

# Cascading Challenges in the Global Water Crisis



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Edited by

Gerard Magill and James Benedict

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We dedicate this book to Duquesne University in tribute to the Endowed  
Annual Conference Series on the Integrity of Creation.



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# INTRODUCTION

## GERARD MAGILL

In 2015, the President of Duquesne University in Pittsburgh in the United States (Charles J. Dougherty) commissioned an endowed annual academic conference series on the *Integrity of Creation* to celebrate the organization's Spiritan mission. The University is Catholic, being founded by members of the Congregation of the Holy Spirit: the Spiritans.<sup>1</sup> The current University President, Ken Gormley, continues to provide outstanding support for the conference, inspiring excellence as the series develops.

This conference series is an interdisciplinary endeavor in the sense that presenters and participants from different disciplines are invited to engage each other in civil discourse on the conference topic. The conference has three goals: to provide a scholarly opportunity to engage with established and emerging research; to foster interdisciplinary discourse; and, to enlighten public awareness and discussion on the selected issues.

In Fall 2015, the topic of the inaugural conference was *Climate Change* as an urgent concern regarding the Integrity of Creation.<sup>2</sup> Before the conference there was the publication in May 2015 of the environmental encyclical of Pope Francis, *Laudato Si'—Praise Be To You*.<sup>3</sup> The Pope invited "every person living on this planet," "all people of good will," "to enter into dialogue with all people about our common home" as "a shared inheritance."<sup>4</sup> The call of Pope Francis for a "respect for the Integrity of Creation" is very similar to the focus of the Spiritan mission.<sup>5</sup> The second annual conference and its proceedings focused on the topic of *Integral Ecology: Protecting our Common Home*,<sup>6</sup> the conference title being inspired by Pope Francis as one of the chapters in his encyclical.<sup>7</sup>

As this conference series evolves, many other topics will be discussed to shed light on the *Integrity of Creation* from multiple perspectives. To safeguard our planet, we must be attentive to the global water crisis, environmental concerns with air pollution, problems that arise from toxicity in the land and ocean regarding food sources and biodiversity, and many other crises, not least of which is how to anticipate the movement of vast populations from coastal regions that may become permanently flooded.

The focus of the third annual conference and its proceedings appears in the title of this book, *Cascading Challenges in the Global Water Crisis*. This title reflects the importance of water in the Papal Encyclical.<sup>8</sup> Although the inspiration for this topic comes from Pope Francis, the analysis engages both secular and religious perspectives on crucial issues related to the global water crisis.

The presentations at this conference resulted from a peer-reviewed process for inclusion at the conference and in these published proceedings. The book chapters reflect the conference presentations and have been written to appeal to a general audience with rigorous scholarship, depicting the interdisciplinary focus of the conference. The chapters are organized into several interdisciplinary categories that relate together integrally. Each section has been designed to present a wide variety of perspectives: science and policy, religion and ethics, and global issues.

The first section sets the *context* for the discussion on the Global Water Crisis. This section provides an overview of the interdisciplinary arguments, indicating that there is an overlapping and cumulative sense of the need to protect water as an essential common good.

The section on *science and policy* introduces a critical perspective on our proper stewardship of water and its quality regarding public health and the need for conservation strategies. The section on *religion and ethics* explores how religion and ethics can renew our relationship with water as a precious resource, for example, enabling us to address water challenges in underserved communities. The next section on *global issues* explores concerns around water and the environment in the Arab Gulf, in the Amazon, and in Africa. The final section is the conclusion that presents the Global Water Crisis as an urgent ethical imperative.

A few words of acknowledgment are appropriate to recognize the contribution of many in planning the inaugural conference that has led to this collection of conference proceedings. Above all, the establishment of an endowment by President Charles J. Dougherty at Duquesne University to support this annual academic conference series presents a lovely legacy. Also, there is sincere appreciation for the continuing support of Ken Gormley as our current University President and for the ongoing support of the Spiritan Congregation that sponsors the University. The editors are very grateful for the meticulous work of a highly dedicated Conference Planning Committee, an outstanding University librarian, Ted Bergfelt, and superb support staff, including a very gifted group of international graduate students. Finally, the extraordinary grace and talent of the conference coordinator, Glory Smith, deserves to be recognized with high acclaim and heartfelt gratitude: this outstanding commitment, in addition to all of her

other daily office duties, continues to be a labor of love that assures success and joy at each conference.

