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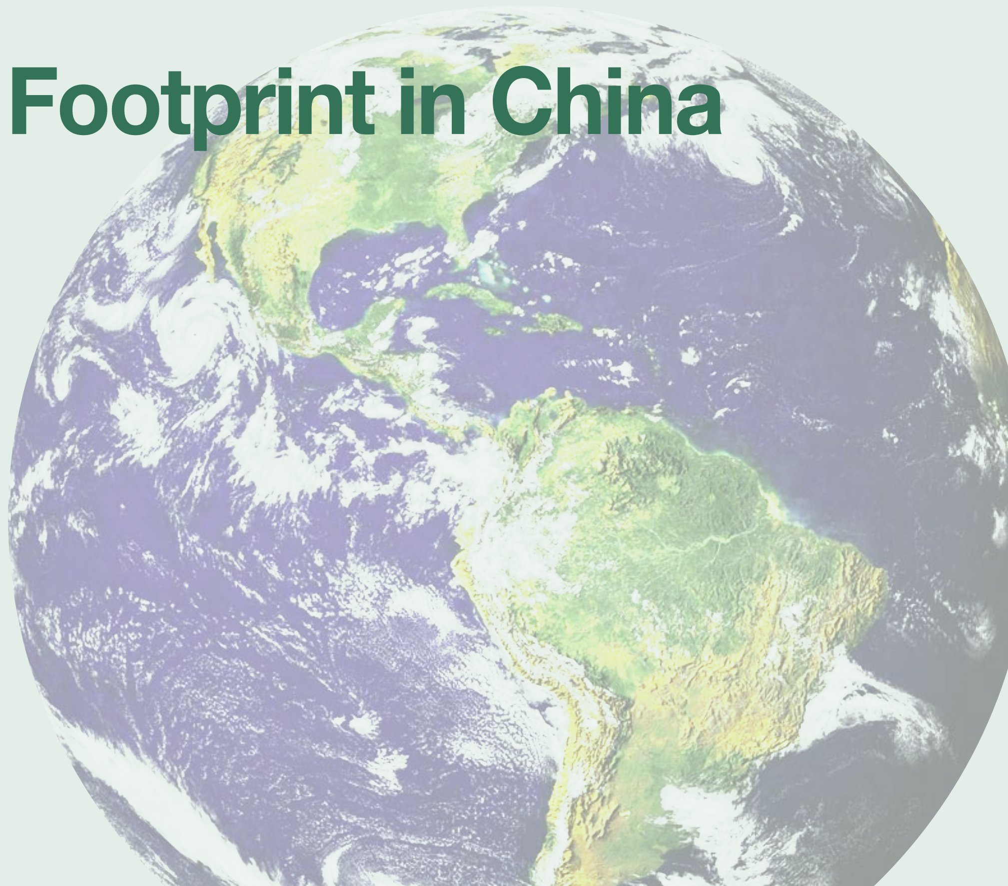
Report on Ecological Footprint in China



Global Footprint Network

Advisors

Shen Guofang[1]
Arthur Hanson[1]
Claude Martin[2]
Chris Hails[3]
Dermot O'Gorman[3]
Li Lin[3]

Authors

Justin Kitzes[5]
Susannah Buchan[5]
Alessandro Galli[5]
Brad Ewing[5]
Cheng Shengkui[4]
Xie Gaodi[4]
Cao Shuyan[4]

[1] Chief Advisor, CCICED(China Council for International Cooperation on Environment and Development)

[2] Former Director General of WWF International and CCICED member

[3] WWF (World Wide Fund for Nature)

[4] IGSNRR(Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

[5] Global Footprint Network

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Foreword

There are two big challenges facing human society in the new century, the environment and development. The continuous degradation of the environment has directly affected the very survival and sustainable development of human beings. How to realise a more balanced development of economic growth and environmental protection has become a critical issue that requires China and the whole world to address urgently.

Globally, the ecological footprint has been widely used to measure the human demands on nature. Human consumption of the natural resources has been constantly increasing over the past four decades to result in a growing overshoot of what the Earth can sustainably supply. It has become a premise and an important guideline to understand the world's and China's ecological footprints and integrate them into the sustainable development strategies for a holistic planning of environment protection in China.

Sustainable development requires humans to manage their demands on natural resources strictly within the Earth's capacity to regenerate, which describes the concept of biological capacity. The Report on Ecological Footprint in China expounds the relation between ecological footprint and biological capacity in China, and proposes how to ease the conflicts between them. The suggestions and strategies will play important roles functioning as guidelines for us to measure and improve the environmental status for the realization of sustainable development in China.

It's a critical period in coming 20 years for China to realize its sustainable development, which is determined by important indicators including the balance between the efficiency of natural resources and the Earth's regeneration capacity improvement. Therefore, the China Council for International Cooperation on Environment and Development (CCICED) has worked with WWF to produce this report on the ecological footprint in China, which we hope, based on researches conducted by experts from home and abroad, will serve its reference accordingly.

Secretary-General
CCICED

As China's economy continues to grow, so does its demand for natural resources. But if China is to develop sustainably then it - like every other country in the world - must have a clear understanding of just how much of nature's resources it is using.

This report on the Ecological Footprint of China, commissioned by the China Council for International Cooperation in Environment and Development and produced in partnership with the Global Footprint Network and WWF in China, is the first-ever effort to gather together the information necessary to reach that understanding and reflects China's commitment to creating an ecological civilization.

The path to sustainable development will not be easy. Around the world, urgent action is needed to avert climate change, to prevent the over-exploitation of our marine and forest environments, and to protect our freshwater supplies. China, too, needs to act.

Three factors determine a country's footprint: population, consumption per person, and the resource-intensity of that consumption. Measuring the trends in each of these factors, and understanding the implications, will help China in its quest to come up with innovative ways to achieve its development goals while ensuring that future generations have the natural resources they need to prosper.

The analysis in this report tells us that the people of China today have an ecological footprint of 1.6 "global hectares" - that is, on average, each person needs 1.6 hectares of biologically productive land to meet the demands of their lifestyle. This figure is still lower than the world average of 2.2 global hectares, but it nonetheless presents important challenges. In fact China is already consuming more than twice as much as can be provided by its own ecosystems.

China partially covers its ecological deficit by importing natural resources from other countries around the world, but many of these have ecological deficits of their own. So, as China's economy continues to grow, it will be critically important to find ways to lighten its footprint. This report proposes the "CIRCLE" approach: Compact urban development, Individual action, Reducing hidden waste flows, Carbon reduction strategies, Land management, and Efficiency increases.

There are two places to begin: (1) The "easy" things – the simple, cheap, and popular steps that can start reducing China's footprint now; and (2) the "slow" things – the decisions made today (highways, buildings, power plants) that will have impacts for decades to come. Most important, is to get started. This report is an important first step.

James P. Leape
Director General, WWF International

Executive Summary

The Ecological Footprint measures the amount of biologically productive land and water area needed to meet the demands of a population. By comparing this demand for area to biocapacity, the amount of biologically productive land and water available within a given region or nation, Ecological Footprint accounts can determine whether a nation, region, or the world as a whole is living within its ecological means. Footprint accounts have been used by governments, businesses, and individuals who wish to better understand the magnitude of their dependence on biological capital and how they might plan strategically in an increasingly resource constrained world.

This report focuses on the Ecological Footprint of China within a global and regional context. Recent Ecological Footprint studies by Chinese scholars are reviewed, and China's Ecological Footprint is showcased in detail, including a discussion of the different types of land and water area necessary to meet China's resource and energy needs. A specific study of selected traded goods shows how the productive areas needed to produce these goods are "traded" with other nations around the world. The report concludes with strategies for managing China's Ecological Footprint and biological capacity.

The report finds that:

- In 2003, the most recent year data are available, global society demanded 25% more biological capacity than the planet was able to provide. This state of global overshoot will inevitably lead to the degradation of the planet's biological capital.
- The United States, the European Union, and China represent more than 50% of the world's total Ecological Footprint and 30% of global available biological capacity. The decisions made by the respective governments and societies will largely determine whether the world is able to meet the sustainable development challenge in the coming century.
- The Asia-Pacific region is home to more than half of the world's population, who demand nearly 40% of the planet's available biological capacity.
- The calculation of Ecological Footprints in China began soon after the concept was first proposed in the mid-1990s, and has been used by local researchers to evaluate the ecological deficits of different provinces in China as well as the impacts of specific business and household activities.
- Focusing on individual lifestyle, China's Ecological Footprint in 2003 was 1.6 global hectares per person, the 69th highest country in the world, and lower than the world average Ecological Footprint of 2.2 global hectares per person.
- Despite this low per person consumption, however, China has run an ecological deficit since the mid-1970s, demanding more biological capacity than its own ecosystems can provide each year. In 2003, China demanded the equivalent of two Chinas to provide for its consumption and absorb its wastes. The majority of this deficit is due to emissions of carbon dioxide from burning fossil fuels that are not sequestered.
- China partially covers its deficit by importing biological capacity, in the form of natural resources, from other nations. In 2003, China imported 130 million global hectares from outside its borders, nearly equivalent to the entire biological capacity of Germany.
- China's Ecological Footprint is connected through trade relations to nearly every country in the world, including many close by and many far away. An analysis of selected traded products suggests that China often imports biocapacity embodied in raw materials from countries such as Canada, Indonesia, and the United States and often exports biocapacity embodied in manufactured products to countries such as South Korea, Japan, the United States, and Australia.
- Three factors control China's Ecological Footprint: population, consumption per person, and the resource-intensity of consumption. Two complementary approaches for reducing China's ecological deficit are quickly addressing (1) activities that are easy and cheap to change, such as the use of energy intensive light bulbs, and (2) investments in infrastructure that will have long-term implications for resource use in the future.
- Specific strategies for China to move towards a sustainable future involve the CIRCLE approach: Compact urban development, Individual action, Reducing hidden waste flows, Carbon reduction strategies, Land management, and Efficiency increases.

2 Introduction

The 20th century was characterized by rapid growth in human societies, and in those societies' impacts on the natural world. Over the last century, world population quadrupled, and energy consumption grew over ten-fold. The planet has seemed, for practical purposes, limitless. The only limitation has been the ability to access resources and to transport them over long distances.

Yet today, with a globalized economy and nearly unlimited transportation capacity, human demand for resources has grown beyond what planet Earth can supply. Humanity is now using at least 25 percent more than what the planet can regenerate (Figure 2.1). This global overshoot means that we are depleting and degrading the biological capital on which the human economy depends, while allowing waste to accumulate around us.

Already, increasing scarcity of resources has begun affecting us all. Fisheries all over the world are under stress, timber supplies come from increasingly distant forests, and many analysts place the blame for ongoing international conflict on competition for fossil fuel and fresh water resources.

The reality of the coming century will be different than the past: the implications of global overshoot will become more and more evident throughout our daily lives.

In the coming world of limits, what will be a successful strategy for government policy? How will global trends shape the options available for decision makers and planners? How will each nation's own ecological deficit situation affect its competitiveness on a global scale? How can national and international businesses remain viable? How can individuals ensure their own quality of life and that of their families?

These questions are global in scope, and answers will need to be developed both globally, by international and multilateral agreements, and locally, by regions, nations, provinces, cities, and individuals.

The Asia-Pacific region will play an increasingly central role in the ecological context of the coming century. With more than 50 percent of the world's population demanding nearly 40 per cent of global biological capacity, decisions made in this region will reverberate around the globe. Will Asia Pacific avoid local and large scale collapses and shield itself from collapses elsewhere? Can it catalyze a shift to global sustainability that will serve as a model for nations elsewhere in the world?

As one of the largest and fastest growing countries in the region, China's decisions will be especially important. As a nation, China consumes 15 percent of the world's

Fig. 2.1: RATIO OF HUMANITY'S ECOLOGICAL FOOTPRINT TO AVAILABLE BIOCAPACITY, 1961-2003

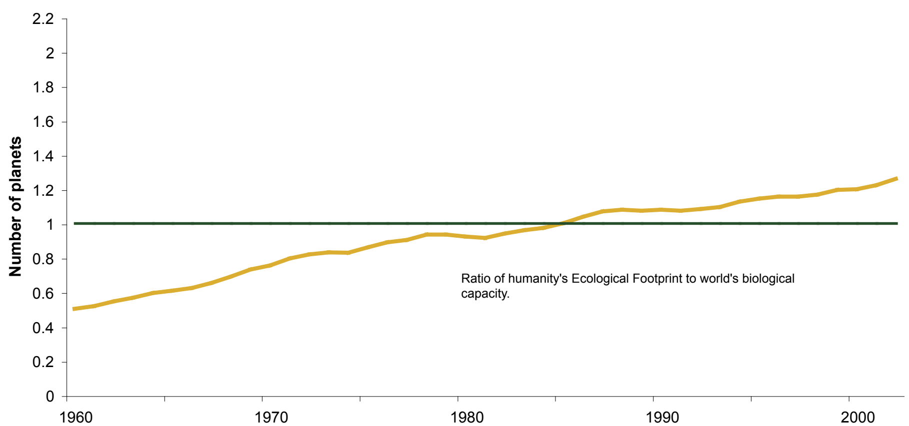
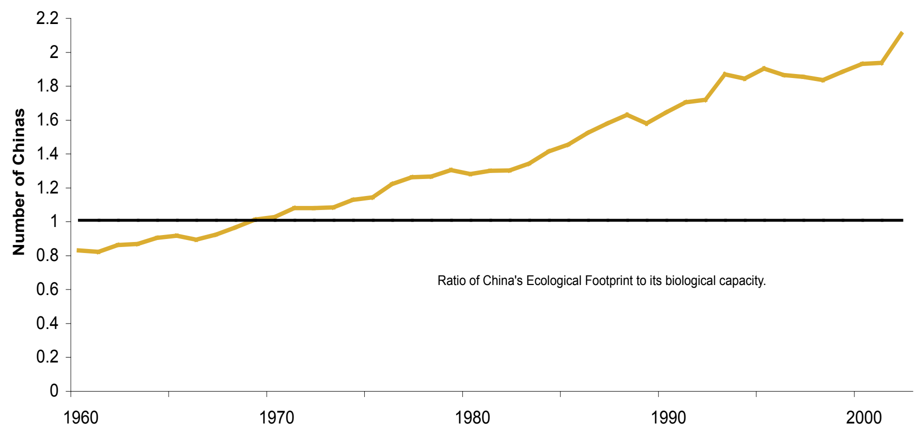


Fig. 2.2: RATIO OF CHINA'S ECOLOGICAL FOOTPRINT TO AVAILABLE BIOCAPACITY, 1961-2003



total biological capacity, the second most of any nation in the world. Although its biological capacity continues to grow through the expansion of productive lands and the introduction of new technologies, this increase in biocapacity can come at the expense of natural ecosystems and biodiversity. Even with this growing biocapacity, each year the residents of China demand more than two times what the country's own ecosystems can sustainably supply (Figure 2.2).

