THE GLOBAL RESOURCE NEXUS: WATER CHALLENGES AND POLICY CONCLUSIONS

RAIMUND BLEISCHWITZ AND COREY JOHNSON*

Introduction

Resource security issues, despite being around for centuries, are much debated these days. This essay considers the resource nexus, i.e., the interlinkages between the use of various resources. Such interlinkages are manifold, as all resources need others for their production and delivery to final customers. Yet, planning for future production and management often is organized in resource silos. With increasing demand becoming more erratic and uncertain, and supplies being dependent on some producing regions under stress, the nexus amplifies single issues and drives regions toward instability and conflicts. Our proposition is that these nexus issues raise new security challenges in different realms, be it for supply chain security and markets, or be it for interstate conflicts, or for public services and human security on the ground. Scholars and analysts thus should pay attention and search for solutions that engage with actors in those different realms.

Grappling with the resource nexus is easier said than done. Some interlinkages are relatively well known and not yet fully conveyed into action, such as the water demand for energy production or the water – energy – food nexus for biofuels. Predominantly, however, the future demand by the multitude of users is not taken into account and will become aggravated by stress multipliers resulting from weather extremes, climate change, and a number of socio-economic factors.

Three factors make these resource nexus uncertainties relevant for a geopolitical perspective: first, global drivers exert considerable pressures on fragile local management structures and reduce the resilience of long-standing mechanisms. Second, the interconnectivity of global flows allows local turbulences to spread farther and faster, with greater risks of impacts on other resources and outbreaks in other regions. Third, powerful countries are affected and may not adhere to principles of a liberal order that have long characterized international relations.

This essay describes the resource nexus in more depth in the next section, explaining the scope and relevance for international business leaders and policymakers. The paper will analyze water, its interlinkages with other resources, and the multitude of services derived from water, in subsequent steps. It will address potential socio-economic impacts resulting from water stress, the human security angle, transboundary river management issues, and the potential threats to international shipping lanes.

Written as a discussion paper, our aim is to stimulate a debate. Recognizing the potential for a “perfect storm,”[1] a confluence and mutual exacerbation of challenges in these areas in the next few decades, the contribution also underlines potential opportunities by addressing common challenges across sectors and across the realms of markets, interstate relations, and the people on the ground. Developing a step-by-step strategy of grasping some opportunities while establishing capacities to deal with risks and unleash further action is probably the wider aim of our approach.

The Resource Nexus

The simple meaning of what we are calling the resource nexus should be readily apparent: understanding the interconnections between demand for, production of, and use of multiple natural resources simultaneously. That these interlinkages exist may seem painfully obvious. Mesopotamian agriculturalists five thousand years ago knew about the ties between water, fertilizer, land, and energy, and they certainly knew that the interplay among different inputs would determine whether there was enough food in their pots at the end of a growing season. They also understood that weather, population growth, conflict, and political decisions were additional variables to consider, and they did not just throw their hands up in the air and hope for the best, but rather planned, adapted, and on occasion took up arms. The Stele of the Vultures, the earliest known monument to a battle, commemorates a battle over the fertile, irrigated land that lay between the city-states of Girsu and Umma in what is now southern Iraq.[2] Much more recently, the ability to cope with such interconnections is part of the wider debate about "planetary boundaries" where earth scientists give a warning that some of such limits might be transgressed and, inter alia, feature the resources nitrogen, phosphorus, and freshwater.[3]

In spite of the intuitive importance of thinking across the artificial boundaries between different categories of resources, the structures of governments, corporations, and the globalized economy more broadly are not set up to acknowledge, much less make productive interventions in, the resource nexus. Moreover, policymakers and business leaders are effectively discouraged from thinking about the unintended consequences of the use or production of one resource on another.

Take, for example, recent trends in car sales. In January 2015, automakers sold 1.5 million new vehicles in the United States, 14 percent more than in the previous January.[4] Of those, more than half were trucks and sport utility vehicles (which saw nearly 20 percent higher sales than the year before), suggesting that low gasoline prices coupled with a strong economy are making gas guzzlers attractive again after years of pallid sales (see Figure 1 on page 41). No serious observer of energy markets views the precipitous drop in the price of oil since summer 2014 as a trend that will continue—and most see the price stabilizing and rising over the next few years. American consumers, though, like consumers elsewhere, typically do not consult the International Energy Agency (IEA) forecasts when thinking about what car to buy; rather, they make decisions based on needs, wants, and short-term price signals. Governments and businesses, though, also treat oil as if it exists in its own silo, fundamentally distinct from water, food, minerals, and materials.

This is where we are not well positioned to understand how such developments cascade beyond just the increased demand for petroleum that more SUVs on the road should create. One might expect cheap oil to cause the markets for biofuels in the U.S., European Union (EU), Brazil, and elsewhere are likely to perform below expectations, with resulting downward pressures on the prices for corn, soybeans, palm oil, and sugarcane, and less new land being converted to grow biofuel crops. However, policy interventions such as the U.S. Renewable Fuel Standard (RFS) mean that ethanol and biodiesel will still need to be produced in large quantities, at least in the U.S. But outside the U.S. and Europe, cheap oil in some cases is already depressing food prices, making farmers less likely to plant crops that will be more costly to produce than their selling price. Will this cause a Chinese investor to decide against purchasing and deforesting a plot of land in Indonesia to plant oil palm trees? As Ford makes more F-150s and Porsche more Cayennes to meet demand, they will be consuming more steel, aluminum, rubber, polyester, leather, and a host of chemical elements, all of which require in various quantities water, energy, and land to produce. The automakers and producers of mined materials will use more water. The increased demand for cheap oil, brought on in part by more people driving longer distances in their new SUVs, will have its own impacts on supplies and prices, as well as on the environment and the use of other resources. In varying degrees, each of these micro-events has implications for the climate and for security as well. These are explored below.

The fact of the matter is that we do not understand the resource nexus very well. Governments and individuals tend to compartmentalize such issues because their interrelationships are too complicated to capture, too difficult to model, and too challenging to address. Yet if the transatlantic community is going to play a constructive role amid the profound changes in the global economy, population, and consumption habits, and in light of the profound threats to livelihoods and security posed by climate change, better understanding the resource nexus will be of utmost importance.

A number of academics, policymakers, and others have in recent years taken up the theme of the resource nexus, but yet there is little consensus as to what precisely is meant by the idea. Early conceptualizations from the policy community and think tanks came out of the 2011 Bonn Nexus Conference,[5] by papers from the Dutch environmental assessment agency,[6] the Transatlantic Academy,[7] the European Union's development report,[8] and Chatham House.[9] Most of these reports foreground the ties among water, food, and energy. A number of academic studies examined various aspects of the resource nexus as well,[10] including specific facets such as water and electricity,[11] land,[12] and geographically specific cases in South Asia[13] and the Middle East and North Africa.[14] In several instances, government organizations have included resource nexus analysis in their planning, such as the United Nations Economic and Social Commission for Asia and the Pacific[15] and the U.S. National Intelligence Council, which identified the food, water, and energy nexus as one of four "megatrends" in its most recent quadrennial "Global Trends" report.[16]

Figure 2 (page 41) shows the many ways in which key resources interact. Some nexus issues may be more obvious than others, such as the connection between food and water suggests. Others have become more pressing recently, such as the water inputs needed for energy production. The implication for decision-making is that all activities that are intended to manage a specific resource shall have knowledge about the estimated inputs needed from other resources.

