

Water-nomics of the Yangtze River Economic Belt:
Strategies & recommendations for green development along the river

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Abstract: This policy brief explores the linkages between water use and allocation, as well as pollution control and economic development in the Yangtze River Economic Belt (YREB). It is jointly published by China Water Risk and the Foreign Economic Cooperation Office of the Ministry of Environmental Protection of the People's Republic of China (MEP-FECO). The brief sets out strategies and recommendations for green development along the river, which is of strategic importance to China. This collaboration expands on China Water Risk's earlier work on trade-offs within the water-food-energy-climate nexus.

Key words: China; Yangtze River; Water-nomics; Green Development; Water Security

The Yangtze River, the longest and largest river in China, represents the cultural and political identity of the nation. It is also the country's social-economic powerhouse. Covering nine provinces and connecting two municipalities (Chongqing and Shanghai), the river provides water to over 584 million people living in the Yangtze River Economic Belt (YREB).

The development of the YREB must take into account the long-term interest of the whole Chinese nation. Indeed, the path of holistic ecological protection and green development along the Yangtze was emphasized by President Xi in a NPC meeting on 5th January 2016 in Chongqing. Only under this path could “clear waters” and “green mountains” bring significant ecological, economic and social benefits to sustain the vitality of the “mother river”.

1 STRATEGIC IMPORTANCE OF THE YREB

For centuries, the Yangtze River has been a ‘golden waterway’ for transporting goods between cities and villages along the river. Many of these commercially active areas have grown into important manufacturing hubs, not only for China but also the world. Products are shipped from inland regions along the river to port cities such as Chongqing and Wuhan, and then delivered to the rest of China via railways and highways. Goods from YREB are also shipped overseas from two of the world's largest ports at the mouth of the Yangtze River Delta (YRD), Shanghai and Ningbo.

China is going through various structural changes, including shifts to its economic mix, to achieve the ultimate goal of a “Beautiful China”. YREB, as one of the most populous and economically vibrant regions, will have to lead this path of green economic development. This is a huge challenge; especially amid a global economic slowdown and constraints imposed by climate change.

To achieve this, the linkages between water use and allocation as well as pollution control and economic development need to be explored. The shift of heavy industry upstream, to promote economic development inland, may need to be re-examined. Pollution discharged upstream is simply carried downstream by the river to the sea adding further pressures to the already polluted YRD. Innovation in technology, policy and finance are also key in finding solutions that are tailored to addressing various sections along the river.

Sustainable economic development of the YREB is not only important for the region, but also has national water, food and energy security implications. The Yangtze River not only provides Northern China with water via the diversion projects but planned hydro and nuclear power expansion along the Yangtze could also help alleviate water stress caused by thermal power development in the North.

In the Upper Yangtze, an estimated 10-12% of water comes from glacial melt (Su et al., 2016). It is thus imperative to mitigate climate change in order to protect such water resources. Indeed, water has been identified at the COP21 in Paris as the most vulnerable sector. More importantly, decisions at the water-energy-climate

nexus, will not only impact China: the upper watershed of the Hindu Kush Himalayan region is also the source of other major rivers feeding 16 countries in Asia. Successful innovations towards the path of economic development and ecological protection in the YREB can be used beyond China. Indeed, China can play a key role in Asia's future development, where many other countries also have to develop their economies with limited water resources.

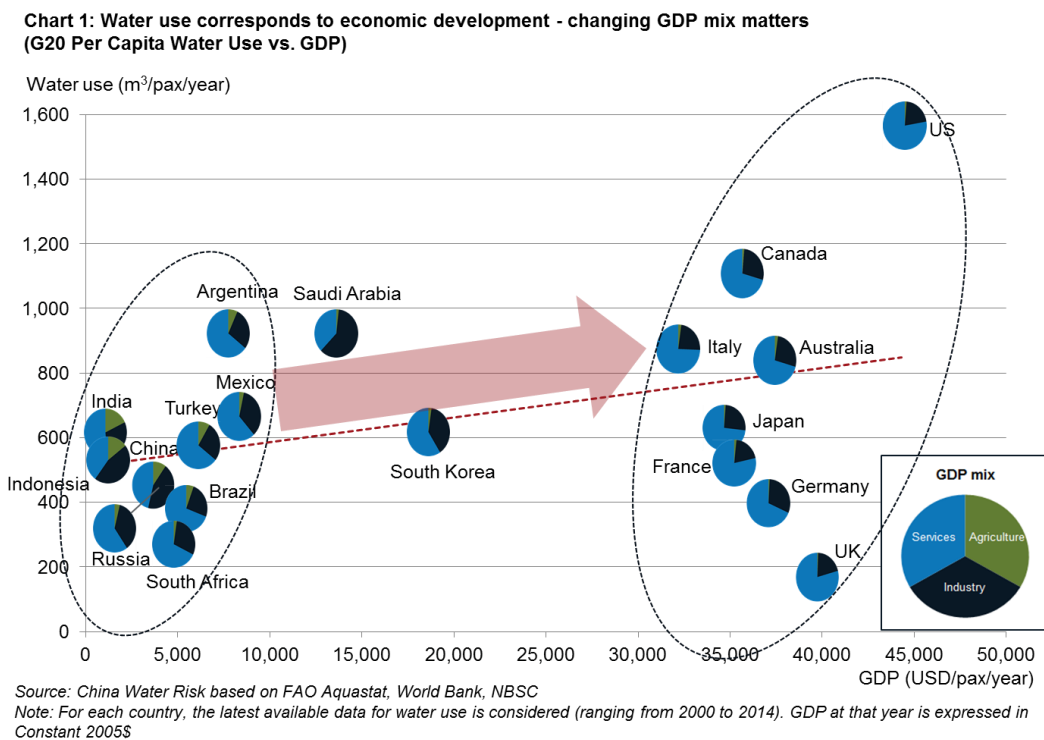
Better understanding of these linkages between water and development or 'water-nomics' at the YREB and the implications for national food and energy security is important to facilitate sound policy decisions today for water tomorrow.

