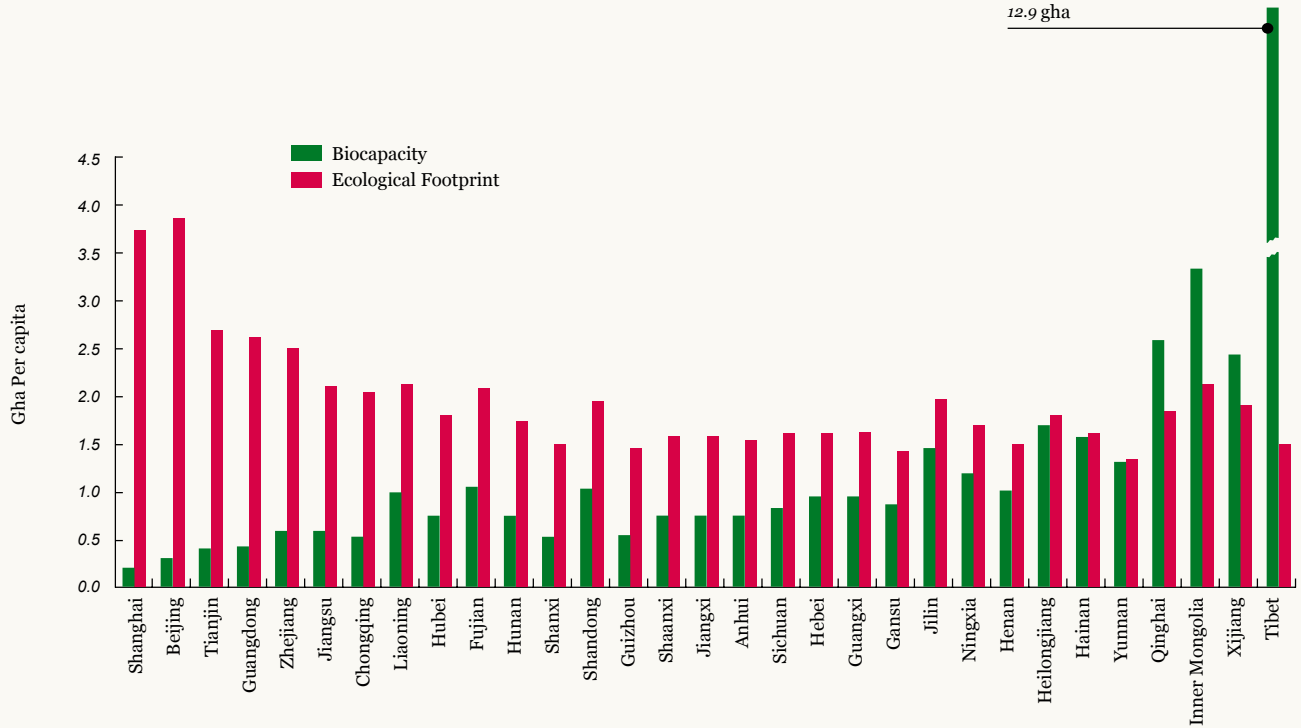
**Figure 4.7. Per person Ecological Footprint in China by province (1985/2008).**

Note: In 1985, Hainan and Chongqing were not yet independent provinces and their Ecological Footprint for this year was set at the levels of Guangdong and Sichuan, under whose jurisdiction they fell.

Data source: IGSNRR, 2010



The ecological pressure experienced by each province is determined by the ratio of its Ecological Footprint to biocapacity. During the period 1985-2008, only Tibet, Inner Mongolia, Xinjiang and Qinghai have consistently maintained an ecological surplus, as their biocapacity exceeded their Ecological Footprint. Fujian, Hainan and Heilongjiang have enjoyed an ecological surplus in some years while the remaining 25 provinces were in biocapacity deficit throughout this period. Heilongjiang has reduced its ecological deficit while the other 24 provinces have long term ecological deficit. Of the provinces with a biocapacity deficit, 70 percent lack sufficient carbon absorption land area even though their other land use types are not in deficit. The other 30 percent of provinces have a total biocapacity deficit.



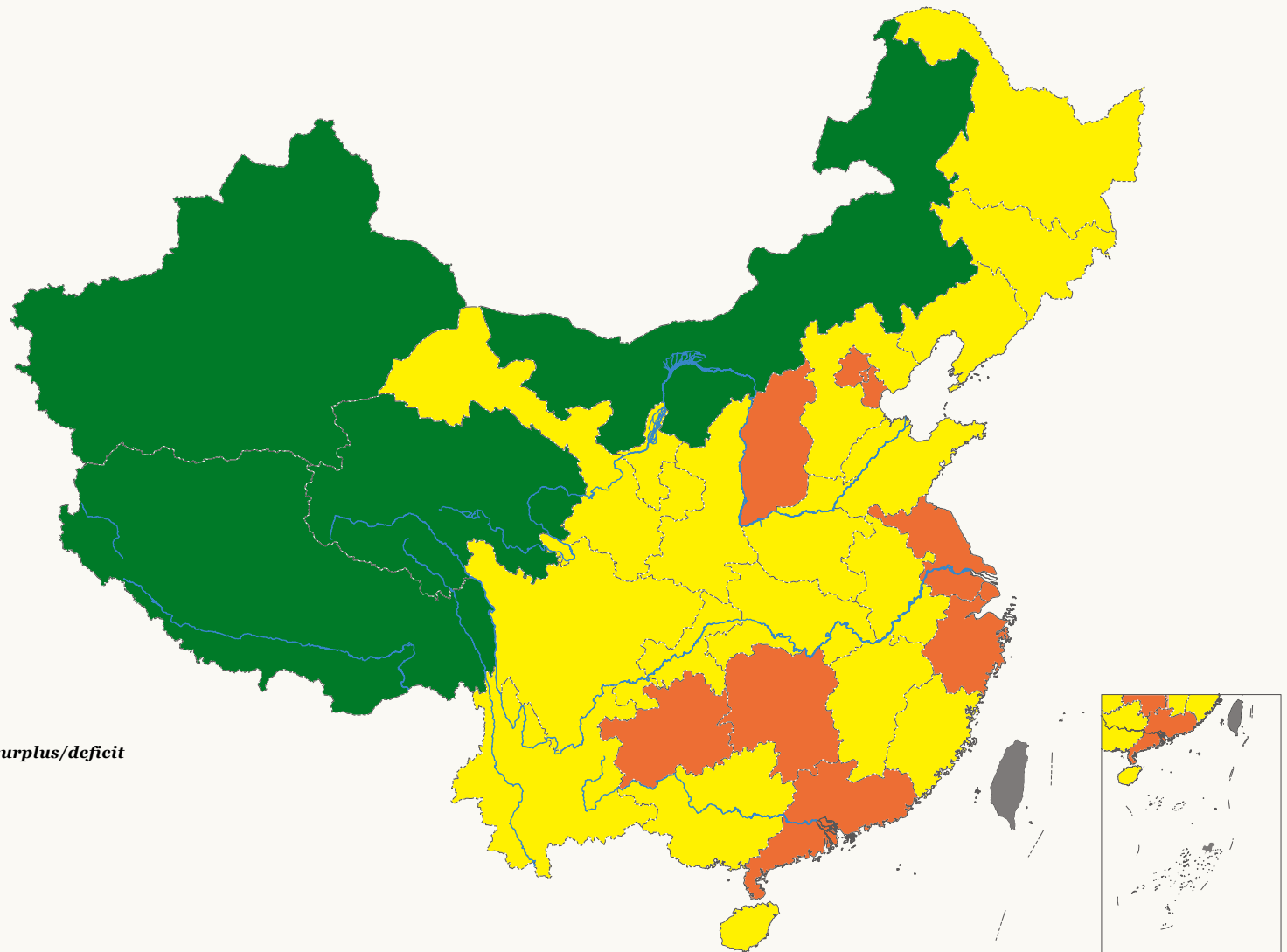
**Figure 4.8. Ecological Footprint and biocapacity in China's provinces (2008).**

China's provinces are ranked according to the difference between per capita Ecological Footprint and per capita biocapacity). The top five provinces in term of per capita biocapacity deficit in 2008 where Shanghai, Beijing, Tianjin, Guangdong and Zhejiang.

Data source: IGSNRR, 2010



- Biocapacity deficit
- Biocapacity surplus (excluding carbon)
- Biocapacity surplus
- No data



**Figure 4.9** China's Ecological Footprint surplus/deficit distribution (2008).

Data source: IGSNRR, 2010

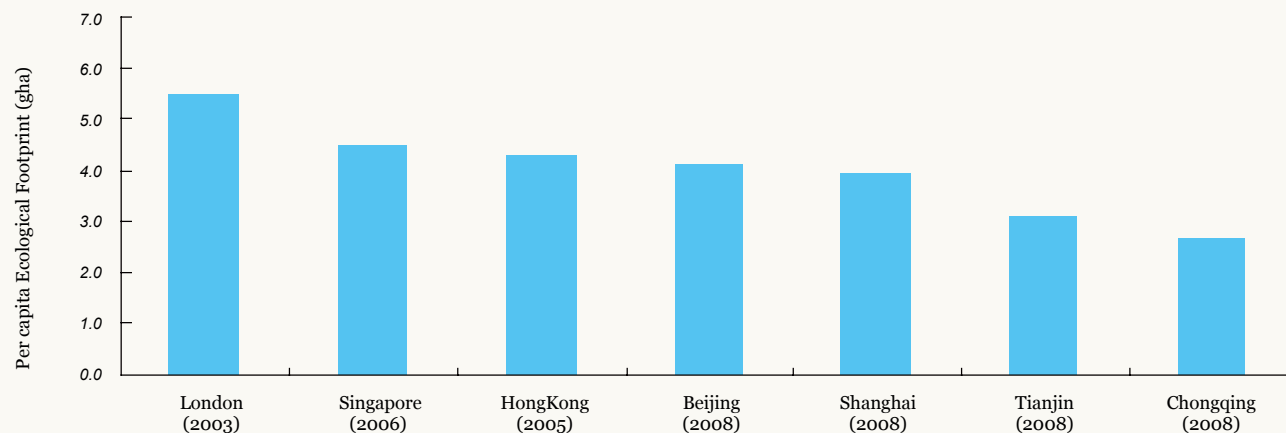
# 5. THE CHALLENGE OF URBANIZATION AND ECOLOGICAL FOOTPRINT

Cities are the economic centers of the world and home to a growing proportion of the world's population. Since 1900, the worldwide urban population has increased by 20 times while the rural population has increased by 2.5 times. As a proportion of the world's total population, urban population has climbed from 10 percent to around 50 percent in the same period.