If China were to follow the lead of the United States, where each person demands nearly 10 hectares of productive area, China would demand the available capacity of the entire planet. This is likely to be a physical impossibility for China, and for the other nations of the world. In contrast, if China can model a new development path that achieves environmental quality, social harmony, and human well-being, it will lead the way for the world as a whole, North and South, East and West. Such development can be made possible through intelligent planning and management, founded on strong scientific principles and knowledge.

This report uses the Ecological Footprint to showcase the current state of demand for biological capacity in China, and to set China's situation in the context of an increasingly constrained world.

As a resource accounting tool that makes demand on biological capital visible, measurable, and manageable, the Ecological Footprint allows decision makers at all levels to identify strategies for sustainable development.

Figure 2.1: Humanity's Ecological Footprint. Human consumption has grown over the past forty years, with global demand for biological capacity exceeding what the planet can supply by 25% in 2003.

Figure 2.2: China's Ecological Footprint. The residents of China currently consume more than twice the capacity that China's own ecosystems can provide.

Figure 2.3: Total Ecological Footprint by nation. As a nation, China has a total Ecological Footprint comparable to the entire EU-27, and the second largest Ecological Footprint of any single nation after the USA.

Figure 2.4: Total biocapacity by nation. China is home to 9 percent of the total biological capacity of the planet.

Fig. 2.3: TOTAL FOOTPRINT, top countries, 2003

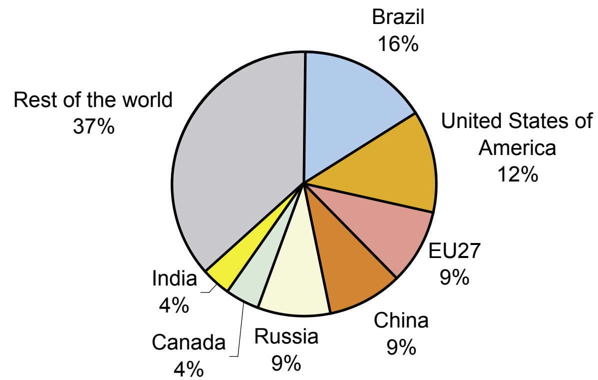
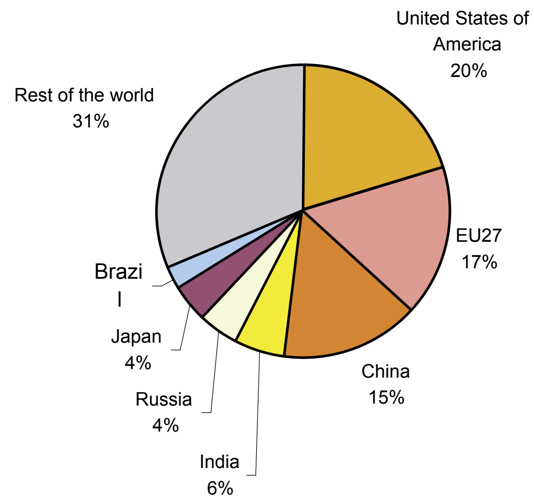


Fig. 2.4: TOTAL BIOCAPACITY, top countries, 2003



3 The Global Context: Humanity's Ecological Footprint

Ecological Footprint accounts are used widely for measuring human demand on nature. The Ecological Footprint of a nation is the total area required to produce the food, fiber and timber that it consumes, absorb its waste, and provide space for its infrastructure. The residents of a nation consume resources and ecological services from all over the world, and its Ecological Footprint is the sum of these areas, wherever they are located on the planet.

In 2003, the global Ecological Footprint was 14 billion global hectares, or 2.2 global hectares per person (a global hectare is a hectare with world-average productivity).

This demand on nature can be compared to the planet's biocapacity, the amount of biologically productive area available to meet human demand. In 2003, the planet's total biocapacity was 11.2 billion global hectares, or 1.8 global hectares per person.

This global average, however, varies significantly by region and nation. Many of the countries with largest per-person Footprints are high-income regions in North America and Western Europe. China's Ecological Footprint in 2003 was 1.6 global hectares per person, giving China the 69th highest Footprint out of the 147 nations measured that year. For both high income nations, and for China, the carbon Footprint makes up about one half of the nation's total Ecological Footprint.

Figure 3.1: Ecological Footprint per person, by nation, by land type. Here, 150 nations are shown with their Ecological Footprint divided into major land types. For most high income nations, the largest portion of the Footprint comes from carbon dioxide emissions, as compared to cropland and pasture for low income nations.

Figure 3.2: Ecological Footprint by income group, over time. The demand for biological capacity in high-income countries began at a higher rate and rose faster than for middle- and low-income counties from 1961 to 2003. Dotted lines indicate gaps in data associated with the dissolution of the Soviet Union.

Fig. 3.1: ECOLOGICAL FOOTPRINT PER PERSON, by country, 2003

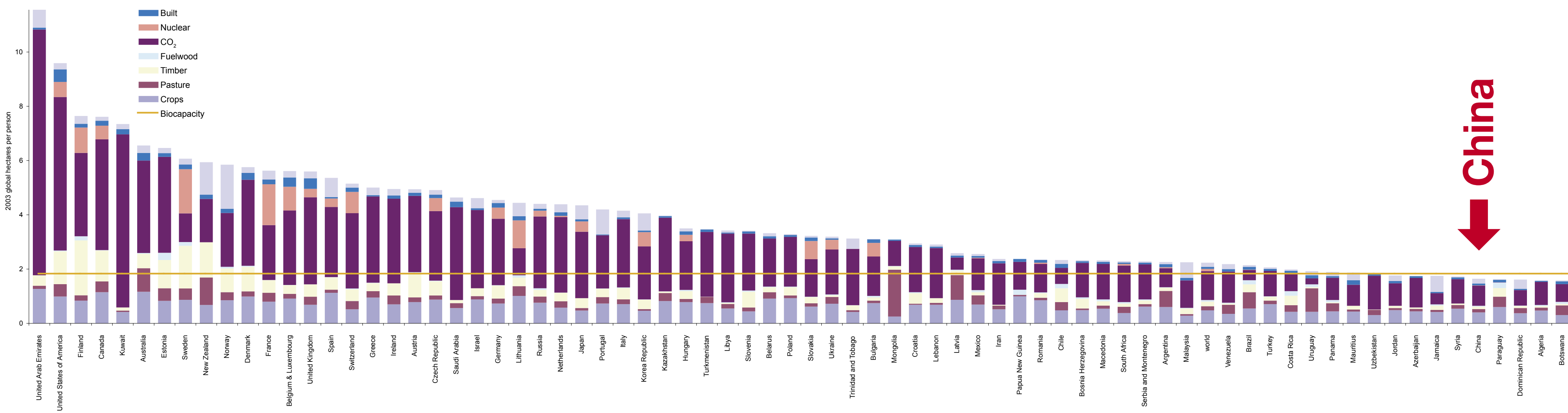
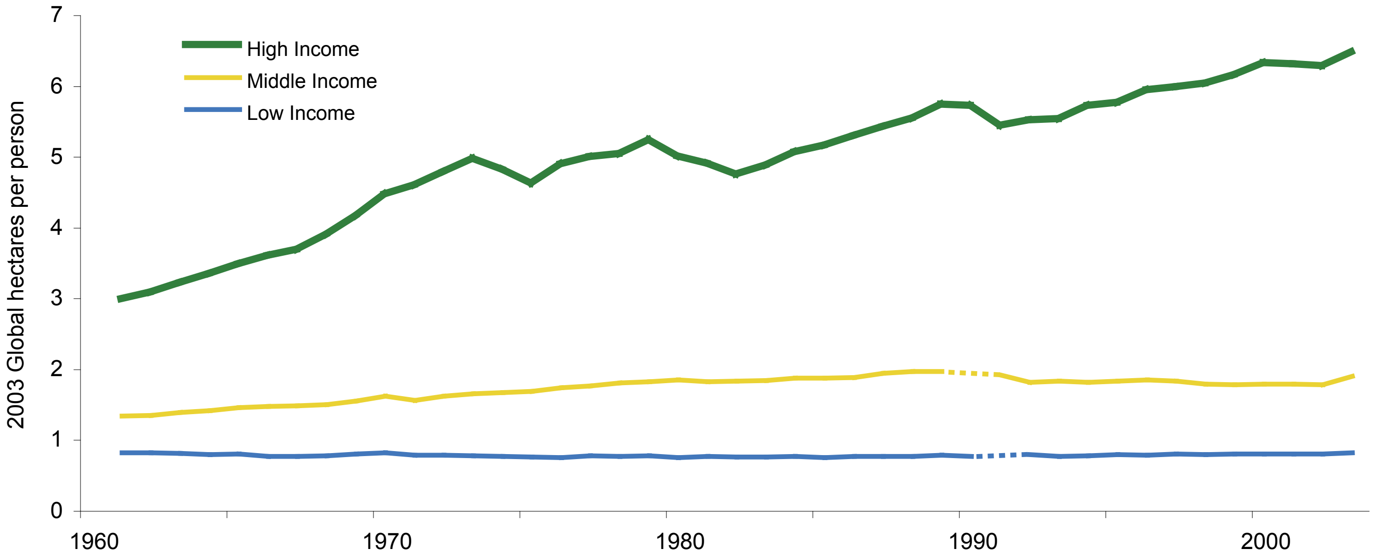
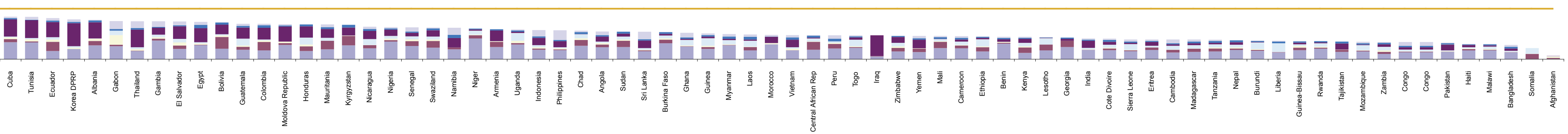


Fig. 3.2: TOTAL ECOLOGICAL FOOTPRINT OF NATIONS, by income group, 2003





4 Asia Pacific's Ecological Footprint

Compared to other regions of the world, the Asia-Pacific region has a relatively low Ecological Footprint per person (Figure 4.1). The large population of the region, however, gives Asia-Pacific the largest total Ecological Footprint of any region in the world. On a global scale, Asia-Pacific contains about 50 percent of the world population, and demands about 40 percent of the total biological capacity of the planet (Figure 4.2 and Figure 4.3).

All together, the Ecological Footprint of the Asia-Pacific region is now 1.7 times as large as its own biological capacity. By comparison, in 1961, the region's total Footprint was only 75 percent of its biocapacity. Although the region's productive capacity has grown over the past forty years, particularly through the green revolution and other technology, demand for resources and ecological services has been growing far more rapidly.

The Asia-Pacific region compensates for its ecological deficit in two ways: first, by importing resources and using the biological capacity of other countries and the global commons, and, secondly, by drawing down stocks of accumulated biological capital within the region (e.g., cutting down trees faster than they can regrow).

Great Footprint variation can also be found within the Asia-Pacific region. While the average Australian lives on 7.7 global hectares, the average Bangladeshi uses only 0.6. The average resident of China uses 1.5 global hectares (Figure 4.3).

China and India clearly stand out as influential in the region for their large populations and large total Ecological Footprints. The per person Footprint of both nations, however, is well below the global average.

Figure 4.1: Ecological Footprint by region. Although North America has the highest Footprint per person, the large population of the Asia-Pacific region gives Asia-Pacific the largest total Ecological Footprint of all major regions. The green dashed lines indicate available biocapacity within the region.

Figure 4.2: Asia-Pacific's use of world biocapacity. The Asia-Pacific region's population and Ecological Footprint continue to grow rapidly. In 2003, the Asia-Pacific region demanded 40 percent of the total biological capacity of the planet.

Fig.4.1: ECOLOGICAL FOOTPRINT AND BIOCAPACITY, by region, 1961-2003

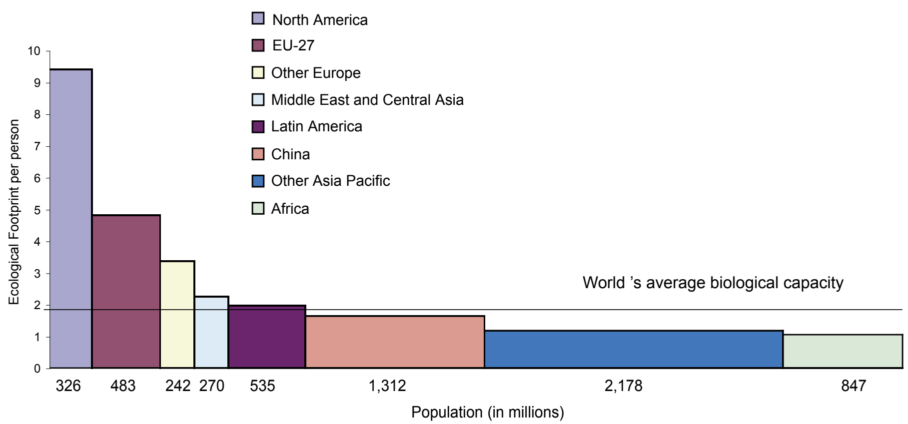
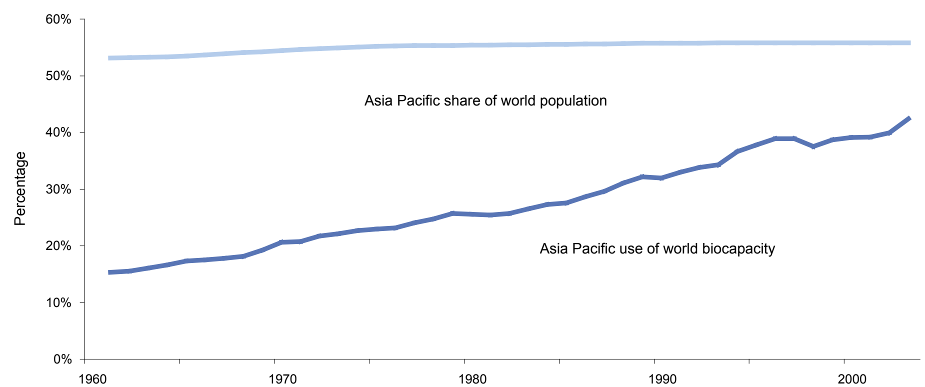