2 WATER-NOMICS: LESSONS FROM G20 COUNTRIES

It is evident that water is important for development. As China develops, the demand for water would likely rise, adding pressure to the already limited water resources. These challenges are explored by looking at the relationships between water and development across the G20 countries below.

2.1 G20 water-nomics

Water is essential for economic development. Analyses of per capita GDP and water use as well as GDP contribution across the G20 countries are set out in **Chart 1** below. Generally, agri-heavy economies fall in the lower left quadrant, while more services-heavy economies use more water and have higher GDP.



Economic mix matters and can help countries with limited water manage water stress (HSBC Climate Change Research Centre, 2015). China aims to double the

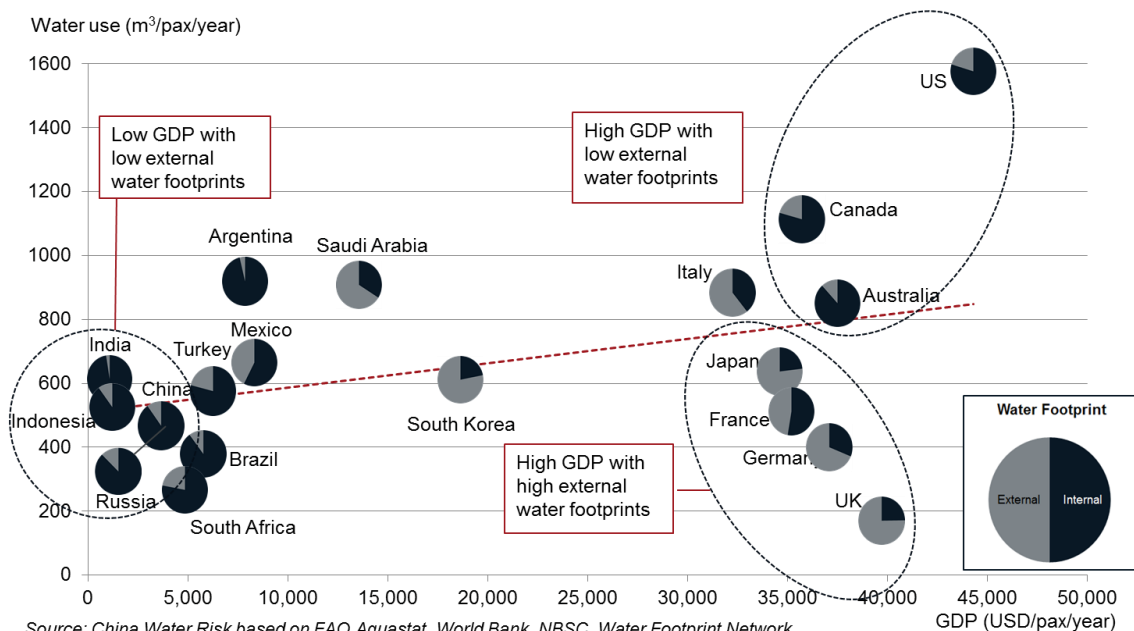
2010 GDP and per capita personal income by 2020, but can it achieve this with limited water resources?

In theory, higher GDP with less water can be achieved with a shift away from agriculture towards more services. However, in practice, the agriculture sector in China employs 228 million people; moreover, it is imperative for China to maintain food security. Have other G20 countries managed to grow their services industries with less water, while maintaining food security?

2.2 G20 developed countries used imports to reduce domestic water use

Some developed countries such as Japan, France, Germany and the UK have succeeded to develop with limited water resources. A closer look shows that this has been made possible by outsourcing part of its water use through higher external water footprints facilitated by the import of water-intensive goods.

Chart 2: Outsourcing water - imports can help reduce domestic water use (G20 Per Capita Water Use vs. GDP)



Source: China Water Risk based on FAO Aquastat, World Bank, NBSC, Water Footprint Network
 Note: For each country, the latest available data for water use is considered (ranging from 2000 to 2014). GDP at that year is expressed in Constant 2005\$

Key takeaways from the above **Chart 2** are:

- **High GDP with high external water footprints:** Japan, France, Germany and the UK have managed to achieve a high GDP with low domestic water use by having a larger external water footprint. This cluster is using the water resources of other countries by importing water intensive goods.
- **High GDP with low external water footprints:** US, Canada and Australia on the other hand is primarily self-sufficient with internal water footprints of 80%, 79% and 88% respectively.
- **Low GDP with low external water footprints:** China and India with low per capita GDP are primarily self-sufficient with internal water footprints of 90% to 97% respectively. In fact many of the developing economies in Asia not only

have low external water footprints, they are in many cases even exporting water – like China with ‘Made in China’.

