

YANGTZE WATER RISKS, HOTSPOTS & GROWTH

Avoiding regulatory
shocks from the march
to a Beautiful China

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This report is published by China Water Risk (CWR) to show how an understanding of China's water-nomics framework can help business and investment communities identify risks, hotspots and growth areas along the Yangtze River. This is especially important as China increases its efforts to evolve holistic 'mountain-to-ocean' development along its key river basin to ensure water security. The Yangtze River Economic Belt is one such pilot region designated by President Xi Jinping for green development actions. As China's industrial heartland and an integral part of global supply chains, policies and regulations introduced to green the region will have implications for multiple industries around the world.

We therefore hope this report not only helps the better navigation of such regulatory shocks from the nation's march toward a Beautiful China but that the policy innovations along the Yangtze also inspire policy makers across Asia to pave the way toward more holistic regulatory action today for a water secure continent.

About China Water Risk (CWR)

CWR is a non-profit think tank that aims to create a world where water & climate risks are embedded in business & finance. Since its launch in 2011, it has worked from its Hong Kong base to engage with global business & investment communities in understanding and managing water risks in China & across Asia so that better decisions can be made today for a water secure tomorrow.

Today, CWR leads the water risk conversation with proprietary research including co-publishing policy briefs with government-related bodies in China and globally. Our website www.chinawaterrisk.org remains the "go-to" resource on water risks. CWR has also been commissioned by financial institutions & corporates to conduct research analysing the impact of water risks across various sectors. Such reports have been considered groundbreaking and instrumental in understanding China and Asia's water challenges.

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Acknowledgements

We would like to thank the many experts who have contributed to CWR, some of whose views have been included in this report, in particular the Foreign Economic Cooperation Office of the Ministry of Environmental Protection of the People's Republic of China (MEPFECO), which in 2017 requested CWR to conduct follow-up research and analysis examining the water-nomic performance of YREB provinces. Such work contributed to and inspired the writing of this report. We are making our analysis public as there is little awareness globally of China's urgent regulatory policies and innovations along this river.

CWR is grateful to our sponsor the ADM Capital Foundation as well as our core funders, the Rockefeller Brothers Fund and the RS Group. CWR's work in water-nomics would not exist without their funding support.



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 socio-economic powerhouse. Covering nine provinces and connecting two municipalities (Chongqing and Shanghai), the river provides water to close to 600 million people living in the Yangtze River Economic Belt (YREB).

On 5th January 2016, President Xi Jinping in a national YREB-focused meeting set the river on the path of holistic ecological protection and green development. 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”. Since then, multiple policy innovations plus tighter regulations have been introduced along the river.

But the Yangtze is not just important for China, the river lies at the heart of global supply chains. It is important to understand the new water-nomic landscape along this river to better navigate risks and hotspots. They are significant and can be disruptive. But with big risks, come big opportunities.

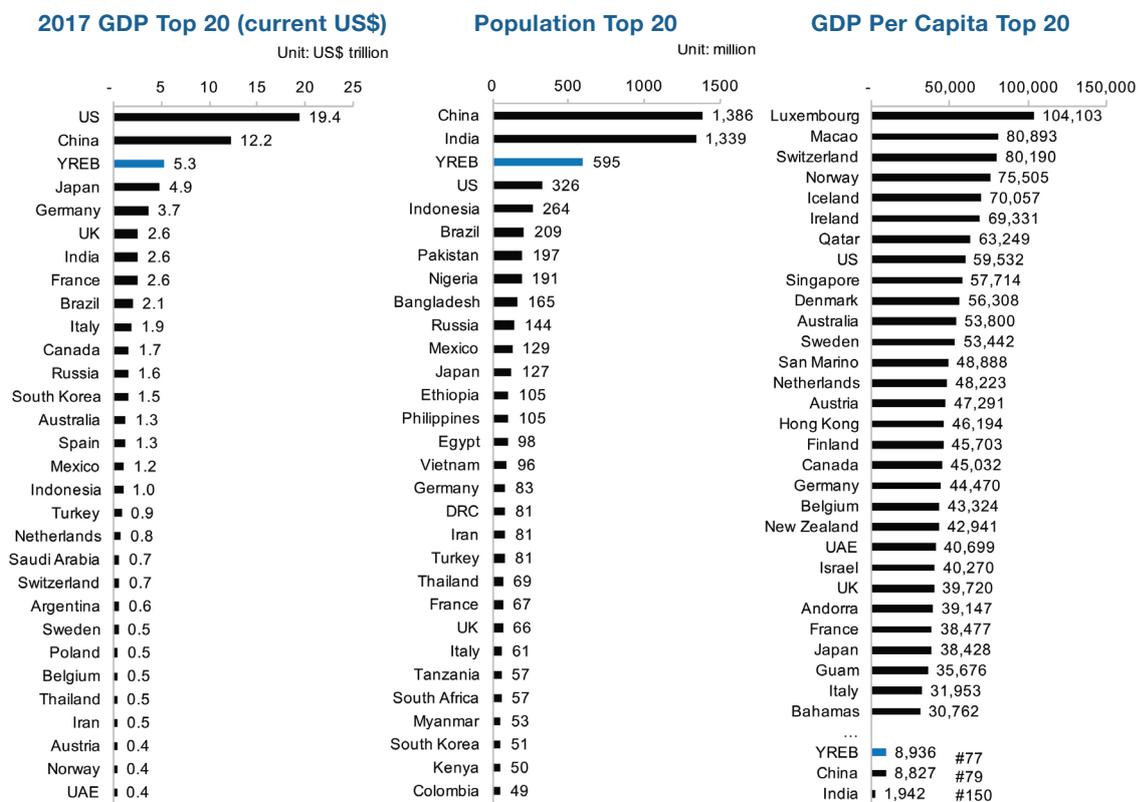
THE WORLD ON A RIVER

The YREB is the 3rd largest economy in the world

The Yangtze River Economic Belt (YREB) comprises 11 provinces and municipalities along the Yangtze river. They are Yunnan, Guizhou, Sichuan, Chongqing, Hunan, Hubei, Jiangxi, Anhui, Zhejiang, Jiangsu and Shanghai.

The YREB is home to 595 million people and the GDP generated in the region was RMB37.4 trillion¹ in 2017 or USD5.3 trillion². This means that if the YREB was treated as a country, it would have ranked 3rd in terms of population and the region would be the 3rd largest economy in the world. However, as can be seen from the charts below, the YREB's ranking falls to No.77 in terms of GDP per capita; albeit higher than China's national average (No.79) and India (No.150). So while it has come far, it still has a long way to develop – its sheer growth potential is tremendous.

YREB vs the Rest of the World



Source: China Water Risk based on World Bank, NBSC

Note: for YREB GDP, the 2017 yearly average exchange rate between USD and CNY (7.030) from Internal Revenue Service of the US is used.

Get on top of this now - what happens to this river matters globally!

With much at stake, China has been acting to ensure the water security of the YREB to safeguard its future. The YREB is thus a core national strategy to seek new development pathways for long-term prosperity. However, since the YREB is an important manufacturing hub to many industries including global electronics and textiles, what happens to this river has global implications across multiple sectors.

The following three chapters are intended to help stakeholders form an understanding of the policies along this river as well as the water-nomics framework to seek growth on less water and pollution. Chapter 1 focuses to the current status of water risks (physical and regulatory) as well as the climate risks ahead in the YREB. An understanding of these challenges plus the historical water-nomic performance of each of the 11 provinces that comprise the YREB hold the key to the identification of economic risks and hotspots. Chapter 2 walks you through how to identify water-nomic risk exposure and provides a case study on how a province can improve performance by changing its industry mix. The risk exposure of city clusters and industrial parks are also covered here. Great risk brings great opportunity; the last chapter focuses on opportunities ahead arising from combating pollution in the YREB, including industries that will likely be on the 'less favoured' or 'more favoured' lists.

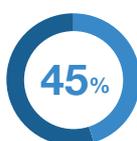
Since these water-nomic risks are often 'hidden' from the public, we hope that this report helps stakeholders navigate current and future regulatory shocks from the march toward a Beautiful China.

The YREB houses >40% of China's population & GDP

The YREB is clearly China's economic powerhouse and industrial heartland. The region is also important for national food security growing almost two-thirds of China's rice and plays a key role in greening China's energy supply with over three-quarters of the nation's hydropower generation. Balancing trade-offs between water, food and energy security will not be an easy task for any government; moreover, the sheer size of the region makes it a monumental challenge. Nevertheless, failure is clearly not an option. It pays to remember what's at stake when weighing the 'seriousness' of the government in enforcing policies along the Yangtze.

YREB at-a-glance 2017¹

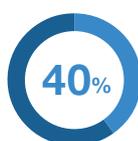
¥ Money



of its GDP



of China's export value



of national import value

🍚 Food & Energy

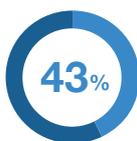


of national rice production



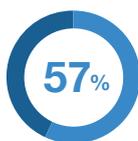
of national hydro electricity generation

👤 People

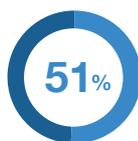


of its population

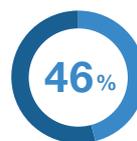
🏭 Industrial Heartland



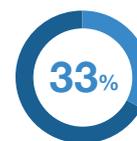
of national cloth production



of national cement production



of national car production



of national crude steel production

🧪 Chemicals & Pulp & Paper



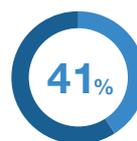
of national chemical fiber production



of national chemical pesticides production



of national chemical fertiliser production



of national machine-made paper & paperboards

Global production: YREB vs Rest of the world



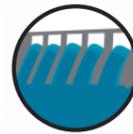
TOO BIG TO FAIL = PROTECT AT ALL COSTS

 **President Xi Jinping**
Wuhan, April 2018

"The Yangtze River is China's mother river, and we must protect it, while enterprises are the major force in protecting and building the ecological environment of the river ..."

"... We must not allow the ecological environment of the Yangtze River to continue deteriorating in the hands of our generation, and we must leave our descendants a clean and beautiful Yangtze River."

 **175**
Cities of 250k+ People

 **24,100**
Small hydros (<50MW)

 **242**
Coal-fired power plants

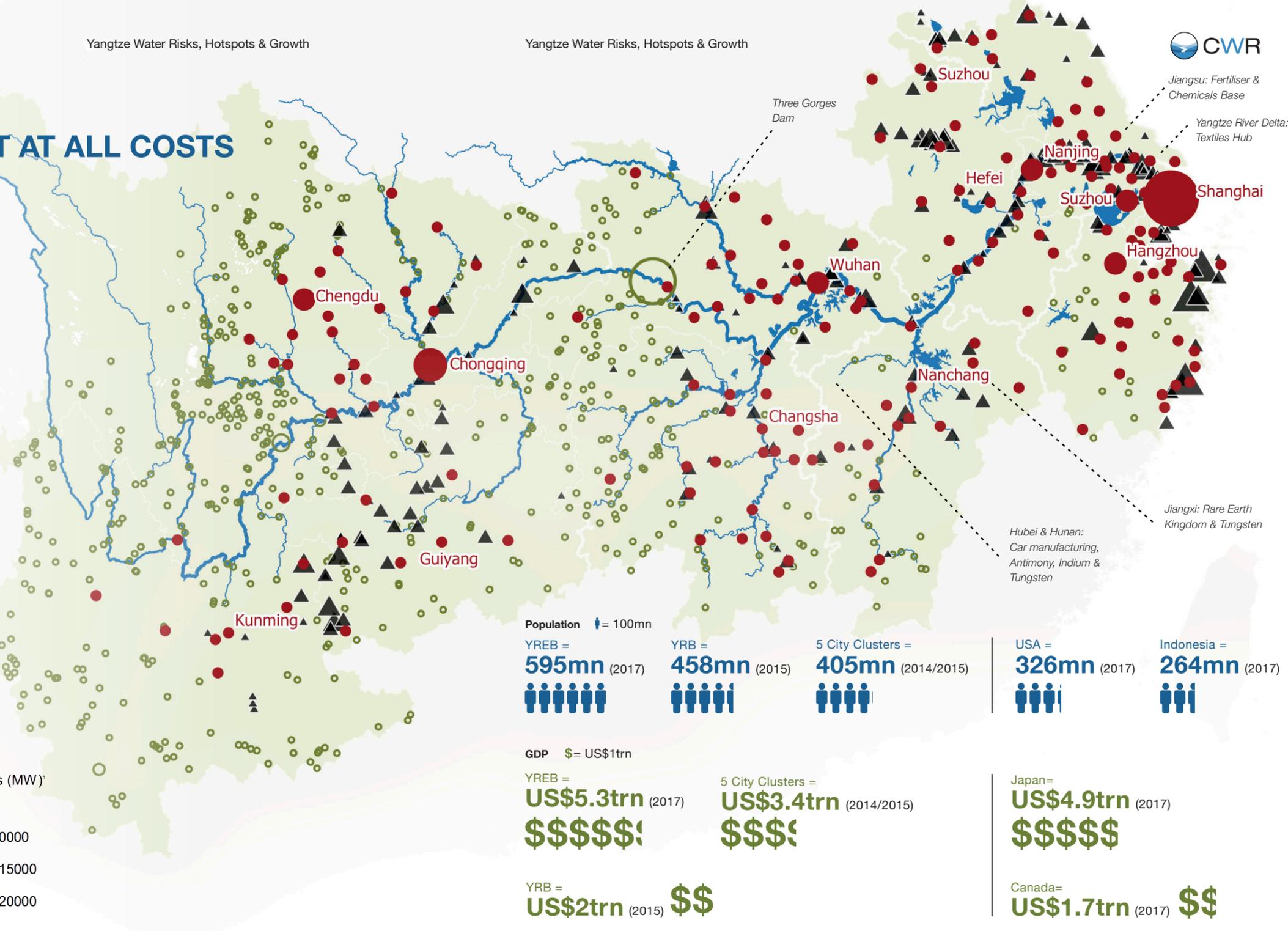
600
Hydropower plants (>2MW)

 **138mn**
Tonnes of Rice grown

- Legend**
-  Glaciers
 -  Lakes
 -  Major Rivers
 -  YREB Provinces

Cities (Population)	Coal-fired Plants (MW)*	Hydropower Plants (MW)*
 250k-5mn	 0 - 1000	 2 - 5000
 5-10mn	 1000 - 2000	 5000 - 10000
 10-15mn	 2000 - 3000	 10000 - 15000
 15-20mn	 3000 - 4000	 15000 - 20000
 >20mn	 4000 - 5000	 20000 - 25000

* As of June 2018



Population  = 100mn

YREB = **595mn** (2017)


YRB = **458mn** (2015)


5 City Clusters = **405mn** (2014/2015)


USA = **326mn** (2017)


Indonesia = **264mn** (2017)


GDP \$ = US\$1trn

YREB = **US\$5.3trn** (2017)


5 City Clusters = **US\$3.4trn** (2014/2015)


Japan = **US\$4.9trn** (2017)


YRB = **US\$2trn** (2015) 

Canada = **US\$1.7trn** (2017) 

Source: China Water Risk, CWR report "No Water No Growth - Does Asia have enough water to develop?" (2018), NBSC (latest year available), World Bank, WRI, various government regulations, policies and plans

PILOT POLICIES & INITIATIVES TO GREEN THE YREB

In the last decade, China has strengthened its water management through the 'Three Red Lines' policy, amendments of its Environmental Protection Law, as well as 'War on Pollution' along with detailed action plans and more stringent regulations on water. Various policy initiatives are being piloted along the YREB, from setting Eco-Redlines, assigning River Chiefs, promoting water use permit and pollution discharge permit trading, to building 'sponge cities'.

These policy instruments could play important roles in incentivising corporate action in water savings, pollution control and stewardship, plus mobilising more funds directed toward the ecological and environmental protection of upper watersheds. Already, three out of the five provinces piloting green finance are in the YREB. They are Zhejiang, Jiangxi and Guizhou; the other two green finance pilot provinces are Guangdong and Xinjiang.

Eco-Redlines – drawn to strictly protect ecological areas

Ecological protection redlines (also called 'Eco-Redline') are defined in MEP & NDRC's 2017 guidelines as "areas with key special ecological functions and that shall be mandatorily strictly protected". They are physical hard-lines that limit industrial development in designated areas. In the 2014 amended Environmental Protection Law, the idea of 'Eco-Redline' was added into the law for the first time. Clause 29 of the new law, which entered into force on 1 January 2015, says, "the state will determine eco-redline zones in areas such as key ecological protection zones, ecologically and environmentally sensitive zones and fragile zones, and carry out strict protection".

YREB's Eco-Redline areas are 6.5% larger than the land area of Thailand

In early 2018, all the YREB provinces and municipalities determined their Eco-Redline areas; these amounted to a total of 0.54 million km². For perspective, this is 6.5% larger than the land area of Thailand. Almost all (95.3%) of these areas are inland; the rest are along the coast and in the sea. These provincial plans have all been approved by the State Council. National parks are also being set up to protect upper watersheds. One such in the source region of the Yangtze, Yellow and Lancang (Upper Mekong) River is nearly the size of Bangladesh's land area – more on this in Chapter 1 – "A hotter future with more rain = Need more resilience"

Sponge cities

More and more cities in China are experiencing floods every year. The government seems to have found an answer to this in sponge cities. In April 2015, 16 cities were selected as pilot cities. These cities can in the next three years gain access to funding to help with their sponge city development: municipalities directly under the Central Government can access RMB600 million/year, provincial capital cities RMB500 million/year, the rest RMB400 million/year.

30 national sponge city pilots to tackle floods ...

A year later, a further 14 cities were selected to be pilot cities, including Beijing, Tianjin, Shanghai and Shenzhen⁴. Of the 30 national sponge city pilots, 12 of these are in the YREB – more on this in Chapter 2 – "Water risk exposure of 5 city clusters house to 405 million people".

...12 are in the YREB

River chiefs – additional safeguards against pollution

River chiefs are government officials who are assigned to take charge of rivers and lakes in their jurisdiction. The concept was first developed in cities in the YRD, where deteriorating surface water quality from pollution and/or algae bloom triggered both the first appointment of a 'river chief' in Changxing County in 2003; and later in 2007, the first establishment of a 'river chief system' in Wuxi City. Other provinces/cities started to adopt the method and by 11 December 2016, the 'Opinions on Fully Promoting the River Chief Mechanism' was released by the General Office of the State Council and the CPC Central Committee, stipulating that the river chief mechanism must be fully established by 2018⁵.

There are 1.23mn river chiefs across China ...

The idea behind such system is to hold the high-ranking government official accountable and ensure strict implementation of environmental regulation. There are four key levels of river chiefs, which are: provincial, city, county and township in descending order of power. In addition, river chiefs are also assigned at the village level⁵.

...over three-quarters of these are at village level

As of January 2019, there were over 1.23 million river chiefs across China, 75.6% of which are at village level. Such village level monitoring could help clean up tributaries – More on this Chapter 1 - "Yangtze overall water quality improving but tributaries are not meeting targets".

Water use & wastewater discharge permits – managing sectoral allocation

Water Use Permits & Wastewater Discharge Permits are used to allocate water & manage pollution by sector ...

To help stay within the water quota and pollution targets of the Three Red Lines, China has been using the concept of “cap-and-trade” in regulating both resources use and emissions. For water, this has been developed into two systems, one is Water Use Permit and the other is Wastewater Discharge Permit. The total caps of such permits are determined at both national and provincial levels, and also allocated to key industries.

...trading of these permits are being piloted

On top of such permit systems, China has also been piloting trading markets allowing companies to sell excessive quote of their permits, if they manage to operate in more water- efficient and/or cleaner ways; or buy additional quote if they wish to expand operation. As a result, the permit trading acts as both ‘carrot’ and ‘stick’, and incentivise water saving and pollution control.

Amongst the YREB provinces, Zhejiang set up its Emission Trading Center in February 2009. During its first 5-year operation, the total pollution discharge permit fees collected, and the market value of traded permits reached RMB2.5 billion, which accounted for two thirds of the national total during the same period. More on water quotas and pollution targets in **Chapter 1 – “Provincial water caps & targets – Jiangsu & Anhui not on track” and “War on pollution! 6 provinces still fail to meet targets”**.

Eco-compensation – managing upstream-downstream pollution challenges

Central govt to establish incentive mechanisms...

According to ‘Opinions on Establishing Eco-compensation Mechanism’ issued by State Council in 2016, central government supports local eco-compensation schemes between upstream and downstream provinces. The Yangtze River is one of the key river basins to promote such scheme between upstream and downstream regions.

... including industry relocation and JV in industrial parks

On 13 February 2018, as per ‘Guiding Opinions on Establishing Eco-compensation & long-term Protection Mechanism in the YREB’ issued by MoF indicates that the central government will establish incentive mechanisms and increase fiscal support towards eco-compensation and protection in the YREB. In addition to direct payment transfer, other forms of compensation such as technical cooperation, industry relocation, training, and joint investment in industrial parks, etc., will also be piloted in the following years⁶. More on upstream-downstream pollution challenges in **Chapter 1 – “Pollution risks along the YREB”**.

There are already several ongoing eco-compensation schemes:

Highly polluted Ganzhou, producer of almost all heavy rare earths in the world, is upstream of a key river serving Hong Kong & Guangdong

- Chishui River is a tributary of the Upper Yangtze and flows through Yunnan, Guizhou and Sichuan. The three provinces set up in total RMB200mn eco-compensation fund for the period of 2018-2020. The assessment includes 3 indicators (i.e. permanganate index, NH₄, total phosphorus) as per the surface water quality standard (GB3838-2002).
- Ganzhou city of Jiangxi Province is a major rare earth production base in China. It sits in the upstream of two rivers: one is Ganjiang River, a key tributary of the Yangtze; and the other is Dongjiang River, the eastern tributary of the Pearl River. Lax environment regulation and illegal mining, fuelled by black markets, led to serious pollution and a hefty clean-up bill. As Dongjiang serves as the main water source for major cities like Guangzhou, Shenzhen and Hong Kong: Guangdong and Jiangxi agreed in October 2016 to contribute RMB100mn each annually to ensure minimum Grade III water quality at the border.
- Zhejiang, along with Anhui, started China’s first trans-provincial basin eco-compensation pilot in 2011. In 2018, it was the first to issue provincial guidelines on eco-compensation schemes between upstream and downstream regions. As per the guidelines, the upstream region that ensures good ecological protection could receive compensation of RMB5-10mn annually from downstream regions.

Still missing ...

... an organization that oversees both water resources + water quality management for the entire YREB

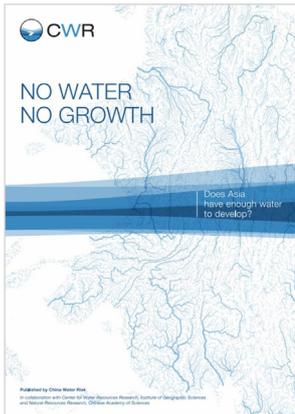
A YREB-wide umbrella body?

Despite the progresses in using innovative policies as well as cross regional cooperation, a joint umbrella organisation that oversees both water resources and water quality management for the entire YREB is still missing. A basin-wide working mechanism will be able to coordinate policies and measures to ensure water security and manage climate risks. Moreover, it will also help embed water considerations into economic policy making and more effectively promote better water use efficiency and wastewater management across sectors. More on this in **Chapter 1 – “Mismatched! Basin water management vs. provincial / central management”**.

CONTEXT

We are heading to a 3°C world: 1 in 2.5 Asians plus at least US\$4.3trn of GDP at risk:

Climate change is evident, but our current efforts in mitigation and adaptation are far from enough. Globally, based on our current national commitments by 2030, we are unlikely to limit warming to 1.5-2°C and are very likely heading to a 3°C world by 2100⁷. This has serious and severe implications for our water resources. Climate change will not only lead to rising sea levels and more severe and frequent storm surges, floods and droughts, it also impacts river flow due to accelerated glacier and snow melt plus changing monsoon patterns. These risks are more imminent than we realise.

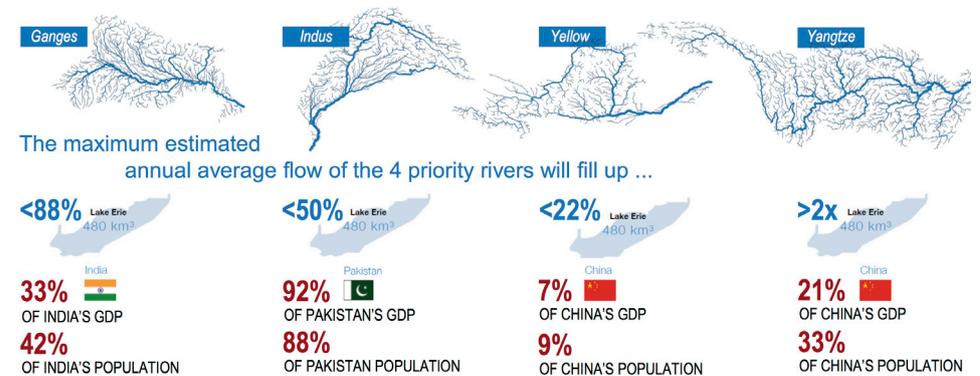


In Asia, our 2018 report **“No Water No Growth – Does Asia have enough water to growth?”** (NWNG Report) warned that 1.77bn people reside in just 10 major river basins which generate GDP of over US\$4.3trn. Already half the basin areas of five of these major rivers face high to extremely high water stress⁸. An report published this year by the International Centre for Integrated Mountain Development (ICIMOD) estimates the number of people living in the 10 basins to be higher at 1.9bn or one in every two Asians⁹.

Asia faces a triple threat and 4 priority rivers are identified for urgent action:

Asia faces a triple threat: 1) not enough water; 2) climate change exacerbating water scarcity; and 3) clustered assets along vulnerable rivers⁸. 280+ sizeable cities, including capitals and economic powerhouses, lie in the 10 river basins and urbanisation means increasingly clustered risks as more people flock to these cities increasing pressure on already stressed river basins. At the same time, the source region, the Himalayan Hindu Kush (HKH) or the Third Pole is melting like the North and South Pole. The 10 rivers flowing through 16 countries feel these impacts differently; our NWNG Report identifies 4 priority rivers for urgent action: the Yangtze, Yellow, Ganges and Indus. No doubt, there are grand challenges ahead and the NWNG Report recommended eight broad inter-linked strategies for managing Asia’s water and climate risks.

Very little water supports a lot of people & GDP for the 4 “Priority Rivers”



Source: CWR based on “No Water, No Growth - Does Asia have enough water to develop?” 2018; Infographic © China Water Risk 2018, all rights reserved. Note: The report identifies four “Priority Rivers” that require urgent attention

8 broad strategies for managing Asia’s water

- Protect Asia's rivers**
to ensure water resources for one in two and a half Asians
- Water-nomics Roadmap**
Rethink our economic & development models
- Revamp Agriculture**
Control agri water use & pollution while ensuring food security
- Water-Energy-Climate**
Choose the right type of power for both water & climate
- Resolve Transboundary**
issues through better water-nomic cooperation
- Basin Focus**
Reorganise & focus on basin-level data, risk assessments & solutions
- Multi-disciplinary action**
and collaboration beyond science to close data & research gaps
- Close funding gaps**
in adaptation & research plus drive financial reform

Source: CWR, “No Water No Growth – Does Asia have enough water to develop?”, 2018

China is acting to protect water & growth; unwavering pursuit of a Beautiful China: Water is a vital resource for economic growth: the economy runs on water. Where there is limited water, the only option is to change the economy. Such is the case of China which has since the 11th Five Year Plan in 2011, pursued the “most stringent management” of its water resources. These included water use caps and targets that pointed to a slowdown of its economy.

When we projected back then that China would grow no more than 7.6% by 2020 and 5.7% by 2030, unless it beat its own water targets¹⁰; we were told by the investment and business communities that China would never sacrifice growth for the environment. Fast forward to today: China has put the environment on par with its economy in the pursuit of a Beautiful China. Achieving an ecological civilisation means that it will continue to transform its economy through policies such as Industry 4.0, circular economies and the Belt and Road Initiative (BRI). Such policies and adaptation measures become increasingly important; especially if we fail to stay within 2°C. In China, as the heart of its industrial revolution, the Yangtze plays a key role.

Yangtze is #1 Priority; President Xi says so: With a third of its population living in the Yangtze River Basin generating around a fifth of the country’s GDP⁸, it is easy to see why the river basin is important to China. Indeed, President Xi Jinping has been acting. As early as 2015, he halted construction of all large projects along the river and since then hundreds of chemical factories located within 1km from the river have been or will be either moved or shut down. For example, in Jiangsu province alone, 195 factories and 37 chemical industrial parks were affected and in Hubei province, another 105 factories were impacted¹¹. Ecological protection zones and city clusters and have been set up and tighter regulations have ensued, culminating in the ‘Yangtze River Protection Law’ expected to be passed by the end of 2019.

Yangtze water-nomics; seeking a roadmap to more GDP on less water & pollution: The Yangtze River Basin is the heart of the Yangtze River Economic Belt (YREB). The YREB comprises of 11 provinces and municipalities along the river, representing nearly 43% of China’s population and over 45% of the national GDP as of 2017. The YREB is one of China’s national strategies to seek new development pathways for long-term prosperity, along with BRI and coordinated development in Beijing-Tianjin-Hebei (JJJ) and the Greater Bay Area (GBA).

As with all things in China, it is hard to grasp the scale of development along the Yangtze River. If the YREB was a country, it would have the third largest economy after the US and China. Regulations made to protect this river will disrupt multiple industries; not just China but the rest of the world will feel the pain. Understanding the importance of the Yangtze and navigating the new regulatory landscape is thus essential to identify risks, hotspots, and opportunities for growth not just in China but beyond.