Fig.4.2 ASIA PACIFIC'S USE OF WORLD BIOCAPACITY, 1961-2003



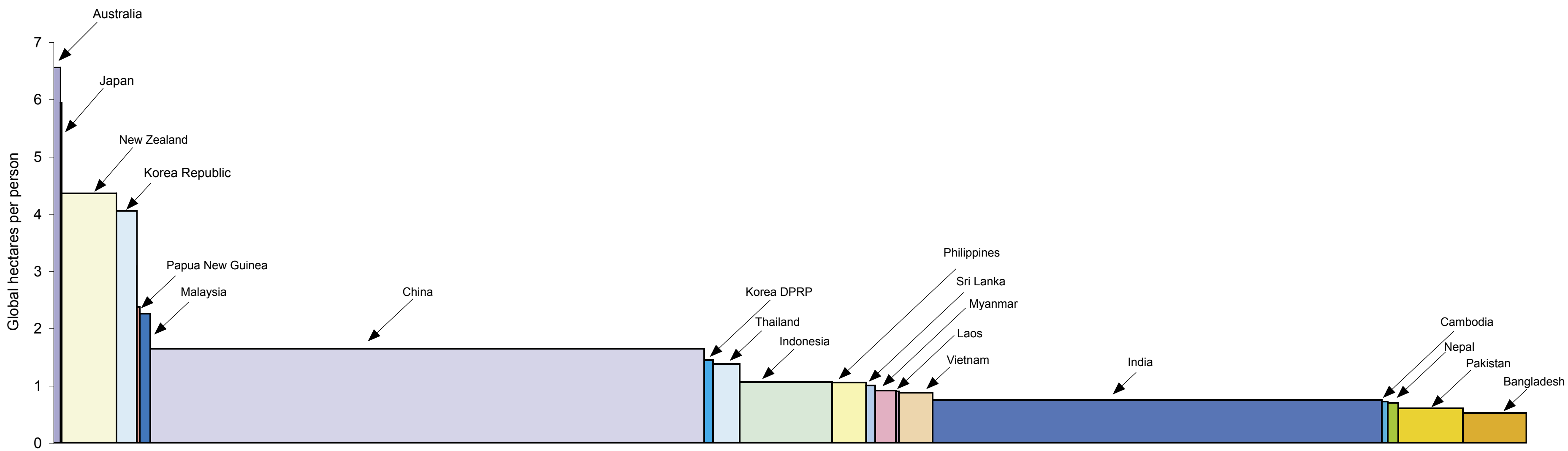


Fig. 4.3: DEMAND ON AND SUPPLY OF BIOCAPACITY, per Asia-Pacific nation, 2003. The per person Footprint of each nation in the Asia-Pacific region is shown on the vertical axis, with population shown on the horizontal axis. The total population of the region is 3.5 billion, and China's population as of 2003 was 1.3 billion. The area of each box represents the total Ecological Footprint of that nation. While Australia and Japan have the highest per capita Footprints, China and India have the largest total Footprints.

5 Ecological Footprint Concept in China

Many ecologists, environmental scientists and sociologists in China have worked to develop indicators for national and regional sustainable development. The Chinese government has been supportive of this research, which it believes will be important to guiding decision making in the coming century.

The first Ecological Footprint calculation in China was completed in 1999 by Zhongmin Xu. The Footprint methodology gained immediate popularity among academics, and, to date, more than 500 Ecological Footprint research papers have been published within China. These studies fall into two groups. General Ecological Footprint Models have been used at the national and provincial level to describe the overall demand on ecosystems found within different geographic regions. Component Ecological Footprint Models have been used to identify the Ecological Footprint associated with specific business and consumer behaviors, such as tourism and transportation.

All of the Ecological Footprint studies reviewed here predate the Ecological Footprint Standards, a set of guidelines and best practices for reports and analyses (www.footprintstandards.org). As a result, these studies provide useful .information, but each apply different methodologies and the findings are not directly comparable.

The Total Ecological Footprint of China and its Provinces

In the early stages of Ecological Footprint research in China, researchers mainly applied the basic methodologies proposed by Mathis Wackernagel and Bill Rees in their book Our Ecological Footprint. In 2001, Chinese researchers first calculated the Ecological Footprint and biocapacity for China (Xie et al, 2001) and its different provinces in time series. The published researches, completed on a massive scale, covered all Chinese provinces, over 70 cities, and 20 counties. The Administrative Center for China's Agenda21 (ACCA21) published these results in time series for all the provinces in China from 1980 to 2000.

The main conclusions from this study were:

• From 1980 to 2000, the number of Chinese provinces that had ecological deficits grew from 19 to 26 (Table 5.1), indicating a much greater possibility of damage to China's ecosystems and the likelihood of importing natural resources from other nations.

• These rising ecological deficits have been mainly caused by increasing consumption of fossil energy.

• The potential for increasing China's total productive area is not great. Thus the only possibilities for increasing China's biocapacity lie in improving yields on already productive areas.

• Compared with world averages, China's Ecological Footprint and biocapacity levels have changed very quickly, indicating China's importance in charting the future of global sustainability.

Overall, the general Ecological Footprint models proposed by Chinese researchers have involved research scales above the city level. Some have begun to use new input-output analytical techniques, although these methods are still at an early stage. Due to the multiple data sources and lack of Standards at the global level at the time when these studies were conducted, the research findings cannot be compared to each other directly, and therefore provide limited guidance to users in their current form. Future work guided by new international Ecological Footprint standards should improve comparability.

The Ecological Footprint of Specific Production and Consumption Activities

A second type of Ecological Footprint analysis, the component model, calculates the Ecological Footprint of specific products and activities, often using life cycle analysis that accounts for activities all the way from gathering raw materials to the final disposal of the finished product. Analysis of products and materials can help organizations and the general public gain a better understanding of the consequences of their behavior, and guide them to adopt production practices and consumption patterns of lower ecological demand.

Previous research in China has focused mostly on urban tourism, water resources, transportation, education, and agricultural products processing, with tourism being the focus of half of all studies (Figure 5.1). The Ecological Footprint of tourism is often divided into six sub-Footprints, including tourist transportation, lodging, catering, shopping, entertainment and sightseeing, which are then summed to obtain the total Ecological Footprint of tourism. Research shows that the average Ecological Footprint per tourist visit in Huangshan is 0.11 gha within average 3.13 days per visit, which would be equivalent to 12.4 gha for a year-round resident and equates to a Footprint of nine times what is typical for local residents (Zhang and Zhang, 2004).

Ecological Footprint research on transportation (Liang et al, 2004) has found that the total Ecological Footprint of driving private cars in Beijing is over five times greater than that of using existing public transportation.

China's water resources researchers have used a “Water Footprint” method, a parallel and similar method of accounting to the Ecological Footprint. According to Jing Ma

(2005), 60 percent of the water resources consumed by China's national economy is green water (soil moisture).

The True Costs and Benefits of Fossil Energy Consumption

Since the 1980s, many countries around the world, including China, have experienced rapid economic growth. The increasing ecological deficits seen in these growing nations are often due to increases in fossil energy consumption. Chinese experts who have evaluated the use of fossil energy (Xie et al, 2006; Cao, 2007), however, believe that this increase in fossil energy consumption, while increasing the nation's total Ecological Footprint, has taken pressure off of local supporting ecosystems that otherwise would have been called upon to produce biomass fuel. In other words, the use of fossil energy has allowed China to preserve their own domestic ecosystem capacity while externalizing its Ecological Footprint to the global commons.

One particularly thorough study, (Cao, 2007) calculated that:

• The Footprint for carbon sequestration associated with burning natural gas, petroleum, and coal is lower than the Ecological Footprint that would be required to produce the same amount of power through biomass fuels in China. By burning enough coal to produce an annual 1 TJ of energy, for example, China increases its Ecological Footprint by 17 gha. Producing 1 TJ of comparable energy from biomass using biomass molding carbonization technology, however, would have required 23 gha of productive area, and as a result the use of coal has saved China 6 gha of Ecological Footprint. (Figure 5.2)

• The savings associated with fossil energy use, however, is achieved at the expense of reducing fossil fuel stocks accumulated over millions of years and build-up of CO2 in the atmosphere. Fossil energy can drive economic development, but it is a short-term choice that is only logical when technologies are not mature enough to tap into renewable energy sources such as wind and solar power. A fossil energy development path will eventually result in the exhaustion of fossil fuel resources, global warming, and increasing ecological risks.

• Through the use of fertilizers, pesticides, and other factors of production, fossil energy has raised yields on Chinese cropland, and this increase in yields appears to increase biocapacity more than the additional Ecological Footprint of the inputs. The role of fossil energy in increasing biocapacity cannot be overlooked, although consideration must be given to other long-term impacts of intensive agriculture, such as soil erosion and degradation, which are not captured by the Ecological Footprint methodology.

Table 5.1: NUMBER OF PROVINCES WITH ECOLOGICAL FOOTPRINT DEFICIT OR RESERVE

	1980	1990	2000
Deficit regions	**19**	**24**	**26**
Very severe deficit (ED>2.0)	0	2	3
Severe deficit (1.0<ED≤2.0)	3	2	4
Moderate deficit (0.5<ED≤1.0)	3	8	12
Minor deficit (0.1<ED≤0.5)	13	12	7
Reserve or balanced regions	**12**	**7**	**5**
Balanced regions (-0.1<ED≤0.1)	4	4	2
Reserve regions (ED≤-0.1)	8	3	3

Table 5.1: The number of provinces in China with ecological deficits has been growing. In 1980, there were 19 provinces in ecological deficit and 12 with ecological reserves or balances; By 2000, the number of ecological deficit provinces had grown to 26. (CSSD, 2004)
ED: Ecological deficit per capita (gha cap^{-1})

Fig. 5.1: ECOLOGICAL FOOTPRINT STUDIES IN CHINA BY SUBJECT AREA

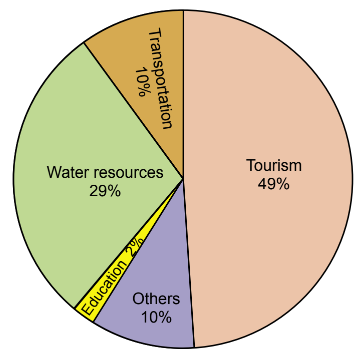


Figure 5.1: Studies of China's Ecological Footprint research commonly focuses on tourism, water resources, transportation, education, and agricultural products processing. Of 42 studies surveyed over the past ten years, nearly half have focused on the Ecological Footprint of tourism.

Future Directions

More recent Ecological Footprint studies in China have begun to focus on fairness, appropriateness, and international trade (Shang et al, 2006;Chen and Yang , 2005;Hu et al, 2006; Xu et al , 2003; Cao and Xie, 2006) Some researchers, for example, have begun to use the Gini coefficient and Hoover Center Index as measuring indicators for the equity of regional distribution of Ecological Footprint and biocapacity(Cao et al, 2007). Regarding the appropriateness of Ecological Footprint, some have recommended a "balanced diet Footprint" as a benchmark indicator for a valid and appropriate Ecological Footprint of food consumption(Cao and Xie, 2006). Finally, some studies are addressing the regional or international transfer of Ecological Footprint carried by domestic or international trade in items such as forestry products, water resources, and agricultural produce (Chen and Yang , 2005; Hu et al, 2006; Yu et al, 2005).

In general, Ecological Footprint methods have been widely used in China, with their significance to decision making appreciated. Prior research results have had important impacts on shaping the government's policies on construction and planning, as well as promoting public awareness on environmental issues (Chen & Mao, 2007; Ye, 2008). Some local authorities have showed preferences for ecological footprint in policy -making. Looking into the future of China's Ecological Footprint, efforts should be made in the following directions:

• In terms of scale, emphasis should be placed on studies at smaller scales and of specific populations to support public education and policy deliberation.

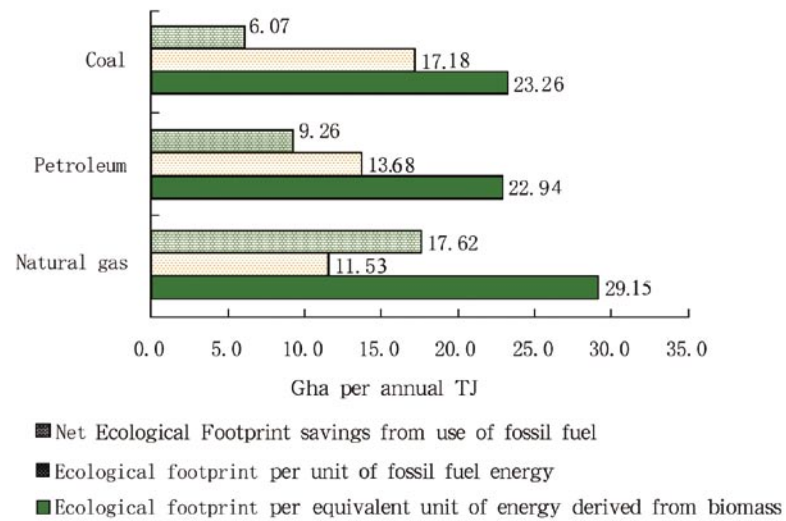
• In terms of duration, emphasis should be placed on longer studies to reveal the changes in regional Ecological Footprint over time, the driving mechanism for these changes, and future trends of regional development.

• In terms of research methodology, future studies should employ common methods and data sets to improve the accuracy and comparability of the final results

• Several important areas should continue to be highlighted, such as the differences between using fossil versus renewable energy resources, fairness of ecological consumption, and regional and global flow.

Fig. 5.2 The Ecological Footprint of three types of fossil fuel, calculated as the area required to sequester the carbon dioxide released through the production of one TJ of energy (orange bars). Compared to the Ecological Footprint that would be required to produce a similar type and quantity of energy using currently available biomass harvesting and processing methods (dark green bars), burning fossil fuels has allowed China to keep its Ecological Footprint lower, assuming the same growth in energy consumption under fossil fuel and biomass energy production scenarios.

Fig. 5.2: ECOLOGICAL FOOTPRINT FOR CARBON SEQUESTRATION PER UNIT OF FOSSIL FUEL COMPARED TO BIOMASS SUBSTITUTION



6 China's Ecological Footprint and Biocapacity

The story of China over the past forty years is the story of growth. Since 1961, China's population has doubled, its per person Ecological Footprint has doubled, and its total demand on the planet has increased by a factor of four. Only the 114th highest user of biological capacity in 1961, China now demands more from the planet than any nation except the United States.

Along with this high demand, however, China is fortunate to have a great amount of available capacity within its own borders. The ability of its croplands to produce useful products is the second highest of any nation in the world. In 2003, China produced more wheat and rice than any other nation in the world, and its available grazing land capacity is greater than all of the OECD nations combined.

Sustainability requires demand remaining within the regenerative capacity of nature, however. If any nation consumes more than its own ecosystems can provide, it runs an ecological deficit. This deficit can only be met in two ways – by relying on biological capital from other nations or the global commons, or by depleting the biological capacity available within its borders.