If these ideas are gaining some traction in academic and policy communities, it is nevertheless important to ask whether this is simply a re-branding of what we have known for a very long time. In other words, what is new? Earlier accounts focused attention on physical scarcity of natural resources: that unregulated population growth and consumption meant that we would literally run out of the stuff ("limits to growth"). Current analysis treats physical scarcity as a second or third order problem ("planetary boundaries," see above). The cases of fossil fuels and minerals are illustrative. The problem with oil is likely its abundance rather than its scarcity, as new technologies have opened up new possibilities from tight oil and gas to oil sands. The exceedingly low price of oil currently does not signal that oil is inexhaustible—of course eventually on present course we will have burned most of it by some point in the future—but rather that there is likely very little incentive to make changes necessary to avoid the alarming impacts related to climate changes[17] that will accompany releasing all of that carbon into the atmosphere. Minerals such as rare earths and iron ore are fairly abundant as well. The issue with scarcity is not so much physical scarcity (with the notable exception of water in particular geographic contexts) but rather the scarcities created by governments, poorly functioning markets, environmental change, and geopolitical upheavals. It is probably one of the strengths of the nexus approach that these governance and security ramifications are actively addressed rather than implicitly suggested.

In addition, there have been tectonic shifts[18] in the global economy, political geography, and the environment that require us to re-visit nearly all assumptions about resources. Humans are a formidable geophysical force, causing the global climate to warm, putting more nitrogen into the earth's system than the earth does on its own each year,[19] likely causing tectonic activity with oil and gas extraction[20] and dam building.[21] Further highlighting the law of unintended consequences, carbon capture and storage schemes—injecting carbon dioxide into underground reservoirs to help mitigate climate change—if put into place may cause more earthquakes,[22] potentially harming not only lives and property but also re-releasing the CO2. Humans have also drastically altered the earth's biodiversity. In light of anthropogenic changes to the environment, some scientists have waved goodbye to the Holocene and pronounced a new geological epoch, the Anthropocene.[23] As the U.S. Department of Defense and many others have argued, climate change itself is a "threat multiplier."[24] The long and the short of it is that these changes to the natural environment, and policy responses to them, will also impact natural resource production and consumption on a variety of levels.

The shift in the center of gravity of the global economy will also continue to impact natural resources. The arrival of China on the stage of global economic powerhouses is by now a truism, but it is only one of the key trends shaping the twenty-first century.[25] Global trade has expanded from $5.5 trillion in 1998 to $16 trillion in 2012. The physical volume of stuff traded has increased by 250 percent over the last thirty years; 10 billion tons of goods are now traded, many of them moving vast distances by ship, rail, and truck.[26] Robust economic growth in various corners of the globe has also fed into and led to American and European consumption habits being copied elsewhere. Governance institutions and supply chains—not to mention the natural environment—are being stretched to cope with the desire of billions of earth's residents converging on consumption ideals that seek not only a chicken in every pot, but a car in every garage and a television in every room. The evidence is striking:[27]

- Since 2008, non-OECD countries have consumed more energy on an annual basis than the OECD. If everyone in the world burned fossil fuels as Americans do, CO_2 emissions would increase by 400 percent.

- There are more people in the world now classified as overweight (1.4 billion) than undernourished (842 million), and the shift to meat-heavy diets means ever more land, water, and energy are required. One-third of food produced in the world goes to waste.

- Global water use over the past century has grown twice as fast as the population.

- Humans extract 50 percent more natural resources than they did thirty years ago, and now pull the equivalent to 41,000 Empire State Buildings by weight out of the ground each year.

Of course, not everyone has seen or will see benefits from this unbalanced growth, so that yawning global inequality also impacts the resource nexus in numerous ways.

There are also geopolitical shifts that make the current situation different. The rising power of China, Russia's regional hegemonic posturing, and America's shifting focus to the Pacific carry with them important consequences for natural resources. These are important and well documented, from China's investments in Africa and naval maneuvers in the South China Sea and Indian Ocean, to Russia in Ukraine, and U.S. base building in the Philippines. But this just scratches the surface of the political re-ordering that is occurring globally and regionally. There are ninety democracies in the world today, but the beginning of a transition to democracy does not guarantee accountability of leaders, functioning state institutions, inclusion of marginalized communities, civil tranquility, etc. Indeed, the order of the day in far too many places is violence and migration, which are but two of the possible scenarios that usually have clear ties to resource issues. The headlines are filled with cases: North Africa, Syria, South Sudan, Bangladesh, and elsewhere.

The resource nexus offers a fresh look at these interlinkages and an analytical tool for dealing with both the metrics of key technology developments and the diverse security and governance ramifications. To illustrate this approach in light of the theme of the papers in this AICGS project, we now turn to the issue of water.

Water-Related Challenges

ENVIRONMENTAL AND ECONOMIC DIMENSIONS

Water is fundamental for human life and well-being. While access to clean drinking water is a key UN Millennium Development Goal and considered a human right, the current provision is unsatisfactory for some 750 million people lacking such access, and for the 2.5 billion people without access to improved sanitation.

The challenges of supplying 7 billion people with clean and safe water, with a further 1 billion expected by 2030, are likely to increase. Just 1 percent of the world's total supply of water is freshwater, with a high proportion being badly managed, spoiled, and polluted. Looking ahead, the growing middle class, ongoing urbanization, and the risks of climate change are all adding to the pressure.

Environmental research highlights the "planetary boundary" of transgressing the safe operating space for using freshwater.[28] Such freshwater flows and use occur at the largest sub-global level in the major river basins around the world, transforming the local and regional challenges into international and global ones. While rivers, lakes, reservoirs, and renewable groundwater stores replenish a stream of "blue water" to overall availability, wide-spread eutrophication from agricultural fertilizers and land-use changes perturb supply especially at a regional scale. Accordingly, research seeks to estimate a maximum monthly withdrawal as a percentage of mean monthly rivers flows[29] (which may change over the course of a year) that's being transgressed in some areas worldwide, indeed with a lot of economic and security ramifications.

Environmental research also underlines water supply as an essential service that can be derived from ecosystems, if those are properly managed. Indeed, the estimate for the value of total global ecosystem services in 2011 is $125 trillion/year with losses over the last few years in the order of approximately 10 - 15 percent and more deterioration going on.[30] While such monetary values may be contested for a number of methodological and other reasons, the important point to stress is that water is more than a constituent to all those ecosystems (open ocean, coastal zones, forests, grasslands, wetlands, lakes and rivers, desert, tundra, ice, cropland, and urban ecosystems): the supply of water is dependent on the ability of ecosystems to perform both their regulatory and provisioning functions as part of the wider natural capital that underpins all economic activities.[31]

A resource nexus view may be helpful to deal with the complexities of environmental change, water, and supply issues. It is often placed centrally in the nexus debate and is strongly interrelated with energy and food, but also quite relevant for the use of minerals and land. The interesting angle from a nexus perspective is the intersection with drivers for demand, security of supply, governance, and innovation.

Analyzing the water challenges as part of a nexus approach, therefore, are likely to allow better decision-making for cooperation across sectors, along value chains, and for transboundary management structures. That is also been the main message from the 2014 Bonn conference on the resource nexus.[32]

More recently, business has become worried about future access to water. Acknowledging the water dependencies of many industrial processes and electricity generation, the water disclosure report[33] can be seen as a wake-up call. Conducted on behalf of 573 investors with assets of $60 trillion, it states that 68 percent of responding companies say water is a substantial risk to their businesses. The perceived risk is not just a short-term one: the data indicate that business is more worried about long-term water stress rather than responding to short-term droughts. In contrast, the response strategy of water productivity and its implications for production and innovation is not yet high on the priorities of strategic management. (See Figure 3 on page 42.)

