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## WATER SCARCITY, CONFLICT, AND SECURITY IN A CLIMATE CHANGE WORLD: CHALLENGES AND OPPORTUNITIES FOR INTERNATIONAL LAW AND POLICY

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## ABSTRACT

Although climate change is expected to have a major effect on the global environment in its broadest sense, one of its earliest and most direct impacts will be on Earth's fresh water systems. While some regions will experience increased precipitation, others will suffer serious water scarcity. And some will endure both as climatic variability impacts regional weather patterns resulting in erratic or abnormal rain and drought events.

This, in turn, will affect human migration patterns, population growths, agricultural activities, economic development, river flows and geographies, and the global environment. This article explores the impact that climate change will have on regional and global fresh water resources and the resulting legal and policy implications that will challenge all nations. In particular, it assesses the ability of international water law to respond to climate change consequences and offers recommendations that could help nations and the international community to meet the challenges posed by this global phenomenon.

## I. INTRODUCTION

Of the various consequences anticipated from global climate change, the earliest and most direct will affect Earth's fresh water systems. These impacts, however, will not be uniform. While scientists expect an overall warmer climate globally, climate change will actually result in great variability in global weather patterns such that some regions will become substantially wetter while others significantly dryer. As noted by the Intergovernmental Panel on Climate Change (IPCC), the tropics and higher latitudes regions, such as northern Europe and northern North America, are expected to experience an increase in precipitation.<sup>1</sup> In contrast, the IPCC projects drying in the sub-tropics

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<sup>1</sup> Intergovernmental Panel on Climate Change [IPCC], Technical Paper on Climate Change and Water, at 32, Doc. IPCC-XXVIII/Doc.13 (8.IV.2008) (Apr. 10, 2008) [hereinafter IPCC Technical Paper].

and mid-latitude areas, such as Central America, southern Europe, northern and southern Africa, and Australia.<sup>2</sup>

More ominous are scientists' projections related to the magnitude, frequency, and intensity of the changes in precipitation levels.<sup>3</sup> Many of the regions likely to dry out—including the Mediterranean region and the subtropical western coasts of each continent—will suffer a reduction in precipitation of up to 20% with longer bouts of dry spells between rain events.<sup>4</sup> Moreover, they are likely to experience more intense, more frequent and longer-lasting heat waves.<sup>5</sup> The result will be protracted droughts in many of the world's most populated areas affecting agricultural production, economic development, the environment, human health, population growth, and power generation.

In contrast, many of the regions expecting an upsurge in precipitation—such as the monsoon region of southern Asia, eastern Africa and the equatorial Pacific Ocean—will experience an annual increase of more than 20% over current rainfall levels.<sup>6</sup> This increase will manifest in more volatile and intense precipitation events over shorter periods of time that likewise could have serious consequences for agricultural production, economic development, the environment, human health, population growth, and power generation.<sup>7</sup> Still other parts of the world will undergo climatic and environmental alterations as a result of changes in the timing of precipitation events. For example, premature spring melts and early or delayed monsoon seasons will have tremendous consequences for ecosystems and local climates and, as a result, on

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<sup>2</sup> *Id.*

<sup>3</sup> See Bernhard Lehner et al., *Estimating The Impact of Global Change on Flood and Drought Risks in Europe: A Continental, Integrated Analysis*, 75 *CLIMATIC CHANGE* 273, 274 (2006) (asserting that “changes in the frequencies of extreme events, such as floods and droughts, may be of the most significant consequences of climate change . . . Moreover, during extreme low and high-flow events the threats to human societies and the environment are likely to be most critical, and the conflicts between competing requirements to be most intense.”); see also Gerald A. Meehl et al., *Global Climate Projections*, in *CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS* 747, 768 (Susan Solomon et al. eds., 2007) (noting that the collective of climate change models evidence indicate considerable variation in the magnitude of change).

<sup>4</sup> IPCC Technical Paper, *supra* note 1, at 33; Meehl, *supra* note 3, at 768, 782.

<sup>5</sup> Meehl, *supra* note 3, at 783. The heat wave that gripped Europe in 2003, resulting in the deaths of at least 20,000, is the type of extreme heat event expected to become more common as average global climatic temperatures increase. *When Warming Affects Health*, in *GLOBAL WARMING* 46 (Kelly Knauer, ed., 2007).

<sup>6</sup> IPCC Technical Paper, *supra* note 1, at 33.

<sup>7</sup> Meehl, *supra* note 3, at 768, 783.

species and livelihoods dependent on particular environmental conditions.<sup>8</sup>

Although it is difficult to predict the full implications of climate change on global and local fresh water resources or on the human and natural environments, the forecasts are distressing. Already, shortages attributed to climatic changes have resulted in record droughts in Australia,<sup>9</sup> southeastern and western United States,<sup>10</sup> southern Africa, and South America.<sup>11</sup> Scientists are also blaming climatic changes for intensifying rain activities in northern Europe and North America by between 10% and 50% and for the related increase in flooding occurring in many of these regions.<sup>12</sup>

Both domestic and international water laws and policies are inadequate to meet the challenges posed by this global phenomenon or to adapt to the additional consequences that appear to be inevitable. Few nations have implemented adequate measures designed to respond to the

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<sup>8</sup> See e.g., *Early Monsoon Floods "Point to Climate Change"*, HUMANITARIAN NEWS AND ANALYSIS, June 25, 2008, <http://www.irinnews.org/Report.aspx?ReportId=78925> (discussing early monsoon floods effects on the Ganges and Brahmaputra rivers and on Bangladesh).

<sup>9</sup> *Australia's Drought to Worsen*, ASSOCIATED PRESS, July 10, 2008, <http://www.msnbc.msn.com/id/25617864/> (last visited 6-18-09) (discussing Australia's ongoing and worst drought of the past century); See generally Neville Nicholls, *Detecting and Attributing Australian Climate Change*, 55 AUSTRALIAN METEOROLOGICAL MAG. 199 (2006).

<sup>10</sup> U.S. GLOBAL CHANGE RESEARCH PROGRAM, GLOBAL CLIMATE CHANGE: IMPACTS IN THE UNITED STATES 33, 43-44 (Thomas R. Karl et al. eds., 2009), available at <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/download-the-report> [hereinafter US Global Climate Change] (providing a map with observed droughts trends over the past 50 years, and concluding that "over the past several decades, extended dry periods have become more frequent in parts of the United States, especially the Southwest and the eastern United States").