Why we are writing this report: In 2016, CWR worked with the Foreign Economic Cooperation Office of the Ministry of Environmental Protection (MEPFECO) on a joint policy brief to explore challenges of the three YREB regions in balancing economic development and water resources management as well as water pollution control¹². Given the economic and pollution disparities along the river, we called for holistic solutions to avoid pollution risks spreading from “mountain-to-ocean”. A broad strategy of “protect, upgrade and advance” was also proposed for the three regions: The Upper Reaches, Middle Reaches and the Yangtze River Delta (YRD).

In 2017, we were further requested by the MEPFECO to conduct follow-up research and analysis examining the water-nomic performance of YREB provinces. Such work contributed to and inspired the writing of this report. We are making our analysis public as there is little awareness globally of China’s urgent regulatory policies and innovations along this river. Many have never even heard of the YREB, yet there are clear implications of these policies and the consequent industrial restructuring for global investment and business communities.

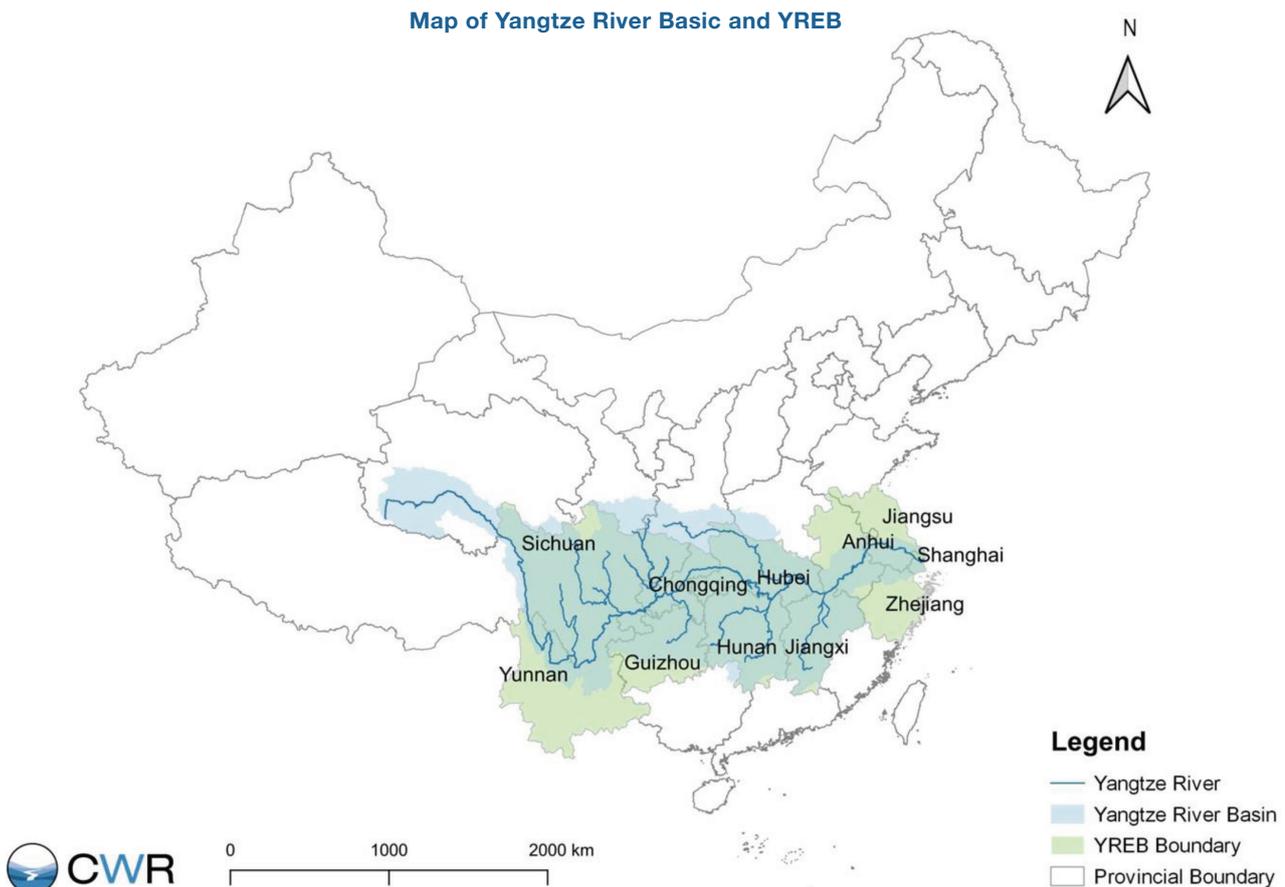
We write this report to close such knowledge gaps and we hope that it will not only be used as guide to navigate the risks, hotspots and opportunities but also to catalyse actions to fast track business unusual. Such actions will not just benefit China but help the world by transitioning its largest emitter to a low carbon future.

We also believe that lessons learned along the Yangtze can be applied to other basins such as the Ganges and Indus. To this end, we hope that this report is useful to policy makers and governments in Asia (and the rest of the world), in rethinking development in the face of mounting water challenges exacerbated by climate change. Like it or not, China’s “reform-transform” movement is here to stay. We can either look such a movement in a negative light or leverage it to find new paths forward across Asia.

DEFINITIONS - MAKING SENSE OF YREB & YRB

Before we start, it is important to understand some key differences in definitions when referring to the Yangtze.

In terms of economic policy, the focus is on the YREB whereas water management is focused at the basin level – the Yangtze River Basin (YRB). As can be seen from the map below, the geographical boundary of the basin and belt are not entirely the same.



Source: China Water Risk based on provincial boundary from Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences, and river shapefile FAO AQUAmaps

The key differences are:

- some parts of YREB provinces are located outside the river basin; and
- the YREB does not include the source region in Qinghai, where ice reserves of the Yangtze River lie.

The YRB thus covers a smaller area than the YREB but comprises parts of 12 provinces. Its estimated share of the population and GDP of China is 33% and 21% respectively in 2015⁸.

The different boundaries for economic strategy (YREB) and river management (YRB), not only presented a challenge in the collection and analysis of data for writing this report, but also in management of water-nomics at both central and provincial levels. Please see “Mismatched! Basin water management vs provincial/ central management” in Chapter 1 for more details.

EXECUTIVE SUMMARY



EXECUTIVE SUMMARY

China is acting to protect its limited water resources and economic growth with its unwavering pursuit of a Beautiful China. As water is the only resource we cannot survive without, this “water-nomics” approach of managing water in tandem with economic development, will help ensure the country’s long term economic, water, food and energy security.

The nation has now deprioritised the pursuit of economic growth in favour of the environment, but this path is not new. As early as the 11th Five Year Plan in 2011, China implemented the “*most stringent management*” of its water resources which included water use caps and targets that already pointed to a slowdown of its economy. At the same time, it also introduced new green “Strategic Emerging Industries” such as Environmental Protection & Energy Savings, Renewables and Electric Vehicles. Back then, we projected that China would grow no more than 7.6% by 2020 and 5.7% by 2030, unless it beats its own water targets for 2020 and 2030.

It is obvious that China is undergoing structural reform, changing its industries and even reshuffling ministries to pursue sustainable growth. Less obvious are the rising regulatory risks from policies & targets set to achieve more economic growth per drop of water used and per unit of wastewater discharged. This water-nomics approach points to holistic management of growth within a watershed; and that economic planning should be based on the ecological boundary rather than the administrative provincial boundary. Beijing’s recognition of this is exemplified in the Yangtze River where multiple policies, regulations and plans have been put in place in recent years to deliver green development along the river from “the mountains to the oceans”. As President Xi Jinping clearly stated in April 2018: “*We must not allow the ecological environment of the Yangtze River to continue deteriorating in the hands of our generation, and we must leave our descendants a clean and beautiful Yangtze River.*”

It is not hard to see why China would want to protect its socio-economic powerhouse, but it is also important to note that the 11 provinces and municipalities along the river, the Yangtze River Economic Belt (YREB), from Sichuan to Shanghai are also key manufacturing hubs to global supply chains as well as significant producers of global critical raw materials essential for a smart and high tech future. Water-nomic policies along this river will thus have global implications across multiple sectors. Such water-nomic risks often remain ‘hidden’ and we write this report to help stakeholders navigate current and future regulatory shocks from the march toward a Beautiful China.

We have been writing about Yangtze water-nomics since 2016 where we published a joint policy brief with the Foreign Economic Cooperation Office of the Ministry of Environmental Protection (MEPFECO). In 2017, MEPFECO requested us to conduct follow-up research and analysis examining the water-nomic performance of each of the YREB provinces; it is this work which contributed to and inspired the writing of this report. With great risk, comes great opportunity, and we hope that this report will not only be used as guide to navigate the risks and hotspots but also to catalyse opportunities to fast track business unusual. Such actions will not just benefit China but help the world by transitioning its largest emitter to a low carbon future. Also, we believe that lessons learned along the Yangtze can be applied to other basins across Asia. To this end, we hope that this report is useful to policy makers and governments in rethinking development in the face of mounting water challenges exacerbated by climate change.

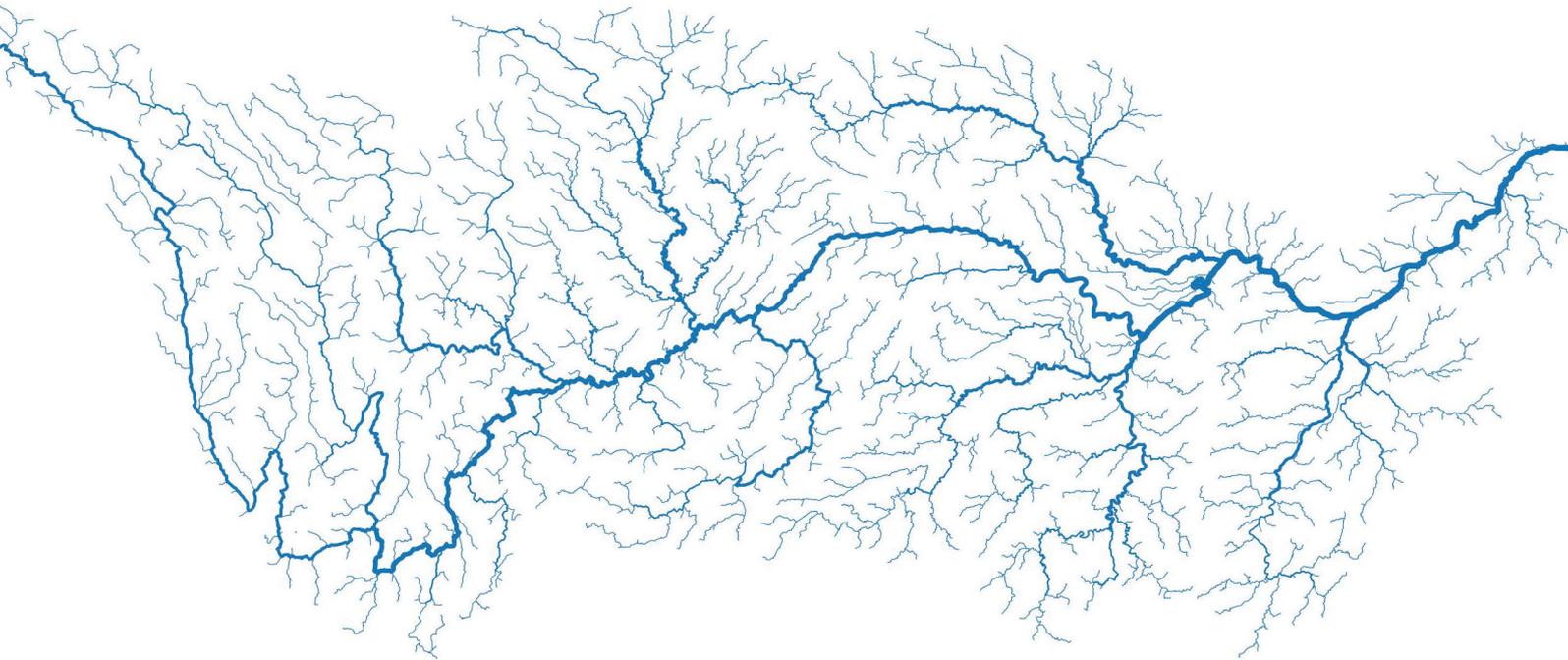
Here are some report highlights:

- **Too big to fail = protect at all costs:** The YREB generates more than 45% of China’s GDP and houses 43% of its population. The region is also important for national food and energy security, producing almost two-thirds of China’s rice and over three-quarters of the nation’s hydropower generation. As China’s industrial heartland, the YREB also has a lion’s share of production across such sectors: cloth (57%); cement (51%); auto (46%) and crude steel (33%). Balancing trade-offs between water & economic growth plus food & energy security is a monumental challenge for the government and failure is clearly not an option. So when weighing the ‘seriousness’ of enforcing policies along the Yangtze, it pays to remember what’s at stake for China.
- **Size Matters! the YREB is the 3rd largest economy in the world:** RMB37.4 trillion of GDP generated and 595 million people live in the YREB. This means that if the YREB was treated as a country, it would be the third largest economy in the world (after the US and China); it would also rank #3 in terms of population (after China and India). Globally, over half of the world’s chemical fibres and medium & heavy rare earths are produced in the YREB as are around two-thirds of global antimony and tungsten. Given what’s at stake in the global supply chain, it is important to understand the underlying water risks (physical, reputational and regulatory) as well as the climate risks ahead in the YREB, so as to avoid shocks and lever opportunities.
- **Mismatched basin & provincial boundaries = difficulties in managing water & the economy:** In terms of economic policy, the focus is on the YREB whereas water management is focused at the basin level – the Yangtze River Basin (YRB). These different boundaries not only presented a challenge in the collection and analysis of data for writing this report, but also in management of water-nomics at both central and provincial levels. Ideally, an umbrella body is needed to coordinate & manage the water-nomics future of the entire YREB.

- Drier provinces generate more GDP - YREB Stress 6 account for 72% of the region's GDP:** Although only 10% of the YREB faces 'high' or 'extremely high' water stress but this share goes up to 99% for Shanghai, 93% for Jiangsu, 70% for Anhui and 42% for Zhejiang. In fact, six out of the 11 YREB provinces have areas facing 'high' or 'extremely high' water stress; these YREB Stress 6 account for 62% of the population & 72% of GDP of the YREB. Thus a significant amount of GDP is generated in areas with less water. Currently, upstream provinces face less water stress but this may change with the 'Go West' development strategy thus the urgent need to manage the river ecologically and economically from *"the mountain to the ocean"*.
- Pollution exacerbates scarcity - 6 YREB Provinces do not meet pollution targets:** The *'Water Ten Plan'* stipulates 2020 targets of 75% of monitoring points for key rivers to meet Grade I-III water quality (fit for human touch); and <5% to meet Grade V+ water (unfit for any use). The Yangtze has its own plan. Introduced last year *'Action Plan for the War to Protect & Rehabilitate the Yangtze River'* has tougher targets: Grade I-III (85%) and Grade V+ (<2%). Yangtze tributaries have yet to meet these targets. Provinces also have different water quality targets: six out of the 11 YREB provinces still fail to meet at least one of the two 2020 water quality target; Shanghai and Anhui fail to meet both targets. Worse still, 5 of these are among the YREB Stress 6.
- Water-nomic report card signals higher risk exposure for Jiangsu, Anhui & Shanghai:** We expanded our previous work with MEPFECO to examine the water-nomic performance of each of the YREB provinces to identify provinces that lag. To do this, we examined both the current status plus historical trends of each of the 11 provinces since 2005; specifically focusing on the past 3 years (2015-2017) of the current 13FYP. We also analysed whether provincial targets are met for water caps, GDP/drop targets and water quality targets. The water-nomic indicators benchmarked include provincial water use/unit of GDP, water use/ unit of industrial value added and wastewater/unit of GDP. There's no doubt, the YREB will face more scrutiny and laggard provinces will likely face aggressive action, so pay attention to polluting & water intensive industries located there.
- Beware! Industrial parks reshuffle & upgrade + YREB specific "favoured or not" lists:** The YREB houses large amounts of China's polluting industries: chemical fiber (78%); pesticides (77%) & fertiliser (44%). The region also carries significant share of heavy metals discharged: Arsenic (70%) Cadmium (70%) & Mercury (60%). Clearly there is a lot of "cleaning up" to do and industrial parks are key to this transformation. We have summarized various YREB specific "Favoured or Not" lists plus provided two provincial case studies: 1) Jiangxi (the rare earth kingdom of the world) on how it is reshuffling industries to meet targets; and 2) Jiangsu (key chemicals producer) on factors to consider when deciding to rectify or shutdown. Ultimately, the 195 industrial parks & development zones in the YREB will be reorganised into five world-class manufacturing clusters.
- Concentrated risks & opportunities in the 5 YREB City Clusters, home to 405mn people:** More people live in YREB's 5 city clusters than the US and nearly 78% of the YREB's GDP are also concentrated there. Already, city clusters such as the YRD have 31% of their areas facing 'high' or 'extremely high' water stress. Going forward, with increasing uncertainty in water availability due to climate change and more demand for water from rising urbanization, it pays to look into the capacity for economic growth given water constraints. Adaptation measures by the government are key and there will also be challenges from extreme weather events. All these could provide infrastructure opportunities in the short to medium term. There are also wastewater opportunities: 6% of urban wastewater in the YREB remains untreated in 2016, this sounds small but 1.2 billion tonnes are equivalent to almost the entire wastewater discharge of the Philippines. There is also clear upside for water reuse: aside from Jiangsu's reuse rate of 18%, other provinces' rates are only single digit.
- YREB policy innovations to safeguard water include water trading; sponge cities for climate change, national parks & river chiefs:** China recognises that climate adaptation & water management are linked and adopts a broad two-pronged approach: 1) Control water demand; and 2) Increase water supply through infrastructure. This includes flood resilience with sponge city pilots to cope with more rain by the mid-century: 12 of the 30 national pilots are in the YREB. Water Use Permits & Wastewater Discharge Permits are used to allocate water and manage pollution by sector. Already, the trading of these are piloted by various provinces: in Zhejiang, the market value of permits traded was RMB2.5bn in 2014. Watersheds are protected by drawing Eco-Redlines (YREB's Eco-Redline areas are larger than the land area of Thailand) and national parks are being created to protect source regions of key rivers. The core protection zone in the YRB source region is the size of the Czech Republic. Finally, there are now 1.23mn "river chiefs" nationally; this concept was piloted in the YREB.
- Trillions of RMB set aside to fight pollution & green the YREB:** Over RMB630bn was spent on ecological & environmental protection (2016-2017) and invested in the treatment of environmental pollution (2016) in the YREB. There are also YREB inter-provincial eco-compensation schemes (each RMB100-200mn), plus RMB5bn has been allocated from the central budget for YREB eco-compensation in 2018. Looking forward, the MoF has also set aside RMB15bn to incentivize & promote YREB eco protection & recovery (2018-2020). Together with private, provincial and multi-lateral funding, this means that at least RMB2.1trn of green investment will be deployed in the YREB, which is 1.35x the total defence expenditure of the EU in 2016. There is clearly much at stake to warrant such investment. Start by mapping your YREB exposure so as to capitalise on its unique opportunities.

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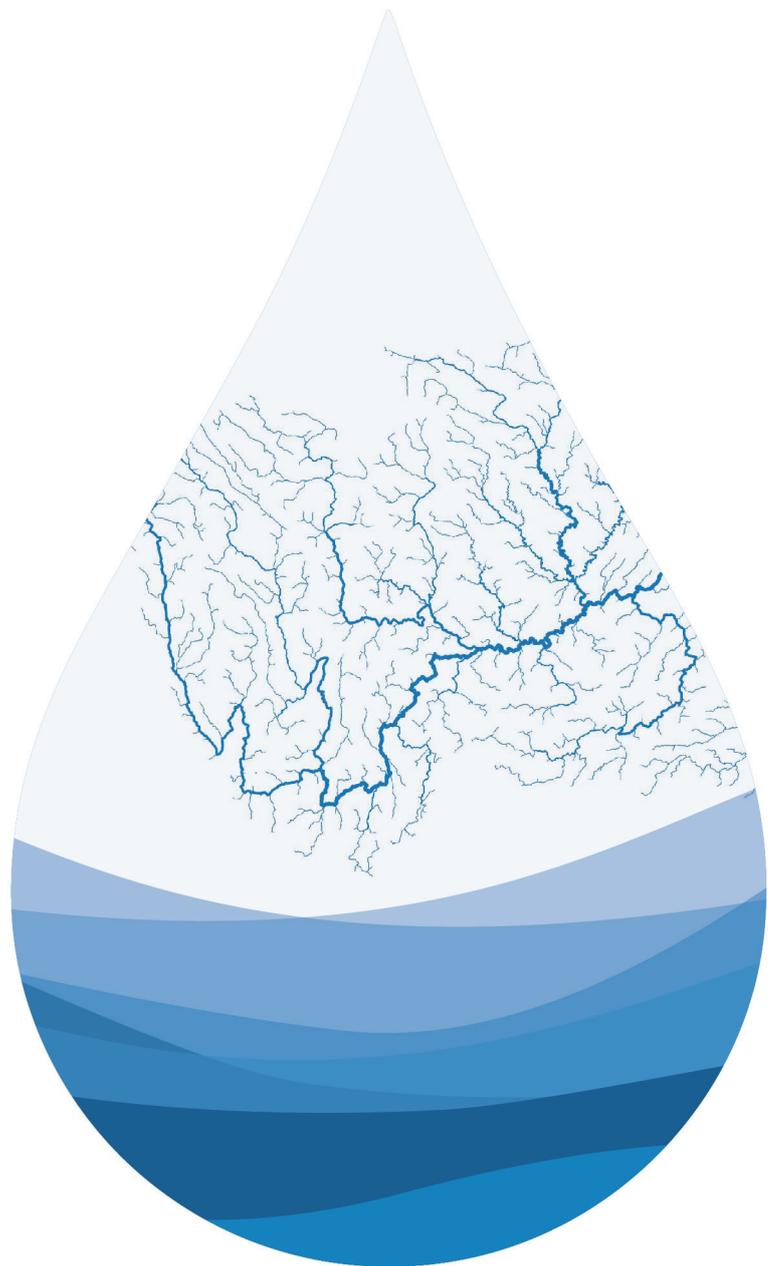


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WATER & CLIMATE RISKS ALONG THE YANGTZE

CHAPTER 1

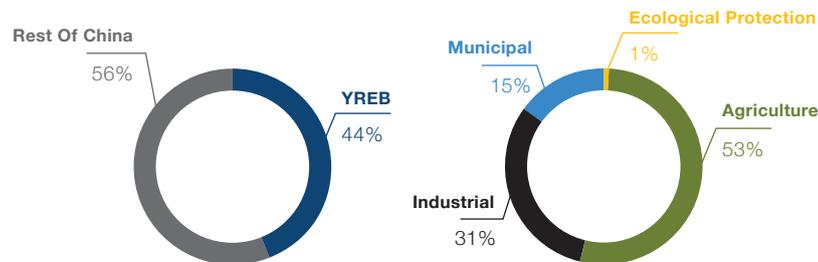


YREB accounts for 44% of China's total water use

In 2017, the YREB accounted for almost 44% of national total water use at nearly 264 billion m³. Over half of this amount (53%) was used in agriculture whereas almost a third (31%) was used by industry. Despite the large population, municipal water use was only 15% and 1% of water was used in ecological protection¹, as shown in the charts below:

YREB water use: agriculture (53%) & industry (31%) ...

2017 YREB Total Water Use & Water Use Mix



... despite large population, municipal water use was only 15%

Source: China Water Risk based on NBSC

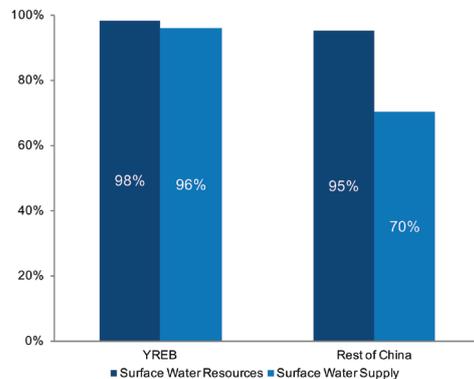
YREB is highly reliant on surface water = spotlight on the basin

Surface water supplies 96% of YREB's water ...

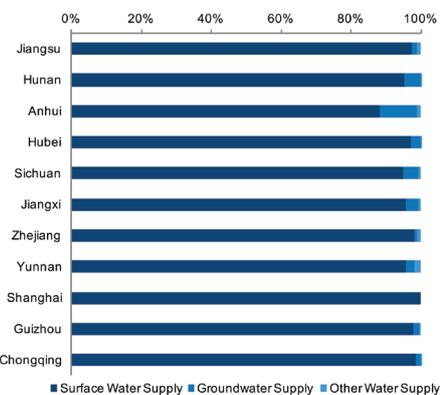
Surface water accounts for almost all of the YREB's (98%) and the rest of China's (95%) total water resources. However, 96% of YREB's water supply is met by surface water resources, while the rest of China reliance on surface water supply is only 70% (see left chart below). Thus, in the YREB, efforts in controlling water use have more direct impact on river flows as well as water levels in lakes and reservoirs.

.. Rest of China reliance on surface water supply is only 70%

2017 Surface Water Resources & Surface Water Supply



2017 YREB Provinces Water Supply Mix



Source: China Water Risk based on NBSC

... Shanghai 100% reliant on surface water

As shown in the right chart above, although reliance on surface water supply varies across the 11 YREB provinces, with the exception of Anhui (88.4%), surface water supply shares exceed 90%; at 100%, Shanghai totally relies on surface water. This high reliance on surface water also shows the vulnerability of the water supply to pollution and climate change. The provinces are ordered by water use – Jiangsu is the largest water user; whereas Chongqing uses the least.

...so this report primarily focuses on surface water

As a result, the discussion in this report primarily focuses on surface water, primarily the YRB as well as key lakes and reservoirs. Since surface water systems are vulnerable to rampant pollution from decades of rapid industrialisation as well as climate change which affects every component of the river basin from rainfall and snowfall to glacial melt. More on pollution later in “Yangtze overall water quality improving but tributaries are not meeting targets” and climate change in “A hotter future with more rain = need more resilience”. This however, does not mean that groundwater in the YREB is not facing challenges such as pollution.

The YREB faces higher water stress than the YRB

Since the YRB provides the lion’s share of surface water for the YREB, it is important to examine water stress in both the economic belt and the basin.

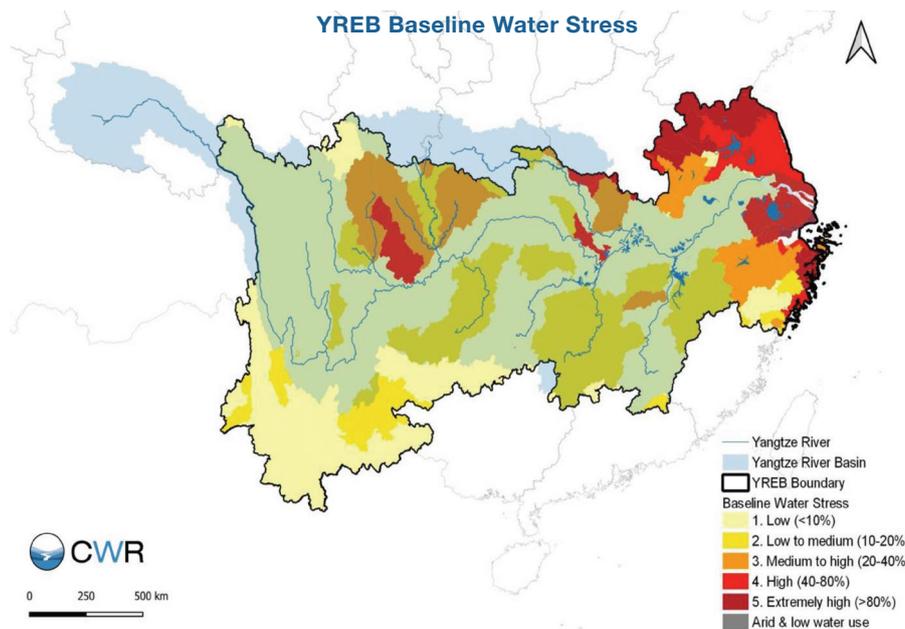
The map below, shows 1) the YREB Boundary (denoted by the black line) and 2) the Yangtze River Basin (shaded in light blue) overlaid on WRI’s Aqueduct Baseline Water Stress map with. This provides us a straightforward overview of water stress exposure of each YREB province.

Measuring Water Stress

A common measure of water stress in a region is the ratio of total annual water withdrawal to average annual available freshwater resources (both surface and groundwater).

It has been widely used by international organisations such as the FAO⁷⁴ and the World Bank⁶⁸ in comparing water management between different countries. It is also the SDG indicator 6.4.2⁷⁵. This indicator is also included in the Aqueduct Global Maps 2.1 developed by WRI⁶⁸.

The Aqueduct tool includes location-specific multi-year average values of baseline water stress, which enable us to analyse water stress conditions at both river basin and provincial levels.



Source: China Water Risk based on Baseline Water Stress from WRI Aqueduct Global Map 2.1, river shapefile from FAO AQUAmaps, and country and provincial boundary from Data Center from resources and Environmental Sciences. Chinese Academy of Sciences

Differences in geographical boundaries of the YREB and YRB have led to different baseline water stress profiles shown in the chart below:

Aqueduct Baseline Water Stress: Yangtze River Basin vs the YREB



Source: China Water Risk based on World Resources Institute Aqueduct 2014

The YREB is clearly more stressed than the YRB; key variations from the above chart are:

Only 4% basin areas face high or above water stress...

... while such share is 10% for the YREB

- Only 4% of the YRB face a ‘high’ water stress, compared to the YREB where 7% face ‘high’ water stress and a further 3% are exposed to ‘extremely high’ water stress;
- 84% of the YRB face ‘low’ or ‘low to medium’ water stress, while such share is lower for the YREB at 79%; and
- No area is classified as ‘arid & low water use’ for the YREB whereas there is 2% of such areas in the YRB. This is because the basin includes the source region in Qinghai, where as the YREB excludes this region.