The path of self-sufficiency like US, Canada & Australia, points to more water use. However, given limited water resources and the Three Red Lines, China needs to look beyond water saving efficiencies to manage its limited water resources. This includes:

- 1) Optimizing economic mix;
- 2) Optimizing industrial and crop mix;
- 3) Importing more water-intensive goods and exporting less water-intensive goods; and
- 4) Shifting output & recycling within China to match local water resource availability.

Solutions to achieve national water security need to be cohesive and comprehensive. Policy decisions across all aspects of the economy matter for water.

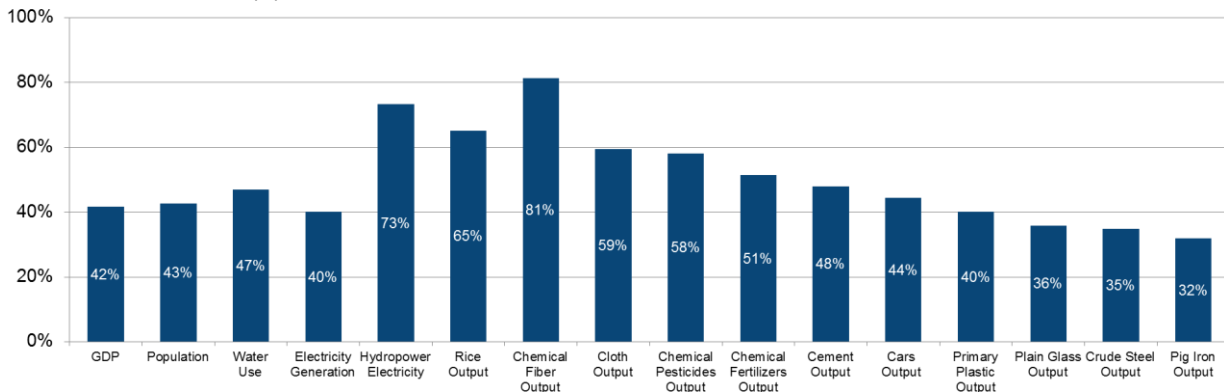
3 WATER-NOMICS OF THE YREB

3.1 YREB must lead China’s path towards water & economic security

The YREB is the socio-economic powerhouse of China. In 2014, the 11 YREB provinces and municipalities, with 43% of China’s population, generated 28 trillion yuan in Gross Regional Product. This represents nearly 42% of the national total GDP. The region is also essential for producing significant amounts of goods that are key to various industries as well as to food & energy security:

- Agriculture: rice (65%), chemical pesticides (58%) and fertilizers (51%);
- Energy: electricity generation (40%), hydropower (73%);
- Building materials: cement (48%), primary plastic (40%) and crude steel (35%); and
- Fashion: chemical fibers (81%) and cloth (59%).

Chart 3: Importance of the YREB across various categories
2014 share of national total (%)



Source: China Water Risk based on National Statistical Bureau of China

However, such impressive dominance in manufacturing has resulted in the heavy use of resources and great pressure on the environment. From a water point of view, the YREB represented 43% (or 30.8 billion tonnes) of the total national wastewater discharge and 47% (or 323 billion m³) of the total national water use in 2014.

Over the last decade, the YREB’s wastewater discharge has been increasing at a compound annual growth rate (CAGR) of 3.40%, albeit slightly slower than the national rate of 4.03%. On the other hand, its water use has been rising at a CAGR of 1.03%, slightly faster than the national CAGR of 0.94%. However, under the Three Red Lines policy, China’s 2020 water use cap only allows for a 2015-2020 CAGR of 1.08%. The 2020-2030 CAGR is even more stringent at 0.44%. Given this, is the YREB’s growth sustainable?

Furthermore, industries in the YREB are under-performing: water use per unit of industrial value-added in 2014 was 24.9% higher than the national average. However, if agriculture and services were included, YREB’s water use per unit of GDP falls and is 4.6% lower than the national average. There is clearly room for the YREB to optimize water efficiencies in industrial water use as well as rethink its industrial, crop and energy mix so that it can grow the economy whilst reducing its impact on water resources and the environment.

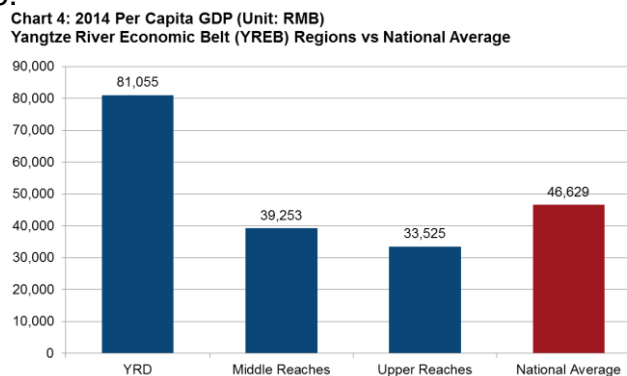
Decisions made in the YREB are important for national economic development and will have national implications for food and energy security. Moreover, decisions for water allocation and pollution management in agriculture, fashion and energy sectors will also have global trade and climate implications. Green solutions found at the YREB can be used to ensure stability and sustainable development in China.