<sup>11</sup> See *Sin Aqua Non*, THE ECONOMIST, Apr. 11, 2009, at 59-61 (noting that "Australia has suffered a decade-long drought. Brazil and South Africa, which depend on hydroelectric power, have suffered repeated brownouts because there is not enough water to drive the turbines properly"); Pilirani Semu-banda, *Africa: Climate Change Imperils Livelihoods on Zambezi River*, INTER PRESS SERVICE, Dec. 26, 2008, available at <http://ipsnews.net/news.asp?idnews=45224>. (considering the impacts of ongoing droughts on southern Africa and how climate change will affect the region); M Marcela Valente, *South America: Scientists Look at Climate Change and Drought*, INTER PRESS SERVICE, Feb. 13, 2009, available at <http://ipsnews.net/news.asp?idnews=45768>. (discussing the ongoing drought in South America and considering the likelihood that it is driven by climate change).

<sup>12</sup> Mohammed H.I. Dore, *Climate Change and Changes in Global Precipitation Patterns: What Do We Know?*, 31 ENV'T INT'L 1167, 1169, 1175 (2005). (reviewing the literature evidencing the increase of precipitation in mid- and high-latitude regions, including northern North America and Europe, resulting from climate change); see also Gerald Wynn, *Floods, Heat Hit Europe, but is it Global Warming?*, REUTERS NEWS, July 26, 2007, available at <http://www.reuters.com/article/latestCrisis/idUSL24785745>. (discussing the ability to link recent European floods to climate change).

expected impacts on their domestic fresh waters.<sup>13</sup> Even fewer have reached across their borders to coordinate efforts over shared fresh water resources, a failure that is especially troubling because, with the exception of most island-nations, nearly every country in the world is hydrologically connected to its neighbors.<sup>14</sup>

This paper examines international law and policy and the collective ability of nations to respond to the effects of climate change on global fresh water resources. It first explores the current and long-term effects of climate change on regional and global fresh water resources and the resulting impact on human and the natural environment. It then assesses the international legal and policy challenges posed by climate change, and identifies mechanisms that are likely to aid both individual

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<sup>13</sup> For articles addressing shortcomings in U.S. law and policy, see Noah D. Hall et al., *Climate Change and Freshwater Resources*, 22 NAT. RESOURCES & ENV'T 30 (2008). (discussing the inadequacy of U.S. law to respond to "the new challenges of climate change and resulting pressures on freshwater resources"); Robin Kundis Craig, "Stationary is Dead"- Long Live Transformation: Five Principles for Climate Change Adaptation Law, 34 HARV. ENVTL. L. REV. (forthcoming 2010) available at <http://ssrn.com/abstract=1357766> (last visited Sept. 14, 2009) [hereinafter Craig 1] (asserting that "American law and policy are not keeping up with climate change impacts and the need for adaptation"). See generally John Lesby, *Notes on a Progressive National Water Policy*, 3 HARVARD L. & POL'Y REV. 133 (2009) (identifying the shortcomings of US water laws in relation to climate change and offering recommendations for enhancing water policy and management). For discussions addressing shortcomings in European law and policy See European Environment Agency, *If the Well Runs Dry – Climate Change Adaptation and Water*, Apr. 14, 2009, <http://www.eea.europa.eu/articles/climate-change-adaptation-and-water> (noting that "[t]he integration of adaptation into key EU policies has been limited" and that "only seven of the 32 EEA countries have actually adopted National Adaptation Strategies for climate change"); U.N. Econ. & Soc. Council [ECOSOC], Econ. Com. for Europe, *Water and Adaptation to Climate Change*, U.N. Doc. ECE/MP.WAT/2009/4 2 (Sept. 1, 2009) available at [http://www.unece.org/env/documents/2009/Wat/mp\\_wat/ECE\\_MP\\_WAT\\_2009\\_4\\_E.pdf](http://www.unece.org/env/documents/2009/Wat/mp_wat/ECE_MP_WAT_2009_4_E.pdf) [hereinafter UNECE Guidance] (asserting that "Very few countries have developed adaptation strategies so far. The fact that many water bodies, especially in the UNECE region, cross boundaries means that risks and challenges are shared and that solutions therefore need to be coordinated. Transboundary cooperation in developing adaptation strategies is currently, however, almost non-existent").

<sup>14</sup> See Gabriel Eckstein & Yoram Eckstein, *A Hydrogeological Approach to Transboundary Ground Water Resources and International Law*, 19 AM. U. INT'L L. REV. 201, 205 (2003) [hereinafter Eckstein & Eckstein 2003a]. Globally, there are 263 rivers that traverse or demarcate international political boundaries and whose basins encompass territory in 145 countries. United Nations Environmental Programme, *Atlas of International Freshwater Agreements 1-2* (2002). Under the auspices of the United Nations Educational, Scientific, and Cultural Organization, an ongoing study has so far inventoried 273 international transboundary aquifers, of which 68 are found in the Americas, 38 in Africa, 65 in eastern Europe, 90 in western Europe, and 12 in Asia. Press Release, UN Educational, Scientific and Cultural Org., UNESCO Publishes First World Map of Underground Transboundary Aquifers, Release No. N°2008-108 (Oct. 22, 2008) available at [http://portal.unesco.org/en/ev.php-URL\\_ID%3D43767&URL\\_DO%3DDO\\_TOPIC&URL\\_SECTION%3D201.html](http://portal.unesco.org/en/ev.php-URL_ID%3D43767&URL_DO%3DDO_TOPIC&URL_SECTION%3D201.html).

nations and the international community to meet the challenges posed by this extraordinary global development.<sup>15</sup>

It is noteworthy that the focus of the recommendations is on state-to-state relations that require bilateral or multilateral implementation rather than on steps that an individual state could take unilaterally. Moreover, the suggestions are intended to foment resilience and adaptive capacity in the system for managing transboundary water resources in light of the expected, and unexpected, variability of climate change.<sup>16</sup> While the recommendations offered are not presented to serve as a blueprint for success, they do herald the obvious—climate change is fundamentally a global phenomenon that defies borders and sovereignty. Only through concerted and collective effort can nations surmount this unprecedented global challenge; anything less will result in disjointed efforts that exacerbate scarcity and water stress, globally and locally.