Mismatched! Basin water management vs. provincial / central management

YWRC was established in 1950 to manage water at basin level

At the basin level, the YWRC was established as early as 1950, with its main responsibilities being the management and coordination of water resource protection, utilisation and disaster mitigation & loss prevention. It covers the entire YRB as well as areas in the west of the Lancang River. However, it lacks the mandate to directly influence non-water related matters, especially economic policies.

But priorities of central & provincial governments may differ ...

Most water and economic policies are made at the central and provincial level. It should be noted that provincial water stress conditions are quite different from that at the basin level. This means that there may be different priorities and actions between the central government, who will focus on the water security of the entire river basin, and provincial governments, which may prioritise provincial needs and targets. Policies set centrally may thus hamper provincial flexibility as they will need to balance water needs within and outside the basin as well as within and outside the province as decisions made by upstream provinces may impact downstream provinces throughout the river.

... so an umbrella body is needed to manage the water- nomics future of the entire YREB

To coordinate and balance water management and economic development in the YREB, it will not only require an umbrella body or some kind of governing arrangement that could cover the entire YREB, but unlike the YWRC, its scope and jurisdiction should also go beyond water management and include socio-economic matters that are directly and indirectly reliant on water.

Multiple efforts have been made over the years including recent amendments of relevant laws to effect more holistic and comprehensive management of the river for both water and economic security:

Multiple policies, targets + changes in law have been made to effect more comprehensive & holistic management ...

- Policies have been put in place in recent years to prioritise ecological protection and green development, and seek integrated development, especially in the delta region. The 'YREB Development Plan', released in October 2016, set the overall strategy as *"prioritizing ecological protection, river basin coordination and integrated development"*. Meanwhile, innovative policy initiatives have been piloted in this region and later expanded for nation- wide adoption such as river chiefs and sponge cities.

As per the amended Water Law, **'integrated planning'** refers to *"comprehensive planning of water resource development, utilisation, water saving, protection and water disaster prevention based on socio-economic development needs and current status of water resources development"*.

- The revised *'Water Pollution Prevention & Control Law'*, passed on 27 June 2017, highlighted in various clauses that environmental protection department at the State Council will be responsible for setting water quality monitoring standards and coordinating unified monitoring stations and information disclosure. This hopefully will help consolidate monitoring efforts in various different government bodies and provide a unified reporting system to monitor progress and guide policies. Already, significant progress has been seen from improved surface water quality to better public information sharing.

- The Water Law was also amended to support integrated planning - Clause 15 of the amended 'Water Law of the People's Republic of China', which was passed in July 2016, indicates that *"the planning for regions within the boundary of a river basin should follow the river basin planning, and the sector planning should follow the integrated planning"*.

- In March 2018, during the Two Sessions, China initiated ministerial reform of its environmental protection and resource management ministries to allow for more holistic management of its natural resources, including water. More on this in the box below **"Ministry Reform: 9 Dragons to 2"**.

... there is also strong support from President Xi

- Continued strong support from the government is evident. In April 2018, President Xi again highlighted during a YREB workshop the need for the region to balance ecological environment protection and economic development and also, in his words, *"getting rid of old growth engines and cultivating new engines"*, as well as its role in promoting high-quality growth of the whole nation¹³.

- On 1 June 2018, a three-year action plan (2018-20) on integrative development of the Yangtze River Delta was agreed on by Zhejiang, Jiangsu, Anhui and Shanghai¹⁴. One key target is *"to fully establish unified and highly efficient river basin management system on the Yangtze"* by 2020. Twelve cooperation themes are identified, including transportation, energy, scientific innovation, industry, IT, environmental protection and public services, etc. By 2030, the socio-economic development of the Upper Reaches, Middle Reaches and the Yangtze River Delta should be fully integrated and well-coordinated whilst ensuring the overall importance of the water quality and ecological environment of the river.

... latest is the setting of
3 Lines & 1 List

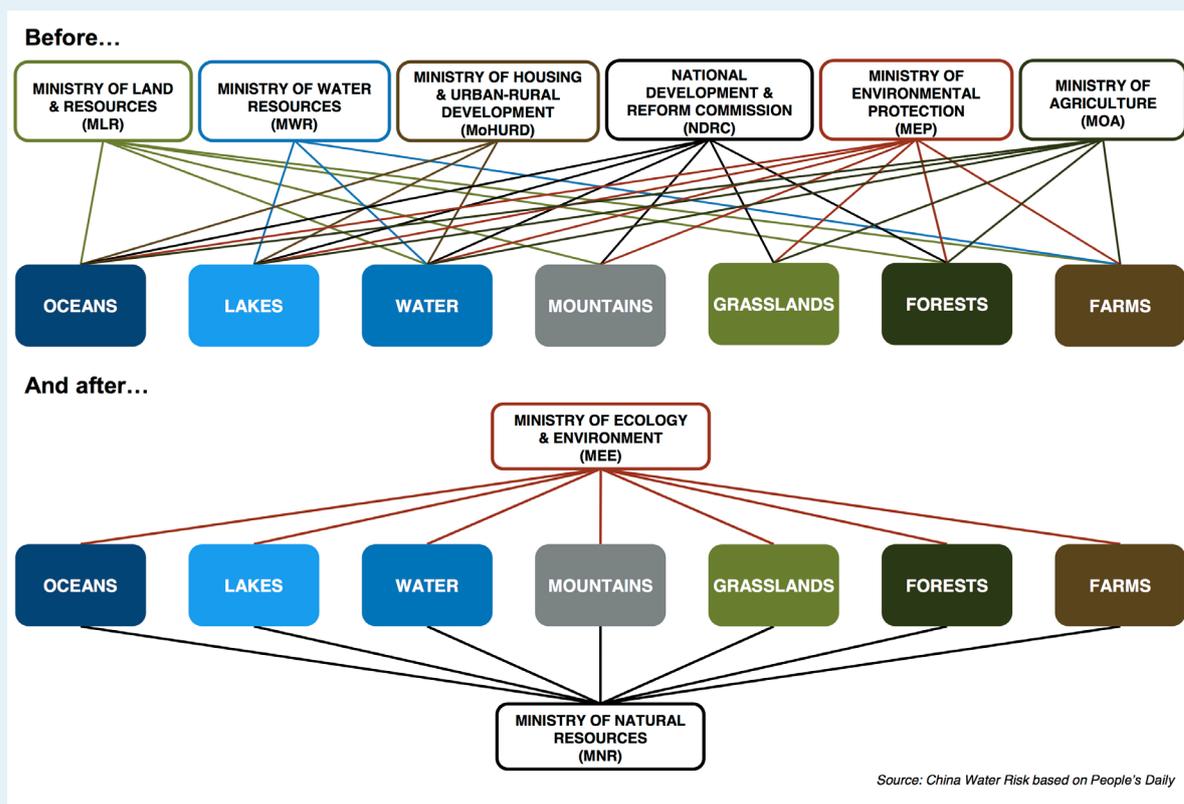
- In the ‘Two Sessions’ in March 2019, ecological and environmental protection in the YREB was again highlighted. According to Ecology & Environment Minister Li Ganjie, China is promoting green development by setting ‘Three Lines’: ‘Eco Redline’ (生态保护红线), ‘Environmental Quality Baseline’ (环境质量底线) and ‘Resource Utilisation Threshold’ (资源上线); and ‘One List’: ‘Environment Negative List’ (环境准入清单)³. For more on Eco Redline, please see “PILOT POLICIES & INITIATIVES TO GREEN THE YREB”.

To identify physical and regulatory risk areas and hotspots, it is thus important to understand provincial-level water stress conditions as well as central government action to rein in water use and pollution. These are explored in more detail in the following sections.

Ministry Reform: 9 Dragons To 2

Ministry reform was announced in March 2018. During China’s “Two Sessions”, President Xi stated in his closing speech that there is a need to “discard the old and introduce the new (for the) pursuit of progress”. The previous Ministry of Environmental Protection (MEP) was supersized into the Ministry of Ecology and Environment (MEE), while a new Ministry of Natural Resources (MNR) will manage China’s natural resources, from water, forests and soil to minerals. The MEE and MNR will absorb duties from three now-defunct ministries (MEP, MLR & MOA) and the two administrations which manage China’s forests and oceans.

This should help streamline the overlapping responsibilities and improve the management of China’s natural resources. As for water, the previous nine ministries or ‘nine dragons’ which managed water is now reformed into two ministries. Overlapping responsibilities across all elements of the environment will be reassigned to two ministries as illustrated in the chart below. The establishment of the MEE with more powers is expected to solve the tangled web of responsibilities once and for all. Meanwhile, the MNR now has oversight across all natural resources; essentially giving minerals, forests and lakes equal weighting. This allows the MNR to comprehensively integrate long-term resource planning with economic development. To this end, it is expected to map ‘ecological red lines’ across the nation - from national parks to freshwater sources, to lakes, to wetlands, red lines to delineate or forbid various resource developments. These reforms herald a structural shift in China and is key to delivering the national vision of balancing the economy and the environment.

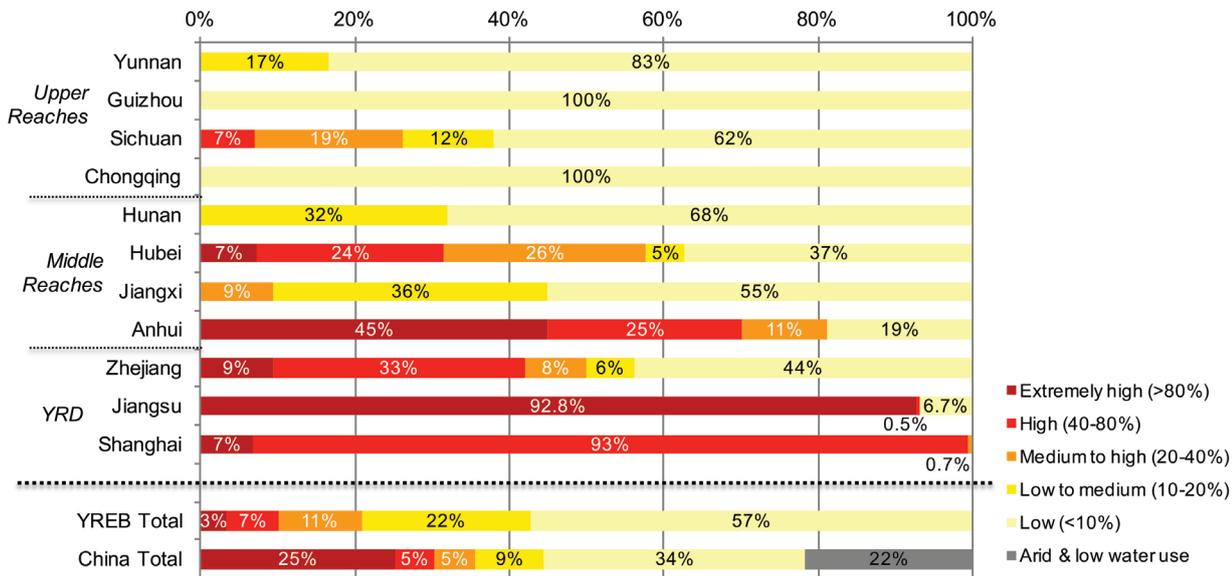


Source: CWR article, “Ministry Reform: 9 Dragons to 2” by Xu & Chan published on the CWR website, 18 April 2018: <http://www.chinawaterisk.org/resources/analysis-reviews/ministry-reform-9-dragons-to-2/>

Provincial level water stress varies greatly – from 0% to 100%

At a provincial level, the baseline water stress conditions of YREB provinces vary greatly with the Yangtze River Delta (YRD) facing greater water stress than the Upper or Middle Reaches as per the chart below:

Aqueduct Baseline Water Stress: YREB Provinces vs National Overview



Source: China Water Risk based on World Resources Institute Aqueduct 2014

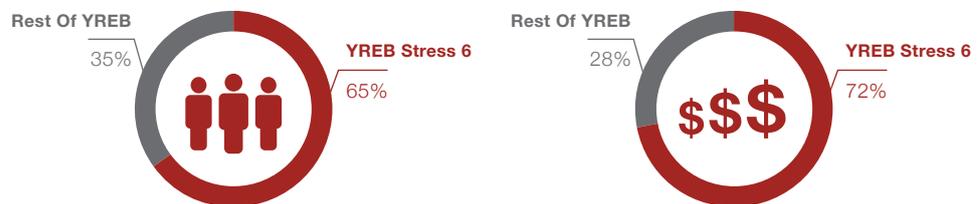
Key points to note from the above chart are:

10% of YREB face 'high' or 'extremely high' water stress...

- ... but this goes up to:
 - 99% for Shanghai
 - 93% for Jiangsu
 - 70% for Anhui
 - 42% for Zhejiang

- For YREB as a whole, only 10% of its areas face 'high' or 'extremely high' water stress. While this is lower than China's national total, some of the 11 provinces in particular those in the YRD are facing more stress than the national average;
- Six out of the 11 YREB provinces have areas facing 'high' or 'extremely high' water stress. They are Shanghai (99%), Jiangsu (93%), Anhui (70%), Zhejiang (42%), Hubei (32%) and Sichuan (7%). We call them 'YREB Stress 6'. As per the charts below, they represent 65% of the YREB's population and 72% of the region's GDP (current price) in 2017; and

YREB Stress 6: Share of YREB Population & GDP



Source: China Water Risk based on NBSC, 2017 figures

YREB Stress 6 account for 65% population & 72% GDP of YREB

Upstream faces less water stress but this may change with 'Go West' strategy...

- Chongqing and Guizhou are the only two provinces/municipalities that do not face higher categories of water stress: they are both classified as 'low' water stress.

Downstream provinces are overall more stressed than upstream provinces. However, the situation may change as cities in the upstream continue to expand and industries shift with China's 'Go West' strategy. Clearly, actions upstream could affect provinces downstream. We need a holistic approach in managing water demand and pollution along the river. Provincial water use caps were thus set based on current needs and expected growth. As can be seen in the following page, some provinces have more leeway before hitting the caps while others need to drastically reduce their water use.

...holistic approach to river management can help avoid this

Regulatory Risk! YREB water cap tightens in 2030 but still room to grow

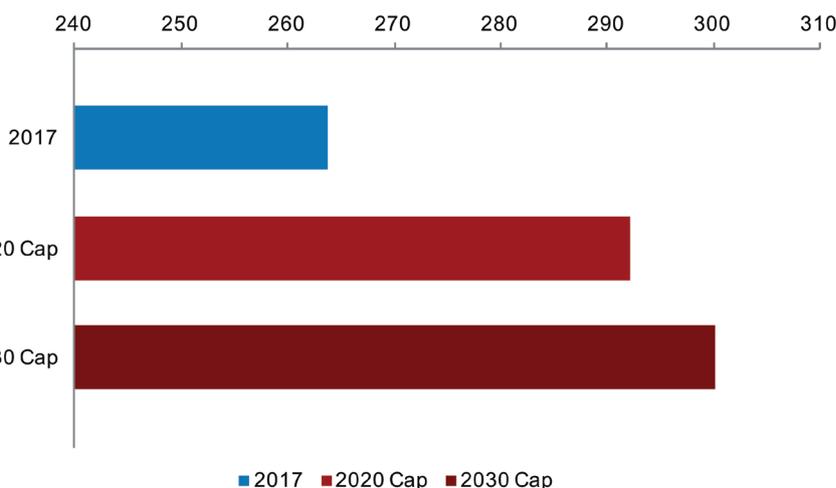
YREB water use caps are set:
 2020 = 292bn m³
 2030 = 300bn m³

The 'YREB Ecological Environment Protection Plan' has reaffirmed provincial caps of total water use, which is 292 billion m³ by 2020 and 300 billion m³ by 2030, as previously set in the 'Three Red Lines' policies.

The YREB as a whole currently uses nearly 264 billion m³, giving it an additional 28.5 billion m³ or a 10.8% growth in water use between 2017 and 2020. After that, additional water allocations for 2020-2030 shrink to 7.9 billion m³ or 2.7%.

YREB currently on track to meet 2020 water caps...

YREB Stress 6: Share of National Population & GDP



...but note the narrowing of growth in water caps in the future ...

... this could point to slower economic growth unless these water targets are bettered

Source: China Water Risk based on NBSC, 2017 figures

No water = no growth and the narrowing of growth in water caps in the future points to slower economic growth unless these water targets are bettered. More on this in the box below on "National Water Caps Could Limit GDP Growth & Catalyse 'Business Unusual'".

National Water Caps Could Limit GDP Growth & Catalyse 'Business Unusual'

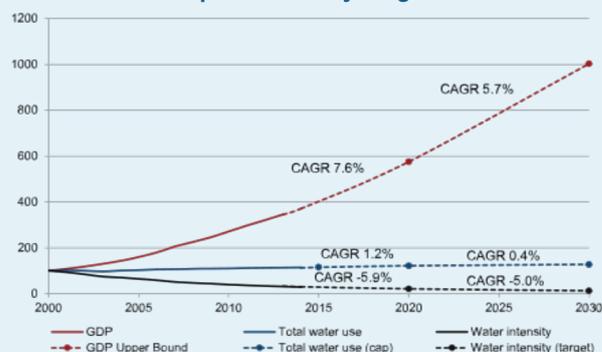
Since 2011, China has set national targets on total water use, water use efficiency as well as water quality (so called 'Three Red Lines' policy).

Unless these water targets set by the government are bettered, we estimated that the water caps and tougher water intensity targets limit China's GDP CAGR to slow to no more than 7.6% between 2014-2020 and 5.7% between 2020-2030.

This means that the government was already signalling back then that they intended to put the environment ahead of GDP growth. By 2017, GDP as the primary indicator of performance was officially deprioritised by President Xi Jinping.

These national water caps were divided amongst provinces and provincial water targets were set for 2020 and 2030. Allocations across provinces were not equal; advanced provinces like Guangdong even face a negative quota having to reduce its total water use by 2020 and again by 2030.

2000-2030F Maximum GDP Growth Given Water use Caps & Intensity Targets



Note: CAGR values correspond to the periods 2014-2020 and 2020-2030

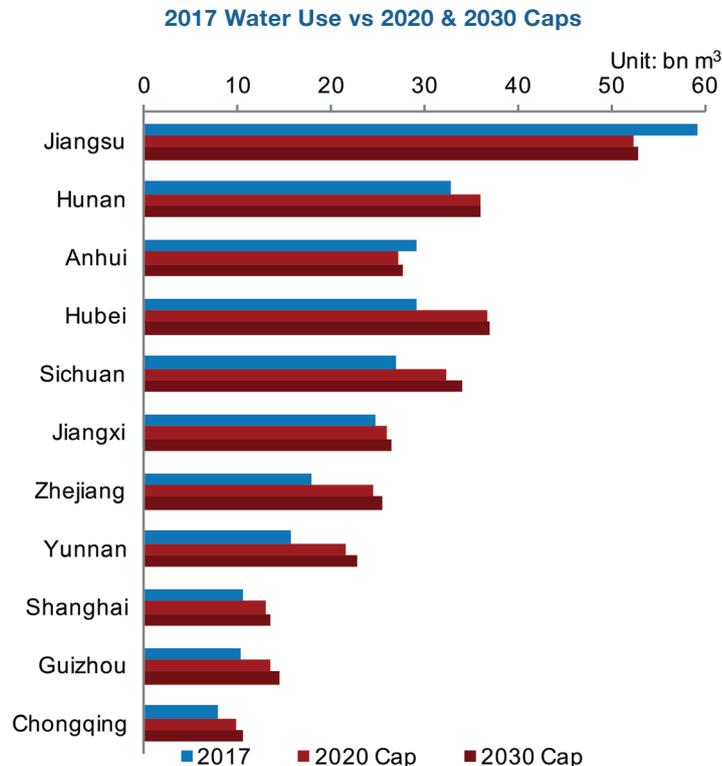
Sources: China Water Risk analysis based on NBSC, MWR, MEP; China Water Risk report "Towards A Water & Energy Secure China – Tough choices ahead in power expansion with limited water resources" 2015; State Council "Most Stringent Water Management Systems Methods" 2013; 2030 Water Resource Group "Charting Our Water Future" 2009

Provincial water caps & targets – Jiangsu & Anhui are not on track

The chart below compares actual water use in 2017 against the 2020 and 2030 water caps of each of the 11 YREB provinces. The provinces are ranked by the amount of water use.

Jiangsu & Anhui will need to cut back their water use from the 2017 level ...

... Hunan, the 2020 & 2030 caps are the same



Source: CWR based on NBSC, YREB Ecological environment Protection

...by 2020, Jiangsu will have to cut water use by 11.4%; Anhui by 6.7%

Except for Jiangsu and Anhui, all provinces have yet to hit their respective water cap targets for 2020 and 2030. This means that Jiangsu and Anhui will need to cut back their water use from the 2017 level. By 2020, Jiangsu will have to reduce its water use by 11.4% while Anhui will have to cut its water use by 6.7%.

Of the others who have yet to reach their 2020 cap, Zhejiang, Yunnan, Guizhou and Chongqing have relatively more room in future use: their respective gaps between 2017 use and 2020 cap are greater than a quarter of their water use in 2017.

Stricter stance on protecting water going forward for all provinces

Also note that the gaps between the 2020-2030 caps are marginally smaller than that of 2017-2020, reflecting a 'stricter' stance on protecting water resources going forward. In the case of Hunan, the 2020 and 2030 caps are the same, signalling a more aggressive stance toward water efficiency gains.

Tighter water allocations + GDP deprioritisation = more aggressive action to upgrade or reshuffle industry

Tight water allocations together with the deprioritisation of GDP targets will mean that provinces may be more aggressive in rolling out water efficiency projects. Also they may be more willing to reshuffle away from water intensive their industries. Clearly in the case of water caps, Jiangsu and Anhui are the two to watch for aggressive action on this front. How much water is used by each sector thus becomes a focal point.

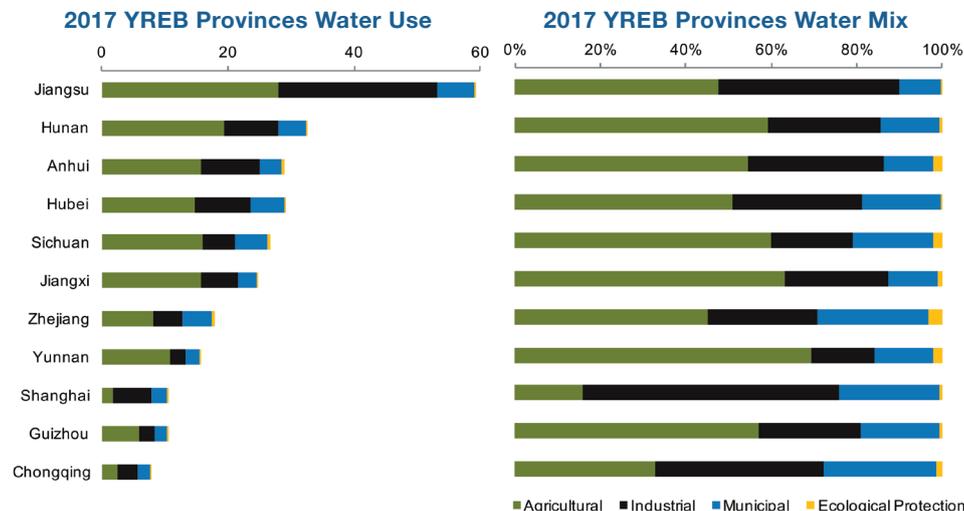
However, before we delve into this the next section, it is also important to note that the government has also set targets for the economic efficiency of water use by province to promote more GDP per drop. Provincial pollution targets have also been set lending further complexity to identifying 'hotspot' regions. Historical provincial performance across all these target indicators can thus help gauge pressure to change and catalyse 'business unusual' – more on water- nomic benchmarks and historic trends in the next chapter.

Agriculture dominates water use mix except for Shanghai & Chongqing

The amount of water used by each province varies dramatically as does how water is used as illustrated in the charts below:

Jiangsu's agri sector: No.1 water user in the YREB

Agricultural water dominates water use across provinces except Shanghai & Chongqing



Source: China Water Risk based on NBSC

While for the entire YREB, 53% of the total water used in the region is for agriculture, 31% for industry and 15% for municipal use, each province displays a different mix.

Key points to note are:

- Agricultural water use dominates the total water use for most of the YREB provinces ranging from a low of 45% to a high of 69%, with the exception of the municipalities of Shanghai (16%) and Chongqing (33%). For the YREB as a whole, 53% of the total water used in the region is for agriculture;
- Jiangsu is by far the largest user of water in the YREB. It's agriculture sector alone is the YREB's biggest water user, representing >10% of the YREB's total water use. Jiangsu also has significant share in industrial water use;
- Industrial water use ranges from 15% in Yunnan to 60% in Shanghai, but for most provinces it is within the range of 24% to 42%;
- Municipal water use ranges from 10% in Jiangsu to 26% in Chongqing and Zhejiang. As urban population increase across the YREB, municipal water use has also been increasing. From 2004 to 2017, the YREB saw a rise of 40% in municipal water; Hubei and Sichuan saw even more extreme increases of 87% and 64% respectively; and
- Ecological water use, accounting for a tiny amount of water use, mainly includes usages in urban green areas and recharge for rivers and lakes. Despite the small share, there are still opportunities for efficiency improvement through rainwater harvesting and use of recycled water.

Jiangsu's agri water use accounts for >10% of YREB's total water use

Municipal water use has been on the rise; increasing by 40% in the YREB 2004 - 2017

Water Use Permits are also used to help manage water allocation within & between industries

Improving irrigation efficiency is a no-brainer but changing crop mix can also help

It is important to note here that Water Use Permits are also used in pilot provinces in China to help manage water allocations within and between industries. These permits are issued and reviewed every five years and renewal of the permit at the same amount of water is not guaranteed. The government has indicated that they may tighten or increase allocation depending on the industry and the status of water resources in the future. More on this in **PILOT POLICIES & INITIATIVES TO GREEN THE YREB.**

Given that agriculture generally dominates the water use mix across provinces, improving irrigation efficiency is clearly a no-brainer but changing crop mix away from water intensive crops may also be considered. However, the reality is that many provinces may not be able to do this as they may be locked into certain crops due to food security concerns (such as rice) or economic reasons (for cash crops). Almost two-thirds of China's rice is grown in the YREB alone. Such provinces may therefore have to turn to upgrading and changing industrial mix instead – "More GDP per drop depends on GDP mix".

Yangtze overall water quality improving but tributaries are not meeting targets

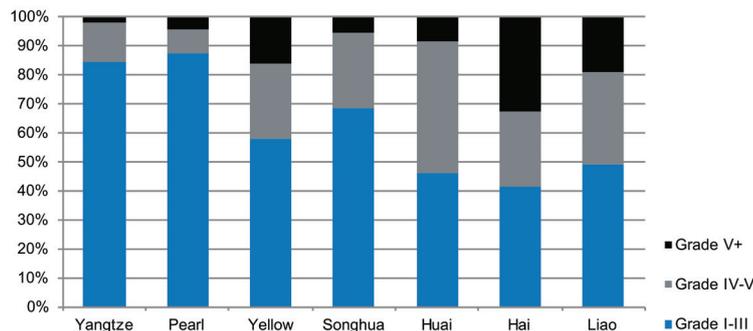
China's surface water quality standard (currently GB3838-2002) classifies water quality into 6 classes, i.e. Grade I, II, III, IV, V and V+, based on 24 basic indicators:

- Grade I-III is considered fit for human touch and used as drinking water sources;
- Grade IV-V water can only be used for industrial and agriculture purpose; and
- If the water fails to meet the Grade V requirement for one indicator, it is classified as Grade V+.

The water quality of the Yangtze fares relatively better than the other six major rivers basins in China, according to the "2017 State of Ecology & Environment Report":

Yangtze water quality better than other major rivers in China

Water Quality of China's Major River Basins 2017

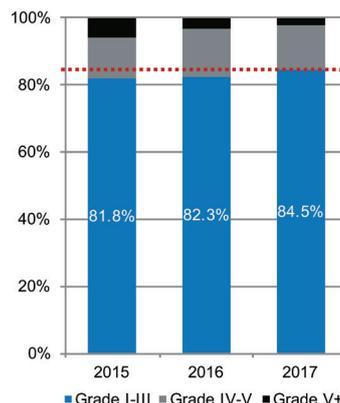


Source: China Water Risk based on MEE, 2017 state of Ecology & Environment Report

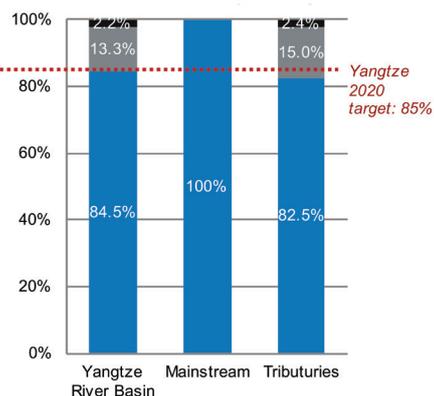
The 'Water Ten Plan' was introduced in 2015 and from 2015 to 2017, we have also seen steady improvement with slight increase of Grade I-III water bodies and reduction of Grade V+ water bodies (see left chart below). This is laudable despite an increasing number of monitoring points in rivers. Monitoring points more than doubled from around 700 during 2012-2015 to 1,617 in 2016 & 2017¹⁵. That said, the water quality conditions are not even throughout the river: water quality in the tributaries was worse than that in the mainstream. In fact, monitoring sections falling under Grade V+ water quality levels were only found in the tributaries (see right chart below).

...water quality has steadily improved from 2015 to 2017

Water Quality of Yangtze



2017 Water Quality of Yangtze



Grade V+ water quality level was only found in the tributaries of the Yangtze...

YREB 2020 targets: 85% of monitoring points must meet Grade I-III + Grade V+ water must be <2% ...