## Notes

<sup>1</sup> See, <http://www.duq.edu/about/mission-and-identity>; also see, <http://www.spiritans.org>.

<sup>2</sup> See the conference proceedings, Gerard Magill, Kia Aramesh, eds., *The Urgency of Climate Change* (Newcastle Upon Tyne, UK: Cambridge Scholars Publishing, 2017), Introduction,” xi-xiv. Permission has been provided to reiterate in the Introduction of this book materials in the Introduction of *The Urgency of Climate Change*.

<sup>3</sup> Pope Francis, *Laudato Si’: Praise Be To You. Encyclical Letter of the Holy Father Francis on Care for Our Common Home* (Vatican City: Libreria Editrice Vaticana, 2015).

<sup>4</sup> Pope Francis, *Laudato Si’*, no. 3, 28, 93.

<sup>5</sup> Pope Francis, *Laudato Si’*, no. 130.

<sup>6</sup> See the conference proceedings, Gerard Magill, Jordan Potter, eds., *Integral Ecology: Protecting Our Common Home* (Newcastle Upon Tyne, UK: Cambridge Scholars Publishing, 2018).

<sup>7</sup> Pope Francis, *Laudato Si’*, no. 124 (in chapter three), and chapter four.

<sup>8</sup> Pope Francis, *Laudato Si’*, chapter 1, section II “The Issue of Water,” no. 2731.

## Literature

Magill, G., K. Aramesh. 2017. *The Urgency of Climate Change*. Newcastle Upon Tyne, UK: Cambridge Scholars Publishing.

Magill, G., K. Aramesh. 2018. *Integral Ecology: Protecting Our Common Home*. Newcastle Upon Tyne, UK: Cambridge Scholars Publishing.

Pope Francis. 2015. *Laudato Si’: Praise Be To You. Encyclical Letter of the Holy Father Francis on Care for Our Common Home*. Vatican City: Libreria Editrice Vaticana.



# **I. CONTEXT**

# CHAPTER ONE

## CASCADING CHALLENGES IN THE GLOBAL WATER CRISIS

### GERARD MAGILL

#### **Introduction**

The cascading challenges in the global water crisis across our planet require a variety of disciplines that engage each other in an integrative way. This book has been organized to let the dialogue in these disciplines unfold in an overlapping manner, with points of view developing from different angles. As mentioned in the book's Introduction, there are several main sections to bring coherence to the contributions. The first section introduces the context of the book, and the subsequent sections present a variety of perspectives on science and policy, religion and ethics, and crucial global issues.

#### **Context**

This opening chapter provides an overview of the interdisciplinary challenges surrounding the Global Water Crisis that appear in the book (using the abstracts submitted by the various contributors).<sup>1</sup> This overview is designed to assist readers in keeping an eye on the big picture as they explore the various topics. The context of the book highlights the interdisciplinary character of each section. As the chapters develop, there is a cumulative sense of water as a common good belonging to all and meant for all (adopting a phrase from the Papal encyclical, *Laudato Si'*).<sup>2</sup>

This study is part of an annual conference series that fosters the wholeness of creation from interdisciplinary and holistic perspectives. The book presents the proceedings of the 3<sup>rd</sup> annual endowed conference on the *Global Water Crisis*. The sections below summarize what are referred to as cascading challenges (adopting the water metaphor) in the global water crisis as we seek to protect our common home.

## Science and Policy

Within this context, the contributions regarding science and policy consider several related topics. First, we must steward water as a precious resource that requires us to understand water management problems. In the United States, a self-inflicted water crisis is looming—even in places that are not unusually dry or hot, communities, farmers, and factories are struggling to find water, sometimes running out altogether. These water woes will get worse before they get better because of the slow pace of change. However, we have the tools to address the water crisis, including conservation, reuse, desalination, price signals, and market forces. These tools offer opportunities to build resilience into the water supply systems, especially in the face of climate change. These tools help to address the water crisis to ensure that it does not become a catastrophe. The urgency of this problem requires action on multiple fronts to solve it. Such action entails combining a market-based system that recognizes water as a commodity but above all as a fundamental human right.