## II. CLIMATE CHANGE AND FRESH WATER RESOURCES

According to the IPCC, “[o]bservational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences on human societies and ecosystems.”<sup>17</sup> This conclusion is easily understood given that the hydrological cycle is inextricably connected to virtually all sectors of the natural and human environments.<sup>18</sup> Projected impacts offered by

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<sup>15</sup> Although the paper does not address domestic legal or policy approaches that states might take on their own, the legal and policy approaches proposed will certainly require considerable domestic reforms.

<sup>16</sup> Resilience refers to the capacity of humans, other life on Earth, and ecosystems to cope with and respond to changes in the environment in a way that ensures survival. See generally Robin Kundis Craig, *Adapting to Climate Change: The Potential Role of State Common-Law Public Trust Doctrines* 15 n. 86 (FSU College of Law, Public Law Research Paper No. 382, 2009), available at <http://ssrn.com/abstract=1431663> [hereinafter Craig 2]. Adaptive capacity relates to the ability of ecosystems, in the face of ever changing environmental and climatic conditions, to regenerate and continue delivering resources and ecosystem services necessary for life and societal development. See generally *id.*

<sup>17</sup> IPCC Technical Paper, *supra* note 1, at 4.

<sup>18</sup> See Jayashree Vivekanandan & Sreeja Nair, *Climate Change and Water: Examining the Interlinkages*, in *TROUBLED WATERS: CLIMATE CHANGE, HYDROPOLITICS, AND TRANSBOUNDARY RESOURCES* 1, 3 (D. Michel and A. Pandya eds. 2009), available at <http://www.stimson.org/rvproto/partner.cfm?SN=RV200902021934> (asserting that “any factor

scientists, non-governmental, and intergovernmental bodies on global water resources vary widely in geographic impact and severity, and range from increased precipitation that will trigger significant floods, to decreases in rainfall that will produce long-term droughts. Coupled with the existing and growing demand for fresh water resulting from expanding populations and economic development,<sup>19</sup> changes in the availability of fresh water could have serious and possibly devastating implications for agricultural production, economic development, the environment, human health, population growth, and power generation.<sup>20</sup> Many climate change proponents are now warning that the world is heading toward a massive global water crisis.<sup>21</sup> The following section briefly reviews some of the climate change implications related to transboundary fresh water resources.

### A. DROUGHTS AND FLOODS

While climate change models suffer from a degree of uncertainty, their conclusions are overwhelmingly consistent: climate change will impact temperatures, precipitation rates, and the consistency

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that triggers change in these variables would ripple through the sectors that are dependent on the hydrological system”).

<sup>19</sup> See IPCC, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY 176 (Martin Parry et al. eds., 2007) [*hereinafter* Climate Change 2007: Impacts] (noting that “[g]lobally, demand for water is increasing as a result of population growth and economic development”). Between 1990 and 1995, fresh water withdrawals grew seven-fold, in part, because of the expansion of irrigated agriculture. See PETER GLEICK, THE WORLD’S WATER 1998-1999, at 6 (1998). While per capita global water use has declined over the past few decades, aggregate demand continues to grow due to population growth and economic development. *Id.* at 10-11. According to Gleick, “[f]reshwater withdrawals increased from an estimated 580 cubic kilometers per year (km<sup>3</sup>/yr) in 1900 to 3,580 km<sup>3</sup>/yr in 1990” while the per capita rate of withdrawal went from around 400 m<sup>3</sup>/p/yr in the early 1990s to a high of around 650 m<sup>3</sup>/p/yr in the mid 1980s. *Id.*

<sup>20</sup> See Vivekanandan & Nair, *supra* note 18, at 6 (noting the threat to food security from dwindling river flows); Z.W. Kundewicz, et al., *The Implications of Projected Climate Change for Freshwater Resources and their Management*, 53 HYDROLOGICAL SCI. J. 1, 5 (2008) (describing the expected consequences of rising temperatures on glacial and snow melt and the impact on the more than one billion people who live in river basins supplied by such water from major mountain ranges, like the Himalaya, Hindukush and Andes).

<sup>21</sup> See, e.g., William A. Jury & Henry J. Vaux, Jr., *The Emerging Global Water Crisis: Managing Scarcity and Conflict Between Water Users*, 95 ADVANCED IN AGRONOMY 1, 3 (2007); MAUDE BARLOW, BLUE COVENANT: THE GLOBAL WATER CRISIS AND THE COMING BATTLE FOR THE RIGHT TO WATER (The New Press 2008) (2007); FRED PEARCE, WHEN THE RIVERS RUN DRY: WATER – THE DEFINING CRISIS OF THE 21 CENTURY (2006); U.N. DEVELOPMENT PROGRAMME [UNDP], HUMAN DEVELOPMENT REPORT 2006: BEYOND SCARCITY: POWER, POVERTY AND THE GLOBAL WATER CRISIS 136 (2006) [HEREINAFTER UNDP].

of precipitation events around the world, which, in turn, will result in considerable climatic variability and change, including more intense and frequent flood and drought events.<sup>22</sup> Experts suggest that by the middle of this century, annual average river runoff and water availability will fall by 10%–30% in the sub-tropics and mid-latitudes, and increase by 10%–40% in the tropical regions and higher latitudes.<sup>23</sup>

In southern Africa, for example, scientists anticipate a sharp decline in precipitation, between 10% and 20%, as compared with average rainfall from the latter part of the 20<sup>th</sup> century.<sup>24</sup> Such a drop is expected to reduce perennial drainage of the region's rivers by as much as 50% including, for example, in the Orange River. The mean annual precipitation rate of the basin of the Orange River, which flows from Lesotho to South Africa and then along South Africa's desert border with Namibia, is approximately 400 mm, which characterizes the basin as highly arid.<sup>25</sup> While actual precipitation varies annually between 2,000 mm in the highlands at the river's source to less than 50 mm at its mouth, evaporation rates range from 1,200 mm to 3,500 mm respectively.<sup>26</sup> As a result, the Orange River is already in deficit and is considered closed for purposes of further development.<sup>27</sup> A reduction of one-half of the Orange River's perennial water supply in an already arid region will further exacerbate existing shortages and elevate regional tensions.

Scientists also expect significant reductions in the annual mean discharge by the end of the century in other transboundary river basins, many of which are already under stress, including the Danube (decrease of 21.9%), Euphrates (decrease of 38%), Rhine (decrease of 13.3%), Rio Grande (decrease of 26.7%), and Syr Darya (decrease of 10.3%).<sup>28</sup> As a

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<sup>22</sup> See Lehner, *supra* note 3, at 274.