Source: China Water Risk based on MEE, 2017 state of Ecology & Environment Report, 2015 & 2016 State of Environment report

... While Yangtze mainstream has met both targets, the tributaries were still failing on both fronts

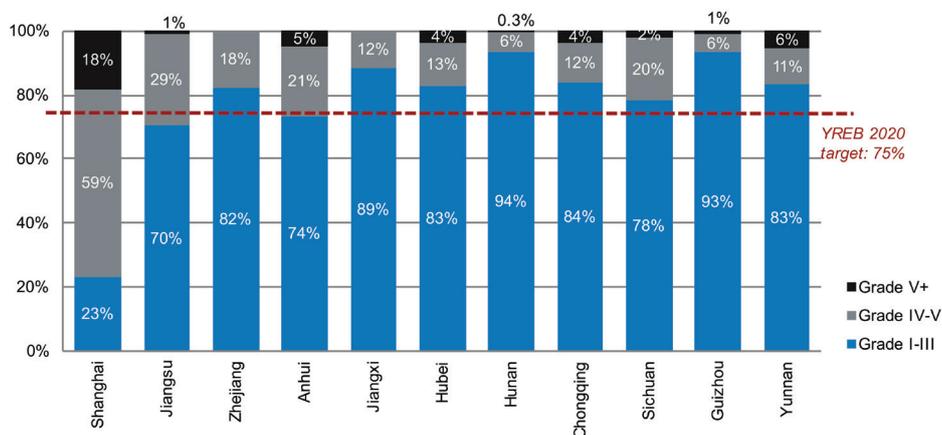
According to the 'Action Plan for the War to Protect & Rehabilitate the Yangtze River' (Yangtze Action Plan) issued on 31 December 2018, at least 85% of monitoring points in the whole basin should meet Grade I-III standard. The Yangtze Action Plan also sets the share of Grade V+ water to be less than 2% by 2020. As of 2017, the mainstream of the Yangtze River has met both measures, but the tributaries were still failing on both fronts.

This is largely due to industrial and agricultural pollution. According to the Yangtze River & Southwest Rivers Water Resources Bulletin, industrial sources accounted for 52.3% of total wastewater. This excludes mine water discharge and one-through cooling water discharge from thermal power plants) discharge into the YRB¹⁶. Pollution also comes from non-point sources which can be more difficult to monitor – see box on the following page on "Everything flows downstream – difficulties in tackling non-source point pollution".

War on Pollution! 6 provinces still fail to meet targets

A broader look beyond the river basin and across the YREB reveals a different picture. The latest surface water quality status across the 11 YREB provinces is shown in the chart below:

2017 Surface Water Quality of YREB Provinces



Performance by provinces vary greatly ...

Source: China Water Risk based on provincial state of environment reports for 2017. For Chongqing, the figures are calculated from separate monitoring results for mainstream and tributaries of the yangtze; for Hubei, Yunnan, the figures are calculated from separate monitoring results for rivers and lakes

Provinces failing 2020

Grade I-III target: Shanghai, Jiangsu & Anhui

Provinces failing 2020

Grade V+ target: Shanghai, Anhui, Hubei, Chongqing & Yunnan

The 'YREB Ecological Environment Protection Plan' issued by MEP, NDRC and MWR in July 2017, set out the following water quality by 2020 for YREB provinces:

- **Grade I-III Target:** over 75% of monitoring sections across the YREB provinces shall meet Grade I-III water quality. By the end of 2017, three provinces fail to meet this target, including Shanghai, Jiangsu and Anhui;
- **Grade V+ Target:** the share of monitoring sections across the YREB provinces under Grade V+ water quality condition shall be less than 2.5%. By 2017, five provinces have not met this target, including Shanghai, Anhui, Hubei, Chongqing and Yunnan. Shanghai fares the worst, with Grade V+ share at an astonishingly 18%.

Shanghai & Anhui fails to meet both targets

In summary, six out of the 11 YREB provinces are still failing to meet at least one of the two 2020 water quality target above with Shanghai and Anhui failing to meet both targets.

China's first-ever basin-wide audit conducted on the YREB (June 2018)

In June 2018, the National Audit Office (NAO) released the first ever audit report on ecological and environmental protection efforts in the YREB, which covers a wide range of issues including pollution violations and fines charged (see highlights in the page on "CHINA'S FIRST EVER BASIN- WIDE ENVIRONMENTAL AUDIT"). According to the audit report, there were still many illegal pollution cases at both city and factory levels.

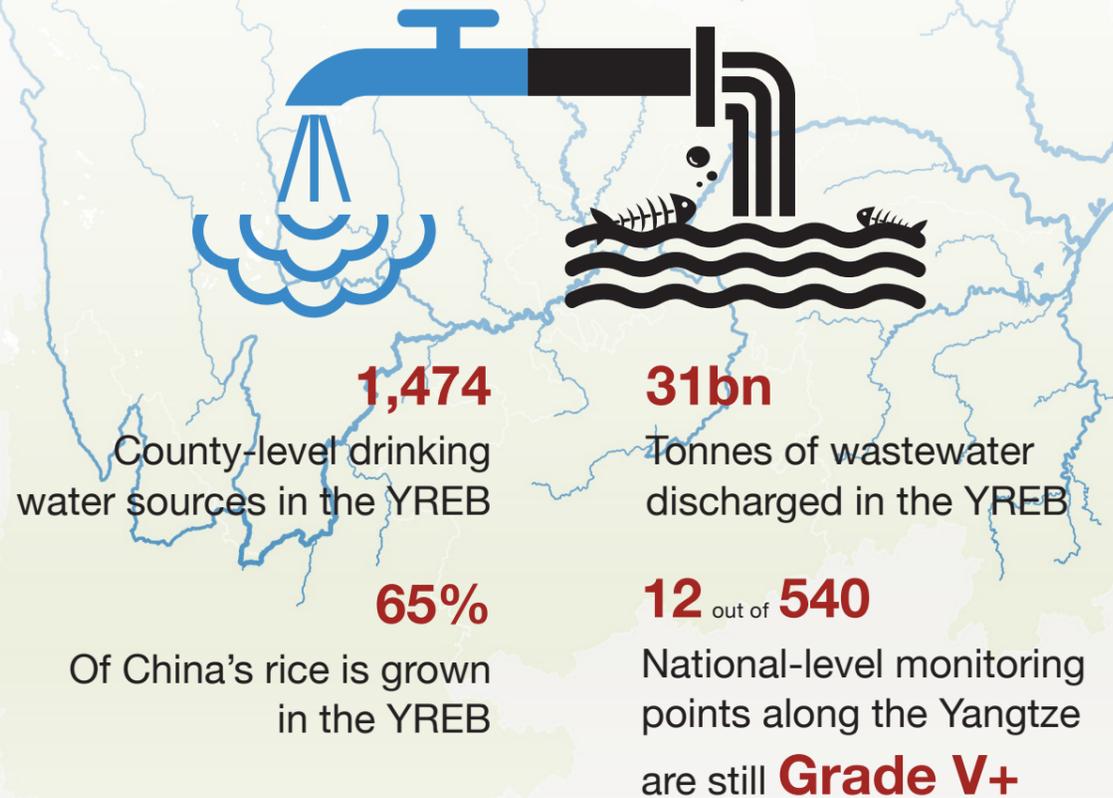
Everything Flows Downstream - Difficulties In Tackling Non-Point Pollution Sources

In 2017, a total of 31 billion tonnes of wastewater was discharged across the YREB provinces, accounting for 44% of the national wastewater discharged¹. As we will discuss in the next Chapter, pollution is clearly linked with economic development, in particular agriculture production and industry mix.

The current monitoring system still has difficulties in tracking pollution from non-point sources (also called diffuse pollution), especially in agriculture where fertilisers and pesticides enter the environment through runoff, soil erosion or irrigation. The good news is that China has started to tackle agriculture pollution by controlling such non-point sources. A policy issued in 2018 hopes to tackle this through various measures such as controlling the use of such chemicals, adopting field and satellite monitoring, increasing financial support to the use of economic incentives and so on. More in the next chapter in the section "More GDP = more pollution – so control is key to improving water".

It is also worth noting here that the Yangtze River tops global rivers in carrying plastics into the ocean - 333,000 tons in 2015, according to one recent study¹⁷. Clearly pollution discharged into the Yangtze matters beyond China. Within China, it is trying to resolve upstream/downstream pollution challenges through eco-compensation schemes – more on this in "PILOT POLICIES & INITIATIVES TO GREEN THE YREB"

POLLUTION RISKS ALONG THE YREB



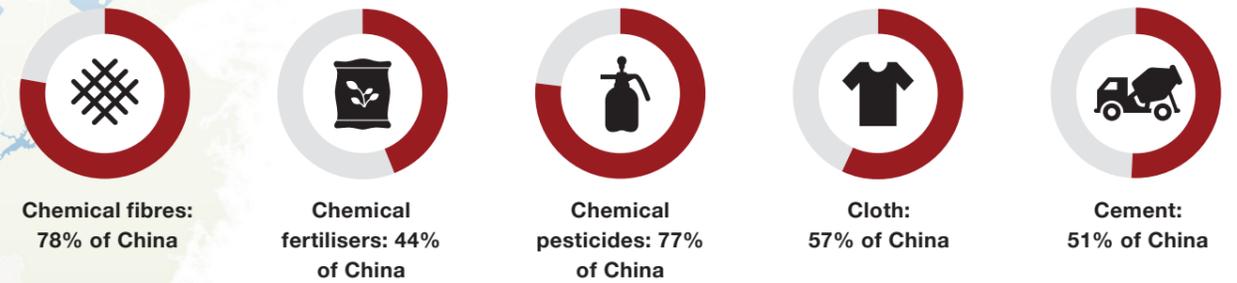
Not fit for use by agriculture & industry

Usage of plastics & chemicals in agriculture:

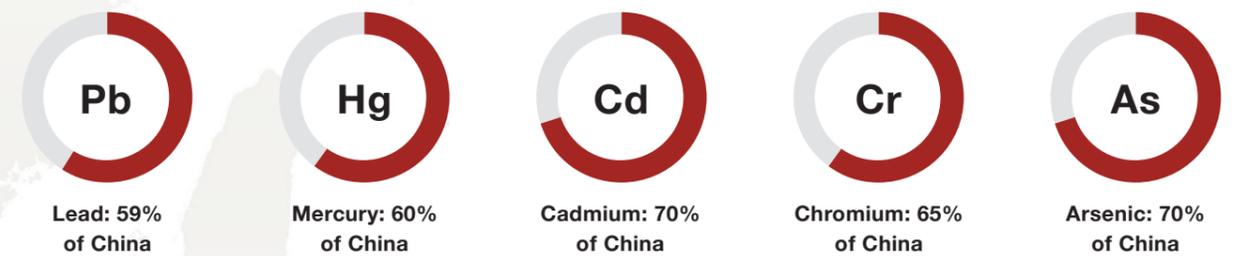


Source: China Water Risk, NBSC (various years), Ganzhou case (MNR, Jiangxi provincial Land & Resources Department, MIIT, Ganzhou city government), Yancheng case (CWR article 16 June 2019: Yuanchao Xu, Jiangsu Chemical Park Explosion: Rectify Or Shutdown? <http://www.chinawaterrisk.org/resources/analysis-reviews/jiangsu-chemical-park-explosion-rectify-or-shutdown/>), Lengshuijiang case (CCTV news, <http://finance.sina.com.cn/g/20100414/21437751287.shtml>), Yichun case (ACEF, <http://www.acef.com.cn/news/lhhd/2018/0625/19764.html>)

Share of polluting industries in the YREB:



Share of heavy metals discharged in the YREB:



An idea of pollution incidents & court cases:

Ganzhou city
Ganzhou city is also known as China's rare earth kingdom. It is located in Jiangxi Province and produces almost 44% of China's MHREs. Pollution from rare earth mining and processing is costly; clean-up and remediation costs are estimated by the MIIT to be RMB38 billion for Ganzhou city alone. The city sits upstream of two rivers: one is Ganjiang River, a key tributary of the Yangtze; and the other is Dongjiang River which provides water to Guangzhou, Shenzhen and Hong Kong – for more see the spread on "JIANGXI WATER-NOMICS: Identifying the least favourite & upgrading industrial mix"

Yancheng city
Yancheng city plays a key role in China's fertiliser and dye supply chain. It is located in Jiangsu province, an important chemicals hub including petrochemicals, salt chemicals, fine chemicals, biochemicals, pesticides & fertilisers, dyes and chemical intermediates. In March 2019, there was an explosion at the Xiangshui Chemical Industrial Park and the entire park was shut down. Jiangsu is stepping up efforts to rectify or shutdown plants in the sector to safeguard its cities and drinking water sources-for more see the spread on "JIANGSU CHEMICALS: Factors to consider when deciding to rectify or shutdown"

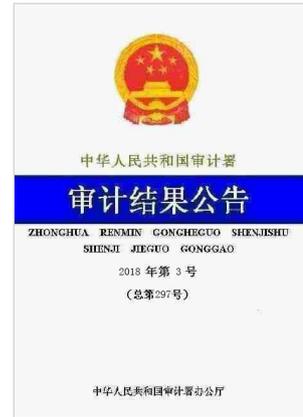
Lengshuijiang city
Lengshuijiang city, located in a remote area in Hunan, is the world's antimony capital, producing around 60% of global supplies. Antimony mining and processing can be toxic to the environment and clean-up could disrupt global antimony markets – antimony is essential for use in flame retardants, lead-acid batteries and plastics. Antimony tin oxide has also been developed as an alternative to the indium coating in touchscreens. A study from 2010 found severe heavy metal soil pollution in the world's largest antimony mine in Lengshuijiang. Concentrations of antimony were higher than background values, while heavy metal by-products of antimony mining such as arsenic, cadmium and mercury were also found.

Yichun
Yichun, Jiangxi: All-China Environment Federation (ACEF) suing Zhong'an Industry Development Ltd. for discharging wastewater containing hazardous heavy metals and arsenic. The company was ordered to pay over RMB37 million for clean-up costs, ecological restoration as well as compensation & monitoring cost.

CHINA'S FIRST EVER BASIN-WIDE ENVIRONMENTAL AUDIT

In June 2018, the National Audit Office (NAO) released the first ever audit report on ecological and environmental protection efforts in the YREB.

Below are some of the key points from the audit report:



Good News

- Since 2016, party officials from the 11 YREB provinces have conferred in 152 meetings and drawn up or revised 293 environmental regulations, with 159,900 officials appointed as river chiefs or lake chiefs
- 665 special inspections have been carried out, uncovering 97,800 illegal cases of logging, waste & wastewater discharge and other environmental violations. As a result, 4,147 cases (2,635 individuals) were transferred to judicial sanctions
- 2,486 small enterprises from 10 polluting industries (papermaking, leathermaking, dyeing, printing, coking, sulphur, arsenic, oil refining, electroplating & fertiliser industries) banned from operation across the YREB, accounting for 99.8% of the earmarked small enterprises
- Centralised wastewater treatment for 90% of industrial parks above provincial designated sizes

VS



Bad News

- Municipalities in 7 provinces violated national and provincial demarcations and illegitimately established 249 development zones, covering 298,000 hectares. 62 of them overlap with key ecological functioning zones or regions where any development has been explicitly prohibited
- 501 enterprises in 10 provinces found withdrawing water without a permit, and another 60 enterprises withdrawing more than their allotted amount
- Since 2016, 21 newly built or expanding projects in polluting industries like papermaking and petrochemicals failed to undergo environmental impact assessments (EIAs) or capacity replacement checks
- More than 34,600 cases of illegal fish electrocution in all 11 provinces in the last 4 years
- 75 development zones still have not completed EIAs as required by law, and 106 development zones have not constructed centralised wastewater treatment facilities
- As of the end of 2017, 118 municipal wastewater treatment plants failed to achieve the Grade A wastewater quality standard required

Source: Woody Chan. Audit! Yangtze River Economic Belt. China Water Risk website, 16 August 2018 The full audit report can be found at: <http://www.audit.gov.cn/n5/n25/c123511/content.html>

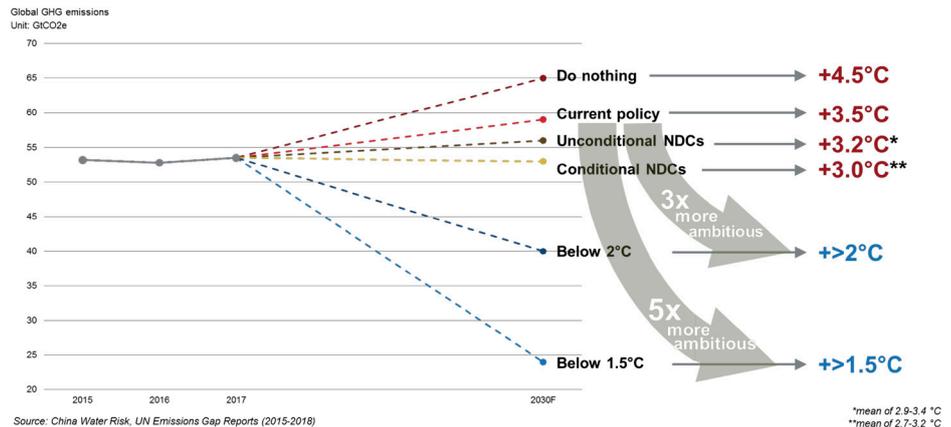
A hotter future with more rain = need more resilience

Climate change is evident & more aggressive actions are needed

Climate change is evident and its impact is being felt around the world. Based on our current national commitments by 2030, we are unlikely to limit warming to 1.5-2°C and are heading to a 3°C+ world by 2100⁷. If all the unconditional contributions in the Paris Agreement are met, at best, new projections show that the world is on a path to 2.9°C to 3.4°C (assuming that climate action continues). If the conditional contributions are also met, we will hit 2.7°C to 3.2°C¹⁸. This has serious and severe implications for our water resources.

We are unlikely to limit warming to 1.5- 2°C ... meeting the Paris Agreement will bring us to 3°C+ world by 2100 ...

CWR We are on track to fail Paris Agreement target of 2°C-must up ambitions by 3x by 2030



Source: China Water Risk based on provincial state of environment reports for 2017. For Chongqing, the figures are calculated from separate monitoring results for mainstream and tributaries of the yangtze; for Hubei, Yunnan, the figures are calculated from separate monitoring results for rivers and lakes

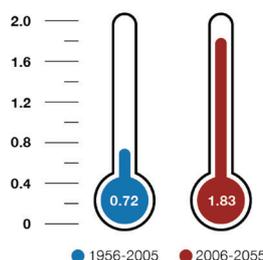
... affecting the entire water cycle

Climate change will not only lead to rising sea levels and more severe and frequent storm surges, floods and droughts, it also impacts river flow due to accelerated glacier and snow melt plus changing monsoon patterns. These risks are more imminent than we realise.

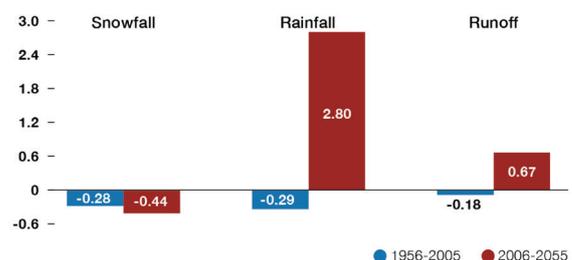
Projections for the entire Yangtze River Basin in our 2018 NWNG Report⁸ indicate a hotter future with more rain. We expect to see continued rising temperatures and decline in snowfall for the next 50 years; whereas rainfall will rise instead of decreasing and runoff will increase instead declining in the next 50 years compare the past 50 years:

Under RCP 4.5, the YRB is projected to see continued warming, increase in rainfall & runoff by 2055 ...

Temperature Change (°C) (RCP4.5)



Hydrological Changes (mm/year) (RCP4.5)



Source: China Water Risk based on data from Center for Water Resources Research, Chinese Academy of Sciences. Rainfall, snowfall and runoff change are expressed in equivalent water height. All data are calculate from ensemble model (BCC-CSM1.1, CanESM2, CCSM4, MIROC5, MPI-ESM-LR)in IPCC AR5.

...let alone under 3°- 4°C scenarios, which will likely mean greater variances

Given that the above projections were made based on a RCP 4.5 scenario, in short a 2°C world, the river will likely see greater variance in 3°C and 4°C scenarios. As it is, the region is already experiencing climate change impacts from accelerated glacier melting to intensifying floods. Every year, millions of people were affected and billions of dollars were lost due to floods.

In the source region of the Qinghai-Tibetan Plateau climate impacts are already evident

In the Qinghai-Tibetan Plateau, the source region of the Yangtze River, climate change is evident. Temperatures in the Upper Yangtze River has been rising and is projected to continue rising in the near term (2011–2040) as well as in the long term (2041–2070) under various climate scenarios¹⁹. Many studies such as Hicks *et al* (2010), Grafton *et al* (2013) and Erikssona *et al* (2015) have warned that climate change will exacerbate water challenges faced by many river basins, in particular water scarcity²⁰⁻²².

For the YREB, there are at least the following two broad challenges:

1 **Increasing uncertainty in water resource availability – too much/too little water**

Rising temperatures have rising led to the accelerated glacier melt & retreat ...

...glacier melt accelerated by 15% resulting in a 4.5% increase in water in the YRB during 1980-2020 vs. 1956- 1979

The direct impact of temperature rising is the accelerated melting and retreating of glaciers; likely leading to increased run-off in the upper watershed. For instance, according to China’s Third National Climate Change Assessment, glacier melt above Zhimenda Village in the source region of the Yangtze River has already accelerated by 15%²³. As a result, the YRB saw a 4.5% increase in water resources during 1980-2020 compared to 1956-1979²³. Compared to the level of 1971-2000, the future runoff of the Upper Yangtze River is projected to increase by 10.7–21.4% during the period of 2041–2070¹⁹.

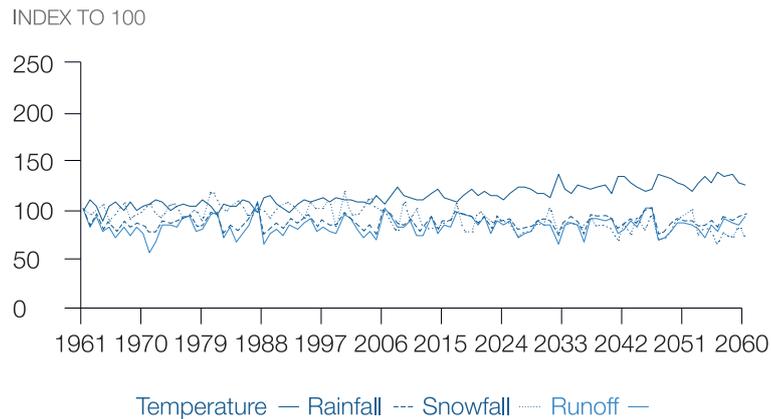
However, the increase in runoffs and rainfall does not necessarily mean more available water resources at the place and the time when water is most desired. In fact, areas experiencing drought has actually increased for the YRB at a rate of 0.13% per decade during 1949-2010²³.

It is important to note that the numbers discussed so far only show the total change in runoff over a period of time. As can be seen from the chart below, year-on-year variations for temperature, rainfall, snowfall and runoff can vary dramatically.

But more rain and meltwater may not be good ... as they accentuate seasonal fluctuations ...

Climate model projections suggest increase in runoff in the near future....

Yangtze River: Climate Change Trend (1961-2060)



Source: China Water Risk based on data calculated by Center for Water Resources Research, Chinese Academy of Sciences based on the version 1.1 of the Beijing Climate Center Climate System Model (BCC_CSM1.1) in IPCC AR5

Note that seasonal variations within a year are also widening. Extremes in the variation of runoff and rainfall throughout the year brings increasing challenges to water management at local level.

.... greater variation of runoff & rainfalls brings more challenges at local level

Urban flooding has become more intensified

2 **Economic costs arising from water-related extreme weather events**

In recent decades, urban flooding has become more intensified along the Yangtze River Basin. One study compared the rainfall records of cities in the Yangtze River Delta over two periods, 1961-1980 and 1981-2010. It found that increases of heavy rainy days exist both in the central cities and suburbs, and the increases were more intensives inside cities. For instance, days of heavy rainy days increased on average 30% for Suzhou and 32% for Ningbo.

Direct economic loss from floods
2016: >RMB166bn
2017: >RMB90bn

Such water-related extreme events have caused significant social economic costs in the YREB. In 2016, the Yangtze River, mainly the Middle and Lower Reaches, experienced the most serious summer floods since 1998, resulting in total affected people of 56 million and direct economic loss of over RMB166 billion²⁴. In 2017, such direct economic loss amounted to over RMB90 billion²⁵.

Water management will be increasingly aligned with climate action

China recognises the linkages between climate adaptation & water management ...

...adopts broad 2 pronged approach:

- 1) Control water demand (caps, efficiency & pollution targets)**
- 2) Increase water supply (build infrastructure)**

Flood prevention & sponge city pilots underway ...

... core protection zone in the YRB source region the size of Czech Republic to be formed

But YREB/YRB actions for climate adaptation & water management can be better integrated...

... A YREB-wide strategy is needed; the YWRC has started, but there's far to go

NDRC's 2018 Report 'China's Policies and Actions on Climate Change' acknowledged that there are clear linkages between climate adaptation and water resource management in addressing imbalanced water allocation and controlling loss and damage²⁶.

To address the impact of climate change, a broad two-pronged approach has been taken to improve the allocation of water resources: 1) control total water demand by setting total water use cap, and improving efficiencies in industries, irrigation and municipal water use; and 2) increase water supply by building new infrastructure. Meanwhile, actions are also being taken in assessing water ecosystem health of key rivers and lakes, and tackling soil erosion.²⁶

For the Yangtze River, current climate adaptation action is mainly focused on building shelter forests and flood prevention and control within the basin. Sponge city pilots, are an example of this, as is the establishment of new national parks to protect upper watersheds.

In January 2018, a national plan was also announced to establish a national park by 2020 in the source region of three major rivers, including the Yangtze, the Yellow and the Lancang (Upper Mekong)²⁷. The total area of the national park is expected to reach 123.1k km², nearly the size of Bangladesh (land area). Over 73% of the park will be the Yangtze source region, where 83.6% of the areas, almost the size of Czech Republic, will be assigned as core protection zone that forbids any agriculture and industrial activities²⁷. For more on sponge cities and the establishment of Eco-Redlines, please see "PILOT POLICIES & INITIATIVES TO GREEN THE YREB".

Nevertheless, in the long term to address the imbalanced water resources allocation and the different baseline water stress conditions between the YRB and YREB provinces, it is also important to align climate mitigation and adaptation actions at the provincial level to form a cohesive and comprehensive YREB-wide strategy for development.

Indeed, the YWRC has already signed a strategic cooperation agreement with China Meteorological Agency on information sharing and research collaboration in June 2017. Such cooperation should create more direct and efficient information which can help guide the formulation of policies and actions to respond to future water-related climate risks.

Such imminent threats on water resources from climate change signal accelerated and likely aggressive policies and action from the Chinese government to ensure water security. This means that it is even more important to understand the current water-nomic framework and performance of each YREB province analysed in the next chapter.

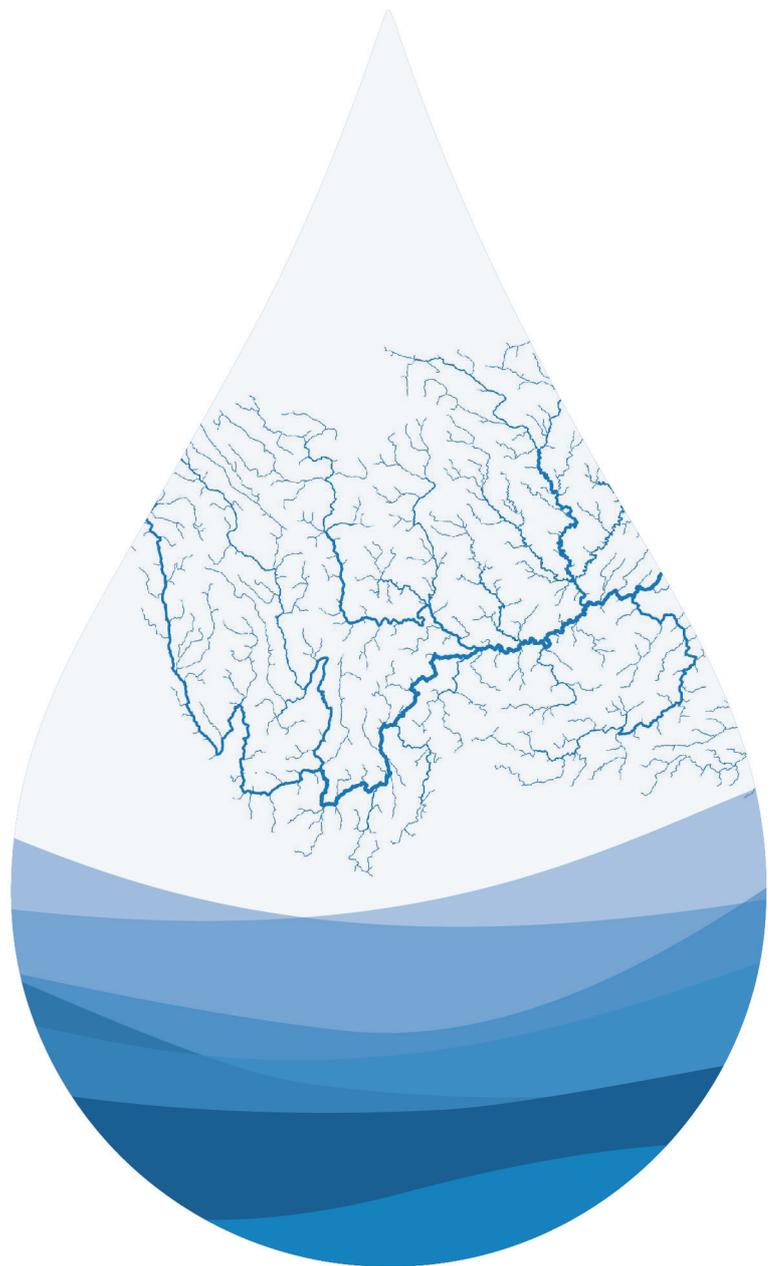


Jinsha River
(Upper Yangtze)



IDENTIFYING AREAS OF HIGH 'WATER-NOMIC' RISK EXPOSURE

CHAPTER 2



How to interpret water-nomic risks along the Yangtze

China is undergoing structural reform, changing its industries to pursue sustainable growth ...

