



Understanding the Water-Energy-Food Nexus

A good signal for environmental reforms and impacts on companies.

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Maria Elena Drew

Director of Research, Responsible Investing

EXECUTIVE SUMMARY

Water. Energy. Food. Three vital components for sustainable development. The interaction of these factors is commonly referred to as the Water-Energy-Food Nexus (WEF-Nexus).

Changes in population, urbanization, diets and economic growth drive demand within each segment—creating complex challenges around the globe. If one WEF-Nexus component is mismanaged, the other two will ultimately feel the impact.

The linchpin of the WEF-Nexus is water—as a finite resource, water scarcity has a direct impact on food supply. If a local WEF-Nexus spirals out of balance, lack of water shifts from being a global, long-term sustainability concept to a more local and immediate problem. As a result, a country's water-energy-food balance can be a good indicator for the likelihood of greater environmental regulation.

Understanding how the three components interact provides a platform for identifying and analyzing potential effects on companies and industries, most notably through the nature and pace of resulting regulatory reform.

This paper analyzes the rise of WEF-Nexus pressures across the globe and highlights how insights into the WEF-Nexus imbalance in China is guiding our investment analysis across a range of industries.

Understanding the WEF-Nexus

Water, energy and food are three vital components for sustainable development. The interaction of these factors is commonly referred to as the Water-Energy-Food Nexus (WEF-Nexus).

As Figure 1 illustrates, a multitude of factors work to drive demand for food, water and energy—including changes in population, urbanization, diets and economic growth. These dynamics are creating complex challenges around the globe.

As we seek to understand the effect of these complex interactions on companies and industries, a key indicator is the nature and pace of resulting regulatory reform.

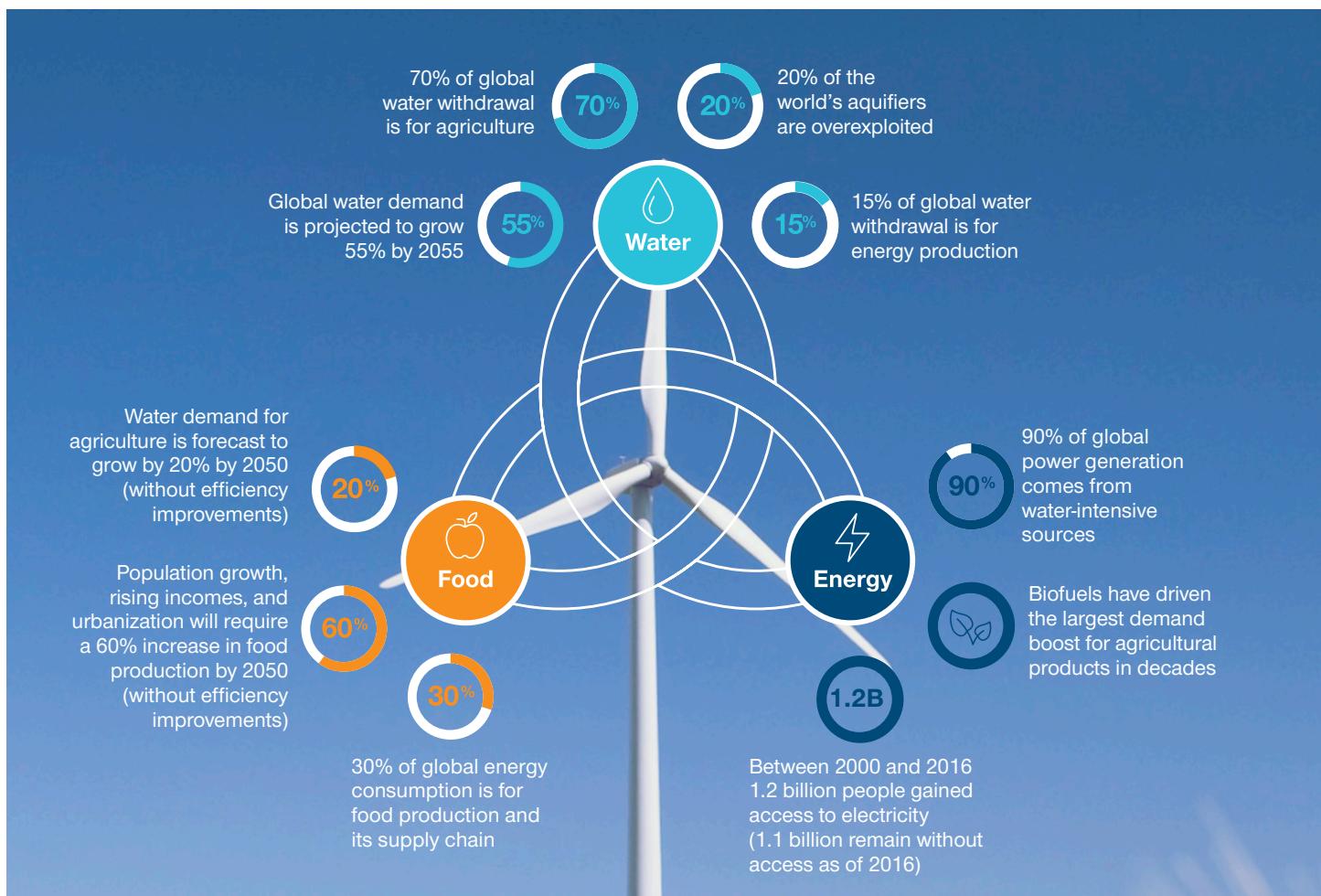
China represents a powerful example of how a WEF-Nexus imbalance works to drive environmental reform. Environmental regulation in China has tightened substantially as the government encourages restructuring of the country's