Since the early 1970s, China has run an aggregate ecological deficit. Its deficit in cropland has narrowed, but China still must import an equivalent of 83,000,000 global hectares of cropland capacity each year. China still has an ecological reserve in grazing land and forest, with demand for these types of capacity within the ability of the nation to provide, but these reserves are shrinking over time. A small reserve in fishing grounds has become a deficit.

The most significant change over this time has been the dramatic increase in the carbon Footprint. This has resulted from an equally dramatic increase in energy consumption per person in China, which has more than tripled since 1961. Given that China's coal-powered electricity is very carbon intensive, the power sector will have a major role to play in reducing China's carbon Footprint in the future.

Figure 6.1: China's Ecological Deficit, 1961-2003. China began demanding more capacity than its own ecosystems could provide in the mid-1970s, and the nation now demands the equivalent of two Chinas' worth of biocapacity

Fig. 6.1: CHINA'S ECOLOGIAL DEFICIT, 1961-2003

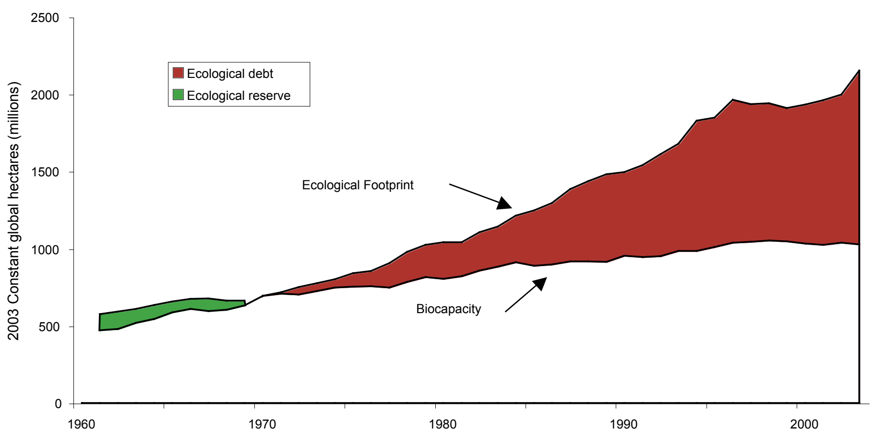


Table 6.1: CHINA'S TOTAL ECOLOGICAL FOOTPRINT AND BIOCAPACITY BY LAND TYPE, 2003.

Land types	Total Ecological Footprint (million gha)	Total Biocapacity (million gha)
Cropland	530	450
Grazing land	160	160
Forest	150	210
CO_2 from fossil fuels	990	-
Nuclear energy	10	-
Built-up land	90	90
Fishing ground	220	120
Total	2,150	1,030

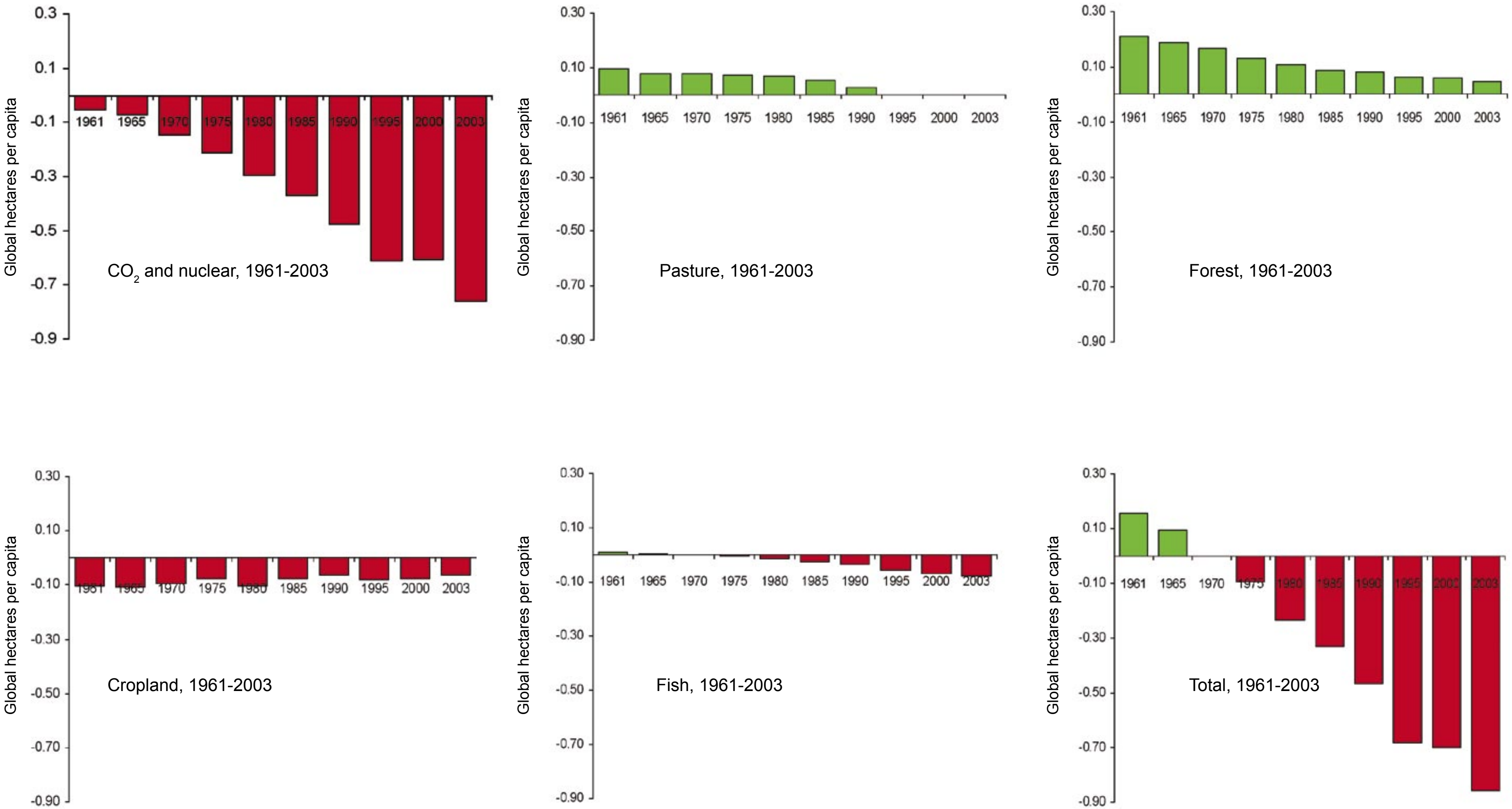


Figure 6.2: China's ecological deficit or reserve, per land type. China has entered ecological deficit for all but one of its land types, i.e. forest land. However, even forest land is not far from dropping into deficit and has been decreasing steadily over the past 40 years. CO_2 land is the most severely in deficit and is the major contributor to pushing China into total ecological deficit. Thus a significant reduction in CO_2 emissions could greatly reduce China's total ecological deficit.

7 China's Global Reach

China's international trade relations are characterized by imports of primary produce and raw materials (e.g., timber) and exports of finished products (e.g., paper and furniture). In 2003, UN Statistics report that China's imports embodied a total of 480 million global hectares, while exports totaled 350 million global hectares. Hence the net import amounted to 130 million global hectares, nearly equal to the entire biocapacity of Germany. These net imports of resources allow China to run an ecological deficit.

Calculations of bilateral trade showing the individual sources and destinations of goods shipped to and from China are shown here for a small subset of selected high-volume products China trades each year. The focus here is placed on large volume goods, such as grains, soybeans, cotton, wool, vegetables, fruit, aquatic produce, animal and poultry meat, timber and timber products. Trade in embodied carbon, which accounts for nearly half of total imports and more than two thirds of total exports, is not included in this preliminary analysis.

For the selected products shown here in 2004, China imported 161 million global hectares of biocapacity and exported 95 million global hectares, representing the majority of non-carbon Footprint trade to and from China (Figure 7.1). Trade in forest land dominates the list of the high-volume products shown here. This result is caused by the comparative scarcity of Chinese forestry resources and heavy industrial reliance on imports of log, pulp, and paper products.

Driven by increasing resource demands for both domestic consumption and production for export, China will almost certainly continue to import biocapacity from other nations into the foreseeable future. In particular, given the dramatic urbanization and economic development in China, the consumption of meat and diary products will likely begin to play a larger role in the diet of Chinese people. This is expected to lead to greater cropland and grassland biocapacity imports in the future.

Table 7.1 and Figure 7.2 show the major trading partners of China for the selected high-volume products. Canada, the United States, and Indonesia are major sources of biocapacity for China, with the biocapacity imported from the United States largely in the form of imported grains, logs, and pulp, and the biocapacity imported from Indonesia in the form of pulp. Major destination countries for China's exports are the United States, Japan and South Korea, which receive exports of woolen and fisheries products, and Australia, which receives a great deal of China's exported paper. Given China's growing ecological deficit, the security of these trade relations will play an increasingly important role in China's future development.

The biocapacity that is imported into China plays three major roles in China's economy: direct consumption, indirect consumption, and re-export to other nations.

- In direct consumption, the imported products are consumed by residents of China without any further processing. A classic example is rice.
- In indirect consumption, the imported products are used as inputs into the economy and transformed into other finished products that are then consumed domestically. An example is imports of corn that are used to raise pigs that produce pork to be consumed within China.
- In re-export, the imported products are used as inputs into local production systems, transformed into other products, and then exported to be consumed internationally. For example, China imports raw wool from Australia and New Zealand, which it then processes and exports as finished woolen fabric and clothing to the United States and Japan. Overall, China's international trade mode is patterned in this way, mainly importing primary products and exporting finished products.

Overall, China's net imports (those imports that remain in the country and are consumed) represent only slightly more than one quarter of the total imports of biocapacity into the country.

TABLE 7.1 CHINA'S FLOWS OF BIOCAPACITY WITH MAJOR COUNTRIES FOR SELECTED HIGH-VOLUME products in 2004(10^6 gha). Trade in embodied carbon is not included here.

Country	Inflow	Outflow	Net outflow	Major products
India	1.5	3.3	1.9	Wool
Indonesia	11.3	2.3	-9.0	Wood products (WP)
Malaysia	1.0	1.7	0.7	Aquatic products (AP)
Japan	1.5	17.2	15.8	AP
Saudi Arabia	0.0	0.6	0.6	Wood
Singapore	0.0	1.2	1.2	Cotton products, pork
South Korea	1.0	14.2	13.3	AP, cotton products
Thailand	3.4	0.6	-2.8	WP, AP
Germany	1.1	3.0	2.0	AP, wool
France	1.2	0.5	-0.7	Flour, grain
Britain	0.4	2.0	1.6	Wool, AP
Italy	0.4	1.2	0.8	Wool
Netherlands	1.3	2.0	0.7	AP
Russia	6.6	2.3	-4.3	AP
Spain	0.3	0.7	0.4	AP
Canada	17.6	1.2	-16.4	WP
United States	13.7	11.4	-2.3	grain, WP, cotton
South Africa	0.4	0.5	0.1	Cotton
Egypt	0.2	0.2	0.0	Wool
Brazil	6.3	0.1	-6.2	WP
Mexico	0.1	0.6	0.6	AP, cotton products
Australia	4.1	12.3	8.2	WP
New Zealand	3.8	0.2	-3.6	WP, wool
Total	**77.1**	**79.6**	**2.5**	

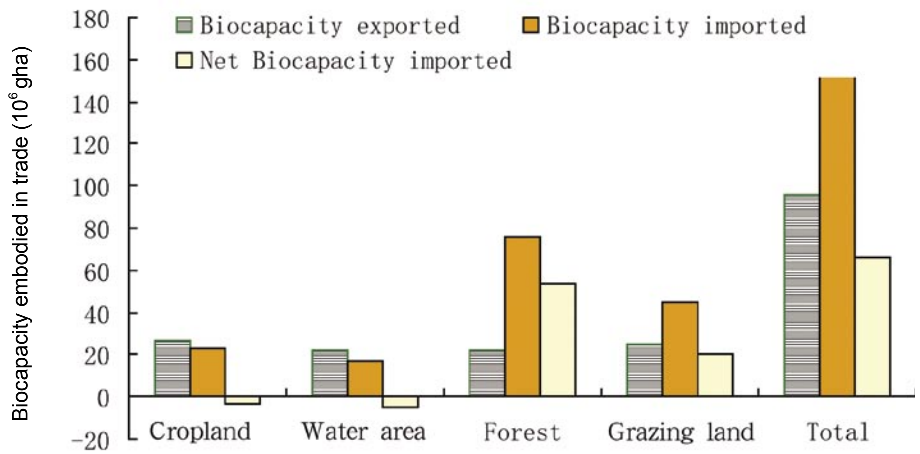


Fig. 7.1 CHINA'S TOTAL BIOCAPACITY IMPORTS AND EXPORTS FOR SELECTED HIGH-VOLUME PRODUCTS (2004)
Shortages of timber resource have made forest land an important type of bioproductive area for Chinese imports.

Fig.7.2 NET BIOCAPACITY FLOWS BETWEEN CHINA AND ITS MAJOR TRADING PARTNERS FOR SELECT HIGH-VOLUME PRODUCTS

Figure 7.2 China is a net exporter to neighboring countries such as South Korea and Japan and a net importer from often distant countries with rich forestry resources such as Canada, Indonesia and Brazil.

A positive number for net import means that imports contain more embodied biological capacity than exports. A negative number for net import points to the opposite. This chart shows only major trading partners. Trade in embodied carbon is not included.

