# Chapter 5 China Ecological Footprint Report 2010

## 5.1 Humanity's Ecological Footprint: Global and Asia Context

### 5.1.1 The Global Context

In 2007, humanity's global Ecological Footprint was 18 billion gha or 2.7gha per person while Earth's biocapacity was only 11.9 billion gha, or 1.8 gha per person representing an ecological overshoot of 50 per cent. 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 $CO_2$ waste that we emitted. 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 ecosystems. In 2007, the average Ecological Footprint per capita in China was 2.2 gha, which is 0.5 gha lower than the global average. This places China 74$^{th}$ among the 153 countries for which a Footprint was calculated.

### 5.1.2 The Asia Context

Asia's total biocapacity is 2 867 million gha, which accounts for 24% of the global biocapacity. Asia has 0.72 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 average per capita Ecological Footprint is 1.8 gha, which is same as the global average biocapacity and well below the global average Ecological Footprint of 2.7 gha per person. Despite its low per capita Ecological Footprint, Asia as whole used 60% of the world's biocapacity and accounted for 40% of humanity's ecological footprint. This is due to its large population, which represents for 60% of the world's total population.

Asia's total Ecological Footprint is 2.5 times its biocapacity. Asia as a whole is an importer of biocapacity with net imports from the rest of the world representing an embedded Footprint equal to 12 percent of Asia's total Footprint of consumption. Asia thus partly meets its ecological deficit by drawing on other regions' biocapacity and using the global commons to absorb its $CO_2$ emissions. (Source: Global Footprint Network)

Asia has the largest ecological footprint growth among all the world's continents. Between 1961 and 2006, the total Ecological Footprint of Asia increased by about 3.5 times or about 4 000 million gha. The increase in Ecological Footprint is a result of an increase both in population and in per capita in Ecological Footprint: per capita Ecological Footprint increased by 46 percent, while Asia's total population grew by 138 percent.

Carbon footprint is the fastest growing component of Ecological Footprint in Asia just as in other regions. In 2007, similar to other regions, carbon footprint accounted 53% of Asia's Ecological Footprint. This compares to just 5% in 1961. Since the per capita Ecological Footprint of Asia is smaller than the global average, the per capita carbon footprint is also lower.

The disparity in per capita Ecological Footprint amongst Asian countries is larger than any other region. This is due primarily to differences in affluence and consumption patterns among the countries. Residents of the United Arab Emirates have the world's highest per capita Ecological Footprint, 10.3 gha, while the per capita Ecological Footprint in Pakistan is 0.75 gha per person. On current trends, and as a result of their large populations, China and India will become the two countries with the largest total Ecological Footprint.

## 5.2 China's Ecological Footprint and Biocapacity

China has experienced an all-round growth during nearly half a century, creating a steadily increasing Ecological Footprint. China now has the second largest total Ecological Footprint; trailing only the United States. China is also, however, endowed with significant biocapacity, behind only Brazil and the United States in terms of total biocapacity.

Prior to the 1970s, China had a yearly Ecological Surplus – the excess biocapacity over Ecological Footprint. However, this changed in the mid-1970s, when China's Ecological Footprint began to exceed its biocapacity. This excess Ecological Footprint is known as Ecological Deficit, and since China first experienced an Ecological Deficit in the 1970s, the deficit has steadily increased.

Both economic-social systems and ecosystems vary across China's provinces (including provinces, municipalities and autonomous regions). The report uses the global average productivity of all bio-productive land types in the year 2005 as the benchmark to measure changes of regional Ecological Footprint (demand on biological natural resources) and biocapacity (the available supply of biological natural resources) resulted from changes of local production and consumption in defined provinces of China during 1985-2008. We made the assumption that 23 percent of the carbon dioxide emissions are absorbed by the ocean and the other 77% of $CO_2$ emissions depend on forest absorption. Carbon dioxide emissions from power plants are determined based on the method of national average energy consumption per unit power, while thermal system carbon dioxide emissions are calculated based on the actual energy consumption of heat supply in various regions. Carbon dioxide emissions in the energy processing and conversion links are amortized to end-users. Under this calculation model, Footprint of consumption/ production and biocapacity in time series reflect the consumption and production pattern changes.

Ecological Footprint and Biocapacity are not evenly distributed across China. In 2008, Guangdong, Shandong, Jiangsu, Henan, Sichuan, Zhejiang, Hebei, Hunan, Hubei, Anhui, Liaoning, Guangxi and Fujian were the provinces with over 75 million gha of total regional Footprint. Their combined total Footprint account about two-thirds of the national total, 9 percent higher than their fraction of China's overall biocapacity. The 5 western provinces of Xinjiang, Gansu, Ningxia, Qinghai and Tibet, as well as Tianjin and Hainan only accounted for 5.9 percent of China's Ecological Footprint, but have 12.3 percent of total national biocapacity. In comparison with the Ecological Footprint, regional biocapacity is more unevenly distributed across mainland provinces of China. The five provinces with the highest per capita Ecological Footprint growth during this period were Shanghai, Beijing, Tianjin, Guangdong and Chongqing, each of which, except for Guangdong, is a Central Government-controlled municipality.

Because population density varies across China, per capita Ecological Footprint varies significantly (Figure 5-1), and differs from total regional Ecological Footprint distribution. For example, in 2008, Beijing had the largest per capita Ecological Footprint, 2.7 times larger than that of Yunnan.