3.2 Challenges faced by the economy, water resources & environment in the YREB

3.2.1 Economic and pollution disparities along the river are significant

China’s GDP per capita stands at 46,629 yuan whereas the YREB’s is only 4.5% higher at 48,727 yuan. However, there is vast economic difference between the Upper and Middle reaches compared to the YRD.

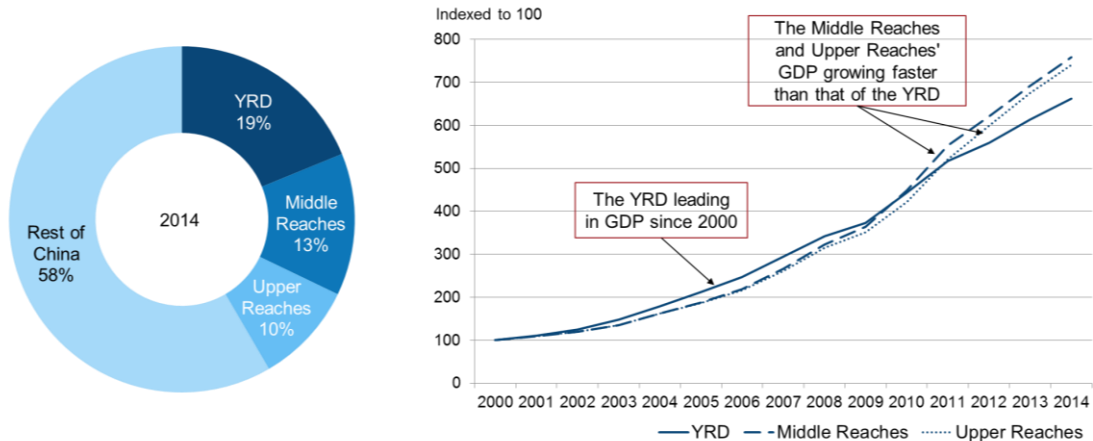
As shown in **Chart 4** below, the YRD is the richest, with a per capita GDP of 81,055 yuan, more than twice of that of the Middle and Upper Reaches. The difference in economic development of the three regions has led to dispersed trends in pollution as well as water use.



Source: China Water Risk based on National Statistical Bureau of China

In 2014, the YRD's GDP reached 12.9 trillion yuan. This is one fifth of the national GDP (see left chart of **Chart 5** below) and 45% of the YREB's GDP. As can be seen from the right chart of **Chart 5**, the YRD has been leading the YREB's economy since 2000. However, since the 12FYP, GDP growth in the Middle and Upper Reaches has overtaken that of the YRD.

Chart 5: The YRD leads the YREB in GDP but upstream growth is rising faster than the YRD
YREB regions' GDP share and historical trends



Source: China Water Risk based on National Statistical Bureau of China

From an economic point of view, it seems logical to move industries inland to where production cost is relatively lower. Inland economies and provinces can also develop, closing the rural-urban and/or inland-coastal income gap. However, industrial growth has brought about rampant pollution and other development issues as discussed below.

In the longer term, if we were to align economic growth with environmental improvement, we need to find the optimum economic mix in each of these three regions to ensure the overall water security of the YREB as well as China.

3.2.2 Upstream economic mix matters: pollution from mountaintop to the sea

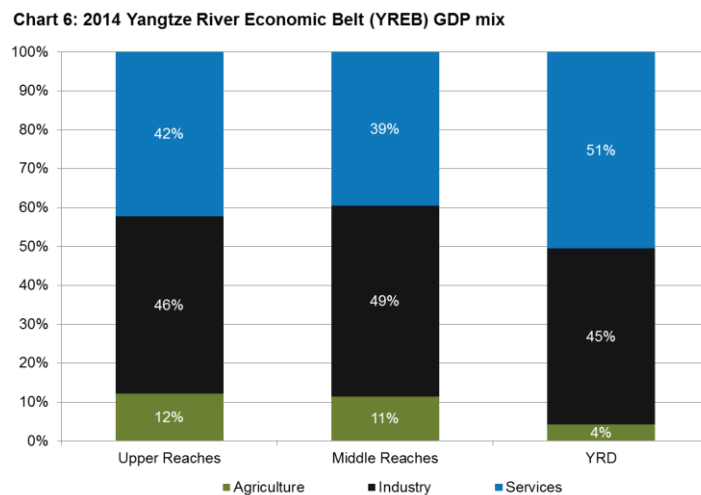
Pollution levels vary amongst the three regions of the YREB. In 2014, the YRD, the Middle Reaches and the Upper Reaches accounted for 40%, 36% and 24% of the total amount of wastewater discharged in the YREB respectively.

However, a closer look at the past 10-year data reveals interesting trends for these three regions:

- The absolute amount of wastewater is increasing for all the three regions;
- During the 12FYP, the growth in wastewater discharge in the YRD has stayed almost flat, whilst the Middle Reaches was still increasing, albeit at a slower rate than that during the 11FYP; and
- Wastewater discharged from the Upper Reaches has undergone a faster rate than the rest of YREB.

Therefore although it is important to focus pollution prevention and control efforts in the YRD currently, it is equally important to look at the rapid rise of wastewater discharged in the Middle and Upper Reaches. After all, such pollution will only serve to exacerbate pollution and scarcity in the already water stressed YRD.