Second, this water crisis is especially evident when considering the vast phenomenon of shrinking and expanding cities, especially insofar as 2010 was the year when the global population living in cities surpassed those living in rural areas for the first time in Earth's history. There are cities with expanding populations under developing economic status. The majority of the world's population growth is occurring in these expanding cities of low and middle-income countries. In contrast, there are cities with shrinking populations and declining economies. In the United States, approximately 15% of the U.S. population, or 48 million people, live in these cities. In both cases, the cities experience underinvestment in urban water infrastructure that can have a substantial impact on drinking water quality. In both cases, the population shift directly affects the performance of urban water infrastructure in ways that may impose risks upon public health. Illustrations of these cascading challenges in the global water crisis are in Addis Ababa, Ethiopia as an example of a rapidly growing city in one of the poorest countries in the world and in Flint, Michigan as an example of a post-industrial shrinking U.S. city.

Third, as we move from global measures to population health in cities, we must face the challenge of sustainability with building infrastructure. In the United States, federal, state and local governments spent more than \$2.2 trillion in the last 59 years on water and wastewater utilities. Inefficient water use is rampant: buildings account for 13.6% of potable water use, while in many places non-potable water should be acceptable, and runoff from impervious surfaces continues to overwhelm sewage treatment plants.

Hence, we need to be smarter about the way we use and treat water. Being smarter is essential for economic and social justice reasons as well as for basic respect of the planet and all other life forms. To address these problems, the Living Building Challenge has established the most rigorous green building standard in the world, with a critical imperative of the standard requiring buildings to be net-zero water. One of 12 Living Building Challenge certified buildings in the world is the Phipps Conservatory and Botanical Gardens' Center for Sustainable Landscapes that strives to serve as a model for innovative water conservation strategies in the built environment. This green infrastructure suggests practical and sustainable ways in which these technologies can inform water conservation policies.

## **Religion and Ethics**

Given these cascading challenges in the global water crisis, it can be helpful to consider how discourse on religion and ethics can provide keen insight to inspire progress.

First, significant responses to the global water crisis appear in solutions that honor our contextualized reality as humans in relationship with the earth. Theological discourse can animate our moral imaginations and orient our worldview to envision more sustainable ways for humans to interact with water. This discourse aligns multiple resources, such as the Catholic social justice tradition and ecofeminism. Taking seriously human rights and the responsibility to protect all of God's creation offer new solutions to the water crisis based on justice. Advocacy for water justice must address the problems stemming from a commodified approach to water and move toward the celebration of water as a sacred gift for all creatures on the Earth.

Second, an example is how the rapport between religion and ethics in service-learning projects can inspire solutions to water quality challenges in underserved communities. This rapport can be especially significant in underdeveloped nations where there may be limited infrastructure and irregular supervision of community water supplies. Because water is a precious resource, information on the desirable or the undesirable qualities of water supply can quickly become a source of controversy. Managing water quality is crucial as well as managing the water itself. Hence, public education about water quality is a vital public health challenge—more people die from unsafe water annually than all forms of violence, including war. Projects inspired by the rapport between religion and ethics can engage these challenges in targeted yet highly effective ways.



## Global Issues

Global issues are widespread and prominent regarding challenges in the global water crisis. Food security in the Middle East presents a situation of urgency, as seen in the analysis of Saudi Arabia's recent policy to abandon wheat production inside the country. Its approach recognizes the fact that water, food, and energy are intimately linked because each affects the other and in turn is affected by it. We need a stance that recognizes the dynamic interrelationship between water, food, and energy. Such an approach would help decision-makers to consider how a plan in one sector could affect various stakeholders in that sector as well as in others. By being attentive to the water-energy nexus, a variety of shared policy objectives arise at the national level. These policy objectives include the following: ensuring the provision, conservation, and efficiency of freshwater; protecting water quality by mitigating human-induced damage of the ecosystem; improving energy security by providing and conserving energy supplies, as well as by increasing energy efficiency; and mitigating climate change by cutting or averting emission of anthropogenic greenhouse gases or sequestering carbon. This type of approach helps to create cross-sectoral policy integration and efficiency throughout the system, as opposed to gains in a particular sector. This approach would be an essential step towards sustainability. Natural infrastructure constitutes a critical component in the water-food-energy nexus.