Despite the varied amounts and changes of Ecological Footprint, both in total and by component, in each province of China during 1985-2008, growth provides a common trend: eleven provinces saw their per capita Ecological Footprint double, ten experienced increases between 85 and 95 percent with the remaining ten experiencing between 40 and 84 percent growth. Moreover, this increase is being driven in large part by carbon, which has become the largest component of the regional Ecological Footprint. Indeed, in 2008 the carbon component accounted for over 50 percent of the Ecological Footprint in 29 of China's 31 provinces, including levels exceeding 65 percent in Shanghai, Beijing, Tianjin and Shandong. Put differently, the carbon component of per capita Ecological Footprint of each province rose by 0.4-2.0 gha, while all other components increased by 0.25 gha or less (1990 was the starting year for calculating Footprint changes in Tibet). This dominance of carbon as the primary and overwhelming component of Ecological Footprint is not expected to change based on current development patterns.

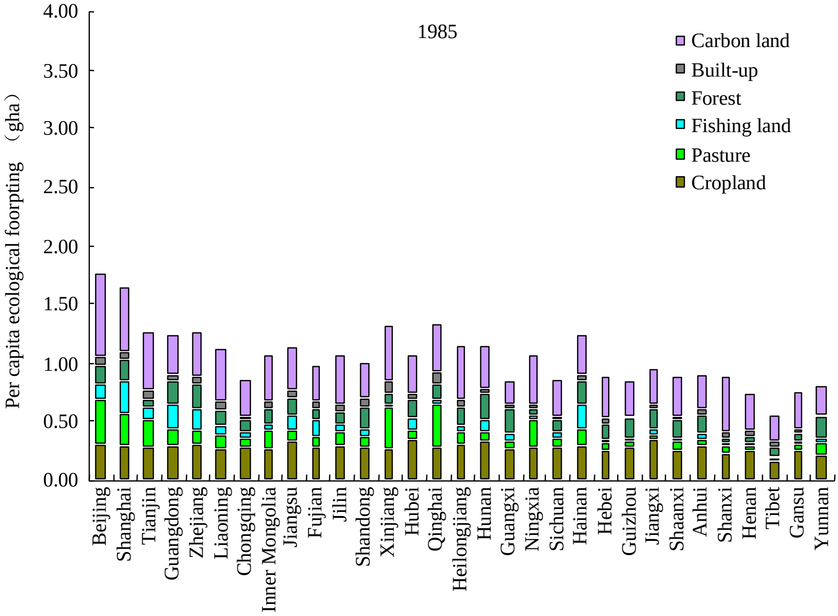


Figure 5-1a Regional Per Capita Ecological Footprint in China (1985)

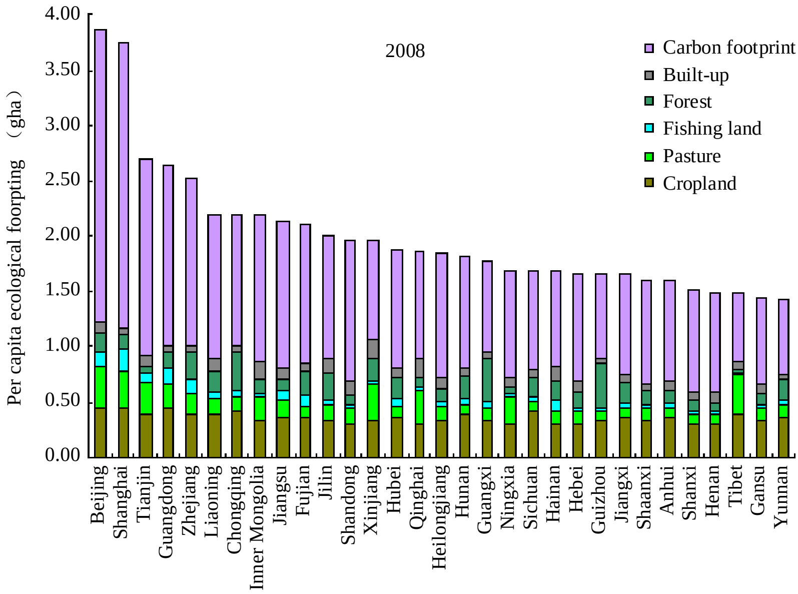


Figure 5-1b Regional Per Capita Ecological Footprint in China (2008)

Note: In 1985, Hainan and Chongqing were not yet independent provincial regions and their Ecological Footprint was averaged with the levels of Guangdong province and Sichuan province, which they fell under the jurisdiction of, respectively.

Data source: IGSNRR, 2010

Per capita Ecological Footprint rise slowed down in most mainland provinces in China during 2005-2008 by comparison with rises during 2000-2005, illustrated by Beijing (Figure 5-2). The reduction in the rate of increase in Beijing can be explained by urbanization stabilization and energy saving activities, as well as a transition towards service industry, rather than goods production, to drive economic growth. In some provinces such as Shandong, per capita Ecological Footprint rise mainly tracked urbanization increase.