industrial sector. China's environmental reform program began nearly a decade ago and, if successful, will drive a structural shift in the economy—with significant investment implications. Key reforms include:

- **Scaling down “non-circular” industries**—The imposition of water caps and pollution targets makes it more difficult for businesses that “overdemand” energy and water usage or cause waste management issues. Key industries in these crosshairs are steel, nonferrous metals, petroleum and petrochemicals, chemicals, building materials, paper, and textiles.
- **Energy sector reform**—The Chinese government is orchestrating a gradual shift in the power generation mix from coal to renewables and natural gas, as well as a shift in transportation infrastructure.

(Fig. 1) The Water-Energy-Food Nexus

The factors driving demand for water, energy, and food



Sources: Water and Energy (UN Water 2014), Food and Agriculture Organization of the United Nations, UNESCO World Energy Outlook (IEA 2017).

- **Agricultural reform**—Growing water shortages and soil pollution in China's main agricultural regions are driving efforts to sustainably improve agricultural yields and reevaluate the range of crops grown.

The WEF-Nexus Social Impact

While this paper largely focuses on the effects of the WEF-Nexus on the environment, it is important to recognize its significant social impact.

Two of the most important social factors affecting environmental reforms are employment and public health. In China, for example, the planned shift to a “circular economy” will stimulate growth in better-quality jobs. The ability of the government to put pressure on “non-circular” industries has been made easier as the growing service sector has created new employment opportunities.

1.6 billion

Number of people currently exposed to water scarcity. The figure is set to double over the next two decades.

Meanwhile, as China's air, soil, and water pollution problems have prompted public health concerns, the government's regulatory agenda has evolved to place a greater emphasis on ecological factors. As in the developed world, public health is often a good catalyst for environmental reform—particularly in countries with universal health care.

The Rise of WEF-Nexus Pressures Globally

Between 2000 and 2016, 1.2 billion people around the world gained access to electricity and many emerging markets experienced rapid industrialization. Between 2000 and 2015, global electricity production increased 57% (3.0% CAGR). The overwhelming majority of this growth came from emerging markets, which grew by 135% over the period. Electricity production in China and India increased 332% and 143%, respectively, while water withdrawals increased 24% and 25%. These rapid changes have had a significant impact on each country's WEF-Nexus, which has been further compounded by the fact that neither is water rich.

Water scarcity isn't only an issue for China and India. Today, nearly a quarter of the world's population live in water-scarce regions. In the next two decades, the number of people exposed to water scarcity is expected to double from the current 1.6 billion, largely due to economic growth and urban migration. Regions and countries facing the greatest water and pollution stresses include:

- **Asia** (Afghanistan, China, India, Pakistan, Philippines, Sri Lanka)
- **Middle East** (Bahrain, Iran, Israel, Jordan, Lebanon, Oman, Qatar, Saudi Arabia, Turkey, UAE)
- **Latin America** (Chile, Peru, Mexico)

