2008

Water Marketing as an Adaptive Response to the Threat of Climate Change

Jonathan H. Adler

WATER MARKETING AS AN ADAPTIVE RESPONSE TO THE THREAT OF CLIMATE CHANGE

Jonathan H. Adler[*]

I. INTRODUCTION

Water is essential for human civilization.[1] It can be a wellspring for prosperity and a source of conflict.[2] For the United States and many other nations, ensuring access to quality water supplies is among the most pressing environmental policy challenges of the twenty-first century – and it is a challenge that water institutions are failing to meet.[3] Water use already exceeds the carrying capacity of natural systems in many places and continues to increase.[4] Demographic changes and existing water use patterns have placed tremendous pressures upon water supplies, particularly in the West. In 2003, a majority of states anticipated water shortages over the subsequent decade, even in the absence of drought conditions.[5] Water policy experts contend, without exaggeration, that "the United States is heading toward a water scarcity crisis."[6]

Global climate change will exacerbate pressures on water resources.[7] Although news reports devote more space to the potential threat of rising

---

[*] Professor of Law and Director, Center for Business Law & Regulation, Case Western Reserve University School of Law. The author would like to thank Andrew Morriss and Roger Meiners for their comments and Tai Antoine for her research assistance. All errors or omissions remain those of the author.

[1] *See*, *e.g.*, James L. Huffman, *Water Marketing in Western Prior Appropriation States: A Model for the East*, 21 GA. ST. U L. REV. 429, 431 (2004) ("On the scale of basic biological needs, water no doubt ranks higher than electricity.").

[2] Control over water supplies is a consistent source of friction between states. *See*, *e.g.*, Greg Bluestein, *Drought Has Georgia Revisiting Border Dispute*, WASH. POST, Feb. 10, 2008, at A9, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2008/02/09/AR2008020902283.html (describing boundary and water dispute between Georgia and Tennessee).

[3] The World Health Organization reports four out of ten people worldwide are already impacted by water scarcity. *See* World Health Organization, *10 Facts About Water Scarcity*, Mar. 20, 2007, *available at* http://www.who.int/features/factfiles/water/en/index.html.

[4] TERRY L. ANDERSON & PAMELA SNYDER, WATER MARKETS: PRIMING THE INVISIBLE PUMP 1 (1997) (stating "our water use is depleting and exceeding the limits of natural systems in many parts of the world").

[5] G. Tracy Mehan, III, *Energy, Climate Change, and Sustainable Water Management*, DAILY ENVT. REP., Dec. 4, 2007, at 4.

[6] Robert Glennon, *Water Scarcity, Marketing, and Privatization*, 83 TEX. L. REV. 1873, 1873 (2005). According to Glennon, "our current water use practices are unsustainable, and environmental factors threaten a water supply heavily burdened by increased demand." *Id.*

[7] Kathleen A. Miller, Steven L. Rhodes, & Lawrence J. MacDonnell, *Water Allocation in a Changing Climate: Institutions and Adaptation*, 35 CLIMATIC CHANGE 157, 157 (1997) (stating "global warming may have profound impacts on water resource availability").

sea-levels, for many places "diminished supplies of fresh water may prove a far more serious problem."[8] For the United States in particular, the climatic effect on water is significantly more ominous than that on coastline. Some water officials go so far as to liken the impact of a dramatic decline in water resources to "Armageddon."[9]

Whereas there has been substantial research on the potential effect of climate change upon water resources, there has been relatively little consideration of the role of institutional arrangements in mitigating (or exacerbating) the potential effects of warming-induced changes in water supplies.[10] Climate change increases the urgency with which water managers and policymakers must address water supply concerns, moving toward water supply institutions and policies that are sufficiently flexible, adaptive, and robust to deal with the uncertain water future. As the IPCC has concluded, "changes in water management practices will have a very significant impact on how climate change affects the water sector."[11] There is "great and arguably unavoidable" uncertainty with regard to future climate change and other potential impact on water supplies, including changes in population and relevant technologies.[12] More efficient water distribution and allocation institutions are necessary. The inefficiencies inherent in existing water institutions are a luxury we can no longer afford.

This article argues that climate change, and its projected effects on water use and supply, calls for a fundamental reexamination of water institutions. The United Nations Intergovernmental Panel On Climate Change (IPCC) has noted that there are numerous policy options that "would generate net social benefits regardless of whether there was a climate change."[13] Examples of such "no regrets" policies would include the elimination of irrigation and development subsidies that artificially increase water demand, as well as the incorporation of environmental values into existing water institutions.[14] This article suggests that the gradual

---

[8] Jon Gertner, *The Future Is Drying Up*, N.Y. TIMES MAG., Oct. 21, 2007, *available at* 2007 WLNR 20645374.

[9] *Id*.

[10] Miller, Rhodes & MacDonnell, *supra* note 7, at 157 (Researchers "have given less attention to the role of institutional factors in determining the efficacy of alternative response strategies.").

[11] CLIMATE CHANGE 2001: IMPACTS, ADAPTATION AND VULNERABILITY – CONTRIBUTION OF WORKING GROUP II TO THE THIRD ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 197 (James J. McCarthy, et al. eds., 2001) [hereinafter CLIMATE CHANGE 2001: WGII].

[12] Stacy K. Tanaka, et al., *Climate Warming and Water Management Adaptation for California*, 76 CLIMATIC CHANGE 361, 367 (2006); *see also* Miller, Rhodes & MacDonnell, *supra* note 7 at 159 ("we must now accommodate competing water demands within the context of increasing hydrologic uncertainty.").

[13] CLIMATE CHANGE 2001: WGII, *supra* note 11, at 219-21.

[14] *Id.* at 221.

implementation of water markets is also such a "no regrets" policy.[15] Many aspects of water markets, including their flexibility, decentralized nature, and ability to create and harness economic incentives, make them particularly well suited to address the uncertain water forecast. A gradual shift toward water marketing and market pricing will improve the management of water supplies, ensure more efficient allocation of available water supplies, and encourage cost-effective conservation measures.

Part II of this article provides a brief overview of current climate change projections and their expected impact on water supplies and use patterns. That climate change will have an effect on water availability is quite certain. Yet, the precise outcome of such effects is uncertain. Indeed, the ultimate effect of climate change on water resources is essentially unpredictable. This uncertainty increases the need for water institutions that are flexible and capable of responding to unanticipated changes in water supplies and demands.

Part III explains why water markets are an appropriate institutional response to the particular challenges posed by climate change. Water markets have substantial benefits over traditional, centralized planning and administration, including their flexibility and utilization of decentralized information. Market-based pricing of water provides additional benefits, including the creation of incentives for increased efficiency and conservation. In short, there is a particularly good match between the primary virtues of water markets and the demands placed on water institutions by the prospect of climate change.

Part IV of the article offers some preliminary thoughts on how to manage the transition to market institutions for water. Like all institutional arrangements, water markets are not perfect. Further, there are political and administrative obstacles that could impede a move toward greater reliance on markets for the allocation and pricing of water. Nonetheless, as this section discusses, water markets have been used to manage water quite effectively in many parts of the world, and could help mitigate the negative impact of global climate change on water supplies.

II. CLIMATE CHANGE AND THE THREAT OF WATER SCARCITY

Extensive scientific research suggests human activity is having a demonstrable effect on the global climate system.[16] The anthropogenic

---

[15] The IPCC has also noted the potential value of water markets and tradeable water rights in addressing climate change-induced water scarcity. *See, e.g.*, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY – CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 191-92 (Martin Parry, et al., eds. 2007) [hereinafter CLIMATE CHANGE 2007: WGII].

