

Climate Change
China
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No water, more trade-offs

Managing China's growth with limited water

Water is essential for economic activity, but some economies import “embedded water” within traded goods to manage limited water resources

China is using its limited water resources to ensure food and energy security – with tough trade-offs ahead

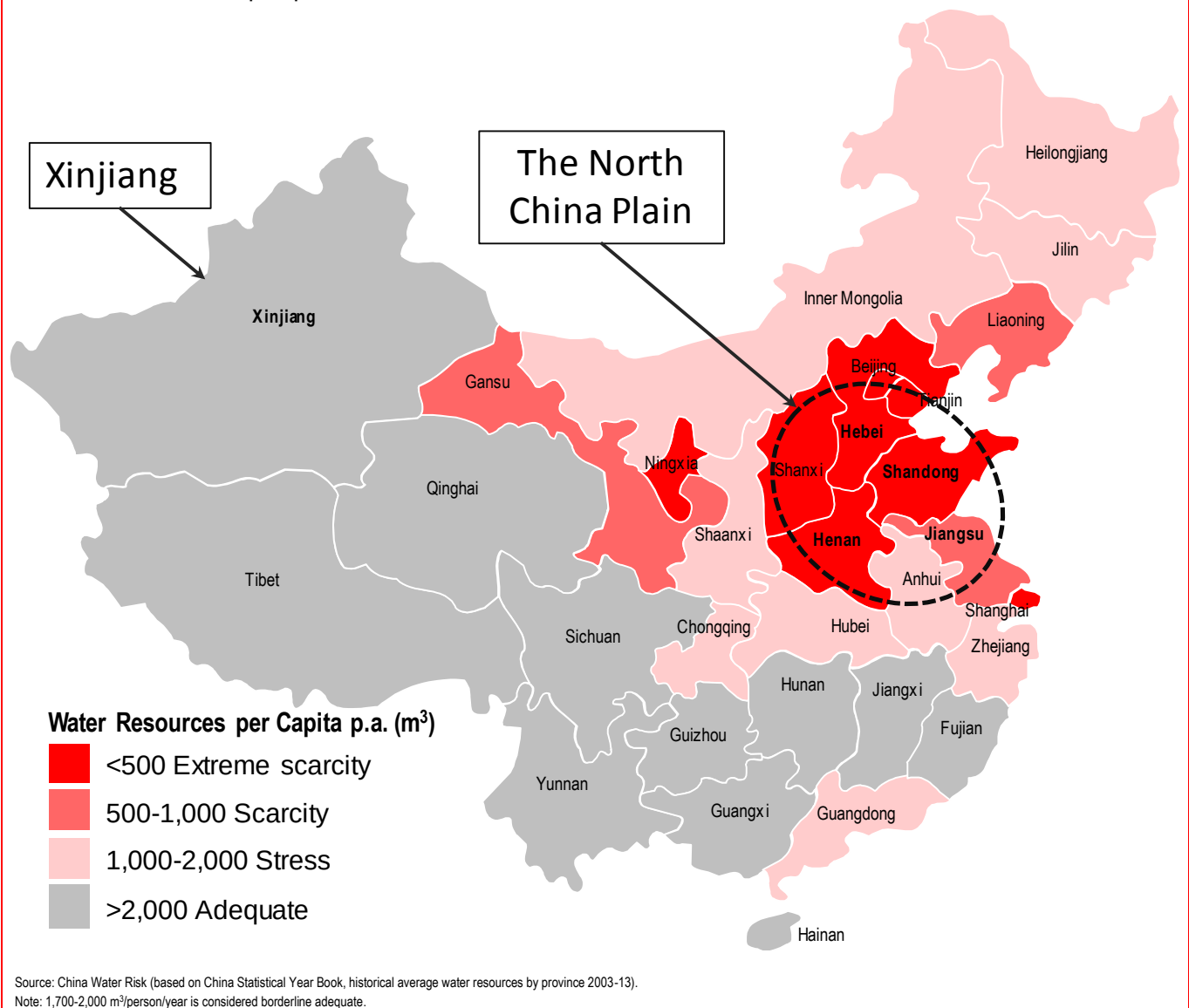
Output may shift within China as cotton clashes with coal to “free up” water

HSBC Climate Change Centre commissioned China Water Risk to research and analyse the findings which form the basis of this report

By Wai-Shin Chan and Zoe Knight

Disclosures and Disclaimer This report must be read with the disclosures and analyst certifications in the Disclosure appendix, and with the Disclaimer, which forms part of it

China's annual water resources per capita



Summary

- ▶ Some economies import “embedded water” through virtual water flows and use this to manage limited domestic water resources
- ▶ China’s government recognises the importance of water to the economy and has set water quotas and water efficiency targets
- ▶ Trade-offs between regions (North China Plain to Xinjiang) and commodities (cotton vs. coal) could help China manage its water

Water is essential for almost all economic activity – agriculture, industry and services. However, the distribution of water across countries is uneven. For example, in per capita terms, Canada has 70 times India’s water resources and 40 times China’s. In broad terms, developing countries tend to be more agriculture-dependent than richer economies, which are more services-based. When it comes to water, agriculture uses the most (around 70% of global water) but contributes relatively less to GDP. As income levels rise, economies use more water on a per capita basis.

The illustrative concepts of *water footprint* and *water embedded in traded goods* explain, to some extent, how some countries, such as the UK and France, have achieved higher levels of income using less water, despite similar economic mixes. By way of illustration, a country, which imports bananas, can be considered to be “consuming” the *virtual water content* of those bananas and, therefore, relying on the water resources of other economies. Adjusting for the *water embedded* in imported goods further highlights just how important water is to economic development.

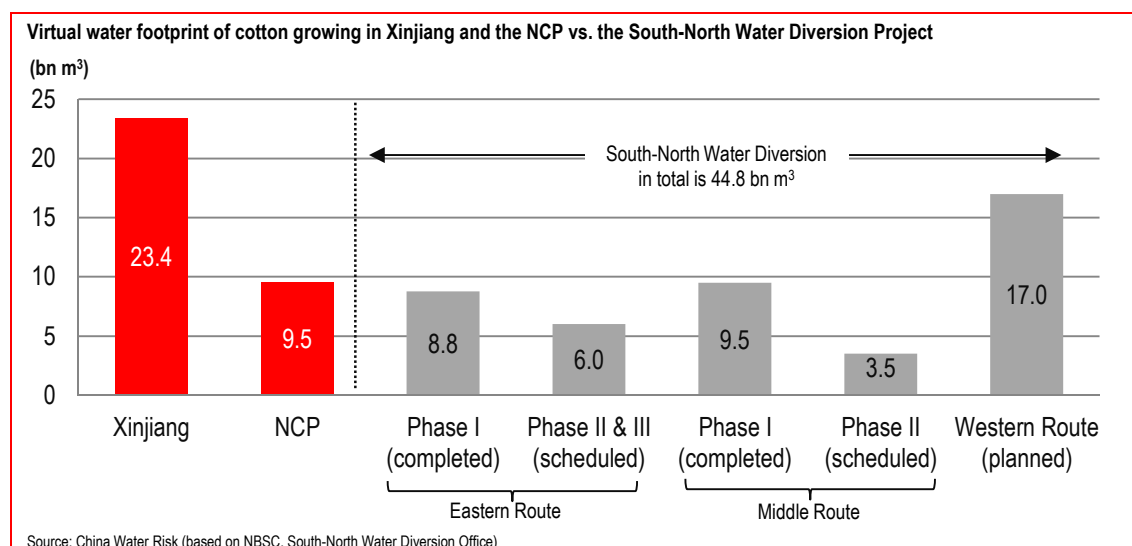
China is managing its water resources through water quotas, improvements in water efficiency, and policies to control pollution. Its agriculture sector, which uses three-fifths of its water to produce a tenth of national GDP, has been trying to rein in water use but has struggled to stay within suggested caps. In addition, much of China’s water use is exported *virtually* through ‘Made in China’ goods. Beyond this, we believe China could manage its water by optimising its economic mix, importing more water-intensive products, and matching local water resources to output by shifting the production bases of certain products.

Balancing food security and energy security may cause China to reconsider how it manages its water resources. For example, China dominates the cotton industry. It accounts for around a quarter of global cotton lint output, with two-fifths of all global cotton lint passing through China in 2013. However cotton is *not edible*. Cotton not only occupies sown land that might be used to grow other – *edible* – crops, it also has a high *water footprint* – in effect, it “consumes” a vast amount of China’s water resources. Similarly, coal mining uses water for cooling mining equipment, reducing dust levels, washing tunnels and extinguishing fires. However, China is mining coal from water-scarce regions to fuel its industrial growth. It already has plans to divert vast amounts of water from the south to the drier north.

We look at how trade-offs between regions and commodities could help China to manage its water.

There are significant differences in the availability of water across provinces; therefore, shifting production of either cotton or coal to areas where water is more abundant could “free up” more water for other uses. Again, we focus on the water-scarce North China Plain (NCP), which covers the four provinces of Henan, Hebei, Shandong, Jiangsu, and parts of Anhui. The NCP generates over a quarter of China’s GDP but has less than 4% of its renewable water resources. We also look at Xinjiang, an autonomous region in the north west of China, which has been earmarked for development in a number of areas.

Shifting cotton production from the North China Plain could “free up” around 9.5bn m³ of water, equivalent to a fifth of the entire South-to-North Water Diversion Project. China is already shifting cotton production to Xinjiang, as the State Council issues more favourable policies towards the region.



China has been consolidating its coal production into coal bases in 12 provinces and is managing the water resources in these areas under the ‘Water-for-Coal Plan’. Coal mining is a major polluter of groundwater (a major source of drinking water in China) and coal consumption can cause air pollution. Under various development plans, China is set to maintain high levels of coal consumption over the short term. In light of growing challenges from water availability, it could shut down coal production from Hebei province, or even the whole North China Plain – shifting this production to Xinjiang. This autonomous region, which has a considerable share of China’s natural resources, could grow as a coal and energy hub, and alleviate pollution concerns elsewhere.

We think tough trade-offs are on the horizon as China manages its water for economic development and ensures appropriate levels of food and energy security. Shifting some of the cotton and coal production to Xinjiang would only be an interim solution, however. Over the longer term, cotton and coal may be headed for a clash as they compete for limited water resources. China may need to consider whether it turns more to imports – and the *water embedded* in the goods of other countries – to manage its water resources. The trade-offs between regions and commodities could change both domestic and international trade flows.

This is the third in our **No water** series of reports. Please also see [No water, no power: Is there enough water to fuel China's power expansion?](#) (September 2012) and [No water, no food: Ensuring food safety and food security in China](#) (March 2014).