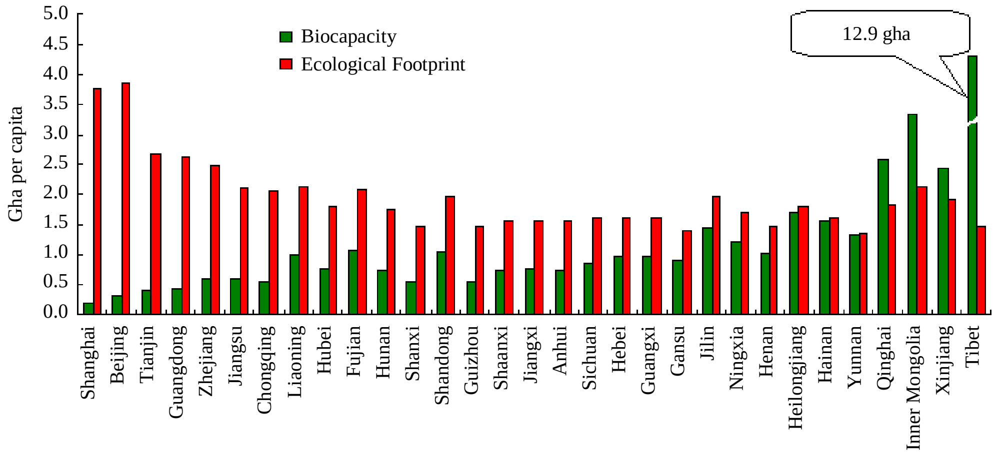


Figure 5-2 Province-based Ecological Pressure and Biocapacity in Mainland China (2008)

Data source: IGSNRR, 2010

Carbon's overwhelming impact on Ecological Footprint creates the situation where a region can have an Ecological Footprint Deficit but it's total non-carbon based Ecological Footprint Surplus (available biocapcity exceeds non-carbon based Ecological Footprint) (Figure 5-3): yellow regions represent this situation, green regions represent an Ecological Footprint surplus, and red regions represent areas with an Ecological Footprint deficit and a non-carbon based Ecological Footprint deficit. Of provinces with an Ecological Footprint deficit in 2008, 70% had a non-carbon based Ecological Footprint Surplus (yellow regions).

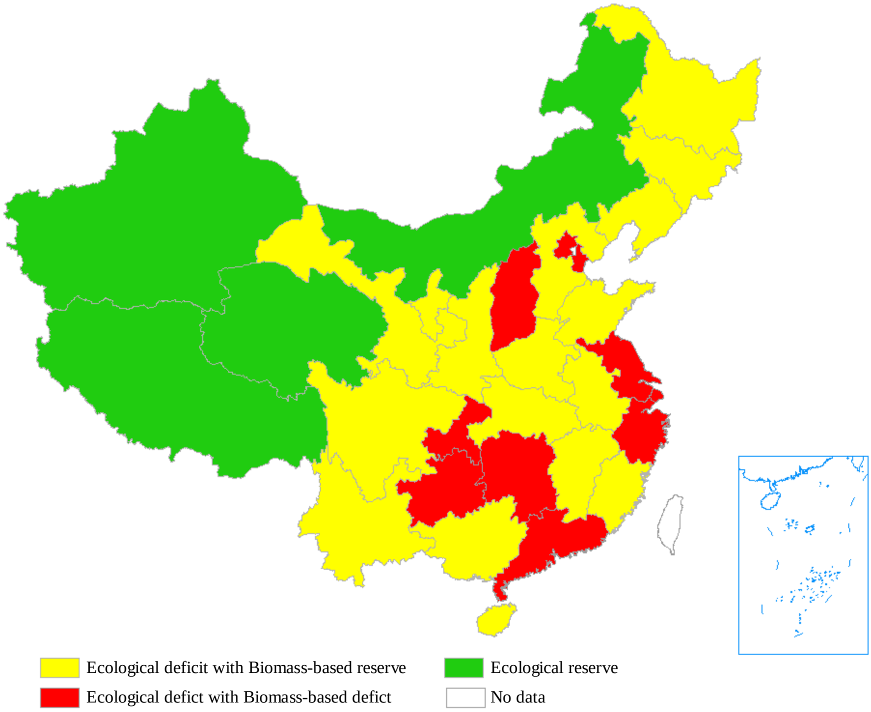


Figure 5-3 China's Ecological Footprint Surplus/Deficit Distribution (2008)

Data source: IGSNRR, 2010

## 5.3 The Challenge of Urban Ecological Footprint

Cities are the center of world economic and technological innovations, the stronghold for the distribution and development of global knowledge-intensive industries as well as the habitat of a large portion of the population. Since 1900, the urban population has increased by 20 times worldwide while the rural population has increased by less than its one-eighth worldwide. Urban population also sees its percentage of the global total population climbing from 10 percent to around 50 percent. As a spatial unit, cities now place the largest demand on natural resources products and services. It is estimated that 80 percent of the world's carbon dioxide emissions are the result of fossil fuel emissions and 75 percent of the timber consumption occur in urban regions (O' Meara, 1999). High population density, high material consumption, high energy consumption and high waste discharge are the main causes of high ecological pressures in cities. Some cities may require an area almost 100 times their own biocapacity to support their socio-economic operation.

The fact that cities worldwide are facing high ecological pressures and high ecological deficits gives China an early warning on the ecological pressure and risks which may arise in its urbanization process. Nevertheless, cities may achieve good results in reducing ecological pressures.

In China, there exists a very notable difference in per person Ecological Footprint between urban and rural areas and this gap may widen fast in the near future. Currently, the gap varies from 0.9 to 1.8 gha from province to province, mainly due to the urban and rural income gap and consequently the combination of consumption gap and energy utilization structure differences. The changes in residential and living styles during urbanization may increase the challenge and risks of fast Ecological Footprint growth for China.