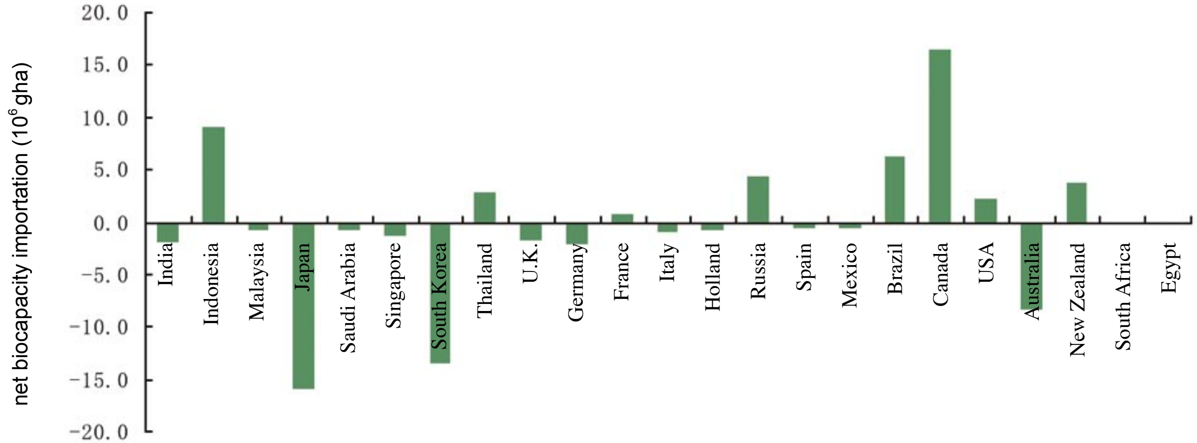
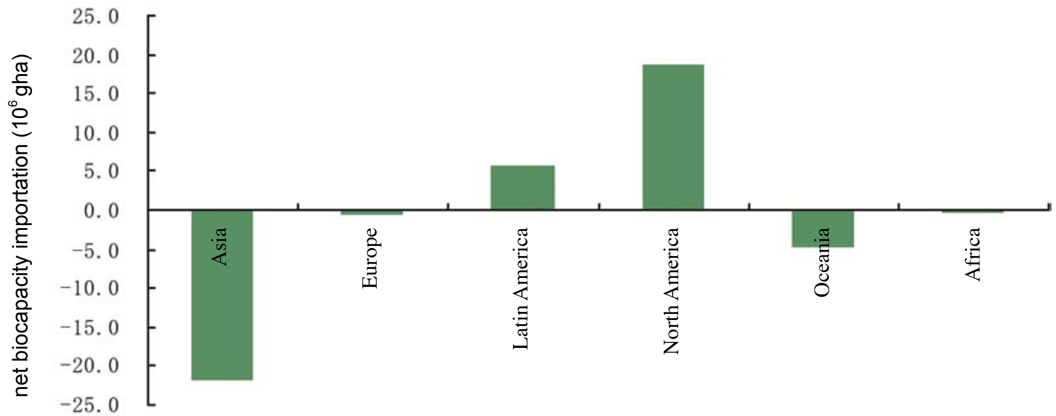


Fig. 7.3 NET BIOCAPACITY FLOWS BETWEEN CHINA AND ITS MAJOR TRADING REGIONS FOR SELECT HIGH-VOLUME PRODUCTS

Figure 7.3: By continent, China mainly exports biocapacity to Asia and Oceania and imports bio-capacity from North America and Latin America. Trade in biocapacity with Europe and Africa is relatively balanced, in ecological terms, for the subset of products examined. Trade in embodied carbon is not included.



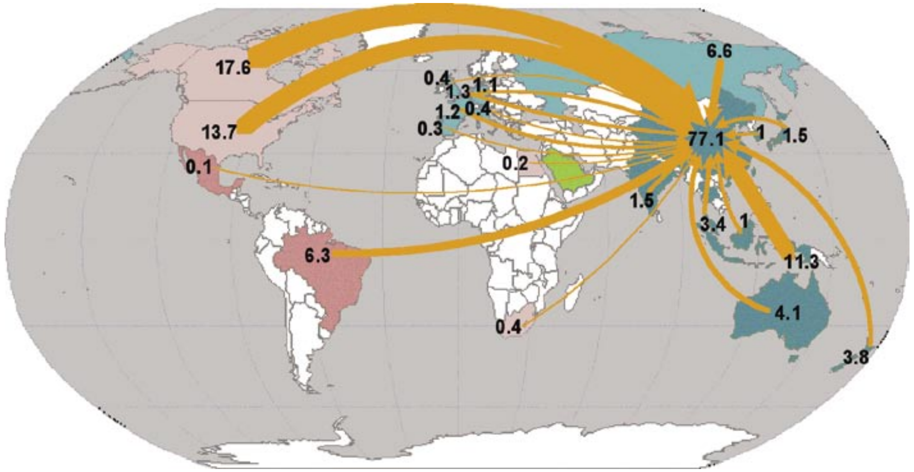


Fig. 7.4 CHINA'S INFLOWS OF BIOCAPACITY WITH MAJOR TRADING PARTNERS FOR SELECT HIGH-VOLUME PRODUCTS (2004)

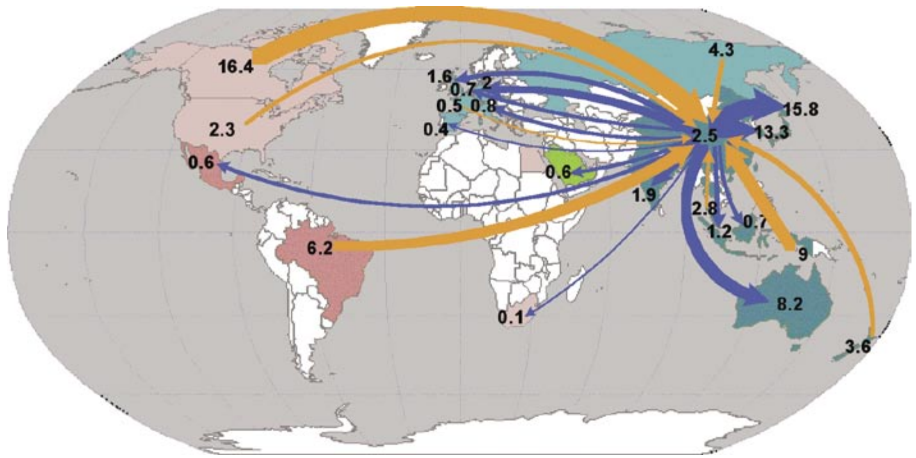


Fig. 7.6 CHINA'S NET FLOWS OF BIOCAPACITY WITH MAJOR TRADING PARTNERS FOR SELECT HIGH-VOLUME PRODUCTS (2004)

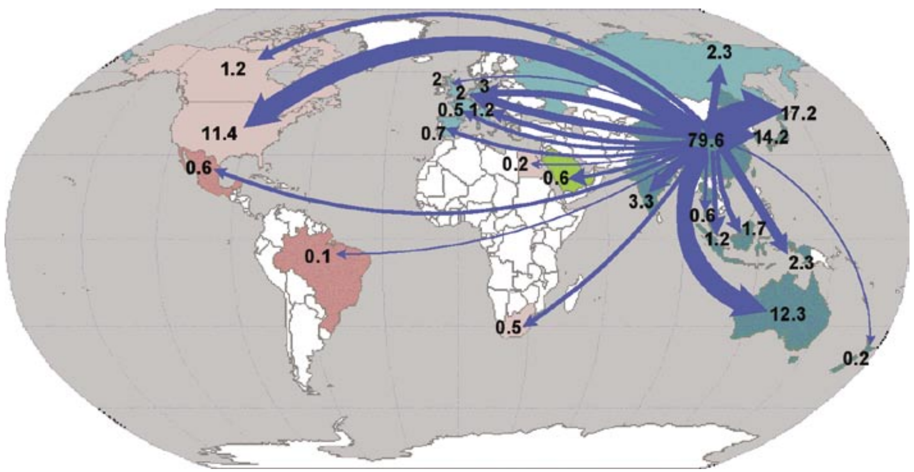


Fig. 7.5 CHINA'S OUTFLOWS OF BIOCAPACITY WITH MAJOR TRADING PARTNERS FOR SELECT HIGH-VOLUME PRODUCTS (2004)

8 The Global Development Challenge

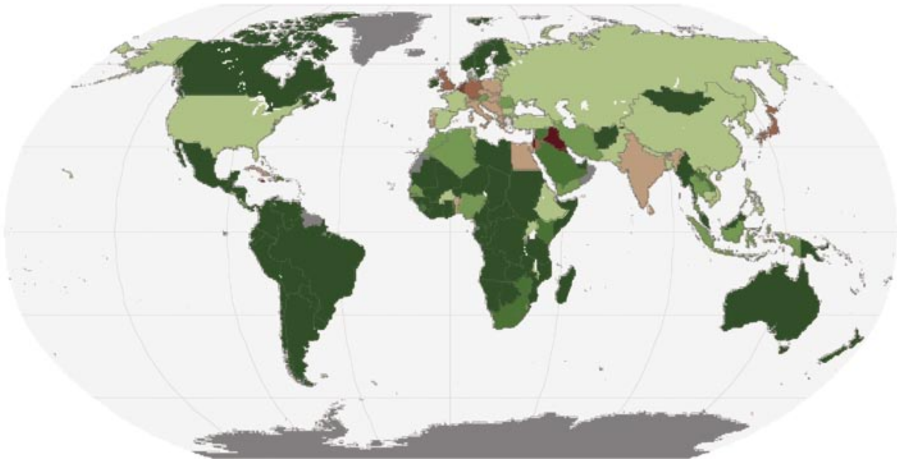


Fig.8.1(a): 1961

Ecological debtor nations are countries that, in aggregate, consume more than the ecosystems within their own borders provide. Ecological creditor nations have ecological reserves, and their residents have Ecological Footprints lower than their own domestic biocapacity per person. The biocapacity reserve of creditor nations may be unharvested or may be harvested for export to other nations. In spite of the reserve, if ecosystems of creditor nations are not carefully managed, it is still possible that some of them get overused.

- Footprint more than 150% larger than biocapacity
- Footprint 100-150% larger than biocapacity
- Footprint 50-100% larger than biocapacity
- Footprint 0-50% larger than biocapacity
- Biocapacity 0-50% larger than Footprint
- Biocapacity 50-100% larger than Footprint
- Biocapacity 100-150% larger than Footprint
- Biocapacity more than 150% larger than Footprint
- Insufcient data

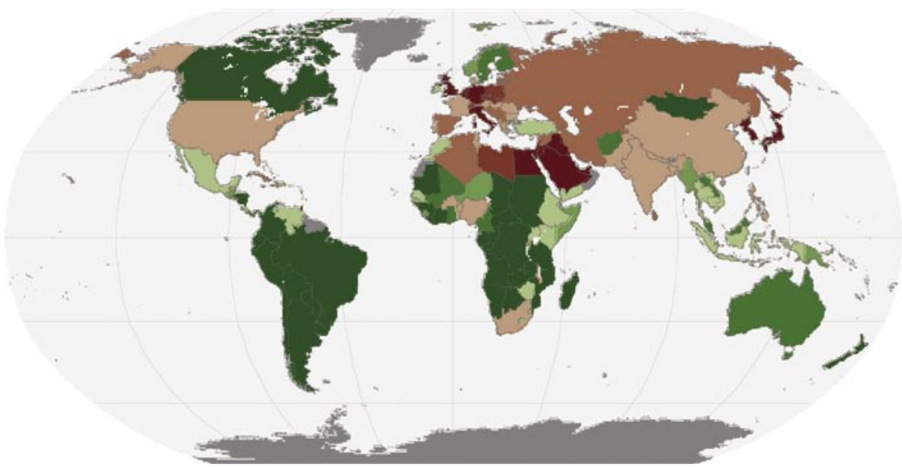


Fig.8.1(b):1982

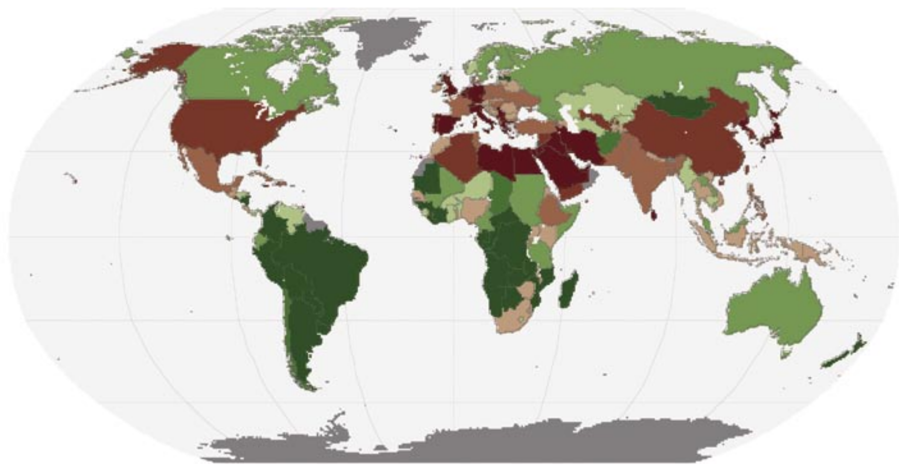


Fig.8.1(c): 2003

With continuing and growing global overshoot, debtor and creditor countries alike will continue to experience the increasing importance of access to ecological assets. Reducing a nation's Ecological Footprint thus becomes a way for a nation to improve its resilience, national security, and competitive advantage in a world with ever larger overshoot.

In fact, as national ecological deficits continue to increase, the European Environment Agency has noted that the predominant geopolitical line may gradually shift from the current economic division between “developed and developing countries”, to a resource division between ecological debtors and ecological creditors.

A reserve alone, however, cannot create human well-being. For instance, countries with severe internal conflicts and low per capita Footprints, such as Afghanistan or Somalia, are ecological creditors because domestic unrest prevents its people from accessing the biocapacity necessary for them to meet their basic human needs. Ecological reserves are necessary, but not sufficient, conditions for human well-being.

Figure 8.1: Ecological debtor and creditor countries, 1961, 1982, 2003. Ecological debtors are shown in red, and ecological creditors in green. In 1961, only 26 out of 147 countries were ecological debtors, but by 2003, 90 countries were running ecological deficits.