<sup>23</sup> Kundzewicz, *supra* note 20, at 5.

<sup>24</sup> Maarten de Wit et al., *Changes in Surface Water Supply Across Africa with Predicted Climate Change*, 311 SCIENCE 1917, 1919 (2006).

<sup>25</sup> See *id.*; see also A.H. Conley & P.H. van Niekerk, Sustainable Management of International Waters: The Orange River Case, 2 WATER POL'Y 131, 132 (2000) (describing the downstream region of the Orange River flows through the Namib Desert, which "is as dry as the Sahara").

<sup>26</sup> See Conley and van Niekerk, *supra*, note 25, at 135.

<sup>27</sup> Anthony R. Turton, *A Southern African Perspective on Transboundary Water Resource Management*, ENV'T'L CHANGE & SECURITY PROJECT REP., 2003, at 78, available at [http://www.wilsoncenter.org/topics/pubs/feature\\_turton.pdf](http://www.wilsoncenter.org/topics/pubs/feature_turton.pdf); Al Conley, *A Synoptic View of Water Resources in Southern Africa*, in SINK OR SWIM? WATER, RESOURCE SECURITY AND STATE CO-OPERATION (Hussein Solomon ed., 1996), available at <http://www.iss.co.za/Monographs/No6/Conley.html>.

<sup>28</sup> Daisuke Nohara et al., *Impact of Climate Change on River Discharge Projected by Multimodel Ensemble*, 7 J. OF HYDROMETEOROLOGY 1076, 1087 (2006) (projecting annual mean discharge

result of declining precipitation, coupled with expected rising temperatures, droughts that are today deemed extraordinary will soon become the norm.<sup>29</sup>

In contrast, an increase in precipitation in the Mekong River Basin, especially, as expected, in more volatile and pronounced rain events, could result in unprecedented floods with devastating consequences. According to the IPCC, during the second half of this century, the maximum monthly flow of the Mekong River during the rainy season is expected to intensify by more than 40% in the basin and by nearly 20% in the delta.<sup>30</sup> Moreover, the Panel suggests that a global temperature rise of only 2°C will flood as much as 23%-29% more land area than is currently inundated by seasonal deluges.<sup>31</sup>

River basins like the Mekong and Vistula are likely to endure both increases and decreases in river flows that will result in both flooding and scarcity condition. Such variations will occur seasonally, in part, because of an overall increase in temperatures that will boost precipitation during the wet season, and amplify evaporation in the dry season.<sup>32</sup>

These variations will also manifest through changes in glacial and snowpack melt. Scientists project that rising temperatures will intensify the melting of glaciers and snowpack<sup>33</sup> causing flows in rivers and lakes that are fed by these meltwaters, like those originating in the

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of 24 rivers around the world as impacted by climate change using a very rapid economic growth scenario with increasing globalization and a projected CO<sub>2</sub> concentration of 720 ppmv by the year 2100). Precipitation reductions in Southern Europe are especially noteworthy as by 2070, the current 100-year drought cycle is expected to occur, on average, every forty years, and in the most extreme cases every ten years. See Lehner, *supra* note 3, at 290.

<sup>29</sup> IPCC Technical Paper, *supra* note 1, at 52 (noting that “by the 2070s, a 100-year drought of today’s magnitude is likely to return, on average, more frequently than every 10 years in parts of Spain and Portugal, western France, Poland’s Vistula Basin and western Turkey”).

<sup>30</sup> *Id.* at 114 (projecting increases as compared to with levels from 1961-90).

<sup>31</sup> *Id.* at 52.

<sup>32</sup> *Id.* at 114 (noting that the Mekong River will be at risk of increased flooding during the wet season and increased water shortages in the dry season); See Lehner, *supra* note 3, at 294 (indicating that the Vistula River in eastern Poland will likely experience an increase in both flood and drought frequencies as a result of changes in the seasonal variability of precipitation and temperature that result in more extreme high and low-flow months).

<sup>33</sup> Rising temperatures pose a two-fold problem for glaciers. It not only reduces the accumulation period and increases the melting season, it also causes more of the region’s precipitation to fall as rain, rather than snow, which does not rebuild glaciers and snow pack and actually hastens melting. XU JIANCHU ET AL., INTERNATIONAL CENTRE FOR INTEGRATED MOUNTAIN DEVELOPMENT, THE MELTING HIMALAYAS: REGIONAL CHALLENGE AND LOCAL IMPACTS OF CLIMATE CHANGE ON MOUNTAIN ECOSYSTEMS AND LIVELIHOODS 4 (2007).

high Himalayan and Andean mountain ranges, to increase over the coming decades. Once the glacial and snowpack source is depleted, though, river flows are expected to decline precipitously resulting in regional water scarcities.<sup>34</sup> Additionally, increased temperatures will bring earlier and more voluminous spring melts, thereby affecting the timing of peak stream flow and the downstream availability of water.<sup>35</sup> Over time, as glaciers recede, snowcaps become depleted, and winter precipitation shifts from snow to rain, many of these glacier and snowpack-dependent regions will suffer further shortages and related maladies.<sup>36</sup> For example, by the third quarter of the current century, summer low flows in Alps-fed central European rivers are projected to decrease by as much as 50% and up to 80% in some southern European rivers.<sup>37</sup>

Significant glacial loss and reduced snow cover has been already observed around the globe. In the Peruvian Andes, for example, the region covered by glaciers has been reduced by 25% over the past three decades as a result of warming trends.<sup>38</sup> By 2015, all Peruvian glaciers

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<sup>34</sup> Ashok Jaitly, *South Asian Perspective on Climate Change and Water Policy*, in TROUBLED WATERS: CLIMATE CHANGE, HYDROPOLITICS, AND TRANSBOUNDARY RESOURCES 17, 21 (David Michel & Amit Pandya eds., 2009), available at <http://www.stimson.org/rvproto/partner.cfm?SN=RV200902021934> (discussing the short-term and long-term impact of accelerated glacial melt on South Asia); T. P. Barnett et al., *Potential Impacts of a Warming Climate on Water Availability in Snow-Dominated Regions*, 438 NATURE 303, 306 (Nov. 2005) (noting that “some areas of the most populated regions on Earth are likely to ‘run out of water’ during the dry season if the current warming and glacial melting trends continue for several more decades” and that “when the glaciers melt and their fossil water is used or lost, their contribution to the water supply of the region will cease”); JIANCHU ET AL., *supra* note 33, at 7.