## 5.4 The National Impact of China's Ecological Footprint

As a result of market mechanisms and trading systems, 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 through the production process ('embedded biocapacity') and transferred to other provinces through inter-provincial and international trade. Generally, the non-carbon component of China's Ecological Footprint is sustained by domestic ecosystems. However, the uneven distribution of biocapacity in China means that transfer of embedded biocapacity through inter-provincial trading can create net importers and exporters of biocapacity through their shipping or receiving embedded biocapacity. 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 flow in China. We can get the conservative value of trans-regional biocapacity flows by looking at the difference between Ecological Footprint of Production and Ecological Footprint of Consumption.

These calculations suggest that cross-provincial Ecological Footprint flows in China exceeded 678 million gha in 2008, accounting for 27 percent of the national Ecological Footprint. Energy and goods and services consumption accounted respectively for 60 percent and 40 percent of this cross-provincial flow. Biocapacity inflows are greatest for provinces with a high level of urbanization, dense population, intensive industrial production but relatively meager energy resources such as Guangdong, Shanghai, Zhejiang and Beijing. Elsewhere, a decrease in biocapacity and bio-productive land due to high-intensity industrial production in Zhejiang province has contributed to its demand for imported biocapacity.

Inter-province 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 in China. On the other hand, power plant and agriculture production are concentrated in coal and land rich provinces.

## 5.5 Development and Ecological Footprint

Progress towards meeting the goals of sustainable development, allowing all people the opportunity to live fulfilling lives within the means of nature, while optimizing development and societal well-being can be examined through the combination of Ecological Footprint, which indicates demand on nature, and the Human Development Index (HDI), a summary composite index that measures a country's average achievements in three basic aspects of human development: health, knowledge, and a decent standard of living, as calculated by the United Nations Development Program (UNDP).

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 HDI to be the minimum level of optimized development. As noted above, the global, average per capita Biocapacity is 1.8 gha, so, in order to meet the minimum levels of sustainability, per capita Ecological Footprint must be also be 1.8 gha. If a nation is fulfilling both of these requirements it is sustainable and optimized development.

Analysis of data for China's provincial units suggests that when the average person begins earning more than he or she needs for basic survival, excess income can become a driving factor for the increase in footprint once basic needs have been satisfied. For provincial units where per capita GDP is lower than 30 000 *yuan*, the average per capita Ecological Footprint is approximately 1.8 gha and variations between provinces can be largely explained by the influence of geography, climate and food preferences. On the other hand, for provincial units where per capita GDP exceeds 30 000 *yuan* the per capita Ecological Footprint shows a positive association with per capita GDP, meaning that as wealth increases above the level needed for basic survival, Ecological Footprint increases accordingly, rendering influences of geography, climate and regional food preferences unimportant (Figure 5-4).

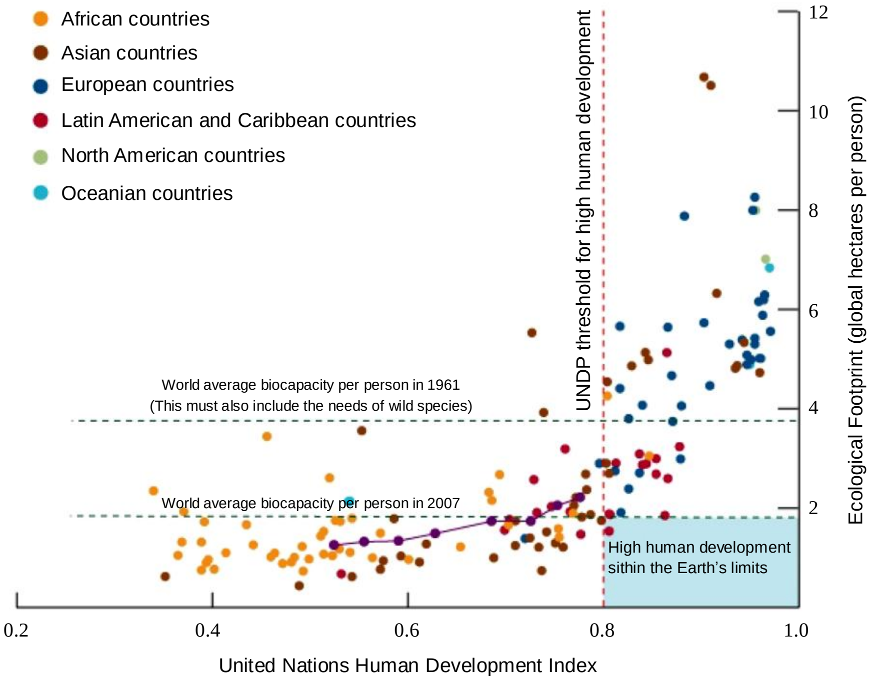


Figure 5-4 Human Development and Ecological Footprint

An HDI value of more than 0.8 is considered to represent "high human development" while a 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 defines 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.

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

## 5.6 Global Impact of China's Ecological Footprint

China's economy also impacts the global flow of Biocapacity. As with the *Ecological Footprint Report of China 2008*, trade data continues to be based on biomass-based footprint, but with traded product items expanded from 43 to 132 categories. In 2008, China's was a net importer of 44.1 million gha of Biocapacity; importing 160.4 million gha in total. Our calculation in this section is based on biomass resources and their product embedded bio-capacity flows.

Forestland is the most active Biocapacity component of both China's imports at 41.3

percent, and exports at 29.1 percent. The net import scale is about 32 million gha. Forest land is in such high demand because of China's relative shortage of forest resources and large export businesses of furniture, paper and printed products.

