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A Declining Water Supply: How Utah Can Become Adept at Adapting to the Impacts of Climate Change

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A DECLINING WATER SUPPLY: HOW UTAH CAN BECOME ADEPT AT ADAPTING TO THE IMPACTS OF CLIMATE CHANGE

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ABSTRACT

Water sustains human life and the ecosystems that make life possible. Yet Utah's current water management places the vital resource in jeopardy. When climate change is included in the calculation of projected water supply, the future looks much more bleak. As Utah's climate changes, its water supplies will diminish. Likewise, the overall quality of water will decrease as demands for potable water reach an all-time high. This Comment suggests adaptation strategies that Utah can pursue to improve its adaptive capacity and fortify its water governance. Ultimately, this Comment recommends that Utah start developing an adaptation framework in order to prepare for the impacts of climate change before it is too late.

INTRODUCTION

Upon their arrival in the Great Salt Lake Valley, the Mormon Settlers found themselves in a vast desert.[2] The first settlers quickly set about turning the desert land into a productive settlement.[3] In doing so, the settlers dug a small irrigation ditch to divert water from City Creek.[4] Eventually, the Mormons went on to build large irrigation canals essential to the survival of the settlers.[5] This effort to make the desert "blossom as the rose"

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[2] *See* Craig Fuller, Utah History Encyclopedia, Irrigation in Utah (1994), http://www.uen.org/utah_history_encyclopedia/i/IRRIGATION.html; *see also* GEORGE THOMAS, THE DEVELOPMENT OF INSTITUTIONS UNDER IRRIGATION, WITH SPECIAL REFERENCE TO EARLY UTAH CONDITIONS (2012).
[3] *See* Fuller, *supra* note 2.
[4] *Id.*
[5] *Id.*

was an important epoch in the development of the American West.[6] Indeed, it set the stage for basic water principles of water law that remain intact today.[7]

Since this early settlement, water has continued to play an indispensible role in the development of Utah.[8] Indeed, "developing Utah's waters has been a mainstay of civilization."[9] However, the next few decades are about to bring about significant challenges that will drastically impact Utah's water resources. Some of these impacts are already occurring.[10] The Mormon settlers responded to climatological conditions.[11] So, too, must Utah adapt its current water policy to the changing climate.

In climate change discourse, scholars have often couched mitigation and adaptation strategies as mutually exclusive.[12] In addition, academic discourse surrounding governmental responses seeks to determine whether it should take place at the local or national level.[13] These dilemmas pervade environmental regulation, despite considerable scholarship advocating for more cohesive permutations.[14] Adaptation measures should not supplant

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[6] *Id.*

[7] *Id.*

[8] DIVISION OF WATER RESOURCES, UTAH'S WATER RESOURCES: PLANNING FOR THE FUTURE 44 (2001) [hereinafter DWR].

[9] *Id.*

[10] U.S. GLOBAL CHANGE RESEARCH PROGRAM, ASSESSMENT OF CLIMATE CHANGE IN THE SOUTHWEST UNITED STATES 414 (Greg Garfin et al. eds., 2013) [hereinafter SW ASSESSMENT].

[11] *See* FRED W. FINLINSON, UTAH'S WATER HISTORY, EVENTS AND LESSONS 3 (2013) (indicating that Mormon settlers would bypass areas without an adequate water supply), *available at* http://www.wcwcd.org/wp-content/uploads/2013/04/UtahsWaterHistory1.pdf.

[12] *See, e.g.,* Lincoln L. Davies, *Reconciling Renewable Portfolio Standards and Feed-in Tariffs*, 32 UTAH ENVTL. L. REV. 311, 311 (2012) (discussing dichotomous misconceptions in contemporary environmental policy); J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENVTL. L. 363, 364 (2010) (mentioning that the perceived urgency surrounding mitigation strategies "snuffed out meaningful progress on the formulation of adaptation strategies."); Lesley K. McAllister, *Adaptive Mitigation in the Electronic Power Sector*, 2011 BYU L. REV. 2115, 2118–2220 (underscoring the disjointed nature between adaptation and mitigation responses to climate change).

[13] *See* Jonathan H. Adler, *Jurisdictional Mismatch in Environmental Federalism,* 14 N.Y.U. ENVTL. L.J. 130 (2005); Henry N. Butler & Jonathan R. Macey, *Externalities and the Matching Principle: The Case for Reallocating Environmental Regulatory Authority,* 14 YALE L. & POL'Y REV. 23 (1996). There is, however, a growing body of literature dispelling this misconception. *See* Davies, *supra* note 12, at 312.

[14] *See, e.g.,* Kirsten H. Engel, *Harnessing the Benefits of Dynamic Federalism in Environmental Law,* 56 EMORY L.J.159, 163–165 (2006) (criticizing dichotomous perceptions between state and federal regulatory policy); Daniel A. Farber, *Climate Change, Federalism, and the Constitution,* 50 ARIZ. L. REV. 879, 910–924 (2008) (discussing the federalism in the context of climate changes responses); Robert L.

mitigation measures, but supplement them.[15] Although Utah has implemented successful mitigation measures,[16] it should seek to build upon this success by adapting to the inevitable changes that will affect Utah's climate.

In Part II, this Comment identifies the unprecedented changes that will occur to Utah's climate and discusses the impact that these changes will have on Utah's water supplies. Further, it demonstrates how Utah's existing water infrastructure is poorly equipped to adapt to the inevitable impacts of climate change. In Part III, this Comment draws from widely accepted adaptation principles and proposes potential adaptation options that Utah can take to facilitate better-prepared water governance. The Comment concludes that Utah should: 1) incorporate climate change into its water planning; 2) create a climate adaptation advisory panel; and 3) price its water on a sliding scale.

I. THE CHANGING CLIMATE

Evidence surrounding the warming of the climate system is "unequivocal."[17] Global climate change will significantly affect water resources around the globe.[18] Because of the growing concentration of greenhouse gases in the atmosphere, climate change will undoubtedly continue to impact the global hydrologic cycle.[19] However, the extent of these future impacts—both globally and domestically—are largely uncertain.[20] This future uncertainty remains the core dilemma that natural resource governance must confront if it is to effectively mitigate and adapt to the impacts of climate change.[21] This section summarizes the observed changes in climate, demonstrates that such changes are attributable to

Glicksman, *From Cooperate to Inoperative Federalism: The Perverse Mutation of Environmental Law and Policy*, 41 WAKE FOREST L. REV. 719, 731–754 (2006) (highlighting the importance of cooperative federalism in climate change responses).

[15] Alejandro E. Camacho, *Adapting Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure* 59 EMORY L.J. 1,16 (2009) ("adaptation should certainly not supplant vital efforts to abate greenhouse gas emissions.").

[16] *See* NATURAL RESOURCES DEFENSE COUNCIL, WATER READINESS REPORT: UTAH 2 (2012), *available at* http://www.nrdc.org/water/readiness/files/water-readiness-UT.pdf.

[17] *See* INTERNATIONAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: SYNTHESIS REPORT § 1.1 (R.K. Pachuari et al. eds.) [hereinafter IPCC], *available at* http://www.ipcc.ch/report/ar5/syr/.

[18] *See* Kathleen A. Miller, *Grapping with Uncertainty: Water Planning and Policy in a Changing Climate*, ENERGY L.& POL'Y J. 395, 396 (2010); IPCC, *supra* note 17, §§ 2.2.2–2.2.3, 2.3.2.

[19] IPCC, *supra* note 17, at §2.

[20] *Id.*

[21] Miller, *supra* note 18, at 406–408. *See also* Camacho, *supra* note 15, at 10.

human causes, shows that the changes in climate will affect Utah's water, and mentions factors that will exacerbate the changing climate in Utah.

A. Observed Changes in Climate

"Climate" consists of long-term averages and variations in weather.[22] The climate system incudes "land surface, atmosphere, oceans, and ice."[23] Aside from reconstructing past climate scenarios, scientists have compiled contemporary models of the climate using satellites, weather balloons, and surface thermometers.[24] This evidence unambiguously demonstrates that the planet is warming.

1. Atmosphere

The atmospheric concentrations of carbon dioxide are higher than they have been for 800,000 years, perhaps longer. [25] This greenhouse gas enables the atmosphere to trap more of the sun's heat, resulting in temperature increases.[26] Each of the last three decades has been progressively warmer.[27] Further, each of these successive decades surpassed every average global temperature since 1850.[28] Since 1895, the average U.S. surface temperature has increased from 1.3º F to 1.9º F, with a rapid increase occurring after 1970.[29] Surface temperatures in the troposphere are continuing to rise,[30] while the stratosphere is simultaneously cooling.[31] By the end of the century, scientists project that the global average temperature will rise 3º F to 5º F under the lower emission impact projections and up to as much as 11ºF under the most extreme emission impact projections.[32]

As a result of the increased temperature, the atmosphere's ability to hold

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[22] *See* U.S. GLOBAL CHANGE RESEARCH PROGRAM, CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT 22 (J. Walsh et al. eds., 2014) [hereinafter USGCRP].
[23] *Id.*
[24] *Id.*
[25] Jeremy Richardson, *Global Warming: Climate Change and the Law*, SR039, ALI-ABA 1 (2010).
[26] *Id.*
[27] IPCC, *supra* note 17, at § 1.1.1.
[28] *Id.* There is, however, substantial decadal variability in regards to global surface temperature. Because these trends are based on relatively short records, these records alone do not establish a long-term climate trend. *Id.*
[29] USGCRP, *supra* note 22, at 28.
[30] *Id.* at 22.
[31] IPCC, *supra* note 17, § 1.1.1.
[32] Richardson, *supra* note 25, at 2.

water has increased.[33] Consequently, precipitation will become less frequent but more intense.[34] Globally, there has already been an observed trend of heavy downpours, and this trend is expected to remain as the atmosphere continues to warm.[35] Alterations in precipitation patterns are not only intensifying, but also shifting where and the state (rain versus snow) in which precipitation falls.[36] For Utah and the rest of the southwestern United States, the new precipitation trends will result in less precipitation—especially in the spring.[37] In addition to lower precipitation levels, Utah will experience less snowfall, which will substantially affect its water supply.[38]

2. Ocean

The ocean has stored the majority (more than 90%) of the increased carbon dioxide emissions since the commencement of the Industrial Revolution.[39] Over the last 250 years, oceans have absorbed 560 billion tons of carbon dioxide.[40] In contrast, the atmosphere has accounted for only 1% of the overall emissions intake.[41] Overall, ocean temperatures have increased,[42] with a higher shift occurring at the surface.[43] In addition, the salinity levels are increasing.[44] As time goes on, increases in greenhouse gas emissions will reduce the ability of the oceans to remove carbon dioxide from the atmosphere,[45] because the solubility of carbon dioxide diminishes as the ocean temperature increases.[46] The oceans' inability to maintain its current intake of carbon emissions will accelerate temperature increases, thereby accelerating the diminishment of Utah's water supply.[47]

B. Anthropogenic Influence is Responsible for the Changing Climate

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[33] USGCRP, *supra* note 18, at 22.
[34] *Id.* at 26. *See also* Noah D. Hall, *Interstate Water Compacts and Climate Change Adaptation,* 5 ENVT'L & ENERGY L. & POL'Y J. 237, 244 (2010).
[35] USGCRP, *supra* note 22, at 26.
[36] *Id.* at 25–26.
[37] *Id.* at 32–33.
[38] *See infra,* notes 125–192 and surrounding discussion**.**
[39] IPCC, *supra* note 17, at § 1.1.2.
[40] USGCRP, *supra* note 22, at 48.
[41] *Id.*
[42] *Id.* at 22.
[43] IPCC, *supra* note 17, at § 1.1.2.
[44] *Id.* Regions with typically low salinity levels, however, have actually experienced fresher (less saline) water. *Id.* However, these regional trends provide further evidence in evaporation and precipitation changes around the globe. *Id.*
[45] Miller, *supra* note 18, at 402.
[46] *Id.*
[47] *Id.*