Another widely recognized geopolitical issue regarding the global water crisis is evident in the environment of the Amazon basin. The Amazon region is home to the largest forest and the largest concentration of freshwater in the world, releasing twenty percent of the global river discharge to the ocean. The Amazon basin area is approximately seventy percent of the continental United States landmass, and the daily Amazon discharge of water is nearly ten times the needs of the United States. As this vast region continues to develop, sustainable preservation is crucial. However, in this endeavor, those living in the region must have influence. It is crucial to recognize that these insiders, who are responsible for preserving the region, see themselves as "suffering" the social, economic, legal and political consequences that flow from preservation policies. Only by being attentive to this insider lived experience can we grapple with the enormity of the dilemmas that arise. Above all, the people living there must be the first ones to be "preserved," and their experience must be included in meaningful dialogue when planning for change.

The global water crisis also can be seen in the Lake Chad basin water crisis regarding the importance of the lake in Africa. The Lake Chad water

crisis has generated environmental, economic, social and eco-ethical issues. Arguably, water constitutes the most basic and indispensable of all natural resources in the world. Without it, we cannot sustain socio-economic development and environmental diversity. In Africa, as occurs globally, there is an ever-growing demand on water use because of the increasing population along with rapid industrialization, mechanization, and urbanization. A significant proportion of the water resources of the African continent are large river basins or underground aquifers which are shared by several countries. Unfortunately, these resources encounter different kinds of socio-economic and political development that impact how they deal with their need for water. All these factors compound the search for an equitable and sustainable solution to water supply problems. A sound response to this water crisis in the Lake Chad basin calls for a holistic approach that is mindful not only of the socio-economic and geopolitical ramifications but also of the eco-ethical implications in maintaining an ecosystem.

## Conclusion

Pope Francis, in his environmental encyclical *Laudato Si'* that was published in 2015, astutely recognized the cascading challenges in the global water crisis as part of a larger trend that depletes natural resources. This depletion occurs because present levels of consumption are unsustainable and because of “the habit of wasting and discarding” that exploits the planet. He especially emphasized that fresh and safe drinking water is of primary importance for human life as well as for terrestrial and aquatic ecosystems. Increasingly, the demand for water in agriculture and industry exceeds the sustainable supply. Also, the quality of available water, especially for the poor and vulnerable, is progressively problematic, such as regarding the spread of water-related disease. The cascading challenges in the global water crisis require reconsideration of widespread practices that deal with water merely as a commodity. There needs to be much greater awareness of access to safe drinkable water as a universal human right that is essential for survival and a condition for the exercise of other human rights. This bold stance of Pope Francis rightly highlights the need for urgent action to avoid an acute water shortage globally and to safeguard planetary life and security.<sup>3</sup>

His realism and optimism are uplifting, insisting that we prevent invested economic interests from trumping the common good. Above all, he argued that it is crucial to avoid separating the environmental crisis from social concerns around the world. His vision is that we are dealing with one

complex crisis that is both social and environmental as we care for our common home, belonging to all and meant for all.

### Notes

<sup>1</sup> This discussion reflects the chapters in this book that constitute the proceedings of the conference on the Global Water Crisis in Fall 2017.

<sup>2</sup> Pope Francis, *Laudato Si': Praise Be To You. Encyclical Letter of the Holy Father Francis on Care for Our Common Home* (Vatican City: Libreria Editrice Vaticana, 2015), §23.

<sup>3</sup> Pope Francis, *Laudato Si'*, Chapter 1, section II, "The issue of water," §27-31.

### Literature

Pope Francis, *Laudato Si': Praise Be To You. Encyclical Letter of the Holy Father Francis on Care for Our Common Home*. Vatican City: Libreria Editrice Vaticana.



## **II. SCIENCE AND POLICY**

## CHAPTER TWO

# MORAL STEWARDSHIP OF OUR MOST PRECIOUS RESOURCE: WATER

ROBERT GLENNON

### **Introduction<sup>1</sup>**

This article will offer an overview of global water problems, then focus on the situation in the United States and suggest that our water management problem is essentially one of supply and demand. I will illustrate some of the new demands that have arisen as water supplies are becoming increasingly strained. Finally, I will offer some solutions. In the end, I am optimistic. We have the tools needed to address the global water crisis. But it will take moral courage and political will to act as good, moral stewards of our most important resource.