Contents

The importance of water	4	Trade-offs: cotton vs. coal	16
Economies run on water	4	Trade-offs to manage water	16
<i>WTA stress in the G20</i>	4	<i>North China Plain – a key region</i>	16
<i>Linking water with economic mix</i>	6	Trade-offs in cotton	17
Water embedded in imports	7	1) <i>Shifting cotton production</i>	17
<i>The importance of water for growth</i>	7	2) <i>Importing more cotton</i>	20
		Trade-offs in coal	21
Managing China's water	9	3) <i>Shifting coal production</i>	21
More water, more growth	9	4) <i>Importing more coal</i>	24
<i>Growing China on limited water</i>	9	Conclusion	24
<i>Options to manage China's water</i>	10	Disclosure appendix	27
<i>The watery path to development</i>	12		
Water for food/energy security	12	Disclaimer	28
<i>Food security – growing to eat</i>	13		
<i>Energy security – weaning off coal</i>	14		

HSBC's Climate Change Centre commissioned China Water Risk (CWR) to research and analyse the findings, which form the basis of this report. Based in Hong Kong, CWR is a non-profit initiative dedicated to addressing business and environmental risks arising from the country's urgent water crisis. It aims to foster efficient and responsible use of China's water resources by engaging the global investment and business communities, civil society and individuals in understanding and managing China's water risk.



The importance of water

- ▶ Water is essential for economic growth, but countries use varying portions of their annual renewable water resources
- ▶ Some economies depend on the water of other countries by importing “*embedded water*” through *virtual water flows*
- ▶ *Virtual water flows* help towards managing limited water resources

Economies run on water

Water is essential for almost all economic activity. It is used in the agricultural, industrial and services segments of the economy, as well as for domestic purposes.

Globally, around 70% of water is used by agriculture; however, this varies considerably by country, depending on the contribution various sectors make to the economy. For example, although agriculture is typically a large user of water, it tends to contribute less to GDP.

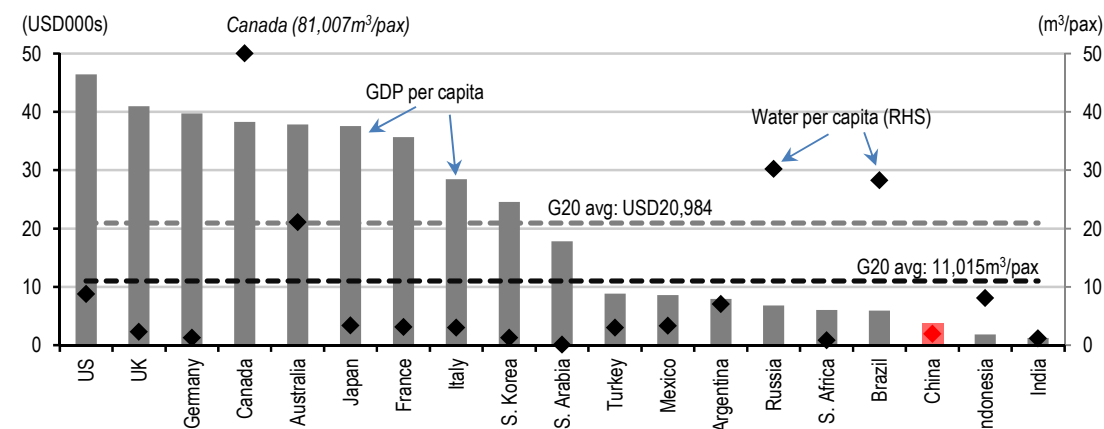
The distribution of water across G20 countries is uneven. For instance, in per capita terms, Canada

has 70x India’s water resources and 40x China’s (Chart 1). How much water a country uses – in relation to how much water it has – is measured using the WTA stress indicator (Box 1).

WTA stress in the G20

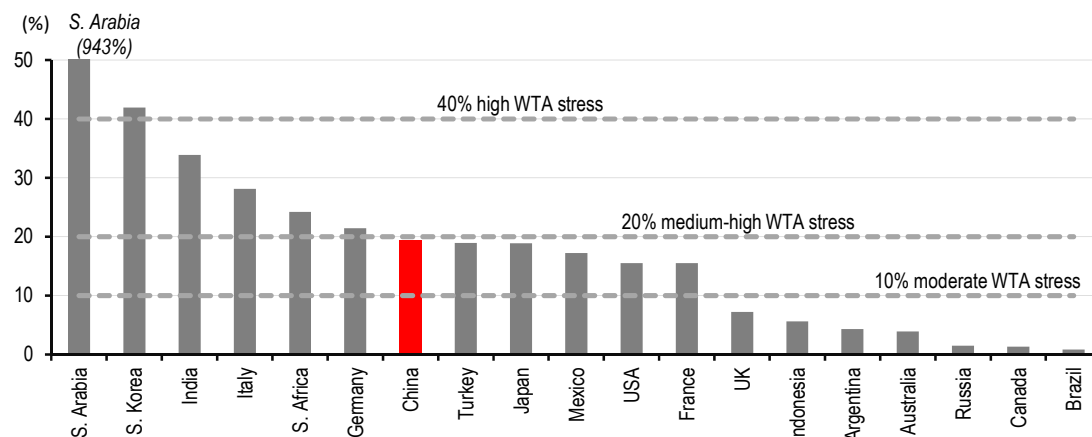
The latest available data (which is not recent in some cases) shows that among G20 countries, Saudi Arabia and South Korea suffer from high to extreme WTA stress, India from medium-high WTA and China from borderline medium-high WTA (Chart 2 overleaf). We note that this is *national* data and, therefore, so may not reflect more WTA stress at local sub-national levels.

Chart 1: G20 per capita GDP and per capita water resources in 2014



Source: World Bank (USD 2005 constant), FAO Aquastat

Chart 2: Many G20 countries suffer from some degree of WTA stress (water use/total renewable water resources), (various years)



Source: FAO Aquastat

Note: Latest available data for water use varies by country: 2000 (South Africa, Indonesia); 2001 (Russia); 2003 (Turkey); 2005 (South Korea, China, USA); 2006 (Saudi Arabia); 2008 (Italy); 2009 (Japan, Canada); 2010 (India, Germany, France, Brazil); 2011 (Mexico, UK, Argentina); 2013 (Australia)

Box 1: Definitions – WTA stress indicator

The WTA stress indicator uses the “water use-to-availability ratio (WTA)” – the ratio of *water use* over *total water resources* over, say, a year.

In 1997, a consortium of UN organisations proposed thresholds for this indicator. A region with a WTA above 10% suffers from *moderate* WTA stress, above 20% is *medium-high* WTA stress, and over 40% is *high* WTA stress.

(The World Resources Institute uses similar thresholds but adds a higher category. It classifies above 80% as *extremely high* WTA stress.)

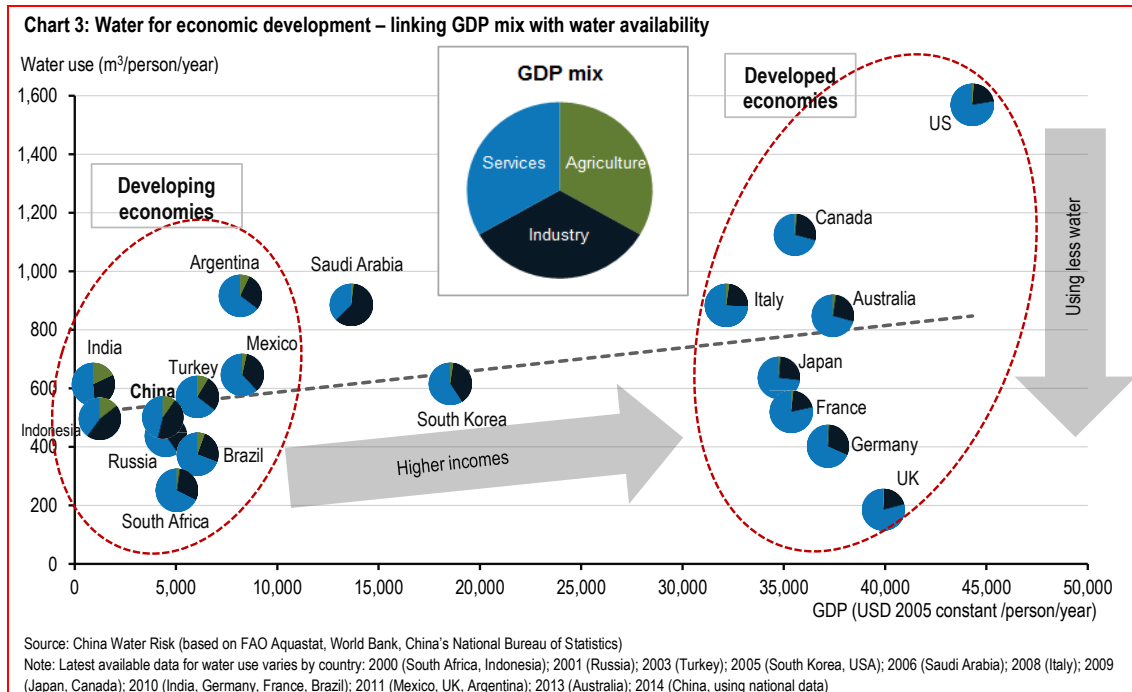
Note: This is different from *water availability*, which measures the “water resources per capita per year” in terms of volume of water (i.e., m³ per person per year).

Box 2: Definitions – Water use, water footprint and virtual water flow

Water Use is the amount of water removed from a surface or groundwater source, whether or not it is ultimately returned to its original catchment. Water use is often called “water withdrawal”.

The **Water Footprint** of a product is an illustrative concept to show the volume of water consumed (evaporated) and/or polluted by that product, measured over the full production chain. It describes the *water embedded* in the product and is also known as *virtual water content*.

Virtual Water Flows refer to *water embedded* in a product that is traded through imports and exports. Therefore, a country, which imports bananas, can be considered to be “consuming” the *virtual water content* of those bananas.



Linking water with economic mix

Chart 3 compares water use and the economic breakdown (GDP mix) of G20 countries. Broadly speaking, developing countries tend to be more agriculture-dependent and richer economies more services-based. Among the latter, the cluster of Japan, France, Germany and the UK has managed to achieve higher levels of per capita income using less water than the US, Canada, Australia and Italy.

Although the services and industrial share of GDP looks similar for these developed economies, water use varies widely from 172m³ per person in 2011 for the UK to over 9x for the US (1,575m³/person in 2005).

This variation can be explained to some extent by trade. Since data for the water use/water withdrawal of goods is not directly available, we use the concept of *virtual water flows* from the Water Footprint Network to approximate these values (see Box 2).

Water embedded in imports

The *water footprint* of an entire country has two components:

- 1 the *internal* water footprint (water embedded in domestically made products), and
- 2 the *external* water footprint (virtual water content of imported products).

We overlay the data from the Water Footprint Network across G20 countries in Chart 4. This shows that many developed countries rely on *water embedded* in imports to “free up” water to expand GDP in other ways.