The warming that has occurred in the past fifty years is unprecedented[48] and cannot be accounted for by natural climate variations.[49] Instead, it can be explained only by considering anthropogenic influences.[50] In particular, the primary causes of climate change during the past fifty years are the burning of fossil fuels and deforestation.[51]

Although it can be difficult to distinguish natural and anthropogenic influences, "the speed and severity" of the observable climate change impacts on natural systems has been "identified and isolated."[52] Objective understanding indicates that human behavior remains the primary driver of climate change.[53]

First, warming trends are consistent with scientific understanding of how certain gases trap heat and how the climate system fluctuates depending upon the quantity and proportion of these gases in the atmosphere.[54] Second, scientists have used tree rings, ice cores, and coral reefs to reconstruct climates of the past.[55] These reconstructions show that the current global surface temperatures exceed those of any time during the past 1300 years, perhaps longer.[56] The atmospheric concentration of carbon dioxide is the highest it has been for at least 800,000 years.[57] Finally, studies that attribute changes to particular causes (i.e., fingerprint studies) reveal certain trends that indicate that natural factors alone, such as volcanic outgassing and solar output, cannot account for the significant warming we are experiencing.[58] Volcanic activity alone would have slightly cooled the earth,[59] and any increase in solar output would warm the entire atmosphere. The stratosphere is actually cooling, revealing that the warming is resulting from an increase in heat-trapping gases in

[48] *Id.*
[49] USGCRP, *supra* note 22, at 22.
[50] *Id.* at 15 ("Global climate is changing and this change is apparent across a wide range of observations. The global warming of the past 50 years is primarily due to human activities.") Particularly, the emissions from the burning of fossil fuels.
[51] *Id.* at 22. These fossil fuels include carbon dioxide, methane, nitrous oxide, particulate matter, which have warming influences. *Id.* It should be noted that fossil fuel emissions produce various sulfates, which have cooling influences. *Id.*
[52] *See* Camacho, *supra* note 15, at 10.
[53] USGCRP, *supra* note 22, at 22.
[54] *Id.*
[55] *Id.; see also* Darrel S. Kaufman, PAGES 2K CONSORTIUM, CONTINENTAL-SCALE TEMPERATURE VARIABILITY DURING THE PAST TWO MILLENIA 6 NATURE GEOSCIENCE 339 (2013); Michael E. Mann et al., *Proxy-based Reconstructions of Hemispheric and Global Surface Temperature Variations Over the Past Two Millenia*, 105 PNAS 13252–13257 (2008).
[56] *Id.*
[57] Richardson, *supra* note 25, at 1.
[58] USGCRP, *supra* note 22, at 24. The scientific consensus concludes that volcanic activity alone would have slightly cooled the earth. Additionally, any increase in solar output would warm the entire atmosphere. The stratosphere is actually cooling, demonstrating that the warming is due to an increase in heat-trapping gases.
[59] *See id.*

the lower level of the atmosphere.[60]

Human influence extends to more than just temperature shifts, affecting precipitation patterns, atmospheric humidity, changes in pressure, and increasing heat content.[61] Amounts of snow and ice are diminishing, the sea level is rising, and the length of growing seasons is changing.[62] The world will continue warming as a result of human-induced emissions[63] and will have serious and potentially damaging effects in the decades ahead. A certain amount of warming is inevitable and would occur even if current emissions were curtailed entirely.[64]

C. Climate Change and Utah's Water

Water supplies in the southwestern United States are already stressed.[65] Non-climatic factors such as population growth and institutional constraints are compounding these difficulties.[66] Absent significant changes in policy, planning, or management, Utah's already stressed water supply will continue to decrease as demand for water increases.[67] This section analyzes Utah's current water supply, reveals changes that have recently occurred to Utah's climate, and raises potential impacts that climate change will have on Utah's future water supply.

1. The current state of water resources in Utah

a. Water Supply

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60 *Id.*; *see also* Benjamin D. Santer et al., *Identifying Human Influences on Atmospheric Temperature*, 110 PNAS 26 (2013).

61 USGCRP, *supra* note 22, at 22.

62 *Id.*

63 *Id.*

64 *Id.*; *see also* H. Damon Matthews, *Climate Response to Zeroed Emissions of Greenhouse Gases and Aerosols*, 2 NATURE CLIMATE CHANGE 338 (2012).

65 ASSESSMENT OF CLIMATE CHANGE IN THE SOUTHWEST UNITED STATES 50 (Garfin et al. eds., 2013).

66 *Id.*

67 *Id. See* BLUE RIBBON ADVISORY COUNCIL ON CLIMATE CHANGE, CLIMATE CHANGE AND UTAH: THE SCIENTIFIC CONSENSUS 9– 11 (2007) [hereinafter BRAC]; John C. Ruple, *Water for Power in the Twenty-First Century, What a Growing Population, Changing Climate, and Energy Development Mean for Utah's Water Resources*, 32 UTAH ENTL. L. REV. 363, 363 (2012) (stating that "non-consumptive value such as instream flows, sensitive species, and aesthetics will compete for water against traditional consumptive uses.").

Utah's water supply is "limited" and "unpredictable."[68] On average, Utah receives 13 inches (61.5 million acre-feet) of precipitation every year.[69] The only state that receives less is Nevada.[70] Despite the low precipitation average, the precipitation accumulates to form Utah's largest stored water supply—its mountainous snowpack.[71] During the winter, snow accumulates in the mountainous areas and acts as a reservoir.[72] The snowpack melts in spring and early summer, releasing the stored water.[73] The release of water from the snowpack "generates the majority of the streamflow across the state."[74] As the Utah Division of Water Resources states, the snowpack is "extremely important to Utah's water supply because it functions as a storage reservoir, releasing the water into streams and aquifers as temperatures rise."[75] Serendipitously, water flows during the times where water demand is highest.[76]

As a result of Utah's semiarid climate, only a small fraction of this water supplies water to local waterways.[77] "Approximately 87% of the precipitation falling on Utah each year is removed by the natural environment through evaporation and transpiration before it reaches a stream or aquifer where it can be used.[78] An additional 7% is removed through evaporation from open water bodies.[79] Before evaporation and transpiration, Utah would have an annual supply of 53.8 million-acre feet.[80] However, only 7.7 million acre-feet of potable water make its way to water bodies.[81] Utah's contractual obligations under interstate water compacts further reduce Utah's potable water supply.[82]After these reductions, Utah's total available water supply has been around 7,311,000 acre-feet per year. As of 2001, Utah was using about 6,616,000 acre-feet per year (90%) of

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[68] DWR, *supra* note 8, at 7 (characterizing its water policy as "not only limited, but also unpredictable")
[69] *Id.* at 8.
[70] DWR, *supra* note 8, at 7.
[71] BRAC, *supra* note 79, at 9–10. BR 1 ("Most of Utah's water resources originate in mountainous areas . . . . The primary source of this water is snowpack.").
[72] *Id. See* Hall, *supra* note 34, at 243 (noting that snowpack is a "critically important source of natural water storage for . . . western states.").
[73] BRAC, *supra* note 79, at 10; *see also* Ruple, *supra* note 67, at 363.
[74] BRAC, *supra* note 79, at 10.
[75] DWR, *supra* note 8, at 7.
[76] Hall, *supra* note 34, at 245.
[77] DWR, *supra* note 8, at 8.
[78] *Id.* at 8–9.
[79] *Id.* at 9. The Great Salt Lake accounts for more than 75% of this evaporation. *Id.*
[80] *Id.* at 8–9.
[81] *Id.* at 13.
[82] *See id.* table 3. *See generally* Hall, *supra* note 34.

this supply.[83] Moreover, Utah's water usage has increased to 6,845,000 in 2015,[84] despite various conservation measures.[85]

Utah collects the water from the snowpack through its rivers and groundwater supply.[86] The largest rivers in Utah are the Colorado River and the Green and San Juan Rivers, which are the Colorado's tributaries.[87] From these, Utah receives around 420,000 acre-feet annually.[88] Its next largest developable supply comes from the Bear River, which supplies 250,000 acre-feet of water per year.[89] Other water bodies that supply water include the Jordan River, Utah Lake, West Desert, Weber River, and Kanab Creek.[90] Utah does not obtain any developable supply from the Sevier or Cedar/Beaver River.[91]

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[83] DWR, *supra* note 8, at 13.
[84] WESTERN ENERGY ALLIANCE, WESTERN WATER STUDY: UTAH 1–2 (2015)
[85] The Utah Division of Water Resources Conservation Program has promoted the use of water wise plants, improved water education, and started the "slow the flow movement." *See* DIVISION OF WATER RESOURCES CONSERVATION PROGRAM, http://conservewater.utah.gov (last visited May 3, 2015).
[86] BRAC, *supra* note 79, at 10; DIVISION OF WATER RESOURCES, CONJUNCTIVE MANAGEMENT OF SURFACE AND GROUND WATER IN UTAH 11–23 (2005).
[87] BRAC, *supra* note 79. at 9.
[88] *Id.* at 14 table 5
[89] *Id.*
[90] *Id.*
[91] *Id.*

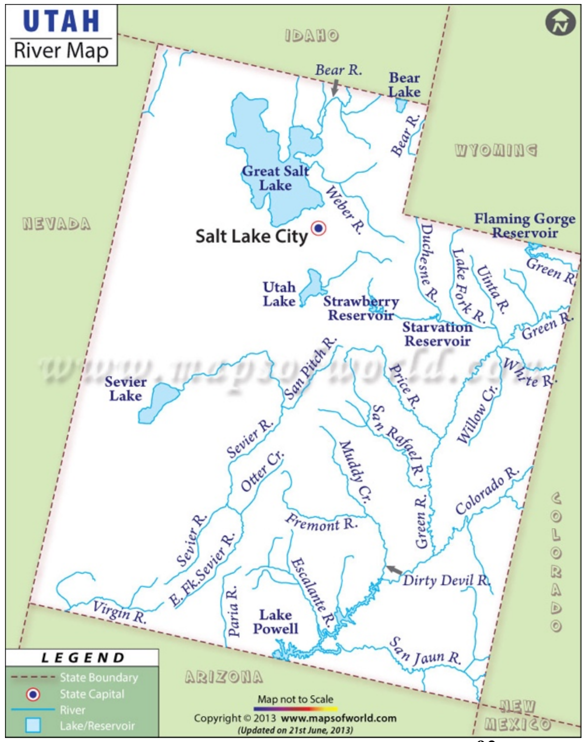

Figure 1: Utah's Waterways[92]

In terms of its groundwater supply, Utah withdraws water from twenty-five different aquifers.[93] Utah withdraws close to 851,000 acre-feet of ground water every year.[94] Aquifers in the Salt Lake Valley, Utah Valley, and Goshen Valley supply more than 25% of Utah's total groundwater withdrawal.[95] Most pumping of groundwater occurs at levels equivalent to or below estimated recharge rates.[96] Because groundwater use in Utah respects recharge levels and Utah is not "mining" its aquifers, Utah will maintain a steady groundwater supply so long as the pumping and recharge levels remain static.