[16] *See* William Collins, et al., *The Physical Science Behind Climate Change*, SCI. AMER. 68 (Aug. 2007) (noting that the 2007 IPCC report concluded it was "very likely" that

emission of carbon dioxide and other greenhouse gases is contributing to a gradual, but increasingly perceptible, increase in global mean temperatures that is expected to continue over the next century.[17] The precise nature and degree of the human contribution is unknown, and may even be unknowable given the complexity of the global climate system. Nonetheless, even if there was a sizable chance that human activity is having little impact in comparison to natural fluctuations, the probability of a significant human impact on the climate system is more than sufficient to warrant policymakers' attention.

If climatic projections are correct, some amount of anthropogenic warming is almost certainly inevitable.[18] The accumulation of greenhouse gases in the atmosphere over the past several decades has ensured some degree of warming over the coming century.[19] Political leaders have considered and debated various emission control policies for decades at the national and international level. Yet an enforceable global, emission-control regime remains elusive.[20] Even if such a regime was put in place, it is exceedingly unlikely that it would impose emission controls or other measures sufficient to result in a significant reduction of projected warming.[21] Policymakers must prepare to deal with the consequences of a future greenhouse warming today.

Adaptation to an inevitable warming of the climate and its consequent effects must be a key element of any meaningful climate change policy. Whereas emission controls and other mitigation measures will not

---

human activity was responsible for most of late twentieth century warming, whereas the 2001 IPCC report concluded that human responsibility was only "likely").

17 *See id.*, at 65 ("Over the past 20 years, evidence that humans are affecting the climate has accumulated inexorably, and with it has come ever greater certainty across the scientific community in the reality of recent climate change and the potential for much greater change in the future."). *See also* CLIMATE CHANGE 2007: WGII, *supra* note 15.

18 *See* Collins et al., *supra* note 16, at 71 (noting that some degree of warming is unavoidable due to past and present emissions).

19 Roger Pielke, Jr., et al., *Lifting the Taboo on Adaptation*, 445 NATURE 597, 597 (2007) (noting some amount of climate change due to antropogenic emissions is "unavoidable").

20 *See* Juliet Eilprin, *Climate Change Compromise Plan Offered in Bali*, WASH. POST, Dec. 15, 2007, at A17.

21 *See* Pielke et al., *supra* note 19, at 597 ("Whatever actions ultimately lead to the decarbonization of the global energy system, it will be many decades before they have a discernible effect on the climate."). *See also* T.M.L. Wigley, *The Kyoto Protocol: CO2, CH4 and Climate Implications*, 25 GEOPHYSICAL RESEARCH LETTERS 2285 (1998) (documenting the marginal impact on future climate projections of the emission reductions required under the Kyoto Protocol).

Even if dramatic emission reductions and other mitigation measures (such as carbon sequestration) could prevent a significant amount of anthropogenic warming over the coming decades, it is not clear that such policies would be desirable in comparison to other alternatives. If emission reductions do not generate benefits in terms of climate risk reduction that are greater than the costs of such reductions and that compare favorably to alternative policy measures, such as adaptation to potential climate changes, they may be a poor policy investment.

produce meaningful results for decades, adaptation has the potential to reduce the impacts of climatic warming and increase societal resiliency in the near term.[22] As former Environmental Protection Agency official G. Tracy Mehan notes, "Adaptation offers immediate, tangible, cost-effective, and, therefore, politically viable methods of coping with climate change."[23]

Many potential adaptive measures would have the added benefit of mitigating existing environmental concerns. In many instances, "vulnerability to climate-related impacts on society are increasing for reasons that have nothing to do with greenhouse gas emissions, such as rapid population growth along coasts and in areas with limited water supplies."[24] Even if the threat of future warming is reduced, existing demographic changes could nonetheless *increase* the costs of climate change in some regions due to its effect on water supplies. Overstretched fresh water supplies, like many other potential impacts from climate change, are *already* a concern.[25] The marginal effects of climate change are only marginal increases on what may already be large costs.[26]

If the precise nature, scope, and timing of global warming over the next century remain somewhat uncertain, the consequent effects of such warming are even more so. Modeling anticipated changes in the climate due to increased contributions of greenhouse gases is immensely difficult, and is dependent upon many assumptions of varying reliability.[27] Identifying specific terrestrial effects from such model results is even more difficult. Another source of uncertainty is the "scale mismatch" between existing climate models and hydrological models.[28]

While there is substantial uncertainty about the details of the impact of climate change on water resources, such uncertainty does not extend to the likelihood of such changes.[29] As the world warms, rising temperatures and

---

22 Gwyn Prins & Steve Rayner, *Time to Ditch Kyoto*, 449 NATURE 973, 975 (2007).

> Current emissions reductions will mainly benefit future generations, whereas the momentum already in the climate system drives the near-term. Faced with imminent warming, adaptation has a faster response time, a closer coupling with innovation and incentive structures, and thereby confers more protection more quickly to more people.

23 G. Tracy Mehan, III, *Energy, Climate Change, and Sustainable Water Management*, DAILY ENVT. REP., Dec. 4, 2007, at 4. Mehan is quick to add the qualification that "This is not the same thing as saying it will be easy."

24 Pielke, et al., *supra* note 19, at 597.

25 *See id.* at 598.

26 *See id*. at 597.

27 S. Vicuna & J.A. Dracup, *The Evolution of Climate Change Impact Studies on Hydrology and Water Resources in California*, 82 CLIMATIC CHANGE 327, 335 (2007) (stating that "[o]ne major limitation to using GCM output data is that the spatial and temporal resolution does not match the resolution needed for hydrologic models.").

28 CLIMATE CHANGE 2001: WGII, *supra* note 11 at 196.

29 *See* CLIMATE CHANGE 2007: WGII, *supra* note 15, at 181 (stating that "[u]ncertainties in climate change impacts on water resources are mainly due to the

changes in precipitation patterns will impact water resources. "The most dominant climatic drivers for water availability are precipitation, temperature, and evaporative demand," all of which will be influenced by greenhouse warming.[30] According to the IPCC's 2001 report, "Available evidence suggests that global warming may lead to substantial changes in mean annual streamflows, seasonal distributions of flows, and the probabilities of extreme high- or low-flow conditions."[31]

The largest effect climate change will have on water resources is likely to result from a shift in the timing, location and amount of precipitation.[32] Different amounts of rain and snow at different times in different places could prove disruptive for many human and ecological communities. A projected warming of the climate will also produce changes in rates of evaporation, snowmelt, and soil moisture, with consequent effects on river flow and groundwater. As the 2007 IPCC report concluded, "A very robust finding of hydrological impact studies is that warming leads to changes in the seasonality of river flows where much winter precipitation currently falls as snow."[33] Even if climate change were not to alter the volume of precipitation in a local area, it would still "increase the variance of water flows."[34] In short, "The prospect of climate change . . . creates considerable uncertainty regarding future water availability."[35]

At the regional scale, the nature and extent of these effects are particularly uncertain.[36] While climate models are reasonably consistent in their temperature projections, there is "greater variability" in their precipitation projections.[37] Existing climate models do not generate consistent projections about "the direction and magnitude of change in average annual precipitation" in specific areas.[38] According to the IPCC's 2001 Working Group II Report, "Changes in precipitation are highly uncertain. There is little agreement across climate scenarios regarding changes in total annual runoff across North America."[39] Likely changes include seasonal shifts in snowmelt and runoff, and a reduction in summer

---

uncertainty in precipitation inputs and less due to the uncertainties in greenhouse gas emissions, in climate sensitivities, or in hydrological models themselves" (citations omitted)).

30 *Id.* at 180.

31 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 745 (citations omitted).

32 CLIMATE CHANGE 2007: WGII, *supra* note 15, at 180 ("A robust finding is that precipitation variability will increase in the future.").

33 *Id*. at 183.