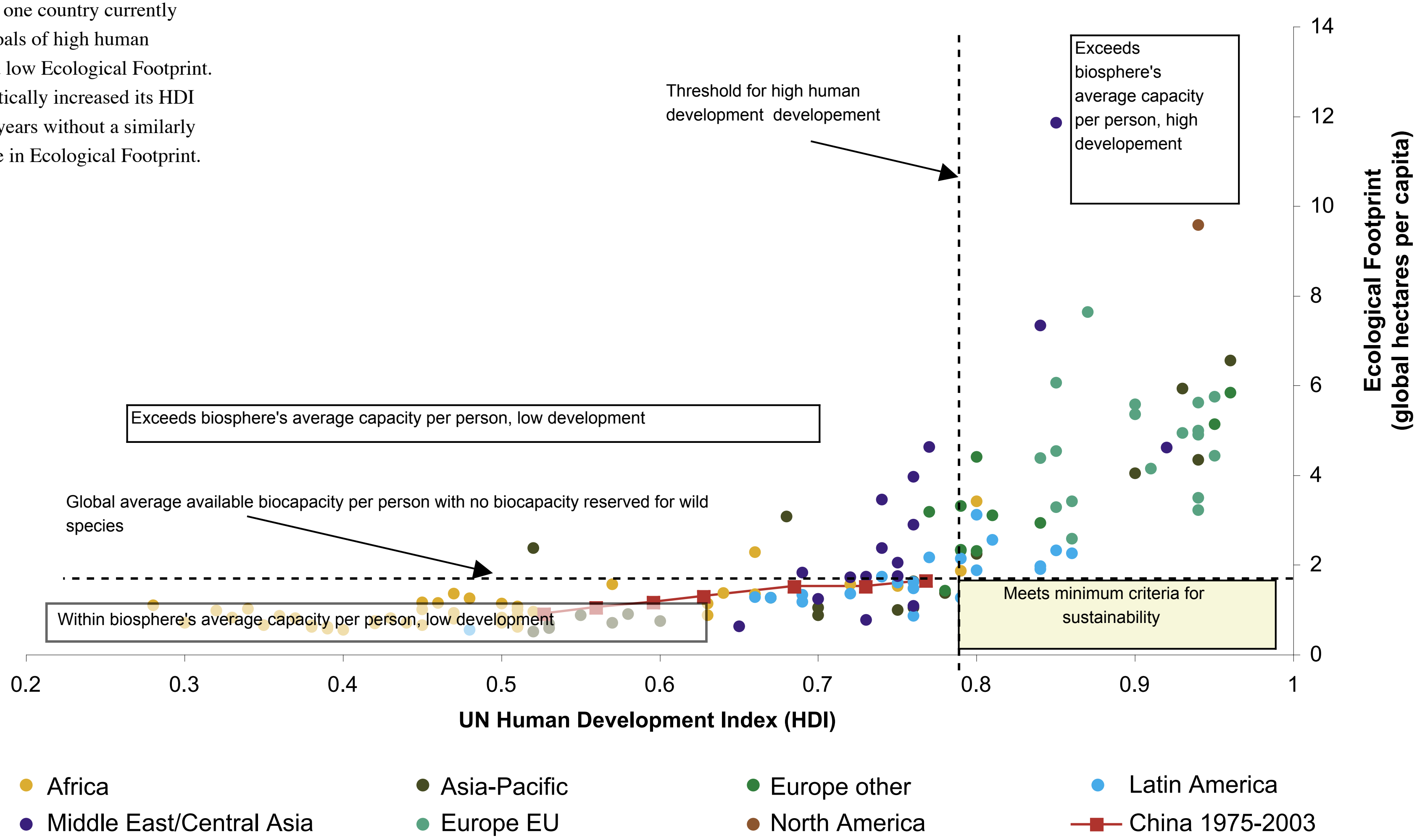
Progress towards meeting the goals of sustainable development, allowing all people the opportunity to live fulfilling lives within the means of nature, can be examined through the combination of the Ecological Footprint, an indicator of demand on nature, and the Human Development Index (HDI), an indicator of basic human development calculated by the United Nations Development Program (UNDP) in their yearly Human Development Report.

UNDP considers countries with HDI values of more than 0.8 to be experiencing “high human development”. An Ecological Footprint lower than 1.8 global hectares per person, the average biocapacity available per person on the planet, means that the country's lifestyle could be sustainably replicated on a global scale. Sustainable development requires that the world, on average, fulfill both of these requirements, shown by the blue quadrant in the bottom right of the graph.

Regionally, in 2003, Asia-Pacific and Africa were demanding less than 1.8 global hectares per person, while the EU and North America had an HDI of greater than 0.8. No region, nor the world as a whole, met both criteria for sustainable development. At the national level, some Latin American countries were close to the Sustainable Development region.

Over the past forty years, China has experienced a rapidly increasing HDI, with a corresponding moderate increase in Ecological Footprint per person. China now sits at a junction: are its economically preferred options leading to high development without high Ecological Footprints? Such development would make China more robust in the face of global ecological overshoot. Finding such a path would involve careful planning and management. The future of both China's and of the world's ecosystems may hinge on the decisions made within China over the coming decades.

Figure 8.2: Human Development and Ecological Footprint, 2003. Countries are shown grouped by regions, with China's time trend since 1961 shown as a series of red dots. Despite growing adoption of sustainable development as an explicit policy goal, only one country currently meets the dual goals of high human development and low Ecological Footprint. China has dramatically increased its HDI over the past 40 years without a similarly dramatic increase in Ecological Footprint.



9 Country Profiles

The world has changed dramatically in many ways over the past forty years. Many nations, including those in the Asia-Pacific region, have experienced economic growth, a reduction of poverty, and the improvement of quality of life. These positive aspects, however, have often been accompanied by a corresponding rise in Ecological Footprint.

Each person alive today consumes more on average than a person alive forty years ago. But at the same time, the amount of biological capacity available per person has fallen, as population growth outpaces increases in the productive area and yield of ecosystems throughout the world. These two pressures have led to growing ecological deficits for nations around the world.

This pattern is also evident in the forty year history of China's Ecological Footprint, biocapacity, and GDP per person (Figure 9.1). Perhaps surprisingly, the largest absolute increases in GDP per person occurred without an equally dramatic increase in Ecological Footprint. This could be caused by an increase in less resource intensive economic activities, or by inequality in the distribution of Footprint and income within different populations in China.

India shows a different trend (Figure 9.2), with a slightly declining Ecological Footprint per person, although population increases have led to a large increase in total Ecological Footprint. The time trends for India also demonstrate how Ecological Footprint can be constrained by biocapacity – in years where biocapacity fell sharply or spiked upward, a corresponding pattern is seen in the graph for Ecological Footprint.

In Japan and the United States (Figures 9.3 and 9.4), high income countries with the ability to import resources from abroad, increases in Ecological Footprint have been dramatic. The decreases in consumption associated with various recessions during the past forty years are clearly evident in these charts. Interestingly, through changes in technology and economic structure, Japan's per person Ecological Footprint in 2003 has risen less than 20 percent since the early 1970s, despite a near doubling in per person GDP over this period.

The United States and the European Union (Figure 9.5) are both notable for their steadily growing Ecological Footprint and biocapacity per person over the past thirty years as compared to the rapidly growing Asia-Pacific nations. The most rapid growth in residents' consumption in these high income nations occurred before 1961, and is thus not evident from these figures.

The trend in Africa is strikingly different (Figure 9.6). Per person consumption has increased very little on the continent as a whole, while rapid population growth has led to a dramatic decline in the available biocapacity per person. While in the aggregate, Africa remains an ecological creditor, some of the continent's reserve is harvested for exports.

Figure 9.1-9.6: Ecological Footprint, Biocapacity and GDP per person for China, India, Japan, the United States, the European Union, and Africa, 1961-2003.

Fig. 9.1: CHINA'S ECOLOGICAL FOOTPRINT, BIOCAPACITY AND GDP, 1961-2003

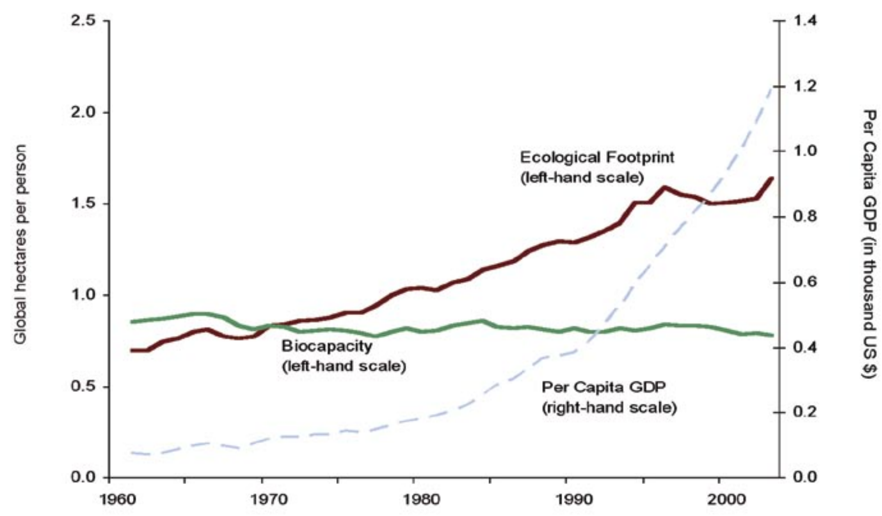


Fig. 9.2: INDIA'S ECOLOGICAL FOOTPRINT, BIOCAPACITY AND DP, 1961-2003

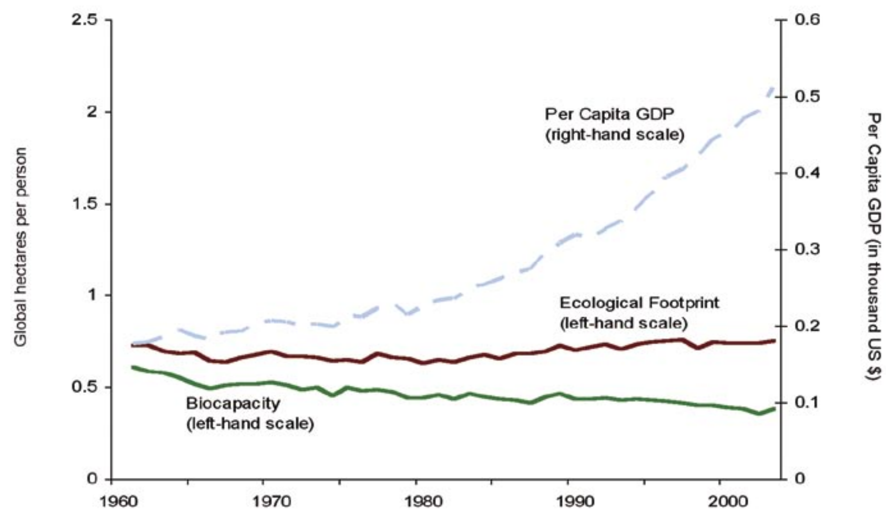


Fig. 9.3: JAPAN'S ECOLOGICAL FOOTPRINT, BIOCAPACITY AND GDP, 1961-2003

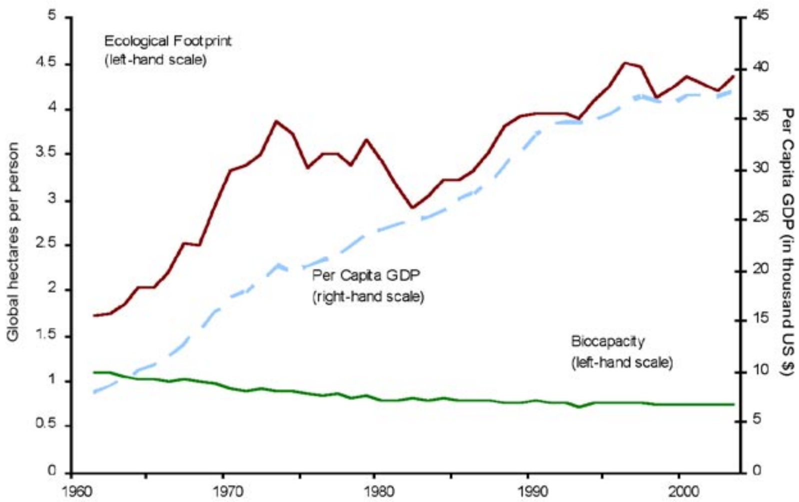


Fig. 9.4: USA'S ECOLOGICAL FOOTPRINT, BIOCAPACITY AND GDP, 1961-2003

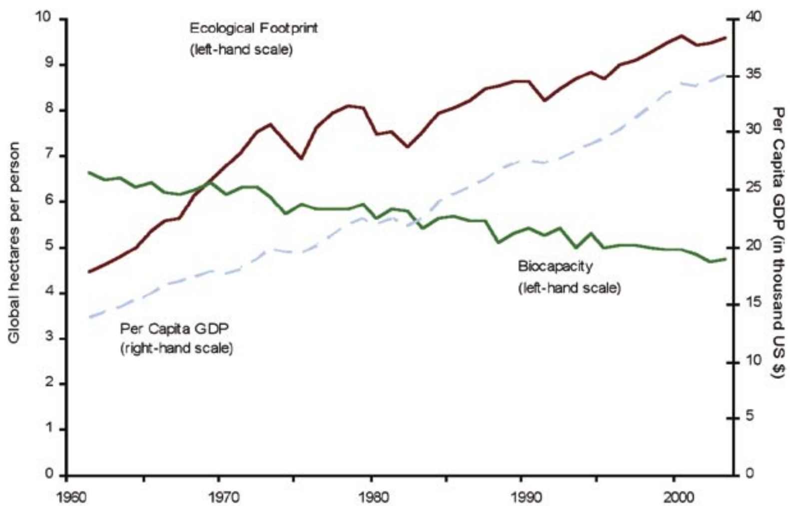


Fig. 9.5: EU-27'S ECOLOGICAL FOOTPRINT, BIOCAPACITY AND GDP, 1961-2003

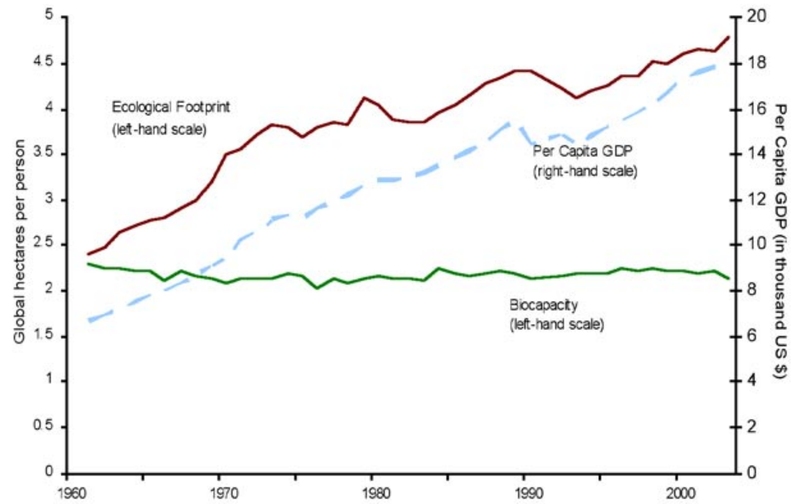
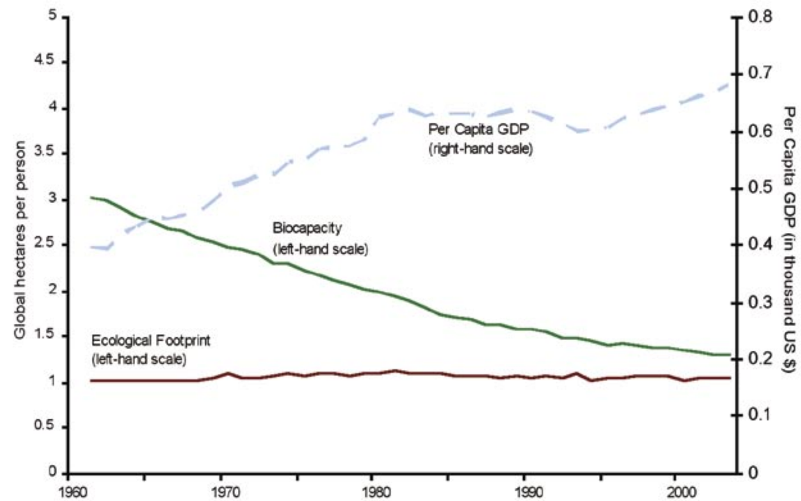


Fig. 9.6: AFRICA'S ECOLOGICAL FOOTPRINT, BIOCAPACITY AND GDP, 1961-2003



10 Paths for The Future

China's options in the coming century will be closely related to the fate of the world as a whole. If global society continues on its current trajectory, even optimistic United Nations projections with moderate increases in population, food and fibre consumption and carbon emissions suggest that, by 2050, humanity will demand resources and ecological services at double the rate at which the Earth can regenerate them. Each year, we would demand the equivalent of two planets.

