PLANET WATER

Investing in the World's Most Valuable Resource

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To Paul, Alex, Lauren, Kate, and Tess; for whom ecological sustainability will be more than words.

Contents

Introduction

When I wrote the treatise "Water: The Untapped Market" back in 1987, I advocated market-based solutions to the governance of expanding global water resource challenges. Actually, as a resource economist, it is more accurate to say that I was enchanted by the potential application of the principles of resource economics to the free market system. As I prophesied over 20 years ago in the introduction to that document, "the dynamics of the water industry are changing rapidly in coincidence with the growing problems inherent in a severe imbalance of supply and demand. Given the natural constraints of the hydrologic cycle and the artificial limitations imposed by the degradation of supplies, it is becoming increasingly apparent that the effective utilization of water resources requires a more productive set of governing institutions." That set of productive institutions was collectively embraced through the marketplace.

At the time, "governing institutions" were effectively limited to federal, state, and local regulatory frameworks and oversight. It was my belief that water pricing mechanisms and the unfettered transferability of water rights, among other market-based solutions, would inevitably lead to equilibrium in the supply and demand for water. Granted, there were hurdles to overcome such as pollution externalities and public (common) good issues where market failure is predictable, but nothing that a close relationship between governments and markets could not work through.

Over 20 years later, I have seasoned to the fundamental realities of a critical industry in transition, subject to pricing challenges and politically restrained to trend toward the equilibrium that is so natural in most other markets and so needed in this one. The allocation of water to this day does not even remotely adhere to the forces of a market seeking equilibrium, and it is clear that a price-driven optimal allocation will not always equate to an optimal distribution. Not coincidentally, the global condition of our water resources has never been more in peril nor the investment opportunities greater.

The inflection point is upon us. Water will be the resource that defines the twenty-first century driven by a substantial increase in its value. This value will inevitably be unlocked as the global population adjusts to the linkages between human health, economic development, and resource sustainability. But what is meant by value? As investors know, value can be an instructive yet elusive concept. Indeed, one of the dilemmas that Adam Smith faced in writing *An Inquiry into the Nature and Causes of the Wealth of Nations* (which set the foundation for the field of modern economics) involved tracing the roots of value. By discovering the source of value, Smith hoped to find a benchmark for measuring economic growth. He identified two different meanings of value (value in use and value in exchange) and observed that things that have a high value in use frequently have very little or no value in exchange. And, conversely, goods that have the greatest value in exchange often have inconsequential value in use.

Smith summed this up in the form of a puzzling contradiction: the diamond-water paradox. Why is it that diamonds, which have limited practical use (and no survival value), command a higher price than water, which is a prerequisite for life? Smith could not solve the paradox and instead identified labor as the source of value. What is instructive, and telling, was how he phrased the explanation: "The real price of every thing, what every thing really costs to the man who wants to acquire it, is the toil and trouble of acquiring it." Price was related to a factor of production (i.e., labor), thereby circumventing the original quest for the source of value to the consumer.

While we must not forget that in Smith's day natural resources were effectively viewed as unlimited, he certainly understood the value of water to someone thirsting in the desert. But again, at the time, such a scenario was a simple issue of supply and demand (neither curve was at issue), not an explanation of why the price of diamonds was greater than the price of water. It was not until the neoclassical economists of the late nineteenth century that the "answer" was told. The resolution of the paradox involved one of the most enduring metaphors in the history of economics and indirectly set in motion a divergence between economics and ecology, with implications far greater than anyone could have imagined.

Enter the theory of marginal utility. This subjective theory of value states that the price of a good is determined by its marginal utility, not by the amount of labor inputs and not by its total usefulness. *Utility* refers to the ability of a good or service to satisfy a want, and the immeasurable units of satisfaction are metaphorically called *utils.*

Water may have a very high total utility, but its general availability creates a low marginal utility and, since price is determined at the margin, a price that is artificially low. As economists suggest, do not confuse *utility* with *usefulness;* in other words, don't confuse the metaphor as a metaphor. The intuitively obvious inelasticity of demand for water is rendered nonsensical by a price that is not rendered at the margin; again, the marginal utility of water is ordinarily low because a single incremental unit seldom commands extraordinary satisfaction. The diamond-water paradox was solved. That was the story then.