Given the high variability of Utah's water supply,[97] these numbers are based on long-term averages. It is common to have supply conditions that are "in extreme excess or deficit of the average."[98] The uncertainty

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[92] MAPS OF WORLD, UTAH RIVER MAP, http://www.mapsofworld.com/usa/states/utah/utah-river-map.html, (last visited May 3, 2015).
[93] *Id.* at p. 11 table 2.
[94] *Id.*
[95] *Id.*
[96] *Id.* at 11. The Beryl-Enterprise area is being pumped in excess of its recharge rate, resulting in an average decline in 1.2 feet per year. *Id.*
[97] DWR, *supra* note 8, at 16.
[98] *Id.* at 14.

surrounding Utah's water supply highlights the importance of its water management in ensuring adequate supply to its citizens.

b. Water Use

Agricultural use of water accounts for 5,152,000 acre-feet after considering consumption and diversion rates[99] and accounts for more than 81% of Utah's water use.[100] Municipal and industrial use of water accounts for about 1,423,000 after considering consumption and diversion rates.[101] Utah's per capita water use is the highest in the nation.[102] Indeed, the vast majority of municipal water use is residential.[103] Thus, unless per capita water use decreases, Utah's overall water consumption will skyrocket as the population grows.[104] Municipal and industrial use will likely exceed current water supply by 2050 as a result of this population growth alone.[105] When considering the diminishing water supply as a result of climate change, there is a serious possibility that water shortage will actually occur sooner.

c. Water Conservation

In 1998, the Utah Legislature passed the Water Conservation Plan Act,[106] which required the Division of Water Resources to approve conservation plans that water retailers and conservancy districts submit.[107] In Utah's water plan, the Utah Division of Natural Resources enumerated six benefits to promoting water conservation: 1) to decrease water demand and conserve water for future use; 2) to delay large-scale infrastructure modifications; 3) to reduce sewage flows; 4) to conserve energy by transporting less water; 5) to lessen chemical leaching into streams and aquifers by promoting irrigation efficiency; and 6) to reduce stream diversions to enhance water quality.[108]

The conservation goal that Utah ultimately set was to reduce per capita

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[99] DIVISION OF NATURAL RESOURCES, MUNICIPAL AND INDUSTRIAL WATER USE IN UTAH: WHY DO WE USE SO MUCH WATER, WHEN WE LIVE IN A DESERT? 3 (2010) [hereinafter DNR]; UTAH FOUNDATION, FLOWING TOWARD 2050 3 (2014).
[100] DNR, *supra* note 111, at 9 Figure 7.
[101] *Id.* at 3–4.
[102] *Id. at* 1.
[103] *Id.* at 7.
[104] *See infra* III.C.4.a.
[105] DWR, *supra* note 8, at 21 Table 7.
[106] UTAH CODE ANN. § 73-10-32 (West 2012).
[107] DWR, *supra* note 8, at 26.
[108] *Id.* at 25–26.

water demand by 25% before the year 2050.[109] This reduction would amount to about a 400,000 acre-feet decrease in water use every year.[110] Absent the reduction, the Utah Division of Water Resources anticipated that the demand for water would exceed its supply.[111] However, its reduction goal assumed that long-term climatic averages would continue to be accurate.[112] Unfortunately, these long-term averages are not representative of future conditions, given the fact that Utah's climate is changing.[113]

2. Observable changes in Utah's climate

The western United States has experienced higher temperature increases than the planetary average.[114] Increases in atmospheric concentrations of greenhouse gases are already contributing to significant changes in climate trends throughout this region.[115] These trends include an overall increase in the frost-free growing season, a warmer spring that is coming earlier each year, earlier spring snowmelt, a greater proportion of precipitation falling as rain instead of snow, decline in mountain snowpack,[116] increased temperatures, increased drought, declines in water supply, increased frequency of floods, increases in wildland fires,[117] and shifts in storm patterns—both in location and intensity.[118]

Recent temperatures in Utah exceeded the 100-year average by

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[109] *Id.* at 26.
[110] *Id.*
[111] *Id.* at 28.
[112] *Id.*
[113] UTAH RIVERS COUNCIL, CROSSROADS UTAH: UTAH'S CLIMATE FUTURE 9 (1st ed. 2012).
[114] BRAC, *supra* note 79, at 1.
[115] *See Id* at 1–4, 9–11. *See also* SW ASSESSMENT, *supra* note 10, at 3–5, *See generally* WILLIAM A. SPRIGG & TODD HINKLEY, PREPARING FOR A CHANGING CLIMATE: THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE, SOUTHWEST (2000) (introducing recent climatological changes the southwestern United States has experienced); THOMAS R. KARL ET AL. GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES (2009) (Illustrating the impacts of climate change in the United States), *available at* http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.
[116] *See* BRAC, *supra* note 79, at 1; SW ASSESSMENT, *supra* note 10, at 199–200; KARL, *supra* note 127, at 11.
[117] *See* SW ASSESSMENT, *supra* note 10, at 21–22.
[118] *Id.* at 200. *See* Tim P. Barnett et al., *Human-Induced Changes in the Hydrology of the Western United States* 319 SCIENCE 1080, 1080–1083 (2008).

approximately 2º F.[119] Utah temperatures will increase and will continue to increase at a faster rate than the rest of the world.[120] Moreover, since 1925, the United States has seen less precipitation falling as snow.[121] As a result, "the volume of snowpack has been dropping over much of the American west."[122] Utah has recently experienced a reduction in snow cover and snow depth,[123] and the reduction will only worsen as climate changes intensify in the future.[124]

3. Future impacts that climate change will have on Utah's water

Climate change has already altered the water cycle in Utah,[125] and additional and large-scale changes will occur in the future.[126] Climatic conditions determine both the "amount of water Utah receives" and the "amount of water that is consumed."[127] For example, by 2050, Utah's average temperatures will be 2–4º F higher.[128] Increasing temperature drastically increases the demand for water,[129] further exacerbating the diminishing water supply.[130] These climatological alterations will impact Utah by decreasing the extent of its mountainous snowpack and making droughts more frequent and severe.[131]

a. Snowpack

As noted, Utah's largest storage of potable water is in its mountainous snowpack.[132] In particular, Utah's snowpack provides over 80% of the water supply for the Wasatch Front.[133] As greenhouse gas concentrations

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[119] IPCC, *supra* note 17, at 1–4.
[120] BRAC, *supra* note 79, at 1. *See also* IPCC, *supra* note 17, at 1–8, 61–63. Utah's rapidly accelerating climate is largely attributable to Utah's distance from the oceans. UTAH RIVERS COUNCIL, *supra* note 125, at 8.
[121] *See* Hall, *supra* note 34, at 244.
[122] *Id. See also* Fact Sheet: What Climate Change Means for Utah and the Southwest, The White House: Office of the Press Secretary, (May 6, 2014).
[123] UTAH RIVERS COUNCIL, *supra* note 125, at 10.
[124] BRAC, *supra* note 79, at 10.
[125] SW ASSESSMENT, *supra* note 10, at 74–92.
[126] *Id.* at 133–139.
[127] DWR, *supra* note 8, at 9.
[128] UTAH RIVERS COUNCIL, *supra* note 125, at 8.
[129] Miller, *supra* note 18, at 398.
[130] *See* Hall, *supra* note 34, at 243; *see generally* UN WATER, CLIMATE CHANGE ADAPTATION IS MAINLY ABOUT WATER 1–2 (2009), *available at* http://www.unwater.org/downloads/UNWclimatechange_EN.pdf.
[131] BRAC, *supra* note 79, at 10.
[132] *See supra* II.C.1.a.
[133] BRAC, *supra* note 79, at VIII-3.

increase, Utah's annual snowpack level will continue to diminish.[134] The anticipated reduction in snowpack levels is attributable to increases in temperature, which decrease the amount of precipitation falling as snow and facilitate a greater loss of snowpack from evaporation.[135]Accordingly, there will be less snow accumulation[136] and the snow will melt earlier,[137] which will coincide with a total reduction in the number of frost days.[138]

Future water supplies are inextricably linked to the amount of precipitation Utah receives.[139] Precipitation events will become scarcer as the air experiences higher saturation humidity,[140] affecting water in multiple ways. For instance, water quality is "sensitive both to increased water temperatures and changes in patterns of precipitation."[141] As precipitation falls as rain instead of snow, less of it finds its way to streams.[142] As a result, lower water volumes and changes in streamflow patterns will increase the contaminant loads entering streams.[143] Increased aridity will exacerbate water quality problems even further.[144]

Further, the loss of water through evaporation and plant transpiration[145] will substantially reduce aquifer recharge[146] and as a result, groundwater supplies will diminish.[147] Both of these processes will be amplified (vis-a-vis positive feedback loops) as the lower atmosphere warms.[148] Heavier precipitation events will tax aquifers even further,[149] because as more water falls, a greater amount of the water will disperse as runoff before it percolates into aquifers.[150]

Snowpack reductions will have very significant impacts.[151] First, the

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[134] *Id.* at 17–18.
[135] UTAH RIVERS COUNCIL, *supra* note 125, at 10.
[136] *Id.*
[137] *Id.*
[138] SW ASSESSMENT, *supra* note 10, at 322.
[139] BRAC, *supra* note 79, at 18.
[140] *See* Hall, *supra* note 34, at 244.
[141] SW ASSESSMENT, *supra* note 10, at 201. *See also* PETER BACKLUND ET AL, THE EFFECTS OF CLIMATE CHANGE ON AGRICULTURE, LAND RESOURCES, WATER RESOURCES, AND BIODIVERSITY IN THE UNITED STATES 8 (2008).
[142] *See* Hall, *supra* note 34, at 244.
[143] *See* UTAH RIVERS COUNCIL, *supra* note 125, at 29; SW ASSESSMENT, *supra* note 10, at 201; BACKLUND, *supra* note 153, at 8.
[144] SW ASSESSMENT, *supra* note 10, at 16.
[145] A hydrological process in which water vapor is released into the atmosphere as it is carried through plant tissue.
[146] *See* UTAH RIVERS COUNCIL, *supra* note 125, at 29.
[147] *See* Hall, *supra* note 34, at 243.
[148] DWR, *supra* note 8, at 8.
[149] *See id.* at 252–53.
[150] *Id.*
[151] *See generally* Philip W. Mote et al., *Declining Mountain Snowpack in Western North*

winter recreation industry will face shorter winter seasons.[152] In relatively low emission scenarios, the reduced duration of the skiing season could cost Summit County upwards of $27 million and 1,500 jobs.[153] In the highest emission scenarios, the figure looks closer to $67 million and 3,700 jobs.[154] Second, reservoirs will recharge at a slower rate.[155] Finally, the water level of the Great Salt Lake will sharply decline.[156] As a result, the salinity levels in the lake will increase,[157] which harms not only the wetland habitat and the wildlife that relies on it,[158] but also commercial and recreational industries that rely on the lake in its current form.[159] Stream inflows will diminish, soil will be drier, and evaporation rates will increase.[160] Indeed, streamflow in the Colorado River will decrease by as much as 45% by 2050.[161]

Finally, warming of local water bodies will impact aquatic life.[162] Trout populations could decline as much as 40-50% by mid-century.[163] Increased temperatures will decrease the amount of dissolved oxygen in the water, making it harder for the fish to breathe.[164] Warmer river flows will also alter the size and hatching patterns of one of the major food sources for trout—the mayfly.[165] In addition to trout, aquatic life in watersheds such as the Beaver Dam Wash and the Virgin River already suffer water deficits from current diversions.[166] The strain on these aquatic life systems will only worsen as water levels decrease.[167]

The Great Salt Lake is expected to incur the largest impact on wildlife.[168] It has the largest wetland system in the western United States,[169] and its ecosystem supports more than 8 million migratory birds every year,

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America, 86 BULL. AMER. METEOR. SOC. 39, 48 (2005) (analyzing the impacts climate change will have on snowpack throughout the western United States).

152 UTAH RIVERS COUNCIL, *supra* note 125, at 12.

153 *Id.*

154 *Id.*

155 SW ASSESSMENT, *supra* note 10, at 219.

156 BRAC, *supra* note 79, at 18–19.

157 *Id.*

158 UTAH RIVERS COUNCIL, *supra* note 125, at 24.

159 *Id.*

160 *See* Hall, *supra* note 34, at 244, 247.

161 *Id.* at 247. *See also* BRAD UDALL, INTERMOUNTAIN WEST CLIMATE SUMMARY, RECENT RESEARCH ON THE EFFECTS OF CLIMATE CHANGE ON THE COLORADO RIVER 2, 6 (2007).

162 UTAH RIVERS COUNCIL, *supra* note 125, at 6, 14.

163 *Id.* at 14.

164 *Id.*

165 *Id.*

166 *Id.* at 22.

167 *Id.*

168 *Id.* at *24*.