As spatial units, cities now place the largest demand on the world's natural resources. Urban regions account for 80 percent of the world's carbon dioxide emissions from burning of fossil fuels and 75 percent of the world's timber consumption (O' Meara, 1999). The main causes of the huge demand that cities place on the environment are high population density, material consumption, energy consumption and waste discharge. Some cities now have an Ecological Footprint of 100 times their own biocapacity.

The environmental stresses and biocapacity deficit faced by cities worldwide provide China with an early warning of the ecological risks which may arise in its urbanization process. Nevertheless, cities can and sometimes do achieve good results in reducing Ecological Footprint. For example, London is a city with an almost entirely urban population (over 90 per cent), and yet its per person Ecological Footprint is 1.5 percent lower than the national average in the UK (Calcott and Bull, 2007). The urban design of cities like Tokyo, Seoul, Paris and London may serve as a reference in terms of reducing carbon dioxide emissions.

At this stage, Chinese cities appear to be doing relatively well in terms of their Ecological Footprint (Figure 5.1).



**Figure 5.1. Comparison of Ecological Footprint of cities.** The figures in brackets show the year for which Ecological Footprint values were calculated. Per capita Ecological Footprint for Beijing, Shanghai, Tianjin and Chongqing are per capita Ecological Footprint of urban population.

Data for Beijing, Shanghai, Tianjin and Chongqing sourced from IGSNRR.

Data for Singapore sourced from Ecological Footprint Atlas 2009 (GFN, 2009).

Data for Hong Kong sourced from Hong Kong Ecological Footprint Report 2008 (WWF & GFN, 2008).

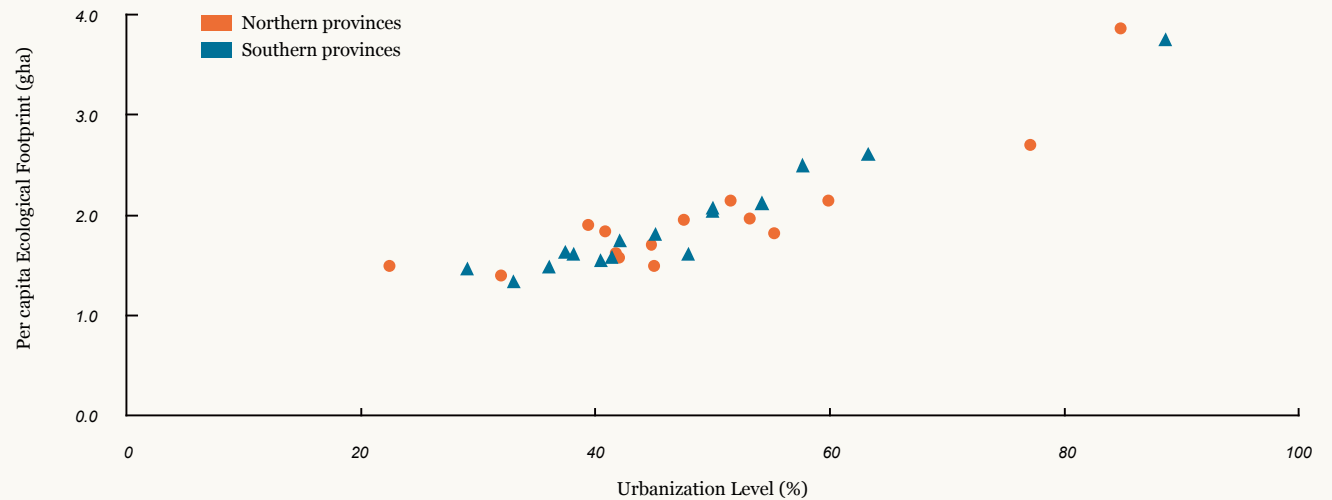
Data for London sourced from the published report by Alan Calcott and Jamie Bull (2007).

However, traffic congestion, pollution and other urban environmental problems have emerged as urban populations and living standards increase. Some Chinese cities are showing signs of environmental decline.

Compared to rural areas, cities have the largest concentrations of high income segments of the population, and are responsible for the bulk of resource consumption and carbon emissions. While dietary preferences and climatic variations between regions do affect Footprint, regional per person Ecological Footprint has a stronger overall association with urbanization (Figure 5.2).

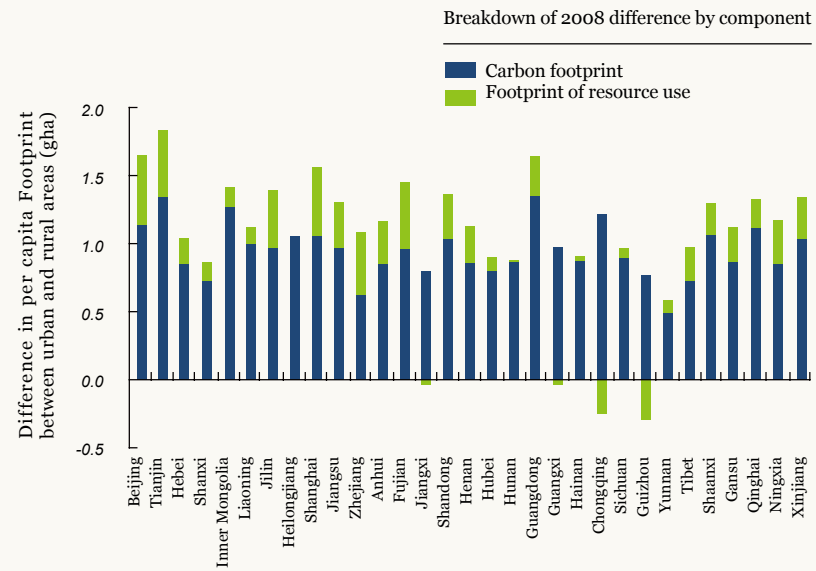
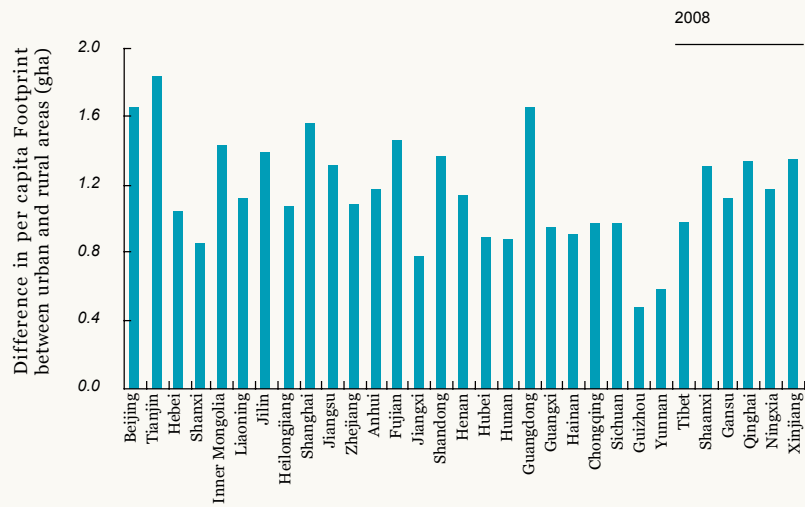
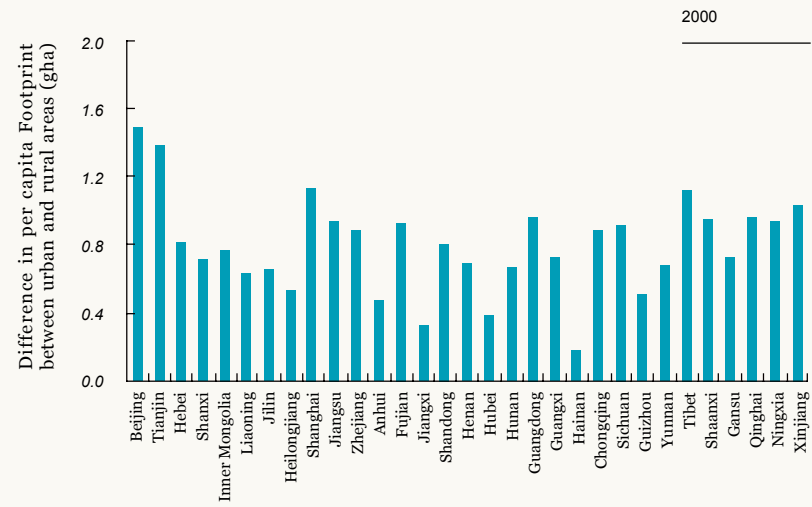
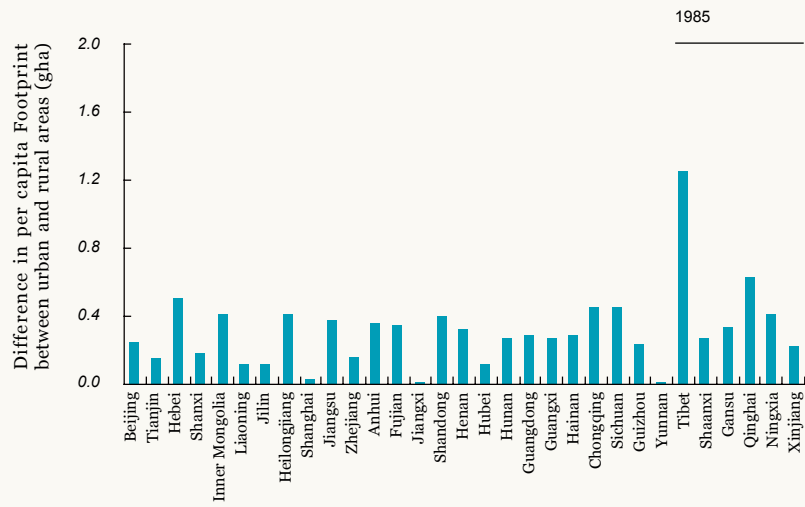
**Figure 5.2. Per person Ecological Footprint and urbanization levels in China (2008).**  
Urbanization level is the percentage of urban population in the total population of the province.