34 Anthony C. Fisher & Santiago J. Rubio, *Adjusting to Climate Change: Implications of Increased Variability and Asymmetric Adjustment Costs for Investment in Water Reserves*, 34 J. ENVTL. ECON. & MGMT. 207, 208, (1997).

35 Miller, Rhodes & MacDonnell, *supra* note 7, at 166.

36 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 745 (stating that "[h]ydrological cannot yet be forecast reliably at a watershed scale").

37 Vicuna & Dracup, *supra* note 27, at 335.

38 E. Elgaali, et al., *High Resolution Modeling of the Regional Impacts of Climate Change on Irrigation Water Demand*, 84 CLIMATIC CHANGE 441, 448 (2007).

39 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 737.

water flows.[40] For instance, the IPCC reports "high confidence" in predictions that warming "will very likely lead to earlier melting and significant reductions in snowpack in the western mountains" of North America.[41] The 2007 assessment also reported that "[f]reshwater resources will be affected by climate change across Canada and the U.S., but the nature of the vulnerabilities varies from region to region."[42] A warmer climate will also increase "the water-holding capacity of the atmosphere and evaporation into the atmosphere," which is likely to produce greater climate variability.[43] This, in turn, is likely to produce "more intense precipitation and more droughts."[44] As one recent review summarized: "Climate change will affect not only initial surface runoff into a stream system, but also rates of evaporative loss, seepage to groundwater aquifers, recharge from those aquifers and rates of consumptive use from irrigation withdrawals along the entire stream system."[45]

Some changes have already been observed, though the direct link to anthropogenic warming may be difficult to demonstrate. Non-climatic drivers of change in water systems remain greater than climate-related changes.[46] Nonetheless, the IPCC's 2007 report concluded that "there is evidence of a broadly coherent pattern of change in annual runoff" and "abundant evidence" of changes in seasonal snow cover and a reduction in the timing and volume of resulting runoff in North America.[47] It is too early to identify the timing and extent of such changes with any precision. At this point, however, seasonal changes in runoff are easier to predict than changes in annual runoff or the regional distribution of such changes.[48] A reduction in snow accumulation periods, for example, seems particularly likely.[49] As one recent study noted, the most significant and predictable impact of a modest warming "would be a large reduction in mountain snowpack and a commensurate reduction in natural water storage."[50]

Climatic effects on water resources will vary from place to place. Recent reviews of river flow trends in the United States have found significant trends in almost thirteen percent of river catchments, with as

---

40 *Id*.

41 CLIMATE CHANGE 2007: WGII, *supra* note 15, at 627.

42 *Id*.

43 *Id*. at 176.

44 *Id.*

45 Miller, Rhodes & MacDonnell, *supra* note 7, at 167.

46 CLIMATE CHANGE 2007: WGII, *supra* note 15, at 176.

47 *Id*. at 90.

48 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 745 ("In general, there is greater confidence in projections of seasonal shifts in runoff and related hydrological characteristics than there is in projections of changes in annual runoff. Regional patterns of precipitation change are highly uncertain.").

49 *Id*. at 745 ("Projections of shorter snow accumulation appear to be more robust.").

50 Tim Barnett, et al., *The Effects of Climate Change on Water Resources in the West: Introduction and Overview*, 62 CLIMATIC CHANGE 1, 6 (2004).

many experiencing increased river flow as are experiencing decreased river flows.[51] Some regions will also be more sensitive to climatic changes than others. Arid and semi-arid portions of the United States, for example, "will be particularly sensitive to any changes in temperature and precipitation," particularly when compared to other regions.[52] At present, most climate models project a reduction in precipitation in the southwest United States.[53]

Global warming's effects on water supplies will be compounded by changes in water demand for various uses as communities adapt to changing temperatures and precipitation patterns.[54] For example, warmer, drier weather that results in increased evaporation will have an effect on weather-sensitive water uses.[55] Water use for irrigation, for example, is likely to increase along with global temperatures, unless temperature increases are offset by increases in precipitation.[56] This is significant because irrigation is responsible for a majority of consumptive water use.[57]

Despite the various uncertainties, one conclusion of recent analyses is that "even with a conservative climate model, *current* demands on water resources in many parts of the West will not be met under plausible future climate conditions, much less the demands of a larger population and a larger economy."[58] According to some model estimates, the American West could be faced with a thirty to seventy percent decline in snowpack by the latter part of the twenty-first century.[59] Yet "even if there were no change in the variability of precipitation, global warming could be expected to increase the variance of water flows," due to effects on snowpack melt and other factors.[60]

Significantly, climatic effects on water supplies will occur against a background of increasing water scarcity throughout much of the nation, and

---

51 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 201, tbl.4-1.

52 *Id*. at 745.

53 *Western Water Resources in a Changing Climate: Hearing Before the Senate Comm. on Energy and Natural Resources, Subcomm. on Water and Power* 110th Cong. (2007) (testimony of Philip W. Mote, Ph.D., Climate Impacts Group, University of Washington, Seattle) *available at* http://www.energy.senate.gov/public/_files/MoteTestimony.pdf.

54 Noah D. Hall, Bret B. Stuntz, & Robert H. Abrams, *Climate Change and Freshwater Resources***,** 22 NAT. RES. & ENV'T (2008) ("The potential for increased demand due to higher temperatures comes from all types of water use. Domestic use, especially for outdoor purposes (such as yard and garden irrigation) is expected to rise with warming temperatures. Industrial use may increase as well. Water is used for cooling on many electrical generating systems. An increase in water temperature would decrease the cooling efficiency of the water and require more water to be used. Similarly, demand for water will increase to compensate for loss of precipitation in many areas.").

55 *See* John J. Boland, *Assessing Urban Water Use and the Role of Water Conservation Measures Under Climate Uncertainty*, 37 CLIMATIC CHANGE 157, 157 (1997).

56 CLIMATE CHANGE 2007: WGII, *supra* note 15, at 179.

57 *Id*.

58 Barnett et al., *supra* note 50, at 6 (emphasis in original).

59 Gertner, *supra* note 8, at 70.

60 Fisher & Rubio, *supra* note 34, at 208.

particularly in the west where urban growth is fueling dramatic increases in water demand.[61] Domestic water use in western states more than doubled from 1960 to 1990, from 6.5 million acre-feet to 14 million acre-feet, and continues to climb.[62] Per capita water consumption increased throughout the twenty-first century, despite increased awareness of pressures on water supplies.[63] As populations continue to grow in western states, demand for water will only increase. Further, demand for instream flows and other water uses is also increasing, while traditional means of augmenting water supply through dams, reservoirs, and the like have reached their limits. Without substantial reforms, existing water institutions will have difficulty meeting *existing* demands on water resources, let alone the increased demands brought about by climate change.

III. THE POWER OF WATER MARKETS

Climate change presents a dilemma for water management. The gradual warming of the atmosphere is certain to change the distribution and availability of water supplies. Yet the precise nature, magnitude, timing, and distribution of such changes are unknown. This uncertainty complicates the task of water managers who are already faced with escalating demands. “It is no longer appropriate to assume that past hydrological conditions will continue into the future (the traditional assumption) and, due to climate change uncertainty, managers can no longer have confidence in single projections of the future.”[64] One way to manage “the uncertainty associated with estimates of future climate change is to adopt management measures that are robust to uncertainty.”[65]

The climate challenge requires the creation of institutional arrangements that can foster greater resilience and adaptability in water management. As the IPCC has observed, “The institutions that govern water allocation will play a large role in determining the overall social impacts of a change in water availability, as well as the distribution of gains and losses across different sectors of society.”[66] Existing water management institutions are already pressed to their limits. There is little question that “current water law and policy are not up to the new challenges of climate change and

---

[61] A. Dan Tarlock & Sarah B. Can de Wetering, *Western Growth and Sustainable Water Use: If There Are No “Natural Limits” Should We Worry about Water Supplies?*, 27 PUB. LAND & RESOURCES L. REV. 33, 38 (2006) (noting the “projected gap” between urban water demands and existing water supplies).