<sup>35</sup> The impact of glacial and snowpack melt is especially concerning because glaciers and snowpacks serve as fresh water storage reservoirs for downstream reaches of river and lake basins. See Vivekanandan & Nair, *supra* note 18, at 6. Over eons, human activity and the natural environment have become dependent on the recurring seasonal cycles of spring and summer meltwaters to sustain agriculture and development, as well as the multitude of species and habitats found in the basins. Global warming-induced changes to this cycle could have serious and possibly devastating implications for agricultural production, economic development, power generation, population growth, and the environment. *Id.* See also Kundzewicz, *supra* note 20, at 5 and accompanying text.

<sup>36</sup> IPCC Technical Paper, *supra* note 1, at 40, 42. A study reported by the IPCC, which simulated glacial melt in 11 glaciers around the world, indicated an average volume loss of 60% by 2050. *Id.* at 37.

<sup>37</sup> IPCC Technical Paper, *supra* note 1, at 125 (describing the expected declines in European river flows in the text and in Table 5.4). Similar impacts are projected for the seven major rivers fed from Himalayan glaciers – the Brahmaputra, Ganges, Indus, Irrawady, Mekong, Salween, and Yagtze. See Vivekanandan & Nair, *supra* note 18, at 6.

<sup>38</sup> See Barnett et al, *supra* note 34, at 306.

below 5,500 meters are expected to disappear as a result of rising temperatures.<sup>39</sup> Similarly, in the Tibetan Plateau of the Himalayas, the glaciated area has shrunken 5.5% over the past 45 years with glacial recession rates averaging between 4 and 65 meters annually.<sup>40</sup> By 2050, climatic changes are expected to reduce the glaciated area of the Plateau by 100,000km<sup>2</sup>.<sup>41</sup>

## B. AGRICULTURE AND FOOD SECURITY

Agricultural production in much of the world is critically dependent on the regularity of the hydrological cycle and the degree to which humans have become accustomed to that cycle.<sup>42</sup> This dependency includes the timing of precipitation and glacial and snowpack melts, as well as the location where water is delivered and the volumes of water made available by the rains, glaciers, snows, rivers and aquifers.<sup>43</sup> Moreover, more than one-sixth of the world's population lives in basins that are critically dependent on glacial and snowmelt water to carry them through the dry season.<sup>44</sup>

Any changes to the delicate hydrologic balance could result in serious and devastating impacts to the ability of farmers and nations to produce sustainable levels of food and fiber and, ultimately, on food security.<sup>45</sup> In particular, changes in the timing and volume of seasonal

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<sup>39</sup> DAN SMITH & JANANI VIVEKANANDA, INTERNATIONAL ALERT, A CLIMATE OF CONFLICT: THE LINKS BETWEEN CLIMATE CHANGE, PEACE AND WAR 14 (2007).

<sup>40</sup> THE UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORG., THE UNITED NATIONS WORLD WATER DEVELOPMENT REPORT 3: WATER IN A CHANGING WORLD 196 (2009) [*hereinafter* UNDR3]. Similarly, the glaciated area of Tien Shan region in Central Asia has contracted by 10.1% over the past 30 years. *Id.*

<sup>41</sup> Climate Change 2007: Impacts, *supra* note 19, at 492.

<sup>42</sup> See UNDR3, *supra* note 40, at 112 (noting that "Agriculture is . . . extremely sensitive to climate change, and it is anticipated that large areas of croplands, in particular in semi-arid zones, will need to adapt to new conditions with lower precipitation"). Agriculture accounts for 70% of water globally withdrawals from rivers, lakes and aquifers, and up to 90% in some developing countries. *Id.* at 99 and 106.

<sup>43</sup> Vivekanandan & Nair, *supra* note 18, at 5-6 (noting that reductions in annual runoff "could cause a significant drop in productivity in agriculture and other climate-sensitive sectors").

<sup>44</sup> See Vivekanandan & Nair, *supra* note 18, at 6; Kundzewicz, *supra* note 20, at 5 and accompanying text.

<sup>45</sup> See Vivekanandan & Nair, *supra* note 18, at 6 (noting the threat to food security from dwindling river flows and that that "[m]any parts of Central Asia, Latin America, and South Asia depend on glaciers for their livelihoods and sustenance"); Kundzewicz, *supra* note 20, at 5 and accompanying text; (describing the expected consequences of rising temperatures on glacial and

flows could disrupt growing cycles in ways that that would make adaptation difficult. For example, the delivery of water in large, unpredictable bursts, rather than periodic or consistent flows, could make agricultural planning considerably more challenging. Similarly, significant reductions in river flows, as expected in many of the rivers originating in the Alps, Andes, and Himalayan mountain ranges, could make current crops unsustainable.<sup>46</sup> Crop yields, for example, are projected to decline by as much as 30% in parts of Central and South Asia, and even higher in the United States, as a result of climate change.<sup>47</sup>

Such climatic variations could make it difficult for nations to meet their food needs into the future. Current patterns indicate that the global community will have to double its food production by mid-century to meet the food needs of the nine billion people expected to live on this planet by 2050.<sup>48</sup> Such an increase undoubtedly will require either considerable improvements in water use efficiency or an increase in the supply of water for agriculture, industry, and municipal use, or some combination of both. The expected changes to the hydrologic cycle, though, will likely make such adaptation goals exceedingly difficult to achieve.

### C. HUMAN HEALTH

Scientists and experts with the United Nations expect changes in the hydrological cycle ensuing from climatic changes to multiply the

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snow melt and the impact the more than one billion people who live in river basins supplied by such water from major mountain ranges, like the Himalaya, Hindukush and Andes).

<sup>46</sup> See UNDR3, *supra* note 40, at 112 (asserting that “Climate change is expected to alter hydrologic regimes and patterns of freshwater resource availability” and pointing out some of the agricultural challenges expected from climate change in the Mediterranean basin and semi-arid regions of Southern Africa, Australia and the Americas).

<sup>47</sup> See Climate Change 2007: Impacts, *supra* note 19, at 479-80; Wolfram Schlenker and Michael J. Roberts, *Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields Under Climate Change*, 106 PROC. OF NAT’L ACAD. OF SCI. E120 (2009), available at [http://www.agcarbonmarkets.com/documents/PNAS2009\\_Final.pdf](http://www.agcarbonmarkets.com/documents/PNAS2009_Final.pdf) (providing new evidence that by the end of the century, crop yields in the United States may decline by 30–46% under the slowest warming scenario, and decrease by 63–82% under the more rapid warming scenario).