Data source: IGSNRR, 2010



Within provinces in China, there is a marked difference in per person Ecological Footprint between urban and rural areas and this gap may continue to widen in the near future (Figure 5.3). The per capita Ecological Footprint of urban areas is 0.9–1.8 gha higher or 1.4 to 2.5 times greater than rural areas. This gap has increased sharply since 1985 and on average 74 percent of the gap is due to carbon footprint. This is mainly due to the urban and rural income gap and consequent differences in consumption and energy utilization. The changes in residential patterns and lifestyles that accompany urbanization present a specific challenge in terms of managing rapid Ecological Footprint growth for China.

China is at a stage of rapid urban expansion, with urbanization growing at an annual rate of 1-1.5 per cent since 1996. Increased urbanization and associated changes in lifestyles might generate further growth in China’s Ecological Footprint, particularly in carbon footprint. Yet cities also present a major opportunity, as reducing Footprint in cities will lead to a significant reduction of overall Ecological Footprint. By pursuing a low carbon and environmentally benign approach to urban development together with a more balanced relationship between urban and rural areas, appropriate urban planning and environmentally-friendly lifestyles, urban areas could lead the way in curbing China’s fast-growing Ecological Footprint.



**Figure 5.3. Ecological Footprint gap between urban and rural areas in China.**

The gap is calculated as average per person Footprint in urban areas minus the average per person Footprint in rural areas

Data source: IGSNRR, 2010

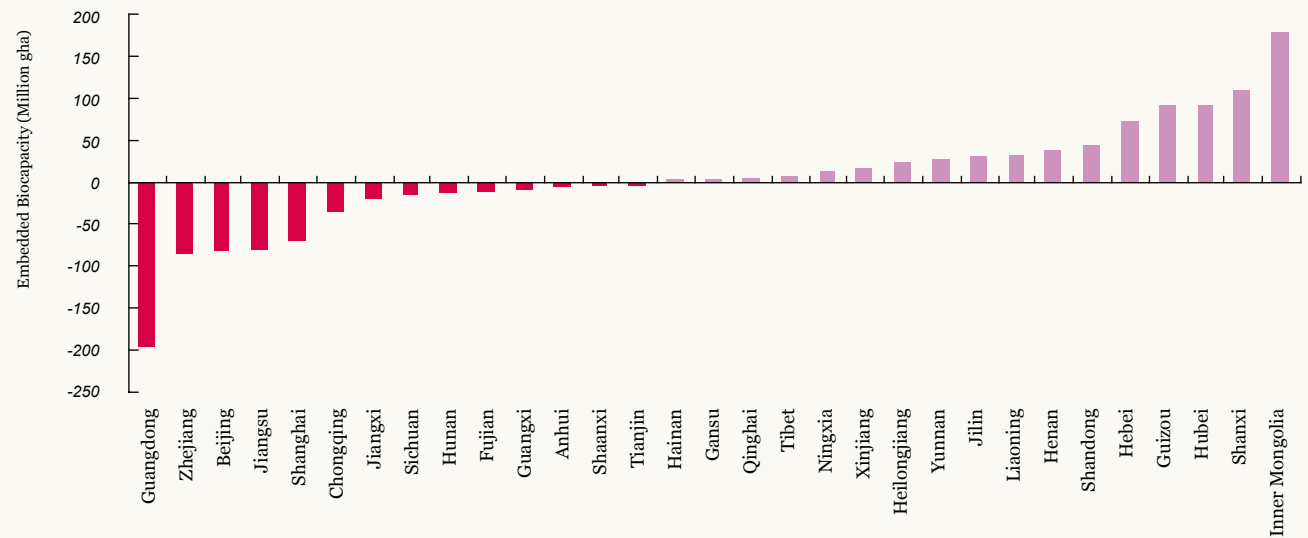
## 6. THE NATIONAL IMPACT OF CHINA'S ECOLOGICAL FOOTPRINT

As a result of market mechanisms and trade patterns, human consumption of ecological resources and services is no longer confined to administrative boundaries. Biocapacity, both local and imported, is embedded in goods and services throughout the production process ('embedded biocapacity') and transferred through inter-provincial and international trade. At a national level, China's total demand for the non-carbon components of its Ecological Footprint could be in theory satisfied by its domestic ecosystems. However, the uneven distribution of biocapacity in China means that transfer

**Figure 6.1. Ecological Footprint in/out flow from each province in China (2008).**

A negative value means that the province utilizes biocapacity of other regions through trade; a positive value means that the province exports biocapacity through trade, thereby placing a demand on local ecosystems or on the global commons due to transfers of footprint embedded in products.

Data source: IGSNRR, 2010



of embedded biocapacity through inter-provincial trade can create net importers and exporters. Development at the provincial level is associated with an increase in the volume of embedded biocapacity involved in cross-provincial flows and an increase in the distances over which this is transported.

Data concerning China's inter-provincial trade is sparse or nonexistent, making it difficult to calculate the scale of inter-provincial biocapacity flows in China. We can derive conservative estimates of inter-provincial biocapacity flows by looking at the difference between Ecological Footprint of production and consumption activities.

These calculations suggest that inter-provincial Ecological Footprint flows in China exceeded 678 million gha in 2008, accounting for 27 per cent of the national Ecological Footprint. Electricity and goods and services consumption accounted respectively for 60 per cent and 40 per cent of this cross-provincial flow. Biocapacity inflows are greatest for provinces with a high level of urbanization, dense population, intensive industrial production but relatively meagre energy resources such as Guangdong, Shanghai, Zhejiang and Beijing. Another factor is loss of productive land area due to development. In Zhejiang for instance, a decrease in biocapacity and productive land area due to high-intensity industrial production has contributed to its demand for imported biocapacity (Figure 6.1).

Inter-provincial flows of embedded biocapacity still represent a relatively low proportion of China's total Ecological Footprint of consumption. This is mainly because production facilities are established close to end users, and power generation and agricultural production are concentrated in coal and land rich provinces.

Resource rich regions in China bear excessive burdens of biocapacity supply to other regions, and inadequate compensation for this gives rise to ecological degradation, low per capita income, as well as inadequate public facilities and social services. It is important to establish markets in ecosystem services and other measures in order to provide economic compensation to regions supplying ecosystem services and to promote the development of fair trade arrangements between regions.

# 7. DEVELOPMENT AND ECOLOGICAL FOOTPRINT

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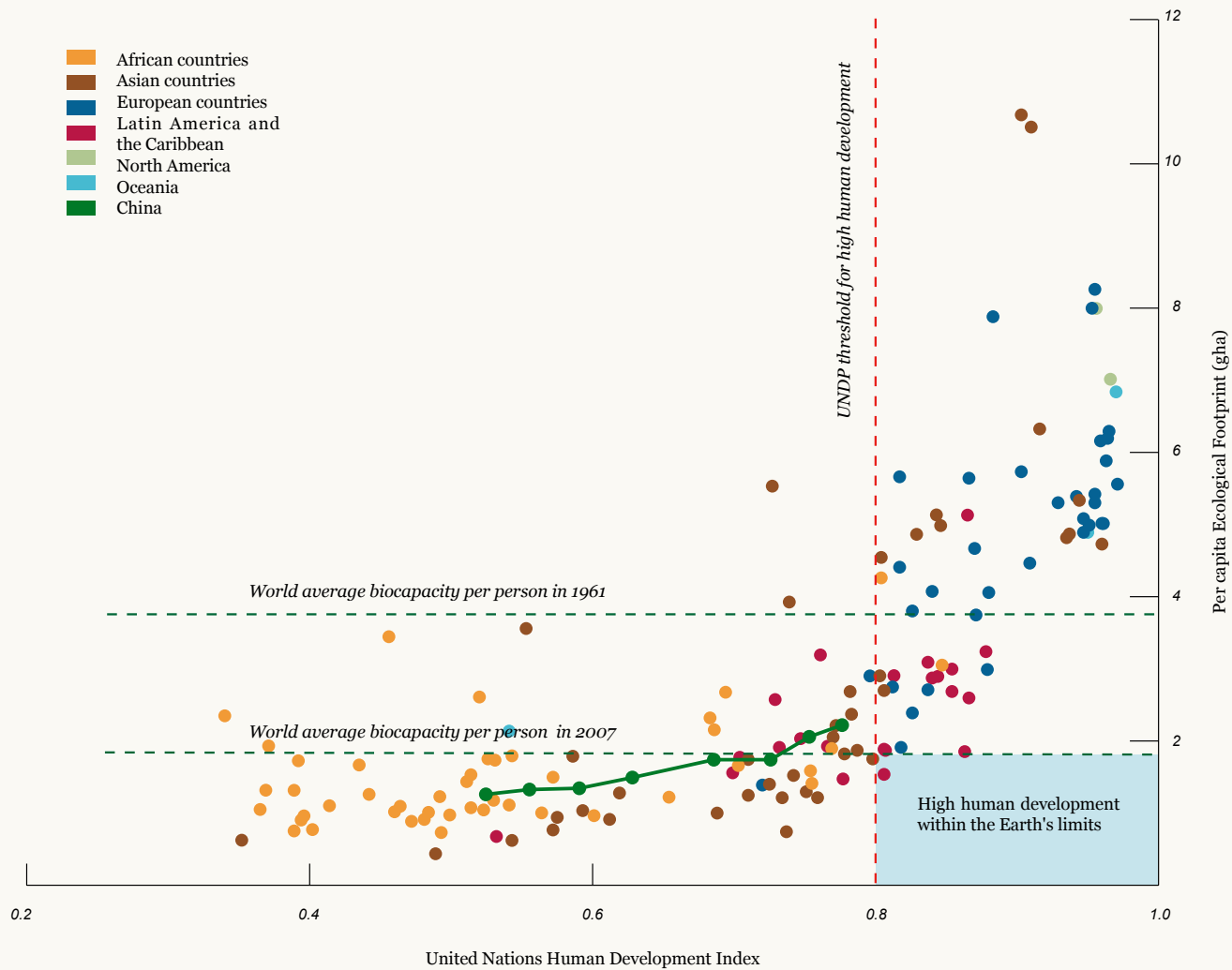
Progress towards meeting the goals of sustainable development can be examined through the combination of Ecological Footprint and the Human Development Index (HDI). The HDI is a summary composite index developed by the United Nations Development Program (UNDP) that measures a country's average achievements in three basic aspects of human development: health, education and standard of living (Figure 7.1).