Wide-ranging efforts and investments will be needed to improve water productivity, from stemming leaks to making better use of recycled water on to collaborating with users about overcoming wasteful consumption of water. Are the utilities prepared to meet such challenges? Are their regulatory agencies and customers willing to accept a need for higher investments and, most likely, higher downstream costs for using water? A 2012 survey conducted on behalf of The Economist Intelligence Unit reports that most utilities will increase their investments but are faced with a number of barriers and risks.[34] Most important will be changes in the behavior of regulation, customers and consumers, and effective strategies to cope with the risks of pollution and impacts of changing weather patterns. Again, the nexus perspective kicks-in here as a way of looking at water in a more integrated manner and organize demand management.

In a wider perspective research underpins the importance of water for economic growth and human development. It's a common misunderstanding to assess the importance of resources according to their relative share in GDP (such as the share of the water sector), which evidently would suggest a low relevance. In contrast, it should be quite clear that water (as is the case with other resources) affects the economic performance of downstream manufacturing sectors, services, and private consumption. A recent OECD paper looks at market distortions and concludes that water shortages can have a devastating impact—particularly in the near term and at a local scale, with power outages, retirement of irrigated crop land, and unemployment.[35] If societies are unable to manage water much more sustainably, this could become a significant drag on the economy.

Looking at affected countries and regions such as India, China, the MENA region, and many others (including the southwestern U.S. and southern Europe), the strategic implication is that relevant hubs of the world economy are at risk. Water stress will most certainly correlate with food stress in many regions, and is likely to have an impact on electricity generation, manufacturing, and extraction activities. This article will analyze the implications for energy, transboundary river management, and international shipping lanes in subsequent sections below.

Climate change is increasingly seen as a stress multiplier. If current trends continue, the world would warm by 4°C by the end of this century, i.e., twice as much as the commonly agreed 2°C target suggests. Drawing upon IPCC findings, a recent report[36] names the regions that are likely to experience a decline in precipitation of 20-50 percent and others with severe flooding risks, all contributing to enhanced global food security issues and risks of poverty, displacement, and migration as well as for economic assets. The agriculture-water-food security are probably most obvious in North Africa and the Middle East,[37] a region strongly dependent on virtual water imports (i.e., water embedded in the trade of agricultural commodities), but also in Central and South Asia where irrigation-based agriculture and groundwater pumping are common practices.

We conclude here in line with a previous paper[38] that water-nexus related conflicts are likely to increase and may escalate in a number of countries, many of which are relevant for the global supply of strategic materials or essential as suppliers of key product components. The critical variables go beyond a stovepipe approach of water management and require a wider analysis of how water is used as an input for other purposes and how societies cope with the challenges of security and adaptive governance.

ACCESS TO WATER

Access to fresh water is considered a fundamental human right by the United Nations. This normative ideal hits up against the challenges of how to provision huge and growing urban populations with water, especially as climate change alters the availability equation in unpredictable ways.

There are now around 600 cities in the world with a population of over 750,000. By 2050, there will be more city dwellers than the entire world population of 2004. Population growth and the dramatic concentration of people in urban areas pose a set of nexus-related challenges, especially surrounding access to clean, fresh water. Most urban population growth is occurring in the poorest parts of the planet, and in places where local water supplies are insufficient to meet demand. Urban and industrial use of water is projected to double by 2050.[39] Poor people, meanwhile, pay more for the water they use than the rich: the slum dwellers of Kibera in Nairobi, Kenya, who rely on private vendors for their water, pay up to seven times more per liter of water than a North American, and fifty times more than their richer neighbors in Nairobi.[40] While the percentage of people living in slums decreased over the last decade, the actual number of slum dwellers increased over the same period because cities are growing so rapidly.

This is a multi-layered challenge, then, for policymakers: one is infrastructural, in investing in supplies, laying the pipes, building pump stations and treatment facilities. But another more daunting challenge is political, in securing access to water supplies located in many instances long distances away from the city itself, in other political jurisdictions.

Water transfers, the process by which water is physically moved across basin boundaries from source to consumer, are nothing new. In the early twentieth century, Los Angeles tapped into Owens Valley water (runoff from the Sierra Nevada) and the Colorado River, both sources 200+ miles away, in legendary fashion. Chinatown-esque scenarios are bound to set the stage for conflicts in the future as cities dig deeper and build pipes farther afield to meet the water needs of growing populations. Mexico City, one of the largest cities in the world, gets 43 percent of its water from inter-basin transfers over distances of up to 154 km, and 0.6 percent of the country's electricity production goes toward pumping the water over the mountainous terrain to the Valley of Mexico.[41]

As for the transatlantic community, issues of water provision in lesser developed countries have both humanitarian and security ramifications. Consider this: in 2010, nearly all of the megacities (greater than 10 million population) in the world experienced water shortages of one form or another. As cities continue to grow, their leaders will have no other choice but to seek additional sources of fresh water (or risk social unrest if they are unable to meet local needs). Yet the means at their disposal are limited: additional withdrawals from local sources such as groundwater, rivers, and reservoirs, at some point are no longer possible. Drawing from well outside the cities raises the potential for conflict, especially between cities and the farmers who depend on water as well and who resent outsiders taking "their" water.

How those conflicts are resolved is highly dependent on governance, but it does not take an overly fertile imagination to envision regional flare-ups in which struggles over water act at least as a stressor. Las Vegas, Nevada, is faced with massive shortages of the Colorado River water upon which it depends, and billions are being spent to build a third intake pipe under Lake Mead (the so-called "third straw,"[42] and, in the longer term, to pipe Great Basin groundwater 300 miles from northern Nevada. The latter project has been hugely controversial with Native American and environmental groups and is currently held up in the courts. The potential for armed conflict over water in Nevada is perhaps not great (Cliven Bundy notwithstanding[43]), but water has been the genesis for urban riots in various quarters of the world in recent decades. For example, there are thirteen documented incidents of water violence and conflict in Pakistan since 2001, much of it related to water allocation in rural areas and municipal service delivery.[44] The nexus approach is likely to facilitate thinking about different water users and their needs, thereby helping to establish participatory planning methods able to deliver on the right to water.

WATER AND ENERGY

Energy and water go hand in hand. Everything from making electricity to refining transportation fuels requires water, while treating and conveying water for human use requires large quantities of energy (about 4 percent of U.S. power generation). Meanwhile, the ways we use water in homes and businesses use an even larger quantity of energy: water heating and clothes washing and drying are responsible for 14 percent of California's electricity consumption and 31 percent of natural gas consumption, for example.[45] Given the changes in the global economy, political geography, and environment described in previous sections, the water-energy nexus will only grow in importance globally as American and European lifestyles are replicated in other parts of the world. These changes will pose policymakers, businesses, and individuals with a host of challenges.