### **The Global Picture**

First, the global picture may shock many of us in the United States. With rare exceptions, we are lucky to have wonderful water that is clean and safe to drink. But around the world, more than 1 billion people of 7.6 billion people on Earth lack access to good water and 2.6 billion lack access to adequate sanitation. Very troubling are the more than one million people—mostly children—who die annually from waterborne diseases, such as cholera.

Projections indicate that the current global population of 7.6 billion is going to increase dramatically. Depending on various projections of fertility rates, the increase will be substantial at the least, and possibly enormous. There doesn't seem to be any easy out. Just at the median level of projected increase, Earth's population will hit 9.8 billion people by mid-century. In other words, in 30 or so years, the planet will be home to at least 2 billion more people. Where are we going to find the resources, including water, to house and feed another 2 billion citizens?

And then there is global climate change. I don't think scientists are prepared to say definitively whether the recent hurricanes that hit Puerto Rico, Florida, and Houston—or the wildfires raging in Montana and California—are due to climate change, or just natural climate variability. But the temperature arrows undoubtedly point up. And the ones that relate to ocean temperature and ocean heat content are the ones that fuel hurricanes.

Is it merely a coincidence that, for the first time in 160 years, the Caribbean and the Southeastern U.S. have suffered two Category Four storms in one year? It could be. But when all the temperature signals point in the same direction, at some point we have to scratch our heads and say, "You know, there is something to this."

According to Justin Gillis of the *New York Times*, 2014, 2015 and 2016 was, in succession, the hottest year in history. The years 2017 and 2018 continued this trend: these five years were the hottest ever. In the 150 years that reliable temperature records have been kept, 16 of the 17 hottest years have occurred since 2000. That's a statistical improbability.

Now, let's consider the consequences of climate change on water supplies. Farmers currently consume more than 70% of all the water that humans divert for everything, including power generation, industry, and domestic use. As hotter temperatures increase water evaporation and impede seed germination, farmers are going to need more water to grow the same amount of food. If we also consider the need to feed an additional 2 billion people by 2050, where are farmers going to get the water they need?

A complicating factor is the deteriorating condition of our nation's water infrastructure. We saw the effects of this neglect in 2017 when the Oroville Dam in California almost collapsed. When a series of heavy rainstorms ended the drought in California, the Oroville Dam couldn't handle all of the water coming into the reservoir. As the dam showed signs of starting to crumble, dam managers began to release water, which forced the evacuation of 180,000 people. Videos of the water release dramatically showed that we have not adequately maintained our water infrastructure.

Another important point about the Oroville Dam has to do with climate change. Not only are our dams old and poorly maintained, but they were not built for a changing climate. Dams and the reservoirs behind them were designed to perform two main functions: to supply water for cities, businesses, and farms, and to control flooding. They were constructed under the assumption that the flow pattern or hydrograph of the dammed river followed a predictable annual pattern.

However, as the climate changes and temperatures increase, there is more rainfall and less snow. Precipitation earlier in the winter is coming in

the form of rain, not snow. Later in the season, snow is melting earlier than it has historically, which in turn is increasing runoff. Dams such as Oroville are getting overwhelmed with water at a time when they weren't designed to receive it. When we think of water storage in the West, we usually think of the big reservoirs behind dams. But that's only the water storage that is easily visible to us. Most water in the West is stored up in the mountains in the form of snow. As climate change reduces the snowpack, there is more liquid water, which is more prone to evaporation loss. And—here's the scary part—these trends apply not just in the United States but globally. We have some very difficult challenges ahead.

## **The Situation in the United States**

In the United States, recent drought monitoring maps present a brighter overall picture than we have seen in the last several years. In 2019, most of the country is drought-free, except for the American West, especially the Colorado River Basin, which is enduring an extreme drought. This more benign picture aligns with climate scientists' predictions of fewer but more ferocious natural disasters. Across the globe—whether hurricanes in the United States or cyclones in the Bay of Bengal surging into Bangladesh—some people and places are being inundated with more ferocious storms, while others are suffering enormously destructive wildfires.

In California, this pendulum swung from the Oroville Dam problem in 2017, to wildfires in Northern California that burned more than 14,000 homes, displaced more than 100,000 people, and caused at least \$3 billion in damage. The 2018 fire season in California was even worse. The Camp Fire in Northern California, the deadliest in a century, consumed the town of Paradise and destroyed 19,000 structures, mostly homes. Climate change has dramatically lengthened the fire season and produced hotter more destructive fires.