...there's increasing regulatory risks from policies & targets set to achieve more economic growth per drop of water used + per unit of wastewater discharged...

...we have called this 'water-nomics'

China has limited water resources to develop under its previous economic model and is now on a path toward eco-civilisation, undergoing not only structural reform but also changing its industries (Made in China 2025 & circular economies) in a bid to achieve sustainable growth.

Provinces are thus not only subject to physical water risks discussed in the previous chapter, but also increasing regulatory risks resulting from policies and targets that drive provinces to achieve more economic growth per drop of water used and per unit of wastewater discharged. We have called this 'water-nomics'. As discussed, imminent threats on water resources from climate change only serve to accelerate the implementation of a comprehensive water-nomic framework as China develops with limited water resources.

In our previous brief with MEPFECO, we compared the water-nomic performance of three regions – Upper Reaches, Middle Reaches and the Yangtze River Delta (YRD) – by using the following two water-nomic indicators:

- 1) Water use per RMB10,000 GDP; and
- 2) Wastewater discharge per RMB10,000 GDP.

The results led to recommendations of priority areas of focus: *“upgrade industrial technologies in the Middle Reaches & Upper Reaches to achieve industrial efficiencies of the YRD”* and also to *“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”*²⁸.

Here in this chapter, we analyse three broad areas:

Provinces: We expand on the previous work to examine the water-nomic performance of each of the YREB provinces to identify provinces that lag. To do this, we have looked at both the current status as well as historical water-nomic performance of each of the 11 provinces for since 2005, specifically focusing on the past 3 years of the current 13th Five Year Plan from 2015-2017. At-a-glance performance of the 11 provinces are set out in **“YANGTZE REPORT CARD 2005-2017 – Can the river continue to feed China’s growth?”**

Each province’s development and water-nomic performance is unique and due to multiple factors such as aggressively improving irrigation or industrial water use to changing their crop mix and industry mix to favour less water intensive crops/sectors that generate more GDP. Given the scope and length of the report, instead of delving into how each province have improved by changing their, we have provided a case study of what one province did. We picked Jiangxi to illustrate this as it was the worst performer when we wrote the first Yangtze Water-nomic brief with MEPFECO in 2015. It is now no longer at the bottom of pack – see how it improved in **“JIANGXI WATER-NOMICS – Identifying the least favourite & upgrading industrial mix”**.

Cities: In addition to provincial analysis, it is important to analyse city clusters. With close to 60% of YREB’s population living in 5 city clusters²⁹⁻³⁴, we look in depth into their water risk exposure in **“Water risk exposure of 5 city clusters – home to 405 million people”**.

Industrial Parks: As China’s industrial heartland, other key clusters to examine are industrial parks in the YREB. With close to 200 industrial parks and development zones³⁵ have been earmarked for the YREB, we take a closer look at the 33 industrial park pilots in the YREB set to lead the region in industrial transformation and upgrading³⁶. More on this in **“Industrial parks & water risk exposure”**. Finally, we have also provided a case study of how a province is dealing with its industrial parks for one of the more polluting sectors in **“JIANGSU CHEMICALS: Factors to consider when deciding to rectify or shutdown”**.

See how Jiangxi improved its water-nomics performance over 2015-2017

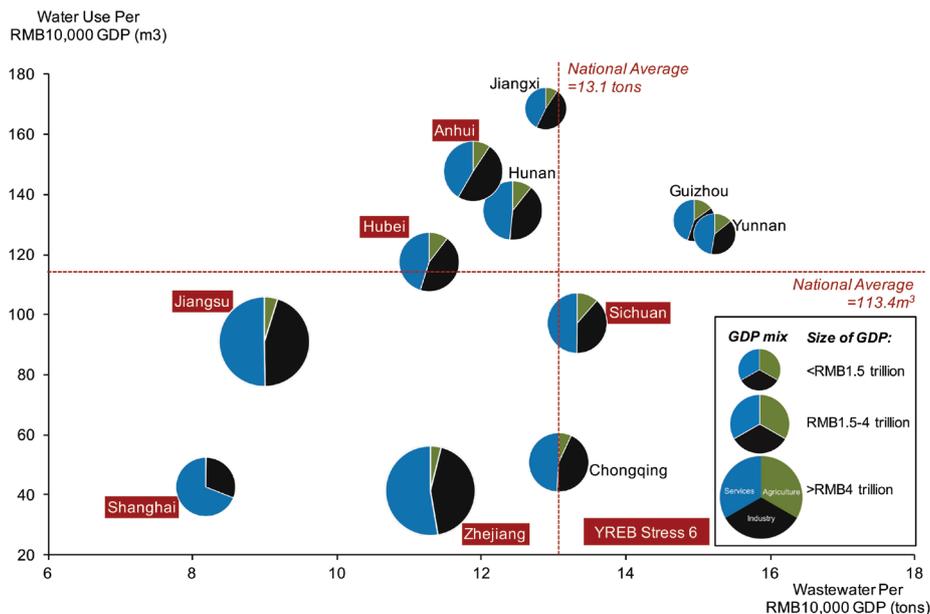
Most Upper & Middle Reaches provinces lag in water-nomic performance

The chart below shows the performance of the 11 YREB provinces and municipalities against the two water-nomic benchmarks water use/RMB10,000 GDP and wastewater discharge/ RMB10,000 GDP. The pie charts illustrate the GDP mix of each province: green, black and blue slices of each pie represent the value added from agriculture, industries and services in each province; while the size of pie charts represents the relative size of provincial GDP (in 2005 price).

YREB provinces are benchmarked against water use & wastewater discharge per RMB10,000 GDP

YRD provinces Shanghai, Jiangsu & Zhejiang (lower-left quadrant) are the best performers...

YREB Per RMB10,000 GDP Water Use vs Wastewater in 2017 (2005)



Source: China Water Risk based on NBSC

Key points to note from the chart above are:

- **The YRD provinces** of Shanghai, Jiangsu and Zhejiang located in the lower-left quadrant are the best performers; beating the national average on both indicators. They also generate the lionshare’s of GDP for the region (denoted by the size of the pie chart);
- **The Upper Reaches provinces** of Guizhou and Yunnan in the upper right quadrant are the worst performers; worse than the national average on both fronts. Sichuan and Chongqing, the other two Upper Reaches regions, perform better on the water use GDP benchmark but do not fare well on the pollution front. In general, more development means more wastewater discharge – more on this later in “**More GDP = more pollution – so control is key to improving water quality**”. Clearly this does not bode well for the river as these are not as developed (smaller size of the pie charts) as those in YRD, plus they are upstream. Here, eco-compensation schemes may be used to manage upstream/downstream pollution challenges - one such is in the Chishui river involving tri-party efforts from Guizhou, Yunnan and Sichuan – for more please see “**PILOT POLICIES & INITIATIVES TO GREEN THE YREB**”; and
- The Middle Reaches cluster fare better on the wastewater discharged per unit of GDP benchmark but are not doing so well on the water use front. Since Hubei and Anhui are part of the YREB Stress 6, they may face pressure to improve their economic efficiency of water use – more on how each province is faring in “**There are targets set for increasing economic efficiency of water**” discussed earlier in Chapter 1;
- **GDP mix matters.** In general, the greater the GDP mix is skewed towards services industries, the better the performance on both indicators as shown by the PRD cluster. We look at relationship between GDP and water use as well as wastewater discharge for the 11 YREB provinces in more detail in the following sections.

...upstream provinces Guizhou & Yunnan are the worst performers in 2017

Eco-compensation schemes can help eg Chishui river involving Guizhou, Yunnan & Sichuan

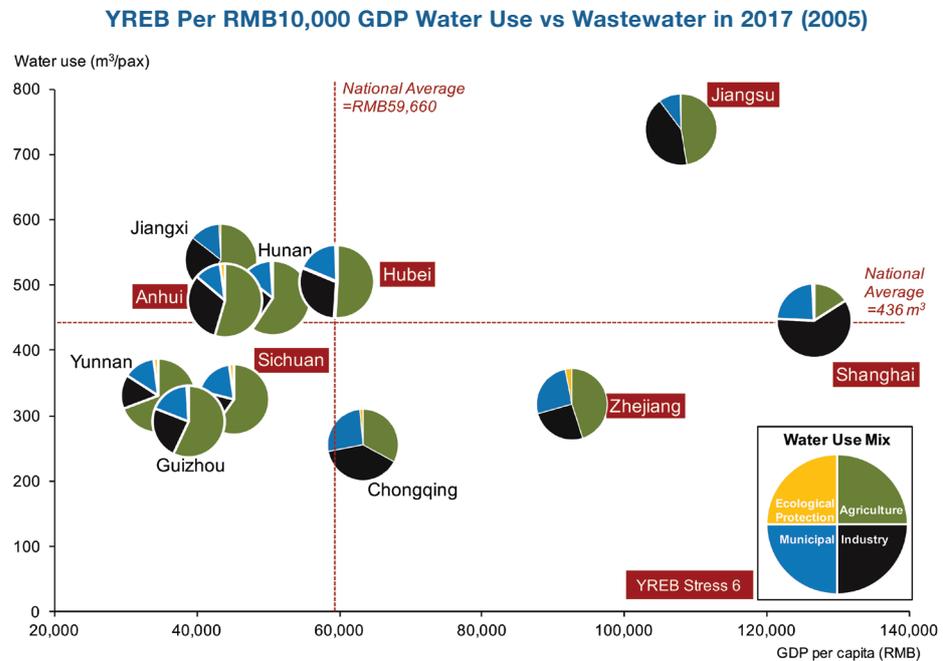
GDP mix matters – those with more services industries generally fare better

More GDP per drop depends on GDP mix

The chart below compares the provincial water use/pax of each YREB province against GDP/pax in 2017. Note that the pie charts below now reflect the water use mix of each province instead of the GDP mix:

YREB provinces are compared for water use per capita & GDP per capita

Yunnan, Guizhou & Sichuan (lower left quadrant) are the worst performers in 2017



Source: China Water Risk based on NBSC

3 out of 5 YREB provinces that use more water/pax than the national average are amongst the YREB Stress 6

Key observations from the chart above are:

- Five YREB provinces use more water/pax than the national average of 436m³. These are Jiangsu, Jiangxi, Hubei, Hunan and Anhui. Three of these (Jiangsu, Hubei and Anhui) are also amongst the **YREB Stress 6**. Of the three provinces, both Jiangsu and Anhui's water use exceed their respective 2020 water cap imposed by the Chinese government, while Hubei is on track to stay well within its water cap. More on water caps in Chapter 1 - "Provincial water caps & targets – Jiangsu & Anhui are not on track";
- Higher GDP/pax generally means higher water use/pax, except in the case of Shanghai which achieves a higher GDP/pax on less water/pax than Jiangsu. However, it may be unfair to compare Shanghai to Jiangsu, as Shanghai is a city with a lower amount of water use for agriculture, whereas Jiangsu is among China's Top 5 farming provinces by agricultural output value;
- Jiangsu is the most water intensive in terms of both total water use and water use/pax. As per the previous chart, it generated the most GDP in absolute terms, but it has the second highest GDP/pax after Shanghai. While it may be unfair to compare it to Shanghai, it is clear that Jiangsu is underperforming when compared to Zhejiang: its water use/pax is more than double that of Zhejiang; but it only generated 13% more in GDP/pax. This is largely due to agriculture – it accounts for almost half the province's water use but only contributed to less than 5% of Jiangsu's total GDP¹. What's worse is that 93% of Jiangsu are classified as 'high' and 'extremely high' water stress as discussed in Chapter 1 – "Provincial level water stress vary greatly – from 0% to 100%". Jiangsu is also not on track to meet its 2020 water cap;
- Hubei needs to better manage its agriculture water. Hubei and Chongqing have similar level of GDP/pax, however water use/pax of the former is almost twice as much as that of the latter. Moreover, 32% of the areas in Hubei face 'high' and 'extremely high' water stress; whilst, all of Chongqing face 'low' water stress conditions. Among the Upper Reach provinces, Chongqing is the top performer achieving around 50% more GDP/pax whilst keeping a lower level of water use/pax; and

Jiangsu water use/pax is more than double that of Zhejiang, but it only generated 13% more in GDP/pax...

It is also 'drier' than Zhejiang

Anhui could also do better ...

- Anhui and Sichuan have similar level of GDP/pax but Anhui's water use/pax is 44% higher than that of Sichuan. They also have very different water stress profiles - 70% of Anhui's area face 'high' and 'extremely high' water stress, compared to 7% for Sichuan. Anhui is also not meeting its water cap as discussed earlier, indicating that the province will likely come under pressure to cut water use to address its high-water stress.

There is clear room for improvement across all provinces ...

There is clear room for improvement across all provinces and they could learn from each other. Improving water use efficiency across all types of water use is a first step and changing crop/industry mix is another.

...they could learn from each other

In addition, to the above, watch out for market mechanisms that are being promoted by the government to encourage and incentivise water saving. An example of this is water rights trading between different water users. There are seven national pilot provinces identified by MWR on water rights trading in 2015; Hubei and Jiangxi are amongst them. More on water trading in "PILOT POLICIES & INITIATIVES TO GREEN THE YREB".

Also watch out for market mechanisms like water rights trading

Finally, and most importantly, do note that China has set targets for each province to achieve more GDP per drop – see below.

There are targets set for increasing economic efficiency of water use

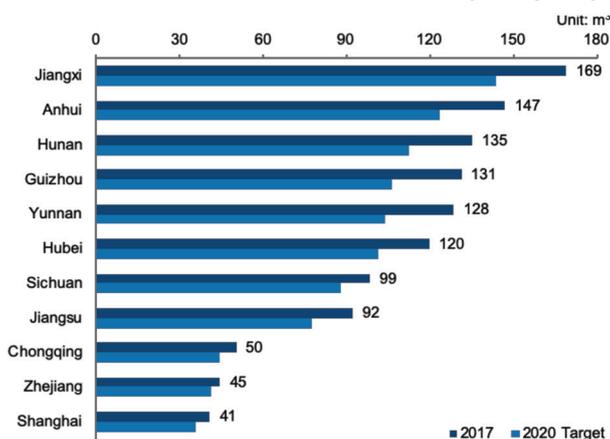
In October 2016, NDRC & MWR issued a '13FYP Action Plan on Controlling Total Water Use and Water Use Intensity' setting provincial reduction targets by 2020 for indicators such as water use per RMB10,000GDP. Based on the actual reduction achieved during 2015-2017 and the 13FYP target, we can also calculate the expected reduction from 2017 to 2020. The chart below shows the achieved figures in 2017 and the 2020 figures calculated based on provincial targets.

Water reduction targets are tied to GDP ...

Targets are set by province

... some have to improve more than others

YREB: Water Use Per RMB10,000 GDP (2005 price)



Source: China Water Risk based on NBSC, NDRC & MWR's 13 FYP provincial targets

Beware ! None of the provinces have yet to meet their 2020 water use/ GDP targets

Note that although some of the provinces are well within their water use caps as per Chapter 1, none of the provinces have yet to meet their respective 2020 water use/GDP targets. Jiangsu and Anhui are currently 'doubly bad' – exceeding their water caps plus far from their water use/GDP targets.

Shanghai, Zhejiang & Chongqing are expected to continue to lead the pack to deliver more GDP per drop

While it is evident that some provinces have further to go than others to meet the target, the targets themselves also vary. In 2017, Jiangxi had to use 3x more water than Shanghai to generate same value of GDP; by 2020, this gap is expected to remain the same, albeit that both should have improved their performance. Jiangxi, Anhui and Hunan are and will remain the least efficient by 2020, whilst the most efficient Shanghai, Zhejiang and Chongqing are expected to continue to lead the pack to deliver more GDP per drop.

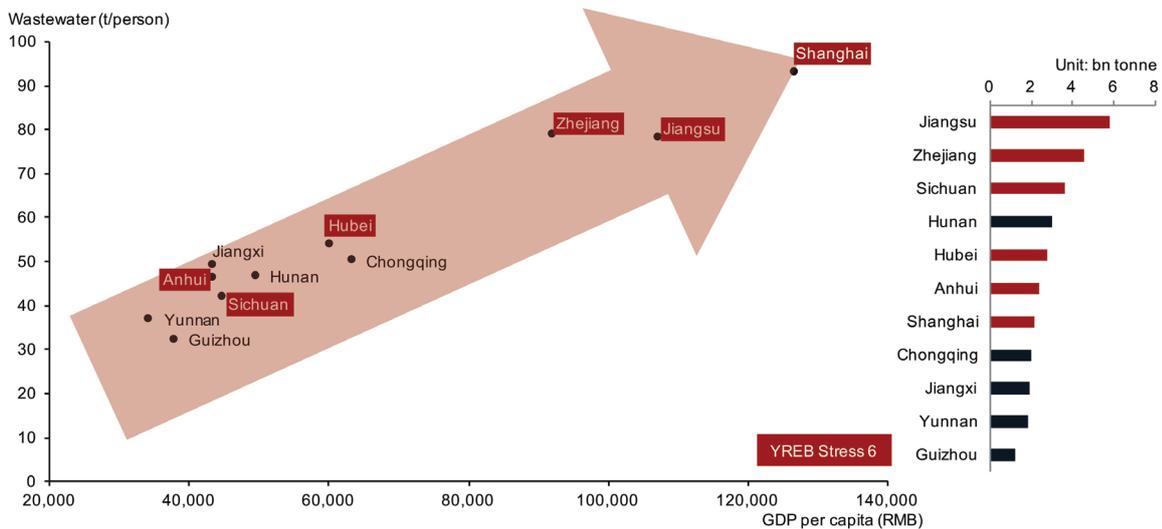
For more on Jiangxi's improvement in 2015-2017– please see "JIANGXI WATER-NOMICS – Identifying the least favourite & upgrading industrial mix". For an at-a-glance view of how each province is faring – please see "YANGTZE REPORT CARD 2005-2017 – Can the river continue to feed China's growth?".

More GDP = more pollution – so control is key to improving water quality

Pollution exacerbates scarcity & the YREB Stress 6 are highlighted in red...

In general, higher GDP/pax points to higher wastewater discharge/pax. As shown in the chart below, which compares GDP/pax to wastewater discharge/pax for the 11 YREB provinces, this trend is more pronounced compared to that of GDP/pax and water use/pax presented earlier:

YREB provinces: Per Capita Wastewater Discharge vs Pre Capita GDP in 2017



Source: China Water Risk based on NBSC

Key observations are:

Jiangsu & Zhejiang are also the two largest polluters in absolute terms

- Pollution exacerbates scarcity. Therefore, the YREB Stress 6 highlighted in the above chart in red, in particular Shanghai, Jiangsu and Zhejiang with the highest GDP/pax and the most wastewater discharge/pax, should focus on wastewater reduction. Indeed, Jiangsu and Zhejiang are the two largest polluters in absolute terms, together representing 33% of the YREB’s total wastewater discharge; and
- As for the other three provinces (Sichuan, Hubei and Anhui) of YREB Stress 6, although on per capita basis they are far less polluting than the three YRD provinces, their total wastewater discharge is still considerable, representing 28% of the YREB total.

Higher wastewater discharge means poorer surface water quality

Provinces with higher wastewater discharge, either on a per capita basis or in absolute terms, have relatively poorer surface water quality. It is important to note here that four of the YREB Stress 6 – namely Shanghai, Jiangsu, Anhui and Hubei are not meeting either one or two of their water pollution targets as discussed in Chapter 1 – “War on Pollution! 6 provinces still fail to meet targets”. Indeed, Shanghai & Anhui are not meeting their Grade I-III and their Grade V+ water quality targets.

... so Shanghai, Jiangsu, Anhui & Hubei may see clampdown or reshuffling of polluting industries
Note that these numbers do not factor in agri pollution ...

Looking forward, this could signal tighter pollution control and even more enforcement in these provinces. It could also signal accelerated transformation away from polluting industry. For more on this please see provincial case study covered later in this chapter “JIANGXI WATER-NOMICS – Identifying the least favourite & upgrading industrial mix”.

... but curbing agri pollution is key to tackling water & soil pollution

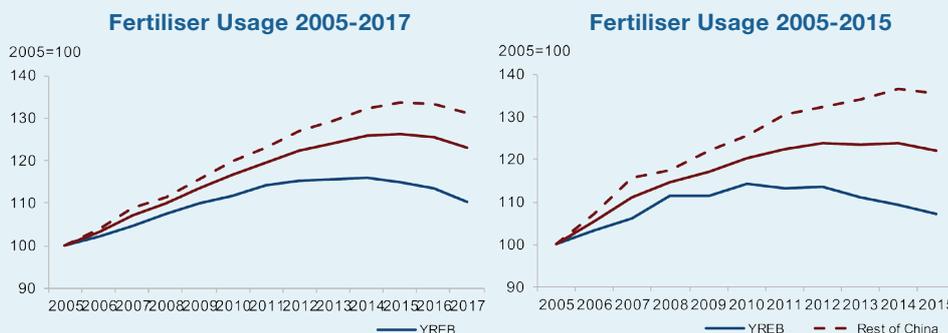
Finally, as with water use, agriculture holds the key to tackling water and soil pollution. The above-mentioned wastewater discharge figures do not include agriculture pollution, as it is not usually in the form of ‘wastewater discharged’ from one point but multiple points. For instance, in crop production, pollution occurs due to the excessive use of fertilisers as excess nutrients are often washed away before they are fixed by soil particles or taken up by plants – more in the box below on “Curbing fertiliser & pesticide use to control water & soil pollution”.

In livestock production, manure is often applied as an organic fertilizer or released directly into watercourses without treatment.³⁷ In some cases, corpses of animals were found to be disposed directly into the river resulting in the ‘dead pigs’ phenomena along the Yangtze. For an overview of pollution please see Chapter 1 – “POLLUTION RISKS ALONG THE YREB”. For opportunities in the War on Pollution please see Chapter 3 – “Trillions of RMB to fight pollution & green the YREB”

Curbing Fertiliser & Pesticide Use To Control Water & Soil Pollution

While the wastewater discharge numbers do not include non-source point pollution, the current monitoring and statistics in China do cover key pollutants from agricultural sources such as chemical oxygen demand (COD), total nitrates, total phosphorus and ammonium (NH₄). In 2015, agriculture sources account for 48% of the national total of COD and nearly 32% of NH₄³⁸. The major sources of these pollution come from excessive use of fertilisers and pesticides.

The diffuse nature of such pollution makes it harder to track down exact polluters and monitor their contribution. As a result, curbing the use of fertilisers and pesticides has become the key strategy to control agriculture water pollution in China. In 2015, the MoA issued 'Actions Plans' to achieve "zero growth" in the use of fertilisers³⁹ and pesticides⁴⁰ by 2020. These policies have led to the slowdown in both the use of fertilisers and pesticides in the YREB in recent years as shown in the charts below:



Source: China Water Risk based on NBSC

In the YREB, according to the 'Guiding Opinions on Accelerating the Control of Agricultural Non-point Source Pollution in the YREB' issued in October 2018, both the use of fertilisers and pesticides in the region are expected to fall by 3% to 5% from the 2015 level during the 13FYP. In some key agricultural regions such as Poyang Lake (Jiangxi) and Dongting Lake (Hunan), the reduction target by 2020 can be greater than 10%. Nationally, the country is on track to meet both the 2020 fertiliser and pesticide use targets; for the YREB, the fertiliser use target translates to -1% to 1% change from the 2017 level, which means 'zero growth' should already be in place in 2017/2018.

Other than curbing use, the above policy also includes other measures such as improving fertiliser utilisation rates, increasing soil test coverage and promoting livestock waste utilisation and treatment and so on. This shows that, it's not just industries and cities in the YREB undergoing fast change due to the War on Pollution; the agricultural sector is also impacted. It is worth noting here that 2017 figures show that all YREB provinces are performing within their 2020 COD & NH₄ emission targets with the exception of Guizhou which exceeds its NH₄ target by 7%^{29,41}.

Historical Trends point to Jiangsu, Anhui & Shanghai as higher risk exposure

Historical performance of the 11 YREB provinces can also help identify hotspots. We have therefore analysed historical water-nomic performance of each of the 11 provinces for since 2005, specifically focusing on the past 3 years of the current 13th Five Year Plan from 2015- 2017.

Historical analysis shows visible trends of improvements across various indicators ...

- From the results, we are able to see clearly the improvement across the following:
- slowed increase in water use;
 - slowed increase or fall in wastewater discharge; and
 - increasing economic efficiency in water use and wastewater discharged.

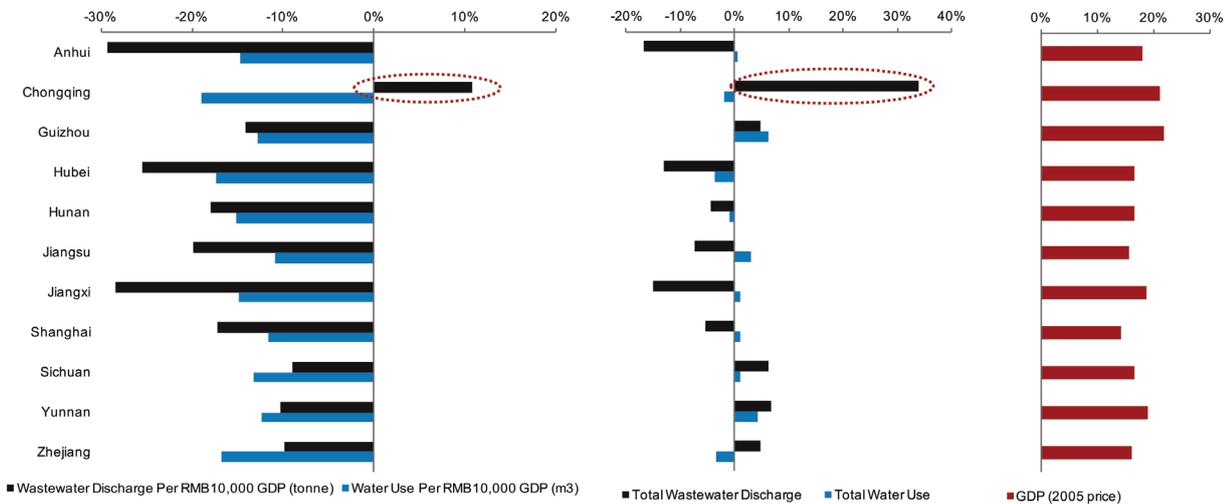
... progress most visible in recent years 2015-2017

Such progress was most visible in the recent years from 2015 to 2017, as a result of more stringent regulations and strengthened policy measures on water as a result of China's 'War on Pollution' and the ensuing Water Ten Plan issued in 2015.

The at-a-glance performance of the 11 provinces against various targets and benchmarks are set out in "YANGTZE REPORT CARD 2005-2017 – Can the river continue to feed China's growth?", while their recent performance (2015-2017) is discussed in detail below.

The charts below show the performance of the 11 YREB provinces between 2015 and 2017 across various water-nomic indicators. The provinces are listed alphabetically:

YREB Provinces: Changes between 2015-2017



Source: China Water Risk based on NBSC, GDP is adjusted for 2005 prices.

It is clear that there are significant improvements across most of the provinces. Key observations of note are as follows:

...GDP has also improved

- GDP has increased by at least 14% (lowest Shanghai; highest Guizhou) across each of the 11 provinces as per the chart on the far-right;

Chongqing is the only province with worsening water-nomic performance

- Chongqing is the only province with worsening water-nomic performance: a 19% fall in water use per RMB10,000 GDP but an 8% increase in wastewater discharge per RMB10,000 GDP as per the chart on the far-left. This was because its total wastewater discharge increased by 34% from 1.5 billion tons in 2015 to 2.0 billion tons in 2017 as per the chart in the middle;

- Guizhou, Sichuan and Yunnan saw increases in both water use and wastewater discharge, but thanks to GDP growth outpacing the rise in both of these measures, their water nomic indicators have improved;

- For improvements in wastewater discharged per RMB10,000 GDP:

- Jiangxi, Anhui and Hubei display the biggest improvements in wastewater discharge per RMB10,000 GDP thanks to >10% fall in total wastewater discharge;

- It should be noted that despite, leading the pack with almost a 30% improvement in wastewater discharged per RMB10,000 GDP, Anhui is still not on track to meet either of its 2020 Grade I-III and Grade V+ water quality targets;

Jiangxi's progress means it's no longer the worst performer; replaced by Guizhou & Yunnan

- Meanwhile, Jiangxi's improvement means that it is no longer the worst performer; Guizhou and Yunnan now takes its place. Moreover, Jiangxi has met both its Grade I- III and Grade V+ water quality targets. For more on how Jiangxi managed this, please see the case study "JIANGXI WATERNOMICS: Identifying the least favourite & upgrading industrial mix".

Anhui is the worst performer amongst the YREB Stress 6

- With regards to the **YREB Stress 6**, we have the following observations:

- Despite improvement, Anhui is the worst performer amongst the YREB Stress 6. Challenges clearly remain as 70.3% of its areas face 'extremely high' or 'high' water stress. What's worse is that Anhui's 2017 water use exceeds that of its 2020 target. Also, since pollution exacerbates scarcity, these observations should be considered along with its laggard performance in meeting its water quality targets discussed above;

Water stress YRD should continue improving ...

- Zhejiang can better rein in pollution;

- Shanghai look to lower wastewater

- Jiangsu prioritise improving water use efficiency

– The three YRD provinces of Shanghai, Jiangsu and Zhejiang all made improvements in both their water-nomic indicators. Given that significant areas are located in ‘*extremely high*’ or ‘*high*’ water stress – Shanghai (99.4%), Jiangsu (93.3%) and Zhejiang (42.0%), it is essential for them to continue improving to ensure long-term water security. However, only Zhejiang (the least stressed of the three), managed to reduce its total water use. That said, Zhejiang could do better with reining in pollution, its total wastewater discharged increased during the period while both Jiangsu and Shanghai managed to reduce theirs, but note that it is meeting both its water quality indicators; while Shanghai like Anhui is not meet either.