It is typically easier for politicians to mobilize around locally impactful issues (like water scarcity, rising food prices, or pollution) than a globally focused, long-term issue like climate change. However, as the impact of climate change intensifies, scientists predict more regions will encounter water scarcity. This means WEF-Nexus pressures will become a local issue in more and more countries over time. Key indicators of looming environmental reforms include:

- More frequent droughts and rising food prices
- Consistent overdraws on river systems and aquifers
- Agricultural inefficiency—low yields and/or tilts to nonfood crops
- Impact of pollution on public health and quality of life
- Low unemployment—politicians can address ecological issues when there is less economic pressure

As the pull on this finite resource forces more regions into water scarcity, we expect greater intervention by governments as they struggle to manage their water, energy, and food resources. This in turn will likely have a downstream effect, impacting the energy, utility, and transportation sectors as well as other sectors indirectly exposed to the WEF-Nexus.

WEF-Nexus Pressures in the Investment Process

From an investment standpoint, water, energy, and food are each important considerations, but the emergence of water issues is often a catalyst for swift regulatory intervention. The mismanagement of water resources is difficult to reverse, and because prices often do not signal a scarcity issue until too late, regulatory responses can be drastic.

Integrating water considerations into an investment process creates unique challenges. Often, the investor cannot register a direct price signal until water resources have become significantly constrained—even then, it might simply be reflected in increased regulation or shortages, rather than a price spike. This is because water markets are relatively underdeveloped

compared with energy and agricultural commodities and are far less penetrated by private industry. Also, water is not easily transported, so it doesn't lend itself well to global trade. However, water trades implicitly on a large scale as it is embedded in many globally traded goods.

As current water data are not always readily available, water often needs to be considered as an intangible factor in the investment process. Figure 2 illustrates how an investment process may be modified to consider the WEF-Nexus. In this example, the traditional "energy trilemma"—which balances the security of supply, price, and environment—is reconfigured to include water dynamics.

While an imbalance of the WEF-Nexus can be a catalyst for swift environmental reforms—as has been the case in China—it is important for investors to consider the interplay of environment, price, and security that policymakers must account for.

Policy measures to improve the environment are generally tied to both environmental and social benefits. However, the attainment of any social benefit is typically longer-term and can come with short-term trade-offs. For example, measures to lower pollution by transitioning to cleaner fuels aim to bring long-term societal health benefits, but energy prices are likely to rise in the short term. This type of trade-off can make it more difficult for policymakers to implement environmental reforms on a consistent basis. It can drive a start-stop approach in regulation implementation due to dependency on prevailing economic conditions.

Managing WEF-Nexus Pressures—China in Focus

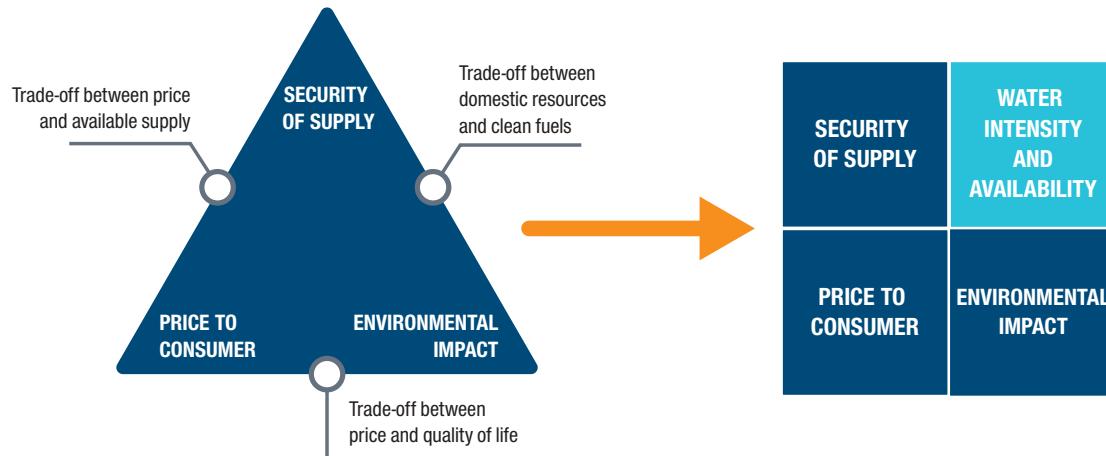
In China, WEF-Nexus problems have been amplified by three decades of exceptional economic growth and rapid industrialization. As the economy expanded, energy demand was largely met by coal-fired generation. As a domestic resource, coal had the benefit of security of supply at a low price, but its use took a toll on the environment in the form of air pollution and water intensity. Overdependence on coal, coupled with relatively lax environmental standards for the industry, has thrown China's WEF-Nexus out of balance. China faces threats to food supplies from soil and water pollution, health hazards for citizens due to poor air quality, and a multitude of risks due to water shortages.