The reality today is that virtually every country in the world is presented with some combination of water quality and quantity issues. Total utility, in the form of ecology, is not afforded the proper treatment. This is the cause of the divergence between economics and ecology; the total usefulness of nature, and water, must be part of the equation. Now today, once again, it is a simple issue of supply and demand because both curves are the issue. If the model of global warming and the metaphor of climate change are necessary to understand the true meaning of ecology, then so be it. Not that six million years of geologic history in our lineage is enough to convince us, but can it be any clearer from the "greenhouse gases" metaphor of climate change that nature "manages" us, not the other way around? To explain why we must fuse the human economy with nature's economy we must also retell the story of water.

I have intentionally stopped short of a more detailed exposition of the implications for water because it is critical that the investor constantly refer back to this paradox throughout the reading. The response to the diamond-water paradox will be a prominent part of the fundamentals associated with investment in water; for now, the answer will remain a question so that the reader refers back to the paradox as often as the content inspires reflection. This foreshadows the transition under way in the water industry; that is, the substantial increase in its value.

Why is all of this so important to investors in water? While the implications will be addressed in more detail in the concluding comments, investors must keep several things in mind as the journey progresses. First, there are no substitutes for water. Second, prices set at the margin should include the marginal cost of water. Third, value in exchange requires a measure of value and the ability to exchange. And fourth, total utility is relevant to ecology.

Can it simply be that this is the first time (or the time of accumulated knowledge) in the history of humanity that we have the experiential ability to tell the story of nature on a planetary scale, that is, once our activities impact nature on a planetary scale? It is in that spirit that the story of water is told. The human species and nature are obviously inseparable. At the same time, the human economy and nature's economy are viewed as divisible; nature serves humanity. Analogous to the division of labor, the mechanistic methodology embraced by modern economics seeks the division of resources, the specialized utilization of our natural resources in the relentless pursuit of growth in isolation from the precepts of ecology. When private and social rates of return diverge, private decision makers will not allocate optimally. The divergence of social and private costs and/or benefits result as much from the "rules" established by institutions as it does from the methodology used to measure such costs.

There is a burgeoning global demand for safe drinking water, environmentally sustainable water use, and industrial process improvement. Yet despite unprecedented economic progress on a global scale, environmental issues have been largely neglected as a critical component of continued growth. For such a basic proposition as clean water, why has the industry dedicated to addressing this need not received more attention? Why is there such a disconnect between the human economy and "nature's economy," as coined by Donald Worster?

The problem is that as economic activity expands, there seems to be an almost cavalier denial of the impact on our natural resources, as if there were no linkage between unbridled expansion and the planet's carrying capacity. It is this fusion of ecology and economics that will reorder the cultural paradigm and facilitate an understanding of our interconnectedness with nature. The assumptions of economic society must be fused with its biological underpinnings. It is time to establish new metaphors that fuse ecology with economics and, in so doing, retell the story of water for the twenty-first century.

Part One

WATER

Chapter 1

Water: Prerequisite for Life and Living

Water is ubiquitous on Planet Earth. As we view our planet from beyond, we are struck by the prevalence of water. It is so much a distinguishing feature on the universal canvas that Earth is commonly referred to as the "Blue Planet." Before we had an interstellar perspective, and before we were even aware of a planetary scheme, the word *earth* took cultural form from the solid footing that was understood—namely, ground, soil, and land. The planet was labeled accordingly. But the reality is that water is a primal driver in shaping the planet and the awareness is that its scarcity is a constraint on its inhabitants. From this modern perspective, it would be more appropriately called Planet Water.

It is believed that large amounts of water have flowed on Earth for 3.8 billion years, most of its existence. There is no coincidence between the abundance of water on Earth and the existence of life. Water is the dominant constituent of virtually all living forms. As Felix Franks of the University of Cambridge puts it, "Without water it's all just chemistry. Add water and you get biology." Water is a prerequisite for life. To understand the intricacies of the water molecule in developing and sustaining life is to understand the economic potential of water in the context of its presence as a prerequisite for living. As humans place burgeoning demands on the substance, water is increasingly recognized for the limitations its distribution places on the socioeconomic well-being of civilizations.

A key requirement for successful investing is a thorough understanding of the business that you are investing in. The fact that we need water to survive, while certainly putting a floor on demand, is not the level of understanding that we are after. Despite the rigors of understanding the many facets of water, it is absolutely critical that investors understand the science. It is the uniqueness of water that governs the technology to maintain its primal purpose, the economics of implementing solutions, and the politics to ensure its sustainable use. All aspects of investing in water are influenced by an understanding of what water represents. One simple fact sets in motion this unprecedented investment opportunity: There is simply no substitute for water.