Looking forward, Shanghai should thus look for further gains in wastewater reduction and pollution control while Jiangsu should prioritise improving water use efficiency; it should by rein in water use as its 2017 water use exceeds that of its 2020 target cap.

Hubei has yet to meet its Grade V+ water target

– Lastly, Hubei needs to continue to diligently continue to reduce wastewater discharge and control pollution as it is yet to meet its Grade V+ water quality target and 31.6% of its areas are facing ‘*extremely high*’ or ‘*high*’ water stress.

Given rising water and climate risks faced by the YREB plus the need for the region to continue to drive growth for China, we expect the country to continue to seek more value from every drop of water used. Already since the 13FYP, indicators such as water use per unit GDP and water use per unit of industrial value added (IVA) have also become important measures.

13FYP includes indicators such as:

- water use per unit GDP
- water use per unit of industrial value added

It is worth noting here that despite improvements in water use per GDP generated, none of the 11 YREB provinces have met Water Use Intensity targets – please see “**There are targets set for increasing economic efficiency of water use**”. On top of such targets, better water governance and market mechanisms will also help accelerate such process by providing incentives and mobilising finance towards local actions.

We also do not expect to see a slowdown in China’s war on pollution, especially for the YREB. In February 2019, the MEE started a two-year YREB wide special programme to inspect and tackle pollution sources along the Yangtze River. Chongqing and Taizhou city (Jiangsu Province) are selected as the two pilots to kick-start this action⁴².

No slowdown in China’s war on pollution ...

Pollution actions along the Yangtze will no doubt face more scrutiny. According to the minutes of a symposium held in February 2019 on issues related to handling criminal cases of environmental pollution, the following two kinds of pollution actions in the YREB will face aggravated punishment⁴³:

YREB will face more scrutiny ... certain pollution actions expected to face aggravated punishment

1. inter-provincial discharging, dumping, disposing of radioactive waste and/or wastes containing infectious disease pathogens, toxic substances or other harmful substances; and
2. the discharging, dumping, disposing of radioactive waste and/or wastes containing infectious disease pathogens, toxic substances or other harmful substances into national level key rivers, lakes and other transboundary rivers.

Given the separation of inter-provincial pollution, we expect to see more focus on eco-compensation schemes – more on this in Chapter 3.

Finally, while provincial performance trends shed light on provincial hotspots, it is also important to examine clustered risks along the river. These come in the form of city clusters and industrial parks which we explore in the next section following the Yangtze Report Card and the Jiangxi Water-nomics Case Study

YANGTZE REPORT CARD 2005-2017 – Can the river continue to feed China's growth?

Anhui Chongqing Guizhou Hubei Hunan

Provincial Map
(The Yangtze River & lakes are shown in blue colour)



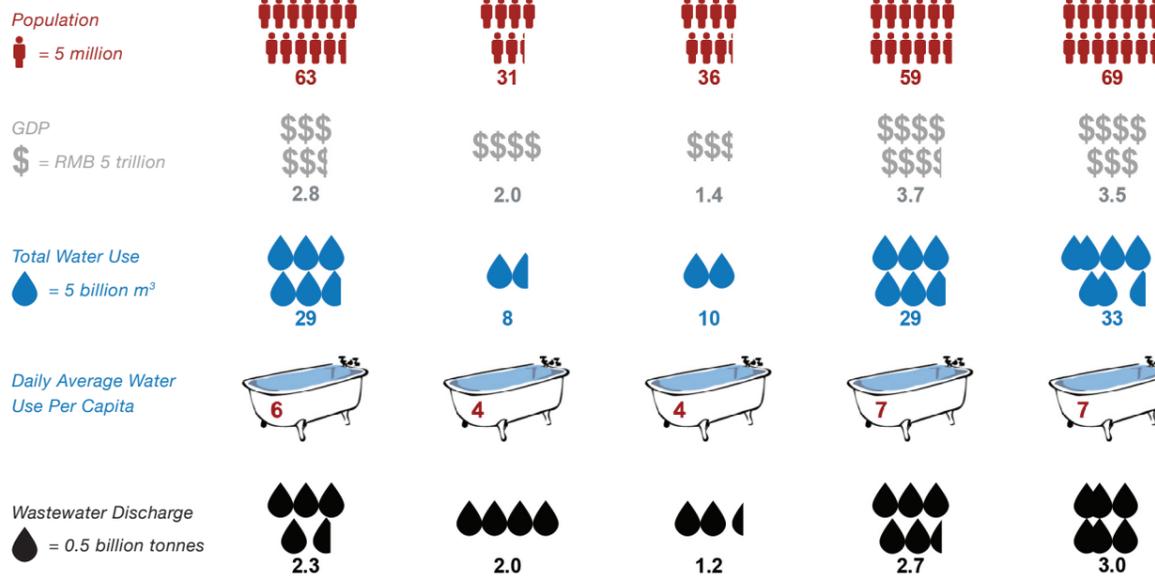
Share of area in 'extremely high' & 'high' water stress



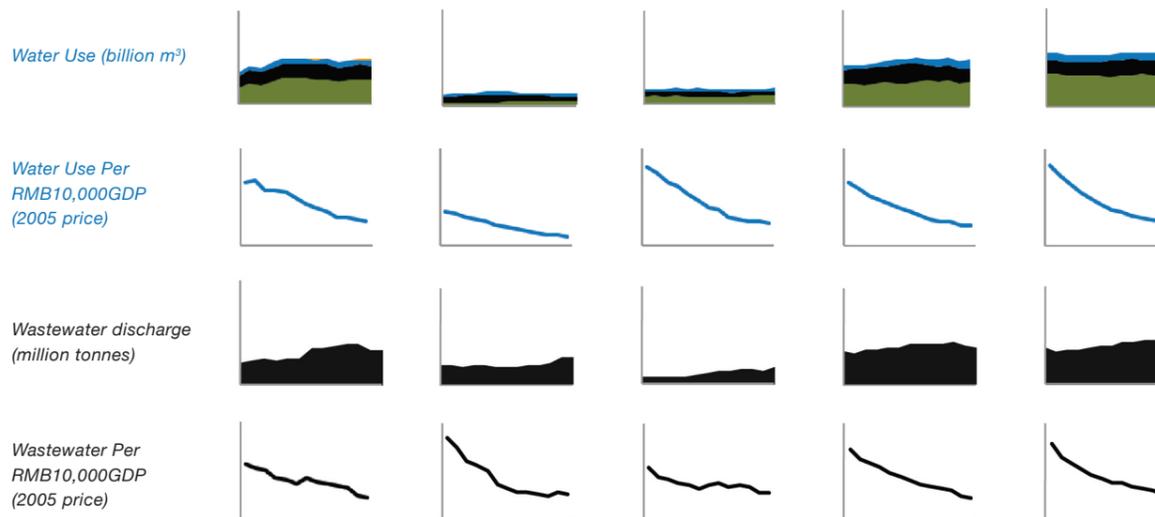
Water quality vs 2020 target:
Grade I-III > 75%
Grade V+ < 2.5%



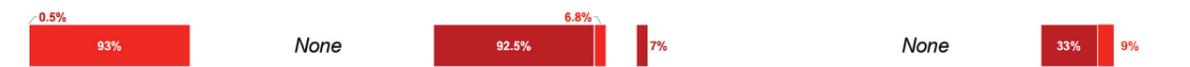
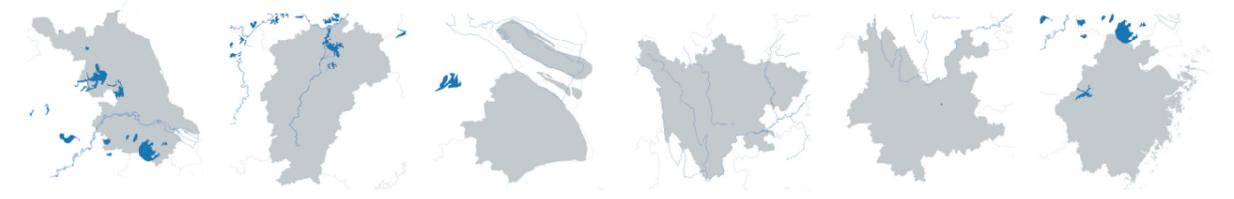
2017 Status



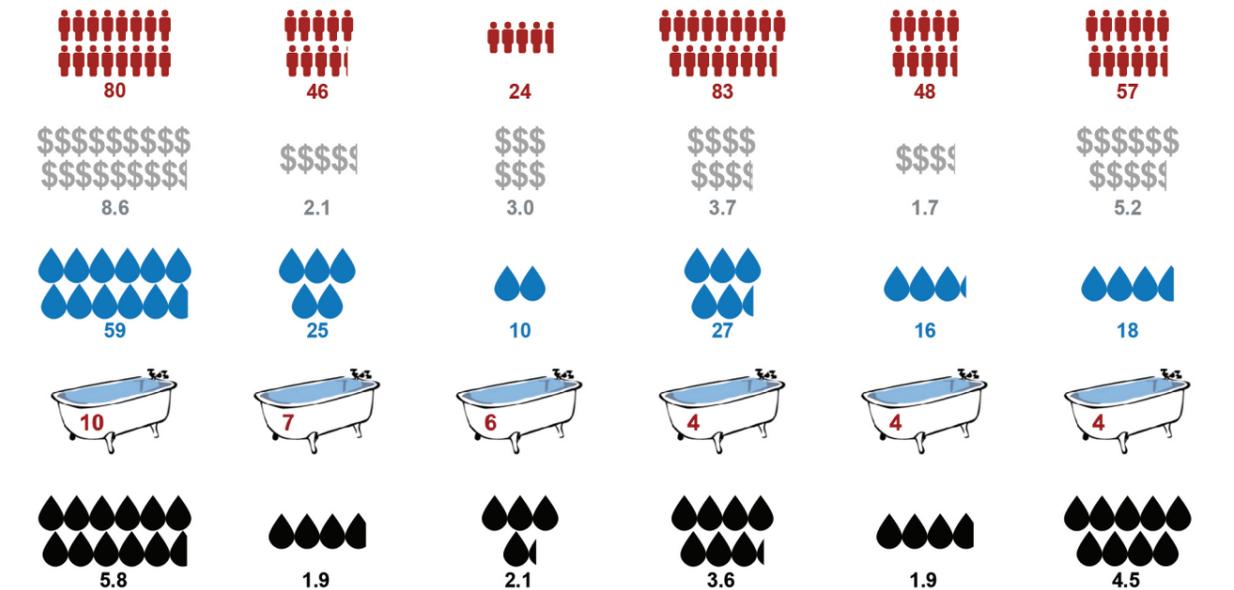
Historical Trend (2005-2017) (Y-axis set in same scale for each indicator)



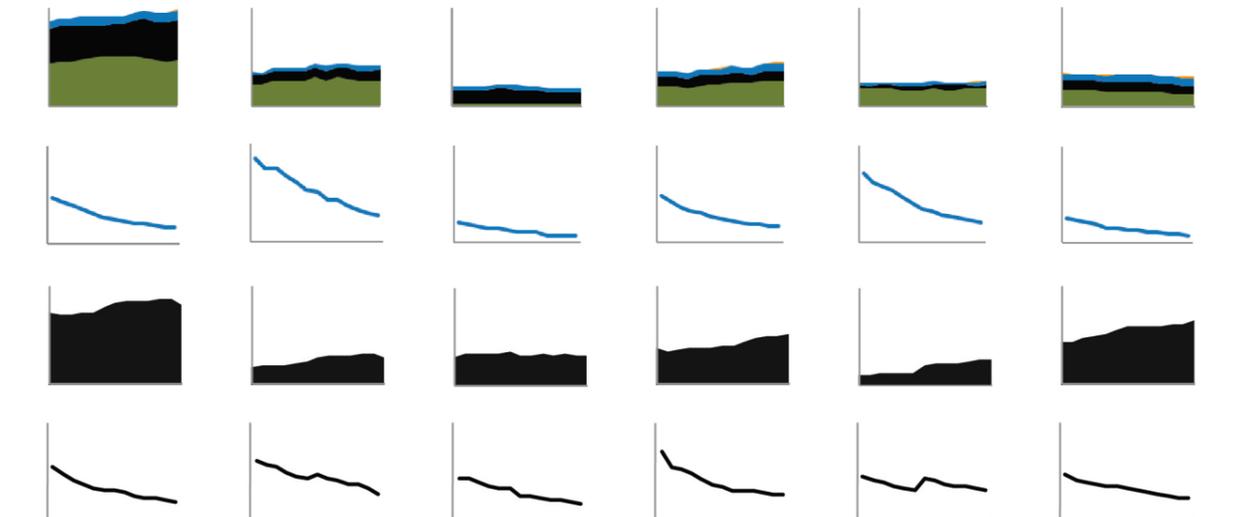
Jiangsu Jiangxi Shanghai Sichuan Yunnan Zhejiang



2017 Status



Historical Trend (2005-2017) (Y-axis set in same scale for each indicator)



JIANGXI WATER-NOMICS: Identifying the least favourite & upgrading industrial mix

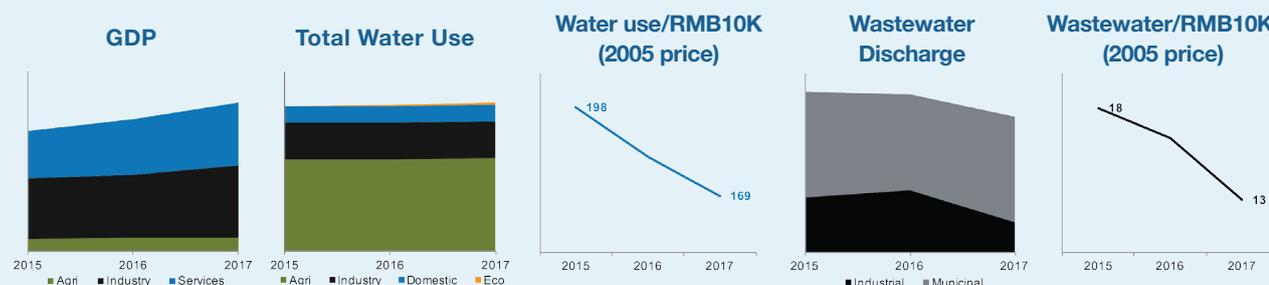


To achieve economic growth with limited water, an ideal scenario would be to choose industries with lower water use, lower wastewater discharge but higher value added to the economy. This does not take into account other factors such as social benefits such as employment, and other environmental impacts such as energy consumption and air emissions.

In our analysis of provincial water-nomic performance in chapter 2, Jiangxi was the worst performer in 2015 but made significant improvement during 2015-2017. Jiangxi thus proves useful as a case study - what actions have been taken done at the provincial level? What triggered such change? What problems remain unresolved?

What has changed during 2015-2017?

As shown in the charts below, Jiangxi's economy is primarily driven by industry and services, while agriculture is the main water user. While GDP rose, total water use stayed relatively flat during 2015-2017 resulting in improvements in water use per RMB10,000 GDP (2005 constant price) by nearly 15% from 198m³ in 2015 to 169m³ in 2017. At the same time, Jiangxi's total wastewater discharge declined by over 15% with monitored industrial sources falling by an astonishingly 46% whilst municipal and other sources remained relatively flat. Such movements led to a marked improvement in its wastewater discharge per RMB10,000 GDP (2005 constant price) by over 28% from 18 tonnes in 2015 to 13 tonnes in 2017.



Source: CWR based on NBSC, China annual statistical yearbooks

Jiangxi's improvements are thus largely industry-led. Provincial wastewater statistics by industry are not complete and only cover key monitored factories. However, they provide good representation: in 2017, they accounted for 90% of the province's total industrial wastewater discharge. That year, 33 out of the 36 industries saw falls in wastewater discharge from the 2015 level and 'smelting & pressing of non-ferrous metals' dropped out of the province's Top 5 most polluting industries, replaced by the 'manufacture of computers, communication equipment and other electronic equipment'.

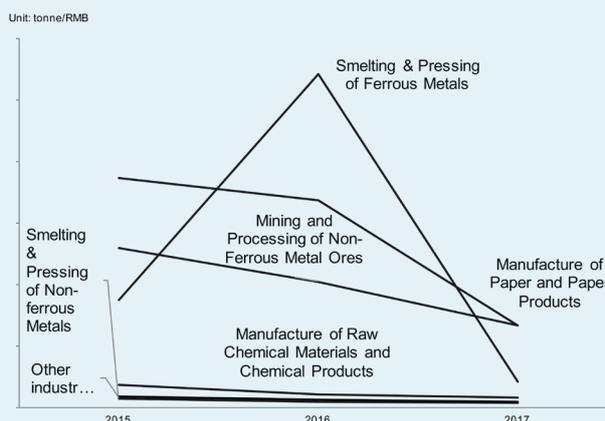
Clearly polluting but not adding value...

In 2015, the top 5 most polluting industries accounted for 61% of total wastewater discharged: they are manufacture of paper & paper products (16%), mining & processing of non-Ferrous metal ores (15%), smelting & pressing of ferrous metals (15%), manufacture of raw chemical materials & chemical products (10%) and smelting & pressing of non-ferrous Metals (5%). Despite the significant share of wastewater, the top 5 most polluting industries only contributed 27% of total IVA in 2015. In particular, the Top 3 contributed merely 6% of total IVA in 2015 but accounted for 46% of industrial wastewater discharge; in 2017, the Top 3 accounted for 5% of total IVA and 41% of industrial wastewater discharge.

Due to difference scope between disclosed data on wastewater discharge by industry and IVA by industry, we are not able to calculate the exact value of wastewater discharge per RMB10,000 of IVA by industry. However, the above mentioned top 5 most polluting industries can be analysed for their relative changes (see right-side chart).

Jiangxi is China's key production base for several non-ferrous metals. According to the production quota set by the Ministry of Natural Resources for 2018, Jiangxi accounts for 44% of China's total production quota of Medium Heavy Rare Earth Elements (MHREEs) (measured in terms of Rare Earth Oxides) as well as 47% of mining quota of tungsten concentrate (measured in terms of Tungsten trioxide)¹. According to the provincial land and resources department, for 2018, 99.9% of Jiangxi's MHREEs (see charts below) and 64.3% of tungsten concentrate production came from Ganzhou city alone⁴⁴.

Jiangxi: Wastewater Discharge/RMB 10,000 Industries Value Added (2015-2017)



Source: CWR based on Jiangxi provincial statistical yearbooks, 2016-2018



Source: China Water Risk based on MNR

Source: China Water Risk based on provincial land & resources department

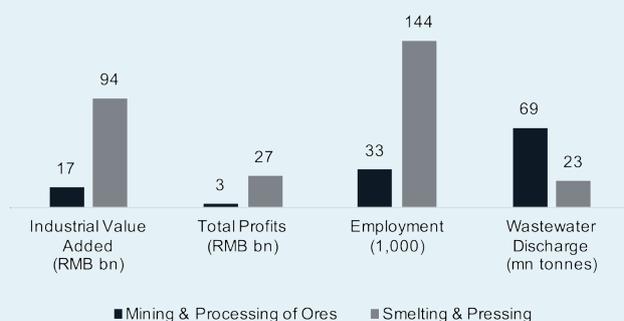
Non-ferrous metals environmental costs of mining outweigh economic gains = moving up the value chain ...

The value added from mining & processing of non-ferrous metal ores in the whole of Jiangxi was only RMB17.2 billion in 2017 and the total profits were RMB2.9 billion⁴⁵. In comparison, the Ministry of Industry & Information Technology (MIIT) estimated that the initial costs to clean up polluted rare earth mines to be RMB38 billion for Ganzhou city alone⁴⁶. Clean-up costs are more than 10x profits!

According to Ganzhou City's '13FYP on Ecological and Environmental Protection', the city intended to invest RMB1.96 billion on ecological environment restoration of abandoned rare earth mines between 2016 and 2020. An additional RMB2.94 billion will be spent on abandoned tungsten and other mines⁴⁷. By 2018, both central and provincial fiscal budget would have allocated nearly RMB2.2 billion towards 107 projects on the geological and environmental restoration of mines⁴⁸. Clearly, Ganzhou City and Jiangxi are operating at a loss.

Given Jiangxi's dominance in supplying MHREEs that are strategic to China, it is unrealistic for the local and provincial government to abandon non-ferrous metals related industries. An option would be to move up the value chain beyond mining & processing of non-ferrous metal ores' to 'smelting & pressing of non-ferrous metals'.

Jiangxi: Comparison of Non-Ferrous Metal related Industries in 2017



Source: China Water Risk based on Jiangxi Statistical Yearbook 2018

As shown in the left-side chart, 'mining & processing of non-ferrous metal ores' discharged 3x wastewater than 'smelting & pressing', but generated only 18% of the IVA of the latter in 2017. In addition, 'smelting & pressing' generated over 8x more profits and employed 3.4x more people.

Thus, it makes sense for Ganzhou city and Jiangxi to expand the industry towards 'smelting & pressing' and making higher-value products using non-ferrous metals. This has been echoed in Ganzhou City's 13FYP where rare earth mining is among sectors that will be restricted, whilst rare earth new materials & application are being encouraged⁴⁹.

Not yet a rosy picture...

However, it is not yet the time to celebrate the positive change in Jiangxi. During one central government environmental inspection carried out in Ganzhou City in June 2018, a series of fraud and forgeries were found⁴⁸. For instance, the report submitted by the Forestry Bureau to the inspection team in 2017 purposefully used the 2018 target figure provided by the Mining Bureau, which led to 10km² less in the total area of abandoned rare-earth mines. The third-party engineering company, assigned by the local Soil & Water Conservation Bureau, conducted field visits for only 20% of the sites, and forged data for the other sites. It even used photos taken in 2015 for conditions in 2017. Nevertheless, the Soil & Water Conservation Bureau still approved the assessment report. In addition, the Mining Bureau made inconsistent reporting in two versions of its report by purposely misreporting 2.61km² of untreated abandoned rare-earth mines as restored.

This misconduct and inaction of local bureaus was partly facilitated by the segregated governance structure, which should be addressed by the ministerial reform announced in March 2018 – more on this in "Ministry Reform: 9 Dragons to 2" in Chapter 1. In February 2019, Jiangxi reformed its 11 city-level natural resource bureaus.⁵⁰

Going forward, the environmental and natural resource departments should strictly enforce relevant central and local laws and regulations. Monitoring should be strengthened and improved by using technologies such as real-time monitoring, satellites and blockchain. The public, especially the media and local NGOs, could be encouraged to become the on-ground force for more regular inspection, instead of being solely reliant on central government inspection.

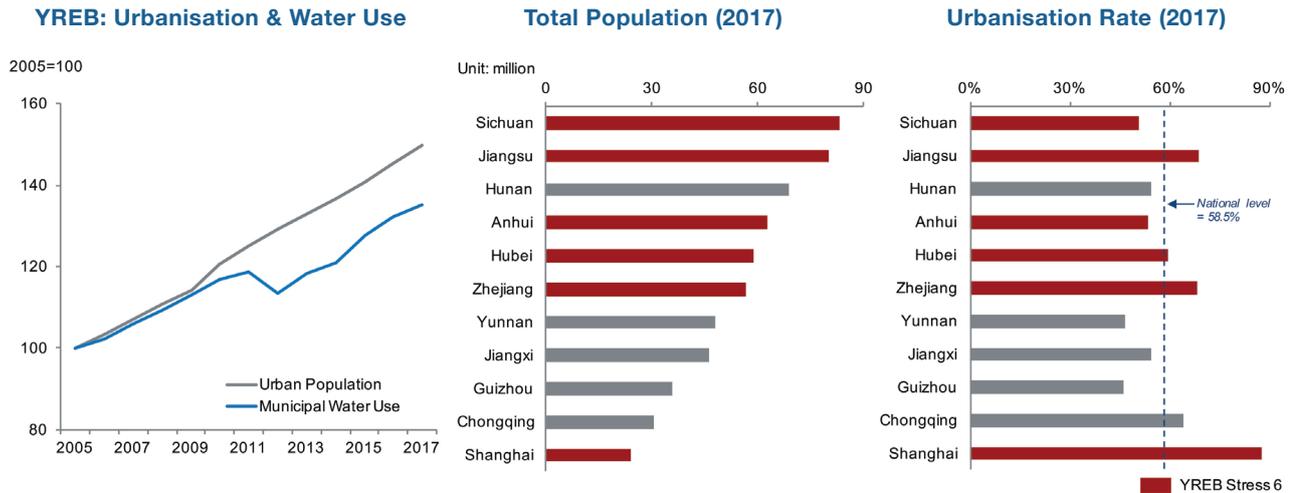
Water risk exposure of 5 city clusters – home to 405 million people

595mn people live in the YREB; most of these live in cities...

...urbanisation rates range from 46% to 88%

Over the past decade, the YREB has been rapidly urbanising and by 2017, 58.3% of its population live in the cities. Not surprisingly, this has been accompanied by rising municipal water use as shown in the left chart below.

By 2017, 595 million people lived in the YREB. The population spread varies from 83 million in Sichuan to 24 million in Shanghai. The urbanisation rates also vary across YREB provinces: from a low of 46% in Guizhou to a high of 88% in Shanghai; four of the 11 provinces have urbanisation rates above that of the national average of 58.5% as per the charts below:



Source: China Water Risk based on Jiangxi Statistical Yearbook 2018

Key points to note are:

- In general, upstream provinces have higher urbanisation rates compared to downstream provinces, reflecting development. The exception is the municipality of Chongqing with nearly 20 million urban residents; and
- The YREB Stress 6 (marked with red-coloured bars) account for 65% of the YREB's urban population and are more urbanised – as a whole, 62% of the group's population live in cities. Except for Sichuan and Anhui, the rest four provinces all have an urbanisation rate similar or higher than the national level of 58.5%.

65% of the YREB's urban population live in the YREB Stress 6

YREB's 5 major city clusters house -RMB24trn -405mn people

...this is greater than the population of the US

There are five key city clusters that are important to the YREB. They are the YRD³⁰, the Middle Reaches³¹, Cheng-Yu (Chengdu-Chongqing)³², Qianzhong (Central Guizhou)³⁴ and Dianzhong (Central Yunnan)³³. Together, they represent a combined GDP of around RMB24 trillion and a total population of 405 million during 2014/2015 driving nearly 78% of the YREB's GDP and accounting for 69% of its population. In short, these 5 city clusters represent 35% of China's GDP and 29% of its national population. For perspective, if the YREB's urban dwellers were to form a country, it will be more populous than the US.

The YREB 5 city clusters are important to China

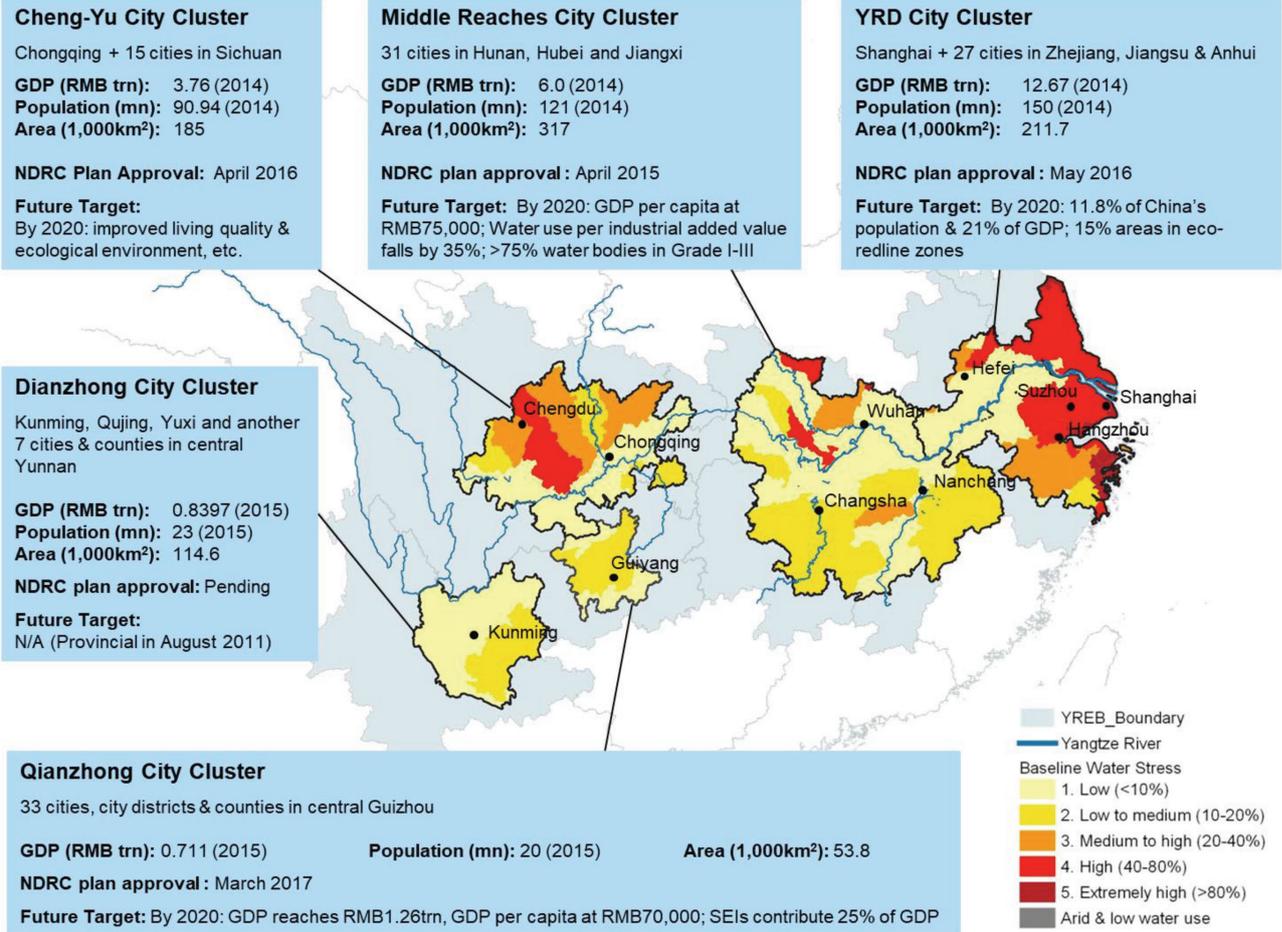
YREB 5 city clusters = roughly a third of China's GDP and population



Source: Development plans of the five city clusters

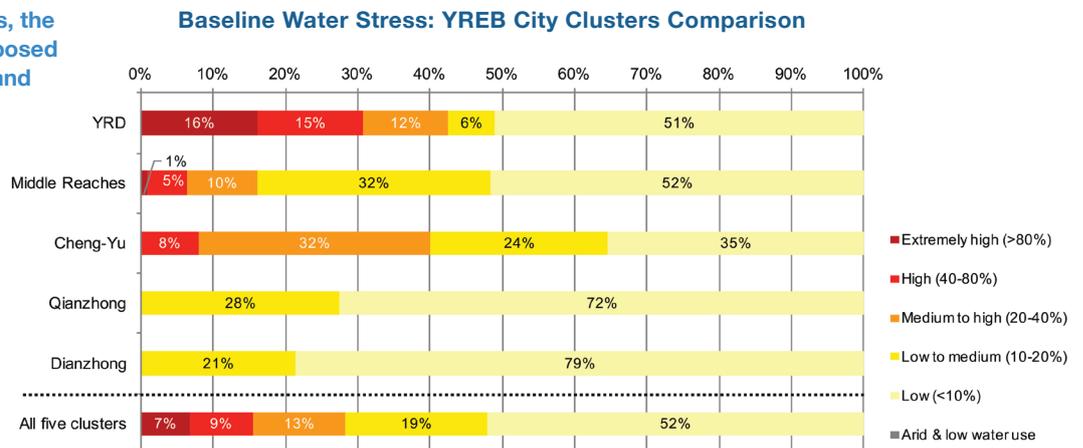
The fact that many of these lie in the YREB Stress 6 gives rise to clustered exposure to water risk. We therefore mapped these city clusters to analyse their water risks. As can be seen from the map and analysis below, significant areas of some city clusters are exposed to 'extremely high' and 'high' water stress.