Arable land is the second most active part of China's cross-country trade flows, and is the second active net-imported component of Biocapacity, accounting for 40.2 percent of imported Biocapacity and 37 percent of exported Biocapacity. In 2008, the arable land capacity included in China's import and export was 64 million gha and 37 million gha respectively. Arable land's large demand was mainly due to China's need of vegetable oil and China's exportation of fruit, vegetables and textiles.

Improving livestock production capacity has pushed China to be a net exporter of grassland biocapacity to the world. In 2008, China's trade resulted in a net exportation of 3 million gha grassland biocapacity, which mainly came from wool textile trade.

China continues to be a net exporter of fishing grounds biocapacity. In 2008, its net fishing ground export reached 13 million gha, making notable contribution to reducing China's net biocapacity import.

In the international trade with China's 23 major trading partners (MTPs), China was a biocapacity importer: inflow-primarily from Russia, Canada, Brazil, the United States and Indonesia-totaled 126 million gha, while total outflow-primarily from Japan, South Korea, Saudi Arabia, Germany and Britain-totaled 83 million gha, resulting in a 43.7 million gha surplus.

The flow of biocapacity in China's international trade is relatively concentrated, with imports being even more concentrated than exports. This concentration is particularly glaring when considered by component. For example, 78.2 percent of the forest land biocapacity imported by China 2008 came from five countries – Russia (42.3 percent), Canada, the United States, Indonesia and Brazil – while the largest share of exports went to the United States (18 percent); 17 percent to Japan, South Korea and Britain, and about 10 percent to Saudi Arabia, Russia, Canada and India. Arable land and grassland have similarly uneven distributions, more than 50 percent of each being imported from two countries, respectively, while neither is exported to any one or group of countries as a similarly large percentage.

Another notable feature of China's biocapacity international flow is trade reallocation. Trade reallocation analyzes imported biocapacity's ultimate fate: a) local consumption, b) domestic reallocation through trade as embedded biocapacity or c) international reallocation through trade as embedded biocapacity. In 2008, the distribution of imported biocapacity was 20 percent consumed directly, 35 percent relocated domestically and 45 percent relocated internationally. The biocapacity involved in international trade reallocation mainly arises with the international trade of products processed from wood, aquatic products, and cotton and wool textiles.

## 5.7 The Water Footprint

Water is one of the basic elements of the natural environment; together with land and energy these three are indispensable factors for human survival and underpins sustainable socio-economical development.

Water footprint measures the total volume of water that is used to produce the good and services that we consume. It consists of three components: the blue, green and grey water[1] footprint. Blue and green water footprints quantify the water that we use in production of goods and services, while grey water quantifies the water that we pollute. By considering all three types of water use, the water footprint broadens the traditional assessment of water resources to better reflect the demand placed on water resources by humans.

### 5.7.1 Water Footprint of Production

The water footprint of production of a region is the volume of freshwater used to produce goods and services within the region, irrespective of where it is 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 has put on local ecosystem. The water stress is defined as the ratio of water use (total of surface water withdrawn for domestic, agriculture and livestock use, polluted volumes of fresh water) to water availability. This is mainly calculated on an annual basis as the ratio of total blue and grey water footprint to total renewable water resources available in a region. The present status of China's water resource is serious. In 2007, 5 out of 31 mainland provinces were facing severe stress (>100%), they are Beijing, Tianjin, Hebei, Ningxia and Shanghai; 4 regions were under high stress (40%-100%); 7 regions experienced moderate stress (20%-40%) and 12 regions were under minimal stress (5%-20%). Among 31 mainland provinces only Yunnan, Qinghai and Tibet had no stress (Figure 5-6), where there was a low level of water footprint of production. The five regions under serious water stress are because of high population (Beijing, Tianjin and Shanghai), intensive agriculture (Hebei and Ningxia) and local climate conditions (Ningxia) respectively. We can tell from the figure that the regions with serious and high stress are mostly concentrated in North-China and Central-China.

[1] Blue water is surface and ground water, green water is in the soil, and grey water is associated with production of goods and services.

Compared to blue water, green water has relatively low opportunity cost and environmental impact. It plays an important role in water resource and food safety. However, green water resources have been neglected in traditional water resource assessment systems. According to our research, for 26 of 31 mainland provinces the footprint of green water account for more than 30% of the total water footprint of production and among them 11 provinces have green water footprints larger than 50% (Figure 5-5). Given that green water footprint contributes so much to the water footprint of production, perhaps another way to tackle water resource problems is by improving green water management.

The grey water footprint evaluates the impact of water pollution from production activities. In 2007, two-thirds of Mainland China's provinces grey water footprint account for more than 25% of local overall water footprint of production. Among them most grey water footprint comes from the chemicals used in agriculture. For example, in the production of wheat and maize in north China, 22.5% and 26.1% of their water footprint of production is grey water footprint. The improvement of fertilizer and chemicals service efficiency is significant for solving water problems.