UNDP considers countries with HDI values of 0.8-0.899 to be experiencing "high human development" (HHD) and 0.9 or greater to be experiencing "very high human development." Accordingly, this report considers the lower boundary of HHD to be the minimum level of optimal development. As noted above, the global average biocapacity per person is 1.8 gha, so in order to meet the minimum levels of sustainability, including the needs of wild species, per person Ecological Footprint must be below 1.8 gha. While these criteria may be necessary for a society to be considered sustainable in the global context, it is important to note that they are not in themselves sufficient to ensure sustainability. There are a large number of environmental, physical, and social factors which these two indicators do not capture, and they should ideally be used in the context of a broader set of indicators to guide sustainable development.

Figure 7.1 shows that while China's HDI increased significantly from 1971 to 2004, per person Ecological Footprint remained smaller than available per capita biocapacity at the global level. In 2007, China's HDI increased to 0.772, slightly lower than the high human development threshold of 0.80, and its per person Ecological Footprint reached 2.2 gha, higher than the available biocapacity per person.

Two of the principal drivers of global Ecological Footprint growth are consumption patterns and population. Figure 7.2 highlights that while the rate of China's population growth has remained steady, the rate of per person Ecological Footprint increase has escalated in recent years and has now overtaken population as the main factor driving national Footprint growth (Figure 7.2).

Analysis of data for China's provinces suggests that when the average person begins earning more than what is needed for basic survival, excess income can become a driving factor for the increase in Footprint (Figure 7.3). For provincial units where per capita GDP is lower than 30,000 RMB per year (approximately 4,500 US dollars), the average per person Ecological Footprint is approximately 1.8 gha and variations between provinces can be largely explained by the influence of geography, climate and food preferences. Conversely, for provinces where per capita GDP exceeds 30,000 RMB, the per person Ecological Footprint appears to show a positive association with per capita GDP, indicating that as wealth increases above the level needed for basic survival, Ecological Footprint also increases, rendering influences of geography, climate and regional food preferences relatively less important.



**Figure 7.1. Human development and Ecological Footprint.** A Human Development Index (HDI) value of more than 0.8 is considered to represent “high human development” while an Ecological Footprint lower than 1.8 global hectares per person, the average biocapacity available per person on the planet, represents a lifestyle that could be sustainably replicated on a global scale. Together, these indicators form a “sustainability box” which can be used to define the criteria that must be met for a globally sustainable society. As world population grows, less biocapacity is available per person and the quadrant’s height shrinks. The green line shows the development trajectory of China from 1971 to 2007.

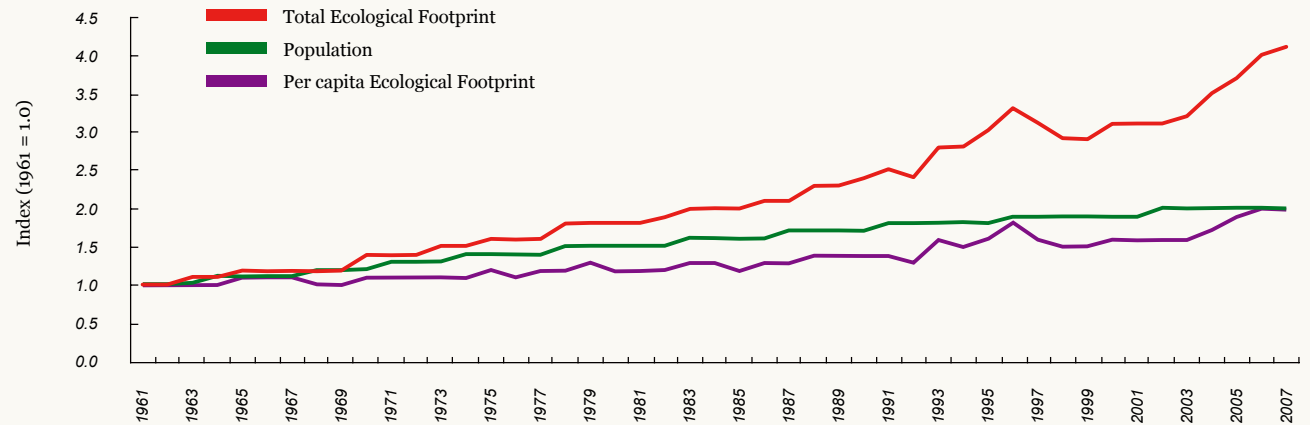
Data source: Global Footprint Network, 2010; UNDP, 2009b.



**Figure 7.2. Changes in China's per person Ecological Footprint, population and total Ecological Footprint (1961-2007).**

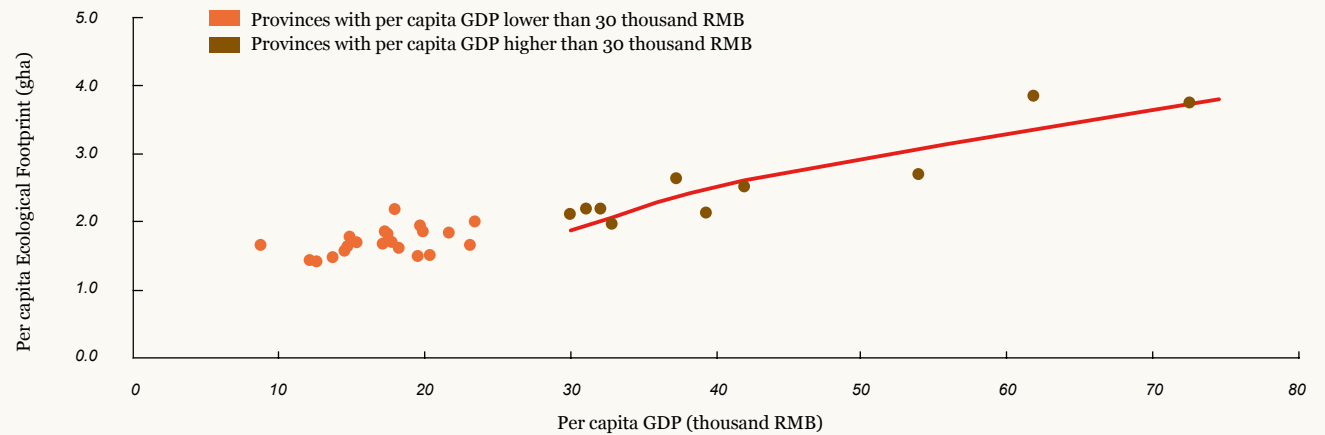
China's per person Footprint and population roughly doubled between 1961 and 2005, together producing more than a four-fold increase in its total Ecological Footprint.

Data source: Global Footprint Network, 2010



**Figure 7.3. Ecological Footprint and GDP in China by province (2008).**

Data source: IGSNRR, 2010



## 8. THE GLOBAL REACH OF CHINA'S ECOLOGICAL FOOTPRINT

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The following analysis of the global impact of China's Ecological Footprint explores the international trade in the resource use and carbon components of Footprint that are embedded in both raw materials and manufactured products, and is mainly based on data and analysis from 2008 provided by IGSNRR. As a country with a net export of industrial products, part of China's carbon emissions are due to embedded carbon consumed in other parts of the world, but there is not yet a consensus on how this should be measured. This analysis suggests that China's net export of carbon footprint embedded in products exceeds 80 million gha. This is equivalent to around 0.06 gha per capita or two times the volume of imported biocapacity, excluding carbon.

With regard to biocapacity, as with the first "Report on Ecological Footprint in China", the trade data in this report is based on Footprint of resource use, with the number of product items considered expanded from 43 to 132 categories. In 2008, China was a net importer of 44 million gha of biocapacity excluding carbon – a result of total imports of 160 million gha and total exports of 116 million gha. Including carbon, China is a net exporter of biocapacity.

Forest land is the most actively traded component of biocapacity, accounting for 41.3 percent of China's imports, and 29.1 percent of its exports of biocapacity. The net import is approximately 32 million gha. Forest land is in high demand because of China's relative shortage of forest resources, while China also exports significant quantities of furniture, paper and printed products.

Cropland is the second most actively traded component of biocapacity in terms of volume and of net imports. Arable land accounts for 40.2 percent (64 million gha) of imported biocapacity and 37 percent (37 million gha) of exported biocapacity. Imports are largely accounted for by vegetable oil while exports include fruit, vegetables and textiles.