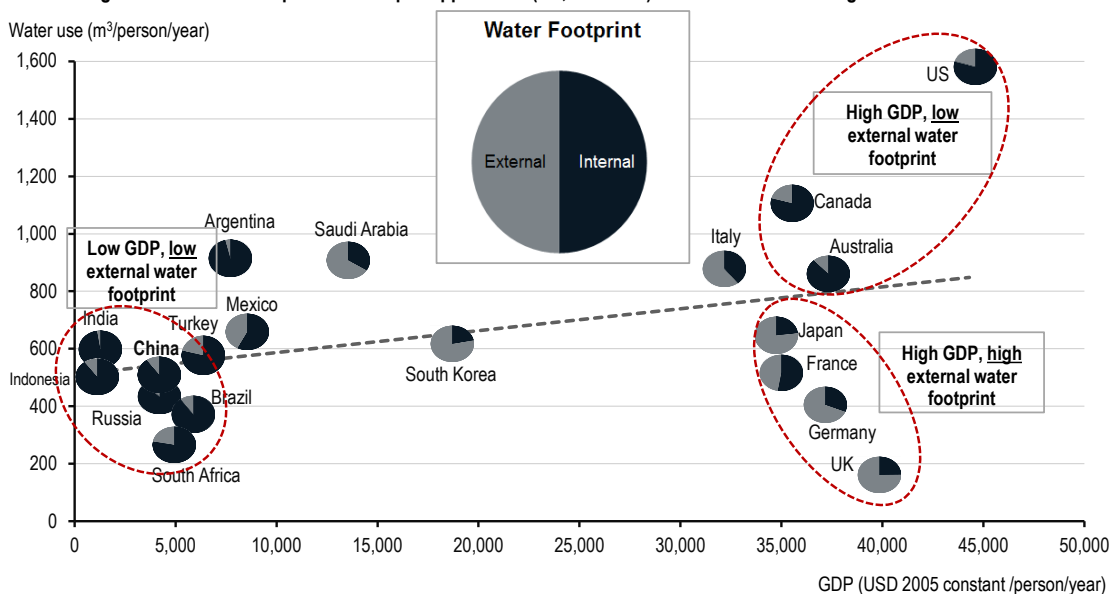
The US, Canada and Australia are primarily self-sufficient with *internal* water footprints of around four-fifths. Although Japan, France, Germany and the UK use relatively less water in per capita terms, they have managed to achieve higher levels of income by having a larger *external* water footprint, i.e., importing goods with high *virtual water content*. For example, Japan’s *external* water footprint is 77%, which means it relies heavily on the water resources of other countries.

On the other hand, developing countries tend to have a higher *internal* water footprint and, therefore, are less reliant on “imported virtual water”. For example, China and India are primarily self-sufficient with an internal water footprint of 90% and 97%, respectively. Many developing economies in Asia not only have a low *external* water footprint but are *exporting* their water, for instance, China and its ‘Made in China’ policy.

The importance of water for growth

In our view, a country with limited water resources should consider how to manage its domestic water use in terms of economic mix and the goods it produces, as this may have an effect on whether the country is able to move towards higher levels of income.

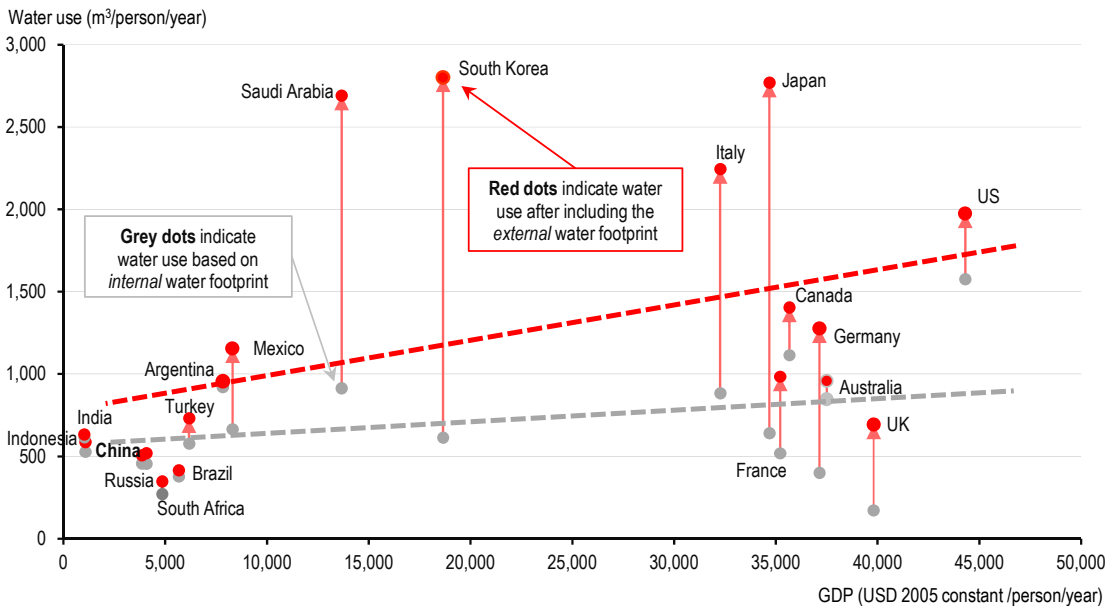
Chart 4: High external water footprints can help “supplement” (i.e., “reduce”) domestic water use to grow GDP



Source: China Water Risk (based on FAO Aquastat, World Bank, China's National Bureau of Statistics, Water Footprint Network)

Note: Latest available data for water use varies by country: 2000 (South Africa, Indonesia); 2001 (Russia); 2003 (Turkey); 2005 (South Korea, USA); 2006 (Saudi Arabia); 2008 (Italy); 2009 (Japan, Canada); 2010 (India, Germany, France, Brazil); 2011 (Mexico, UK, Argentina); 2013 (Australia); 2014 (China, using national data)

Chart 5: The reliance of an economy on water becomes clearer after adjusting for water embedded in imports



Source: China Water Risk (based on FAO Aquastat, World Bank, China's National Bureau of Statistics, Water Footprint Network)

Note: Latest available data for water use varies by country: 2000 (South Africa, Indonesia); 2001 (Russia); 2003 (Turkey); 2005 (South Korea, China, USA); 2006 (Saudi Arabia); 2008 (Italy); 2009 (Japan, Canada); 2010 (India, Germany, France, Brazil); 2011 (Mexico, UK, Argentina); 2013 (Australia)

The water in imported goods (*virtual water content*) can also be taken into account to reflect the real 'total water use' required for economic development (Chart 5).

Please note that adjusting for the 'external water footprint' is for *illustrative purposes* only. There is an element of 'double-counting', because the water embedded in exported goods is not deducted from a country's total water footprint. This is because that water is still required for economic development (exports contribute to GDP) – in other words, "not using it" would result in less production.

Water is even more important to economies

Adjusting for the virtual water content of imports by illustrating the hypothetical water needs of each country shows how reliant economies *really* are on water. Interestingly, the trend line steepens notably, which shows a stronger relationship between water and GDP.

The US, Canada and Australia, which rely much less on imported virtual water, see small shifts, while the UK, France, Germany and Italy see larger shifts. South Korea, Japan, Italy and Saudi Arabia use significantly more *virtual water* than is average for their respective level of income.

This analysis demonstrates that as economies move away from agriculture and more towards services, *virtual water flows* can help in managing limited water resources and potential future water availability. In the next chapter, we look at how this concept could be applied to China.

Managing China's water

- ▶ China's economy relies on water; the government has recognised this by setting water quotas and imposing water efficiency targets
- ▶ The country does not rely heavily on importing *virtual water*, but this may change as incomes rise and industries are upgraded
- ▶ To balance food and energy security, China may choose not to grow inedible cotton and wean itself more off coal

More water, more growth

We believe China's economic growth is closely related to its water resources, especially in power generation and agriculture. For more details, see [*No water, no power: Is there enough water to fuel China's power expansion?*](#) (September 2012) and [*No water, no food: Ensuring food safety and food security in China*](#) (March 2014).

Water is high on the political agenda, because protecting water underpins development. The focus on pollution has further highlighted the importance of water resources.

Growing China on limited water

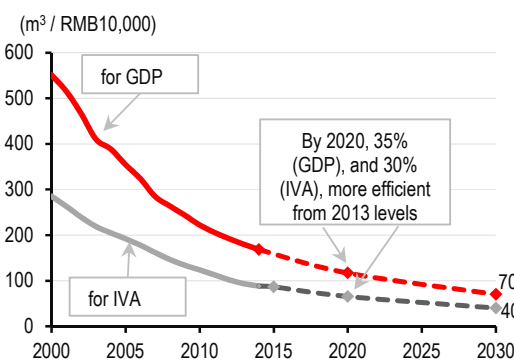
The previous chapter demonstrated how an economy runs on water. It makes sense that more water – from internal or external sources – is almost a prerequisite for more growth.

In China, agriculture accounted for 63% of total water use in 2014 but contributed less than 10% towards GDP. As industry and services account for ever larger shares of the economy, we think water use in China must also change.

Imposing water caps and efficiency targets

In 2011, China imposed total water use caps of 670bn m³ in 2020 and 700bn m³ by 2030. The Ministry of Water Resources (MWR) also set water intensity (water use/production) targets for GDP and 'industrial value-added' (IVA) for 2020 and 2030. These targets of a 30-35% improvement in water efficiency by 2020 from 2013 levels were reiterated in the recent 'Action Plan on Water Pollution Prevention and Control' (known as the 'Water Ten Plan'). We recap some of China's recent water policies in Box 3.

Chart 6: China's water intensity targets



Source: China Water Risk (based on NBSC, MWR, MEP). Note: RMB 2000 constant.

Chart 6 shows the historical improvement in water intensity; however, more efforts are required to reach the target of 70m³ per RMB10,000 of GDP by 2030. For reference, in 2005 (latest available), the comparable water intensity of GDP in South Korea was 47m³, while in the US it was 51m³.

Box 3: A brief recap of China's water policies

China's new environmental law came into force in January 2015 and the 'Water Ten Plan' was finally issued in April 2015, providing the 'third leg' to China's 'Three Red Lines Policy':

1. Control water use. The 'Most Stringent Water Management System', 2011, introduced national and provincial *water quotas*. Provincial water quotas by sector (agriculture, industry and municipal) are currently being set.

China has also been experimenting with *water use permits* since 2000. These are designed to manage the allocation of water resources between agricultural, industrial and municipal demand and allow the trading of water use permits between industry and agriculture. In 2014, this concept was formalised into seven provincial pilot schemes, with a view to moving towards a national trading scheme in the future.

2. Control water efficiency through agriculture (irrigation improvements) and industry (equipment upgrades across water-intensive sectors). There are also targets for water intensity per unit of GDP and IVA. Water tariff reforms, including the *Water Resource Fee*, also help to rein in water use and improve water efficiency.

3. Control water pollution. The 'Water Ten Plan' along with a series of more stringent industrial water standards is core to tackling water pollution. These are to be coupled with the trading of wastewater discharge permits and increases in wastewater discharge fees. In our view, the enforcement of the new environmental protection law is key here.