[62] Nicole L. Johnson, *Property Without Possession*, 24 YALE J. ON REG. 205, 206 (2007).

[63] *See* Indur M. Goklany, *Comparing 20th-Century Trends in U.S. and Global Agricultural Water and Land Use, in* THE WATER REVOLUTION: PRACTICAL SOLUTIONS TO WATER SCARCITY 25 (Kendra Okonski ed. 2006).

[64] CLIMATE CHANGE 2007: WGII, *supra* note 15, at 199.

[65] *Id.* at 200.

[66] *Id.* at 191.

resulting pressures on freshwater resources."[67] Indeed, "even with a conservative climate model, *current* demands on water resources in many parts of the West will not be met under plausible future climate conditions, much less the demands of a larger population and a larger economy."[68] Effective institutions must be robust enough to accommodate changes in water availability by facilitating reallocation of water supplies, while encouraging cost-effective conservation measures and efficiency enhancements and remaining sufficiently flexible and adaptable to account for the uncertain climate forecast.

The demands of current and projected water management challenges can best be met through a greater reliance on water markets for water management. As Professor Thompson concludes, "As competing demands for our limited water supplies grow, and as the possibility of global warming threatens to increase our water supplies' year-to-year variability, the need for robust water markets will increase."[69] Specifically, water management must shift toward recognition of transferable rights in water that facilitate voluntary exchanges and the market pricing of water resources. While such reforms may be difficult, and there are no panaceas for the water management challenges faced by the western United States, greater use of water markets offers the best opportunity to adapt to climate change and its impacts on water supplies. Even the IPCC acknowledges that "improving the functioning of water markets could help create the kind of flexibility needed to respond to uncertain changes in future water availability."[70]

Markets are powerful institutions for resource allocation. They facilitate the allocation of resources to their highest value use through voluntary exchange and the generation of information about relative scarcity and demand. "The invisible hand of the marketplace is demonstrably far more efficient in the allocation of scarce resources, in the sense of maximizing net social welfare, than the invisible hand of politics." [71] Unlike administrative allocation methods, water markets provide for the compensation of those who "lose" from the transfer of water resources. Markets take advantage of localized and dispersed information about resource supplies and demands, including subjective valuations and individualized uses for different resources in different places. Such information is virtually impossible to centralize in an administrative agency. Markets allow for the reallocation of risk to those who are best able to bear the risk of uncertainty.

67 Hall, Stuntz, & Abrams, *supra* note 54.

68 Barnett, et al., *supra* note 50, at 6.

69 Barton H. Thompson, Jr., *Water Markets and The Problem of Shifting Paradigms*, *in* WATER MARKETING – THE NEXT GENERATION 1, 24 (Terry L. Anderson & Peter J. Hill eds., 1997).

70 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 748.

71 *See* Huffman, *supra* note 1, at 432.

While it should be reiterated that markets are not perfect – no human institutions are without flaws – markets provide a superior institutional framework for addressing the water management problems global climate change will create. Markets are essential for the efficient allocation and distribution of many physical resources. While water marketing presents some challenges, they are not insuperable. Indeed, "the efficacy of markets for averting resource shortages is no better demonstrated than with water."[72]

A. Market Foundations

Water markets have been used in many parts of the world for the allocation and distribution of rights in water.[73] In the United States, for instance, water markets emerged in many western states as an outgrowth of the prior appropriation doctrine, which recognized property rights in water.[74] These rights are usufructary rights – that is rights to *use* water, rather than rights to the water itself. "Water rights are usufructary not because water is special or because the public has a particular interest in water but because the physical nature of water is unique."[75] This may make water markets "more complex than markets for other resources," and may increase transaction costs for water transfers.[76] Nonetheless, water rights can be widely transferable, almost like most any other marketplace good.[77] However limited existing water rights in the U.S. may be, the overall volume of water transfers is quite substantial and is increasing over time.[78] "Efficiency gains from tradable water rights appear to be significant."[79] Indeed, by some estimates, the net welfare gains from water markets exceed the value of the water rights themselves.[80]

---

[72] Terry L. Anderson & Peter J. Hill, *Introduction: Taking the Plunge*, *in* WATER MARKETING – THE NEXT GENERATION xi, xi (Terry L. Anderson & Peter J. Hill eds., 1997).

[73] For a summary, *see* Paul Holden & Mateen Thobani, *Tradable Water Rights: A Property Rights Approach to Resolving Water Shortages and Promoting Investment* (World Bank Policy Research Working Paper No. 1627, July 1996), *available at* http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/1996/07/01/000009265_3961214131318/Rendered/PDF/multi_page.pdf.

[74] *See* Andrew P. Morriss, *Lessons from the Development of Western Water Law for Emerging Water Markets: Common Law vs. Central Planning*, 80 OR. L. REV. 861 (2001) (tracing the development of water rights under the common law).

[75] Huffman, *supra* note 1, at 439.

[76] *See* Jedidiah Brewer et al., *Water Markets in the West: Prices, Trading and Contractual Forms*, Arizona Legal Studies Disc. Paper No. 07-07 (Feb. 2007), at 3.

[77] In most U.S. jurisdictions, there are regulatory, administrative or other legal restraints on water rights, such as requirements that diversions of surface water be in the "public interest." *See* Jedidiah Brewer et al., *Transferring Water in the American West: 1987-2005*, 40 U. MICH. J.L. REFORM 1021, 1026 (2007).

[78] *See* Brewer et al., *supra* note 77, at 1042; Brewer et al., *supra* note 76, at 3.

[79] Marian L. Weber, *Markets for Water Rights Under Environmental Constraints*, 42 J. ENVTL. ECON. & MGMT. 53, (2001).

[80] Andrew Morriss, *Real People, Real Resources, and Real Choices: The Case for Market Valuation of Water*, TEX. TECH L. REV. 973, 982 (2006).

To be most effective, water rights must be well-defined, enforceable, and transferable.[81] The precise contours and content of the rights can vary, however. Water rights can be defined in terms of actual water volume, a share of a given water body or water flow, or in terms of the availability of water of a particular quantity at a given place.[82] Water rights can also be consumptive or non-consumptive, and may or may not be held subject to the rights of third parties or other water right holders.

Water markets do not only consist of outright sales of water rights. As water markets evolve over time, potential buyers and sellers develop contracts and instruments to address specific demands and needs. While outright transfers of water rights occur, so do various short-term and long-term leases, "sale-leasebacks,"[83] and option contracts. Where state law authorizes the purchase or lease of instream water flows, conservation organizations have negotiated innovative deals with water rights owners in order to enhance the habitat value of rivers and streams.[84] As the IPCC observed, "Where feasible, short-term transfers can provide flexibility and increased security for highly valued water uses such as urban supply, and in some circumstances may prove more beneficial than constructing additional storage reservoirs."[85]

As with property rights in any other saleable good or commodity, water rights are the foundation for water markets and can provide substantial incentives for increased efficiency and allocation of rights to their highest valued use. "Waste generally rears its ugly head where a transfer of resources is not permitted."[86] Where an individual is using a transferable resource in an inefficient or wasteful manner, there is an opportunity for an entrepreneur to gain from acquiring the resource and putting it to better use. Where rights to water are transferable, water prices will reflect the value of alternative uses. This gives the rights holder an incentive to allocate the water to its highest

---

81 ANDERSON & SNYDER, *supra* note 4, at 23; *see also* Brewer et al., *supra* note 77, at 1024 ("Most economists agree that an efficient system of property rights requires three elements: a complete definition; exclusivity; and transferability."); RICHARD L. STROUP, ECONOMICS: WHAT EVERYONE SHOULD KNOW ABOUT ECONOMICS AND THE ENVIRONMENT 18-20 (2003).