Prerequisite for Life

The way the water compound is structured, and the resulting interaction with other key biogeochemical cycles, creates an intricate fabric that forms the basis of life on Earth. It is the oft-made statement that life depends on the anomalies of water. It is a critical biomolecule, structuring proteins, nucleic acids, and cells. Remarkably, the behavior and function of water, despite considerable research, is still far from completely understood.

The Life-Enabling Anomalies of Water

The simplicity of the atomic structure of a water (or hydrogen oxide) molecule belies its extraordinarily unique electrochemical properties. The V-shaped water molecule consists of two light hydrogen (H) atoms and a relatively heavier oxygen (O) atom at the vertex. The difference in mass gives rise to the molecule's ease of rotation and the constant movement of the hydrogen nuclei. The way in which the two hydrogen atoms are bonded to the oxygen atom is particularly significant. The electrons are shared between the atoms (covalently bonded) but are not distributed equally. The oxygen atom, therefore, attracts the electrons more strongly than the hydrogen side. The resulting asymmetrical distribution of charge, or dipolarity, creates a net positive charge on the hydrogen side of the molecule and a net negative charge on the opposite oxygen side. Hydrogen bonding causes molecules of water to be attracted to each other, forming strong molecular bonds, and explains many of the anomalous properties of water. The oxygen atom's strong affinity for chemical bonding with other nuclei enables many of life's reactions. Hydrogen bonding also allows water to separate polar solute molecules. The partially negative dipole end of the water molecule is attracted to positively charged components of a solute, while the opposite occurs on the positive dipole end. This polarity explains water's ability to dissolve many "contaminants" (the fact that oil is a nonpolar molecule is the reason that water and oil do not mix). In fact, water is known as the "universal solvent." This seemingly innocuous property accounts for an enormous proportion of the money spent in the water and wastewater industry. All sorts of dissolved substances (some a nuisance, some deadly) must be removed to make water suitable for most end uses, drinking water in particular. Investment applications include all aspects of water and wastewater treatment, nonpoint source surface water (runoff), stormwater, and groundwater. This is why treatment is viewed as such a compelling part of investing in water and why every location has a different treatment challenge.

As essential for life, however, the solvent properties of water are vital in biology, because many biochemical reactions can occur only in aqueous solution and also because this feature enables water to carry solvent nutrients to living organisms. This is also the reason why water seldom has a neutral pH of 7.0. Only pure water is neither acidic nor basic (acid rain, caused by sulfur dioxide and nitrogen oxide emissions from coal-burning power plants and automobiles, can have a pH as low as 2.3—as acidic as lemon juice).

Because of the extensive hydrogen bonding between molecules, water has the second-highest specific heat capacity of any known chemical compound, except ammonia, as well as a high latent heat of vaporization. These two unique properties allow water to moderate the Earth's climate by buffering large fluctuations in temperature. The large heat capacity of the oceans allows them to function as heat reservoirs in this buffering process. These properties have monumental ramifications in the advent of global warming.

The specific heat also helps organisms regulate their body temperature more effectively. Another life-enabling property of water is its high surface tension, the highest among nonmetallic liquids. The stability of water drops is critical in transporting water through the roots and stems of plants via the xylem. It is also responsible for the capillary action that allows water and dissolved substances to move through the blood vessels in our bodies.

In addition, the presence of hydrogen bonds provides another unique behavior for water upon freezing. As water molecules seek to minimize energy when cooled to the freezing point, the hydrogen bonds allow the formation of a hexagonal crystal structure that is more expansive than in the liquid state. Unlike almost all other substances, the solid state of water is, therefore, not as dense as the liquid form; that is, ice floats. This has environmentally significant implications. If water were denser when frozen, susceptible lakes and rivers, and oceans in polar biomes, would freeze solid, preventing thermal stratification from occurring and widely impacting biological systems in the lower aquatic life zones.