<sup>48</sup> WORLD ECON. FORUM, THE BUBBLE IS CLOSE TO BURSTING: A FORECAST FOR THE MAIN ECONOMIC AND GEOPOLITICAL WATER ISSUES LIKELY TO ARISE IN THE WORLD DURING THE NEXT TWO DECADES 21 (2009).

number of human health maladies including death,<sup>49</sup> especially in lesser-developed countries.<sup>50</sup> Such health effects will occur through water-borne and vector-borne diseases, especially in countries where precipitation increases and flooding events overwhelm existing sewer and treatment systems.<sup>51</sup> As a result, bacteria, parasites and algal blooms will flourish, including the protozoan parasites *Cryptosporidium*, hepatitis A viruses, *E. coli* bacteria, and more than 100 other pathogens.<sup>52</sup> International organizations, like the World Health Organization (WHO), estimate that globally, malnutrition causes the annual deaths of 5.62 million children under the age of five, while diarrheal diseases take the lives of another 1.8 million young children each year.<sup>53</sup> Overall, nearly three million deaths annually can be directly attributed to inadequate and impure water, improper sanitation, and improper hygiene.<sup>54</sup>

As temperatures rise, many experts expect vector-borne diseases like malaria and dengue fever to expand their geographic range into

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<sup>49</sup> Kari Lydersen, *Risk of Disease Rises with Water Temperatures*, THE WASH. POST, Oct. 20, 2008, at A08; see generally UNDR3, *supra* note 40, at 73 (stating that “Climate change can affect health through multiple pathways, such as greater frequency and intensity of heat waves, fewer cold-related illnesses, increased floods and droughts, changes in the distribution of vectorborne diseases and effects on the risk of disasters and malnutrition”).

<sup>50</sup> UNDR3, *supra* note 40, at 73 (asserting that “populations in low-income countries are likely to be particularly vulnerable to the adverse effects” of climate change).

<sup>51</sup> KURT M. CAMPBELL ET AL., THE AGE OF CONSEQUENCES: THE FOREIGN POLICY AND NATIONAL SECURITY IMPLICATIONS OF GLOBAL CLIMATE CHANGE 63 (2007), available at [http://www.csis.org/media/isis/pubs/071105\\_ageofconsequences.pdf](http://www.csis.org/media/isis/pubs/071105_ageofconsequences.pdf). In the United States, for example, the sewer systems of more than 700 cities in northern states regularly overflow into municipal water supplies during heavy rain events, mixing sewage water and clean water. Lydersen, *supra* note 49. Much of the developing world, where the vast majority of the world’s population is found, has no functioning sewer or water treatment facilities. UNICEF & WHO, MEETING THE MDG DRINKING WATER AND SANITATION TARGET: A MID-TERM ASSESSMENT OF PROGRESS 6 (2004), available at [http://www.who.int/water\\_sanitation\\_health/monitoring/jmp04.pdf](http://www.who.int/water_sanitation_health/monitoring/jmp04.pdf) (estimating that 2.6 billion people in the world lack adequate sanitation services); WHO, HEALTH THROUGH SAFE DRINKING WATER AND BASIC SANITATION, [http://www.who.int/water\\_sanitation\\_health/mdg1/en/index.html](http://www.who.int/water_sanitation_health/mdg1/en/index.html) (last visited Mar. 3, 2009) (noting that 2.6 billion people – half the developing world – lack even a simple ‘improved’ latrine).

<sup>52</sup> Lydersen, *supra* note 49.

<sup>53</sup> See UNDR3, *supra* note 40, at 88 (stating that “In 2000 diarrhea accounted for 17% of the 10.6 million deaths in children younger than five . . . Undernutrition is an underlying cause of 53% of all deaths in children younger than five”); See also World Health Organization, Burden of Disease and Cost-Effectiveness Estimates, [http://www.who.int/water\\_sanitation\\_health/diseases/burden/en/index.html](http://www.who.int/water_sanitation_health/diseases/burden/en/index.html) (last visited Jan. 20, 2009).

<sup>54</sup> See UNDR3, *supra* note 40, at 89 (providing breakdown of statistics in Table 6.3).

regions that previously had been inhospitable to them.<sup>55</sup> The WHO suggests that climate change-related warming and precipitation trends since the mid-1970s have already caused more than 150,000 deaths annually.<sup>56</sup> By 2030, the number of deaths directly related to climate change is expected to grow to 300,000 per year.<sup>57</sup> Moreover, global warming has been linked to food-borne infectious diseases; 30% of reported cases of salmonellosis in continental Europe have been linked to episodes of higher than average temperatures.<sup>58</sup>

In addition, flooding and drought also could drastically affect human health. More than seven million people have died from flooding since 1900, while those who suffered ill health, personal tragedies and property losses number in the multiple billions of people.<sup>59</sup> Notably, the incidence of deaths and people affected by floods is rising as a result of more frequent deluges occurring in recent decades, as well as a greater vulnerability to flooding events.<sup>60</sup>

Similarly, a reduction in precipitation coupled with a rise in temperature will also take a toll on human health. The heat wave that ravaged Europe during the summer of 2003, which was responsible for

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<sup>55</sup> See, e.g., Matthew Zinn, *Adapting to Climate Change: Environmental Law in a Warmer World*, 34 *ECOLOGY L.Q.* 61, 74 (2007); Frank C. Tanser et al., *Potential Effect of Climate Change on Malaria Transmission in Africa*, 362 *LANCET* 1792, 1797 (2003) (finding a correlation between climate change and a rise in malaria in Africa that projects a 5%-7% increase of altitudinal exposure to malaria with an accompanying 16-28% increase in overall exposure by 2100); Jonathan Patz, *Impact of Regional Climate Change on Human Health*, 438 *NATURE* 310, 311 (2005) (noting infectious agents such as protozoa, bacteria and viruses and their associated vector organisms have reproduction and survival highly impacted by temperature).

<sup>56</sup> Patz, *supra* note 55, at 313.

<sup>57</sup> Andrew Jack, *Climate toll 'to Double Within 25 Years'*, *FINANCIAL TIMES* Apr. 24, 2007, [http://www.ft.com/cms/s/0/054ff7ca-f282-11db-a454-000b5df10621.html?nclick\\_check=1](http://www.ft.com/cms/s/0/054ff7ca-f282-11db-a454-000b5df10621.html?nclick_check=1).