Fossil fuels require water in their production phases, and newer "unconventional" forms of fossil fuel extraction, such as hydraulic fracturing, require even more water than their conventional counterparts. Refining and processing of fuels such as oil, gas, and uranium requires large quantities of water. Much of the coal used in power generation is transported as slurry—ground coal mixed with water—and coal is the largest fuel source for electricity.[46] Meanwhile, emissions controls at power plants use water to extract materials such sulfur, mercury, and CO2 from emissions. Biofuels contain massive quantities of "embodied water," when one considers the amount of water needed to grow the biomass and then process it into combustible hydrocarbons. When irrigated corn or soybeans are used to make bioethanol or biodiesel, water use per gallon of fuel exceeds that of the equivalent quantity of refined petroleum by a factor of 1,000 or more.[47] (See Figure 4 on page 42.)

Electricity production is a major user of fresh water. In the U.S., upward of 90 percent of electricity is produced using thermally driven water-cooled energy conversion (thermoelectric power plants),[48] while the remaining power generation comes from hydroelectric dams, solar panels, and wind turbines. Thermoelectric plants use 39 percent of all water withdrawals in the U.S., with only agriculture requiring a larger percentage.[49] Much of this use is not consumptive, since most of the water used for cooling or turning turbines is not lost to evaporation, but some is, and the water leaves the plant warmer than when it entered. Both thermoelectric and hydroelectric plants require dependable access to water.

As water becomes more precious, the water-energy nexus becomes more apparent. Periods of droughts can lead to blackouts in electricity, or put electricity production at risk. The shutdown of nuclear power plants in France in 2003 may serve as an example. Furthermore, water-stressed regions in the Middle East, Australia, and North America are looking to desalination as a means of ensuring stable supplies of freshwater. Desalination is an extremely energy-intensive method to obtain freshwater, and the saltier the water, the more energy-intensive it is. In California, there are seventeen desalination plants in the planning stage, with the largest plant in the Western Hemisphere under construction at Carlsbad near San Diego.[50] California's recent drought has led farmers to intensify their groundwater withdrawals in the Central Valley, so that water-intensive high value crops such as almonds can continue to be harvested, while coastal communities attempt to speed progress toward desalination as a silver bullet to deal with growing demand amid constrained supplies. In April 2015, Governor Jerry Brown announced mandatory 25 percent cuts to municipal water providers but spared farmers, who account for 80 percent of the state's water use.

In the Persian Gulf region, several countries have embarked on plans to construct nuclear power plants. The UAE signed contracts with a South Korean consortium to build four reactors by 2020, with a total capacity of 5.6 gigawatts.[51] The original feasibility study for developing nuclear power capacity in the Gulf cited desalination as a major need for the additional energy capacity need.

Like California, much of Brazil has faced an epic drought last year, its worst in eighty years. Despite being the country with the largest volume of freshwater in the world—12 percent of the global total—the geography of Brazil has most of the population in the south and most of the fresh water in the north, while high inter- and intra-annual variability of rainfall make planning for water shortages challenging. Shortages and extreme heat have affected many of the country's key commodities, including coffee, sugar, soy, and beef.[52] There are numerous ripple effects of drought on energy production in Brazil. Reservoirs in southeastern Brazil (close to the major population centers of Rio and Sao Paulo) produce most of the country's hydroelectric power, which accounts for two-thirds of electricity generation. Dramatically low water levels could lead to electricity rationing in the country if conditions do not improve, and a massive blackout in January 2015 may be a harbinger of future challenges. The causes of the drought are undoubtedly complex, but deforestation is emerging in the scientific community as a major culprit. Amazonia's forests churn huge quantities of water vapor into the air, described as "flying rivers," which then circulate elsewhere in South America providing a moisture source for otherwise dry areas.[53] So the sinister nexus scenario is thus: deforesting the Amazon to advance an agricultural frontier so that farmers may grow soybeans and sugar, much of which goes toward Brazil's massive and growing appetite for beef and biofuels, may in fact be cutting off the water that supplies not only the megacities of South America with water, but also much of the electricity fueling its economic growth. One can easily see how social unrest would result from drought-induced brownouts.

In short, water and energy are thoroughly integrated, yet they are not treated as such by policies and markets. Water efficiency measures are de facto energy saving measures, and the waste of either of these resources constitutes waste of the other. The resource nexus suggests that accounting for the interlinkages across these resources, and numerous others, would have benefits in a variety of realms, bolstering human security and national security while also making markets more efficient and making a dent in anthropogenic climate change.[54]

TRANSBOUNDARY RIVER MANAGEMENT

In 2012, the National Intelligence Council released a study that began with the following sobering statement: "We assess that during the next 10 years, water problems will contribute to instability in states important to U.S. national security interests. Water shortages, poor water quality, and floods by themselves are unlikely to result in state failure. However, water problems—when combined with poverty, social tensions, environmental degradation, ineffectual leadership, and weak political institutions—contribute to social disruptions that can result in state failure."[55]

The report paid particular attention to transboundary rivers, and concluded that water in shared basins was likely to become more politicized as demand increases and climate change alters its availability. It further said that transboundary water was likely to be used by terrorists to further their causes in coming years.

Indeed, although there are legion examples of cooperation between states that share transboundary water resources, such as rivers and lakes, the centrality of water to life, transportation, energy generation, and agriculture, also provides ample tinder for conflict as well. Hydropolitics are central to the resource nexus. The strength of institutions designed to manage water resources across boundaries, meanwhile, varies widely across geographic contexts, as do vulnerability and resilience to changes that occur naturally or artificially that affect water resources.[56] A host of factors impact transboundary rivers and a population's ability to utilize the resource, from upstream dam building, to pollution, to drought and floods (and the management of drought and flood). Some changes occur rapidly, others over long time spans. While certain ripple effects of changes can easily be predicted, others are incredibly difficult to model and predict. Because transboundary rivers involve state security and sovereignty, incentives to cooperate and negotiate are too often trumped by political gamesmanship and hubris.

Positive examples of transboundary cooperation on issues of water management include several from the transatlantic community. The Columbia River Treaty, for example, has governed relations between the U.S. and Canada over the Columbia since the 1950s, and has generally been viewed as a positive example of collaborative management of transboundary water, although it is worth noting that after 2024 the treaty may be renegotiated or terminated by either side.[57] The European Union requires every member state to work with neighboring states on managing water resources through its Water Framework Directive, and the history of managing the European river of the Danube also dates back to times of the Cold War. Both examples highlight the role that institutions play in successfully managing competing demands and interests and avoiding conflict, which is not to say that in either North America or the EU that conflict over water is out of the question.

Several additional cases outside transatlantic space serve to highlight transboundary water issues and how the resource nexus can help shed light on them.

The Nile Basin covers 3.2 million square kilometers, spanning 35 degrees of latitude and eleven countries. The river is the basis for Egypt's economy and population, but most of its flow originates in upstream states, especially Ethiopia, where an estimated 82-95 percent of the water comes from in the form of runoff from the highlands to Nile tributaries.[58] There are tremendous growing pressures on the Nile's water resources and on the institutions that currently govern the river. Population is growing in the basin, its waters are increasingly being viewed by Ethiopia and Sudan as an engine of economic development in the form of hydro power, and climate change is impairing water availability in the basin. The Nile Waters Agreement of 1959, which currently governs the river's water allocations, only has Sudan and Egypt as signatories, and other upstream countries view it skeptically and have pursued their own instruments to govern the river.[59]

Enter Ethiopia and its ambitious Grand Renaissance Dam. Ethiopia is a largely agrarian country that nevertheless has seen double digit growth rates recently.[60] The dam is being built on the main stream of the Blue Nile near the country's border with Sudan, and its 6,000 MW of generating capacity is part of the government's plan to lift much of the population out of poverty by 2025. Egypt has voiced numerous concerns about the dam's possible impacts on flows in the Nile, and some, including former Prime Minister Mohamed Morsi, have used bellicose language toward Ethiopia. What is clear is that the new dam will have not only impacts on the flow downstream upon which Egyptian agriculture depends, but also impacts on electricity generation at existing Nile dams in Sudan and Egypt.