82 *See* Holden & Thobani, *supra* note 73, at 2.

83 As described by Anderson and Snyder, a "sale-leaseback" involves "purchase of land and water rights followed by lease of the land and water rights back to the sellers." ANDERSON & SNYDER, *supra* note 4, at 103-04. Such contracts can be used to keep agricultural land in production after the sale of land and adjoining water rights.

84 *See* Janet C. Neuman, *The Good, The Bad, and the Ugly: The First Ten Years of the Oregon Water Trust*, 83 NEB. L. REV. 432, 440 (2004) ("The Trust has developed a number of innovative market devices that go beyond outright water rights purchases to create transactions that work in varying circumstances with diverse water users.").

85 CLIMATE CHANGE 2007: WGII, *supra* note 15, at 198.

86 Andrew Morriss et al., *Principles for Water*, 15 TUL. ENVTL. L.J. 335, 343 (2002).

valued use.[87] Transferability also creates substantial incentives for conservation, particularly insofar as rights holders can sell the water they conserve to other users.[88] Such incentives can be quite powerful, particularly given the wide disparity between the prices agricultural users and others pay for water in the United States.

Many agricultural users pay little for the water they use, sometimes nothing more than the cost of pumping the water from a federal irrigation project to the land where the water will be used.[89] The U.S. government has subsidized agricultural water use for decades, encouraging profligate and wasteful water use in irrigation. Combined with the fact that property rights in land have been more well-defined and defended than rights in water, farmers have more incentive to improve the efficiency of land use than to focus on efficient water use, and to use water or irrigated land as a substitute for dry land in the production of crops.[90] Between 1910 and 2000, the amount of crop land in the United States declined by three percent, despite increased food demand, due to increases in per acre productivity.[91] At the same time, water withdrawals for irrigation increased 251 percent and the amount of irrigated land increased by over 350 percent.[92] In short, this period saw dramatic increases in agricultural land-use productivity, while water-use productivity stagnated.[93]

Simply allowing farmers to sell their water rights to "thirsty cities" would provide substantial incentives to increase water use efficiency in the agricultural sector.[94] The result is a win-win situation: the farmer receives payment for giving up water rights that he no longer needs and the "thirsty city" gets water that it would otherwise not have (or need to pay even more to obtain). The possibility of a voluntary transaction increases efficiency and produces gains for buyer and seller alike. The potential for such transfers is quite large: "It is estimated that 80 percent of consumptive use (CU) of water in the arid west of the United States is from agriculture, and irrigated land increased from 3.5 million acres in 1950 to 15 million acres in 1990 . . . ."[95] Further, "[i]n the western USA, water-market transactions and other

---

[87] *See* Holden & Thobani, *supra* note 73, at 11 ("Tradable water rights allow the price of water to reflect the value of its alternative uses, which creates incentives to put it to the most productive use.").

[88] Morriss, et al., *supra* note 86, at 336 ("Water markets create incentives for conservation by offering water rights holders the potential to sell the water they conserve.").

[89] Jedidiah Brewer, Robert Glennon, Alan Ker, & Gary Libecap, *Water Markets in the West: Prices, Trading and Contractual Forms* (Feb. 2007) (unpublished discussion paper, filed as no. 07-07 with the Arizona Legal Studies Department).

[90] Indur M. Goklany, *Comparing 20th Century Trends in U.S. and Global Agricultural Water and Land Use*, 27 WATER INTL. 321 (2002), *available at* http://members.cox.net/igoklany/Water%20International%202002.pdf.

[91] *Id.* at 321-22.

[92] *Id.* at 322.

[93] *Id.* at 325-26.

[94] Brewer, et al., *supra* note 77, at 1022-23.

[95] Elgaali et al., *supra* note 38, at 442.

negotiated transfers of water from agricultural to urban or environmental uses are increasingly being used to accommodate long-term changes in demand (e.g. due to population growth) as well as short-term needs arising from drought emergencies."[96] This would provide significant benefits in the context of climate change. As the IPCC itself has noted:

> If water supplies decline in particular locations or seasons, water markets could soften the impacts by moving water from lower to higher valued uses. In the western United States, where irrigation now accounts for more than 80% of consumptive water use, water market activity is likely to continue the current trend of movement of water out of irrigated agriculture to accommodate other water uses.[97]

With water markets, buyers and sellers of water rights get to determine what water is worth to them, and make decisions about whether to engage in voluntary transfers accordingly. Where transfers occur, it is because a buyer values the water more than the seller. Thus, water transfers reallocate water rights from lower value uses to higher value uses, producing a more efficient allocation of the resource. Insofar as some users, or would-be water users, hold particularly idiosyncratic value preferences, these are also incorporated into the price, as water rights are only transferred when both buyer and seller agree.

B. Prices and Information

Prices are an essential component of working markets.[98] Price signals and the potential to profit from differences in valuation provide powerful incentives for innovation. Those who uncover ways to facilitate trades or increase efficiency can profit from such discoveries. Price signals provide powerful incentives for conservation while simultaneously communicating information about collective judgments about the relative scarcity of resources across time and space.

Prices enable markets to operate as a powerful coordination mechanism. Prices communicate information about the relative scarcity of goods and services in various places, and the valuation placed upon the good for current and alternative uses.[99] As market conditions fluctuate, market prices change accordingly. As environmental economist Richard Stroup explains, "market prices adjust constantly to all of the supply and demand variables, providing each buyer and each seller with up-to-date information

---

96 CLIMATE CHANGE 2007: WGII, *supra* note 15, at 198.

97 *Id.* at 748.

98 *See generally* STROUP, *supra* note 81, at 27-29.

99 Morriss, *supra* note 80, at 979 ("When we observe a market price, we have a remarkably compact source of fairly dense information.").

on changes in relative values in the world around them."[100] This function is performed in a hyper-efficient manner, particularly in comparison to administrative mechanisms that seek to measure relative scarcity, and enables market participants to take account of changing market conditions without specific knowledge about such conditions. Such information is communicated in the market price.

Through the price system, markets incorporate and account for far more information than centralized administrative entities, and at far less cost.[101] This is important because information is both extremely valuable, and quite costly to uncover and accumulate.[102] "By conveying the alternative valuations of resources, prices enable market actors to compare their present use of a resource to the potential use others might make of it without knowing the details of those potential uses."[103] Accumulating and processing the same volume of information through an administrative process would be exceedingly costly, and would be difficult (if not impossible) to achieve in as timely a fashion.

A regulatory system that seeks to limit the amount of water used for various purposes to "appropriate" amounts would require the collection and consideration of myriad amounts of information concerning the relevant information about how water is and could be used within various industries in different places and at different times. Such efforts rarely succeed as planned because centralized decision-makers are not able to collect and process a sufficient volume of information.[104] An adaptive system, such as is required to respond adequately to the threat of climate change, is even more information intensive.[105] A market system, in which users pay for the resource that they use, enables individual water users to weigh the trade-off between the cost of obtaining additional water, the cost of reducing or conserving water use, and other relevant factors. Such decentralized approaches may sacrifice the potential for "expert" centralized water management, but they make greater use of specialized knowledge about individual circumstances and preferences.[106] As Professor Andrew Morriss

---

[100] STROUP, *supra* note 81, at 27; *see also* Morriss, *supra* note 80, at 988 ("Market prices respond to events quickly, sending market participants signals about the impact of events on the goods and services sold in markets.").

[101] Morriss et al., *supra* note 86, at 358 ("The information requirements for markets are significantly lower than for administrative allocations because markets are able to rely upon price signals.").

[102] *See* STROUP, *supra* note 81, at 11-12; Morriss et al., *supra* note 86, at 337 ("Information is costly to acquire and to process. All else equal, therefore, a solution that requires more information is more costly than one that requires less.").