169 *Id.*

with 230 different species spanning across its shoreline.[170] These wetlands are heavily reliant upon the Bear River, which provides more than 60% of the Great Salt Lake's inflow each year.[171] With the changing climate, Bear River stands to experience a 5–18% reduction in river volume.[172] In addition to natural stressors on this river, proposed diversion projects intend to take 20% of the annual flow, and as a consequence, potentially reduce the Great Salt Lake's water level by four feet.[173]

b. Drought

Although the anticipated temperature increase (2-4ºF) seems relatively small, it will have significant impacts. As one example, a 0.5ºC change in the eastern Pacific Ocean means the difference between la Niña and El Niño conditions.[174] In Utah, the 2º F temperature shift will make droughts more ubiquitous and more severe.[175] Specifically, it will increase the frequency of droughts throughout Utah by 33% and result in a 25-fold increase in the chances of experiencing an extreme drought.[176] In the future, prolonged drought will be the paramount feature of Utah's climate.[177]

Drought will immediately impact Utah agriculture. In 2012, for example, 16 Utah counties declared drought seasons to afford farmers

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[170] *Id.*
[171] *Id.*
[172] *Id.*
[173] *Id.* at 25.
[174] NATIONAL GEOGRAPHIC, EL NINO-SOUTHERN OSCILLATION, http://education.nationalgeographic.com/education/encyclopedia/el-nino/?ar_a=1, (last visited May 3, 2015).
[175] UTAH RIVERS COUNCIL, *supra* note 125, at 9.
[176] *Id.* The watersheds in southern Utah are especially susceptible to drought. *Id.* at 10.
[177] BRAC, *supra* note 79, at 9–10, 18. ("the threat of severe and prolonged episodic drought in Utah is real and ongoing"). The southwest is already susceptible to droughts lasting months or years. *See* SW ASSESSMENT, *supra* note 10, at 62–63; *see also* Daniel R. Cayan et al., *Future Dryness in the Southwest US and the Hydrology of the Early 21st Century Drought*, 107 PNAS 21271, 21271–21276 (2010); Connie A. Woodhouse et al., *A 1,2000-Year Perspective of 21st century Drought in Southwestern North America*, 107 PNAS 21283, 21283–21288 (2009). While Utah maintains a surplus to its overall apportionment of its interstate water compact from the Upper Colorado River System, "plans for [future] development far exceed the amount of water likely available during most years." Ruple, *supra* note 67, at 376. Additionally, the Upper Colorado River system is expected to suffer significant fluctuations in supply levels, making Utah's reliance on this water source seem baffling. *See id.* Utah will not be able to rely exclusively on its interstate water compact, seeing as it is likely to suffer similar supply problems in relation to climate change. *See* Hall, *supra* note 34, at 285–86 (determining that the relevant watershed faces "severe" climate change risks, while simultaneously concluding that the existing interstate compact agreement is "inadequate" to address said risks).

relief.[178] These declarations occurred shortly after 19 Utah counties received disaster relief in 2009.[179] During these droughts, soils were dryer, crops were less productive, and farmers slaughtered their cattle more often than in non-drought years.[180]

The agricultural industry will likely face more austere conditions in the upcoming years.[181] Farmers will need greater amounts of water to fulfill agricultural demands, and water scarcity will increase the competition for water resources.[182] The increased agricultural demands will occur because soils will begin to dry out more rapidly,[183] and heightened temperatures may surpass crop tolerance levels.[184] Indeed, scientists expect increasing temperatures to negatively affect alfalfa, Utah's most commonly produced crop.[185] In addition, drier soils further jeopardize Utah's snowpack, because they render it more susceptible to wind erosion,[186] accelerating snowmelt.[187]

Aside from the impacts climate change will have on local farmers, it will also have significant effects on Utah's economy. In 2008, the agricultural industry employed over 66,000 Utahans and generated over $16 billion in revenue for the state.[188] Changes in Utah's water resources have potentially significant affects on other industries, as well.[189] These include winter tourism, which will experience reductions in the duration of the winter season;[190] power producers, which will have to use more water to cool power plants as the cooling efficiency of water decreases;[191] and the

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[178] UTAH RIVERS COUNCIL, *supra* note 125, at 26.
[179] *Id.*
[180] *Id.*
[181] BRAC, *supra* note 79, at 19.
[182] Economic and Social Development Dep't, Food and Agriculture Organization of the United Nations, Water Resources, The State of Food and Agriculture (1993), http://www.fao.org/docrep/003/t0800e/t0800e0a.htm.
[183] BRAC, *supra* note 79, at 18.
[184] *Id.* In the mid 1990's, the corn and soybeans experienced significant yield decreases due to the impacts of rising temperatures. *See* IPCC, INTERGOVERNMENTAL PANEL ON CLIMATE CHANE, CLIMATE CHANGE 2007: CLIMATE CHANGE IMPACTS, ADAPTATION, VULNERABILITY, 624 (2007).
[185] UTAH RIVERS COUNCIL, *supra* note 125, at 26.
[186] BRAC, *supra* note 79, at 20.
[187] *Id.*
[188] UTAH RIVERS COUNCIL, *supra* note 125, at 26.
[189] *See* Richardson, *supra* note 25, at 19–20 ("Disruptions may include: damage to core operations, such as factories and office buildings; diminished quality and quantity of key inputs, such as water resources and forestry products; restricted access to the broader supply and demand infrastructure, such as electric utilities and transport networks; and sudden (or gradual) changes in demand for products and services.").
[190] *See* Mote, *supra* note 163, at 48.
[191] *See* Hall, *supra* note 34, at 253; *see also* SW ASSESSMENT, *supra* note 10, at 201; NICOLE T. CARTER, ENERGY'S WATER DEMAND: TRENDS, VULNERABILITIES, AND

insurance industry, which will have to protect against increased flood risks that arise from heavier precipitation events.[192]

4. Factors that exacerbate Utah's climate change preparedness

a. Population growth

The greatest stressor on Utah's water supply besides climate change will be its rapidly growing population.[193] Recently, the Utah Division of Water Resources acknowledged that the "demands for water imposed by a growing population will exceed presently developed supplies available for municipal and industrial purposes."[194] Moreover, this statement does not take into consideration climate change, which will compound the problems of future supply by reducing the presently developed water resources.[195]

Utah currently has a population of 2,942,902[196] and enjoys the fourth largest population growth rate in the United States.[197] By 2050, the population will rise to more than 5 million people.[198] As a result, estimated municipal demand will soar to a whopping 2,000,000 acre-feet per year.[199] Utah is already one of the nation's highest water users because of residential watering needs.[200] The overall amount of water used will continue to increase with the population.[201] When considering Utah's per capita water use,[202] a diminishing water supply may result in the demand for water surpassing its supply quicker than Utah anticipated.

MANAGEMENT 4 (2001); UTAH DIVISION OF WATER RESOURCES, THE WATER-ENERGY NEXUS IN UTAH 39–41 (2012).

[192] UTAH RIVERS COUNCIL, *supra* note 125, at 26. This is especially true for southern Utah. In 2005, the Santa Clara and Virgin Rivers were flooded, causing between $150–180 million in damage. *Id.* The flood risk, however, is not exclusive to southern Utah. In 2012, Saratoga Springs experienced a destructive flood. *Id.*

[193] DWR, *supra* note 8, at 1.

[194] *Id.* at 25. This recognition was one of the main motivations spurring a revitalized conservation plan. *Id.*

[195] *See* UTAH RIVERS COUNCIL, *supra* note 125, at 5 (revealing a letter in which the Utah Division of Water Resources stated that it cannot consider "the effects of climate change on Utah's water supply unless the state legislature sees fit to appropriate money specifically for that purpose.").

[196] UNITED STATES CENSUS BEREAU, STATE & COUNTY QUICK FACTS (2014), http://quickfacts.census.gov/qfd/states/49000.html.

[197] DWR, *supra* note 8, at 18.

[198] *Id.* at 17. By 2060, Utah's population will be close to 6,840,000. Ruple, *supra* note 67, at 365.

[199] DWR, *supra* note 8. at 21, Table 7.

[200] *Id.* at 22, Table 8.

[201] *Id.* at 21, Table 7.

[202] *See* DNR, *supra* note 111, at 1.

b. Politicization of climate change

A study by the National Resources Defense Council indicated that Utah is one of the least prepared states to respond to 21st century climate change.[203] In fact, it was in the lowest category of preparedness.[204] Debates in Utah about whether climate change is in fact real have generated widespread confusion whether action is needed.[205] In addition, this discourse raises concerns of whether mitigation or adaptation can make a difference[206] and whether either is too expensive to pursue.[207]

Utah's governmental branches have not been consistent in their climate change approach. In 2007, the Governor's Office outlined the impacts that climate change poses to Utah and its water system.[208] Its report included various mitigation measures that Utah could take to reduce its emissions of greenhouse gases.[209] Additionally, Utah's drought study almost expressly acknowledges that climate change is occurring.[210] It states, "Climate across much of the U.S. has been getting warmer for about 20–25 years, especially in the winter and spring. These conditions contribute to drought by increasing the rate of snow melt in the spring and early summer, and also by increasing water evaporation."[211]

However, despite this recognition, Utah fails to consider more permanent alterations in its climate.[212] For example, the Division of Water Resources has refused to study how diminishing snowpack levels will affect Utah's water supply.[213] Specifically, the agency has stated that it "cannot undertake additional studies of the effect of climate change on Utah's water

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[203] *See* NATURAL RESOURCES DEFENSE COUNCIL, READY OR NOT: AN EVALUATION OF STATE CLIMATE AND WATER PREPAREDNESS PLANNING 3 Figure ES-2 (2012) [hereinafter NRDC, Evaluation of State Climate Preparedness].
[204] *Id.*
[205] Bob Graves, *The Question of Climate Change in Salt Lake City*, FUTURESTRUCTURE (Mayor Becker states that "Utah . . . is still living in this bubble, with this head-in-the-sand approach about the risks we are facing and the effects we are seeing in climate change.").
[206] NATIONAL RESOURCE COUNCIL, ADAPTING TO THE IMPACTS OF CLIMATE CHANGE 122 (2010).
[207] *Id.*
[208] *See* UTAH WATER READINESS REPORT, *supra* note 16.
[209] *Id.*
[210] UTAH DEPARTMENT OF NATURAL RESOURCES, DROUGHT IN UTAH: LEARNING FROM THE PAST—PREPARING FOR THE FUTURE 75 (2007).
[211] *Id.*
[212] *Id.* This is evidenced by the suggestion that local and regional water managers take advantage of "normal" or "wet" precipitation years to mitigate the effects of drier years. *Id.* at 2. Utah will have to incorporate the changing precipitation patterns in this recommendation.
[213] *See* UTAH RIVERS COUNCIL, *supra* note 125, at 5.

supply unless the state legislature sees fit to appropriate money specifically for that purpose."[214]

House Joint Resolution 12 of the 2010 General Session further exacerbated the lack of consideration of climate change in water resources management. The resolution urged the United States Environmental Protection Agency to cease its climate change responses until the science is "substantiated"[215] and attempted to discredit evidence of climate change.[216] Specifically, House Joint Resolution 12 questioned temperature analyses, denies the "hockey stick" increase in greenhouse gases (commonly known as the Keeling Curve), asserted that many scientists deny that climate change is anthropogenic, and pointed to a cooling period (the "Little Ice Age") in attempts to demonstrate that modern climate change does not exceed natural variations.[217] House Joint Resolution 12 effectively deprived state agencies of the authority to incorporate climate change considerations into their responsibilities.[218]

The resolution's flippant reaction to climate change is baffling, especially considering that Utah faces a loss of $10.5 billion in Gross Domestic Production (GDP) and over 72,200 jobs by 2050 because of changes in its climate.[219] However, attitudes may be changing. Recently, Salt Lake City's Division of Sustainability emphasized that adaptation to climate change is crucial to protecting its water resources.[220] Unfortunately, this statement represents nothing more than an idealized "agenda"[221] that agencies are free to disregard. Agencies cannot act on climate change until the Utah Legislature authorizes them to do so.[222] Legislative actions, however, are subject to high levels of public scrutiny.[223]

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[214] *Id.*

[215] H.R.J. Res. 12, 2010 General Session (enacted), *available at* http://le.utah.gov/~2010/bills/static/HJR012.html.

[216] *Id.*

[217] *Id.*

[218] *See, e.g.,* UTAH RIVERS COUNCIL, *supra* note 125, at 5.