China began a "war on pollution" many years ago and is beginning to see benefits, including regional improvements in air and water quality. T. Rowe Price analysts and portfolio managers have been navigating China's changing environmental landscape for several years and believe it is still early innings for what will likely be a multi-decade restructuring of the country's economy.

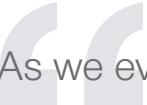
Environmental damage in China is felt at both global and local levels. Consequently, the country's ecological reform program has a twofold approach. At a global level, China's water supply is predominantly sourced by rivers flowing from the Hindu Kush Himalayan glaciers, referred to as the "water towers of Asia." These are vulnerable to climate change and are showing signs of retreat. Retreating glaciers not only affect China's long-term water supply, but also have the potential to instigate regional conflict.

(Fig. 2) The Energy Trilemma Reconsidered

Integrating water dynamics into the investment process



Source: T. Rowe Price.



As we evaluate the winners and losers of industry reforms, ESG factors will play an important role alongside financial analysis.

— Maria Elena Drew
Director of Research—Responsible Investing

In 2015, China made a strong commitment to help address climate change by pledging to reduce its carbon intensity by 60%–65% by 2030 relative to 2005 levels. To achieve this, the country intends to double the level of low-carbon fuels within its energy mix to 20% by 2030. Power generation is expected to drive the bulk of this shift, with coal de-emphasized while renewables are prioritized as a key industry on the “Made in China 2025” agenda.

China’s efforts to mitigate global climate change should yield domestic dividends in the form a healthier water system and rivers. It should also help reduce water demand from energy generation due to lower dependency on water-intensive, coal-fired electricity production.

The country is also aggressively managing its economy at the local level to bring its WEF-Nexus back into balance. At the heart of its local environmental reforms is a shift toward a circular economy, which is de-emphasizing any industry that overextends China’s natural resource balance without a commensurate social gain.

In 2009, the Chinese government targeted 10 industries that needed to “close the loop” and go circular: coal, power, steel, nonferrous metals, petroleum and petrochemicals, chemicals, building materials, paper, food, and textiles.

“Closing the Loop” Is Changing China’s Investment Landscape

What does it mean to “close the loop” or go circular? Companies in targeted sectors need to reduce waste and improve energy and water efficiency through their entire production cycle. They must also consider the life cycle of their products.

The following outlines the changes taking place in a selection of industries impacted by the government’s go-circular mandate, as well as the investment implications for our portfolios.

Apparel and Textiles

The main environmental stresses created by the apparel and textiles industry are water intensity and pollution. In terms of water intensity, the industry’s supply chain is exposed on both the agricultural side (such as cotton and leather production) and the chemical side (such as synthetic fiber manufacturing). Textile manufacturing itself is water-intensive and polluting—discharges are often directed into water systems and/or soil.

Textile manufacturing accounted for 10% of industrial wastewater discharge in 2013, ranking third behind pulp and paper and chemicals and just ahead of coal. Adding further pressure is the fact that much of the industry has been concentrated in water-stressed regions. Around 80% of yarn, 89% of cloth, and 89% of chemical fibers are manufactured in the “dry 11” provinces.¹

As part of its circular economy agenda, the Chinese government has imposed new regulations and standards and stepped up enforcement for companies operating in this industry. Measures include:

1. New national standards for water pollution targets (effective 2016/2017),
2. Mandatory equipment upgrades for wastewater recycling,
3. Water-challenged regions facing stricter environmental controls,
4. Stricter management of water permits and water discharge permits,
5. New industrial standards for both direct and indirect wastewater discharge,
6. Encouragement of consolidation within the industry, and
7. Encouragement of top-performing companies to expand internationally.

China’s textiles industry also has a direct relationship with the country’s food security. Cotton production competes for arable land use and has contributed to soil pollution. Not surprisingly, cotton is one of the largest inputs in the textiles sector—accounting for 35%–40% of textile production. It is a very water-intensive crop and heavily reliant on pesticides. Unfortunately, excessive use of fertilizers and pesticides has contributed to devastating soil pollution problems in China (alongside chemicals and metals such as lead, cadmium, and arsenic).