**Figure 8.1. China's biocapacity flows in international trade (2008).**

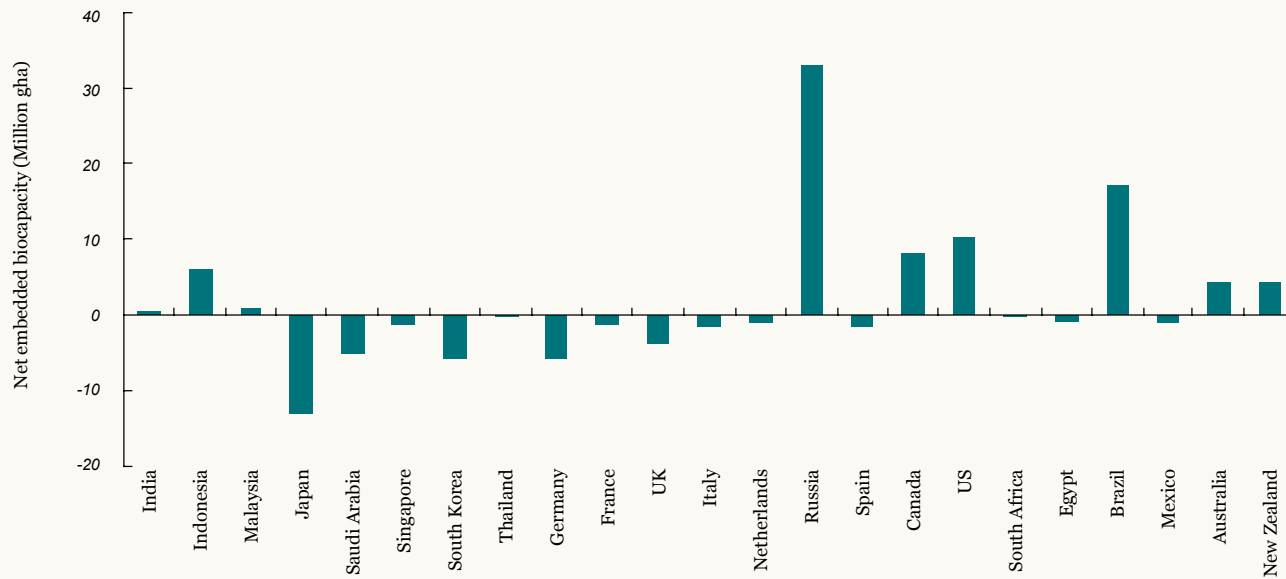
Data source: IGSNRR, 2010



China has now become a net exporter of grazing land biocapacity as a result of improvements in livestock production capacity. In 2008, China's trade in embedded grazing land resulted in net exports of 3 million gha of grazing land biocapacity, mostly in the form of wool textiles.

China continues to be a net exporter of the fishing grounds component of biocapacity. In 2008, its net export of fishing grounds reached 13 million gha, making notable contributions to reducing China's overall net imports of biocapacity.

An analysis of resource-based biocapacity flows (excluding carbon and built-up land) between China and its 23 major trading partners shows that China was a net importer in 2008 with biocapacity inflows - primarily from Russia, Canada, Brazil, the US and Indonesia - totalling 126 million gha, and outflows - primarily to Japan, South Korea, Saudi Arabia, Germany and the UK - totalling 83 million gha. This resulted in a net inflow of 44 million gha (Figure 8.2).



**Figure 8.2. Net resource-based biocapacity flows between China and its major trading partners (2008).**

Notes:

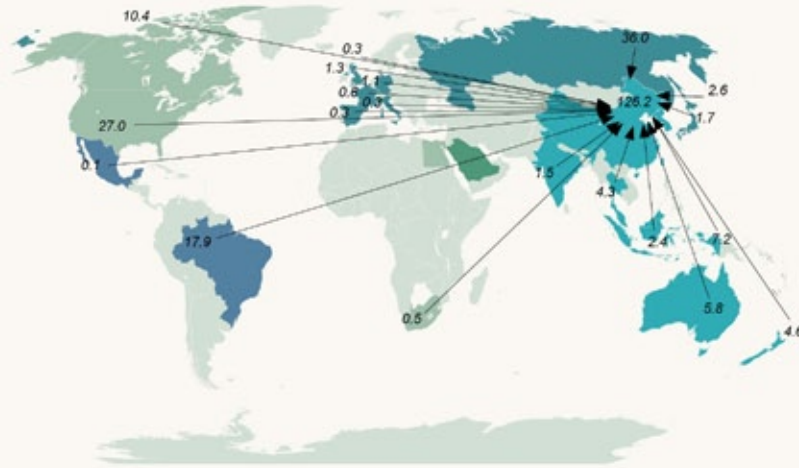
(1) Positive values indicate net import; negative values indicate net export.

(2) Between 21-30 percent of China's internationally-traded biocapacity concerned countries other than those listed in the figure.

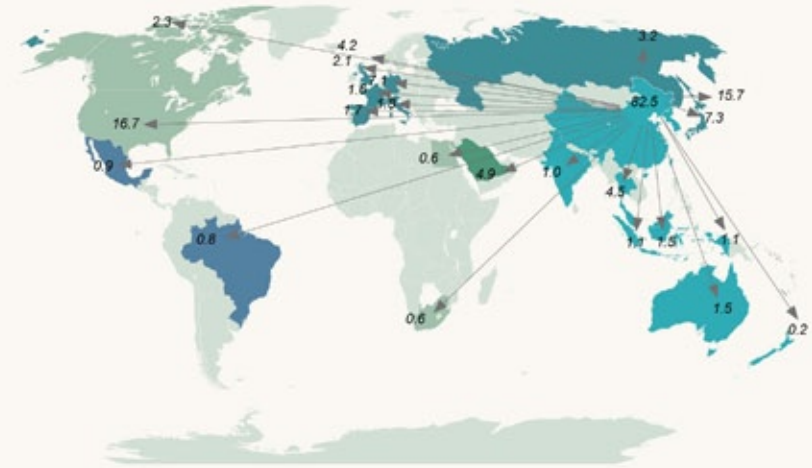
Data source: IGSNRR, 2010

The flow of resource-based biocapacity in China's international trade is relatively concentrated in terms of the number of trading partners, with imports more concentrated than exports. This concentration is particularly striking when considered by component. For example, 78.2 percent of the forest land biocapacity imported by China in 2008 came from just five countries: Russia, which provided 42.3 percent of imports, and Canada, the US, Indonesia and Brazil which together accounted for a further 35.9 percent. The largest share of exports went to the US (18 percent), with Japan, South Korea and the UK together accounting for 17 percent of exports, and Saudi Arabia, Russia, Canada and India a further 10 percent. Over half of China's imported cropland biocapacity came from the US and Brazil, while over half of grazing land capacity came from Australia and New Zealand. China's exports of cropland biocapacity went to Japan (18.4 percent), US (10.9 percent), UK (7.9 percent) and South Korea (6.6 percent). In contrast, the export destinations of grazing land biocapacity were highly dispersed.

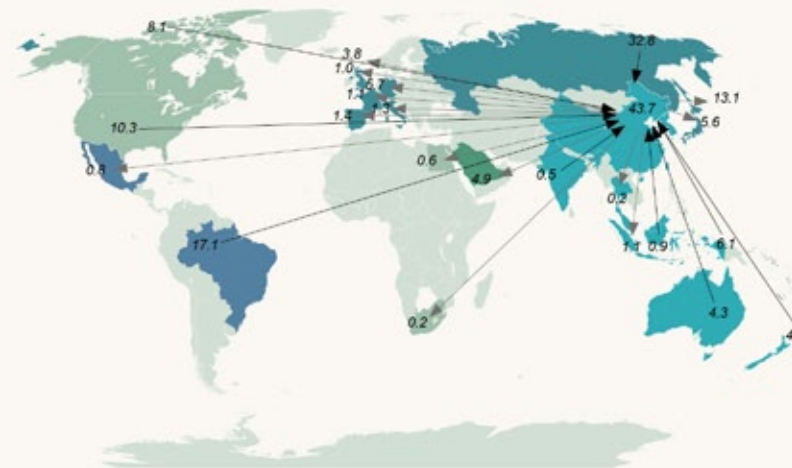
Further insights into international biocapacity flows are provided by trade reallocation analyses. These look at the ultimate fate of imported biocapacity, in direct local consumption, domestic reallocation through trade as embedded biocapacity in manufactured or processed products, and international reallocation through trade as embedded biocapacity. In 2008, 20 percent of China's imported biocapacity was consumed directly, 35 percent was reallocated domestically and 45 percent was reallocated internationally. International trade reallocation of biomass-based biocapacity is largely accounted for due to trade in wood-based products, seafood, and cotton and wool textiles.



**Figure 8.3. China's resource-based biocapacity inflow (2008).**  
Data source: IGSNRR, 2010



**Figure 8.4. China's resource-based biocapacity outflow (2008).**  
Data source: IGSNRR, 2010



**Figure 8.5. China's net resource-based biocapacity inflow and outflow (2008).**  
Data source: IGSNRR, 2010

If we take the import and export of both natural resource products and industrial products into consideration in the calculations of total ecological footprint, China is not only a net exporter of commodities, but also a net exporter of biocapacity. In light of the above analysis, China should implement policies to control the import and export of carbon, energy and resource intensive products in the global flows of biocapacity. It is also important to control the import of natural resource commodities from ecological degraded lands and protect both China's and the world's ecological security.

# 9. WATER FOOTPRINT

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Water, together with land and energy, is an indispensable factor for human survival that underpins biological productivity and sustainable socio-economic development. Humanity's demand on water resources can be quantified and analyzed by water footprint.

Water footprint measures the total volume of water that is used to produce the goods and services that we consume. It accounts for the volume of green (rain) and blue (withdrawn) water consumed in the production of agricultural goods from crops and livestock – the major uses of water – as well as the grey (polluted) water generated by agriculture and from household and industrial water use. The water footprint broadens the traditional assessment of water resources to better reflect the availability of water and the demand placed on water resources by humans.

## **Water Footprint**

The Water Footprint is the volume of freshwater used by people to produce goods, measured over the full supply chain, as well as the water used in households and industry, specified geographically and temporally. It has three components:

- **Green water footprint:** the volume of rainwater that evaporates during the production of goods; for agricultural products, this is the rainwater stored in soil that evaporates from crop fields.
- **Blue water footprint:** the volume of freshwater withdrawn from surface or ground water sources that is used by people and not returned: in agricultural products this is mainly accounted for by evaporation of irrigation water from fields.
- **Grey water footprint:** the volume of water required to dilute pollutants released in production processes to such an extent that the quality of the ambient water remains above agreed water quality standards. Given the negligible volume of water that evaporates during domestic and industrial processes, the Water Footprint of Production only includes the grey water footprint for households and industry (Hoekstra and Chapagain, 2008).