Water targets affect GDP growth

By using the water caps and water intensity targets for 2020 and 2030, and assuming they are strictly adhered to, China Water Risk calculates a potential GDP growth rate of 7.6% per annum (p.a.) for 2014-20 and 5.7% p.a. for 2020-30. GDP growth could be higher if either the water quotas are not met, or if the water intensity targets are exceeded.

It is worth noting that these are similar levels to the growth assumptions used in China's climate pledge to the UN in June 2015, which were for GDP growth of 6.9% p.a. for 2014-20 and 5.3% p.a. for 2020-30, according to the National Center for Climate Change Strategy and International Cooperation (NCSC).

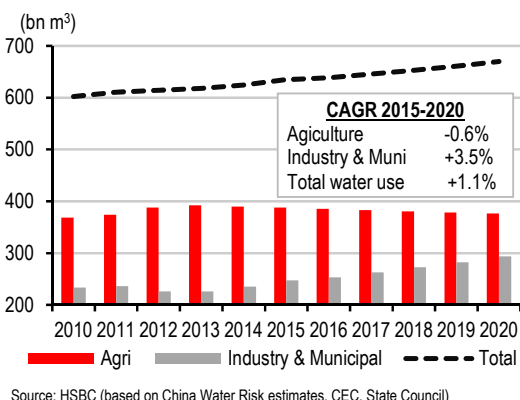
Options to manage China's water

Besides improving water efficiency, there are other options to manage water resources. These include: 1) optimising the economic mix – in terms of industrial, as well as crop mix; 2) importing more water-intensive products; and 3) matching output to localised water resources by shifting production bases.

Saving water use from agriculture

In 2014, China's total water use was 622bn m³, on track to meet the 2015 cap of 635bn m³. To meet the 2020 water cap of 670bn m³, China is looking to use water saved from agriculture to supplement rising industrial and municipal water demand (Chart 7).

Chart 7: Saving water from agriculture to meet the growing needs in industry and municipalities



However, this is easier said than done. The government has previously indicated that it would like to cap water use by agriculture at 360bn m³ by 2025. However, water use by agriculture actually rose from 369bn m³ in 2010 to 392bn m³ in 2013. The difficulty in enforcing this cap is evidenced in May's 'National Sustainable Farming Action Plan, 2015-2030', which anticipates irrigation water use to be around 372bn m³ in 2020 and 2030 – above the official cap of 360bn m³.

Regardless, the intention to achieve water savings from agriculture is clear. In [No water, no food](#), we discussed how China is trying to increase the irrigated land area, as well as irrigation efficiency,

alongside a 30bn m³ discrepancy. At the same time, China wants to shift the country's diet away from water-intensive meats. Another potential method to save water is to optimise the crop mix away from water-intensive agricultural products and turn instead to imports.

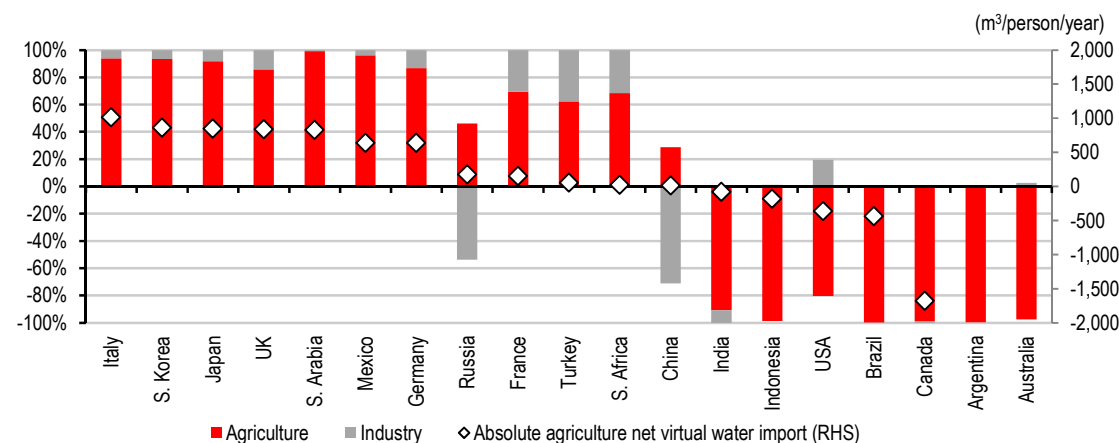
Importing agricultural products to save water

Agricultural products represent much more *virtual water* imports than industrial products, on a per capita basis (Chart 8). China's only net virtual water imports are in agriculture (primarily soy beans). However, the absolute volume (the diamond markers on the RHS axis of Chart 8) is low (13m³/person/year) compared to over 1,000m³/person/year for Italy.

For China, however, not growing certain water-intensive crops and importing these instead runs counter to the importance it places on food security. It has already signalled its intention to maintain a minimum amount of farmland to achieve basic grain self-sufficiency.

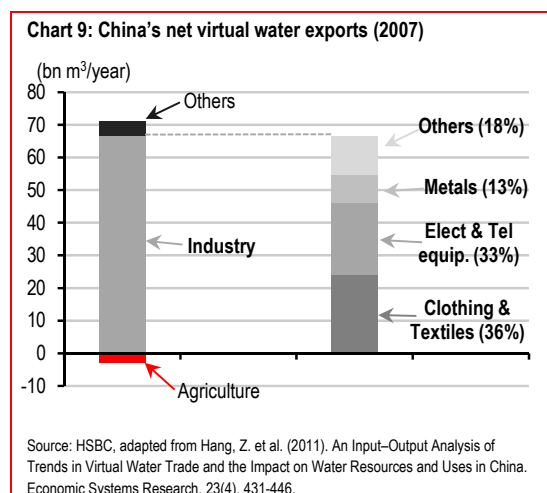
In China, some crops are grown in regions that have an abundance of water, whereas others are exposed to water-stressed provinces. Considering China's size, giving up water-intensive crops in water-challenged regions might make sense. We discuss this in more detail in the next chapter.

Chart 8: Net virtual water imports from agriculture are much greater than net virtual water imports from industry



The virtual water factory of the world

Much of China's water use is exported virtually through 'Made in China' goods. A study by Zhang et al. in 2011 (*An Input–Output Analysis of Trends in Virtual Water Trade and the Impact on Water Resources and Uses in China*) shows that industry is responsible for most of China's virtual water exports. In 2007, over two-thirds of this came from two industries – clothing and textiles, and electrical and telecoms equipment (Chart 9).



In theory, China could save, or “free up”, large amounts of water (and reduce water pollution) if it made fewer clothes and electronics for the rest of the world. Given industry contributes far more to GDP than agriculture, freeing up water from agriculture – both through efficiency and imports – is a viable option, in our opinion.

The watery path to development

As discussed above, development and managing water resources are related. We look at how China might plot a course to further development in a more water-efficient manner.

Policies, such as ‘Made in China 2025’, ‘Internet Plus’ and ‘Circular Economy’, corroborate the intention to upgrade the industrial mix with ‘higher value-add’ industries and more advanced technologies, similar to Japan and Germany. Interestingly, China's borderline WTA stress

indicator is similar to Germany and Japan's WTA stress indicator (Chart 2 on page 5) and China was the third country in the world to enact a law on ‘Circular Economy’ after those two. However, China's *external virtual water footprint* (i.e., that attributed to imports) of 10% is far from Japan's 77% and Germany's 69%. In our view, this highlights the potential for China to import more in the future.

On the other hand, Australia's *external virtual water footprint* of 12% is comparable to China's 10%. However, it uses 850m³ of water per capita to generate USD37,500 of GDP per capita, compared to China's 450m³ of water per capita, which generates USD4,000 of GDP per capita. If China is to develop further, we think it must find alternative means *beyond* just water savings to raise income levels using *less* water – and all the while staying within its water caps.

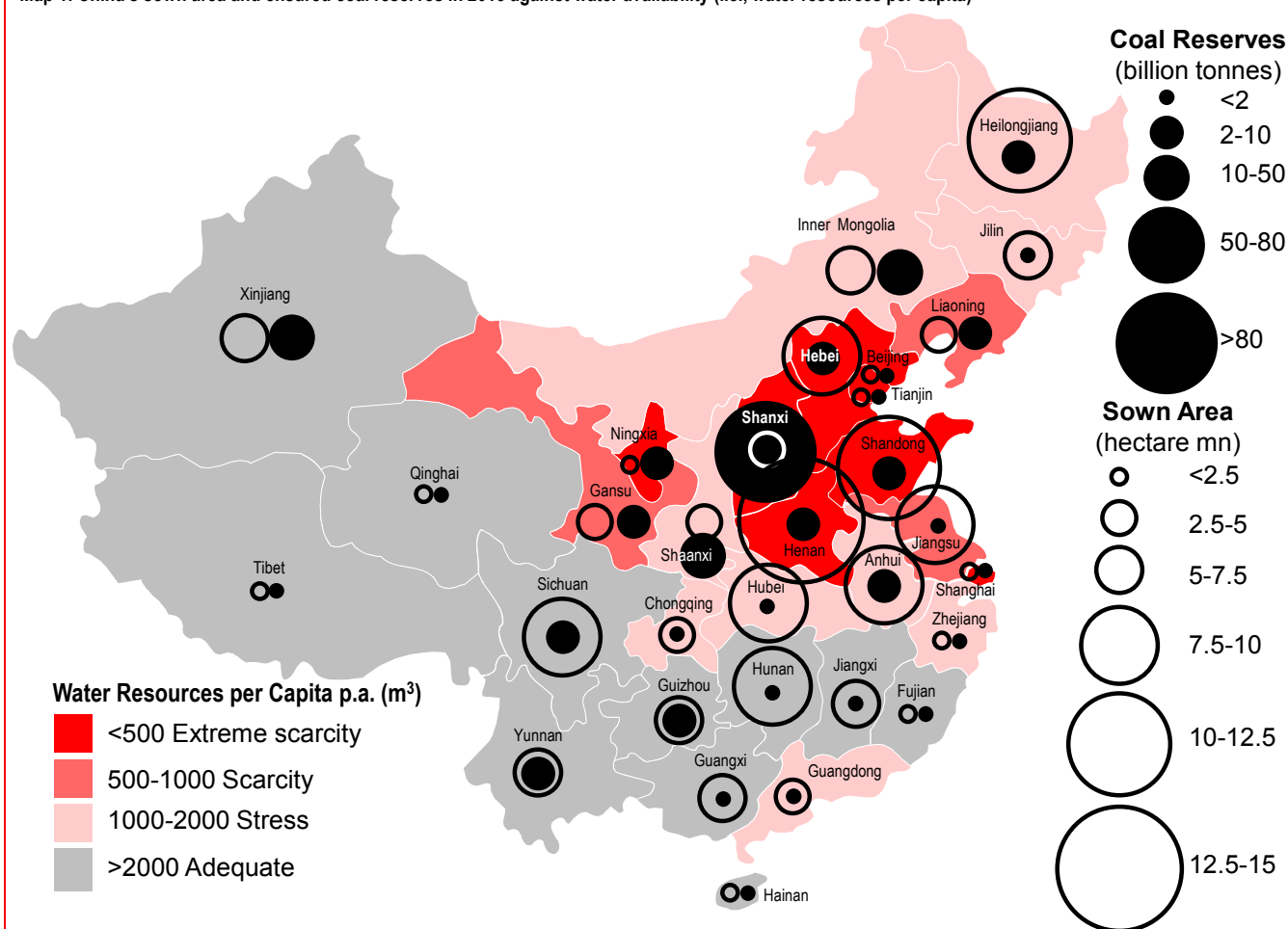
Water for food/energy security

We look at some of the changes China might make to balance food and energy security within the bounds of available water resources.