[103] Morriss, et al., *supra* note 86, at 358.

[104] This is the insight of Nobel Laureate economist Friedrich Hayek. *See, e.g.*, F. A. Hayek, *The Use of Knowledge in Society*, 35 AMER. ECON. REV. 519 (1945).

[105] Denise Lach, Helen Ingram, & Steve Rayner, *Maintaining the Status Quo: How Institutional Norms and Practices Create Conservative Water Organizations*, 83 TEX. L. REV. 2027, 2048-2049 (2005).

[106] *See generally*, Morriss, *supra* note 86, at 338.

observes, "it is markets' connection with real choices, made by real people with real consequences for the people making the choices that enables markets to value resources, including water, in a fashion that leads to better outcomes than the alternatives."[107]

When unforeseen events alter resource supply and demand, prices quickly shift to account for the relevant changes. In this fashion, market institutions "encourage individuals to adapt to changed circumstances."[108] Markets also quickly incorporate – and market prices reflect – changing values and increased knowledge about a particular resource. If a new technology increases or decreases demand for the resource in question, prices will respond as individual buyers and sellers begin to take account of this new development.

C. Prices and Efficiency

Another reason to rely upon market pricing for water is that it will encourage consumers to use water more efficiently. The use of price mechanisms, such as drought demand rates, can "enhance the efficiency of water resource allocation among customers."[109] Price-related measures that can encourage greater conservation include excess surcharges, drought demand rates, variable seasonal rates and time of use rates.[110]

While potentially more effective than other demand control measures, use of market prices is not always politically popular, and political authorities are often responsible for making retail-level water pricing decisions.[111] Water is heavily subsidized throughout the United States, particularly in the agricultural sector, which accounts for the vast majority of western water use. As a general matter, water prices are below prices that would prevail in competitive markets.[112] As Professor Glennon laments, "the price of water in the United States is ridiculously low."[113] In some cities, there is little charge for water, and water use is not even measured.[114] Even

---

[107] Morriss, supra note 80, at 974.

[108] *Id.* at 988.

[109] Williams James Smith, Jr. & Young-Doo Wang, *Conservation Rates: The Best 'New' Source of Urban Water During Drought*, WATER & ENV'T J. (2007) (OnlineEarly Articles), at 9.

[110] *Id.* at 2.

[111] Mehan, *supra* note 5, at 2 ("Full-cost pricing is a hard goal to obtain given that most of America's water and wastewater utilities are publicly owned; and any decision on water rates is, of necessity, a political decision – often a controversial one.").

[112] Sheila M. Olmstead, W. Michael Hanemann, & Robert N. Stavins, *Water Demand Under Alternative Price Structures*, 54 J. ENVTL. ECON. & MGMT. 181, 183 (2007) ("Water prices in North America generally lie below the long-run marginal cost (LRMC) of water supply, the efficient price.").

[113] Glennon, *supra* note 6, at 1883.

[114] *See id.*

where water is metered, only rarely do consumers pay for the actual costs of the water they use, largely due to political pressures.[115]

Given that most consumers pay artificially low water prices, few have much incentive to economize on their water use. Profligate water use is a predictable response to artificially low water rates – rates that are effectively subsidized by government management or political interventions in the marketplace. As economists Anderson and Snyder explain, "[w]hat is seen as waste or inefficient water use in rural or urban areas is simply the users' rational response to low water prices."[116] This is the direct result of longstanding government policy: "Water prices have been kept artificially low, and the inevitable shortages have followed. Governments have responded by attempting to restrain demand, ration water, and increase the available supply."[117]

It is often assumed that residential water demand is "relatively price inelastic," and therefore price changes will not produce dramatic changes in water use patterns.[118] This position is maintained by many water policy experts and administrators.[119] Yet experience shows that many water users will reduce water consumption when faced with higher prices. The responsiveness of different water users, at different times and places, will vary, but users will respond.[120] "If the price of water rose, people would carefully examine how they use water, for what purposes, and in what quantity."[121] Further, if water users are able to transfer their water rights to others, they may respond to higher prices by selling their water to those with higher value water uses.

Empirical evidence finds that "both sides of the market exhibit surprising price responsiveness or elasticity."[122] Faced with higher prices, consumers will prioritize and economize their water use.[123] Different

---

[115] Olmstead et al., *supra* note 112 ("Water prices are usually set by elected or appointed entities, such as city councils or, for the relatively small number of investor-owned water utilities, by public utility commissions. Consumers may or may not influence the adoption of particular price structures, and even the magnitude of marginal price, through the political process.")

[116] ANDERSON & SNYDER, *supra* note 4, at 10.

[117] *Id.* at 7.

[118] Mary E. Renwick & Richard D. Green, *Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies*, 40 J. ENVTL. ECON. & MGMT. 37, 37 (2000).

[119] Olmstead et al., *supra* note 112, at 181 ("Water managers traditionally have maintained that consumers do not respond to price signals, so demand management has occurred most frequently through restrictions on specific water uses and requirements for the adoption of specific technologies.")

[120] ANDERSON & SNYDER, *supra* note 4, at 8.

[121] Glennon, *supra* note 6, at 1883.

[122] Anderson & Hill, *supra* note 72, at xi. Anderson and Hill cite studies finding significant decreases in water consumption from 10 percent increases in water prices. *See id.* at xii.

[123] Glennon, *supra* note 6, at 1883. *See also*, Robert Glennon, *The Price of Water*, 24 J. LAND RESOURCES & ENVTL. L. 337 (2004).

residential consumers will respond differently to changes in water prices, however.[124] According to one study: "Aggregate single family household demand was responsive to price changes. However price responsiveness varied seasonally. In particular, aggregate demand was 25% more price responsive in the summer months, reflecting the more discretionary nature of outdoor water use."[125]

Increased efficiency can have a dramatic effect on water use patterns. Water use can vary significantly by locality, even within regions. For example, the average resident of Los Angeles uses approximately 125 gallons of water per day, whereas the average resident of Tucson only uses 114 gallons.[126] Surprisingly enough, the United States, as a whole, uses less water today than it did 25 years ago, according to Peter Gleick of the Pacific Institute. [127]

Water usage rates vary substantially within individual industries.[128] In the residential sector, strikingly different water use patterns emerge based on how water is priced. Professor Glennon reports that per capita water use is approximately 300 gallons per day in Fresno, California, where water use is not metered.[129] In the neighboring community of Clovis, however, water is metered, and per capita water use is thirty three percent lower.[130] In the 1970s, price increases and other measures reduced the average peak daily water demand by approximately 20 percent.[131]

In agriculture, where the potential for water use savings may be greatest, price increases create incentives for producers to "substitute labor and capital for water," and use more efficient, and less water-intensive, irrigation techniques.[132] Forced to pay the market value of water, many agricultural users may sell their water to other users who can better afford its higher cost. These agricultural users would also find conservation measures to be better investments than before, particularly if they could sell any conserved water.[133] "Rate increases would encourage the elimination of marginal economic activities and the movement of water toward more productive uses," and encourage technological innovation as well.[134]

Allowing water prices to fluctuate with changes in supply and demand would likely force many consumers to pay significantly more for water, particularly in areas where water is heavily subsidized. As a

---

124 Smith & Wang, *supra* note 109, at 7.

125 Renwick & Green, *supra* note 118, at 51.

126 Gertner, *supra* note 8.

127 *Id.*

128 *See* ANDERSON & SNYDER, *supra* note 4, at 8-9 & tbl.1.1.

129 *See* Glennon, *supra* note 6, at 1883.

130 *Id.*

131 ANDERSON & SNYDER, *supra* note 4, at 18.

132 Anderson & Hill, *supra* note 72, at xii; *see also* Goklany, *supra* note 90.

133 Thompson, *supra* note 69, at 1 ("The opportunity to sell water for often considerable sums would encourage valuable conservation.").