South and Southeast Asia present further, even more complex, cases of the resource nexus and hydropolitics.[61] China's downstream states, basically all of the countries in mainland South and Southeast Asia, depend on rivers rising in China and are worried about China's massive dam construction and the impact this will have on both the quantity and quality of water flowing through their territories. The major rivers of these regions all originate on the Tibetan Plateau, and climate change threatens source waters because of glacier melt. More immediately, perhaps, the spate of dam building on the Mekong poses a serious challenge to downstream populations that depend on fisheries, dependable flow patterns, and silt and nutrients to sustain agriculture. While the Mekong River Commission (MRC) is a reasonably successful multilateral institution governing the river basin, China—which of course manages the headwaters and three provinces of the country through which the river flows—only participates in the MRC as a "dialogue partner." China's seven megadams and twenty further planned dams are a source of serious downstream concern, but even downstream states are planning or constructing an additional eleven hydro dams.[62] A bevy of research suggests that the dam building will have negative impacts on food security—fisheries and agriculture—in Southeast Asia. Plus, the plans require energy and materials for their construction and will have impacts on regional ecosystems. Looking at water and energy issues as well as at other resource interlinkages in a more integrated manner, the nexus approach is likely to enhance risk analysis and facilitate the deliberation for solutions in transboundary river management across scales.

WATERWAYS, INTERNATIONAL TRADE, AND MARITIME SECURITY

There is yet another dimension related to water and the resource nexus that should be of interest: the world's oceans and the many waterways used for shipping and international trade.

Again, this is not entirely new. Dating back to the Bible, mankind always has had a strong religious and symbolic notion of oceans. The ancient Romans called "Mare Nostrum" what is today the Mediterranean Sea, considering it a homeland for their citizens. What's relevant today is the amount of goods traded on international shipping lanes and the erosion of an international order that was established after World War II.

Some 80 percent of all goods traded internationally use international shipping lanes according to UNCTAD data. Oil, coal, iron ore, bauxite and other aluminum pre-products, phosphate, and a few other commodities make up for roughly one-third of international maritime trade measured by tonnage, with staple goods, mass goods, and containers contributing other significant shares. The share of containers is rising constantly due to international supply chains, and one may also expect a rise in liquefied natural gas (LNG).

The environmental importance of the oceans is increasingly recognized.[63] Research shows that being used as sinks for waste—including chemical hazardous substances such as persistent organic pollutants (POPs), radioactive waste, and plastics—gives alarming signals about acidification, warming, and the pollution of oceans. The waste water dimension is especially important from a nexus perspective, as nutrients flowing into the oceans cannot easily be recovered and contribute to lower yields in fishery and other parts of the food chains. No surprise that the estimations about the world's natural capital give oceans and coastal ecosystems highest values.[64]

There are high the expectations about using the oceans and the seabeds as a future source for extraction of energy and materials. Existing processes feature sand and gravel extraction used for many construction purposes, but also diamonds, pearls, salt, manganese, and gas hydrates. Future seabed mining is seen as lucrative because the quantity of minerals occupying the ocean floor is potentially large. The EU is fascinated about a future "blue growth,"[65] while companies with illustrative names such as "Nautilus Minerals Inc." have started activities all over the world.

Besides environmental concerns about potentially negative impacts and safety and health issues, there are also severe maritime security ramifications that need to be considered.

The rise of China to exploit the "string of pearls," a colloquial term for Chinese-funded ports and related infrastructure along the Indian and Pacific Oceans, becomes more and more visible. It stretches from small islands such as the Kingdom of Tonga in the South Pacific on to the Indian Ocean and the European port of Piraeus. One may expect raw material partnerships to arise that give China a preferred exploration right or access to seabeds located in the 200 mile zones of those areas.

Gunboat diplomacy continues in the Chinese Seas. The Chinese claims on "their" South and East China Seas are antagonizing the neighbors in Japan, the Philippines, and Vietnam. The now more nationalist government in Japan has started to develop a tough position. With historians such as Herfried Muenkler reminding us that the Great War emerged out of a similar constellation in Europe in 1914,[66] one should clearly be worried about what potentially could escalate into a serious confrontation. Access to the manifold resources is clearly one of the driving forces in this conflict. (See Figure 5 on page 43.)

What also adds to the picture are asymmetric threats such as piracy and maritime terrorism along essential choke points of international shipping.[67] Piracy in and around the Strait of Malacca has been on the rise recently, despite accounts of ongoing stringent measures by the concerned littorals. The situation off the West African Gulf of Guinea is also serious. Piracy off Somalia has been another example of the maritime consequences of instability and lawlessness on land, albeit the situation there has become slightly better since 2011. With volatile adjoining regions, one may expect more "professional" types of piracy with more engagements of terrorists and international organized crime using ungovernable spaces as territory.

We have called this a "redux of the resource curse"[68]: triggered by the emergence of a food and/or water crisis—whatever the causes may be—local and national governance mechanisms are vulnerable and may not be able to cope with such a shock. If people start rioting for access to water and food and if the existing institutional resilience is low, fragile states and regions will be put at risk of further instability, where the mechanisms of piracy, fundamentalism, secessionism, terrorism, and organized crime might escalate. Any such escalation may then lead to interruptions of supply chains for essential materials and have international repercussions.

To a certain extent, shipping is immune to security risks because if one area of the ocean becomes unsafe then ships will re-route. For example, if Suez becomes impassible, then it would be possible for more ships to go around Africa. In the present market there may even be enough spare capacity for this to happen with only a minimal impact on freight rates. Industry now uses Automatic Identification System (AIS), which enables the positioning of vessels as they move around the globe. The other way that the industry has dealt with piracy is just to treat it as an insurance cost—plenty of operators who are still actively trading with, for example, East Africa charge a higher price and buy back the ship with ransom money if it is captured. There is also a rise in the use of privately contracted armed security personnel (PCASP). That's not to say that there are not strategic sea lanes; clearly a conflict that blocks the Straits of Hormuz and Malacca would be enormously disruptive to world oil supply and other value chains.

The International Maritime Organization (IMO) is actively dealing with those issues. They host a registry of piracy incidents and security arrangements. For the Strait of Malacca, for instance, it shows 148 allegedly committed attacks, 40 attempted attacks, and further 405 incidents without a geographical position system. There are amendments to the 1974 Safety of Life at Sea Convention (SOLAS), the most far-reaching of which enshrined the International Ship and Port Facility Security Code (ISPS Code), which contains detailed security-related requirements for governments, port authorities, and shipping companies in a mandatory section (Part A), together with a series of guidelines about how to meet these requirements in a second, non-mandatory section (Part B). Regional cooperation among states has an important role to play, too, as evident through the Regional Cooperation Agreement on Combating Piracy and Armed Robbery against ships in Asia (RECAAP) and the Djibouti Code of Conduct. In addition, there is an unprecedented international mobilization of maritime security coalition between the EU naval forces of Operation Atalanta, plus two U.S. and NATO task forces, along with ships from other countries (China, Japan, South Korea, and Russia).