Fortunately, there is good news as well. In 2018, the United States Geological Survey (USGS) released an important report, *Estimated Water Use in the United States in 2015*. Across virtually every category, we've done pretty well. We're using less water now than we did before, in some places a lot less. Cities such as Phoenix and Las Vegas are using about the same amount of water as they did 30 years ago, even though their populations have increased by hundreds of thousands. Why is that? A number of things are going on. One was the Great Recession. Due to the recession, people abandoned their homes or used less discretionary water for activities like landscaping.



Another factor was government rules and regulations. For those who think that legislation and regulation seldom accomplish anything, this is an instructive counterexample. The Clean Air Act and Clean Water Acts have had powerful impacts on companies that run power plants, and on industry generally, encouraging them to use less water to create fewer emissions. That's had a wholesome effect on air and water quality. In addition, the Environmental Protection Agency's (EPA) WaterSense program promulgated standards for toilets, shower heads, and faucets that over time have been implemented in most homes. Front-loading washers and low-flow toilets and shower heads use a lot less water than appliances did in times past. And, in the last few years, cities such as Las Vegas and even Los Angeles have begun to rethink the role of lawns in outdoor landscaping. Both cities have spent hundreds of millions of dollars paying people to rip out lawns.

Still, we face some significant challenges. A photo of Lake Mead, the reservoir behind Hoover Dam on the Colorado River, shows a wide, white bathtub ring above the water's surface that reveals how far the water level has dropped since the ongoing drought began in 2000. The lifeblood of the American Southwest, the Colorado River Basin faces a problem of supply and demand. Adding up the legal rights to Colorado River water, we come up with 16.5 million acre-feet (maf). (An acre-foot is enough water to cover an acre of land to the depth of a foot, approximately 325,000 gallons.) Tree-ring scientists at the University of Arizona calculated the last thousand years of Colorado River flows and determined, over that period, that the median annual flow in the Colorado is not 16.5 million acre-feet but just 14 million acre-feet. From that number, we need to deduct 1.6 maf for evaporation loss off Lake Mead and Lake Powell. Instead of 14 maf, we're now down to 12.4 maf. Now consider that climate change is predicted to reduce precipitation by 10 to 30 percent in the Colorado River Basin. It's a problem of math, and, in the long term, a huge one. But the Colorado River Basin is not the only place suffering from an imbalance between paper water rights and wet water.

## **A Human Right to Water?**

In 2016, Pope Francis in an encyclical, *Laudato Si'*, proclaimed access to safe drinking water a universal human right.<sup>2</sup> It was courageous for the Pope to do and he got many people's attention. The United Nations declared water a human right in 2010; California in 2012 enacted a statute providing that safe drinking water should be universal.

The Pope's encyclical and the UN's declaration are important statements of moral principle but are not enforceable in a court of law. International law, other than treaties between countries, is pretty squishy. The rights are ill-defined and actually enforcing them can be problematic. In California, the statute specifically states that the right to drinking water is not enforceable in court. Why would that happen? It happened because, as the California Legislature was considering the bill, California water providers (both municipal water departments and private water companies regulated by the State Public Utilities Commission) opposed the bill. They argued: We're going to get sued if we don't comply with this proposal, but we don't have the financial means to comply. We agree with the idealistic vision of what should happen, but we cannot snap our fingers and make it so. To protect against a flood of lawsuits, the bill that ultimately passed protected water suppliers by providing that the statute was not enforceable in court.

Does that render the California statute irrelevant? Not at all. Legal change happens in subtle and myriad ways. When the Pope, the United Nations, and the California legislature proclaim that water is a fundamental human right, they continue an important conversation about the moral obligation to ensure that everyone has access to water. As Martin Luther King, Jr. said: "The arc of the moral universe is long, but it bends toward justice."

## **Supply and Demand**

### **The Demand Side**

Not everyone has the same vision as Pope Francis about what should be done with water. One example is California Senator Dianne Feinstein, who thinks "it's a God-given right of Californians to be able to water gardens and lawns."<sup>3</sup> This may have been a bad hair day for the Senator; it surely ranks as one of the silliest things she's ever said. But it embodies the culture at the time. In 2015, Damon Winter, a photographer for the New York Times, captured this idea in an aerial photograph of a community near Palm Springs, CA. From the air looking straight down, the left side of the photo is a residential subdivision replete with green yards and blue swimming pools. On the right side is the bleak and arid Mojave Desert. This stark contrast encapsulates Senator Feinstein's view of the world—a constructed human environment completely disconnected from the desert that surrounds it.