Water, food and energy security are important to China and it is working hard to balancing these. For example, in June 2015, the National Development and Reform Council (NDRC), the State Administration of Grain, and the Ministry of Finance jointly released a ‘Grain Storage and Supply Security Plan 2015-2020’. The plan sets out to reduce grain losses by 13m tonnes p.a. and in doing so save 10bn m³ of water and 4.68m tonnes standard coal equivalent.

Map 1 overleaf shows the distribution of China's sown area and the location of its ensured coal reserves. Regions facing extreme water scarcity also account for a large portion of China's sown area, as well as a significant share of ensured coal reserves.

Map 1: China's sown area and ensured coal reserves in 2013 against water availability (i.e., water resources per capita)



Source: China Water Risk (based on China Statistical Year Book, historical average water resources by province 2003-13). Note: 1,700-2,000 m³/person/year is considered borderline adequate.

Food security – growing to eat

Cotton is not edible, and compared to other key grains, it is water-intensive (Chart 10 overleaf). In addition, cotton production is highly polluting – a quarter of global insecticides and a tenth of global pesticides are used in cotton production (according to a WWF study). In theory, China could “free up” some water and alleviate some water pollution by not growing cotton – whilst maintaining sufficient levels of food security.

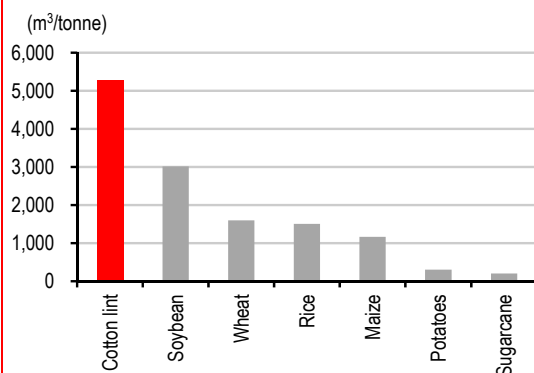
Cotton: an inedible crop

In 2013, global cotton production was 24.5m tonnes with 89% coming from the top 10 cotton producing countries. China and India alone account for half of global production (Chart 11).

China and India have long been the top growers of cotton despite both having limited water resources. While India’s production has continued to rise, China’s production has stabilised in recent years. However, this stabilisation has been paired with a rise in imports, so that around 43% of all global cotton lint passed through China in 2013 (Chart 12 overleaf).

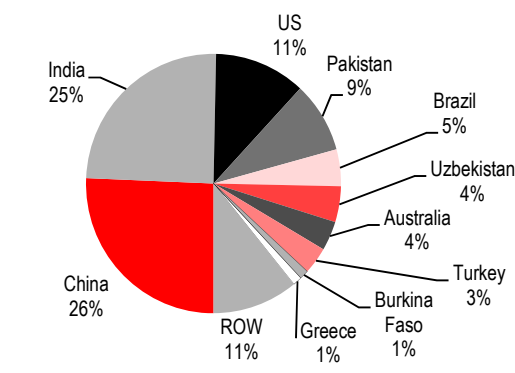
China’s dominance of the global industry means any domestic change in cotton production, or textile and apparel policies, would likely impact the global cotton trade. For example, the ‘Water Ten Plan’ specifically singled out tackling pollution from textiles dyeing and finishing. Textile factories in China are expected to comply

Chart 10: Average water footprint of key crops grown in China in 2010-11



Source: Water Footprint Network

Chart 11: 2013 World's top 10 cotton lint producers



Source: FAOSTAT

with this policy or be shut down by 2018 (or by 2017 for Beijing, Hebei, Tianjin and the Yangtze and Pearl River Deltas, the current textile hubs in China). We think China could shift away from growing cotton in water-scarce regions.

Energy security – weaning off coal

We explored the coal industry's use of water in *China Coal and Power: The water-related challenges of China's coal and power industries* (June 2013).

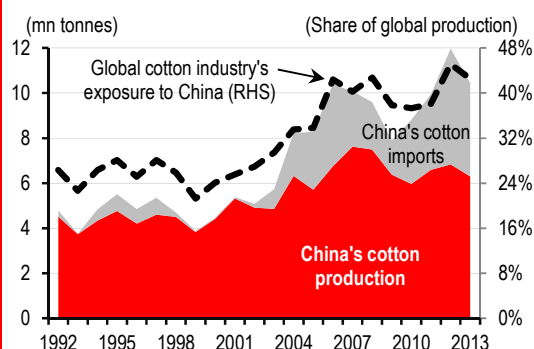
Four-fifths of China's ensured coal reserves and coal output are derived from either water-scarce or water-stressed regions. Recently, China has been consolidating its coal production into 14 large coal bases located in 12 provinces. It is targeting these coal bases to provide 95% of the

nation's coal by 2020. It is also managing water resources in these coal bases under the 'Water-for-Coal Plan'. We believe this indicates that regional water availability in China will strongly influence coal development plans for the future.

Less water, less coal

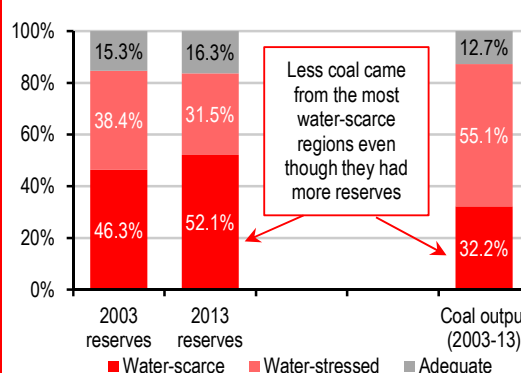
Coal mining uses water for cooling mining equipment, reducing dust levels, washing tunnels and extinguishing fires. Mining coal depletes ensured coal reserves – however, reserves have been declining at different rates across China depending on water availability. For example, although more coal reserves are to be found in water-scarce regions, much more coal output comes from areas with relatively more water (Chart 13).

Chart 12: Global cotton is heavily exposed to China



Source: China Water Risk (based on FAOSTAT, NBSC)

Chart 13: Less coal is coming from regions with less water



Source: HSBC (based on China Water Risk, NBSC)

It is difficult to know the primary reasons for this ‘reserves-to-output’ discrepancy, although we suspect water availability may be one reason. If mining coal from regions with more water is a deliberate strategy, then it leaves more of China’s coal reserves in regions with less water. This could pose problems for future coal mining, given uncertain water availability from either climate change, or even pollution regulations.

Diverting water and importing coal

Given the importance of energy security, China already has plans in place to divert 17bn m³ of water from the south to the north via the Western Route of the South-North Water Diversion Project. Although this is expensive, it does potentially cover the water needs of the coal provinces along the Yellow River (in the north).

We consider water diversion a risky strategy since climate change alters historical patterns of water availability. For example, droughts in southern China may leave less water available for diversion to the north.

We think China could consider increasing its *external* water footprint by importing more coal (rather than mining domestically to meet incremental demand). In our view, importing an “acceptable” level of coal could help protect China’s limited water resources.

We note that although China accounts for more than a quarter of the global coal trade, less than a tenth of domestic consumption is met by imports. Any change in regional production, if it were to be met by imports, could significantly affect the world’s global coal trade.

***Note:** We consider the continued decarbonisation of China’s economy (i.e., using less fossil fuel) to be the best overall strategy to ensure energy and food security since it lowers the possibilities of unpalatable impacts from climate change. These include, for example, changing patterns in average water availability and weather extremes. (For more details, please see IPCC: Impacts, Vulnerability and Adaptation, 31 March 2014.)*

Trade-offs: cotton vs. coal

- ▶ China's provinces vary greatly in their water resources, offering opportunities for trade-offs between commodities and regions
- ▶ The production of both cotton and coal could be moved out of the North China Plain towards the north-western region of Xinjiang
- ▶ However, as Xinjiang's economy grows, more pressure is put on its water resources, possibly prompting China to turn to imports

Trade-offs to manage water

Given China's vast size, there are regional differences in water availability and, therefore, differences in how the production mix – of cotton or coal – may be managed. Here, we examine some of the options available to China to manage the key commodities of cotton and coal, along four main trade-offs:

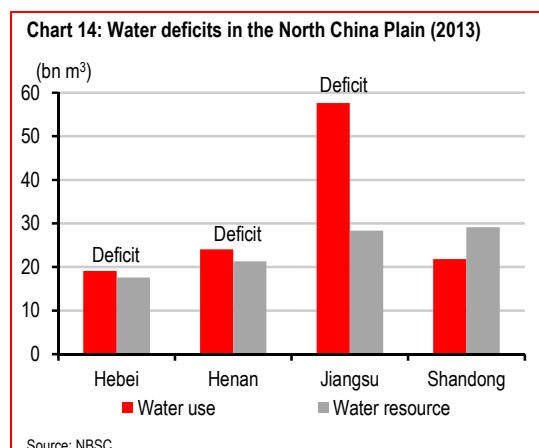
- 1 Shifting cotton production domestically
- 2 Moving towards importing more cotton
- 3 Shifting coal production domestically
- 4 Moving towards importing more coal

North China Plain – a key region

In this chapter, we focus again on the North China Plain (NCP) – the four provinces of Henan, Hebei, Shandong, Jiangsu, and parts of Anhui province. The NCP is a key agricultural region and an important coal base for China. It is also one of the most water-scarce regions in China.

Note: For the purposes of this report, data related to the NCP only includes the four provinces of Henan, Hebei, Shandong and Jiangsu.

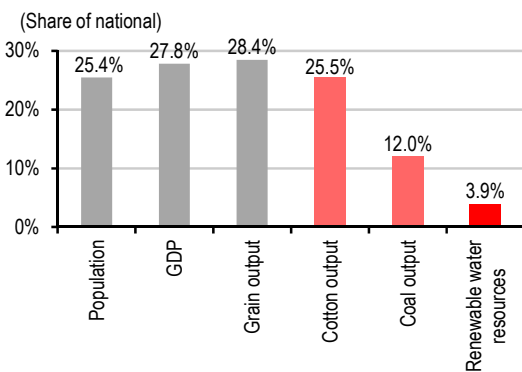
Three NCP provinces – Hebei, Henan and Jiangsu – have exceeded their renewable water resources and run water deficits (Chart 14) in recent years.



Managing coal, grain, people and GDP

The main four provinces of the NCP accounted for well over a quarter of China's GDP and grain output (wheat, corn, rice and beans) in 2012 and 12% of coal output. However, with a quarter of China's population, its 343m residents have only 4% of China's national renewable water resources (Chart 15 overleaf) and, therefore, the NCP faces water pressures.