There are many additional anomalous properties of water, from the opposite properties of hot and cold water to its unique hydration properties for biological macromolecules that clearly place water in a unique class among the determinants of life on Earth. Interestingly, although the molecular structure of water is assumed stable in molecular thermodynamics, there are studies that have indicated that at the quantum (nanoscale) level, water may behave differently. At very small timescales, the structural permanence of water is more questionable, possibly with nanotechnology implications. The science of water tells us that water is a prerequisite for life and, in this respect, cannot be overemphasized. From an investment perspective, it is an undeniable fact. But the way water is cycled on the planet is the process that determines availability and accessibility from a societal perspective.

The Recycling of Water Energy

The hydrologic cycle is one of the life-sustaining biogeochemical (literally, life-earth-chemical) cycles—natural processes that cycle critical constituents from the abiotic (nonliving) environment to biotic (living) organisms and then back again. As cycles, the assumption is that these systems, for all intents and purposes, are closed, powered by energy from the sun and moving a fixed amount of matter in a continuous process.

Water is the most abundant molecule on the surface of the Earth. It is the only common substance found naturally in all three physical states of matter within the relatively small range of temperatures and pressures encountered on the planet's surface. It composes approximately 75 percent of the Earth's surface in liquid and solid (frozen) states, in addition to being the third most abundant gas in the atmosphere in the form of water vapor. Further, of the atmospheric constituents that vary in concentration both spatially and temporally, water vapor is the most abundant. While the variable components of the atmosphere make up a very small portion of atmospheric gases, they have a much greater influence on both weather (short-term) and climatic (long-term) conditions. Water vapor redistributes heat energy on the Earth through latent heat energy exchange, condenses to create precipitation, and warms the Earth's atmosphere as one of the original greenhouse gases.

The hydrologic cycle is often modeled as having distinct phases; evapotranspiration, condensation, precipitation, and collection. It is viewed as a constant system—water molecules in continuous movement cycling through well-defined states. But that model of uniformity, couched in terms of a human timescale, is increasingly seen, along with other elements of our ecosystem, as a fragile balance between determinism and chaos. While the overall volume of water is not changeable on a human timescale, it is clear that we can, and are, directly and indirectly affecting the spatial and temporal distribution of water on the planet. In other words, we are impacting the hydrologic cycle. This is not only in the obvious sense that we are depleting aquifers, diverting surface water flows, and exacerbating runoff, but we are also impacting the hydrologic cycle by altering the carbon cycle, creating infinite mini–storage units of water in all types of products, and generally mismanaging water in a rapid divergence from sustainability.

The role of water as a prerequisite for life, and its availability as a constraint on the human condition, combine with the natural distribution of water on the planet in a collision course with a rapidly expanding human population driven by economic development. The hydrologic cycle is one of the links between the biosphere (the collection of the earth's ecosystems) and the ascension of civilizations. As human activity approaches globalization, it has a greater ability to alter this global life-support system; that is, an expanding global economy becomes larger relative to the nonexpanding biosphere.

Human activities affect the biogeochemical cycles in vastly different ways. All of these cycles have extraordinarily complex features. The phosphorus cycle, for example, is exceedingly slow. On a human timescale, it can be viewed as a one-way flow from land to oceans. The carbon cycle, on the other hand, is unique in that while carbon-containing fossil fuels take millions of years to form, human activities can relatively quickly change the form, but not the absolute amount, of carbon. The carbon cycle includes carbon dioxide (CO_2) gas that regulates the Earth's thermostat—too little CO_2 in the atmosphere and it will cool; too much and the atmosphere warms. Here, human activities are capable of rapidly altering the mix. Fossil fuels are nonrenewable on a human timescale. In addition, water has now become a limiting factor in economic development: It is a prerequisite for living.

Prerequisite for Living

By "prerequisite for living" it is meant that water is a crucial factor in human well-being and the quality of life. Just behind income, the availability of water ranks as the second most critical factor in a survey of "well-being" among those most burdened in society. Water, through its many consumptive uses, permeates virtually all aspects of the socioeconomic fabric and affects many of our life choices. The lack of water, of acceptable quality and in sufficient quantity, is a major factor in poverty, food insecurity, human disease, economic development, and, ultimately, geopolitical conflict. It is this rapidly accelerating realization that forced water challenges onto the global stage, spotlighting the role of water as a prerequisite for living.