The economic mix of these three regions may provide some explanation. As shown in **Chart 6** below, the YRD has a much smaller share of primary industry (agriculture, forestry & fishery) than the Middle and Upper Reaches. The YRD also has a materially higher share of the service industry and lower contributions from secondary industry compared to the other two upstream regions.



Source: China Water Risk based on National Statistical Bureau of China

Since the agriculture and industry sectors are both significant contributors to pollution, this would explain the continued rise in wastewater from these two upstream regions. Achieving the right economic mix across these three regions can thus help manage water use and pollution.

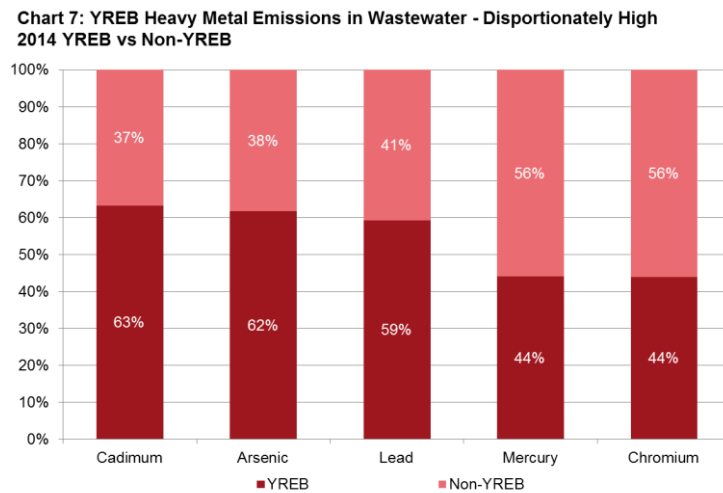
Meanwhile, wastewater treatment infrastructure in the two upstream regions is still lagging behind. This is especially true for the Upper Reaches - its urban daily sewage treatment capacity is only 11.6 million m³ in 2014 - a third that of the YRD and half that of the Middle Reaches. Without proper treatment, pollutants discharged upstream can be carried by the river from the mountaintop to the sea.

It will require significant investment and take time to upgrade the local treatment capability in the Upper Reaches to reach the level of the YRD. It will take an even longer time to change the economic mix to minimise the impacts on water resources and water quality. Thus, we should be cautious in moving polluting industries further upstream. Any transfer of industry upstream must comprehensively address such rivers-to-the-sea pollution issues.

3.2.3 Hazardous heavy metal pollution can threaten food security & safety

Besides being carried by the river, pollutants can either seep into sediment or into soil. A closer look into heavy metals discharged reveals a worrying trend for the YREB. Although the region as a whole accounts for 43% of total wastewater discharged nationally (which is in line with population and economic contribution), it

is has a disproportionately high heavy metals discharge, especially in Cadmium (63%), Arsenic (62%) and Lead (59%) as per **Chart 7** below:



Source: China Water Risk based on National Statistical Bureau of China

Hunan and Hubei account for a lion’s share of the YREB’s discharge of Cadmium, Arsenic, Lead at 69%, 71% and 63% respectively. Indeed, the industrial mix in these two provinces means that they account for more than half of the discharge across these five heavy metals with the exception of Chromium.

Nationally, Hunan alone accounted for 38% of Cadmium, 33% of Arsenic, 30% of Lead and 20% of Mercury emissions. These levels are worrying as both Hunan and Hubei are important rice producing provinces. Together they produce over a fifth of China’s rice production.

However, such heavy metal industrial pollution could flow downstream along the river and pose a wider threat to the food safety of China’s key staple. Thanks to the fertile soil and favorable climate conditions, the YREB produces around 65% of China’s rice. Moreover, there are food security implications given the magnitude of other agriculture produce along the Yangtze River, and limited arable land across the country.

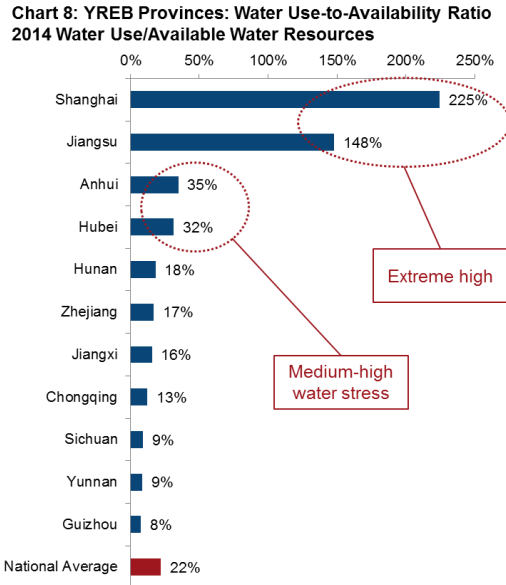
To tackle soil pollution, addressing non-point source pollution in agriculture production is key. Already plans are set to ensure zero increase in fertiliser and pesticides utilization by 2020. However, we should also pay close attention to the risks of soil contamination arising from industrial pollution.

Understanding the industrial mix is a first step. To achieve this “optimum water-nomics”, it is important to find solutions tailored for each of the three regions along the river. Furthermore, these three regions need to be considered holistically as the impact of a decision upstream will affect the regions downstream.