CWR 5 Important City Cluster in the YREB & Water Stress



Source: China Water Risk based on baseline Water Stress from WRI Aqueduct Global Map 2.1, river shapefile from FAO AQUAMaps, and country and provincial boundary from Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences

Of the 5 city clusters, the YRD is the most exposed to 'extremely high' and 'high' water stress



Source: China Water Risk based on World Resources Institute Aqueduct 2014 and development plans of the five YREB city cluster

16% of 5 YREB city clusters' area in 'high' or 'extremely high' water stress

The chart above summarises the baseline water stress conditions of the five city clusters. Key points to note are:

- As a whole, nearly 16% of the areas in the 5 YREB city clusters face 'high' or 'extremely high' water stress;
- The YRD, Middle Reaches & Chengyu are clearly exposed to these two levels of high water stress. Such share is highest in the YRD City Cluster at nearly 31%, whilst only 6% for the Middle Reaches City Cluster and 8% for the Cheng-Yu City Cluster; and
- The two clusters in the Upper Reaches have most of their areas under 'low' or 'low to medium' water stress.

Urbanisation = even more people & GDP in the 5 city clusters

As the YREB continues to urbanise, future population will be even more concentrated in such city clusters. Water demand in these cities will likely rise while water supply is increasingly uncertain due to climate change. The plans of these five city clusters thus all highlight the need to ensure water security and safety, control total water use, and improve water quality and water efficiency. The plan for the Middle Reaches City Cluster also sets a specific target to cut water use per unit of IVA by 35% from 2014 to 2020.

12 out of the 30 'Sponge City' pilots are in the YREB

In addition, the plans all included disaster alleviation, especially floods. The need to cope with climate change is also recognised in the plans for the Middle Reaches, Cheng-Yu and Qianzhong clusters. In fact, 12 out of the 30 national 'Sponge City' pilots are in the YREB, covering all the provinces. That said, a YREB-wide climate strategy is still missing.

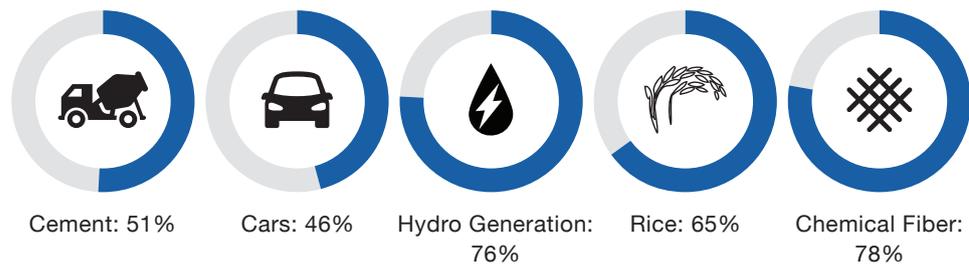
The good news is that relevant research has been initiated. In 2018, the National Natural Science Foundation of China (NSFC) selected "Water cycle changes in the YREB and its feedback mechanism on urban green development in the Middle & Lower Reaches" as one of its key projects⁵¹. The project, led by several leading institutes, was launched in January 2019²⁶.

Industrial parks & water risk exposure

The YREB is home to some of the most important manufacturing hubs in China. Since the YREB's industrial water use accounted for almost two-thirds of China's total industrial water use, optimizing YREB's industry is key in optimizing growth on limited water. For more perspective, as of the end of 2017, the YREB also accounted for 46.7% of China's export and 39.8% of import in value⁵³. The region also held significant shares of key agriculture, industrial and energy production as shown in the charts below:

YREB is key in China's agri, industrial & energy production....

YREB's significant shares of China's agricultural, industrial and energy products (2017)

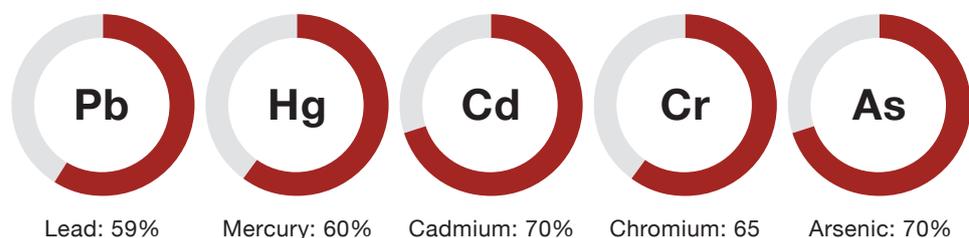


Source: China Water Risk based on NBSC

Unfortunately, booming industries came with hefty environmental costs. The YREB accounts for a significant part of China's 2017 heavy metals discharge across the 5 heavy metals measured by the government as shown in the chart below:

....but also contribute significant shares of heavy metal discharge

YREB's significant shares of China's heavy metal discharge in wastewater (2017)



Source: China Water Risk based on NBSC

China has been focusing on industry upgrading & economic transformation ...

Since many of the factories and industrial areas are located within or near the city clusters, plus some are already facing 'high' to extremely high' water-stress, it is important to draw up cohesive and comprehensive plans for the future growth of both city clusters and industrial parks.

In recent years, the YREB, especially the YRD, has been at the forefront of China's path more growth on less water and less pollution. Industry upgrading and economic transformation have been the government's key focuses. In July 2017, NDRC and four ministries issued a joint policy to 'green' industries in the YREB through multi-pronged strategies listed in the diagram below:

Greening industries in the YREB

Optimise industry spatial distribution

- Improve industry planning
- Upgrade industrial parks
- Guide & regulate industry clustering
- Strictly control polluting industry relocation clustering

Greening traditional manufacturing industries

- Clean production
- Improve energy efficiency
- Resource recycling
- Green manufacturing system

Water saving & pollution control

- Increase water efficiency
- Water recycling & reuse
- Control key pollutants

... Multiple actions implemented to green the YREB

Assurance measures

- Strong governance
- Standards & technical support
- Preferential policies
- International exchange & cooperation
- Public education

Adjust industry mix

- Cut backward & excess production capacity
- Accelerate technological upgrade of heavy & chemical industries
- Promote smart & service oriented manufacturing
- Scale up energy saving & environmental protection industry

Source: China Water Risk, various policies to green the YREB

Water consumption per unit IVA expected to fall by 25% from 2015 to 2020

According to the policy, by 2020, energy consumption and water consumption per unit industrial value added of industries in the YREB are expected to fall by 18% and 25% compared to 2015, respectively.

47 hazardous chemical plants will be relocated & retrofitted by 2020

To achieve these targets, multiple actions need to be made in improving water efficiency, optimizing industrial mix, and promoting water saving by all users. Factories in polluting industries such as steel, non-ferrous metal, paper & pulp, dyeing, electroplating and chemicals, which are located in urban areas along the river, are required to be relocated, retrofitted or shut down. Before 2020, 47 hazardous chemical plants along the river will need to be relocated and retrofitted; many of which will move into industrial parks where waste and wastewater will be centrally collected and treated.

Industrial parks are key to the transformation ...

Industrial parks are key to this transformation. China hopes to form 195 industrial parks and development zones in the YREB into five world-class manufacturing clusters along the Yangtze – they are electronics & IT, high-end equipment, cars, home appliances, and textiles & apparel⁹⁵. These five world-class industry clusters will be supported by the five city clusters, providing highly skilled workforce and good logistic networks.

...195 parks & development zones will be reorganised into 5 world class manufacturing clusters

5 World-class industry clusters in the YREB envisaged

● Number of industry parks / development zones
● Provinces



Source: China Water Risk, various policies to green the YREB

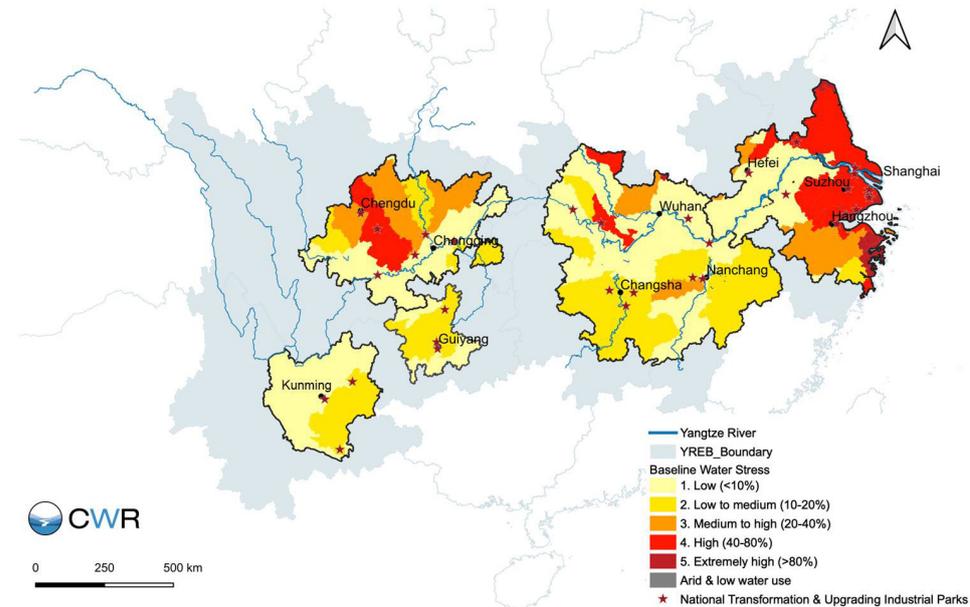
33 are selected national pilots are selected to lead ...

Amongst the YREB's many industrial parks and development zones, 33 have been selected as national pilots to lead in industrial transformation and upgrading. These are shown as red stars in the map below; all of them are located within the five key city clusters and 12 of them are located in areas facing 'high' or 'extremely high' water stress.

... they are all located in the 5 city clusters

33 National Industrial Park & Development Zone Pilots In City Cluster In The YREB Exposure To Water Stress

Going forward, there will be inevitable competition for water



Source: China Water Risk based on Baseline Water stress from WRI Aqueduct Global Map 2.1, river shapefile from FAO AQUAMaps, and country and provincial boundary from Data center for Resources and Environmental Sciences, Chinese Academy of Sciences

Going forward, there will be inevitable competition for water between industries and domestic use for these industrial parks and development zones. Climate change will only lend further complexity as well as urgency to becoming good water stewards.

Water stewardship can be a way forward to ensure water security ...

The good news is that there are already some leaders. Industrial parks in Kunshan City, nested between Shanghai and Suzhou in Jiangsu Province, is a good example - more in the box below.

...Industrial park stewardship in Kunshan City is a leading example

WATER STEWARDSHIP IN INDUSTRIAL PARKS IN KUNSHAN

Under a cooperation framework involving WWF and the Jiangsu Provincial Development and Reform Commission, the park's water management innovation expert group was established, led by WWF. Starting from August 2016, the expert group and the Qiandeng Town Environmental Protection Bureau jointly promoted the industrial park's water stewardship enterprise capacity building project. AWS is one of the key members of the project and is involved in the implementation of the project.

In its first phase, 12 enterprises were selected from circuit boards, chems and printing & dyeing industries. Chosen enterprises withdrew water from both water plants and directly from rivers, and after being treated at either the Qiandeng Wastewater Treatment Plant, Qiandeng Torch Sewage Treatment Plant or Qiandeng Fangyuan Wastewater Treatment Plant, discharged into the Wusong River.

Source: Zhenzhen Xu, Aihui Yang, Dadi Feng. Water Stewardship In Industrial Parks: The Kunshan Case. China Water Risk website, 17 October 2017

全 责 任

重 于 泰 山

安全第一 预防为主
综合治理 保障安全



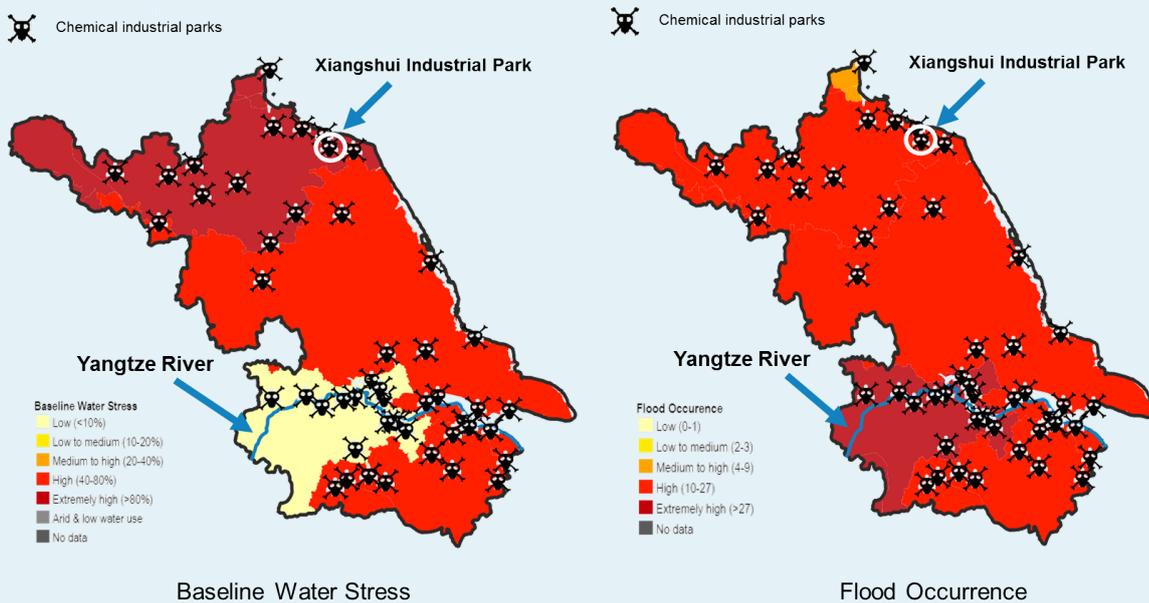
JIANGSU CHEMICALS: Factors to consider when deciding to rectify or shutdown

Chemical industrial parks in Jiangsu ...

Jiangsu is a large producer of fertilisers and dyes; it is indeed one of the Top 2 provinces in China in terms of chemical production. Since 2008, the chemical sector’s contribution to Jiangsu’s GDP has remained large at over 20%. China’s reliance on Jiangsu can high - 87% of China’s dimethomorph (pesticide), 78% of propylene glycol methyl ether (PGME) and 67% of ethylene glycol monobutyl are produced in Jiangsu, according to equities research house Guotai Junan Securities.

Currently, Jiangsu has a total of 53 chemical industrial parks, densely distributed in northern Jiangsu and along the Yangtze River. According to WRI’s baseline water stress and flood occurrence maps, it is not hard to see that most of the chemical industrial parks are located in places which are either extremely water stressed (northern Jiangsu) or frequently flooded (along Yangtze river).

CWR Chemical Industrial parks In Jiangsu Province



Source: CWR, Jiangsu government, WRI

Jiangsu stepping up efforts to rectify or shutdown ...

The chemical sector has been earmarked for pollution control in China’s War on Pollution. Moreover, Jiangsu has yet to meet its Grade I-III pollution targets. However, an explosion causing 78 deaths at the Xiangshui Chemical industrial Park in Yancheng city on 21 March 2019 has hastened action. Aside from the large number of deaths and people injured, the explosion has shaken the entire chemical industry in Jiangsu, severely impacting China’s chemical supply chain.

In the immediate aftermath, on 1 April 2019, Jiangsu province released a consultation paper on the ‘Plan for Regulating and Improving the Chemical Industry of Jiangsu Province’ that proposes to:

- reduce the number of chemical enterprises to 2,000 by 2020, and 1,000 by 2022 (currently 6,884);
- reduce the number of chemical industrial parks to 20 (currently 53);
- stop production at chemical enterprises not fulfilling related safety/environmental norms; and
- prohibit new projects on pesticides/medicines/dye intermediates.

Although only a consultation paper, it still reflects the strong resolution of the government. Definitive action came three days later on 4 April 2019 when the government of Yancheng city decided to shut down the Xiangshui Chemical Industrial Park permanently.

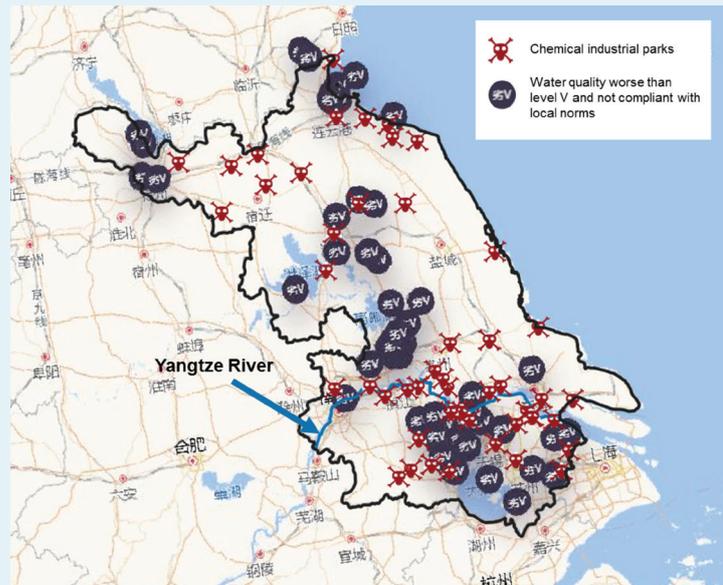
Guotai Junan Securities warned that the park had played an important role in the supply chain of dyes and fertilisers and forecasted that the shutdown will drive up the prices of corresponding chemical products and companies that were not involved. They were soon proven right when the stock market reacted. The futures prices of many chemical materials started to rise and over 40 stocks rose by the daily limit (10%) in the morning of 8 April 2019 (the first trading day after the decision to shut down). However, not everybody benefited; companies directly impacted by the news saw their share prices plummet.

Where the risks lie ... pollution, population, drinking water source

The consultation paper mentions compliance, population density and environmental sensitivity as three key criteria for deciding a chemical plant's shutdown. We have thus applied these criteria to chemical industrial parks to give a general picture of the environmental/regulatory risk of industrial parks.

- 1) **Pollution** – We have layered chemical industrial parks on the compliance map from the Institute of Public and Environmental Affairs (IPE). As per the graphic below, many industrial parks are located in places with both bad environmental conditions and violation records. As such, they may face stricter inspections in the near future.

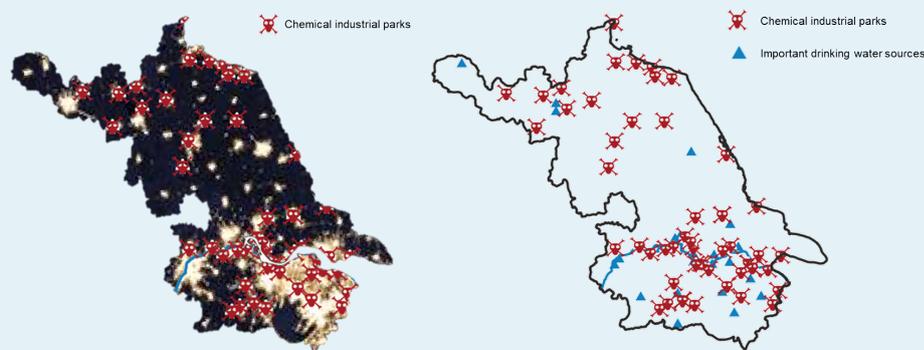
CWR Chemical Industrial Parks & Compliance Map



Source: CWR, IPE's compliance map of June 2019

- 1) **Population density** is another factor to consider. While it was difficult to obtain such data in Jiangsu, the NASA Earth At Night map does provide us with an indication of population density. From the analysis mapped below, it is clear that there is a perfect match between chemical parks and night light clusters, especially along the Yangtze River. With respect to shutdowns due to population density, almost all industrial parks are worth considering.
- 2) **Drinking water source regions** are highly sensitive to pollution and no factories are allowed within these areas. However, some of the chemical parks are located relatively close to important drinking water sources as shown in graphic below, indicating their potential environmental risks, strict enforcement or even shutdowns in future.

CWR Chemical Industrial Parks Overlap Urban Clusters & Important Drinking Water Sources



Source: CWR, NASA, MWR as of June 2019

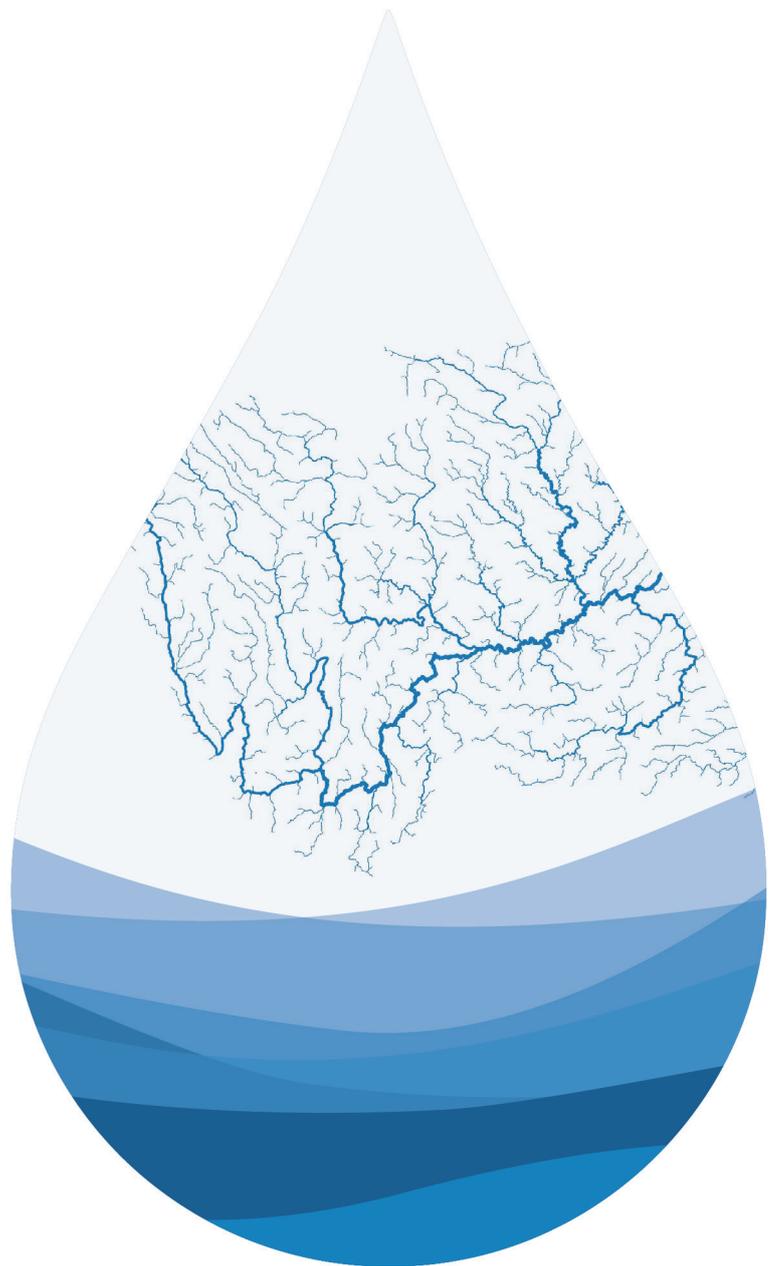
The risks are clear. Whether or not the consultation paper goes into force, it is time for enterprises/industrial parks and governments to factor in environmental and regulatory risks especially in a tightening regulatory landscape. The final decision on the paper may depend on a more comprehensive review factoring in the economy, employment, environment and so on as well as the impact on China's chemical supply chain. Regardless, of whatever happens, good environmental performance is always a plus.

Source: Yuanchao Xu, Jiangsu Chemical Park Explosion: Rectify Or Shutdown?, China Water Risk website, 16 June 2019. <http://www.chinawaterrisk.org/resources/analysis-reviews/jiangsu-chemical-park-explosion-rectify-or-shutdown/>



OPPORTUNITIES FOR GROWTH IN THE YREB

CHAPTER 3



YREB plays a key role in the march to a Beautiful China

The Chinese word for ‘crisis’ is 危机 (*weiji*), a combination of two words danger (危) and opportunity(机). When there are risks, there are opportunities. As President Xi said as early as 2005 (when he was the governor of Zhejiang), “*clean water and green mountains are mountains made of gold and silver*”⁵⁴.

YREB is a ‘grand pilot’ to build a ‘Beautiful China’

There is no doubt that China is set on a path to becoming “Beautiful”. The YREB, with its complex development path riddled with water and climate challenges ahead, is a ‘grand pilot’ for China to trial various policy innovations. Given the YREB’s size in terms of population and economy as well as its contribution to food and energy security, innovations to green the YREB are imperative if the government is to build a Beautiful China.

It has its own Ecological & Environment Protection Plan ...

The importance of this direction is reflected and supported by various national and regional policies in recent years that promote holistic governance and introduce economic instruments to address environmental challenges. To recap, these include:

- The YREB has its own ‘*YREB Ecological & Environment Protection Plan*’⁵⁵. Introduced in 2017, it sets out various policy directions which complement national policies such as the ‘Three Red Lines’ policy and action plans for ‘War on Pollution’. The YREB, especially the YRD region, faces either more stringent targets or tighter deadline in compliance. In early 2019, Ecology & Environment Minister Li Ganjie listed 8 key tasks in 2019⁹ in order to meet targets set out this plan in the box below:

.... Tasks are set for the year in order to meet targets set in the plan

YREB ECOLOGICAL & ENVIRONMENTAL PROTECTION 8 KEY TASKS IN 2019

1. Drinking water source protection
2. Black & odorous (B&O) water body treatment & restoration
3. ‘Green Shield Action’ – ecological protection
4. ‘Clean Waste Action’
5. Treating Grade V+ water body (12 out of 540 national-level controlling points along the Yangtze are still in Grade V+)
6. Inspection & pollution control of discharge points along the river
7. Controlling three sources of phosphorus pollution (phosphorus mines, phosphorus chemical plant, phosphogypsum storage)
8. Special control of wastewater treatment facilities in provincial-level industrial parks in the YREB

YREB is also at the forefront of China’s policy innovation

- The YREB is also at the forefront of national efforts to test several new policy ideas such as the River Chief system, which was first initiated by local governments in the YREB. This pilot was then recognised and promoted by the central government for nation wide implementation. Please refer to the spread on “**PILOT POLICIES & INITIATIVES TO GREEN THE YREB**”;

“Coordination mechanisms” are also set up at inter-provincial, city & county levels

- The YREB also leads in cross-department and inter-provincial/city cooperation in water management. Cities in the YREB were early adopters of water rights trading and eco-compensation schemes to solve conflicts with their neighbours. Since the release of the ‘*Water Ten Plan*’⁵⁶, efforts are being made to establish ‘*Water Pollution Control Coordination Mechanisms*’ at inter-provincial, city and county levels. In the YRD, a special working group on water pollution has been set up since 2014, involving provincial and city governments.

All these create a unique set of risks for the YREB ...

Such regulations and policies create a unique set of risks for the YREB. The underlying physical water risks, climate change plus “beautification” and water-nomic policies will have significant implications for multiple industries and will likely disrupt the supply chain. Impacts are real and material for businesses and investors and it is essential under such conditions to know how to navigate such transition risks – so as to mitigate them and seek opportunities. Although by no means a complete list, we have set out some examples of opportunities ahead in this chapter.

...but also opportunities

Navigating physical & regulatory risks to mitigate or seek opportunities

Going forward, to avoid regulatory shocks and leverage opportunities, it is crucial to 1) understand the underlying physical and regulatory risks and 2) to look at China's YREB economic development models through a water-nomic lens - these have been set out in the previous chapters.