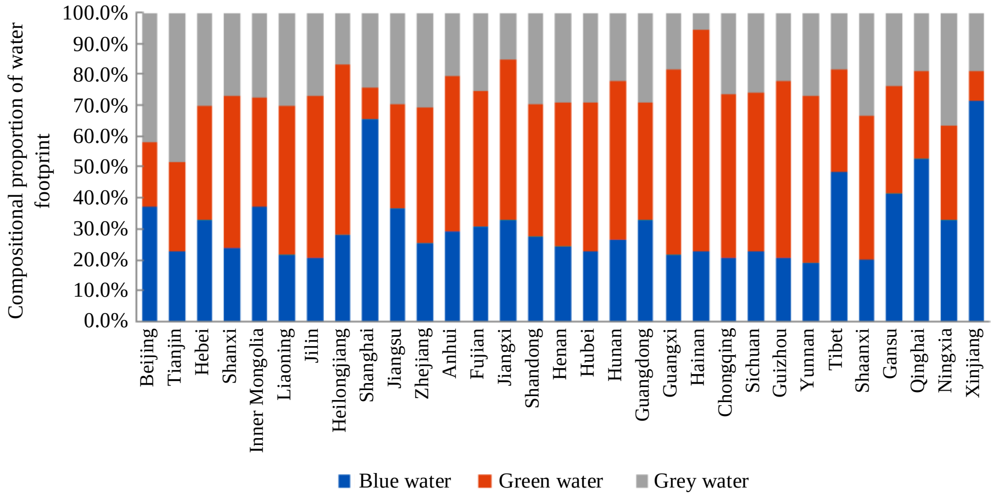


Figure 5-5 Water Footprint of Production in China's Provinces (2007) and Listed for 31 Mainland Provinces

Data source: IGSNRR, 2010

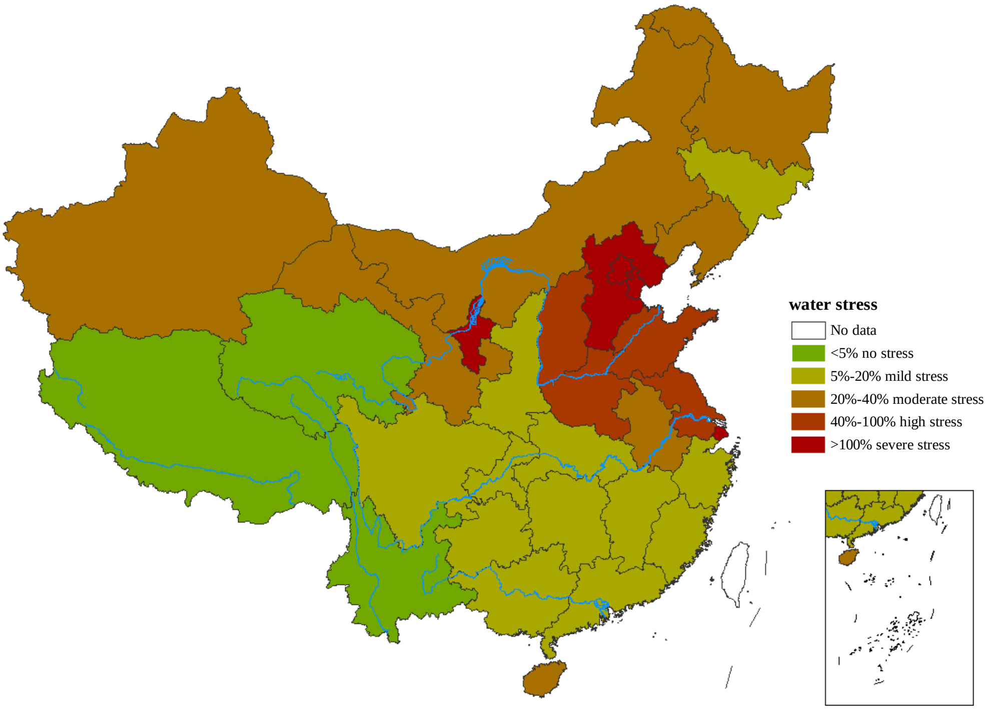


Figure 5-6 Water Resources Stress in China's Provinces (2007)

Data source: IGSNRR, 2010

## 5.7.2 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 the concerned region, irrespective of where the goods and service are produced. According to the source, the water footprint of consumption includes internal water footprint and external water footprint. Internal footprint is the volume of total water volume used from domestic water resources to produce the goods consumed by inhabitants of the country. The external water footprint of a country/region is the volume of water resources used in other countries/regions to produce the goods consumed by the inhabitants of the concerned country/regions.

In 2007, the average water footprint of consumption in China is only 679m$^3$/capita/year, which is about 43% of global average (1 564 m$^3$/capita/year). However, there is a large spatial variation across different regions in China. The top six provincial units with water footprint higher than national average were Xinjiang, Shanghai, Guangdong, Jiangxi, Fujian and Beijing, which apart from Xinjiang because of its intensive agriculture are municipalities or more developed coastal provinces (Figure 5-7). From the figure we can tell that the major influential factors for water footprint of consumption in China include economic development level, agriculture and living style.

Most regions in China have high self-sufficient level on the water footprint of consumption. In 2007, two thirds of the regions have a self-sufficient rate larger than 90%. The biggest external water footprint is found in Beijing, which is amount to 50% around. While in Guangdong, Shanghai, Tianjin and Jiangxi about 18%-26% water footprint of consumption is external water footprint. For water shortage regions, externalizing water footprint to water surplus regions may be a very effective solution.