Within this global context, China's ecological deficit continues to rise, making China more dependent on the use of biological capacity outside its borders and putting its own ecosystems at risk of degradation or collapse. As limits become increasingly evident, this deficit presents an increasing risk to China's economy and society.

How will China make successful decisions within this new ecological reality? What steps might China take to continue to improve its residents' quality of life while reducing its ecological deficit?

Five factors determine the size of China's ecological deficit (Figure 10.1). Three of these factors influence China's total demand on the planet: population size, average consumption per person, and the footprint intensity per unit of consumption. Two additional factors control biocapacity, or what China's ecosystems are able to supply: the amount of biologically productive area available, and the productivity or yield of that area.

1. The Population Factor.

Increase in population can be slowed and eventually reversed by supporting families in choosing to have fewer children. Offering women access to safe and affordable family planning, better education, economic opportunities, and health care are proven approaches to achieving this. Changes in population size are slow moving, and decisions today will have consequences for several generations into the future.

2. The Consumption Factor.

The potential for reducing the amount of resource consumption per person depends on an individual's economic situation and the social and cultural context in which

Fig. 10.1: FIVE ECOLOGICAL FOOTPRINT AND BIOCAPACITY FACTORS THAT DETERMINE OVERSHOOT

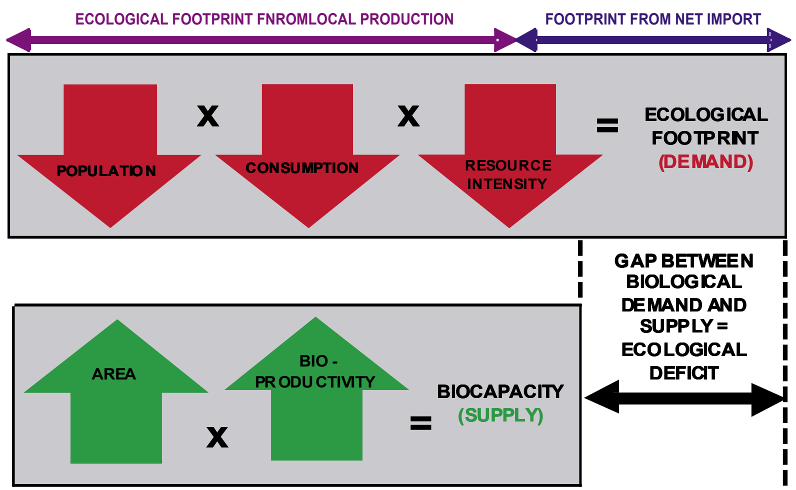
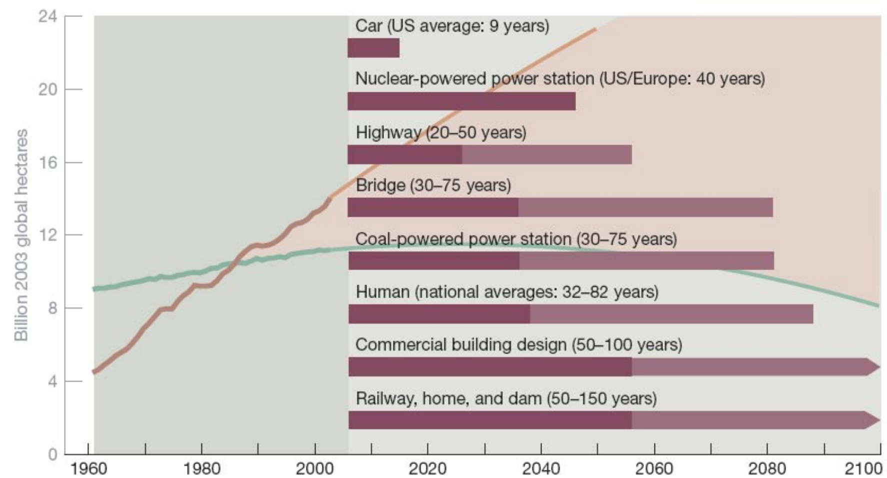


Fig. 10.2: LIFESPAN OF PEOPLE, ASSETS AND INFRASTRUCTURE



they live. While people living at or below subsistence levels may need to increase their consumption to move out of poverty, there are ways for the affluent to reduce their consumption without, arguably, reducing their quality of life. The average resident of Italy, for example, lives on less than one half the average Footprint of a resident of the United States.

3. The Technology Factor.

With any number of people and any given level of consumption, the Ecological Footprint used to provide goods and services can often be significantly reduced. Lowering the Footprint intensity of consumption can be achieved in many ways, from increasing energy efficiency in manufacturing and in the home, through minimizing waste and increasing recycling and reuse, to building fuel-efficient cars and reducing the distance many goods are transported. Business and industry do adjust to government policies and incentives to promote resource efficiency and technical innovation, where such policies are clear and long term, as well as to consumer pressure.

4. The Area Factor.

In some cases, the total amount of bioproductive area available for human use can be increased. Degraded lands can be reclaimed through careful management, terracing has had historical success in mountainous regions, and irrigation can make previously unusable land productive. Decisions and policies to increase productive area must be made carefully, however, to avoid negative impacts on biodiversity and the health of wild species. Care must be taken to ensure that new lands will remain productive beyond the initial years, and good land management must ensure that currently bioproductive area is not lost to urbanization, salinization, or desertification.

5. The Productivity Factor.

The total amount of useful production per hectare depends both on the type of ecosystem being considered and the way that it is managed. Agricultural technologies can boost productivity, but can also diminish biodiversity, and gains can be reversed if the land is degraded. Energy intensive agriculture and heavy reliance on fertilizer may increase yields, but at the cost of a larger Ecological Footprint associated with increased inputs.

Out of all of the possible decisions and investments China could make, which are the most important to consider today? Two general strategies for reducing ecological deficit stand out as important:

A. Easy Things First.

This strategy involves solving the simplest, cheapest, and most publicly acceptable challenges first. Investments in clean technology, such as energy efficient light bulbs, often are able to quickly reduce Footprint intensity without reducing the quality of life of end consumers or the profits of businesses. This strategy can result in very rapid, short-term gains that build momentum and help to set society on a low-Footprint path.

B. Slow Things First

Reducing China's ecological deficit in the long run will require considering which decisions today are likely to have long term impacts (Figure 10.2). Often, the most important decisions made today are not those that place the greatest demand on the planet today, but rather those that have a moderate to high current demand but last for a long time. Although highways may be cheaper to maintain as compared to the construction of a new light rail system this year, over the long term, the highways will result in a much higher future demand than the light rail system. Decisions and actions related to human populations and buildings are two examples of slowly changing factors with long lifespans that will influence the ecological deficit of China well into the coming century.

11 China: A CIRCLE Approach to Sustainability

In the next 10 to 20 years, China's consumption will likely continue to pose threats to China's own ecosystems and place increasing pressures on global biocapacity. With the acceleration of urbanization, industrialization and globalization, each resident of China will also demand more natural resources. If no measures are taken, the growing population and a growing Ecological Footprint per capita will lead to a greater ecological deficit, with the associated risks of drawing down the national and international natural capital stocks upon which future generations will depend.

The Chinese government has realized the significance of this issue, and has included sustainable development as one key objective for building a well-off society. The government specifically recognizes that it needs to take steps to promote sustainable development, to improve the natural environment of China, to enhance energy efficiency, and to foster the harmony between human beings and nature so that the whole society can embark on a path characterized by productive development, human well-being and ecological soundness.

The general strategies outlined in the previous section lead to specific recommendations for China. An integrated strategy named by the acronym CIRCLE: Compact, Individual, Reduce, Carbon, Land, and Efficiency, will be important to achieving China's sustainable development goals.

1. Compact: A strategy to control urban expansion

There is a significant difference in per capita Ecological Footprint between the urban and rural population in China, with residents in urban areas requiring much more capacity to support their lifestyles than rural residents (Figure 11.1). While urban living can be more resource efficient than rural living, this effect is compensated by the higher income in urban areas. It is estimated that by 2020, the total Chinese population will reach 1.45 billion with 55% of the population living in urban centers. This implies an increase in urban population by 220 million in the next 12 years.

One of the most effective ways to prevent a large increase in China's Ecological Footprint as more residents move to cities will be the use of a compact urban development strategy. Although total productive land area has remained relatively stable from 1982 to 2000 (Table 11.1), the annual 1.5% expansion of built-up areas and the ever-decreasing productive area per capita delivers a warning signal to an urbanizing China. A compact urban development strategy has two parts:

Spatially compact city: Though a spatially compact urban development plan may not be appropriate for all countries committed to sustainable development, it is an ideal solution for China, especially in the densely populated middle and eastern part of China where rural land is not readily available to support urban expansion. A spatially compact city can shorten the per capita annual transportation distance, and therefore lower the consumption of energy and the emission of greenhouse gases. It can also make heating and cooling more effective as walls are shared between apartments. The Chinese government is prioritizing and subsidizing public transportation, aiming to concentrate the urban layout and check the uncontrolled expansion of urban areas.

However, due to the lack of planning, many Chinese cities still continue to expand like a pancake. It is difficult to find a Chinese city with a multi-center layout to shorten the distance that individuals need to travel on a daily basis Meanwhile, increasing incomes have led to the surge in demand for bigger, more spacious apartments, creating a glut of older empty apartments on the market. As a result, the urban areas continue to expand to cover productive land.

Eco-functional city: In China's highly urbanized areas, the productive green space available within the urban center remains quite high. Take Tianjin, Beijing and Shanghai for example, the green space per unit of urban land in these cities is 2 to 6 times of the national average, largely due to the use of urban agriculture and gardens. From the perspective of supply and consumption of ecosystem services, it is advisable to reserve some green areas within built-up areas to better public living conditions and to save the Ecological Footprint incurred from importing and transporting natural resources from far away regions.

2. Individual: a strategy to promote responsible consumption

Ecologically sensitive consumption should be a code of conduct for every global citizen to practice. Each person should also be sensitive to their role in the economy and the way that their activities create high Footprint or low Footprint products for others to consume.

The most urgent needs for change in individual behavior are in the following areas:

(1) Improve the utilization efficiency of water resources. This is an area that farmers, industrial workers, and individual households can address.

(2) Consumers can adopt energy efficient technologies, such as compact fluorescent light bulbs, and demand and encourage energy-efficient buildings to save energy and raw materials.

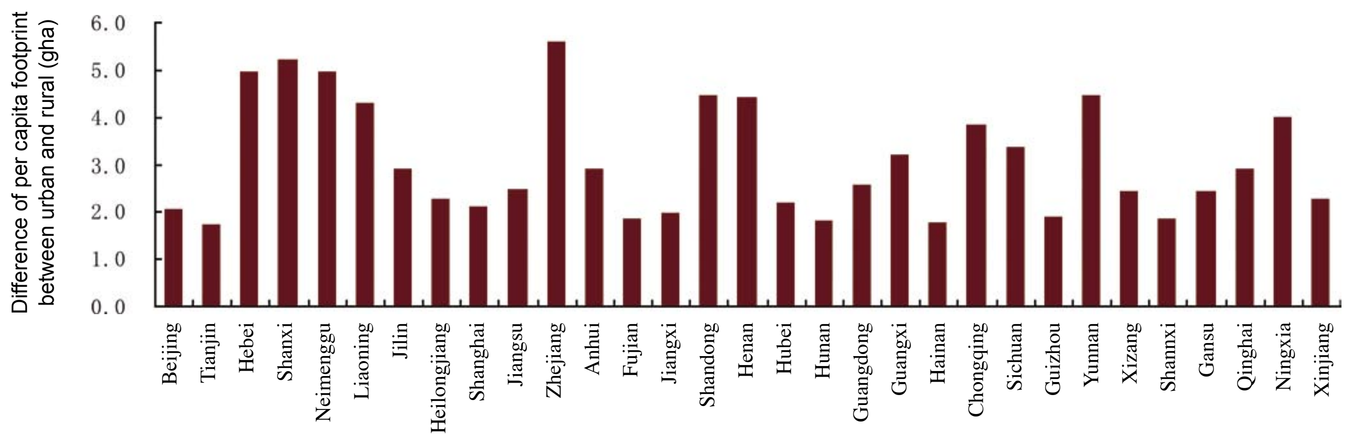
(3) Individuals can cultivate a balanced diet. Promoting a diet and lifestyle that is healthy can also be very sustainable. The traditional Chinese diet structure centering on vegetable food is recommended.

(4) Individuals can try to select the most environmentally friendly transportation means to lower their demand on the environment.

Table 11.1: THE AREA CHANGE OF DIFERENT LAND TYPES (1982-2000). These results are grouped into an earlier set of land type classifications that are different from the more current analysis shown elsewhere in this report.

	Forest	Grazing	Arable land	Garden	River or lake	Built-up	Unused land
			Total area (10^6ha, %)				
1982	198.7	264.0	126.7	5.8	36.5	27.8	300.5
2000	229.2	263.8	127.6	10.6	22.0	36.4	270.3
Rate of change	15.3	-0.1	0.7	82.8	-39.7	30.8	-10.0
			Per capita area (ha, %)				
1982	0.20	0.27	0.13	0.01	0.04	0.03	0.30
2000	0.18	0.20	0.10	0.01	0.02	0.03	0.21
Rate of change	-11.74	-23.55	-22.94	39.83	-53.88	0.18	-31.18

Fig. 11.1: DIFFERENCE OF PER CAPITA ECOLOGICAL FOOTPRINT BETWEEN URBAN AND RURAL AT PROVINCIAL LEVEL IN 2004



3. Reduce: a strategy to reduce China’s hidden consumption impacts

Many materials consumed within China come with large hidden impacts. Producing one tonne of fossil fuel resources in China, for example, creates approximately two tonnes of waste material. Reducing this hidden resource flow will be an important part of China's sustainable development.