134 Glennon, *supra* note 123, at 340.

consequence, some are concerned that price mechanisms are regressive. Yet given the choice between price mechanisms, rationing, and mandatory restrictions, pricing is the "most timely and equitable approach" to managing drought-induced supply shortfalls.[135]

"An underappreciated but significant advantage" of price mechanisms is their "positive environmental impact."[136] "The reduction in the consumption of water allows for an increased amount of water to remain in the natural environment, thus buoying ecological systems and multistakeholder user rights in a manner championed in integrated water resources management literature."[137] Even rather modest reforms, such as the implementation of drought demand surcharges can "make an immediate and powerful *short-term positive impact* both in terms of supply and ecology."[138]

Public water authorities are reluctant to subject consumers to higher prices, even during drought conditions. Increasing water rates imposes visible costs on their constituents, and risks political unpopularity. Public officials would rather impose moratoria on "wasteful" water uses than subject water use to the discipline of price changes that reflect market conditions.[139] This is a particularly inefficient way to manage water consumption because it ignores the heterogeneity of consumer preferences and the marginal benefits arising from different users who alter their consumption in different ways.[140] "Under-pricing water and restricting its use by law and tradition result in inefficient use, lost development opportunities, interruptions in service, and higher costs for new users."[141]

Where price is used instead of a command-and-control use restriction, individual users can alter their water use so as to ensure that they are maximizing their utility. If there is a concern that temporary price increases resulting from drought conditions are regressive, this could be addressed through targeted, means-tested subsidies for those in need without sacrificing the underlying benefits of a reliance upon price signals to encourage more efficient use.[142]

Some further oppose the use of prices to manage water supplies because water is viewed as a necessity, or even a right, rather than an

---

135 Smith & Wang, *supra* note 109, at 2.

136 *Id.* at 10.

137 *Id.*

138 *Id.*

139 *See* Erin T. Mansour & Sheila M. Olmstead, *The Value of Scarce Water: Measuring the Efficiency of Municipal Regulations*, NBER Working Paper 13513, Oct. 2007, at 1 ("During droughts, municipal water restrictions focus almost exclusively on the residential sector, rather than on commercial and industrial water users. Rather than allowing prices to reflect scarcity rents during periods of excess demand, policy makers have mandated the curtailment of certain uses, primarily outdoor watering, requiring the same limitations on consumption of all households.")

140 *Id.* at 2.

141 Kenneth D. Frederick, *Adapting to Climate Impacts on the Supply and Demand for Water*, 37 CLIMATIC CHANGE 141, 149 (1997).

142 *See, generally*, Smith & Wang, *supra* note 109.

economic good.[143] Yet as Professor Huffman observes, it is precisely water's "specialness," and resulting scarcity, that requires its allocation through institutions that maximize efficiency; for "it is abundantly clear that no social institution yet conceived will yield greater net social welfare from a scarce resource than a well-functioning market."[144]

D. Accounting for Uncertainty

One of the greatest challenges posed by climate change is the uncertainty it magnifies, if not creates. The precise scope, timing and location of its effect on water supplies are uncertain. The range of potential effects in any given place is quite large. Traditional planning tools are poorly equipped to address climatic effects on water supplies. "Even under the presumption of a stable climate, imprecise hydrologic information is now frequently at the heart of costly conflicts over proposed water transfers and new water developments."[145] As Kenneth Frederick of Resources for the Future explains, "to plan for and justify expensive new projects when the magnitude, timing, and even the direction of the changes are unknown . . . Building for changes that never materialize or failing to build facilities to deal with changes that do occur are both potentially costly."[146] Those administrative agencies tasked with water management have been quite timid in modernizing or reforming their management strategies to account for current and projected stresses on water supplies, and have done little to prepare for the threat of climate change.[147] As the IPCC further concluded, "water planners need to recognize that it is not possible to resolve all uncertainties, so it would not be wise to base decisions on only one, or a few, climate model scenarios. Rather, making use of probabilistic assessments of future hydrological changes may allow planners to better evaluate risks and response options."[148] Such uncertainty also highlights the need for flexible and adaptive water management institutions.

Water markets can both reduce uncertainty for water users and provide security against the harms that uncertainty can produce.[149] If water users are able to purchase additional water rights from other users, this can

---

143 *See* Renwick & Green, *supra* note 118, at 38. *See, e.g.*, VANDANA SHIVA, WATER WARS (South End Press 2002).

144 *See* Huffman, *supra* note 1, at 432.

145 Miller, Rhodes & MacDonnell, *supra* note 7, at 167.

146 Frederick, *supra* note 141, at 142.

147 *See generally* Lach et al., *supra* note 105, at 2027-28 (discussing the bureaucratic timidity of water management organizations).

148 CLIMATE CHANGE 2007: WGII, *supra* at 196. *See also* Kenneth D. Frederick, David C. Major, and Eugene S. Stakhiv, *Water Resources Planning Principles and Evaluation Criteria for Climate Change: Summary and Conclusions*, 37 CLIMATIC CHANGE 291, 301 (1997) (discussing potential for adaptation through institutional change).

149 Barton H. Thompson, Jr., *Uncertainty and Markets in Water Resources*, 36 MCGEORGE L. REV. 117, 119 (2005).

reduce the impact of droughts and other local or temporal supply disruptions.[150] While all water users in a given region may suffer from drought conditions, the costs to some water users may be greater than others. Transferable water rights enable water users to shift these costs to those who are best able to bear them, thereby reducing the overall costs of such unforeseen supply disruptions.[151] The availability to transfer water also reduces "the cost of sudden reductions in water supply resulting from droughts . . . by permitting reallocation of the remaining water to its highest uses."[152]

> Such flexibility is an important virtue of water markets. While certainty of supply remains a dominant concern for water users in the western states, flexibility to move water from one type of use to another has become increasingly valuable. The value of flexibility is reflected in the increasing numbers of market transfers of water rights throughout the region and in efforts to devise new mechanisms to facilitate short-term transfers of water entitlements.[153]

Flexibility helps water users accommodate potential risks to water supplies, and is quite valuable as a result.

The ability to transfer water rights in advance of potential supply changes also enables water users to reallocate the risk of uncertainty.[154] Water users can acquire options that will enable them to obtain water necessary to address unanticipated changes in future supply. As in commodity markets, such options are an important risk management instrument. This "ability of markets to 'shift' uncertainty is important both because the law might mistakenly misallocate the burden of uncertainty and because the government cannot always determine who can best bear the burden" of uncertainty or unanticipated losses.[155] As compared to administrative allocations, markets are a far superior, and far more flexible and adaptable, means of accommodating uncertainty. As Professor Morriss explains:

> Water use, even if optimized today, must change tomorrow to remain optimal. A planned solution is thus unable to remain optimal without continual readjustment. Market solutions, on the other hand, allow for continuous adjustment without central intervention. Reaching a planned optimum requires a great deal of information to be available

---

[150] *Id.* at 133.
[151] *See id.* at 135.
[152] Thompson, *supra* note 69, at 1.
[153] Miller, Rhodes & MacDonnell, *supra* note 7, at 162.
[154] Thompson, *supra* note 149, at 134.
[155] *Id.*

to the planner. Markets, by contrast, allow decentralized processing of information.[156]

IV. THE MOVE TO MARKETS

It may well be that the most efficient systems of water markets evolve over time and cannot simply be imposed from above by government fiat.[157] Yet there are still several steps government agencies can take to facilitate the development of water markets and greater reliance upon market institutions in the allocation and management of water resources. The steps include 1) defining, and recognizing the security and transferability of property rights in water resources; 2) eliminating government subsidies for water use and distribution; 3) moving toward market-based prices for water; and 4) identifying and reducing legal and regulatory barriers to water transfers, particularly interbasin and interstate water transfers.[158]

Existing obstacles to water markets include regulatory barriers, "inconsistent legal paradigms, opposition by government agencies that control much of the water and key transportation facilities, and to a growing extent, concerns about the impact of transfers on exporting communities."[159] State rules that limit the lease and sale of water unduly obstruct the development of efficient water markets.[160] Many regulatory jurisdictions deliberately inhibit water transfers outside of their jurisdiction.[161] The threat of administrative expropriation can also discourage private investments that would facilitate water transfers.[162] Overall, the more governmental agencies are involved in water distribution and allocation, the greater the obstacles to water markets.[163]

The single most important step administrative agencies and law-making bodies can take is to recognize and protect water rights so as to provide the institutional foundation upon which water markets may be built or evolve. As Professor Thompson observes, "By providing the legal infrastructure for water markets and actively encouraging such markets, the government can help reduce the harm from uncertainty in water rights and

---

156 Morriss, *supra* note 74, at 933.

157 ANDERSON & SNYDER, *supra* note 4, at 13 ("It is unlikely that the institutions necessary for a well-functioning market can be imposed through a central government.").