A main root cause for piracy, however, is the poverty and lack of livelihood along major coastlines that motivates people to join criminal gangs. It is here where the resource nexus might become a key abatement strategy: securing a better management for water, energy, and food in rural areas is probably the best strategy to minimize the risks of piracy and environmental degradation. It is here where the action emerging for a sustainable energy for all, a right to water, a responsible supply chain management, low carbon shipping, and eco-innovations shall converge.

Conclusions

The resource nexus raises a number of challenges for international security. It deepens existing conflicts and leads to new ones.

Quite often, water is at the heart of such dynamic instabilities. The provision of water is essential for energy production and a number of industrial processes, for human life, and for the provision of ecosystems services that are essential for food production. The resource nexus helps to understand which resources depend on a well-functioning water provision, what risks may emerge in case of disturbances, and what opportunities may arise from crossing the silos of water, energy, and others. If societies are unable to manage water much more sustainably, this could become a significant drag on the economy.

The security implications are manifold. Water has been the genesis for urban riots in various quarters of the world in recent decades, with nexus ramifications amplifying outbreaks of fundamentalism, piracy, terrorism, threats for supply chain security and homeland security, and international conflicts.

Probably most important is to understand the resource nexus as a preventive tool to understand such interlinkages and translate them into action on the ground where business, citizens, and policy coalitions have a role to play to minimize risks and turn them into opportunities for sustainable resource management. The transatlantic policy toolbox should be widened to include resource efficiency, supply chain security, and greening international trade.

Notes

* We wish to thank Tristan Smith, Tim Boersma, and Steve Szabo for helpful comments and remarks on a draft version of this paper.

1 Professor Sir John Beddington, Speech at the Sustainable Development UK Conference, 19 March 2009, available at: http://www.govnet.co.uk/news/govnet/professor-sir-john-beddingtons-speech-at-sduk-09

2 I. J. Winter, "After the Battle Is Over: The 'Stele of the Vultures' and the Beginning of Historical Narrative in the Art of the Ancient Near East," *Studies in the History of Art*, vol. 16 (1985): 11-32

3 J. Rockström et al., "A safe operating space for humanity," *Nature*, vol. 461, no. 7263 (2009): 472-475; W. Steffen et al., "Planetary boundaries: Guiding human development on a changing planet," *Science*, vol. 347, no. 6223 (2015).

4 James R. Healey, Greg Gardner and Alisa Priddle, "Trucks, SUVs power blazing January auto sales," *USA Today*, 3 February 2015, <http://www.usatoday.com/story/money/2015/02/03/january-auto-sales/22765369/>

5 H. Hoff, "Understanding the Nexus (Background paper for Bonn 2011 Conference: The Water, Energy and Food Security Nexus)," Stockholm Environment Institute (Stockholm, 2011).

6 PBL, "Scarcity in a sea of plenty?" PBL-Netherlands Environmental Assessment Agency (The Hague, 2011).

7 P. Andrews-Speed et al., *The Global Resource Nexus: The Struggles for Land, Energy, Food, Water, and Minerals* (Washington, DC: Transatlantic Academy, 2012) and *Want, waste or war? : the global resource nexus and the struggle for land, energy, food, water and minerals* (London, New York: Routledge, 2015).

8 European Union, "Confronting scarcity: Managing water, energy and land for inclusive and sustainable growth," *European Report on Development* (Brussels, 2012), http://erd-report.eu/erd/report_2011/documents/erd_report%202011_en_lowdef.pdf

9 B. Lee et al., "Resources futures," Chatham House (London, 2012).

10 M. Bazilian et al., "Considering the energy, water and food nexus: Towards an integrated modelling approach," *Energy Policy*, vol. 39, no. 12, (2011): 7896-7906.

11 F. Ackerman and J. Fisher, "Is there a water–energy nexus in electricity generation? Long-term scenarios for the western United States," *Energy Policy*, vol. 59, no. 0 (2013): 235-241.

12 C. Ringler, A. Bhaduri, and R. Lawford, "The nexus across water, energy, land and food (WELF): potential for improved resource use efficiency?" *Current Opinion in Environmental Sustainability*, vol. 5, no. 6 (2013): 617-624.

13 G. Rasul, "Food, water, and energy security in South Asia: A nexus perspective from the Hindu Kush Himalayan region," *Environmental Science & Policy*, vol. 39, no. 0 (2014): 35-48.

14 A. Siddiqi and L.D. Anadon, "The water–energy nexus in Middle East and North Africa," *Energy Policy*, vol. 39, no. 8 (2011): 4529-4540.

15 UNESCAP, "The Status of the Water-Food-Energy Nexus in Asia and the Pacific," United Nations Economic and Social Commission for Asia and the Pacific (Bangkok, 2013), http://www.unescap.org/sites/default/files/Water-Food-Nexus%20Report.pdf

16 National Intelligence Council, "Global Trends 2030: Alternative Worlds," National Intelligence Council (Washington, DC, 2012).

17 World Bank, "Turn down the heat: Confronting the new climate normal," World Bank (Washington, DC, 2014); see also the assessment reports published by the Intergovernmental Panel on Climate Change (IPCC).

18 National Intelligence Council, "Global Trends 2030: Alternative Worlds," National Intelligence Council (Washington, DC, 2012).

19 J.N. Galloway et al., "The nitrogen cascade," *BioScience*, vol. 53, no. 4 (2003): 341-356.

20 K.M. Keranen et al., (2014) "Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection," *Science*, vol. 345, no. 6195 (2014): 448-451.

21 C.D. Klose, (2013) "Mechanical and statistical evidence of the causality of human-made mass shifts on the Earth's upper crust and the occurrence of earthquakes," *Journal of Seismology*, vol. 17, no. 1 (2013): 109-135.

22 M.D. Zoback and S.M. Gorelick, (2012) "Earthquake triggering and large-scale geologic storage of carbon dioxide," Proceedings of the National Academy of Sciences, vol. 109, no. 26 (2012): 10164-10168.

23 W. Steffen, P.J. Crutzen, and J.R. McNeill, "The Anthropocene: are humans now overwhelming the great forces of nature," *AMBIO: A Journal of the Human Environment*, vol. 36, no. 8 (2007): 614-621.

24 U.S. Department of Defense, "Quadrennial Defense Review 2014," Defense Department (Washington, DC, 2014),http://www.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf (3 May 2014).

25 E. Economy and M. Levi, *By All Means Necessary: How China's Resource Quest is Changing the World* (Oxford: Oxford University Press, 2014).

26 P. Andrews-Speed et al., *Want, waste or war? : the global resource nexus and the struggle for land, energy, food, water and minerals* (London, New York: Routledge, 2015).

27 Ibid.

28 W. Steffen et al., "Planetary boundaries: Guiding human development on a changing planet," *Science*, vol. 347, no. 6223 (2015).

29 Note that this indicator does neither capture groundwater nor the collection of rainwater suggesting that future supply might become better, if measures are taken.

30 R. Costanza et al., "Changes in the global value of ecosystem services," *Global Environmental Change*, vol. 26 (2014): 152-158.

31 UK Natural Capital Committee, "Towards a Framework for Defining and Measuring Changes in Natural Capital," *Working Paper* 1 (London: Natural Capital Committee, 2014).

32 See "Sustainability in the Water-Energy-Food Nexus," International Conference, Berlin, Germany, 19-20 May 2014, http://wef-conference.gwsp.org

33 CDP, "From water risk to value creation: CDP Global Water Report 2014," Carbon Disclosure Project (London, 2014).

34 Economist Intelligence Unit, "Water for all? A study of water utilities' preparedness to meet supply challenges to 2030," *The Economist* (2012).