3.2.4 Pollution exacerbates scarcity in the already highly water stressed YRD

Regardless of pollution, the YRD already faces high water stress. According to the UN definition, a water use-to-availability (WTA) ratio of >20% indicates medium-high

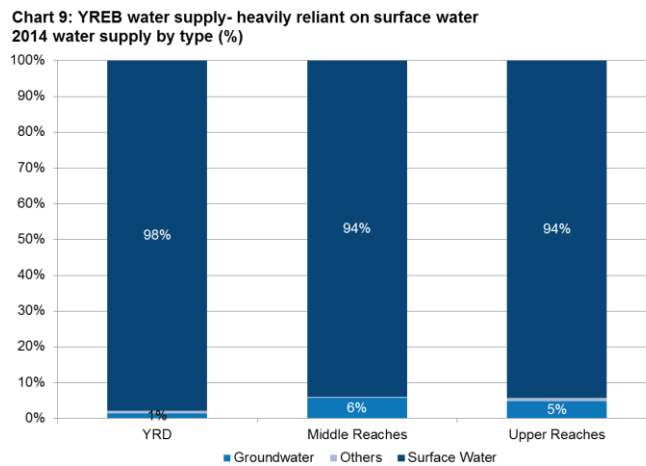
water stress and above 40% denotes high water stress. China's national ratio in 2014 was 22% but WTA ratios vary widely across YREB provinces. As shown in **Chart 8** below, Shanghai and Jiangsu (in the YRD) are the most water stressed with WTA ratios of 225% and 148% respectively.



Source: China Water Risk based on National Statistical Bureau of China

This means that Shanghai and Jiangsu face extreme high water stress. Therefore, despite having the lowest wastewater discharge per unit of GDP, more efforts must be made to manage wastewater in these two provinces so as not to exacerbate scarcity. As for the rest of YREB, only Anhui and Hubei (two provinces in the Middle Reaches) face medium-high water stress.

Almost all of the YREB's water resources are surface water. For the YRD, surface water accounts for 92% of YRD's total water resources. Since the Yangtze forms a large part of this, it is therefore important to rein in pollution carried by the river. As shown in **Chart 9** below, water supplies across the three regions are highly reliant on surface water. YRD is the most reliant with surface water providing 98% of its water supply.



Source: China Water Risk based on National Statistical Bureau of China

Pollution carried by the river (especially heavy metal pollution) will inevitably impact the YRD's water supply. Therefore, it is imperative to tackle water pollution from mountaintop to the sea: water security must be ensured to sustain the YRD, which is the home to 159 million people and a fifth of the nation's GDP.

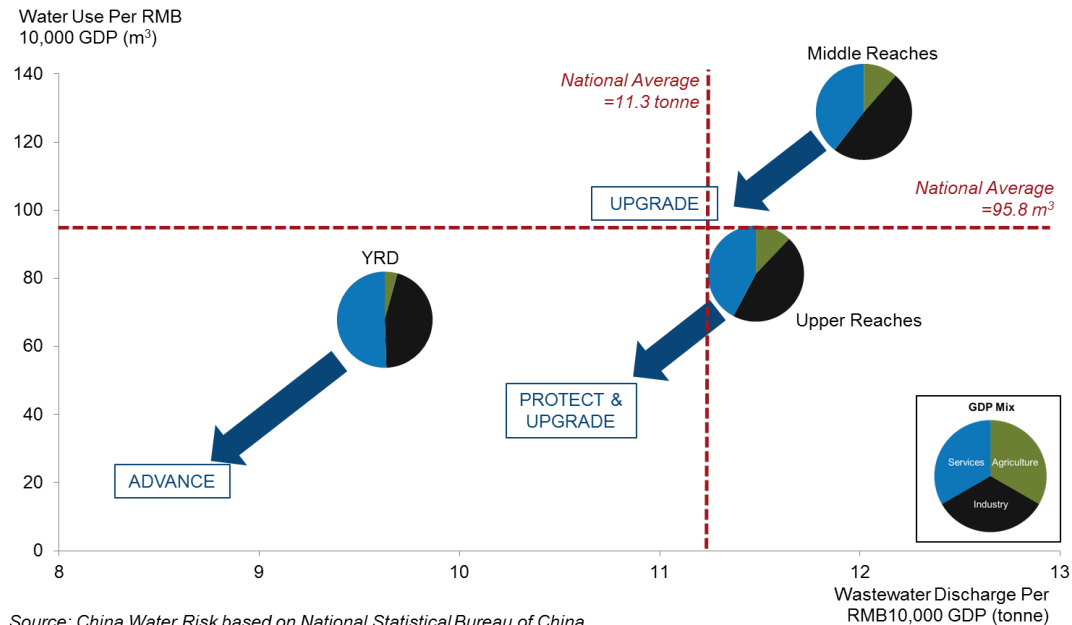
4 POLICY RECOMMENDATIONS FOR ACHIEVING HARMONIOUS DEVELOPMENT

As discussed above, water and economic development are interlinked. To achieve harmonious development on the Yangtze, policy making should focus on managing trade-offs in balancing water allocation and pollution with economic mix. Further improvement requires optimizing industrial and crop mix at the provincial level. In addition, shifting imports & exports and domestic output can also help balance water and development within the YREB.