Chart 15: North China Plain's contribution to output (2012)



Source: NBSC, CNKI

Trade-offs in cotton

1) Shifting cotton production

Giving up cotton in the North China Plain...

We consider managing the crop mix to be an effective method of managing water resources. Since cotton is water-intensive and inedible, one obvious way for the NCP to “free up” more water would be to stop growing cotton. However, in 2012, the NCP region produced a quarter of China’s cotton or around 6.6% of *global* cotton – more than the fifth largest global producer (Brazil). Therefore, any change in cotton production from the NCP could impact global cotton prices and influence the global trade of this commodity.

...would save a diversion’s worth of water

Not growing cotton in the NCP would “free up” 1.5m ha of sown land area, which could be used to plant edible crops and improve food security. For example, the water freed up from one tonne of cotton in China could be used to grow over three tonnes of wheat instead.

Using the *virtual water content* of cotton, China Water Risk estimates that the NCP’s total 2012 cotton output would “free up” 9.5bn m³ of water. This 9.5bn m³ is equivalent to the entire capacity of the South-to-North Water Diversion Project’s Middle Route (Phase 1). Phases 1 & 2 of the Middle Route are expected to transfer 13bn m³

from the south to the north per year (see Chart 17 on page 19).

Box 4: Xinjiang Uyghur Autonomous Region

Xinjiang is China’s western-most province, although officially it is an autonomous region of China. It is similar in size to Iran but with around a quarter of the population.

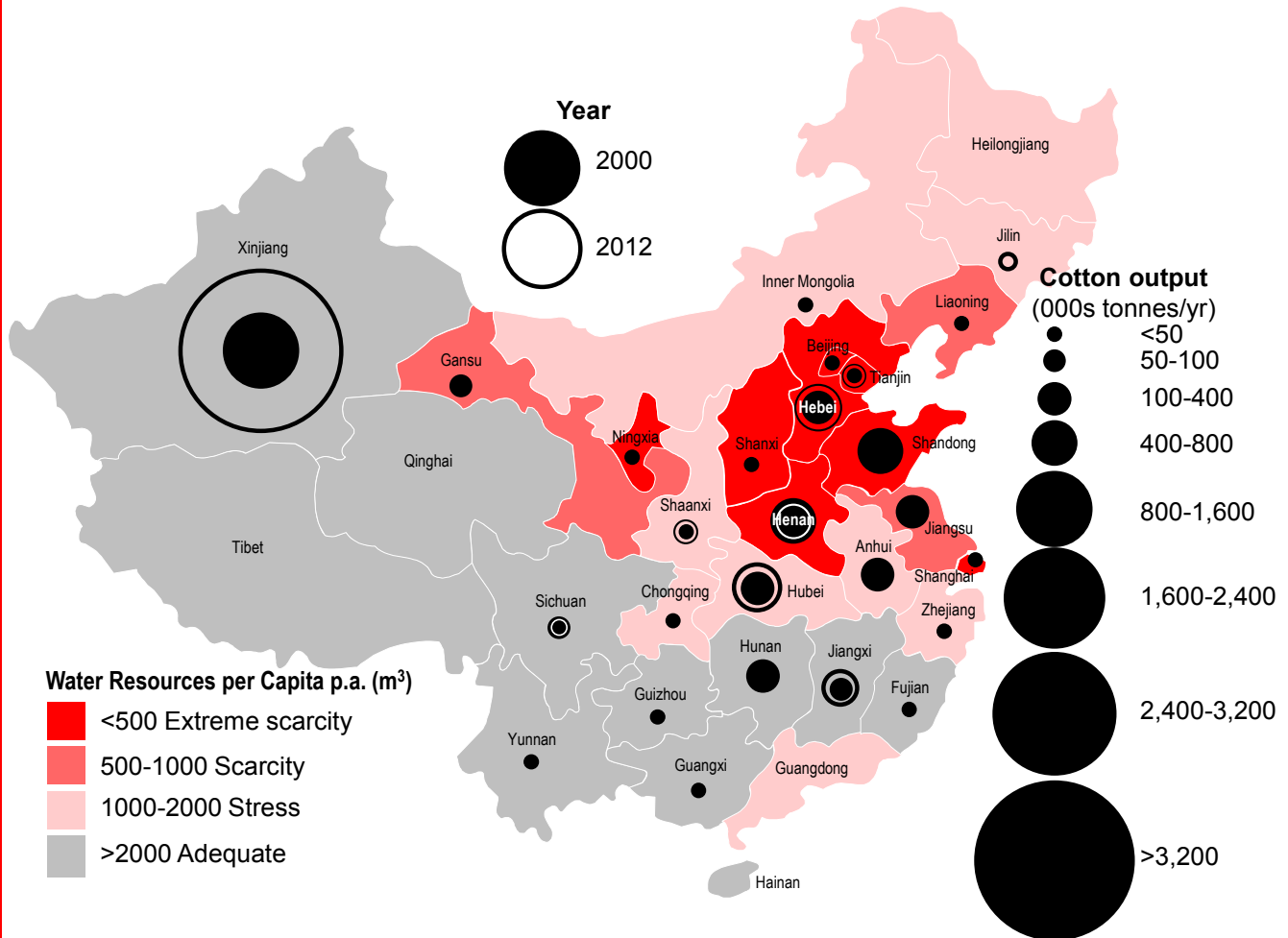
Its 23m people share the water resources from three surrounding snow-capped mountain ranges (Tianshan, Kunlun and Altay), as well as sizeable glacial reserves (two-fifths of China’s total glacial area), which flow through the region’s 570 inland rivers. Xinjiang’s average water resource per capita per year was 4,333m³/person/year (2003-13).

However, as a whole, the region uses a lot of water. At 2,527m³/person/year, it used 25% more than the average water availability per person in China (2,015m³/person/year) over the 2003-13 period. Therefore, despite having adequate amounts of water per capita, its high usage puts it close to the 60% level on the WTA stress indicator.

Moving cotton production to Xinjiang

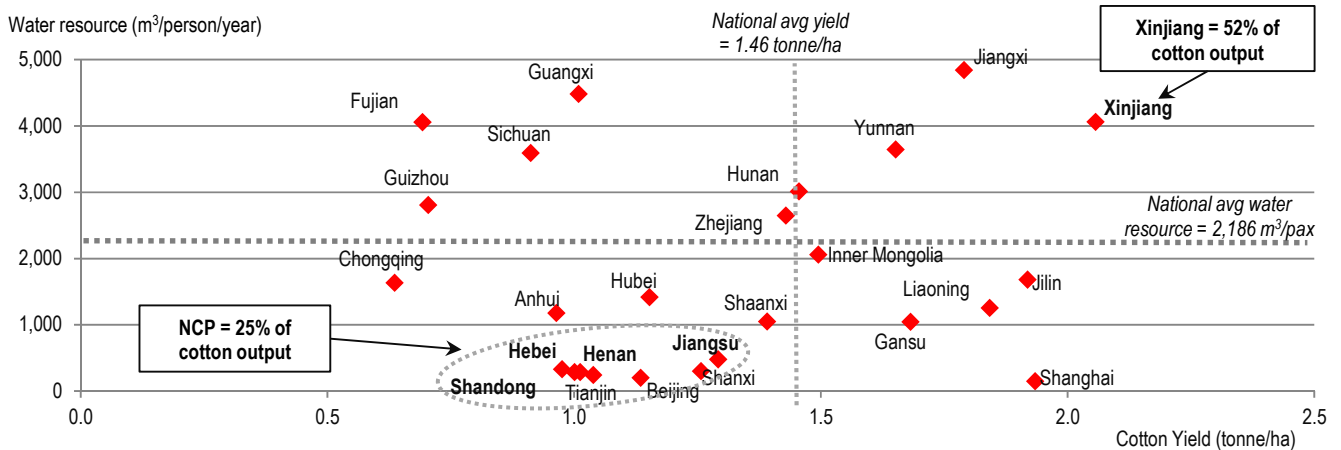
China seems to be planning a large restructuring of its cotton and apparel industry, by shifting production to Xinjiang. For example, between 2000 and 2012, cotton production in Henan actually shrank by almost two-thirds (around half a million tonnes), whilst production in Xinjiang grew 2.4x, or an extra 2m tonnes. In 2012, Xinjiang accounted for 52% of national cotton output as production grew rapidly from 2000-12 (see Map 2 overleaf).

Map 2: Changes in China's cotton output from 2000 to 2012 against water availability (i.e., water resources per capita)



Source: China Water Risk (based on China Statistical Year Book and Provincial 12FYPs, historical average water resources by province 2003-13). Note: 1,700-2,000 m³/person/year is considered borderline adequate.

Chart 16: Cotton yields in provinces where cotton was farmed in 2012, scattered with water resources per capita in 2012



Source: China Water Risk, NBSC

Moving for better yields and more water

Cotton yields vary across provinces – from 2.06 tonnes/ha in Xinjiang to 0.64 tonnes/ha in Chongqing. Combining provincial water availability with cotton yields (i.e., water efficiency) makes the case for shifting more production to Xinjiang stronger, in our view.

Chart 16 shows Xinjiang and the NCP in diagonally opposite quadrants. Xinjiang has more water resources *and* the highest yields, whereas the NCP has fewer water resources *and* lower yields. We think this strengthens the argument to shift production away from the provinces in the lower left quadrant towards the upper right.

Policies favour Xinjiang as a textile hub

In 2013, cotton production in the NCP fell by 0.26m tonnes, while Xinjiang's cotton production rose by 2.1m. We expect this trend to continue as the government continues to overhaul its cotton stockpiling programme. For example, subsidies to Xinjiang growers are already higher than those for inland (i.e., NPC) growers. In addition, the State Council issued its 'Guiding Opinions on Promoting Textile Apparel Industry in Xinjiang' in June 2015, which set out various preferential policies (such as financing, training, infrastructure and transportation) towards Xinjiang.

Virtual water from Xinjiang cotton

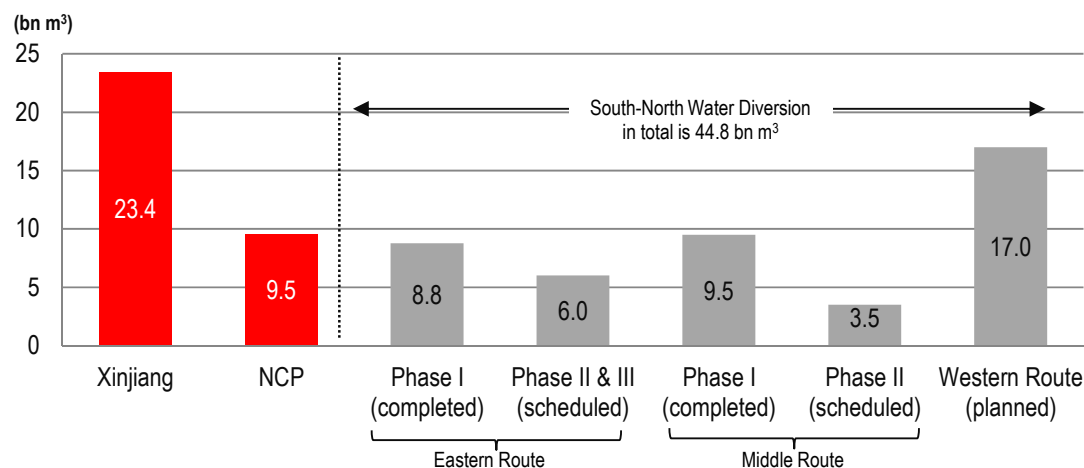
Despite these favourable policies, the *virtual water embedded* in cotton is still significant. The sheer volume of cotton grown in Xinjiang makes the potential virtual water that would be "freed up" by not growing cotton in the region attractive.