Today, the average extraction rate, the portion of a deposit that can be economically extracted, is only 30 percent for coal mines, while for crude oil and natural gas, the extraction rates are 27 percent and 35 percent respectively. The Ecological Footprint of this low-efficiency extraction process can be very high. With coal resources, for example, over 20 percent of transportation energy is wasted through the movement of non-marketable materials such as solid waste from coal processing.

Considering biological materials, China consumes over 4.5 million cubic meters of timber and 1.4 billion tonnes of water resources for wood and paper packaging each year, and consumes almost 2 million tons of metallic resources such as iron, aluminum, tin for metal packaging. Plastic packaging consumes 1.5 percent of all crude oil resources used in China. The total losses incurred during crop harvesting, storage, transportation, processing, distribution and consumption amount to nearly 20 percent.

The reduced hidden waste strategy will involve:

(1) Lowering the total volume of resources, both non-renewable and renewable, extracted by improving extraction efficiency. The separation of waste should happen close to the extraction site to reduce the needless consumption of energy during transportation.

(2) Using available raw materials more efficiently during resource processing and manufacturing.

(3) Reducing unnecessary packaging.

(4) Reducing losses incurred during storage and transportation.

4. Carbon: a strategy to diversify the energy Footprint

Consumption of fossil energy is responsible for nearly one half of China's and the world's total Ecological Footprint. Lowering the Footprint of China's energy use will be critical for achieving sustainable development. Specific measures are:

(1) Improve energy efficiency in each stage of the energy life cycle, in both production and consumption;

(2) Adopt biomass energy technology to substitute fossil fuel energy in those cases where biomass has a lower Ecological Footprint than fossil fuels;

(3) Adopt carbon capture and storage technology for existing and planned fossil fuel electricity plants.

5. Land: a strategy to increase land productivity

With limited capacity to expand its available productive land area, one fundamental way for China to balance its ecological deficit is to improve yields on existing productive land while ensuring that this productive land base does not shrink.

Concrete measures to promote agricultural productivity include:

(1) Maintain stocks of forest land and pasture land to provide insurance against risks of water resource scarcity and provide ecosystem services that support agriculture;

(2) Make use of high yield crop varieties, move towards integrated crop management and local wild crop species, and improve irrigation efficiency;

(3) Optimize the structure and amount of chemical fertilizer applications and increase mechanic inputs in land management, crop management, and crop harvest; and

(4) Improve the scientific basis of agricultural management.

(5) Maintain the functionality of both natural ecosystems as well as those under human management.

These changes must be made in consideration of the large Ecological Footprint of chemical fertilizer use, however, which can rapidly increase yields but brings with it ecological costs. The energy efficiency of China's crop production has fallen over time, and China now harvests only 1.5 GJ of caloric energy for each 1 GJ of energy used in cropland inputs (Figure 11.2). Considering each individual hectare of cropland, the increasing application of fossil energy has raised yields, but these increases in yield have begun to level off (Figure 11.3).

6. Efficiency: a strategy to gather information for moving toward a circular economy and society

In a simple model of society, our economic system extracts natural capital from the biosphere and discharge wastes back to the biosphere. These two activities together form our Ecological Footprint. Adopting a circular economic model in which the “wastes” from our economy are recycled and reused will lead to less materials being extracted from nature and less wastes discharged.

In China, the most important measures for creating a circular economy are:

(1) Develop circular agriculture at the household level and within the agriculture sector. In particular, organize the rural economic system to integrate planting, animal husbandry and fisheries, and recycling of materials.

(2) Develop circular manufacturing and industries that are linked together into a web of industrial systems. China could promote eco-industry parks, for example, where the waste materials and heat discharged by one factory serve as inputs into other industrial processes.

(3) At household, enterprise, and city levels, the waste treatment and recycling industry should be expanded and upgraded. An integrated management strategy for processing wastes from disposal, collection, transportation, stockpile, reuse, and treatment stages should be formed.

(4) On the national level, incentive policies for developing a circular economy should be encouraged. Such measures could include a true-cost pricing system, green accounting system, rational industrial development pattern, and governmental approval and support for clean production technologies.

These integrated CIRCLE strategies form a basic roadmap for China to begin moving towards a sustainable future.

In summary, this report has shown that, from a global perspective, the lifestyle of China's residents requires relatively little biological capacity to support as compared to residents of more developed countries. China's large size, however, makes the nation one of the world's largest holders of biological capacity and gives it one of the world's largest total Ecological Footprints. China's own growing ecological deficit, and extensive trade networks with other nations, may pose challenges for the nation as resources become increasingly limited over the coming century.

The strategies and policies suggested in this report are intended only a starting point for further discussion. Through continued research into China's relationship to natural ecosystems, and the use of this research in decision making, China will have the unique opportunity to set the course for the future of sustainable development for nations around the world.

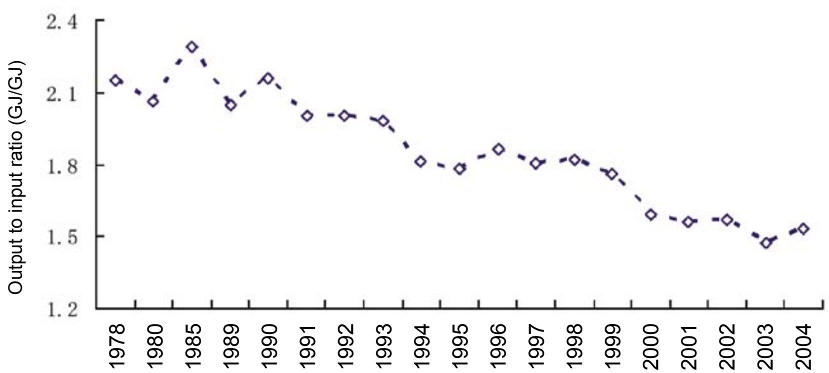


Fig. 11.2 CHANGE OF ENERGY EFFICIENCY OF CHINA'S AGRICULTURAL INDUSTRY FROM 1978 TO 2004

The calories of crop output per calorie of fossil fuel input has been falling over time, but remains greater than one (i.e., more energy is harvested from fields than is put into fields).

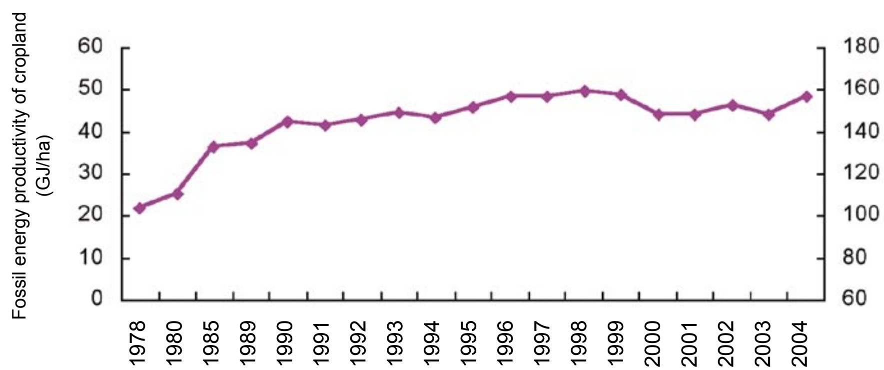


Fig. 11.3 EFFECTS OF FOSSIL FUEL ENERGY ON LAND PRODUCTIVITY FROM 1978 TO 2004

Though increases of fossil energy input have increased agriculture productivity, this effect has leveled off recently.

12 Technical Notes

Note: This section is modified from Kitzes, J., A. Peller, S. Goldfinger, and M. Wackernagel. 2007. Current Methods for Calculating National Ecological Footprint Accounts. Science for Environment & Sustainable Society. 4(1) 1-9. (data@footprintnetwork.org)

ECOLOGICAL FOOTPRINT ACCOUNTING

The Ecological Footprint is a well known resource accounting tool that measures how much biologically productive land and water area an individual, a city, a country, a region, or humanity uses to produce the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management. The Ecological Footprint is most commonly expressed in units of global hectares. A global hectare is a hectare that is normalized to have the world average productivity of all biologically productive land and water in a given year. Because of international trade and the dispersion of wastes, hectares demanded can be physically located anywhere in the world.

China's Ecological Footprint measures the biological capacity needed to produce the goods and services consumed by residents of China, as well as the capacity needed to assimilate the biological waste they generate. Resources used for the production of goods and services that are exported are counted in the Ecological Footprint of the country where the goods and services are ultimately consumed.

Biocapacity (or biological capacity) is the capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans using current management schemes and extraction technologies. "Useful biological materials" are defined for each year as those used by the human economy that year. What is considered "useful" can change over time (e.g. the use of corn stover to produce cellulosic ethanol would result in corn stover becoming a useful material, thereby increasing the biocapacity of maize cropland). Like the Ecological Footprint, biocapacity is expressed in units of global hectares, and is calculated for all biologically productive land and sea area on the planet.

An ecological deficit represents the amount by which the Ecological Footprint of a population exceeds the available biocapacity of that population's territory in a given year. A national ecological deficit measures the amount by which a country's Footprint exceeds its biocapacity. A nation can operate its economy with an ecological deficit by importing biocapacity from other nations, by placing demands on the global commons (e.g., carbon stocks in the atmosphere, fishing in international waters), or by depleting its own domestic ecological assets. A global ecological deficit, however, cannot be offset through trade and inevitably leads to the depletion of ecological assets and/or the accumulation of wastes.

Populations with an Ecological Footprint smaller than their available biocapacity run an ecological reserve, the opposite of an ecological deficit. A nation's ecological reserve is not necessarily unused, however but may be occupied by the Footprints of other countries that import biocapacity from that nation. Countries may also choose to reserve this biocapacity for wild species or use by future generations.

DATA SOURCES

The Ecological Footprint calculations of China and other nations found in this report are drawn from Global Footprint Network's National Footprint Accounts, 2006 Edition. These accounts calculate the Ecological Footprint and biocapacity of 150 nations from 1961-2003. These data are available by request from Global Footprint Network (data@footprintnetwork.org).

National Footprint Accounts calculations are based primarily on international data sets published by the Food and Agriculture Organization of the United Nations (FAO), the International Energy Agency (IEA), the UN Statistics Division (UN Commodity Trade Statistics Database – UN Comtrade), and the Intergovernmental Panel on Climate Change (IPCC). Other data sources include studies in peer-reviewed science journals and thematic collections.

Data sources for sub-national Ecological Footprint analyses within China that are cited in this report can be found in the reference list below.

METHODOLOGY

Ecological Footprint accounting is based on six fundamental assumptions:

- The majority of the resources people consume and the wastes they generate can be tracked.

- Most of these resource and waste flows can be measured in terms of the biologically productive area necessary to maintain flows. Resource and waste flows that cannot be measured are excluded from the assessment, leading to a systematic underestimate of humanity's true Ecological Footprint.

- By weighting each area in proportion to its bioproductivity, different types of areas can be converted into the common unit of global hectares, hectares with world average bioproductivity.

- Because a single global hectare represents a single use, and all global hectares in any single year represent the same amount of bioproductivity, they can be added up to obtain an aggregate indicator of Ecological Footprint or biocapacity.

- Human demand, expressed as the Ecological Footprint, can be directly compared to nature's supply, biocapacity, when both are expressed in global hectares.

- Area demanded can exceed area supplied if demand on an ecosystem exceeds that ecosystems regenerative capacity (e.g., humans can temporarily demand more biocapacity from forests, or fisheries, than those ecosystems have available). This situation, where Ecological Footprint exceeds available biocapacity, is known as overshoot.

The methodology behind Ecological Footprint accounting continues to undergo significant development and regularly incorporates new data and scientific knowledge as it become available.

More than 200 resource categories are included in the 2006 Edition of the National Footprint Accounts, including crop products, fibres, livestock, wild and farmed fish, timber, and fuelwood. The accounts also explicitly track one major waste product – carbon dioxide. Demand for resource production and waste assimilation are translated into global hectares by dividing the total amount of a resource consumed (or waste generated) by the global average yield of the land type that produces that resource (or absorbs that waste). This area is multiplied by the appropriate equivalence factor to express the total demand in global hectares for each resource consumed. Yields are calculated based on various international statistics, primarily those from the United Nations Food and Agriculture Organization.

Manufactured or derivative products (e.g., flour or wood pulp), are converted into primary product equivalents (e.g., wheat or roundwood) for the purposes of Ecological Footprint calculations. The quantities of primary product equivalents are then translated into global hectares.

Pending further research, each unit of energy produced by nuclear power is currently counted as equal in Footprint to a unit of energy produced by burning fossil fuels.

LIMITATIONS

Although the goal of Ecological Footprint accounting is to measure human demand on the biosphere as accurately as possible, no single indicator can capture every aspect of the relationship between human activities and natural ecosystems. The current Ecological Footprint methodology is commonly viewed as having several limitations that suggest areas where other additional indicators may be used for more complete decision making.

Because the Footprint is a historical account, many activities that systematically erode nature's future regenerative capacity are not included in current and past Ecological Footprint accounts. These activities include the release of materials for which the biosphere has no significant assimilation capacity (e.g. plutonium, PCBs, dioxins, and other persistent pollutants) and processes that damage the biosphere's future capacity (e.g., loss of biodiversity, salination resulting from cropland irrigation, soil erosion from tilling). Although the consequences of these activities will be reflected in future Ecological Footprint accounts as a decrease in biocapacity, Ecological Footprint accounting does not currently include risk assessment models that could allow a present accounting of these future damages.

Similarly, Ecological Footprint accounts do not directly account for freshwater use and availability, since freshwater acts as a limit on the amount of biological capacity in an area but is not itself a biologically produced good or service. Although the loss of biocapacity associated with water appropriation or water quality degradation is reflected as a decrease in overall biocapacity in that year, an Ecological Footprint of its use is not currently allocated to the consumer of the water resource.

Tourism activities are currently attributed to the country in which they occur rather than to the traveler's country of origin. This distorts the relative size of some countries' Footprints, overestimating those that host tourists and underestimating the home countries of travelers. Current data constraints also prevent the Footprint associated with the generation of internationally-traded electricity from being allocated to the final consumer of this energy.

The demand on biocapacity resulting from emission of greenhouse gases other than carbon dioxide is not currently included in Ecological Footprint accounts. Incomplete scientific knowledge about the fate of greenhouse gases other than carbon dioxide makes it difficult to estimate the biocapacity required to neutralize their climate change potential.

The carbon dioxide added to the atmosphere by human-induced land disturbances, such as slash-and-burn agricultural practices, is not currently accounted for in the Ecological Footprint, nor are the emissions of greenhouse gases other than carbon dioxide.

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CCICED Secretariat
No. 115, Xizhimen Nanxiaojie,
Beijing 100035, China
Tel: 86 10 66556547
Fax: 86 10 66556539
Website: www.ccicede.org

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Fax: +86 10 65227300

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