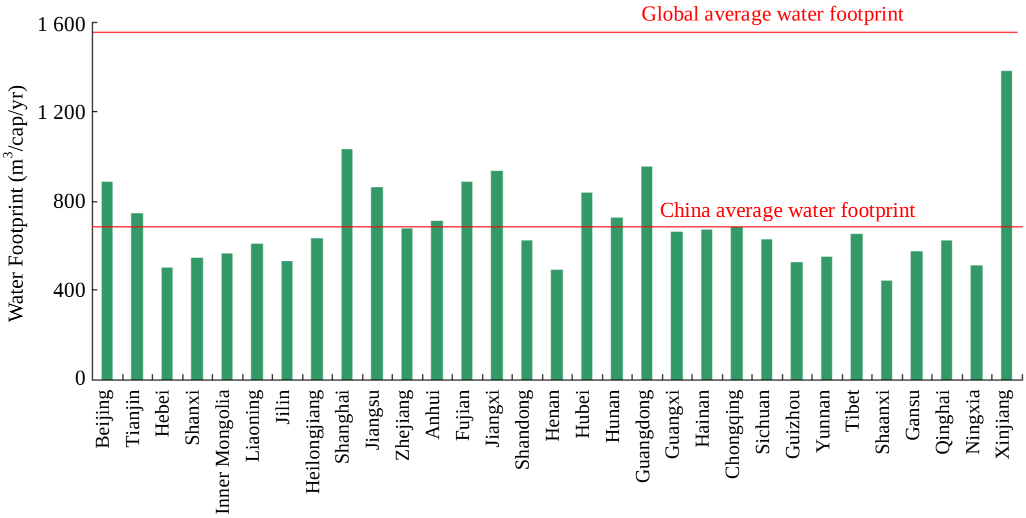


Figure 5-7 Provincial Variations in Average Water Footprint per Person in China (2007)

Data source: IGSNRR, 2010

According to preliminary data, considerable water has been exported to other countries embedded as part of the production of Chinese agriculture products. As a water intensive industry, the exportation of agriculture products may make water shortage in some regions worse. It is important for the government to establish monitoring mechanism to control the exportation activities, optimize local industry structure and promote efficient use of water resource.

## 5.8 China: Transforming Toward Sustainable Development

In a world with limited resources and regeneration capacity, if humanity is to realize sustainable development and continuously improve human welfare, then we have to live within the capacity of the ecosystems of the planet Earth. The results presented this report clearly indicate that humanity's Ecological Footprint is continuing to grow with the average per capita Ecological Footprint reaching 2.7 gha in 2007. This mean we now need one and a half planets to keep up with humanity's demand for resources, or, put another way, the global ecosystem would need one and half years to regenerate the natural resources consumed and absorb the carbon dioxide emitted in 2007. In China, the average per capita Ecological Footprint has reached 2.2 gha. While China's per capita Footprint is lower than the global average level, China's total Ecological Footprint was two times greater than its available biocapacity, and its ecological deficit is continuing to increase year by year.

The Earth's fate will determine the common destiny of all people. In the face of a global ecological credit crunch, China has long taken a highly responsible attitude, actively committing itself to seeking sustainable consumption, efficient production and the maintenance of a sound ecological foundation. While raising the level and quality of human life, the country has set out to improve the carrying capacity of its life support systems and slow the growth rate of its Ecological Footprint and Water Footprint in order to improve the sustainability of development.

The analyses presented in this report show that in last half century China achieved a rapid increase in its human development as measured by the 'Human development index' (HDI) and is in 2007 was close to the threshold for high human development. Per capita income increased more than 50 times over the same period while per capita Ecological Footprint increased only by around 4 times. China per capita Footprint has just overtaken the level of available per capita bio-capacity on a global basis, some 30 years after the world as a whole crossed this threshold.

There are signs that China is at 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 that enjoy an ecological surplus. The growth in Ecological Footprint of China is influenced by levels of urbanization and individual wealth. China is fully engaged in establishment of an ecological society and is facing up to the challenge of reducing its ecological deficit by increasing biocapacity and curbing growth in Ecological Footprint. At the heart of this challenge is the need to decouple economic growth and from growth in Ecological Footprint.

Based on the analyses presented in this report we propose the following policy suggestions:

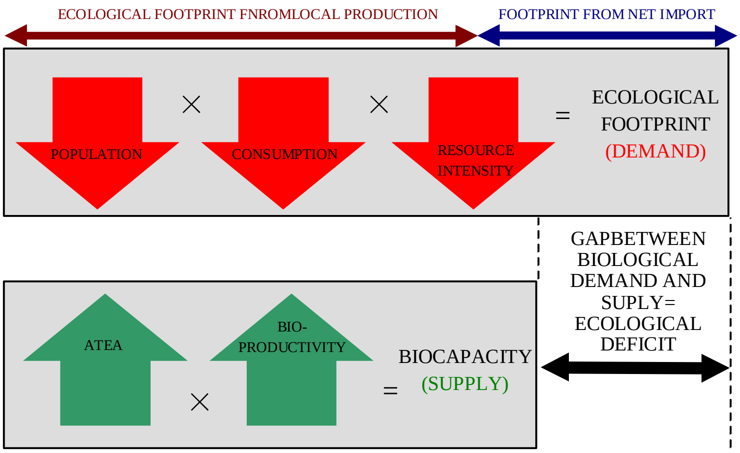


Figure 5-8 Five Major Factors Affecting Ecological Overshoot

Data source: Global Footprint Network, 2010

### 5.8.1 The Relationship between Ecological Footprint and Bio-Capacity can be Used to Analyze Whether a Society is in Ecological Balance

This report suggests that 'ecological society', as the next step in societal development after an agriculture society and an industrial society, is now the strategic choice for China's future development. 'Ecological society' is based on the premise that Ecological Footprint must be reduced and biocapacity must be increased in order to create a Society that is ecologically sustainable. By comparing human demand on the environment, represented by Ecological Footprint, with the capacity of natural ecological system, represented by biocapacity, in order to determine whether the demand creates an ecological surplus (where biocapacity exceeds Ecological Footprint) or an ecological overshoot (where Ecological Footprint exceeds biocapacity), we can assess the environmental impact of human development. We suggest using the measures of Ecological Footprint and biocapacity as a method for determining whether or not a society is on track to becoming an ecological society. This can be monitored by establishing a national Ecological Footprint and biocapacity accounting and monitoring system to track, in real time, utilization of, and changes in, local ecological resources. This system can, in turn, be used to support industry policy-making and local development plans by offering straightforward scientific analyses.