[219] *See* UTAH WATER READINESS REPORT, *supra* 16, at 1; *see also* GEORGE BACKUS ET AL., ASSESSING THE NEAR-TERM RISK OF CLIMATE UNCERTAINTY: INTERDEPENDENCE AMONG THE U.S. STATES (2010), *available at* cfwebprod.sandia.gov/cfdocs/CCIM/docs/Climate_Risk_Assessment.pdf.

[220] SALT LAKE DIVISION OF SUSTAINABILITY, SUSTAINABLE SALT LAKE: PLAN 2015 14–15, *available at* http://www.slcdocs.com/slcgreen/sustainablesaltlake_plan2015.pdf.

[221] SLC GREEN, http://www.slcgov.com/slcgreen/about, (last visited May 3, 2015).

[222] *See Utah Light & Traction Co. v. Psc*, 118, P.2d 683, 694 (Utah 1941) ("The legislature . . . may delegate [agencies] power to determine some fact, or state of things, upon which the law makes, or maintains to make, its own action depend.").

[223] *See* DWR, *supra* note 8, at 64.

Public opinion heavily restrains Utah's responses to climate change.[224] Indeed, most of the majority of pressure on executive agencies emanates from public pressure rather than scientific incapability.[225] The sheer amount of public pressure played a role in Governor Huntsman's decision to formally withdraw from the Western Climate Initiative.[226]

Accordingly, Utah needs to approach the topic uniformly, with a comprehensive strategy to fortify Utah's water supply in light of future changes to its climatological conditions. Doing so would decrease the risk that information is misconstrued as advancing a political agenda,[227] as well as give the Division of Sustainability's proposal enforceable bite.

II. ADAPTATION

Climate change will continue to place increased stress on perpetually limited natural resources such as water.[228] To safeguard these resources, governments must expand their current ability to respond to uncertain changes that will occur in the future.[229] Increased flexibility will augment entities' ability to address vulnerabilities.[230] However, legislators around the United States, including Utah, are only beginning to consider adaptation measures as a response to the impacts posed by climate change.[231]

Adaptation is the process by which natural and man-made systems

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[224] *See, e.g.,* Miller, *supra* note 18, at 414.

[225] *See* Camacho, *supra* note 15, at 6; *see also* Susan K. Snyder & Barry R. Weingast, *The American System of Shared Powers: The President, Congress and the NLRB*, 16 J.L. ECON. & ORG. 269, 269–70 (2000) (demonstrating that political influence has empirically affected regulation); Holly Doremus, *The Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate*, 34 ENVTL. L. 397, 402 n.21 (2004) (discussing how political pressures affect the decision to list species as threatened or endangered); J.R. DeShazo & Jody Freeman, *The Congressional Competition to Control Delegated Power*, 81 TEX. L. REV. 1443, 1468 (2003) (concluding that politics had more influence than science on agency's listing decision); TERRY M. MOE, THE POLITICS OF STRUCTURAL CHOICE: TOWARD A THEORY OF PUBLIC BUREAUCRACY, IN ORGANIZATION THEORY: FROM CHESTER BARNARD TO THE PRESENT AND BEYOND 116, 125-27 (Oliver E. Williamson ed., 1990) (noting that OSHA policy making reflects the political preferences of its administrative leaders).

[226] WATER READINESS REPORT, *supra* 16, at 2. *See also* Sonja Klinsky, *Bottom-Up Policy Lessons Emerging from the Western Climate Initiative's Development Challenges*, 13 CAMBRIDGE CENTRE FOR CLIMATE CHANGE MITIGATION RESEARCH 143, 149 (2013).

[227] *See* Orr Karassin, *Mind the Gap: Knowledge and Need in Regulating Adaptation to Climate Change,* 22 GEO. INT'L ENVTL. L. REV. 383, 409 (2010).

[228] *See* Camacho, *supra* note 15, at 17.

[229] *Id.*

[230] *See* Miller, *supra* note 18, at 399.

[231] *Id.*

adjust in response to climatological alterations.[232] Humankind has been adapting throughout its history.[233] Humans have proven that they can thrive in a wide variety of climates, settling in drastically different regions such as the arid western United States and the polar regions of Alaska.[234] The diversity of settlements exemplifies the ability of humans to adapt to climatological conditions.[235] In this climate change era, adaptation is a way in which government entities can use their vested power to reduce vulnerability to the impacts of climate change.[236]

Moreover, although adaptation can take the form of national and international strategies, many important adaptations must occur at the state and local level.[237] Given the high degree of variability in climatological impacts,[238] it makes sense for state and local governments to pursue actions in light of their superior knowledge of their locales.[239] First, local governments will generally have a better understanding their local conditions.[240] Second, local entities can more readily involve all stakeholders.[241] Unsurprisingly, involving every stakeholder on a national scale would be much more inefficient.

To secure its future water resources, Utah must start to pursue adaptation strategies. This section demonstrates the necessity for adaptation, reveals effective adaptation practices, raises potential impediments to adaptation, and then recommends adaptation strategies that Utah could pursue effectively.

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[232] *See* Karassin, *supra* note 239, at 384–385. Adaptation does not only reduce harm, but it also exploits potential benefits. IPCC, *supra* note 17, at 84.

[233] WILLIAM E. EASTERLING III ET AL., PEW CENTER ON GLOBAL CLIMATE CHANGE, COPING WITH GLOBAL CLIMATE CHANGE: THE ROLE OF ADAPTATION IN THE UNITED STATES iii (2004).

[234] *Id.*; ALASKA DEP'T OF LABOR AND WORKFORCE DEV., A HISTORY OF ALASKA POPULATION SETTLEMENT 4–6 (2013).

[235] EASTERLING, *supra* note 245, at iii.

[236] *See Id.* This can include legislation, regulation, as well as market mandates.

[237] *See* Richardson, *supra* note 25, at 3.

[238] IPCC, *supra* note 17, at 1 ("the globally averaged surface temperatures exhibits substantial decadal and interannual variability.").

[239] That's because state localities have authority over "land use planning decisions, including zoning and building codes, as well as transportation infrastructure." Richardson, *supra* note 25, at 8.

[240] *See* Karassin, *supra* note 239, at 416. *See generally* Lars Otto Naess et al., *Institutional Adaptation to Climate Change: Flood Responses at the Municipal Level in Norway*, GLOBAL ENVTL. CHANGE 125 (2005) (suggesting that climate change adaptation is more effective at the local level).

[241] *See* Ted Rutland & Alex Aylett, *The Work of Policy: Actor Networks, Governmentality, and Local Action on Climate Change in Portland, Oregon*, 26 ENV'T & PLAN. D: SOC'Y & SPACE 627, 636 (2008).

A. Necessity of Adaptation Measures

Greenhouse gases emitted into the atmosphere can survive for long periods of time.[242] As a result, modern emissions will continue to affect the climate in the future.[243] With global emission rates at an all-time high, adaptation efforts are necessary to decrease the potential effects of impacts associated with climate change.[244]

Because the impacts are already beginning to occur, Utah cannot rely solely upon its mitigation strategies.[245] Indeed, given the continued increase in greenhouse gas emissions, some degree of climate change is inevitable.[246] Unfortunately, mitigation efforts have been the exclusive climate change strategy that Utah has pursued.[247] While mitigation strategies are worth pursuing, governments must also pursue adaptation strategies to respond to the current and projected impacts of climate change.[248] At this point, "[a]dressing climate change is no longer a choice, but an imperative."[249]

Mitigation and adaptation are not mutually exclusive. In fact, if coordinated, both will complement one another in developing flexible strategies that are robust enough to deal with the future impacts of climate change.[250] Adaptation can fortify against future damages[251] and in no way detracts from Utah's efforts to abate excessive greenhouse gas emissions.[252] While Utah should continue to act to mitigate climate change, it must also consider the impacts that will occur notwithstanding the potential success of

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242 *Id.* at 2 ("carbon dioxide and other greenhouse gases can remain in the atmosphere for decades to many centuries after they are emitted . . . .").
243 *Id.*
244 *Id.* at 2–4. *See also* IAN BURTON ET AL., ADAPTATION TO CLIMATE CHANGE: INTERNATIONAL POLICY OPTIONS 9–12 (2006); CLIMATE IMPACTS GROUP, PREPARING FOR CLIMATE CHANGE: A GUIDEBOOK FOR LOCAL, REGIONAL, AND STATE GOVERNMENTS 25–28 (2007).
245 SW ASSESSMENT, *supra* note 10, at 414.
246 Richardson, *supra* note 215, at 2–4.
247 Utah WATER READINESS REPORT, *supra* 16, at 2–3.
248 *See* TERRI L. CRUCE, PEW CENTER ON GLOBAL CLIMATE CHANGE, ADAPTATION PLANNING: WHAT U.S. STATES AND LOCALITIES ARE DOING 1 (2009).
249 Richardson, *supra* note 25, at 3.
250 EASTERLING, *supra* note 245, at 2, 32.
251 *Id.* at 5.
252 *See id.* "Recognizing a role for adaptation does not, however, diminish or detract from the importance of mitigation in reducing the rate and likelihood of significant climate change." *Id.* at v. Utah has taken mitigation strategies, *see* UTAH WATER READINESS REPORT, *supra* note 16, at 2–3., and these are positive steps towards readiness. However, they are not in and of themselves sufficient avert future damages that climate change will bring. EASTERLING, *supra* note 245, at 5.

its mitigation measures.[253]

The Utah Water Plan itself notes that "[i]n order to make good water development and management decisions, water quality, environmental and other values need to be properly addressed."[254] This is precisely what adaptation is. However, in the water management context, governmental measures tend to be reactive in nature.[255] This tendency does not bode well when impacts are unpredictable or irreversible.[256] By the time the impacts reach their full extent, it may be too late to respond.[257] Instead, "effective water resource planning" must anticipate and try to reduce the impacts of climatological alterations to water supply.[258]

However, this is not the state of contemporary water management. The governance of water resources throughout the nation is "fragmented, poorly informed, and un-adaptive."[259] In order to reverse this reality, Utah needs to integrate climate change into its water management and planning.[260] Adaptation to the impacts of climate change is not going to be a simple process.[261] Additionally, some necessary adaptation measures will be expensive.[262] While entities will make mistakes,[263] adaptation to climatological alterations is not an "instantaneous occurrence but one that develops over time."[264] Mistakes are crucial to improving the resiliency of climate responses. Once Utah takes these first steps, it can develop a more flexible water management system[265] and establish an "adaptive water governance."[266]

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[253] CRUCE, *supra* note 260, at 1.
[254] DWR, *supra* note 8, at 5.
[255] *See* Richardson, *supra* note 25, at 17.
[256] *Id.* Reactive strategies are most effective when the impacts are slow in developing and the impacts are predictable. *Id.*; *see also* Camacho, *supra* note 135, at 18–19. Threats of future climate change do not exemplify these characteristics.
[257] Richardson, *supra* note 25, at 17.
[258] *See* DWR, *supra* note 8, at 25.
[259] Camacho, *supra* note 15, at 25–26.
[260] UTAH WATER READINESS REPORT, *supra* note 16, at 3.
[261] *See* EASTERLING, *supra* note 245, at 33.
[262] *Id.*
[263] *See id.* This is especially true at the outset. Because the climate change the planet is experiencing is a relatively new phenomenon, the best strategies have not been revealed. *Id.* at 5. The most effective strategies will probably be revealed through a process of trial and error. IPCC, *supra* note 17, at 56.
[264] EASTERLING, *supra* note 245, at 6.
[265] *See* Camacho, *supra* note 15, at 50 (noting that a flexible framework arises from using these errors to develop a "methodology for assessing and adjusting government decision making over time.").
[266] Barbara Cosens et al., *The Adaptive Water Governance Project: Assessing Law, Resilience and Governance in Regional Socio-Ecological Water Systems Facing a Changing Climate*, 51 IDAHO L. REV. 1, 10 (2014).