The *virtual water footprint* of Xinjiang's 2012 cotton production was over 23bn m³, more than both the completed phases of the Eastern and Middle Routes of the South-to-North Water Diversion Project (Chart 17). This water (and freed up sown land area) could be used to grow edible, less water-intensive crops, which would further enhance China's food security.

Balancing the trade-offs

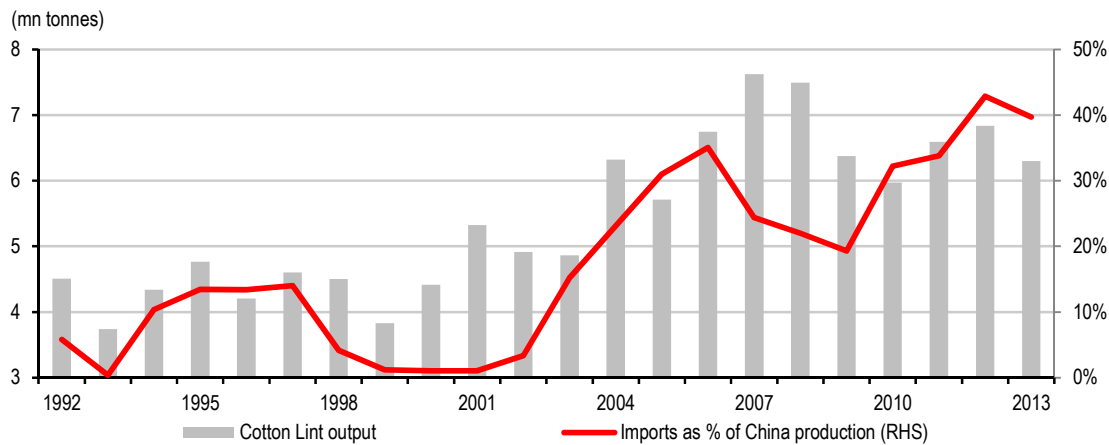
Balancing multiple strategies, such as growth, employment, food security and land area, is not easy. Various policies focus on specific areas, sometimes without appearing to consider the whole picture (this is similar to the development of energy without due consideration to water requirements, which we highlighted in [No water, no power](#)). For example, another government policy aims to develop more agriculture and livestock in the northwest of China (including Xinjiang, where cotton accounts for about a third of sown area).

Chart 17: Virtual water footprint of cotton growing in Xinjiang and the NCP vs. the South-North Water Diversion Project



Source: China Water Risk (based on NBSC, South-North Water Diversion Office)

Chart 18: China's imports of cotton have risen to two-fifths of its total production



Source: HSBC (based on FAOSTAT, NBSC statistics). Note: This refers to the ratio of imports over China's total production (domestic output + imports)

2) Importing more cotton

Cotton imports or swapping for coal

That said, Xinjiang could move up the apparel value chain by doing more spinning, dyeing and finishing, while importing the required cotton. China has been steadily importing more cotton over recent years (Chart 18) and further imports would affect the global trade of this commodity.

It is possible that cotton growing in Xinjiang loses out not only to growing edible crops for food security but also more coal mining for energy security. We look at trade-offs in coal next.

Trade-offs in coal

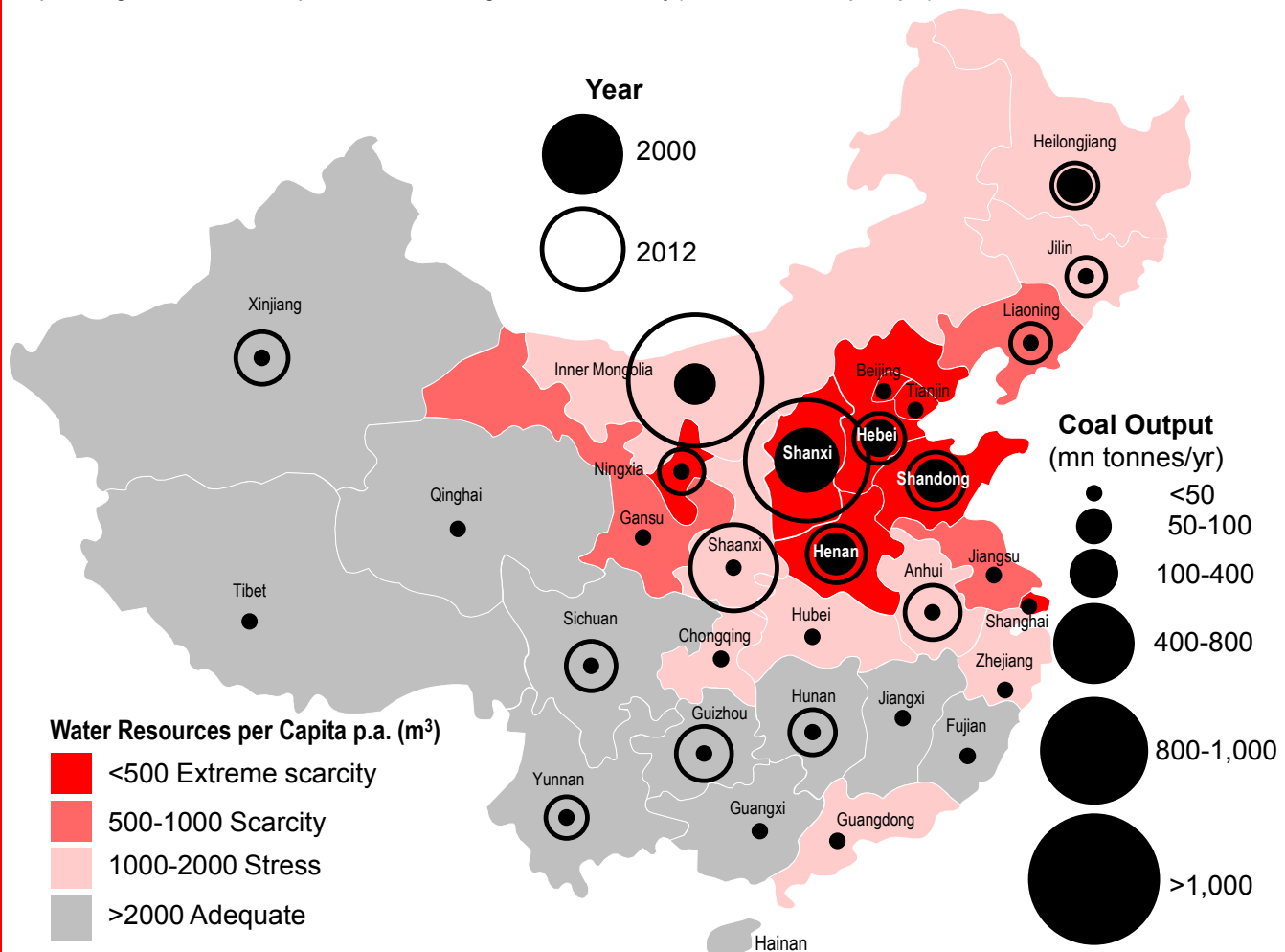
3) Shifting coal production

Coal output shifting to account for water risk

China's coal output almost tripled between 2000 and 2012. Over this period, three provinces, Inner Mongolia, Shanxi and Shaanxi, accounted for two-thirds of the *growth* in output (see Map 3). As discussed above, there has been a relative shift away from mining coal in water-scarce regions. The North China Plain's share of coal output halved from 25% in 2000 to 12% in 2012 – however, in absolute terms, the volume of coal output from the NCP more than doubled.

The China Institute of Water Resources and Hydropower Research estimates that water used across the entire coal chain (based on coal consumption of 3.92bn tonnes) is around 86bn m³, equivalent to three-fifths of total industrial water use across China, or equivalent to double the total South-to-North Water Diversion Project. Although coal mining in isolation does not directly use as much water as cotton farming, instead it comes with significant impacts on groundwater resources (see Box 5).

Map 3: Changes in China's coal output from 2000 to 2012 against water availability (i.e., water resources per capita)



Source: China Water Risk (based on CNKI, historical average water resources by province 2003-13). Note: 1,700-2,000 m³/person/year is considered borderline adequate.

Box 5: Coal mining and groundwater

Many northern Chinese cities rely primarily on groundwater for drinking. However, groundwater pollution is rampant. Recent official data shows four consecutive years of deterioration in groundwater quality. The recent 'Water Ten Plan' reiterated the need for protection of groundwater resources.

The coal and agriculture sectors not only rely on groundwater, but they also contribute to some of its quality deterioration through pollution.

We covered groundwater issues in the North China Plain in [No water, no food](#) (March 2014). For example, severe groundwater pollution leads to soil pollution and food safety issues, whilst over-extraction causes subsidence.

Draining groundwater for coal mining

Some 95% of coal in China is mined underground, which makes it difficult to avoid mine water drainage and groundwater impact. Underground mining can cause fissures that can be dangerous for underground mining and, to avoid these dangers, water close to underground mines is often pumped or drained to the surface.

We look at the coal output of the 12 coal-based provinces and the groundwater use-to-resources ratio in Chart 19. Hebei province has the highest groundwater use-to-resource ratio (this is similar to the WTA stress indicator, where higher means potential over-use of groundwater resources).

It is followed by Henan and Shandong – these three are NCP (i.e., farming) provinces.

For the NCP, coal mine water drainage between 2007 and 2012 was 8.6bn m³, which is more than the accumulated groundwater depletion over the same period (according to the MWR's 'Monthly Groundwater Reserves Monitoring Reports').

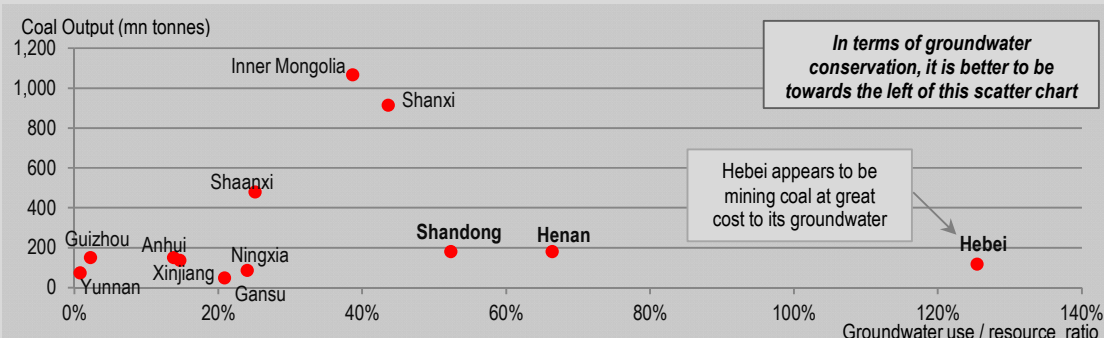
Note that detailed groundwater monitoring data only extends to the monitored plains in the north.