35 T. Hertel and J. Liu, "Implications of water scarcity for economic growth," *ENV/EPOC Report* 17, OECD (Paris, 2014).

36 World Bank, "Turn down the heat: Confronting the new climate normal," World Bank (Washington, DC, 2014).

37 Ibid., 130.

38 See R. Bleischwitz, C. M. Johnson, and M. G. Dozler, "Re-Assessing resource dependency and criticality. Linking future food and water stress with global resource supply vulnerabilities for foresight analysis," *European Journal of Futures Research*, vol. 2, no. 1 (2014): 1-12.

39 UN-Water Decade Programme on Advocacy and Communication, "Cities coping with water uncertainties," Media Brief, www.un.org/waterforlifedecade/swm_cities_zaragoza_2010/pdf/02_water_uncertainties.pdf

40 See K. Engel, et al., "Big Cities. Big Water. Big Challenges. Water in an Urbanizing World," WWF Germany (Berlin, 2011); Ibid.

41 K. Engel, et al., "Big Cities. Big Water. Big Challenges. Water in an Urbanizing World," WWF Germany (Berlin, 2011).

42 See K. Thompson, "Last Straw: How the Fortunes of Las Vegas will Rise of Fall with Lake Mead," *Popular Science*, 11 June 2014.

43 Bundy has been involved in a two decade legal dispute with the U.S. Bureau of Land Management over grazing lands in southeastern Nevada. In April 2014 there was an armed confrontation between law enforcement officers and Bundy and his supporters.

44 D. Mustafa, M. Akhter, and N. Nasrallah, "Understanding Pakistan's

Water-Security Nexus," *Peaceworks*, United States Institute of Peace (Washington, DC, 2013).

45 Cited in U.S. Department of Energy, "Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water," DOE Office of Environmental Management (Washington, DC, 2006).

46 "How It Works: Water for Electricity," Union of Concerned Scientists (Cambridge, MA), http://www.ucsusa.org/clean_energy/our-energy-choices/energy-and-water-use/water-energy-electricity-overview.html

47 U.S. Department of Energy, "Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water," DOE Office of Environmental Management (Washington, DC, 2006).

48 P. Torcellini, N. Long, and R. Judkoff, "Consumptive Water Use for U.S. Power Production," U.S. National Renewable Energy Laboratory (Golden, CO, 2003), http://www.nrel.gov/docs/fy04osti/33905.pdf

49 Ibid.

50 Kevin Fagan, "Desalination plants a pricey option if drought persists," *SF Gate*, 15 February 2014, http://www.sfgate.com/news/article/Desalination-plants-a-pricey-option-if-drought-5239096.php

51 "Nuclear Power in the United Arab Emirates," World Nuclear Association (March 2015), http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/United-Arab-Emirates/

52 Anna Flavia Rochas and Roberto Samora, "Brazil water supply, crops still at risk a year after epic drought," *Reuters*, 9 January 2015, http://www.reuters.com/article/2015/01/09/us-brazil-rain-idUSKBN0KI1EJ20150109; Andrew Maddocks, Tien Shiao and Sarah Alix Mann, "3 Maps Help Explain São Paulo, Brazil's Water Crisis," World Resources Institute Blog (4 November 2014), http://www.wri.org/blog/2014/11/3-maps-help-explain-s%C3%A3o-paulo-brazil%E2%80%99s-water-crisis

53 Jan Rocha, "Drought Takes Hold as Amazon's 'Flying Rivers' Dry Up," *Climate Central*, 28 September 2014, http://www.climatecentral.org/news/drought-takes-hold-as-amazons-flying-rivers-disappear-18097

54 M. Howells and H.-H. Rogner, "Water-energy nexus: Assessing integrated systems," *Nature Climate Change*, vol. 4, no. 4 (2014): 246-247.

55 National Intelligence Council, "Global Water Security," Intelligence Community Assessment, NIC (Washington, DC, 2012).

56 J.D. Petersen-Perlman et al., "Case Studies on Water Security: Analysis of System Complexity and the Role of Institutions," *Journal of Contemporary Water Research & Education*, vol. 149, no. 1 (2012): 4-12.

57 B. Cosens, ed., *The Columbia River Treaty Revisited: Transboundary River Governance in the Face of Uncertainty* (Corvallis: Oregon State University Press, 2012).

58 J.C. Veilleux, "The human security dimensions of dam development: the grand Ethiopian renaissance dam," *Global Dialogue*, vol. 15, no. 2 (2013): 1-15.

59 P. Andrews-Speed et al., *Want, waste or war? : the global resource nexus and the struggle for land, energy, food, water and minerals* (London, New York: Routledge, 2015).

60 J.C. Veilleux, "The human security dimensions of dam development: the grand Ethiopian renaissance dam," *Global Dialogue*, vol. 15, no. 2 (2013): 1-15.

61 B. Chellaney, *Water : Asia's new battleground* (Washington, DC: Georgetown University Press, 2011).

62 "Mekong Mainstream Dams," International Rivers (Berkeley, CA), http://www.internationalrivers.org/campaigns/mekong-mainstream-dams

63 German Advisory Council on Global Change, "World in Transition: Governing the Marine Heritage," WBGU (Berlin, 2013), http://www.wbgu.de/en/flagship-reports/fr-2013-oceans/ (29 March 2014).

64 R. Costanza et al., "Changes in the global value of ecosystem services," *Global Environmental Change*, vol. 26 (2014): 152-158.

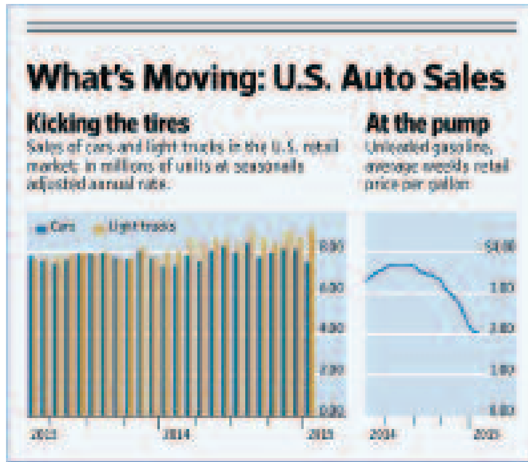
65 European Commission, "Blue Growth: opportunities for marine and maritime sustainable growth," European Commission (Brussels, 2012).

66 See Herfried Münkler, "Lessons from 1914," *The European*, 10 February 2014, http://en.theeuropean.eu/herfried-muenkler—2/7984-the-misleading-analogy-between-1914-and-2014

67 UNITAR, "UNOSAT Global Report on Maritime Piracy: a geospatial analysis 1995-2013," United Nations Institute for Training and Research (Geneva, 2014).