Water and the Quality of Living

If water plays such a vital role in human well-being and economic development, we would expect to face our greatest challenges in areas of the world where water is extremely scarce. And that is certainly the case. As the human population and economy grow, however, it is becoming apparent that hydrocentric constraints are permeating many more activities than would be expected from an obvious imbalance of supply and demand. Accordingly, while water availability is subject to spatial and temporal variations, it is constructive to get some sense of social condition in relation to water resources. The Water Poverty Index (WPI) was developed by the Center for Ecology and Hydrology for just such a purpose. The WPI is designed to be a scalable "evaluation tool for assessing poverty in relation to water resource availability." The composite index is a numerical measure that can be utilized by decision makers in water policy processes. The WPI is one way to produce a standardized framework to capture the complexity of water management issues as they relate to quality-of-life issues. But it is the theoretical basis of the WPI framework that is useful for our current purpose—that of linking water resource availability to, in their words, "the socioeconomic indicators of poverty drivers," or in my words, the quality of living.

Lack of water does not cause poverty, but poverty virtually always includes a lack of water. While *poverty,* like *standard of living,* can be defined in measurable terms, quality of living is a relative condition. It makes sense, then, to focus on a quantifiable level rather than a qualitative notion when viewing water as a prerequisite for living. As such, the long line of advancements that poverty is circumscribed by capability deprivation extends well to the ideal of quality of living encompassed in an ability to make livelihood choices. Having access to adequate water supplies for domestic and productive use clearly falls into the category of capability deprivation. To maintain effective livelihood choices, five capabilities have been identified by Desai (1995):[1]

1. Capability to stay alive/enjoy prolonged life
2. Capability to ensure biological reproduction
3. Capability for healthy living
4. Capability for social interaction

5. Capability to have knowledge and freedom of expression and thought.

Water is linked to all of these capabilities.

Given that water is a prerequisite for life and for living, it bears upon the investment implications going forward to get a sense of the baseline global water condition and to project the likely global water scenarios into the future.

Chapter 2

The Global Water Condition

The statistics are telling. The World Health Organization (WHO) estimates that 1.1 billion people do not have access to improved drinking water and that 2.6 billion people (40 percent of the world population) live in families with no proper means of sanitation. Half of all hospital beds in the world are filled with people suffering from waterborne and water-related diseases. The health burden also includes the annual expenditure of over 10 million person-years of time and effort by women and children carrying water from distant sources. If the average of one hour per day saved by each household member through the convenience of more proximate safe drinking water were used in a livelihood earning a minimum daily wage, this labor input would be worth $63.5 billion dollars per year.

The proliferation of statistics on the global water condition belies the notion that we have a firm grasp of the extent and depth of the impacts of the shortfall in potable water and sanitation. The impact of water scarcity is devastating: pervasive poverty, food insecurity, conflict, and morbidity. But none are as chilling as the fact that the lack of water and sanitation services kills about 4,500 children per day.

The Human Cost of Waterborne Disease

There are few things more tragic than a resource vital to human life taking life. Yet that is the case every day. Contaminated water causes a wide variety of communicable diseases through ingestion or physical contact. Waterborne disease remains one of the most significant threats to human health worldwide. Strictly speaking, waterborne diseases are caused by the ingestion of water contaminated by human or animal waste containing pathogenic bacteria or viruses including cholera, typhoid, amoebic and bacillary dysentery and other diarrheal diseases. More broadly, water-caused diseases also include water-washed diseases caused by poor personal hygiene and skin or eye contact with contaminated water (scabies; trachoma; and flea, lice, and tick-borne diseases); water-based diseases caused by parasites found in intermediate organisms living in water (dracunculiasis, schistosomiasis, and other intestinal helminths); and water-related diseases caused by insect vectors which breed in water (dengue, filariasis, malaria, onchocerciasis, trypanosomiasis, and yellow fever).

While global mortality figures vary considerably, the human toll from water diseases is clearly unacceptable. An estimated 1.8 million deaths occur annually from diarrheal diseases alone, and 90 percent of those are children under the age of five, mostly in developing countries. According to WHO statistics, there are approximately 4 billion cases of diarrhea each year, caused by a number of different pathogens, including *Shigella, Campylobacter jejuni, Escherichia coli, Salmonella,* and *Vibrio cholerae.* In Bangladesh alone, diarrheal diseases kill over 100,000 children every year. The alarming rate of urbanization, and the crowded condition of Dhaka's slum communities, adds significantly to the morbidity rate. And this scenario is played out in many parts of the world, such as Ethiopia, India, Kenya, Guatemala, Nigeria, and Honduras, to name just a few.