### 5.8.2 Strengthen Ecosystem Management and Improve Bio-Capacity

China has limited natural resources, and increasing this ecological base is a key strategy for China to ensure national ecological security and reduce ecological overshoot. Hence, China should continuously strengthen ecosystem management and increase biocapacity through the following measures:

**(1)** ***Maintain ecological land and bio-capacity.*** As a country with very scarce ecological resources on a per capita basis, it is vital that China preserves its existing natural ecosystem for future generations. This can be accomplished by ① enforcing strict land utilization policies; ② implementing ecological restoration and nature conservation policies; ③ increasing the scale of ecological land and optimizing the land utilization types according to local geographical and climate conditions; ④ implementation of ecological compensation policies that compensates net biocapacity exporting regions through a variety of economic measures; and ⑤ recovering or restoring ecologically degraded regions and improving their productivity and pollution absorption capacity.

**(2)** ***Increase land productivity and promote increases in bio-capacity.*** Unlike most other countries, the biocapacity of China has continuously increased; for example, forest coverage has increased continuously over the last 30 years and the scale of production of aquaculture and agriculture has expanded one fifth of the world's grain, half of its vegetables and one third of its meat products were produced in China. We suggest that the government work to reinforce this trend by ① investing in agriculture, forestry, animal husbandry and fishery; ② optimizing the distribution of agricultural products; ③ developing high-efficiency agriculture; ④ promoting three-dimensional breeding; ⑤ increasing agriculture production concentration and the degree of mechanization; ⑥ encouraging comprehensive utilization of agriculture residues; and ⑦ increasing land productivity and quality.

### 5.8.3 Reduction of Carbon Footprint should be the Primary Focus for Decreasing Ecological Overshoot and Realizing an Ecology Society

Carbon footprint has become the primary force driving the increase in Ecological Footprint and any effort to reverse this trend and reduce Ecological Footprint must therefore focus on reducing carbon footprint. The following are suggestions for reducing carbon footprint.

**(1)** ***Establish and promote a low carbon economy*** by ① adjusting and optimizing industry structures according to local biocapacity; ② restricting and prohibiting certain industry sectors while encouraging energy conservation and production patterns that are ecologically friendly and resource efficient; ③ increasing the utility and conversion efficiency of fossil fuels throughout their life cycles; and ④ increasing the proportion of renewable energy in the energy portfolio. For regions where per capita GDP is less than 30 000 *yuan*, the focus should be on investment patterns that will slow or prevent increase in Ecological Footprint.

**(2)** ***The urbanization process in China should focus on low carbon and sustainable development.*** Based on the preliminary study of the relationship between urbanization and Ecological Footprint, we found that although urbanization is associated with higher Ecological Footprint, there are ways this relationship can be optimized. To that end, the urbanization process in China should follow a low carbon and an "ecologization" plan that includes restricting living space and transportation patterns, controlling the expansion of cities and towns, promoting centralized residences with locally available facilities such as shops and schools, improving ecological efficiency in residential areas, and decreasing carbon footprint in buildings and transportation.

**(3)** ***Introduce low carbon consumption patterns*** by: ① advocating and promoting low carbon and resource efficient consumption patterns through encouraging rational consumption and choice of environmentally friendly goods and services, ② and stimulating the development of an eco-market where the government should set an example by establishing green procurement policies and low carbon offices; and ③ improving the lifespan of public facilities and optimizing their design in order to avoid waste and ecosystem pressure created by repeated construction and poor quality control.

Plans for encouraging changes in carbon footprint should account for regional development and ecology consumption levels. For examples, in provinces where per capita GDP is above 30 000 *yuan*, the plan should focus on changes in consumption patterns that will slow or eliminate increase in Ecological Footprint.

### 5.8.4 Balance Ecological Deficit through Resource Allocation

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

**(1)** ***Formulate a domestic trade policy that encourages reasonable biocapacity flow.*** China should adopt a range of economic and administrative measures that promote efficient allocation of regional ecological resources and minimization inappropriate exportation and trans-regional transfers of biocapacity and water resources through (a) innovative tax system systems such as an energy resource tax and a carbon tax that encourages enterprises to invest in new technologies that conserve energy and reduce emissions; and (b) development of trade policies that promote rational flows of biocapacity, minimize the export of biomass resources from degraded areas, and strictly control and punish damaging and purely profit-oriented trading activities.

**(2)** ***Encourage international cooperation in order to promote rational flows of biocapacity through international trading activities.*** Global trade reflects the ecological interdependency amongst countries and highlights that ecological problems are global in nature. Pay attention to unsustainable imports and exports of ecological biocapacity in order to lessen the ecological impact of trade on China and other countries. Through international cooperation, improve bio-capacity based on promoting efficient utilization of ecological resources and improved bio-capacity.