Our moral philosophies are not entirely in sync. I don't think the Pope had in mind Palm Springs when he proclaimed access to water a universal human right. Senator Feinstein's statement proves that one can invoke a higher being for pretty much any purpose.

Edward Abbey, the acerbic author of *The Monkey Wrench Gang*, once observed, "There is no lack of water in the Mojave Desert unless you try to establish a city where no city should be." What city would that be? That would be Las Vegas. When casino developer Steve Wynn conceptualized what would become the famous fountain at Bellagio Hotel and Casino, he went to Pat Mulroy, then head of the Southern Nevada Water Authority, and said, "This is my vision. I want to have a water feature." The Bellagio Fountain cost 40 million dollars, has a footprint of 8 acres, holds 27 million gallons of water, and has 250 heads that spray water up into the desert sky. For some, it's the epitome of wastefulness and a symbol of Las Vegas's wretched excess.

But there's a different narrative, because all of the fountain's water is recycled. Pat Mulroy told Wynn she'd grant the permit, but challenged him to use recycled water, clean up the contaminated groundwater below the casino site, install a reverse osmosis system, and install low-flow fixtures in every hotel room. Wynn incorporated all of these conservation measures at the Bellagio. The amazing thing about Las Vegas's Strip is that it uses only three percent of the city's water, yet is the economic driver of the state, second to none. Water has important spiritual and cultural aspects, but it's also an economic resource that is a prerequisite to development in the arid West.

The demand for water includes some uses that seem self-indulgent. One is bottled water. The actress Jennifer Aniston often graces the pages of magazines touting Smart Water, which is basically plain water with nutrients in it. One could get the same amount of protein from a handful of almonds. I was the first to point the finger at bottled water in 2002 in *Water Follies*. The controversy hasn't ended; bottled water manufacturers, such as Nestlé Waters North America, continue to engender hostility around the country. Bottled water is a curious cultural phenomenon because, with very few exceptions (such as the recent water crisis in Flint, MI) there is no need to drink bottled water in the U.S. Municipal water is perfectly safe and actually better than bottled water in many instances—not to mention 1,000 times less expensive.

The bottled water industry, as Peter Glick has shown in *Bottled and Sold*, has engaged in a campaign to discredit and undermine confidence in the public water supply. This has affected how people generally think about water. The industry has suggested it's better to drink bottled water because

it's safer. In fact, there is no assurance that bottled water is safer than tap water: bottled water is loosely regulated by the Food and Drug Administration, while tap water is regulated by the EPA, which has stringent standards for tap water.

Bottled water has a narcissistic element to it. "It's available; I can drink it; so I choose to." But bottled water is not the only water use that I find rather wasteful. One of my favorites is the plumbing supply company Kohler's "power shower." The shower has 10 shower heads, each with enough water pressure to take paint off walls. It is very popular in Phoenix, which is why we in Tucson look down our noses at the people in Phoenix.

Some demands for water are indulgent, whimsical, or wasteful; others are key to human well-being. Energy production is one critical use. As we witnessed the horror that unfolded in Puerto Rico in the aftermath of Hurricane Maria, there is a stark lesson: without electricity, modern society can't function.

There's been a lot of controversy about ethanol, and about the use of fracking to extract gas. I don't have a dog in these fights, but I find it curious how much water it takes to refine ethanol. Even in an ethanol plant that recycles its water, four gallons of water are needed to refine one gallon of ethanol. A 50-million-gallon refinery requires 200 million gallons of water. But first, someone has to grow the corn. That's not usually a problem in Minnesota or other places east of the hundredth meridian, where farmers can dry-land farm. But anywhere West of that, farmers need to irrigate, and corn is a very thirsty crop. It can take 2,500 gallons of water to grow enough corn to refine one gallon of ethanol. By statute, Congress in its wisdom proclaimed that the United States should produce 36 billion gallons of biofuels in 10 years. By my math, that's 36 billion, times 2,500, times 4—that total has a lot of zeroes. Who would have believed that something as seemingly innocuous as refining ethanol could be so water-intensive? All of that water would otherwise be used for growing food.