B. Effective Adaptation

An adaptation is considered successful when it responds to impacts in such a way that maintain the welfare of the system before the disturbances occurred.[267] Although entirely offsetting the impacts of climate change would certainly be an incredible feat,[268] we should consider adaptation measures to be successful if they can respond and incur minor loss.[269] Indeed, perfect adaptation response is probably untenable, especially when considering the inexperience of local governments in dealing with widespread changes.[270] This section highlights the principles used in effective adaptation and introduces various adaptation concepts and strategies.

1. Principles for effective adaptation

Successful adaptation strategies demands adequate information regarding risks and vulnerabilities before it can prioritize its response action.[271] In fact, actions based on insufficient information can result in maladaptation—that is, action that puts the system acted upon in a worse condition than before.[272] These assessments aid decision makers in understanding the overall impacts likely to occur, as well as myriad adaptation options available to them.[273]

Adaptation assessments can take various forms. First, there are impact-based approaches, which focus on the physical impacts that climate change will have on natural and manmade systems.[274] Second, vulnerability-based assessments focus on the threatened risks in order to develop the most favorable response.[275] Finally, adaptation-based approaches examine the adaptive capacity of natural and manmade systems and explore measures to make the systems more resilient.[276]

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[267] *See* EASTERLING, *supra* note 245, at 6.
[268] *Id.*
[269] *Id.* Gives an individual farmer example as a justifiable loss. Probably try to find own example.
[270] *Id.* at 2 (noting that the complexity, scale, and limited experience in regards to the effects of climate change explain the limited adaptation efforts).
[271] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IMPACTS, ADAPTATION, AND VULNERABILITY 11 (2014) [hereinafter IMPACTS, ADAPTATION, AND VULNERABILITY].
[272] *Id.* at 28.
[273] *Id.* at 11.
[274] *Id.* at 850.
[275] *Id. See also* W. Neil Adger, *Vulnerability—Global Environmental Change*, 17 GLOBAL ENVTL. CHANGE 268, 269 (2006).
[276] IMPACTS, ADAPTATION, AND VULNERABILITY, *supra* note 283, at 850. *See also* Barry

In 2006, Governor Huntsman formed the Blue Ribbon Commission to identify potential mitigation measures Utah could take.[277] Although the Governor's Blue Ribbon Commission conducted an initial assessment, it was exclusively impacts-based.[278] Further, the assessment focused solely on mitigation measures.[279] Utah should conduct more assessments and integrate of all these approaches into a more usable strategy to adapt to climate change.[280]

Additionally, adaptation options surrounding climate change should involve all stakeholders.[281] Because the impacts associated with climate change are of such a large magnitude, adaptation planning "should involve representatives from federal, state, and local government; science and academia; the private sector; and local communities."[282] Scientists and academics can provide expertise that will enable the other parties to more accurately consider the potential adaptation measures.[283] Although different stakeholders will have different needs, shared information is the best way to create agreements that will benefit all parties.[284]

Finally, adaptation measures should emphasize taking action and then scrutinizing it to make future actions more effective.[285] Assessment will require accurate information and a solid understanding of the underlying policy mechanisms.[286] If done correctly, assessments will result in robust and flexible strategies that can be integrated into future adaptation measures.[287] The end goal of integrating adaptation strategies is to create an adaptation system that learns from its mistakes and builds upon its successes.[288]

2. Adaptation strategies

There is no standard terminology for adaptation,[289] and in order to

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Smit & Johanna Wandel, *Adaptation: Adaptive Capacity and Vulnerability*, 16 GLOBAL ENVTL. CHANGE 282 (2006).

[277] BRAC, *supra* note 79, at § I.

[278] *See id.*

[279] BRAC, *supra* note 79, at § I.

[280] IMPACTS, ADAPTATION, AND VULNERABILITY, *supra* note 283, at 850.

[281] *See* Richardson, *supra* note 25, at 3.

[282] *Id.* at 19.

[283] *Id.*

[284] IMPACTS, ADAPTATION, AND VULNERABILITY, *supra* note 283, at 842.

[285] *Id.* at 849.

[286] *Id.* at 849–850.

[287] *See* Camacho, *supra* note 15, at 49–50.

[288] *Id.*

[289] EASTERLING, *supra* note 245, at 5. BARRY SMIT ET AL., ADAPTATION TO CLIMATE CHANGE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT AND EQUITY (2001) (explaining

increase its efficacy, governmental entities must employ adaptation measures through a process that is amenable to the appropriate regional context.[290] While there are certain benefits to national adaptation efforts, adaptation must also occur at the state and local level.[291] The need for local adaptation efforts is highlighted given the fact that the impacts of climate change will vary greatly depending on the region.[292]

a. Proactive versus reactive strategies

Climate change discourse often conflates resilience with adaptation.[293] The differing strategies of these two concepts exemplify the distinction.[294] Reactive adaptation closely resembles the concept of resilience[295] and refers to the ability of a system to experience a disturbance or impact and return to its prior state.[296] In the water context, water managers and planners have increased storage capabilities, pursued heightened conservation goals, and developed more nuanced techniques regarding water transfers as reactive adaptation strategies.[297] While these actions are commendable, it is highly unlikely that they will entirely offset the anticipated impacts of climate change.[298] As the impacts of climate change magnify, existing strategies will have to "adapt."[299]

Reactive adaptation is backwards looking in nature and seeks to recover from observed effects.[300] Although reactive responses are subject to less uncertainty than proactive measures, they are not without problems. First, high degrees of damage can occur before entities respond to them.[301]

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that adaptation can take different forms).

290 *See* Karassin, *supra* note 239, at 416. *See generally* Lars Otto Naess et al., *Institutional Adaptation to Climate Change: Flood Responses at the Municipal Level in Norway*, GLOBAL ENVTL. CHANGE 125 (2005) (suggesting that climate change adaptation is more effective at the local level).

291 Richardson, *supra* note 25, at 8.

292 *Id.*

293 EASTERLING, *supra* note 245, at 5.

294 *Id. See also* Robin Kundis Craig & Melinda Harm Benson, *The Next Generation of Environmental and Natural Resources Law: What has Changed in Forty Years and What Needs to Change as a Result: Replacing Sustainability*, 46 AKRON L. REV. 841 (2013).

295 *Id.*

296 *Id. See also* C.S. HOLLING, THE RESILIENCE OF TERRESTRIAL ECOSYSTEMS: LOCLA SURPRISE AND GLOBAL CHANGE 292 (W.C. Clark & R.E. Munn eds, 1986) (explaining how ecological responses occur in the context of reactive adaptation).

297 EASTERLING, *supra* note 245, at 19.

298 *Id.* at 19–20.

299 *Id.*

300 Camacho, *supra* note 15, at 18–19.

301 *Id.*

This damage extends to both infrastructure as well as ecosystems.[302] Second, these responses are subject to higher costs.[303]

Proactive strategies, on the other hand, more closely resemble the strategy of adaptation.[304] Proactive adaptations take place before the impacts associated with climate change have manifested[305] and create long-term strategies to respond to future impacts.[306] Because they are proactive, these strategies are susceptible to the considerable uncertainty inherent in predictive climate change models and scenarios.[307] However, proactive measures can incorporate the inherent uncertainty of future climate changes into their overall strategy[308] by anticipating disturbances and impacts to the current system and making alterations to enable a more effective response to them.[309] Unlike reactive strategies, proactive adaptation strategies fundamentally alter the current system to improve its response capacity.[310]

Utah has already considered measures to increase resilience (i.e. reactive approaches).[311] For example, in 2008, the Utah Department of Environmental Quality implemented a statewide goal to reduce its greenhouse gas levels.[312] In that same year, the Governor's Blue Ribbon Advisory Council released a report outlining various options Utah had to reduce state emission levels.[313] It is now time for Utah to take a more

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[302] *Id.*
[303] *Id.*
[304] EASTERLING, *supra* note 245, at 5.
[305] Camacho, *supra* note 15, at 18.
[306] EASTERLING, *supra* note 245, at 5 (explaining that proactive adaptation fundamentally reorganize systems to improve adaptive capacity).
[307] Camacho, *supra* note 135, at 18. Otherwise, entities will "muddl[e] through" changes while simultaneously impeding long-term adaptation. EASTERLING, *supra* note 245, at 13. For example, in the early to mid 1980's, the Great Salt Lake rose 12 feet. The rise resulted in flooding that damaged mineral industries, highways, railroads, and residences adjacent to the lake. *Id.* Assuming it was an anomaly, governmental entities pursued short-term strategies and continued to dike and raise the highway. Although these resolved the immediate sea-level rise, it failed to protect against future changes in sea level as well as future shoreline development. *Id.*
[308] *Id.* at 24 ("Proactive adaptation, unlike reactive adaptation, is forward-looking and takes into account the inherent uncertainties associated with anticipating change. Successful proactive adaptation strategies are therefore flexible; that is, they are designed to be effective under a wide variety of potential climate conditions, to be economically justifiable (i.e., benefits exceed costs), and to increase adaptive capacity.").
[309] *Id. See also* HOLLING, *supra* note 308, at 301–305.
[310] EASTERLING, *supra* note 245, at 5.
[311] *See* UTAH WATER READINESS REPORT, *supra* note 197, at 2.
[312] *Id.*
[313] *Id.* Utah did not implement any of the possible measures, despite the fact that the assessment concluded that regulations on the electricity sector could significantly curtail

proactive approach. Proactive adaptation can effectively reduce Utah's vulnerability[314] by improving governmental capacity to respond by incorporating climate change into long-term decision-making.[315] It can also disincentivize maladaptation[316] while simultaneously incentivizing positive behavior modifications.[317]

b. Substantive versus procedural strategies

In addition, adaptation efforts can be substantive or procedural.[318] The majority of academic discourse surrounding climate change adaptation involves substantive options,[319] which are the actions entities take to manage the effects of climate change.[320] Procedural strategies have a different focus. Instead of focusing directly on managing the effects of climate change, they attempt to manage the process of adaptation itself to develop more effective substantive strategies.[321] For instance, a procedural strategy could alter the decision-making process that government entities use to select substantive adaptation strategies.[322]

Although the value of substantive strategies is readily apparent, procedural alterations to institutional governance are "even more vital given the uncertainties that exist for addressing the impacts of a warming climate."[323] Procedural strategies do not decide whether entities pursue adaptation to climate change. Rather, they seek to determine what procedural reform will be most effectively enable successful adaptation measures.[324] Indeed, procedural adaptation approaches have been seen as a "bridge" between uncertainty and substantive adaptation measures.[325]

For instance, California recently created the Climate Adaptation Advisory Panel ("CAAP") in its climate action plan.[326] CAAP will assess near-term priorities, identify climate adaptation strategies, and establish a

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emissions. *Id.*
[314] EASTERLING, *supra* note 245, at 33–34.
[315] *Id.* at 24.
[316] *Id.* at 33–34.
[317] *Id.*
[318] *See* Camacho, *supra* note 135, at 20–22.
[319] *Id. See, e.g., id.* n. 95 and surrounding discussion.
[320] *Id.* at 21–22.
[321] *Id.* at 23–24.
[322] *Id.* at 23.
[323] *Id.* at 24.
[324] *Id.* at 23–24.
[325] *Id.* at 25.
[326] CALIFORNIA NATURAL RESOURCES AGENCY, 2009 CALIFORNIA CLIMATE ADAPTATION STRATEGY 23 (2009), *available at* http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf.

framework to promote collaboration within and among state agencies to implement adaptation strategies.[327] CAAP procedurally alters California's adaptation process by identifying the solutions that will be prioritized as well as designating the appropriate agency to implement them.[328]

c. Adaptation options

Within the process of adaptation are a host of decision-making frameworks. This Comment highlights the main three. First, there are the so-called "no-regrets" decisions.[329] These are actions that that benefit the state regardless of the impacts (or lack thereof) Utah will experience from climate change.[330] For example, protecting presently threatened ecosystems produces a benefit regardless of the extent of climate change.[331] Second, there are co-benefit strategies.[332] A co-benefit decision is essentially a win-win strategy where entities pursue measures that both reduce the impacts associated with climate change and create ancillary benefits.[333] For instance, an entity improving its cooling efficiency would simultaneously lower its electricity bill, increase its property value, and reduce its emissions of greenhouse gases.[334] Finally, there are exclusive adaptation efforts.[335] These approaches are actions taken solely for purposes of reducing vulnerability to the impacts of climate change and lack other ancillary benefits[336] and could include actions such as relocating populations.[337]