¹ Today’s Fight for the Future of Fashion, China Water Risk (August 2016).

In 2014, the government published a national survey that identified 16.1% of all soil and 19.4% of farmland as contaminated. Soil pollution is much tougher to reverse than air and water pollution. When a former industrial site in East London was cleaned for the 2012 Olympics, it cost around USD 3,900 per square meter. If this price was applied to clean China's 250,000 square kilometers of polluted land, the cost would amount to USD 1,000 trillion.²

Obviously, a cleanup of this standard over such a significant amount of land is not economically viable. The Chinese government stated in July 2017 that it expected the soil pollution cleanup could cost as much as 1 trillion yuan (USD 150 billion). Confronted with a problem of this magnitude, it's easy to see how a government would push to phase out specific industries. In China, these changes are happening at the provincial level through regulation and enforcement, such as the phaseout of cotton subsidies in the North China Plain.

For any industry facing a "go-circular" mandate, we consider how a company is working to align its business to meet the government's aims. Within the apparel, footwear, and textiles industries, supply chain pressures in China are not new. Rising labor costs, for example, have seen many fashion brands move sewing and assembly activities offshore over the last 10 years. China's steadily tightening environmental reforms have served to further drive up cost structures and accelerate this shift.

At the same time, a growing consumer conscience has heightened reputational risks for fashion brands associated with environmental damage or human rights abuses in their labor force. This has prompted some of the big fashion brands to work directly with original equipment manufacturers to exert greater control on their suppliers' standards. Some fashion brands are also putting a focus on eco-designed products that avoid hazardous chemicals as well as considering the full life cycle of their product. These eco-credentials are even beginning to appear on product labels and in advertising.

At T. Rowe Price, considering factory locations and modernization, access to water permits, as well as other environmental factors in the apparel and textiles sector have been important factors in making investment decisions. We consider the confluence of supply chain issues and how companies are readjusting business models to solve them. On average, we have identified larger-sourcing companies as medium-term losers. These have incurred greater costs associated with ramping up capacity outside of China. In addition, some of their traditional clients have less need to outsource their supply chain than they did in the past.

Mining, Metals, and Materials

Industries such as coal, steel, aluminum, cement, and chemicals are among those targeted to "close the loop" in China. The government's global and local environmental agendas target these industries due to their carbon-intensive nature and associated contribution to local air quality problems.

We expect companies exposed to heavy industry to face heightened operational risks in the years ahead, particularly in regions that are not meeting pollution targets. The Ministry of Environmental Protection (MEP) is likely to continue to use temporary shutdowns of polluting industries as a key policy tool to meet annual targets. To this end, the MEP is also using a number of additional measures, including remote monitoring (installation of equipment for online direct reporting emission data at factory/mine, using satellite images and drones), prohibiting polluting vehicles in sensitive areas (e.g., barring diesel trucks into Tianjin port), raising emission standards (ultralow emission coal-fired power plants), higher national standards for petroleum products, and restructuring energy usage (switching from coal to gas/electricity) in some areas.

Heightened environmental scrutiny across these heavy industries coincides with reforms of state-owned enterprises (SOEs). We expect that the combined impact of environmental and SOE reforms will result in significant consolidation between companies. With some heavily polluting facilities proving too costly to remediate, a supply-side tightening of capacity is also likely, leading to improved industry dynamics.

As we evaluate which companies will be the winners and losers of these industry reforms, we believe environmental, social, and governance factors will play an important role alongside financial analysis.

Conclusion

Insights into the WEF-Nexus provide a valuable lens from which we can better understand the potential impact of environmental dynamics on company performance. When we see one WEF-Nexus component fall out of balance, we can monitor the impacts likely to be experienced by the other WEF-Nexus components and the companies that operate within them.

Among the three components in the WEF-Nexus, water (demand and shortages) represents a valuable lead indicator of change—mismanagement of this vital resource typically proves a catalyst for swift regulatory intervention that can influence company behavior and ultimately performance.

²The Bad Earth, The most neglected threat to public health in China is toxic soil, The Economist (June 8, 2017); The Lancet Commission on pollution and health (October 19, 2017); Energy, Climate Change & Environment 2016 Insights, International Energy Agency, Water and Energy, The United Nations World Water Development Report 2014.

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