Energy is something that we just can't seem to get enough of in the United States. An important demand for energy comes from Google to supply its "server farms," which run search operations. Powering the web and storing data in the cloud by Google, Amazon Web Services, Facebook, and Microsoft requires thousands of industrial buildings, each housing tens of thousands of computers, all linked up, all generating heat, and all needing to be cooled.

Every time we do a Google search, watch a YouTube video or shop online, a server farm provides the electricity. We spend a lot of energy doing these things. Google revealed that we upload on YouTube 100 hours of video every minute. Next time you're tempted to upload a video, remember

that those videos of your cat are not that interesting. For that matter, do we really need 24/7 access to the Kardashians' antics? At the same time, tremendous economic development comes from activities on the web. This economic activity is reducing overhead and the detailed data it creates generates cost savings and increases efficiency. But one cost that is often overlooked is water. It takes huge volumes of water to produce energy and, conversely, huge volumes of electricity to pump, move, cleanse and deliver water.

### **The Supply Side**

These demands for water—whether indulgent or essential—are placing strains on our supply. What are we going to do about it? Business as usual is not a viable option. Until recently, when we needed more water, we diverted more water, built a new dam, or drilled new groundwater wells. Now, we've diverted so much water from our rivers that diminished flows have devastated riparian ecosystems. Other rivers, such as the Colorado River and the Rio Grande, go dry before they even reach the ocean.

As for dams, we are really good at building dams in the United States. Bruce Babbitt, a former Secretary of the Interior, once quipped that we have built a dam every day of every year since Thomas Jefferson signed the Declaration of Independence. We've dammed pretty much every river that flows. New dams are not going to solve our water problems. They are prohibitively expensive and generate fierce political and environmental opposition.

The third thing we have done is to drill wells. We have over-pumped many of our aquifers. For example, in California's Central Valley excessive pumping has caused land subsidence in excess of 25 feet. The removal of so much water compacted the soils of the Earth and the level of the ground declined.

How have we permitted that to happen? Think of an aquifer as a giant milkshake glass that contains water that has accumulated over thousands of years. The water table is the top of the milkshake in the glass. And think of each well as a straw in the glass. The law in many U.S. states and many countries around the world permits a limitless number of straws in a single glass. It's an invitation to pump to your heart's content. It is a classic example of the tragedy of the commons. Water is a common pool resource—it is fundamentally a shared community resource, not a private one. It's also a limited resource (the amount of water in an aquifer is relatively fixed, as groundwater replenishes extremely slowly). But the legal

system allows unlimited access to this finite resource. Eventually, under existing law, we will exhaust the supply.

Therefore, business as usual—more diversions, dams, and wells—is not a viable solution to our water woes.

## **Surreal Solutions**

Some people would like to experiment with cloud seeding, or “weather modification,” as those in the industry prefer to call it. The concept is pretty simple: shoot some silver iodide into clouds when there’s a lot of moisture in the area and, then, hope it’ll rain. But the scientific community is agnostic as to whether cloud seeding works. The National Research Council of the National Academies has concluded that there is “no convincing scientific proof” of the efficacy of weather modification.

As a final desperate effort to secure additional water supplies, some people have advocated for diverting rivers in British Columbia or towing an iceberg from the Arctic. There was even a highway billboard in Michigan that captures the paranoia of the Midwest about the Southwest’s motives. It shows a cartoon map of the Great Lakes, with caricature figures from southwestern states, each with a straw into a different Great Lake. I taught at Wayne State University Law School in Detroit and whenever I’m back in the Midwest to give a talk, I show a slide of this billboard and say, “Shame on you! This is a scurrilous attack on those of us in the Southwest. We have no desire to divert all of the Great Lakes and bring the water to the Southwest. We’d be happy if you just let us take one of the smaller ones.”

So, business as usual, cloud seeding, and large inter-state diversions are not going to get the job done. What, then, are the real solutions, rather than the surreal ones?

## **Viable Solutions**

Water scarcity poses formidable challenges, yet I’m optimistic for the future because we have a menu of options available to address the water crisis and avert a catastrophe. No single appetizer or even a main course will solve the problem of scarcity. But a combination of courses holds the potential of quenching our thirst.

### **1. Conservation**

First, conservation remains the low-hanging fruit. Let me suggest two things that each of us can do to save water. First, stop using your kitchen