C. Impediments to Adaptation

1. Planning problem

One—and perhaps the most substantial—difficulty in determining the appropriateness of adaptation measures emanates from the lack of certainty regarding the variability of the climate.[338] Indeed, most reports on climate change focus on macro-trends, which make it difficult to adapt these trends

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[327] *Id.*
[328] *Id.*
[329] *See* Richardson, *supra* note 25, at 25.
[330] *Id.*
[331] *Id.*
[332] *See* Camacho, *supra* note 15, at 20.
[333] *Id.*
[334] *Id.*
[335] *Id.*
[336] *Id.*
[337] *Id.*
[338] *Id.* at 12.

to a local context.[339] Utah's water system—like most other natural systems—is subject to many feedbacks.[340] The temperature range is highly variable and drastically complicates the prediction of precise impacts.[341] The climate system is highly volatile, meaning that uncertainty will pervade all climate change responses.[342] This uncertainty will complicate adaptation measures because water managers and planners must act despite this uncertainty.[343]

Indeed, "[a]dapting to climate change necessitates the coordination and mobilization of scientific and management information to a degree never attempted."[344] Although difficult, it is necessary for this collaboration to occur. If done correctly, adaptation will afford entities an increased adaptive capacity, which only increases the regulatory flexibility they have in dealing with the impacts of climate change.[345]

When faced with uncertainty, state entities are under substantial pressure when committing to decisions that later turn out to be unnecessary—or worse, harmful.[346] Uncertainty has resulted in states' reluctance to pursue potential adaptation measures.[347] As one scholar puts it, "[s]earch[es] for optimal decisions are severely hampered by the absence of reliable estimates of probabilities."[348] State entities should not seek to precisely anticipate every impact climate change will have on water. Given the variability of the climatological conditions, it would be nearly impossible to successfully perform this task. Rather, state entities should focus on near-term solutions that would increase future flexibility to deal with whatever harm arises.[349] Such strategies will evolve over time, responding to climate changes and new information.[350]

Unfortunately, current programs fail to treat climate change responses

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[339] *Id.* at 13–15.
[340] *See* BRAC, *supra* note 79, at 16–20.
[341] Camacho, *supra* note 15, at 14–15.
[342] *Id.* 12–15.
[343] *See* Miller, *supra* note 18, at 403–407.
[344] Camacho, *supra* note 15, at 16.
[345] *Id.* at 7–8. *See also* Ruple, *supra* note 67, at 378 (stating "[t]he prospect of a changing climate, extended drought, and increasing demand necessitate careful planning and management consideration to ensure that during times of scarcity, existing water resources are allocated equitably and impacts are minimized to the maximum extent possible."
[346] *See* Miller, *supra* note 18, at 410–411.
[347] *See* Camacho, *supra* note 15, at 25–26.
[348] *See* Miller, *supra* note 18, at 410. *See also* ROBERT J. LEMPERT ET AL., SHAPING THE NEXT ONE HUNDRED YEARS, NEW METHODS FOR QUANTITATIVE LONG-TERM POLICY ANALYSIS (2003), *available at* http://www.rand.org/pubs/monograph_reports/MR1626.html.
[349] *See* Miller, *supra* note 18, at 411.
[350] *Id. See also* LEMPERT, *supra* note 360, at 1–2.

as "an ongoing experiment" and thus fail to capitalize on the information gathered from past strategies.[351] The EPA's National Estuaries Program ("NEP") exemplifies this missed opportunity.[352] The NEP is a program that relies on intergovernmental coordination and collaboration to protect estuaries.[353] The Charlotte Harbor National Estuary Program includes "eight federal agencies, twenty-six state agency divisions, seven counties, twenty-four cities, two water management districts, three regional planning councils, and at least eight other special districts" in its decision-making process.[354] Further, the Climate Ready Estuaries Program ("CRE") exemplified NEP's ability improve adaptive capacity vis-à-vis procedural strategy.[355] The CRE addressed the inherent uncertainty surrounding localized effects by creating a publicly accessible bibliography that assesses the relative value of adaptation strategies.[356]

Despite the improvement on interagency collaboration and information infrastructure, however, the NEP has not provided a framework that evaluates the past performance of estuarine management strategies.[357] Thus, while the initial decisions consider the various effects of climate change, the NEP programs lack assessment capabilities that would otherwise enable the programs to modify and improve over time.[358] Absent "rigorous monitoring and systematic assessment" of adaptation strategies, agencies are doomed to "repeat[] mistakes from prior adaptive regulatory experiments."[359]

Historically, making decisions in the face of uncertainty is a defining feature of water planning.[360] Considerations such as the rate of population growth, the amount of water used in households, potential legislation or regulation, and competition from competing water users are all factors that water planners have routinely had to account for.[361] While these considerations are certainly less variable than the projected impacts of climate change, they are still based on long-term averages.[362] The important thing is to make sure that climate change is part of the consideration. Only then will water resource managers truly be considering all factors that may potentially affect water supply. Considering climate change in water

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[351] Camacho, *supra* note 15, at 56–59.
[352] *Id.*
[353] *Id.*
[354] *Id.*
[355] *Id.*
[356] *Id.*
[357] *Id.*
[358] *Id.*
[359] *Id.*
[360] Miller, *supra* note 18, at 406–407.
[361] *Id.*
[362] *Id.*

planning does not, however, remove the necessity of an updated adaptation assessment in Utah.

Despite the relative uncertainty regarding the impacts of climate change, aspects of Utah's water future are perfectly clear. The stress on Utah's water supply will continue to worsen because of population growth. Indeed, Utah was expecting to surpass its available water supply even without accounting for long-term alterations in its climate. Decreasing snowpack has impacted the water supply of surface and ground water, as well as increased the frequency of drought. Ultimately, conservation and efficiency measures make sense regardless of the extent of climate change, but they must be coupled with a consideration of climate change. Otherwise, Utah will maintain a status quo water governance too rigid to adapt to the changing climate.

2. Contemporary water management paradigm

Stationarity is the principle guiding modern water management[363] and it assumes that the future will resemble past hydrologic patterns.[364] Contemporary water management lacks a replacement principle and that hole is ultimately "inhibiting the process of adaptation and the search for solutions."[365] Although stationarity is a largely criticized paradigm, replacing it is proving to be extremely difficult for water management.[366] Despite its difficulties, replacing the deeply-rooted paradigm of stationarity is not impossible.[367] Rather than maintain the current emphasis on preservation, Utah must shift its focus to increasing its adaptive capacity.[368]

D. Adaptation Measures Utah Should Take

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[363] *See* SW ASSESSMENT, *supra* note 8, at 205.
[364] *Id.*
[365] *Id.* at 198.
[366] *Id.* at 205. *See also* P.C.D. Milly et al., *Stationarity is Dead: Whither Water* Management, 319 SCIENCE 573, 573–574 (2008); JOSEPH BARSUGLI ET AL., WATER UTILITY CLIMATE ALLIANCE, OPTIONS FOR IMPROVING CLIMATE MODELING TO ASSIST WATER UTILITY PLANNING FOR CLIMATE CHANGE (2009); Casey Brown, *The End of Reliability*, 136 J. OF WATER RESOURCES PLANNING AND MANAGEMENT 143, 143–145 (2010); EDWARD MEANS III ET AL., WATER UTILITY CLIMATE ALLIANCE, DECISION SUPPORT PLANNING METHODS: INCORPORATING CLIMATE CHANGE UNCERTAINTIES INTO WATER PLANNING (2010).
[367] *See generally*, Robin Kundis Craig, "*Stationarity is Dead"—Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL. L. REV. 9 (2008).
[368] *Id.* at 31–40.

The recommendations I make in this section are not intended to be exhaustive. Further, there is more than one way to obtain some of the benefits isolated in this section. That said, these recommendations are low-risk and benefit the State of Utah and its water resources regardless of the future climate changes that occur.

1. Utah should conduct its own assessment to adapt to the impacts of climate change and develop a climate action plan

Institutional ability to pursue adaptation strategies has been inhibited by distorted information surrounding climate change responses.[369] This an especially relevant concern given Utah's polarized status regarding the issue of climate change.[370] Knowledge and vulnerability assessments are crucial to justifying adaptive measures.[371] The state should pursue "no regrets" strategies wherever possible, because they are justified regardless of what climate changes occur.[372] Implementing these strategies will provide Utah an opportunity to at least start pursuing adaptation measures while it conducts assessments.

Before considering other adaptation alternatives that are available, Utah should conduct a climate assessment and develop a climate action plan. The state cannot respond to the impacts of climate change unless it understands its vulnerability, exposure, sensitivity, and adaptive capacity.[373] Vulnerability measures the susceptibility of natural and manmade system to climate change[374] and is determined by aggregating the system's sensitivity, exposure, and adaptive capacity.[375] Sensitivity measures the impacts

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[369] EASTERLING, *supra* note 245, at 28. *See also Utah Water Districts' Plan Needs to Account for Climate Change*, SALT LAKE TRIBUNE, (2015), *available at* http://www.sltrib.com/opinion/2245483-155/editorial-utahs-water-plan-needs-to; Brandon Loomis, *Utah Criticized for Ignoring Climate Change in Water Planning*, SALT LAKE TRIBUNE (2012).

[370] Sierra Rayne, *80% of Utah Residents Don't Think Humans are Primary Drivers of Climate Change*, AMERICAN THINKER (Jan. 15, 2015, 4:05:13 AM), http://www.americanthinker.com/articles/2015/01/80_of_utah_residents_dont_think_humans_are_primary_drivers_of_climate_change.html.

[371] IMPACTS, ADAPTATION, AND VULNERABILITY, *supra* note 283, at 850.

[372] EASTERLING, *supra* note 245, at 28–29. *See also* Brian Hurd et al., *Relative Regional Vulnerability of Water Resources to Climate Change*, 35 JAWRA 1399, 1400–1408 (2007).

[373] EASTERLING, *supra* note 245, at 3–4. *See also* IMPACTS, ADAPTATION, AND VULNERABILITY, *supra* note 283, at 850.

[374] EASTERLING, *supra* note 245, at 3.

[375] *Id.*

systems would incur without adaptation actions.[376] Exposure monitors the extent of contact between climate-dependent systems and the climate.[377] Finally, a system's ability to respond to changes in climate determines its adaptive capacity.[378]

Wealth, technological availability, and decision-making processes heavily influence the adaptive capacity of a system.[379]

After Utah determines its vulnerability to climate change, it should prioritize its response actions based on the projected and observed impacts of climate change.[380] The IPCC has devised criteria to aid states in identifying the most pressing concerns.[381] When evaluating the impact, Utah should consider the magnitude, timing, reversibility, likelihood, and importance of the potential impact.[382] Assessing Utah's overall vulnerability will help it develop a framework for its climate action plan and determine which problems it must address first.

In the interim, Utah should pursue "no regret" or "co-benefit" options. Utah should pursue these strategies—as opposed to doing nothing—on the basis of the precautionary principle. This principle holds that it is preferable to prevent negative consequences by employing anticipatory responses, rather than react to potentially irreversible impacts and run the risk that nothing needed to be done.[383] "No regrets" and "co-benefit" strategies benefit the state, even if the state ultimately decides against adaptation measures.