Tightening water use in the coal industry

China's 2013 'Water-for-Coal Plan' already stipulates that mine water drainage is the only permitted use of groundwater by the coal industry. The government also set targets for the recycling or re-use of coal mine water to be 75% by 2015. The National Energy Agency expands on this by requiring different targets, depending on the water situation: 95% in water-scarce regions by 2020 and 80% in water-stressed regions.

In our view, groundwater preservation could cause the government to revise which provinces are designated as coal bases. The 'Water-for-Coal Plan' already prioritises the protection of water resources, for example, water use and efficiency, water pollution in mining, as well as cooling technology recommendations for coal-fired power generation. We think coal miners in areas with high groundwater use-to-resource ratios could face even stricter regulations.

Chart 19: China's coal-based provinces vs. their groundwater use-to-resource ratio



Source: China Water Risk (based on NBSC, CNKI). Note: Groundwater use-to-resources ratio is the average value over the 2003-13 period.

Shutting down coal output

China is not afraid of shutting down coal mines; it has issued edicts to shut down 2,000 small and ‘backward’ coal mines by 2015. In addition, last year, China banned coal production across five provinces (Beijing, Tianjin, Shanghai, Guangdong and Zhejiang).

Given the extreme water scarcity and the acute groundwater situation in Hebei, we examine whether China could cut coal production from that province altogether.

Hebei produced just under 3% of China’s coal in 2012. While relatively small nationally, its 118m tonnes is similar to India’s total imports of thermal coal in 2012. At the same time, policies to curb air pollution in Hebei (which surrounds Beijing) are aimed at reducing coal consumption in the province. In theory, *if* China still requires that coal, it could either increase coal production elsewhere or import it.

Shifting coal production

The Chinese Academy of Sciences (CAS) estimates that the capacity of the 14 coal bases will increase from 3.6bn tonnes in 2015 to 4.7bn tonnes in 2020. We note that this is more than enough to meet the coal consumption cap of 4.2bn tonnes by 2020. Interestingly, the CAS expects Xinjiang to potentially grow the most over this

period (Chart 20). Its potential additional capacity of 600m could easily take up the slack from a shutdown of coal production in the NCP.

Making Xinjiang an energy hub

The government does appear to have plans for Xinjiang as a coal and energy hub, especially given its low population density and its adequate water resources (on a per capita basis). It also has a considerable share of China’s energy resources, including oil and gas (Chart 21).

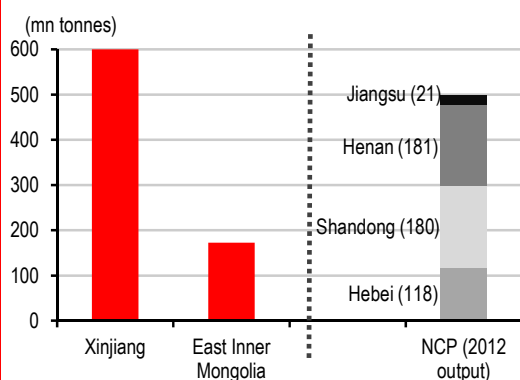
Another key reason, in our view, is the distance between Xinjiang and other major cities – moving coal and related industries far out west alleviates some of the air and water pollution problems of more densely populated areas.

Xinjiang’s long-term water management

In terms of managing China’s water resources, we believe Xinjiang is not a long-term solution, however. Its 600m tonnes of additional coal capacity *could* replace the whole NCP; its higher cotton yields *could* “free up” water and sown land area for edible crops, and its distance from population centres means pollution is less of an immediate concern.

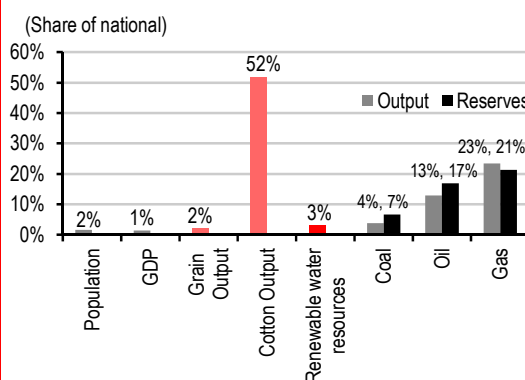
Nonetheless, over the long term, we think this shift would also put a strain on the Xinjiang’s own water resources, which are uncertain in light of

Chart 20: Xinjiang’s additional capacity by 2020 could absorb the NCP’s entire coal production



Source: Chinese Academy of Sciences (CAS), CNKI

Chart 21: Xinjiang’s contribution to output (2012)



Source: China Water Risk (based on NBSC)

climate change. China may need to choose what it produces domestically and then shift some production out of the country altogether and, therefore, turning to *virtual water imports* to manage its water resources more effectively.

4) Importing more coal

Importing 120m tonnes of coal (around Hebei's production) would bring the 'coal consumption met by imports' figure to 12%, which we think China would find "acceptable" in terms of energy security. If, however, coal production were shut down in the whole of the NCP (half a billion tonnes in 2012), we believe this may not be considered "acceptable".

In any case, it would affect the global coal trade. For example, according to the UN, China imported almost 300m tonnes of coal last year –two-thirds from Indonesia and Australia. The NCP's 500m tonnes of coal production is equivalent to half the world's total exports of thermal coal.

We consider the continued decarbonisation of China's economy (i.e., using less fossil fuel) to be the best overall strategy to ensure energy and food security since it lowers the possibilities of unpalatable impacts from climate change. As such, perhaps the reduction of coal production in water-scarce regions would be in tune with an overall reduction in coal consumption. Therefore, no imports would be required at all.

Conclusion

Managing water for economic development and ensuring both food and energy security at the same time points to tough trade-offs.

Our analysis shows that cotton and coal are headed for a clash as they compete for limited water resources. In our view, cotton is likely to lose out, because it uses much more water as a whole and it has a lower contribution to GDP.

In addition, not growing cotton would release large areas of land and "free up" water for growing other crops, which helps to ensure food security. Although coal mining pollutes water, the wastewater discharge from the textile, apparel & footwear industry in China is double that of the entire coal industry in China.

Not only do China's domestic policies in managing the economy with limited water matter but those of its individual provinces matter as well. Any trade-offs between regions and commodities in a bid to manage water could change both domestic and international trade flows.

Notes

Notes

Disclosure appendix

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Issuer of report

The Hongkong and Shanghai Banking Corporation Limited

Level 19, 1 Queen's Road Central
Hong Kong SAR

Telephone: +852 2843 9111

Fax: +852 2596 0200

Website: www.research.hsbc.com

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Global Climate Change & Clean Technology Team

Climate Change Centre of Excellence

Zoe Knight
Head, Climate Change Centre of Excellence
 +44 20 7991 6715 zoe.knight@hsbcib.com

Wai-Shin Chan, CFA
Director, Climate Change Strategy – Asia-Pacific
 +852 2822 4870 wai.shin.chan@hsbc.com.hk

Ashim Paun, CAIA
Director, Climate Change Strategy
 +44 20 7992 3591 ashim.paun@hsbcib.com

HSBC Climate Change Indices

Joaquim de Lima
Global Head of Equity Quantitative Research
 +44 20 7991 6836 joaquim.delima@hsbcib.com

Vijay Sumon
Director, Head of Indexation
 +44 20 7991 6839 vijay.sumon@hsbcib.com

Amit Shrivastava
 +44 20 7991 3095 amit1.shrivastava@hsbcib.com

Clean Technology

Sean McLoughlin
Vice President - Clean Technology
 +44 20 7991 3464 sean.mcloughlin@hsbcib.com

Evan Li
Director, Head of Utilities & Alternative Energy – Asia-Pacific
 +852 2996 6599 evan.m.h.li@hsbc.com.hk

Charanjit Singh
 +91 80 3001 3776 charanjit2singh@hsbc.co.in

Gloria Ho, CFA
 +852 2996 6941 gloriapyho@hsbc.com.hk

Summer Y Y Huang
 +852 2996 6976 summeryyhuang@hsbc.com.hk

Simon Fang
 +852 2822 4665 simon.w.fang@hsbc.com.hk

Christian Rath, CFA
 +49 211 910 3049 christian.rath@hsbc.de

Murielle André-Pinard
 +33 1 56 52 43 16 murielle.andre.pinard@hsbc.com

Ravi Jain
 +1 212 525 3442 ravijain@us.hsbc.com

Utilities

Adam C Dickens
Head of Utilities - EMEA
 +44 20 7991 6798 adam.dickens@hsbcib.com

Verity Mitchell
 +44 20 7991 6840 verity.mitchell@hsbcib.com

Pablo Cuadrado
 +34 91 456 6240 pablo.cuadrado@hsbc.com



Wai-Shin Chan, CFA
Climate Change Strategist
The Hongkong and Shanghai Banking Corporation Limited
+852 2822 4870
wai.shin.chan@hsbc.com.hk

Wai-Shin joined HSBC in 2011 as the Director for Climate Change Strategy in Asia Pacific. The role involves helping HSBC's clients to prepare their portfolios for the effects of climate change, as well as internal consulting for different business functions within the bank. Before HSBC, Wai-Shin worked as a fund manager where he was centrally involved in the integration of Environmental Social Governance (ESG) issues into the investment decision-making process. He is a former Executive Director of ASrIA (Association for Sustainable and Responsible Investment in Asia) and was previously the ESG equity analyst for Asia at an investment bank. Wai-Shin holds a degree in Mathematics and Physics from Durham University (first class honours) and is a CFA charterholder.



Zoe Knight
Head, Climate Change Centre
HSBC Bank plc
+44 20 7991 6715
zoe.knight@hsbcib.com

Zoe Knight is Head of the Climate Change Centre of Excellence at HSBC. She joined HSBC in 2010 and has been an investment analyst at global financial institutions since 1997, initially focusing on pan-European small-cap equity strategy before moving into socially responsible investing, covering climate change issues. She contributed to the FTSE's 2009 book 'Investment opportunities for a low-carbon world'. Since joining HSBC Zoe has co-authored reports on low-carbon opportunities in bond and equity markets, as well as long-term carbon and water risks. The Climate Change Centre of Excellence produces reports on 2°C finance, climate policy and climate impacts which are aimed at institutional investors. Throughout her career Zoe has been ranked in Extel and Institutional Investor surveys. She holds a BSc (Hons) Economics from the University of Bath.

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