<sup>58</sup> Patz, *supra* note 55, at 311 (noting also that “[i]n the UK, the monthly incidence of food poisoning is most strongly associated with the temperatures occurring in the previous two to five weeks”).

<sup>59</sup> Heather Cooley, *Floods and Droughts*, in *THE WORLD WATER 2006-2007* at 91, 106-08 (Peter Gleick ed. 2006).

<sup>60</sup> See *Id.* See also UN ECON. COMM’N FOR EUROPE, GUIDANCE ON WATER AND ADAPTATION TO CLIMATE CHANGE, ECONOMIC 7 (2009) [*hereinafter* UNECE Guidance on Water and Climate Change], available at [http://www.unece.org/env/documents/2009/Wat/mp\\_wat/ECE\\_MP.WAT\\_30\\_E.pdf](http://www.unece.org/env/documents/2009/Wat/mp_wat/ECE_MP.WAT_30_E.pdf). (noting that between 2000-2006, the global frequency of disaster resulting from “extreme climate events” increased by 187% as compared with the previous decade; between 2000-2008, disasters from “extreme climate events” caused the deaths of 33,000 people and affected another 1.6 billion, and resulted in more than US\$25 billion in global economic damages).

between 22,000–45,000 heat-related deaths, is but a warning of the types of maladies that will likely beleaguer humanity in the coming decades.<sup>61</sup>

#### D. ECOSYSTEMS, HABITATS AND SPECIES

Another consequence of climate change will be its impact on ecosystems and habitats worldwide. Predictions of the effects of climate change on terrestrial biodiversity suggest that over the next 50 years, between 15% and 37% of terrestrial species will become extinct.<sup>62</sup> Recent studies indicate that warming waters could result in the loss of up to 40% of Northwest salmon and 60% of western trout populations in the United States.<sup>63</sup> Another study predicts a loss of fish biodiversity as high as 75% by 2070 in 52 rivers around the world due to a reduction in river discharges, especially where combined with an increase in consumptive human uses.<sup>64</sup>

Projected climate change consequences are not limited only to changes in water temperatures and volumes. Scientists also expect significant impacts on the physical, chemical, and biological traits of fresh water ecosystems worldwide.<sup>65</sup> This is evidenced by already-documented changes that show rising temperatures in surface waters of lakes and rivers, warming hypolimnetic layers of large lakes, retreating ice-cover in northern and high altitude lakes, decreasing stream flows and lake levels in southern regions, changing chemical and biological characteristics of lakes at various elevations, and variations in life-cycles and geographical ranges of certain species.<sup>66</sup> These changes in the

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<sup>61</sup> Patz, *supra* note 55, at 310; WHEN WARMING AFFECTS HEALTH, *supra* note 5, at 46 (asserting that “as average temperatures climb, there will be more frequent and longer heat waves of the sort that contributed to the death of at least 20,000 Europeans in August 2003”).

<sup>62</sup> See Chris Thomas et al., *Extinction Risk From Climate Change* 427 NATURE 145 (2004). See also Bryan Walsh, *The New Age of Extinction*, TIME, Apr. 13, 2009, at 43-50 (describing the impact of climate change on species survival and extinction and suggesting that as many as 20-30% of all species on Earth may disappear by the end of the century).

<sup>63</sup> See US Global Climate Change Impacts, *supra* note 10, at 87.

<sup>64</sup> See Marguerite Xenopoulos et al., *Scenarios of Freshwater Fish Extinctions From Climate Change and Water Withdrawal*, 11 GLOBAL CHANGE BIOLOGY 1557, 1561 (2005).

<sup>65</sup> See generally Jani Heino et al., *Climate Change and Freshwater Biodiversity: Detected Patterns, Future Trends and Adaptations in Northern Regions*, 84 BIOLOGICAL REV. 39 (2009); Craig 2, *supra* note 16, at 12 (noting that an increase in water temperatures also affects the chemical reactivity of water and its components and explains that warmer waters reduce a water body’s ability to hold dissolved oxygen and, thereby, its ability to support animal life).

<sup>66</sup> See Rick Battarbee, *Climate Change and Projection on Water Quality Changes in Europe Aquatic Ecosystem Responses to Climate Change: Past, Present and Future*, in INTERNATIONAL

characteristics of fresh water ecosystems have already had, and will continue to have, a drastic effect on flora and fauna, especially species that are environmentally sensitive and limited in their ability to migrate or adapt.<sup>67</sup>

Regions that the IPCC projects to endure higher water temperatures and increased precipitation will likely see an increase in water pollution from sedimentation, nutrients, agricultural chemicals, and dissolved organic substances.<sup>68</sup> As a result, algal blooms, bacteria, and fungi content will flourish, further challenging sensitive species and altering the delicate balance of ecosystems and habitats.<sup>69</sup>

An increase in the intensity of rain events will foster soil erosion, which will increase the volume of suspended solids in lakes and reservoirs.<sup>70</sup> According to the IPCC, this will result in greater amounts of pathogens and other dissolved pollutants being transported to surface and ground waters and will further degrade water quality. The more intense rainfall also could tax existing sewer and water treatment facilities, thereby allowing polluted water into the environment.<sup>71</sup>

### E. WATER, SECURITY, AND CONFLICT

The link between water and a nation's security has long been argued to be a potential source of international conflict: "Because international freshwater is shared, unequally divided, scarce, and has the potential of being mismanaged, nations often have two choices: conflict or cooperation."<sup>72</sup> In January 2008, while addressing business leaders at the World Economic Forum at Davos, Switzerland, UN Secretary

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WORKSHOP: CLIMATE CHANGE IMPACTS ON THE WATER CYCLE, RESOURCES AND QUALITY RESEARCH-POLICY INTERFACE – SCIENTIFIC AND POLICY REPORT 71 (Moren-Abat, Marta, et al. eds., 2007), available at <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.113.178&rep=rep1&type=pdf#page=71>.

<sup>67</sup> See IPCC Technical Paper, *supra* note 1, at 53; cf. Xenopoulos, *supra* note 64, at 1557 (describing the potential impact of climate change on fresh water fish).

<sup>68</sup> IPCC Technical Paper, *supra* note 1, at 53.

<sup>69</sup> *Id.* at 53.