## **Water Footprint of Production**

The Water Footprint of Production of a region is the volume of freshwater used to produce goods and services within a given area, irrespective of where those goods and services are consumed. With the support of water stress analysis, the Water Footprint of Production can be used to evaluate the pressure that national or regional production is placing on local ecosystems. Water stress is defined as the ratio of water use to water availability. This is mainly calculated on an

annual basis as the total amount of blue and grey water use compared with the total renewable water resources available in a region.

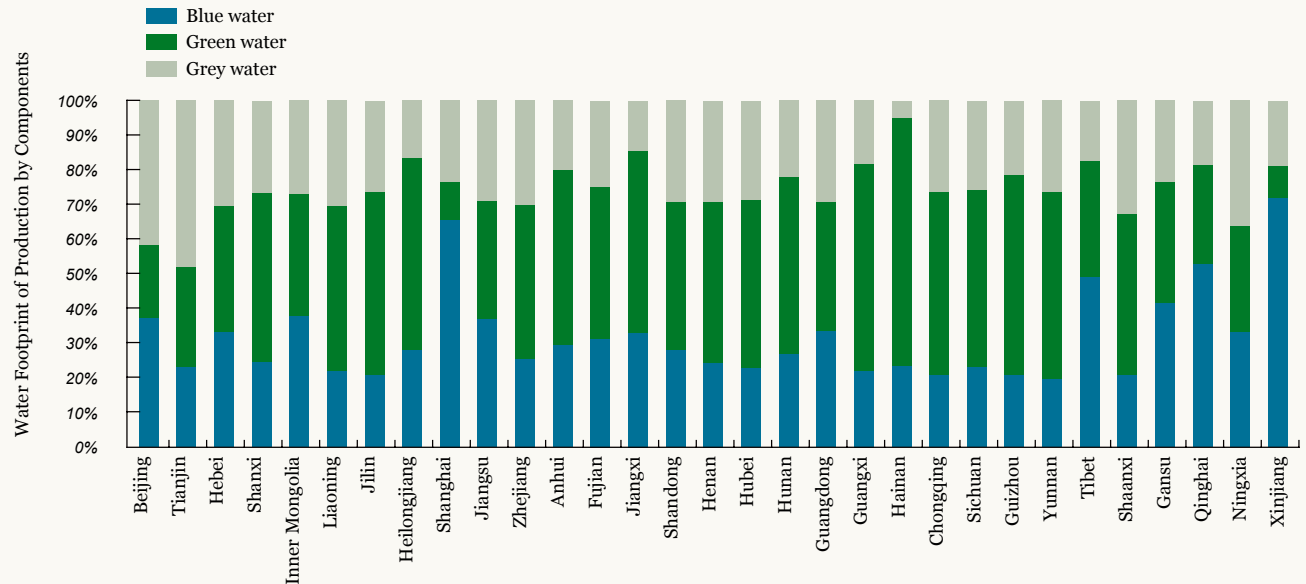
The present status of China's water resources is serious. In 2007, 5 out of 31 provinces (Beijing, Tianjin, Hebei, Ningxia and Shanghai) were experiencing severe stress (>100 percent), four regions were experiencing high stress (40-100 percent); seven regions moderate stress (20-40 percent) and 12 minimal stress (5-20 percent). Of the 31 provinces, only Yunnan, Qinghai and Tibet suffered no water stress (Figure 9.2). Severe water stress is a result of high population (Beijing, Tianjin and Shanghai), intensive agriculture (Hebei and Ningxia) and local climatic conditions (Ningxia). Regions in northern China, central China, and in downstream areas of the Yellow and Yangtze rivers are facing the most serious stress.

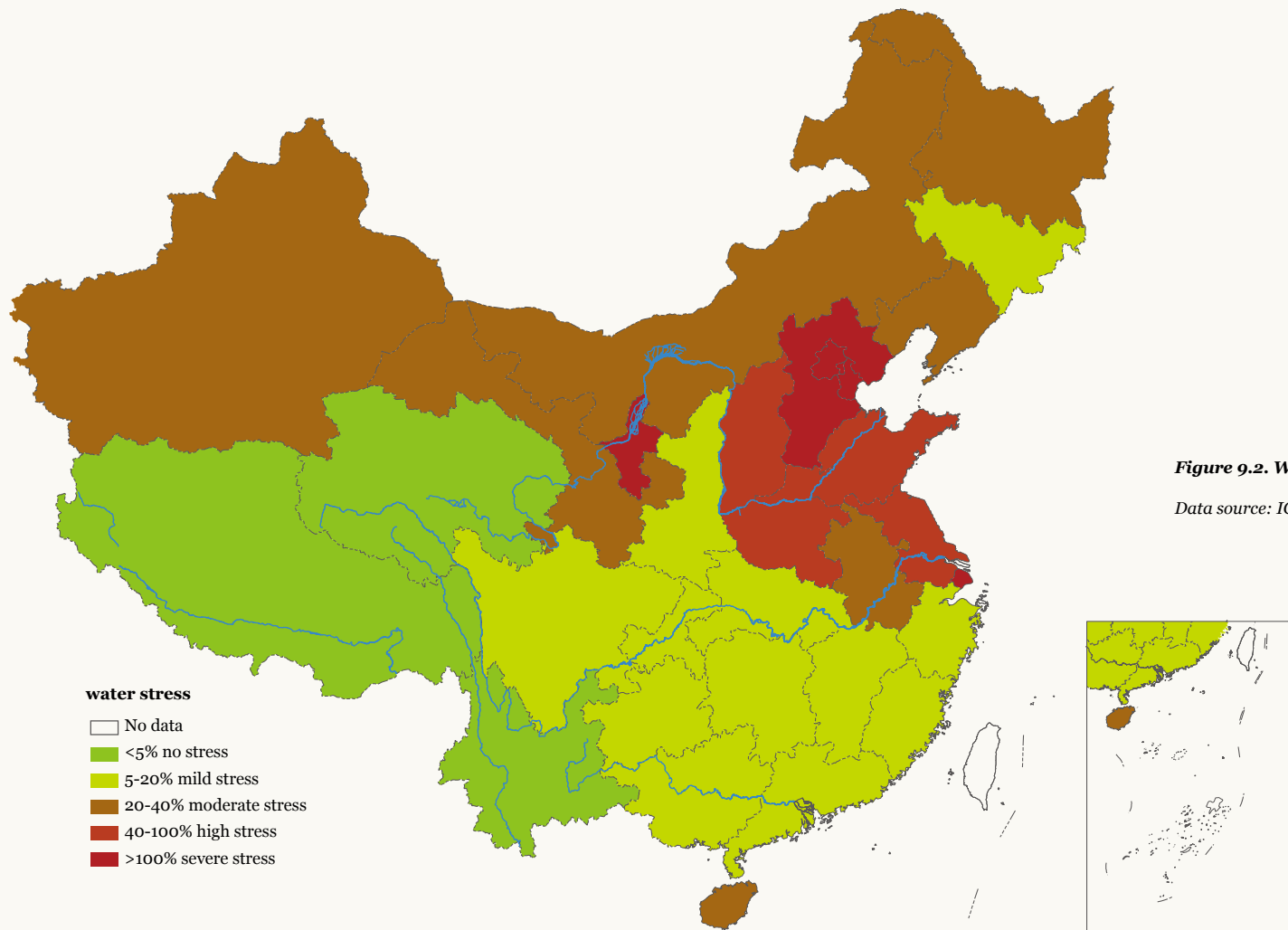
Use of green water has a lower opportunity cost and environmental impact than extraction of blue water and plays an important role in water and food security. However, green water has been largely overlooked in traditional water resources assessment systems, despite accounting for more than 30 percent of the Water Footprint of Production in 26 out of 31 provinces. In 11 provinces green water footprint exceeded 50 percent of Water Footprint of Production (Figure 9.1), suggesting it should not be overlooked in developing solutions to water problems.

Grey water footprint evaluates the impact of production activities on water quality. In 2007, grey water footprint accounted for more than 25 percent of the Water Footprint of Production in two thirds of China's provinces, mainly as a result of application of agricultural chemicals. Grey water footprint accounted respectively for 22.5 and 26.1 percent of the total Water Footprint of Production in the wheat and maize producing areas in northern China. Improvement in the efficiency of fertilizer and pesticide applications is thus significant both for the agriculture sector and for tackling the water challenge.

**Figure 9.1. China's Water Footprint of Production by province showing components by percentage (2007).**

Data source: IGSNRR, 2010





**Figure 9.2. Water resources stress in China's provinces (2007).**

*Data source: IGSNRR, 2010*

### **Water Footprint of Consumption**

The Water Footprint of Consumption of a region is the volume of water used in the production of goods and services consumed by the inhabitants of that region, irrespective of where the goods and service are produced. The Water Footprint of Consumption comprises internal water footprint (the volume of domestic water resources used to produce the goods consumed in that region) and external water footprint (the volume of water used in other countries/regions to produce the goods consumed by that region).