4.1 Balancing the economy with water use and pollution within the YREB

Clearly an economic mix which gives a high GDP per unit of water use as well as high GDP per unit of wastewater discharged is preferred. China Water Risk's analysis compares water use and wastewater discharge per 10,000 yuan across the three regions in the YREB while taking into account GDP contribution from agriculture, industry and services sectors. The results are shown in **Chart 10** below:

Chart 10: 2014 YREB Regions - Per RMB10,000 GDP Water Use and Wastewater Discharge



Source: China Water Risk based on National Statistical Bureau of China

It is clear from **Chart 10** above that to generate the same amount of GDP:

- The Middle Reaches are the most water intensive as well as the most polluting among the three regions. This is likely due to 1) the high industry share of GDP and 2) higher grain crop production – the Middle Reaches

produces 50% more grain crops tonnage than the Upper Reaches and 1.5x more than the YRD;

- The Upper Reaches are slightly more water efficient compared to the national average, however it is underperforming in terms of wastewater discharge; and
- The YRD outperforms the national average on both water use and wastewater discharge. This is likely due to 1) the small share of agriculture in the GDP mix and 2) a high share of services – significantly higher than the other two regions.

Strategies to balance the economy with water use and wastewater discharge can therefore be grouped into three broad approaches:

- 1) **Upgrade** industrial technologies in the Middle Reaches & Upper Reaches to achieve industrial efficiencies of the YRD;
- 2) **Protect** the water supply from the Upper Reaches from pollution by 1) rethinking industrial led growth of the YRD and Middle Reaches and 2) leapfrogging to less polluting services led growth; and
- 3) **Advance** the performance of the YRD in water use and wastewater discharge so as to alleviate its high water stress.

Optimizing industrial and crop mix can help further improve the “water-nomic” performance across these three regions, especially in the YRD.

4.2 Optimizing industrial & crop mix for better water-nomic performance

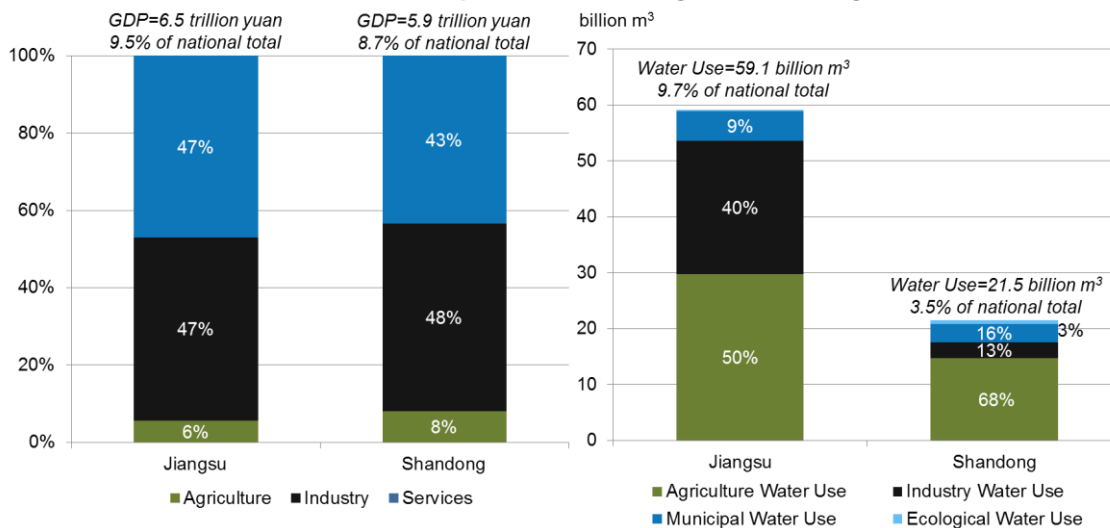
So how can the YRD advance its industrial & crop mix? A closer look into wastewater discharge and water use per unit of GDP across YREB provinces reveals greater disparities. Jiangsu, in the YRD, has the largest GDP in the YREB; yet it is the most productive in terms of wastewater discharge amongst YREB provinces. That said, Jiangsu lags in water use per unit of GDP generated.

Nationally, Jiangsu is among the Top 3 GDP generating provinces in China; it ranks No.2 after Guangdong, ahead of Shandong. Actually, Jiangsu and Shandong are provinces with generally similar GDP size and mix: representing 9.5% and 8.7% of China’s total GDP respectively. Although they are amongst China’s Top 5 farming provinces by agricultural output value, both provinces have a very small share of agriculture in GDP due to significant industrial and services sectors as can be seen in left graph in **Chart 11** below.

However, when we look at the water use mix, Shandong used only 21.5 billion m³ of water to generate 5.9 trillion yuan, compared to Jiangsu which used 59.1 billion m³ to generate 6.5 trillion yuan as shown in the right graph of **Chart 11**. In short Jiangsu uses almost 3x more water than Shandong to generate 9.2% more GDP.

Shandong is also far more efficient in water use across sectors compared to Jiangsu. In agriculture, Shandong uses half of Jiangsu’s agricultural water use amount. More surprisingly, Shandong’s industrial water use is only 12% of that of Jiangsu, despite a similar size of industrial value-added.

Chart 11: 2014 GDP mix & water use mix comparison between Jiangsu and Shandong



Source: China Water Risk based on National Statistical Bureau of China

These differences in water use between Jiangsu and Shandong may be due to factors such as crop mix, industry mix, local water regulations, technological level of production and so on. Shandong's more efficient water use could possibly be attributed to the fact that it has only a third of the water resources of Jiangsu.