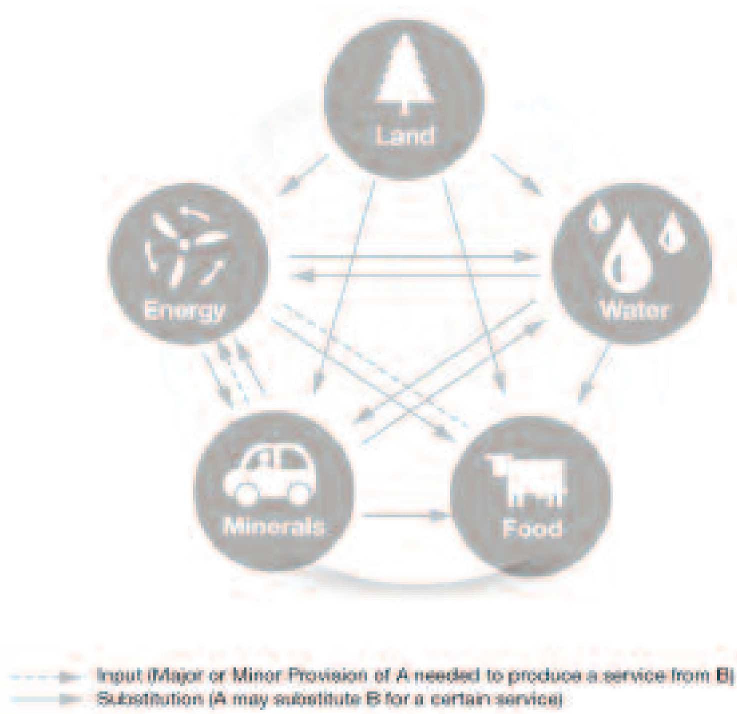
68 R. Bleischwitz, C. M. Johnson, and M. G. Dozler, "Re-Assessing resource dependency and criticality. Linking future food and water stress with global resource supply vulnerabilities for foresight analysis," *European Journal of Futures Research*, vol. 2, no. 1 (2014): 1-12.

Figure 1: U.S. Auto Sales and Gas Prices



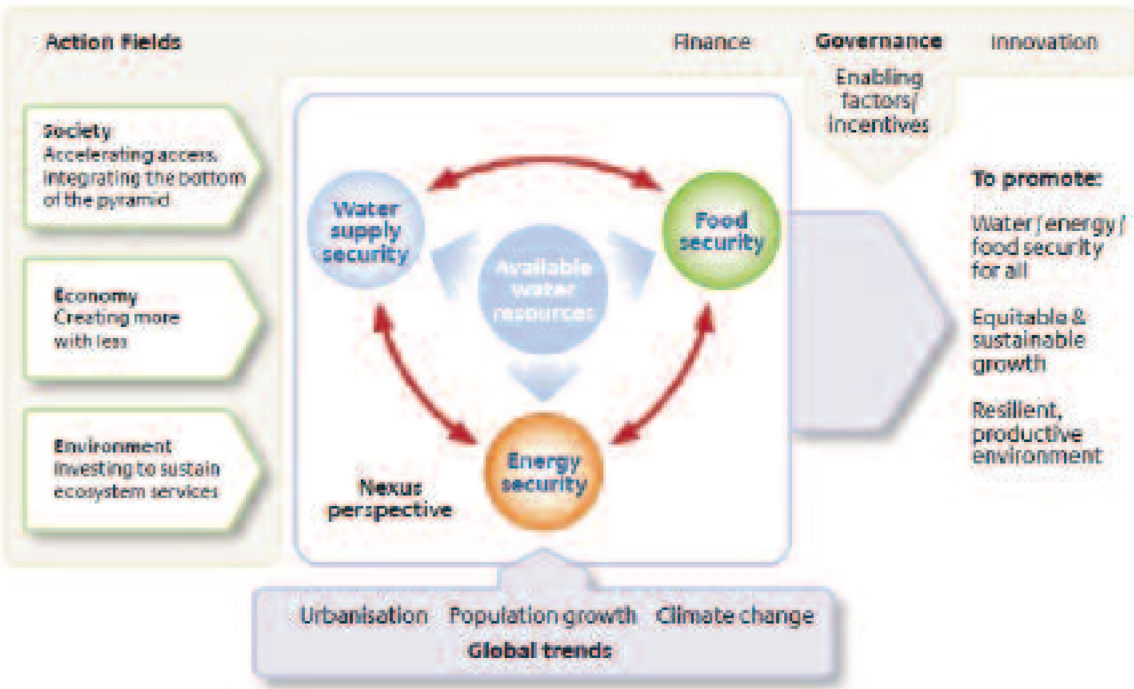
Source: Wall Street Journal, http://online.wsj.com/mdc/public/page/2_3022-autosales.html

Figure 2: The Resource Nexus



Source: P. Andrews-Speed et al., *Want, waste or war?: the global resource nexus and the struggle for land, energy, food, water and minerals* (London, New York: Routledge, 2015): 9.

Figure 3: The Water, Energy, and Security Nexus



Source: H. Hoff, "Understanding the Nexus (Background paper for Bonn 2011 Conference: The Water, Energy and Food Security Nexus)," Stockholm Environment Institute (Stockholm, 2011).

Figure 4: Water and Energy Nexus

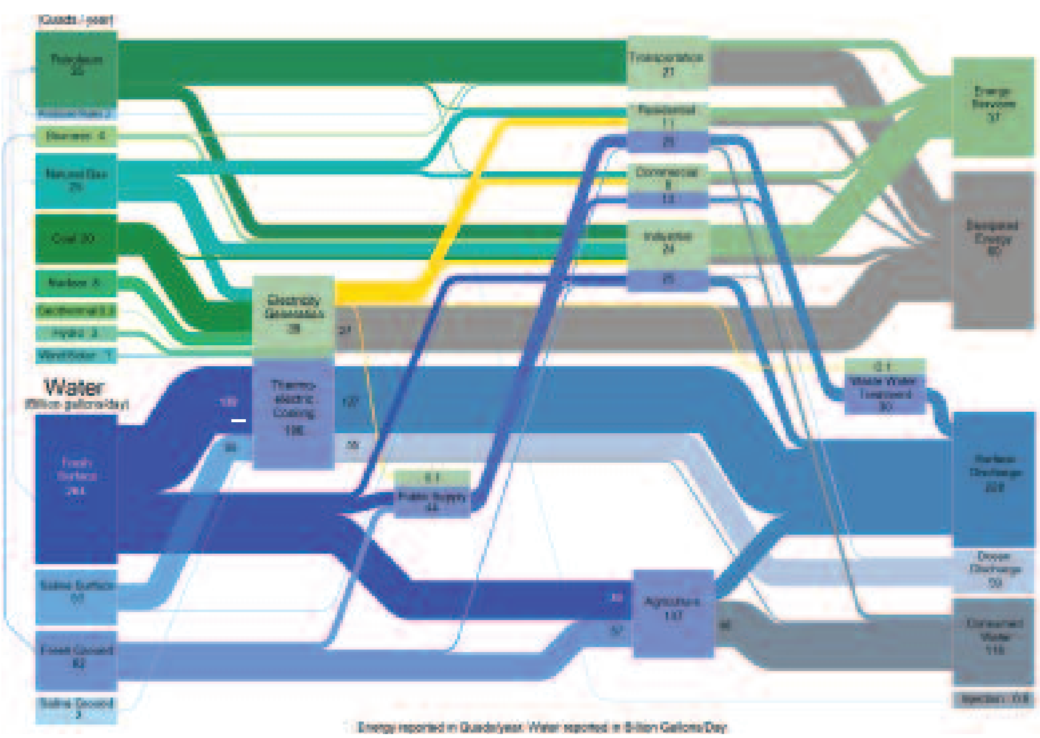


Figure 5: China Seas

Source: P. Andrews-Speed et al., *Want, waste or war?: the global resource nexus and the struggle for land, energy, food, water and minerals* (London, New York: Routledge, 2015).

American Institute for Contemporary German Studies

JOHNS HOPKINS UNIVERSITY