For instance, Utah could improve its conservation measures. Indeed, "water conservation is the single most important 'no regrets' strategy for reducing risk from climate change impacts on water resources."[384] The trajectory of Utah's population growth indicates that water demand will exceed supply.[385] The stress on water supply will be exacerbated by long-term changes to Utah's climate.[386] Even assuming, however, that no climate changes occur, conservation measures would still benefit Utah.[387]

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[376] *Id.* at 4.
[377] *Id.*
[378] *Id.*
[379] *Id. See also* Gary Yohe & Richard S.J. Tol, *Indicators for Social and Economic Coping Capacity—Moving Toward a Working Definition of Adaptive Capacity*, 12 GLOBAL ENVTL. CHANGE 25 (2002).
[380] *See* Richardson, *supra* 25, at 19.
[381] *Id.*
[382] *Id.*
[383] Camacho, *supra* note 15, at 19. See also MIND THE GAP page 13
[384] Hall, *supra* note 34, at 264. *See also* EASTERLING, *supra* note 245, at 29.
[385] UTAH DIVISION OF WATER RESOURCES, UTAH'S MUNICIPAL & INDUSTRIAL WATER CONSERVATION PLAN: INVESTING IN THE FUTURE 1 (2014).
[386] *See supra* § II.C.2–3.
[387] *Id. See also* Amy Morsch & Ryan Bartlett, *State Strategies to Plan for and Adapt to*

2. Utah should create its own climate change agency

Institutional changes can advance proactive adaptation.[388] Indeed, it is the institutions that pursue (or neglect) options that will significantly influence the overall vulnerability of a specific region to the impacts of climate change.[389] As a first adaptation measure, it is vital that Utah start to consider climate change in its water planning process.[390]

In order to pursue this goal, Utah should create its own climate advisory panel. This panel would: 1) be responsible for increased watershed science;[391] 2) act as a mediator between different agencies; and 3) be a regulator of decisions that might present a future danger because of climate change.

Because climate change adaptation is a new consideration, Utah would need to redesign existing institutions to incorporate it.[392] Indeed, agencies "are not likely to engage in adaptive management . . .unless required to do so."[393] Modern natural resource governance is often subject to the jurisdiction of multiple agencies.[394] Overlapping jurisdiction has effectively deterred agency action because early actors receive smaller amounts of credit, and those who do nothing receive credit for making changes.[395] "Diluted credit" disincentivizes devoting scare resources to adaptation.[396]

For instance, if a water issue involved multiple state agencies with differing agency missions, "fragmented" responses and "competing credit claims" would ensue.[397] In Utah, the Division of Natural Resources and Department of Environmental Quality include multiple sub-agencies that

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Climate Change, OCT. 2011 DUKE NICHOLAS INSTITUTE FOR ENVIRONMENTAL POLICY SOLUTIONS 1–5.

[388] *See* EASTERLING, *supra* note 245, at 26–29.

[389] IMPACTS, ADAPTATION, AND VULNERABILITY, *supra* note 283, at 842.

[390] *See* Miller, *supra* note 18, at 407 (noting that incorporating climate change into the planning process is a vital first step for climate change adaptation).

[391] *Id.* at 416.

[392] *See* Karassin, *supra* note 239, at 419 ("As adaptation is a relatively new challenge, most existing institutions would require climate proofing or redesigning in ways that facilitate rather than hinder adaptive decisions." (citing Kate Urwin & Andrew Jordan, *Does Public Policy Support or Undermine Climate Change Adaptation? Exploring Policy Interplay Across Different Scales of Governance*, 18 GLOBAL ENVTL. CHANGE, 180 (2008)).

[393] Camacho, *supra* note 15, at 60.

[394] *Id.*

[395] *See id.* at 28 ("Regulators who act early are likely to receive diluted credit as other regulators free ride on their efforts while status quo biases and risk aversion create additional incentives for regulatory inaction." (citing William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1, 5–6 (2003)).

[396] *Id.*

[397] *See* Buzbee, *supra* note 407, at 32–33.

regulate water, including the Division of Water Rights,[398] the Division of Water Resources,[399] the Division of Drinking Water,[400] and the Division of Water Quality.[401] The differing agency missions implicate a level of heterogeneity that can lead to clashing regulatory choices.[402] If an agency produces a regulatory innovation, other agencies can copy said innovation and obtain partial credit.[403] If, however, the innovation is a failure, other agencies have the opportunity to distance themselves from the action.[404] Ultimately, Utah's current water management incentivizes acquiescence by forcing agencies to bear the entirety of the risk while only enjoying diminished credit for innovative regulation regarding climate change.[405]

Further, existing institutions may not have the necessary resources or expertise to pursue certain adaptation options,[406] which could prove a serious drawback given the importance of the issue. Other entities have created new agencies to implement their adaptation strategies and these efforts have largely been successful.[407] For example, the United Kingdom established the United Kingdom Climate Impacts Programme ("UKCIP") in 1997.[408] The climate agency consists of adaptation experts, climate scientists, and communication experts. UKCIP provides information promoting anticipatory adaptation,[409] and in doing so, bridges the boundary

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[398] "Legally, all waters within the state are owned by the State of Utah. The Utah Department of Natural Resources' Division of Water Rights administers a program which grants legal rights for the use of the State's water. The Division also administers rules for the drilling of wells (as does the Division of Drinking Water), licenses well drillers, issues well drilling permits, and conducts a dam safety program.." UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY, http://www.waterquality.utah.gov, (last visited May 3, 2015).

[399] "The Utah Department of Natural Resources' Division of Water Resources is involved with the funding of agricultural and municipal water projects. It also is involved with water resource planning activities for the State." *Id.*

[400] The UDDW works to provide the public a "safe and reliable" drinking water supply. UTAH DIVISION OF DRINKING WATER, http://www.drinkingwater.utah.gov/docs/2014/07Jul/DDW_intro.pdf, (last visited May 3, 2015).

[401] "The Utah Department of Environmental Quality's Division of Water Quality deals primarily with the prevention of water pollution. It has programs to prevent the degradation of the state's rivers, streams, lakes, and reservoirs." UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY, http://www.waterquality.utah.gov, (last visited May 3, 2015).

[402] *See* Buzbee, *supra* note 407, at 32–33.

[403] *Id.*

[404] *Id.*

[405] *Id.* (noting that the "first state regulator might make the usual free riding decision, banking that someone else would take the lead.").

[406] *See* Camacho, *supra* note 15, at 63.

[407] *See* Karassin, *supra* note 239, at 410.

[408] *Id.*

[409] *Id.*

between scientific research and policymaking.[410] UKCIP has improved adaptive capacity building by providing integrated knowledge to organizations taking adaptive measures.[411]

3. Utah should price its water on a sliding scale

Water policies that encourage waste deter the adoption of water-saving strategies.[412] Utah has encouraged waste by having one of the cheapest water rates in the country.[413] The average monthly consumer paid only $37.11 every month—only $1.34 per 1,000 gallons.[414] These rates are 43% lower than the national average, and 45% below those of other western states.[415]

One reason why the rates seem so low is that the cost is partially subsidized by property tax.[416] Overall, property taxes account for approximately 8% of water revenue.[417] Water providers in Utah use property taxes as a stable source of revenue to fund both the construction and maintenance of infrastructure projects.[418] Water conservancy districts take these funds in lieu of monthly consumer fees.[419] For example, the Weber Basin Water Conservancy District used property taxes to pay off its loans for its water project.[420] Rather than charge monthly maintenance fees, the Weber Basin Water Conservancy District collected the fees directly through a property tax.[421]

While the property tax guarantees a steady source of income, as well as reduces the monthly bills of consumers, it distorts the true cost of water.[422] Utah's should alter its water plan so that the price fluctuates with water availability,[423] as opposed to imbedding the cost in property taxes.[424] This

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[410] UKCIP, http://www.ukcip.org.uk/about-us/, (last visited May 3, 2015).
[411] *See* Karassin, *supra* note 2039, at 409.
[412] EASTERLING, *supra* note 245, at 21.
[413] UTAH RIVERS COUNCIL, *supra* note 1215, at 5.
[414] UTAH DIVISION OF NATURAL RESOURCES, THE COST OF WATER IN UTAH: WHY ARE OUR WATER COSTS SO LOW? 3 (2010).
[415] *Id.* at 4.
[416] *Id.* at 15–16.
[417] *Id.* at 15.
[418] *Id.*
[419] *Id.*
[420] *Id.* at 16.
[421] *Id.*
[422] *Id.*
[423] EASTERLING, *supra* note 245, at 21. ("water allocation policies that enable prices to fluctuate with water availability and allow water to be traded among users tend to encourage more efficient use of water. Market-oriented water transfers can provide valuable flexibility in adapting to changes in water scarcity.")

alteration would hold consumers accountable for the amount of water that they use by making the cost more transparent.[425] Consumers are more likely to change patterns of water consumption if they get an actual water bill.[426] If the property tax obscures the cost, consumers will not necessarily make the connection that increased property taxes are the result of their water consumption patterns. If this strategy were pursued, it would provide tremendous flexibility for future drought years, while adjusting market prices to years where water supply is adequate.[427]

Pricing water on a sliding scale would require little initial economic cost. Water prices would remain close to the same (perhaps a little higher to deter waste) because the present adequacy of the water supply. However, water prices would increase during times when the water supply is low in order to decrease demand.[428] As prices form consistent trends, more and more Utahans would pursue conservation measures, such as alternate landscaping or improving irrigation efficiencies.[429] Additionally, encouraging conservation will increase Utah's surplus supply.[430] A surplus water supply can quell future population concerns, or can be sold. Utah can sell water at a premium to states experiencing water troubles, such as California.[431] For purposes of public perception, Utah could posit such an action as a "no regrets" strategy. Accordingly, it would appear more palatable to the polarized constituency of Utah.

This proposal is not, however, devoid of potentially negative consequences. First and foremost, it imposes a burden on a natural resource that is vital to life, making it a difficult policy shift to justify.[432] Moreover, it could also negatively impact the agricultural industry. Even incremental increases in water prices could have significant impacts on the cost of food.[433] Because food will cost more to produce, farmers will have to sell it at higher prices to retain a profit. Ultimately, a sliding-scale water system could have the unintended consequence of pricing Utah farmers out of the national market. As such, it is vital that Utah consider agriculture when

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424 UDNR, *supra* note 426, at 15–16.
425 *See* Utah Taxpayers Association, *Eliminate the Property Tax Subsidy for Water*, 61 THE UTAH TAXPAYER 1–5 (2011).
426 *Id.* at 2.
427 EASTERLING, *supra* note 245, at 21.
428 Utah Taxpayers Association, *supra* note 437, at 2.
429 DWR, *supra* note 8, at 28–30.
430 Utah Taxpayers Association, *supra* note 437, at 2.
431 Sarah Goodyear, *Got Spare Water? You Can Make Millions in California* NEXT CITY (July 7, 2014, 05:47:34 PM), http://nextcity.org/daily/entry/drought-west-california-water-selling.
432 SPRINGER SCIENCE & BUSINESS MEDIA, WATER AND THE FUTURE OF HUMANITY: REVISITING WATER SECURITY 177 (2013).
433 *See* BRAC, *supra* note 79, at 19.

pursuing altering its water pricing to improve its adaptive capacity.

One possible way Utah could address negative agricultural impacts could be to couple higher prices with subsidies for more efficient irrigation technology. Not only would such a measure reduce the economic burden of water costs upon farmers, but it would also enable them to grow more food and offset the increased water costs.

Another possible measure would be to exempt food production from the requirement altogether. Differing prices for farmers and residential users could still decrease waste and simultaneously avoid spikes in food prices. The exemption, however, would render any sliding scale ineffective in an industry that wastes more water than any other.[434]

CONCLUSION

Climate change is happening and it will impact Utah's water supply. The extent of the impact cannot be determined precisely. Despite this unpredictability, Utah should pursue procedural adaptation measures based on the precautionary principle. Enhancing Utah's adaptive capacity is not harmful, but failing to do so could be. An adaptation assessment will aid Utah in identifying vulnerabilities as well as provide it with a framework to prioritize the more significant impacts. Finally, Utah's water price option is an example of a co-benefit strategy that works in tandem with Utah's mitigation strategies. Such synergistic effects take full advantage of Utah's climate change response capabilities and provide the state the flexibility it will need to respond to the future impacts of climate change.

[434] *See* Sophie Wenzlau, *To Combat Scarcity, Increase Water-Use Efficiency in Agriculture*, WORLDWATCH INSTITUTE (March 1, 2013), (claiming that the United Nations Food and Agriculture Organization estimates that 60% of the water diverted or pumped for irrigation is wasted). http://www.worldwatch.org/combat-scarcity-increase-water-use-efficiency-agriculture-0.