In 2007, the average per capita Water Footprint of Consumption in China was only 679 m<sup>3</sup> per year, or 43 percent of the global average of 1564 m<sup>3</sup> per year (Chapagain and Orr, 2008) in 2004 (the most recent year when global data

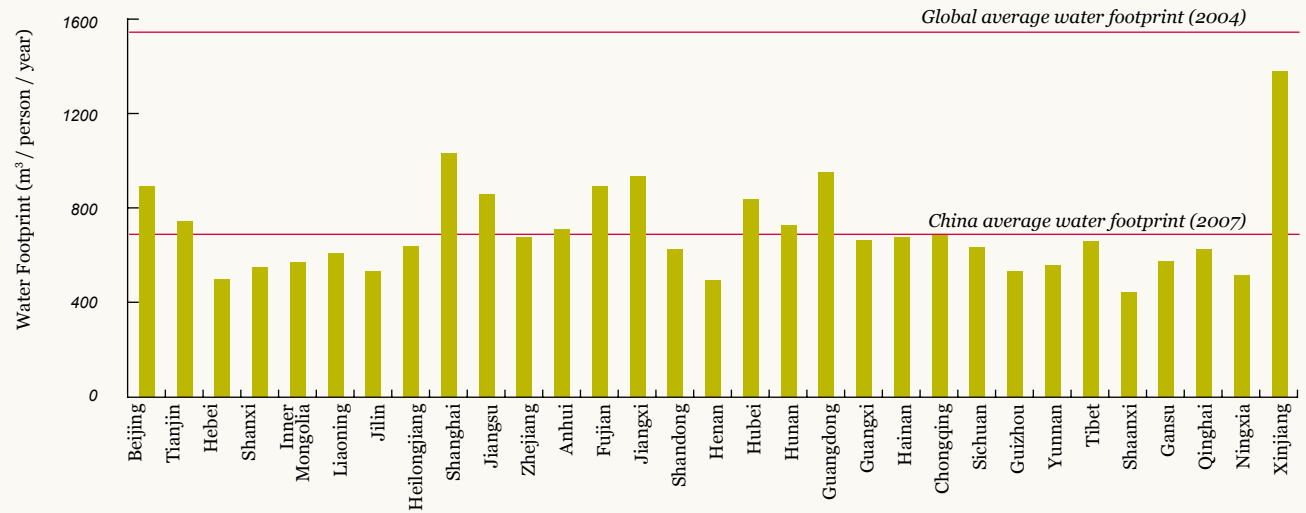


was available). There is a large variation across different provinces in China (Figure 9.3). Factors influencing the Water Footprint of Consumption in China include high level of economic development, changes in lifestyle and water use patterns in agriculture.

Some two thirds of China's provinces rely on their own water resources almost entirely, with their internal water footprint representing more than 90 percent of their Water Footprint of Consumption (Figure 9.4). Beijing has the largest external water footprint, at around 50 percent, while the external water footprint of Guangdong, Shanghai, Tianjin and Jiangxi is between 18-26 percent of their Water Footprint of Consumption.

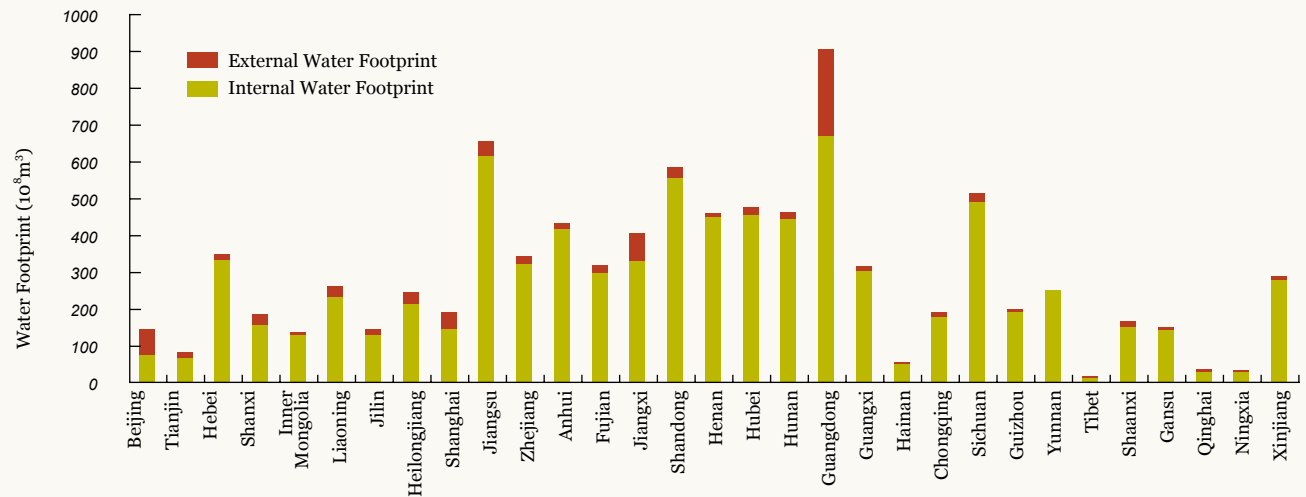
**Figure 9.3. China's average Water Footprint of Consumption per person by province (2007).**

Data source: IGSNRR, 2010



**Figure 9.4. China's Water Footprint of Consumption by province (2007), showing internal and external components.**

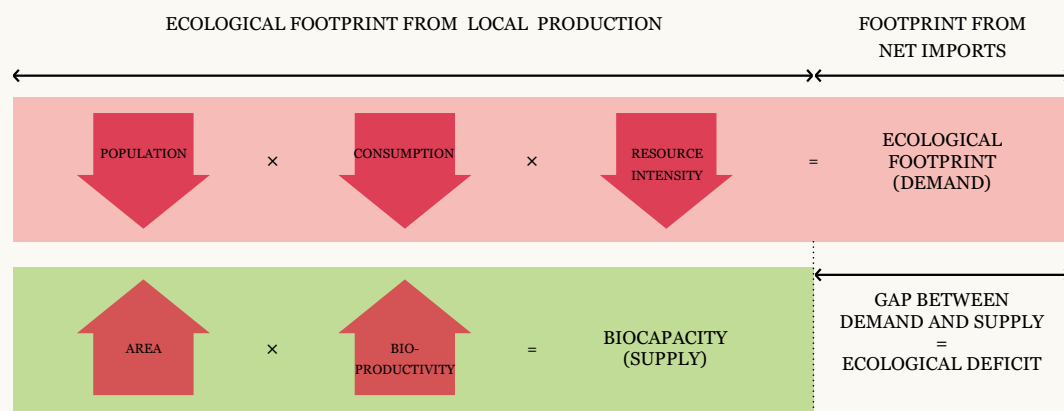
Data source: IGSNRR, 2010



# 10. CHINA'S TRANSFORMATION TOWARDS SUSTAINABLE DEVELOPMENT

In a world with limited resources and regeneration capacity, if humanity is to develop sustainably, continuously improve human welfare while leaving space for nature, we have to live within the capacity of the ecosystems of planet Earth and that means reducing ecological overshoot. Of the five factors that determine ecological overshoot (Figure 10.1), China's ecological footprint will depend more on its population's level of consumption and resource use intensity, while biocapacity will depend on the amount and productivity of ecologically productive land.

On a global level, Ecological Footprint is continuing to grow, with the average per person Ecological Footprint reaching 2.7 gha in 2007 – 50 percent larger than the biocapacity available per person. This means that in 2007, people used the equivalent biocapacity of 1.5 planets to support their activities, or, put another way, that global ecosystems would need one and half years to regenerate the natural resources consumed and absorb the carbon dioxide emitted that year. In China, the average per capita Ecological Footprint has reached 2.2 gha in 2007. While China's per person Footprint is lower than the global average level, China's total Ecological Footprint is two times greater than its available biocapacity, and its biocapacity deficit is continuing to increase year by year. If all the world's inhabitants consumed resources at the same level as the average Chinese person, then we would need 1.2 Earths to meet this demand.



**Figure 10.1 Five major factors affecting biocapacity deficit.**

Five factors determine the size of a country's biocapacity deficit. Three of these factors influence the country's total demand on the planet: population size, average consumption per person, and resource use intensity. Two additional factors determine biocapacity, or what the country's ecosystem's can supply: the amount of biologically productive area available, and the productivity or yield of that area. The amount by which a country's Ecological Footprint exceeds its biocapacity is its biocapacity deficit.

Data source: Global Footprint Network, 2010

In the last half century, China achieved a rapid increase in human development as measured by the 'Human Development Index' (HDI), and in 2007 was close to the threshold for high human development. While per capita income increased more than 50 times, this study shows that per capita Ecological Footprint increased by around four times in the same period. China's per person Footprint has recently overtaken the level of biocapacity available per person on a global basis, some 30 years after the world as a whole crossed this threshold.

There are signs that China is at an important turning point. For example, the rate of Footprint growth slowed in two thirds of China's provinces between 2005 and 2008, compared to the previous five year period. However, overexploitation of natural resources is a concern and has led to loss of ecosystem services in some areas, even in resource rich provinces. The growth in Ecological Footprint of China is influenced by levels of urbanization and individual wealth. China is currently engaged in the establishment of an environmentally-friendly society and is facing up to the challenge of reducing its biocapacity deficit by increasing biocapacity and curbing growth in Ecological Footprint. At the heart of this challenge is the need to decouple economic growth from growth in Ecological Footprint while leaving space for nature. Measures suggested below can contribute to achieving this goal.

### **Recommendations:**

#### **1. Use the relationship between Ecological Footprint and biocapacity as one of the key indicators of progress towards an 'ecological civilization'.**

The term 'ecological civilization' is commonly used in official discourse in China. China aspires towards the development of an 'ecological civilization' as its path towards sustainability following earlier agricultural and industrial stages. Reducing Ecological Footprint and increasing biocapacity are both important pathways towards achieving an 'ecological civilization'. By comparing human demand on the environment, represented by Ecological Footprint, with the capacity of natural ecological systems, represented by biocapacity, in order to determine whether the demand creates an ecological surplus (where biocapacity exceeds Ecological Footprint) or an ecological deficit (where Ecological Footprint exceeds biocapacity), we can assess the environmental impact of development. It is recommended to use these measures for determining whether or not a society is on track to better manage natural resources. This can be monitored by establishing a national Ecological Footprint and biocapacity accounting system to track utilization of, and changes in, local ecological resources. This system, together with other indicators, can be used to support economic policy-making and local development plans by offering straightforward scientific analyses.

#### **2. Strengthen ecosystem management and improve biocapacity.**

China has limited natural resources on a per capita basis, and improving this ecological base is a key strategy to ensure national ecological security. Hence, China should strengthen ecosystem management and increase biocapacity through the following measures:

(1) Maintain a healthy natural environment and preserve biologically productive forests, grassland, etc. As a country with scarce ecological resources on a per capita basis, it is vital that China preserves its existing natural ecosystems for future generations. This can be accomplished by (a) enforcing strict land use planning policies; (b) implementing ecological restoration and nature conservation policies; (c) increasing the area of ecologically

productive land and optimizing the use of land according to local geographical and climatic conditions; (d) compensating net biocapacity exporting regions through a variety of economic and administrative measures; and (e) restoring ecologically degraded regions, thereby improving their productivity and pollution absorption capacity.