The risks and hotspots identified in earlier chapters all have a silver lining:

More scrutiny in the YREB Stress 6: Shanghai, Anhui, Zhejiang, Hubei & Sichuan...

... trillions of RMB is allocated to ensure success

Jiangsu & Anhui are in the spotlight as they are not meeting 2020 targets ...

...we recommended mapping exposure to these provinces

... and assess clustered risks in 5 key city clusters + the need to focus on adaptation

Industrial parks / industries are being shuffled ...

... key is figuring out which industry is favoured and what's not

In short, embrace risks to leverage opportunities

- **Watch out for regulations, policies and enforcement in the YREB Stress 6** - six provinces with areas under 'high' or 'extremely high' water stress: Shanghai, Jiangsu, Anhui, Zhejiang, Hubei and Sichuan. Together, they represent 65% of the YREB's population and 72% of the region's GDP in 2017; they will likely face more scrutiny ahead in terms of achieving more growth on less water use. As discussed above, policy mechanisms used are not just provincial/sectoral water caps, there are provincial water quality targets and heavy metals plus other pollutant targets as well. Moreover, watch out for water use permit trading, wastewater permit trading, provincial eco-compensation schemes and ecological red zones - these are covered in "**PILOT POLICIES & INITIATIVES TO GREEN THE YREB**". Finally, since the YREB is "the" pilot region, China has allocated trillions of RMB toward their success creating multiple opportunities - more on this later in "**Trillions of RMB for YREB Green Development**".

- **Extra vigilance on polluting & water intensive industries in Jiangsu & Anhui** - While four of the YREB Stress 6 are operating within their 2020 target water use cap, Jiangsu and Anhui's 2017 water use exceeds that of their respective water caps. These two may face more aggressive action on improving irrigation and industrial water efficiency as well as upgrading and changing their industrial or agricultural mix away from water intensive and polluting sectors and crops with low economic value. Other PRD provinces such as Shanghai and Zhejiang may also be expected to lead the way to green the YREB. We recommend you map your asset and/or supply chain exposure to these provinces. However, there are research and data gaps; filling these could catalyse fintech/big data opportunities - more on this later in "**Mapping YREB Water Risk Exposure & Fintech Opportunities**".

- **Pay attention to clustered risks presented by the 5 YREB City Clusters** - Nearly 78% of the YREB's GDP and 69% of its population are located in the five key city clusters. In total, 16% of the areas of the five city clusters are already in 'high' or 'extremely high' water stress but individual city clusters such as the YRD can be as high as 31%. With rising urbanisation continuing to drive up water demand and increasing uncertainty in future water availability thanks to climate change, it pays to look into the capacity to grow given water constraints. Adaptation measures by government are also important as there will also be challenges from extreme weather events but also more wastewater discharge and water demand; these could provide infrastructure opportunities in the short to medium term. More on this later in "**YREB Urban Wastewater & Reuse for More People than the USA**".

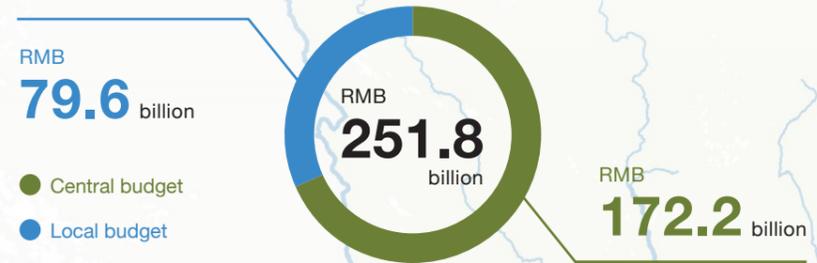
- **Beware of industrial park & development zone reshuffle & upgrade** - China has singled out various polluting industries for action nationally, but special attention is paid to YREB industries. Here, it pays to explore provincial water-nomics performance to see how provincial governments are likely to reshuffle industries to meet targets. We provided a case study on this in "**JIANGXI WATER-NOMICS: Identifying the least favourite & upgrading industrial mix**". Provinces that are "falling behind" on targets may also feel more pressure to act and industries on the 'highly polluting' list will likely be hit first. In that case, identifying plants/parks that local governments are likely to prioritise for upgrade or shut down becomes important. We have set out an example of this in "**JIANGSU CHEMICALS: Factors to consider when deciding to rectify or shutdown**". With competition for water with cities on the rise, get on top or what's hot and what's not in "**Favoured or Not? Different "lists" for multiple industries along the river**".

It's time to embrace and leverage opportunities brought by the changing risk landscape along the Yangtze. A greener YREB will not only be more liveable, but also more prosperous. A future with water will mean that the region can continue to drive China's economy.

TRILLIONS OF RMB TO FIGHT POLLUTION & GREEN THE YREB

2016 & 2017 YREB spending on environmental infrastructure & pollution control

251,800,000,000 ¥



2016 YREB total investment in treatment of environmental pollution

397,700,000,000 ¥



5,000,000,000 ¥
For eco-compensation in the Yangtze River Basin from the central budget in 2018

15,000,000,000 ¥
To incentivise & promote ecological protection & recovery in the YREB set aside by the MoF for 2018-2020

2.1,000,000,000 ¥

At least 2.1 trn will be deployed by the public & private sector in the next few years for green investment in the YREB

This is greater than the EU's 2016 defence budget

Source: China Water Risk, National Audit Office of People's Republic of China, NBSC, provincial government reports, MoF, MEE, NDRC, MWR, Xinhua & other news sources, ADB, CECEP, European Parliament

Trillions of RMB for YREB green development

China's spend on treatment of environmental pollution = RMB922bn (2016)

There's much at stake for China. The government's commitment to pollution control, efficiency improvement and ecological protection is reflected by its growing investment. China's total investment in the treatment of environmental pollution of RMB922bn in 2016 is 6.9x of the spend in 2001.

Spending for green development in the YREB has also been significant, and more has been set aside. Here are some figures:

... YREB accounts for 41% of this

- Total investment in the treatment of environmental pollution amounted to RMB380bn in the YREB which accounts for 41% of the national total in 2016. Almost a third or RMB122bn was spent on projects that passed EIA acceptance in 2016; whereas almost 59% or RMB225bn would be spent on urban environmental infrastructure -RMB68bn of this is for sewerage works. The remaining 8.5% or RMB32bn would be spent on industrial pollution treatment - RMB5.7bn is for wastewater treatment projects

Central govt put RMB5bn aside for eco-compensation in 2018

- RMB252bn of fiscal funding was spent on ecological and environmental protection in the YREB during 2016 and 2017⁵⁷; RMB172bn (68%) of this came from the central budget while provincial budgets footed the remaining RMB80bn (32%);

+ MoF allocated RMB15bn to incentivize & promote YREB eco protection & recovery (2018- 2020)

- In 2018, RMB5bn from central budget was specifically allocated to support eco-compensation in the Yangtze River Basin; and
- For 2018-2020, the MoF also set aside RMB15bn from the central budget to incentivize and promote ecological protection and recovery in the YREB.⁵⁸

In addition, both governments and banks have made plans to provide trillions of RMB investment to promote green development in the YREB. The financing spans from the source region to the delta – examples of these made over the past few years are listed below:

+ Major Chinese banks & ADB are financing green projects in YREB

- From 2016 to mid 2018, China Development Bank (CDB) provided RMB71bn in loans to support pollution control and ecological remediation in the YREB, and RMB208bn for scientific innovation and industry upgrading⁵⁹. As of 31st December 2018, CDB's outstanding loans to the YREB amounted to RMB3.85trn⁶⁰;

- The Asian Development Bank (ADB) has set up a new Yangtze River Economic Belt Framework to support the twin issues of economic and environmental development in the upper and middle reaches of the river. The ADB will provide about USD2bn loan over 2018–2020 under this framework⁶¹;

- China Industrial Bank (CIB) plans to provide RMB20bn in green finance to Qinghai over five years. This includes amounts for ecological and environmental protection⁶². Although Qinghai is outside the YREB, part of it is integral to the YRB and CIB's capital commitment to the source region of the Yangtze will help ensure the water security of the YREB;

Spending also increased significantly in Guizhou (26%) ...

- Guizhou province saw a 16% increase in fixed asset investment in 2018, the highest amongst provinces in China. Its investment in ecological and environmental protection saw an even bigger rise by 26%⁶³;

... Chongqing & Zhejiang mobilised private capital of up to RMB50bn

- Chongqing city government signed a Memorandum of Understanding (MoU) with China Three Gorge Corporation (CTGC) in June 2016 to set up three funds to invest in industry reform and strategic emerging industries such as new energy and new materials during 13FYP. The size of each of these three funds was RMB10bn⁶⁴;

- Zhejiang province signed a MoU with China Energy Conservation and Environmental Protection Group (CECEP) in July 2018 to invest RMB20bn over 3 years on ecological remediation and pollution control⁶⁵; and

... while Hubei lays out RMB1.3trn on 91 green projects

- Hubei province, located in the Middle Reaches of the Yangtze, will invest in total RMB1.3trn to promote green development through 91 key projects. One of the targets is to grow the total output value of the energy saving and environmental protection industry to RMB500bn⁶⁶; and

At least RMB2.1trn of green investment to be deployed in YREB ... this is greater than EU's defence budget in 2016

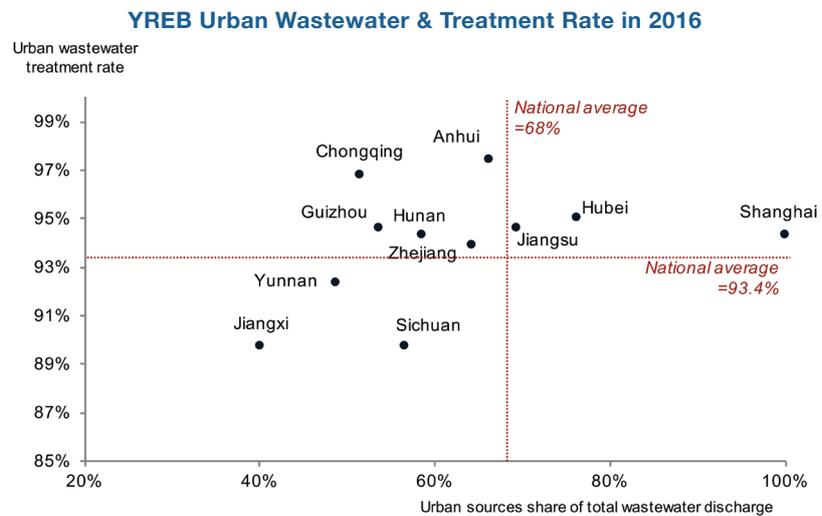
The above evidently shows the government's determination to clean up the environment, plus develop the green industry as one of the 'Strategic Emerging Industries'. Just taking the amounts above (which by no means is the complete number) means that RMB2.1trn has been and will be deployed to the region in the next few years. This is around 1.35x that of the total defence expenditure of the European Union of EUR199bn in 2016⁶⁷. For an at-a-glance view, please see the infographic "TRILLIONS OF RMB TO FIGHT POLLUTION & GREEN IN THE YREB"

YREB urban wastewater treatment & reuse for more people than the USA

>50% of YREB's wastewater discharged from urban areas

At least half of the monitored wastewater discharged in the YREB occurs in urban areas; including discharge from both municipal and industrial sources. In 2016, on average, 94% of urban wastewater in the YREB was treated with 10 out of the 11 YREB provinces outperforming the national level as per the below chart below.

94% of urban wastewater in the YREB was treated in 2016 ...



Source: CWR based on NBSC, China Environmental Statistical Yearbook 2017

... but 6% means ~1.2 bn tonnes of wastewater is discharged untreated ...

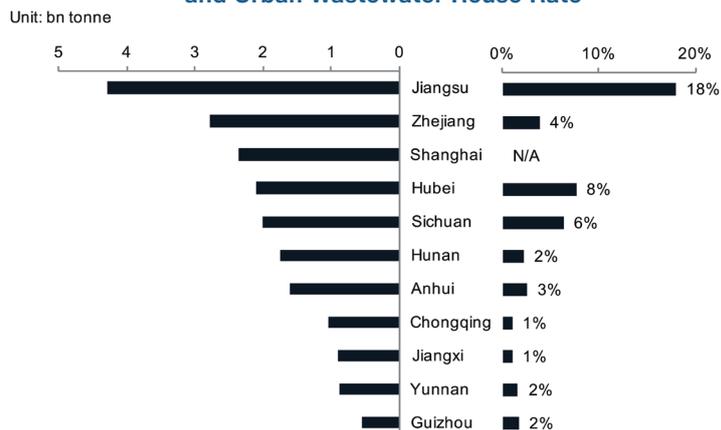
The high treatment rate is likely due to better infrastructure and proximity between sources and treatment plants in cities for easier collection as well as centralised treatment. However, 6% of untreated urban wastewater still means around 1.2 billion tonnes of wastewater was discharged directly in 2016. For perspective, this is almost equivalent to the entire wastewater discharge of the Philippines⁶⁸.

...this is almost equivalent to the entire wastewater discharge of the Philippines

Given water risks faced by key city clusters in the YREB discussed earlier in Chapter 2, there is clearly room for improvement to not only bring the urban treatment rate up to 100%, but to also improve on wastewater reuse. As shown in the chart below, the current urban wastewater reuse rate is still quite low across the YREB - at least 7 out of the 11 provinces have a rate lower than 5% (no data is available for Shanghai). Remember, YREB's 5 city clusters house more people than the US.

Also, there's clear upside in water reuse in urban areas ...

2016 YREB Total Urban Wastewater Discharge and Urban Wastewater Reuse Rate



... while Jiangsu's reuse rate is 18%; other provinces are only single digit

Remember, YREB 5 city clusters have more people than the US

Note: Reuse rate is calculated as wastewater reuse/wastewater treatment (note reuse/discharge)
Source: China Water Risk based on NBSC

Favoured or Not? Different “lists” for multiple industries along the river

Eco & enviro protection = consolidation & reshuffling of industries

The YREB Development Plan clearly recognises that resources and environmental carrying capacity is the basis for optimising industries and urban development. To achieve economic growth with limited water, provinces need to optimise agriculture and industry mix and prioritise those with lower water use, lower wastewater discharge but higher added value.

Beware the various lists ...

This signals the consolidation and reshuffling of multiple industries. Recent government policies have named specific industries to be either restricted for ‘development along the river; or face more pressure in cleaning up; or use less water; or promoted to be core industries. We have set out some of these different “lists” in the table below. The industries are not ranked in any particular order; they are listed as they appear in the respective plans.

8 strictly controlled industries along the river	8 highly water-intensive industries to equip water-saving measures	10 key industries with special pollution control actions	6 water intensive industries that will face higher tariff	5 world-class manufacturing clusters
<i>“Guiding Opinions on Strengthening YREB Industrial Green Development” (2017)</i>	<i>“YREB Ecological & Environmental Protection Plan” (2017)</i>	<i>“Action Plan for the War to Protect & Rehabilitate the Yangtze River” (2018)</i>		<i>“Guiding Opinions on Strengthening YREB Industrial Green Development” (2017)</i>
<ul style="list-style-type: none"> • Petroleum processing • Chemical raw materials • Chemical manufacturing • Pharmaceutical manufacturing • Chemical fibre manufacturing • Non-ferrous metals • Printing & dyeing • Papermaking 	<ul style="list-style-type: none"> • Power • Steel • Papermaking • Petroleum chemicals • Chemicals • Printing & dyeing • Chemical fibre manufacturing • Food fermentation 	<ul style="list-style-type: none"> • Papermaking • Coking • Nitrogen fertilizer • non-ferrous metals • Printing & dyeing • Agricultural & sideline food processing • Raw material medicine manufacturing, • Leather making, pesticides • Electroplating 	<ul style="list-style-type: none"> • Thermal power • Steel • Textiles • Paper making • Chemicals • Food fermentation 	<ul style="list-style-type: none"> • Electronic information • High-end equipment • Automobiles • Home appliances • Textiles & apparels

Must map to determine exposure to hotspots

Industries that appear in more than one list warrant closer attention – such as chemicals. We have laid out the case on why in **“JIANGSU CHEMICALS: Factors to consider when deciding to rectify or shutdown”**. Note that geospatial analysis was deployed in the case study which was also only focused on Jiangsu. Mapping is essential to determine exposure and highlight hotspots, whereas provincial focus is necessary as each province has unique targets and are at various stages of achieving them.

Such lists signals more integrated approach in water management & economic decision making ...

With such lists and the water-nomic regulatory focus, it is evident that both government and business need to take a more integrated approach in water management and economic decision making.

....but not so easy to ‘get rid’ of some strategic industries

Here, we urge you to explore provincial water-nomics as explained in Chapter 2 to tease out future trends. As our analysis in Chapter 2 shows, provincial water-nomic performance vary greatly; even for relatively better performers, there is clear room for improvement in better managing both their water use and pollution. However, provincial governments may not simply be able to ‘get rid’ of some strategic industries. Indeed, our Jiangxi case study, analysing the province’s 36 industries, reveals no choice but to clean up and move up the value chain in rare earths and other non-ferrous metals. For more, see **“JIANGXI WATER-NOMICS: Identifying the least favourite & upgrading industrial mix”**.

For businesses and investors operating or holding assets in the YREB, it’s time to ask: is your company or investment in the right industry, or in the right company with good water practice? Start mapping your exposure now.

Mapping YREB Water Risk Exposure & Fintech Opportunities

Clearly, it is important to understand the current and future exposure to water risks and the impact of climate change on the hydrological cycle across the YREB. The fact that we are now likely heading to a 3 C-4 C world, means that water and climate risks are rising and must be addressed urgently¹⁸.



“If these threats are not factored in, Asian banks and insurers may well inherit the water and climate risks of their clients.”

*Debra Tan,
Head & Director of CWR*

Our recent report co-authored with Manulife Investment Management and the Asia Investor Group for Climate Change warns that water and climate risks are more imminent than you think and warns: *“Climate change is multiplying risks for investors in Asia as we head for a 3°C world, with serious, severe impacts on water resources. Investment portfolios of Asian asset owners are uniquely exposed due to their high domestic investment concentration, putting the continent’s savings at risk”.*

The report also highlights that *“investors in Asian assets may not be fully aware of such interlinked risks”* and to better navigate the new risk landscape, the report identifies five key water and climate risks to illustrate how the portfolios of Asian asset owners might be affected. These include the impact on logistics from rising sea levels and storm surges; increasing risks from extreme weather events affecting dense areas and regulatory risk triggered by water-nomic policies. The report goes on to recommend investors to *“map their portfolios to the inter-linked, systemic risks posed by climate change to understand their real and clustered risk exposure along particularly vulnerable river basins”.*

Each of the risks listed in the report are prevalent in the YREB and given the region’s importance to not only China, but global supply chains, we urge businesses and investors to start mapping regional risk exposure of their assets and investments now.

That said, there are some stumbling blocks when carrying out basin analyses including the lack of multi-disciplinary research and data as highlighted in the box below. The YREB is no different. To address some of the complex challenges faced by the YREB in managing water risks in a changing climate, more support can be given to inter-disciplinary research; even fundamental research on various complex challenges that serves the big picture is missing.

There are big data gaps & more support can be given to inter-disciplinary research...

... even ‘big picture’ fundamental research is missing

Consistent & clear measurements across provinces and watersheds are needed

Multi-Disciplinary Research & Data Gaps In Basin Risk Assessments

There were multiple challenges in conducting basin analysis for 10 major rivers in Asia for our report *“No Water No Growth”*. One of the biggest challenges we encountered was data availability and consistency. There is limited comparable data across countries and rivers. The fact that many indicators related to socio-economic development are constantly changing, also didn’t help. Also, most socio-economic data is currently collected and collated along county, city and provincial lines and not from the perspective of the river basin.

Another stumbling block in understanding and resolving these issues is the multi-disciplinary nature of the action required from scientists, policy makers, businesses, engineers to financiers. These various specialised disciplines tend to only operate ‘in their own box’. A banker or a business owner is unlikely to crawl over research papers to search for natural risks that may impact their assets; but neither are scientists or engineers expected to know what would be considered a business risk and how water and climate risks could be factored into in to government/corporate strategy or credit policy.

Source: The above is an excerpt taken from the Context section of “No Water No Growth – Does Asia have enough water to develop?” CWR, 2018

Even when writing this report, during the data collection and analysis, we found inconsistencies in the use of measurements and discrepancies in data disclosed by central and provincial reports. For instance, some provinces didn’t state whether they used constant price GDP or current price GDP for the calculation, which could lead to very different results due to inflation.

On top of that, occasional discrepancies between central and provincial data on both GDP and water use also complicate analyses. Without consistent and clear measurements across provinces, as well as throughout the years, it is difficult to assess the true progress of water use productivity improvements and evaluate the performance of YREB provinces against their 2020 targets. There is thus urgent need to address this at the provincial level.

The magnitude of the exposure warrants action

However, just because it is difficult, doesn't mean that we do not attempt such analysis. The magnitude of the exposure warrants action. We therefore write this report as a deeper dive into a basin, following our NWN Report as an attempt to catalyse more granular actions. Hopefully, this report will lead more companies, financial institutions and investors to stress test their assets/loan books/portfolios to assess their water and climate risk exposure in the YREB as well as initiate and fund new water-nomic research and analyses to provide more relevant data points for strategic and operational decision making. In the long term, such actions should lead to better water stewardship of the entire YRB to ensure the long term prosperity of the YREB.

Beyond the YREB, trends that point toward assessment of exposure to water and climate risks are also clear:

40 central banks have now acknowledged that climate change is a source of financial risk ...

- **34 central banks and supervisory bodies** have acknowledged that climate change is a source of financial risk and are calling for action⁶⁹. As part of the Network for Greening the Financial System (NGFS), they warn that it “falls squarely within the mandates of central banks and supervisors” to ensure financial resilience and that “catastrophic impacts of climate change are already visible” and “if companies and industries fail to adjust to this new reality, they will fail to exist”. At the time of writing, the NGFS has 40 members; the People's Bank of China along with the Bank of England, which also lead the G20 Green Finance Study Group (GSFG) are also part of the Steering Committee of the NGFS,

+ Trends toward better ESG disclosure & TCFD scenarios

- **Global push for TCFD scenarios & more ESG disclosure.** The Task Force on Climate Related Financial Disclosures (TCFD) was set up by the Financial Stability Board (FSB) to develop voluntary, consistent climate-related financial risk disclosures for companies to better inform investors, lenders, insurers and other stakeholders. TCFD encourages the use of scenario analysis to assess how climate-related risks and opportunities may evolve, allowing organisations to appropriately incorporate the potential effects of climate change into their planning processes. Moreover, many key stock exchanges globally are adopting a “comply or else” stance on ESG reporting; while China is heading towards mandatory disclosure by 2020.

Water crisis are imminent; especially for some major cities ...

- **Water risks are not 50-100 years away but are here today.** For example, Manila had a 140 million litre daily water shortage this year⁷⁰, and Cape Town implemented severe water restrictions on homes and businesses in 2018⁷¹. Even London is warning that it will run out of water within the next decade unless investments in water infrastructure are made⁷². In Jakarta, the over-extraction of water from its aquifers has resulted in subsidence and Indonesia has announced that it will move its capital⁷³.

... prompting regulations for water security; Chinese banks have started stress testing impact of such regulations

- **Regulatory risks are rising in China as it acts to avoid shortages and flooding in the YREB.** Although protecting assets in the long run, there will be greater short-to-medium term regulatory risk exposure with direct impact on valuations through upfront capital expenditure for upgrade and new equipment and the corresponding operating expenditures. Such regulatory water-related transition risks have yet to be factored in by many banks and businesses. In China, banks such as ICBC have started to stress test their loan portfolio against new environmental regulations.

Improving transparency, monitoring & data collection is a first step ...

All of these actions and trends point to more transparency and better environmental disclosure. A first step would be to improve the current monitoring and data collection system as well as data sharing by governments. Plus, they will encourage the development and application of new technologies from big data, blockchain to machine learning/artificial intelligence to finesse the granularity required and climate scenarios.

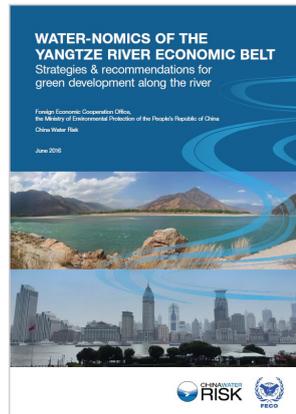
... also need better analysis of enviro data & risks + more tools = fintech opps

Different tools can be developed to fit the different needs of complex and interdisciplinary data analysis. As highlighted in the G20 GSFG 2017 report, publically sourced environmental data can also be an important source of information for financial risk analyses³. There are also opportunities for “translators” - although not complete, there is a plethora of environmental and hydrological data plus countless scientific studies available, they just have not been “translated” into finance speak.

YRD could be a pilot for location-based granular risk assessment

With China's State Council wish to embed environmental risk into the country's credit lending policies plus the focus of central government on promoting integrated development of the delta region, the YRD could be the perfect pilot region for such actions to obtain more granular assessments of the real impact of water and climate risks. We urge banks, credit rating agencies, businesses and investors to start mapping risks; this will create demand for data and fintech and help grow and commercialise current nascent enviro-fintech pilots and initiatives.

RECOMMENDED READING



CWR with MEP-FECO 2016
ENG/CHI



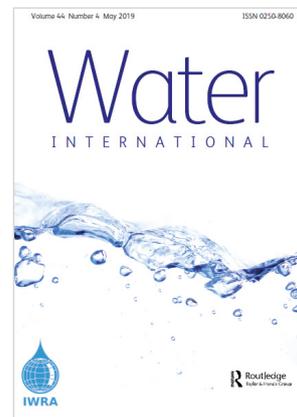
CWR with MEP-FECO in 2016
journal "Environmental Protection" CHI



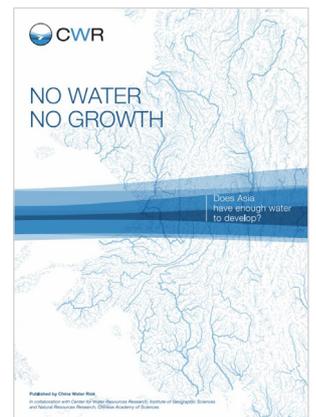
CWR for G20 2016
ENG



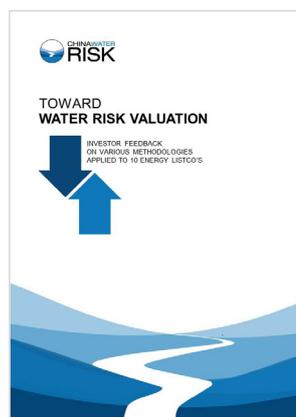
CWR for HSBC 2015
ENG



CWR with global experts 2018
ENG



CWR with CAS 2018
ENG



CWR 2016
ENG/CHI



CWR for China GFC 2018
CHI



CWR with Manulife Asset Management & AIGCC 2019
ENG

YREB Polluting Sectors

- CLSA U® – "Dirty Thirsty Fashion: Blindsided by China's Water Wars" (2014)
- CWR – "Rare Earths: Shades Of Grey – Can China continue to fuel our clean and smart future?" (2016)
- CWR – "Insights From China's Textile Manufacturers: Gaps to overcome for clean & circular fashion" (2017)
- CLSA U® – "Toxic Phones: China controls the core" (2017)

ABBREVIATIONS

12FYP	12th Five Year Plan (2011-2015)
13FYP	13th Five Year Plan (2016-2020)
ADB	Asia Development Bank
AIIB	Asia Infrastructure Development Bank
BRI	Belt and Road Initiative
CAS	Chinese Academy of Science
CDB	China Development Bank
CECEP	China Energy Conservation and Environmental Protection Group
CGI-2	The Second Chinese Glacier Inventory
CIB	China Industrial Bank
COD	Chemical Oxygen Demand
CPC	National People's Congress
CTGC	China Three Gorge Corporation
CWR	China Water Risk
ESG	Environmental, Social and Governance
FAO	Food and Agriculture Organization of the United Nations
FSB	Financial Stability Board
GBA	Greater Bay Area
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRP	Gross Regional Product
G20 GSFG	G20 Green Study Finance Group
HKH	Hindu Kush Himalaya
ICIMOD	International Centre for Integrated Mountain Development
IGSNRR	Institute of Geographic Sciences and Natural Resources Research
IPCC	Intergovernmental Panel on Climate Change
IPE	Institute of Public and Environmental Affairs
IVA	Industrial Value Add
JJJ	Jing-Jin-Ji (Beijing-Tianjin-Hubei Region)
m ³	Cubic metre
mm	Millimetre
MEE	Ministry of Ecological Environment
MEP	Ministry of Environmental Protection (now the MEE)
MEPFECO	Foreign Economic Cooperation Office, Ministry of Environmental Protection of China (now MEEFECO)
MHREE	Medium and Heavy Rare Earth Elements
MIIT	Ministry of Industry and Information Technology
MLR	Ministry of Land and Resources (now absorbed into the MEE & MNR)
MNR	Ministry of Natural Resources
MoA	Ministry of Agriculture (now absorbed into the MEE & MNR)
MOHURD	Ministry of Housing and Urban-Rural Development
MoF	Ministry of Finance
MoT	Ministry of Transportation
MoU	Memorandum of Understanding
MWR	Ministry of Water Resources
NAO	National Audit Office
NDRC	National Development and Reform Commission
NGFS	Network for Greening the Financial System
NH ₄	Ammonium
N ₂ O	Nitrous Oxide
NO _x	Nitrogen Oxides
NSFC	National Natural Science Foundation of China
NWNG Report	No Water, No Growth – Does China have enough water to develop?, CWR 2018
PPP	Public-Private Partnership
SNWTP	South-North Water Transfer Project
TCFD	Task Force on Climate-related Financial Disclosures
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute
YRB	Yangtze River Basin
YRD	Yangtze River Delta
YREB	Yangtze River Economic Belt
YWRC	Yangtze Water Resources Commission

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NOTES

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