Therefore, there is still room for Jiangsu to improve, even if it is one of the better-performing provinces in the YRD. That said, in reality, both provinces can do more as they are running a "water deficit", with WTA ratios of 148% for Jiangsu and 145% for Shandong in 2014.

To further advance and optimize Jiangsu and other YRD provinces' water use and wastewater productivity, there is a need for more comparative research that looks into their industrial & crop mix to find better mixes that are good for both water and economy. In addition, further uplift can be achieved by using domestic and international trade to help better manage water.

4.3 Shifting outputs, imports/exports & recycling to manage water: trade-offs in fashion raw materials

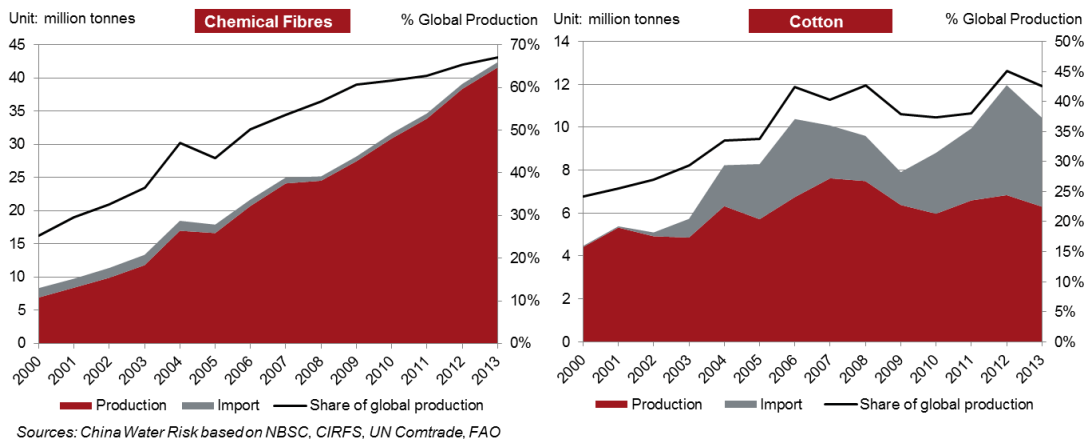
Further gains in managing water and economy can be achieved by shifting domestic output, managing imports and exports for water and promoting recycling within China. To illustrate this, we focus on a key product of the YREB: fashion raw materials.

Cotton and chemical fibre are important fashion raw materials accounting for over 90% of all global fashion fabrics. China produces two thirds of global chemical fibres and 43% of global cotton is either grown in or imported by China. The fact that YREB produces 81% of the nation's chemical fibres underscores the region's importance as a manufacturing hub for the global fashion industry. Indeed, the YRD alone accounted for over half of global production of chemical fibres.

Chart 12 below shows China's rising global dominance in chemical fibres and cotton:

- Cotton import has increased significantly since 2000 while cotton production in China has flattened. Combining domestic production and import, the global cotton exposure to China was 43% in 2013; meanwhile
- Chemical fibres output has been soaring over the past decade: the 2000-2013 CAGR of chemical fibres is 15%, 2.2x that of cotton production and import combined. Also, note that China's chemical fibre output was 66% of the global total.

Chart 12: 2000-2013 Global Industry Exposure to China



By importing more water-intensive and highly polluting cotton, China can alleviate pressures on water resources as well as release farmland to grow edible crops. It is estimated that not growing cotton in the North China Plain would “free up” 1.5 million hectares of sown land as well as around 9.5bn m³ of water. This is equivalent to the entire capacity of the South-to-North Water Diversion Project’s Middle Route (Phase 1). Indeed, current agricultural subsidies favour a shift in cotton production from the North China Plain to the far west.

Meanwhile, shifting from cotton to more chemical fibres, helps reduce water demand. However, given China’s dominance in both these materials, although some production process such as cutting and sewing have moved overseas; polluting processes like weaving and dyeing still remain in China.

Should China continue to grow production of these textile raw materials? Or should it seek growth from recycling textile waste? According to the China National Textile and Apparel Council, recycling the 26 million tonnes of annual textile waste, can save up to a third of farmland needed to grow cotton. These farmers can switch to growing edible crops and the “circular economy” will create new green investments, revenue streams and jobs.

This circular economy appears to be winning proposition across multiple fronts: rein in agricultural water and soil pollution, reduce water use, free up farmland for food security and alleviate landfill pressures. Unfortunately, the recycling rate in textile waste is currently less than 1%. Barriers exist in current policies and business models to incentivize recycling. There is clearly much room for advancement on the circular economy front; not just for textiles but also in other resource-intensive

industries. These barriers can be addressed through more dialogue between government and businesses: for example, closed-door workshops with various stakeholders to discuss practical technical and management solutions to promote waste recycling.

5 CONCLUSIONS

As can be seen above, there are many trade-offs. These trade-offs need to be examined, understood and considered in the decision making of business as well as policy makers.

Given the economic and pollution disparities along the Yangtze River, holistic solutions are needed to avoid pollution risks spreading from mountaintop to the sea and even threatening food safety and security. To balance YREB's economy with water use and wastewater discharge, the broad three-pronged "Upgrade, Protect and Advance" Strategy can be adopted along the Yangtze River.

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