(2) Increase land productivity, promote increases in biocapacity while conserving biodiversity. Unlike some other countries, the biocapacity of China has continuously increased; for example, forest coverage has expanded over the last 30 years and the scale of production of aquaculture and agriculture has increased – in recent years, one fifth of the world's grain, half of its vegetables and one third of its meat products were produced in China. It is recommended that the government work to reinforce this trend by (a) investing in sustainable agriculture, forestry, animal husbandry and fisheries; (b) optimizing the distribution of agricultural production, developing high-efficiency and sustainable agriculture while promoting inter-cropping; (c) increasing agricultural productivity and the degree of mechanization; (d) encouraging comprehensive utilization of crop residues; and (e) increasing land productivity and quality.

### **3. Reduce carbon footprint as a primary focus for decreasing biocapacity deficits.**

Carbon footprint has become the primary force driving the increase in China's Ecological Footprint and any effort to reduce Ecological Footprint must therefore focus on reducing carbon footprint. China can reduce carbon footprint through the following measures:

(1) Establish and promote a low carbon economy by (a) adjusting and optimising industry structures according to local biocapacity; (b) restricting and prohibiting certain industries while encouraging energy conservation and production patterns that are environmentally friendly and resource efficient; (c) increasing the utility and conversion efficiency of fossil fuels throughout their life cycles; and (d) increasing the proportion of renewable energy in the energy portfolio. For regions where per capita Gross Domestic Product (GDP) is less than 30,000 RMB (US\$ 4,500) – the amount above which Ecological Footprint shows a positive association with per capita GDP – the focus should be on investment and development patterns that do not cause a rapid rise in Ecological Footprint.

(2) Focus on building low carbon cities / eco-cities in China's urbanization. Although urbanization is associated with higher Ecological Footprint, there are ways this relationship can be optimised. To that end, the urbanization process in China should follow a low carbon, environmentally friendly approach to urban planning that includes controlling the expansion of cities and towns, deploying appropriate transportation systems, promoting residences with locally available facilities and decreasing carbon footprint in buildings and transportation.

(3) Promote sustainable consumption by: (a) encouraging low carbon and resource efficient consumption patterns and selection of environmentally friendly goods and services, (b) having government set an example through establishing green procurement policies and low carbon offices; and (c) improving the lifespan of public facilities and optimizing their design in order to avoid waste and poor construction quality. It is important to account for regional development and consumption levels when formulating plans for encouraging changes in carbon footprint. In provinces where per capita GDP is above 30,000 RMB, the plan should focus on changes in consumption patterns to slow down or freeze the increase in Ecological Footprint.

#### **4. Reduce biocapacity deficits through resource allocation.**

Biocapacity and water resources are unevenly distributed both globally and in China. There is often limited correlation between resource availability and population distribution, thus it is often impossible to meet consumption demand within local limits. Trade is one means to redress this imbalance, but poorly planned and irresponsible trade practices can lead to overexploitation of natural resources and weakening of local natural capital. Accordingly, special attention should be given to biocapacity, water and other resources embedded in international and domestic trade through measures that promote sustainable natural resource flows as a basis for long term economic development. This can be achieved through the following measures:

(1) Formulate a domestic trade policy that encourages appropriate biocapacity flows. China should adopt a range of economic and administrative measures that promote efficient allocation of ecological resources and minimize inappropriate exportation and inter-provincial transfers of biocapacity and water resources through (a) innovative tax systems such as an energy resource tax and a carbon tax which encourages enterprises to invest in new technologies that conserve energy and reduce emissions; and (b) development of trade policies that encourage sustainable flows of biocapacity, minimize the export of resources from degraded areas, and curtail irresponsible trade practices.

(2) Encourage international cooperation in order to promote sustainable trade flows. Global trade reflects the ecological interdependency among countries and highlights that environmental problems are global in nature. It is recommended to pay attention to unsustainable imports and exports of biocapacity in order to lessen the ecological impact of trade on China and other countries.

# TECHNICAL NOTES

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## **How is the Ecological Footprint calculated?**

The Ecological Footprint measures the amount of biologically productive land and water area required to produce the resources an individual, population or activity consumes and to absorb the waste it generates, given prevailing technology and resource management. Footprint calculations use yield factors to normalize countries' biological productivity to world averages (e.g. comparing tons of wheat per UK hectare versus per world average hectare) and equivalence factors to take into account differences in world average productivity among land types (e.g. world average forest versus world average cropland).

A detailed methods paper and copies of sample calculation sheets can be obtained from [www.footprintnetwork.org](http://www.footprintnetwork.org).

## **What is included in the Ecological Footprint? What is excluded?**

To avoid exaggerating human demand on nature, the Ecological Footprint includes only those aspects of resource consumption and waste production for which the Earth has regenerative capacity, and where data exist that allow this demand to be expressed in terms of productive area. For example, toxic releases are not accounted for in Ecological Footprint accounts. Nor are freshwater withdrawals, although the energy used to pump or treat water is included.

Ecological Footprint accounts provide snapshots of past resource demand and availability. They do not predict the future. Thus, while the Footprint does not estimate future losses caused by current degradation of ecosystems, if this degradation persists it may be reflected in future accounts as a reduction in biocapacity.

Footprint accounts also do not indicate the intensity with which a biologically productive area is being used. Being a biophysical measure, it also does not evaluate the essential social and economic dimensions of sustainability.

## **How does the Ecological Footprint account for the use of fossil fuels?**

Fossil fuels such as coal, oil and natural gas are extracted from the Earth's crust and are not renewable in ecological time spans. When these fuels burn, carbon dioxide (CO<sub>2</sub>) is emitted into the atmosphere. There are two ways in which this CO<sub>2</sub> can be stored: human technological sequestration of these emissions, such as deep-well injection, or natural sequestration. Natural sequestration occurs when ecosystems absorb CO<sub>2</sub> and store it either in standing biomass such as trees or in soil.

The carbon footprint is calculated by estimating how much natural sequestration would be necessary to maintain a constant concentration of CO<sub>2</sub> in the atmosphere. After subtracting the amount of CO<sub>2</sub> absorbed by the oceans, 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. CO<sub>2</sub> sequestered by artificial means would also be subtracted from the Ecological Footprint total, but at present this quantity is negligible. In 2007, 1 global hectare could absorb the CO<sub>2</sub> released by burning approximately 1,450 litres of gasoline.

The contribution of CO<sub>2</sub> emissions to the total Ecological Footprint is based on an estimate of world average forest yields. This sequestration capacity may change over time. As forests mature, their CO<sub>2</sub> sequestration rates tend to decline. If these forests are degraded or cleared, they may become net emitters of CO<sub>2</sub>.

### **Does the Ecological Footprint say what is a “fair” or “equitable” use of resources?**

The Footprint documents what has happened in the past. It can quantitatively describe the ecological resources used by an individual or a population, but it does not prescribe what they should be using. Resource allocation is a policy issue, based on societal beliefs about what is or is not equitable. While footprint accounting can determine the average biocapacity that is available per person, it does not stipulate how this biocapacity should be allocated among individuals or countries. However, it does provide a context for such discussions.

### **Water Footprint**

Water Footprint (WF) of a country or region shows the total volume of water directly or indirectly used to produce the goods and services consumed by inhabitants there. Water footprint consists of two parts: the internal and the external Water Footprint:

Internal Water Footprint (WFI) is defined as the total water resources of a region to produce the goods and services consumed by inhabitants of the region. It is the sum equal to total domestic water resources used in the national economy minus the Volume of Virtual Water (VWEdom) exported to other countries through product trade.

External Water Footprint (WFE) refers to the volume of water used by other countries to produce products and services consumed by the inhabitants of the countries concerned. It is equal to Virtual Water Import (VWI) minus Virtual Water Volume (VWEre-export) exported to other countries as a result of re-export of imported products.

The difference between virtual water export and virtual water import is the national virtual water balance for the reported period. Positive balance indicates a net export of virtual water, whereas negative balance indicates a net import of virtual water. Both internal and external water footprint consists of blue, green and gray water footprint.

### **Methodology**

In this report, Ecological Footprint and biocapacity results are presented based on the National Footprint Accounts as well as analysis conducted by IGSNRR. The National Footprint Accounts are based mostly on United Nations datasets and reported at the national level. IGSNRR results are based on datasets from the National Bureau of Statistics in China and include sub-national results by urban and rural populations. All Ecological Footprint and biocapacity results are expressed in units of global average bioproductive hectares (global hectares).

The unit of cubic meters is used to express Water Footprint. Water Footprint classification and accounts are generally consistent with those reported in the WWF Living Planet Report. The Water Footprint calculations are based on the Food and Agriculture Organization datasets.

Due to limited data, the accounting of regional Ecological Footprint flow and external water footprint are based on the balance between total production and sales of regional agricultural products, but the result is lower than the actual level due to aggregated classifications.

The original language of this report is Chinese, and the English version is a translation thereof. While the two versions are closely aligned, they are not exactly identical.

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**With special thanks for review and contributions from:**

Rosamunde Almond, Ashok Kumar Chapagain, Chen Boping, Seth Cook, Claudia Delpero, Tracy Doten, Fang Li, Nicole Freeling, Monique Grooten, Guo Jing, Li Lifeng, Li Yong, Li Yonghong, Liu Junguo, Joy Larson, Jennifer Mitchell, Vincent Pellecchia, Anders Reed, Qin Hu, Ren Yong, Mathis Wackernagel, Wang Lei, Yu Hai, Zhang Jianyu, Zhou Guomei, Zhou Shuang.

Thanks to WWF, especially to WWF-Netherlands, for financial support.

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## DEVELOPMENT

In the last half century, China achieved a rapid increase in human development and income per person grew more than 50 times.

## BIOCAPACITY


China's productive land has increased since 1961 but on an average per capita basis is among the world's lowest.

## ECOLOGICAL FOOTPRINT

China's per capita demand of ecological resources has recently overtaken the biocapacity available per person on a global basis, some 30 years after the world as a whole crossed this threshold.

## WATER

China has scarce water resources; water stress is most serious in northern and central China, as well as in downstream areas of the Yellow and Yangtze rivers.

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