158 *See* CLAY J. LANDRY, HOW WATER MARKETS CAN END CONFLICTS: A GUIDE FOR POLICY MAKERS (2001) (providing an overview of reforms that would facilitate the development of water markets).

159 Thompson, *supra* note 69, at 6.

160 *See* Huffman, *supra* note 1, at 440.

161 Thompson, *supra* note 69, at 13.

162 James L. Huffman, *Institutional Constraints on Transboundary Water Marketing*, *in* WATER MARKETING – THE NEXT GENERATION 34 (Terry L. Anderson & Peter J. Hill eds., 1997).

163 Thompson, *supra* note 69, at 5 ("The vast governmental involvement in water distribution has deterred water transfers in a variety of ways.").

deliveries."[164] The unfortunate reality is that "the way to water marketing has been strewn with the obstacles of a legal regime designed to secure water, often with the benefit of taxpayer subsidies, to politically influential water users."[165] Therefore, "because of water law's historic hostility toward markets, water markets need all of the government affirmation and support they can get."[166]

According to Professor Howe, the most important legal change to encourage greater efficiency in water use is "salvage legislation" that ensures that those who manage to reduce their consumptive use of water do not suffer reductions in their water rights as a result.[167] In many states, farmers and other rights owners operate under a "use it or lose it" regime that only recognizes the validity of water rights for certain uses recognized as "beneficial."[168] A consequence of such rules is that there is little incentive to improve water use efficiency.[169] Under "salvage legislation," however, those who conserve water would acquire a valuable commodity: a transferable water right that could be sold or put to other uses.

Legal and administrative barriers are not the only obstacles to greater water marketing. In some cases, water transfers are simply too costly to complete due to transportation or other transaction costs. Where there are no legal or institutional barriers to such trades, however, the potential for a wealth-maximizing trade creates incentives for would-be entrepreneurs to uncover ways of lowering such transaction costs so as to make a deal. This does not mean other concerns should be ignored. Special accommodations may have to be made for water markets to adequately take account of instream flows and sensitive biological resources.[170] But such accommodations should be made in the context of water markets, and such concerns should not be an excuse to forestall market reforms. Indeed, water markets have substantial environmental benefits, including increasing opportunities for conservation organizations to directly influence water allocation decisions as market participants.[171] In many places, "environmental interests have actively supported improved transferability of

---

164 Thompson, *supra* note 149, at 125.

165 Huffman, *supra* note 162, at 31.

166 Thompson, *supra* note 149, at 132.

167 Charles W. Howe, *Increasing Efficiency in Water Markets: Examples from the Western United States*, *in* WATER MARKETING – THE NEXT GENERATION 93 (Terry L. Anderson & Peter J. Hill eds., 1997).

168 *See* Huffman, *supra* note 1, at 438-39; *see also* ANDERSON & SNYDER, *supra* note 4, at 59 (discussing "beneficial use doctrine").

169 Ironically, the "use it or lose it" rules were adopted in order to prevent waste. Whatever their merits at the time of adoption, today they produce waste "by encouraging water owners to use all the water to which they own rights, even if less would be sufficient for their purposes." ANDERSON & SNYDER, *supra* note 4, at 59.

170 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 748; *see also* Johnson, *supra* note 62, at 206 (discussing obstacles to water markets in instream rights).

171 *See generally*, BRANDON SCARBOROUGH & HERTHA L. LUND, SAVING OUR STREAMS: A PRACTICAL GUIDE (2007).

water rights, because they see market transfers as an environmentally less damaging alternative to new dams."[172]

While much ink is spilled over concerns that allowing water transfers could harm those communities from which water is transferred, water markets provide a more equitable means of water transfer than the administrative alternatives.[173] In water markets, water is transferred as a result of voluntary transactions between a willing buyer and a willing seller. Those who had rights to water are compensated for giving up their rights. While there still may be third parties who suffer indirect effects from the water transfer, this is true under *any* water transfer scenario. Only in the absence of water markets are such losses compounded by the public harms resulting from inefficient water allocation and waste.

One transitional measure that has shown much promise is the implementation of water banks to facilitate regional transfers. A water bank essentially operates as a clearinghouse to facilitate the rental of surplus water where it is needed. Among the benefits of water banks is that they can reduce the transaction costs associated with contracting for water transfers.[174] Further, transfers conducted through water banks "clash less with the public resource paradigm" and existing regulatory institutions than do pure, open-market transfers of water.[175] California has had positive experiences with the use of water banks. In the 1970s, a temporary federal water bank helped alleviate drought impacts.[176] In the 1990s, the California Department of Water Resources created water banks that efficiently reallocated large volumes of water among both public and private users.[177] Water banks have been used in Idaho as well.[178]

V. CONCLUSION

Climate change presents many challenges, but it also presents opportunities. In the case of water, the need to prepare for the impact of climatic warming creates an opportunity to improve on existing institutions. In particular, the threat of climate change could provide the long-needed impetus to shift away from centralized political management of water resources, toward market-based institutions. Such a shift holds the potential to increase the efficiency and environmental soundness of water use in the United States.

---

172 Miller et al., *supra* note 7, at 162.

173 *See* STROUP, *supra* note 81, at 7-9 (noting that market exchange encourages positive sum interactions).

174 Thompson, *supra* note 69, at 10.

175 *Id*.

176 Frederick, *supra* note 141, at 150.

177 Howe, *supra* note 167, at 87.

178 Frederick, *supra* note 141, at 151.

Climate change is ultimately a problem about environmental risk, albeit a very large risk. Risk management polices can be viewed as various types of insurance. The purpose of such policies is to reduce the risk up front, provide compensation in the event of loss, or to otherwise reduce the likelihood or magnitude of future losses. To be worthwhile, however, the cost of insurance premiums must be justified by the degree of risk reduction or protection that is acquired. Given the relatively high costs of emission controls at present, the technological obstacles to wide-scale carbon sequestration, and the comparatively low cost of some adaptation measures, the ideal form of insurance for climate change will consist of a combination of mitigation and adaptation measures. In the case of water, the development of market institutions is a particularly apt form of adaptation.

Water markets are not a panacea. As the IPCC concluded, "although well-functioning water markets may ameliorate socioeconomic impacts of reduced water availability, they cannot completely eliminate the adverse impacts of a drying scenario."[179] In practice, "[t]he effectiveness of water marketing in promoting flexible adaptation to prospective climate change will depend on the nature of the markets."[180] Despite these limitations, water markets should play a central role in efforts to mitigate the potential harms of climate change within the water sector.

---

179 CLIMATE CHANGE 2001: WGII, *supra* note 11, at 748.
180 Miller, Rhodes & MacDonnell, *supra* note 7, at 173.