<sup>70</sup> *Id.* at 54.

<sup>71</sup> *Id.*

<sup>72</sup> Shlomi Dinar, *Water, Security, Conflict, and Cooperation*, 22 SAIS REV. 229, 248 (2002); see also Jaitly, *supra* note 34, at 27 (asserting that "[c]onventional wisdom suggests that distribution of natural resources in the context of scarcity conditions would in all probability create a conflict situation").

General Ban Ki-moon cautioned that water scarcity could spell an increase in future conflicts, and added that “[p]opulation growth will make the problem worse. So will climate change. As the global economy grows, so will its thirst. Many more conflicts lie just over the horizon.”<sup>73</sup>

Between 1800 and 1995, the global per capita availability of water declined from an annual 40,000 m<sup>3</sup> per person to 6840 m<sup>3</sup> per person merely as a result in the growth of human population; by 2025, it is estimated to decrease further to 4692 m<sup>3</sup> per person.<sup>74</sup> Geographically, though, water is very poorly distributed—in patterns that do not correlate with population size or needs. For example, while Canada enjoys an enviable annual availability of 91,420 m<sup>3</sup> of water for each of its 32 million citizens, Algeria, which has a similar sized population, has a mere 440 m<sup>3</sup> per year for each of its citizens.<sup>75</sup> Moreover, while countries in the Middle East and North Africa are home to 5% of the world’s population, they possess less than 1% of the world’s usable fresh water resources.<sup>76</sup>

While population growth and development are principal factors in assessing per capita availability of water in the future,<sup>77</sup> scientists

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<sup>73</sup> UN News Centre, *At World Economic Forum, Ban Ki-moon Pledges Action on Water Resources*, Jan. 24, 2008, <http://www.un.org/apps/news/story.asp?NewsID=25398&Cr=davos&Cr1>. It is noteworthy that the Secretary General’s predecessor, Kofi Annan, warned in 2001 that “fierce competition for fresh water may well become a source of conflict and wars in the future.” David Michel, *A River Runs Through It: Climate Chance, Security Challenges, and Shared Water Resources*, in *TROUBLED WATERS: CLIMATE CHANGE, HYDROPOLITICS, AND TRANSBOUNDARY RESOURCES* 73, 76 (D. Michel and A. Pandya eds., 2009), available at <http://www.stimson.org/rvproto/partner.cfm?SN=RV200902021934>.

<sup>74</sup> Nils Petter Gleditsch et al., *Conflict Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries*, 25 *POL. GEOGRAPHY* 361, 363 (2006) (describing the dwindling availability of water resources as a function of the growing global human population, albeit incorrectly in terms of “runoff” rather than total [surface and ground water] fresh water resources); UNITED NATIONS ENVIRONMENTAL PROGRAMME, *VITAL WATER GRAPHICS* (2008), <http://www.unep.org/dewa/vitalwater/article28.html> (noting that global water availability decreased from 12,900 m<sup>3</sup> per capita per year in 1970, to 9,000 m<sup>3</sup> in 1990, and to less than 7,000 m<sup>3</sup> in 2000, and that availability is projected to drop to 5,100 m<sup>3</sup> per capita per year by 2025).

<sup>75</sup> UNITED NATIONS, *WATER: A SHARED RESPONSIBILITY – THE UNITED NATIONS WORLD WATER DEVELOPMENT REPORT 2*, at 132 (2006) (detailing the annual per capita availability of water for every nation on Earth).

<sup>76</sup> See Gleditsch, *supra* note, at 363.

<sup>77</sup> Paul R. Hensel et al., *Conflict management of Riparian Disputes* 25 *POL. GEOGRAPHY* 383, 386 (2006) (citing to various scholars who suggest that the growth in the global population and economic activity, including agricultural production, will decrease the availability of fresh water and increase the potential for conflict).

expect climate change to exacerbate the inequity of water availability and distribution. Over the next 40 years, experts predict that climate change-induced water scarcity will affect river discharge in every populated basin on the planet.<sup>78</sup> As noted above, the perennial drainage of the Orange River in southern Africa, as well as many of the Alps-fed central European rivers, are expected to decline by one-half<sup>79</sup> and of the Euphrates by more than one-third.<sup>80</sup> By 2030, nearly one-half of the world's population will live in areas suffering from high water stress, most of which will be found in the developing world.<sup>81</sup>

A lack of adequate water supplies could have a significant impact on the ability of people and nations to ensure their economic and social development as well as to maintain their accustomed standard of living.<sup>82</sup> Reduced precipitation and water flows could enhance droughts and scarcity, thereby diminishing agricultural productivity, endangering public health, impacting migration and settlement patterns, and placing considerable strain on livelihood and social well-being. Similarly, increased rain events and water flows could produce destructive floods that jeopardize human lives, raze crops and habitats, force human relocation, and damage the social fabric of communities. As a result,

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<sup>78</sup> Michel, *supra* note 73, at 73.

<sup>79</sup> See *supra* note 24 and accompanying text.

<sup>80</sup> See *supra* notes 34. See generally *supra* note 25 and accompanying text.

<sup>81</sup> Michel, *supra* note 73 at 73 (noting that by 2030, approximately 3.9 billion people, mostly in the developing world, will live in basins experiencing high water stress); UNDP, *supra* note 21, at 136 (suggesting that by 2025, "more than 3 billion people could be living in water-stressed countries"). While there are various standards to define water stress, the Falkenmark water stress index is one of the more widely accepted standards. Using a per capita minimum of 100 liters per day for basic health and household needs (s.a., cooking, drinking, and washing), and then allocating a multiplier to account for agriculture, industry, and energy production, this scale suggests that at a level of 1,700 m<sup>3</sup>/person/year, water problems are unlikely. It then defines moderate water stress as ranging between 1,700 and 1,000 m<sup>3</sup>/person/year; and high water stress as below 1,000 m<sup>3</sup>/person/year. High water stress is described as chronic water shortages that negatively impacts human health, economic development, and general well-being. Below 500 m<sup>3</sup>/person/year, the level of water stress is considered a serious constraint on human life and development. See Malin Falkenmark, *The Massive Water Shortage in Africa: Why isn't it Being Addressed?* 18 *AMBIO* 112, 115-16 (1989); see also Malin Falkenmark & Carl Widstrand, *Population and Water Resources*, 47 *POPULATION BULL.* 2, 19, 25 (1992)

<sup>82</sup> Campbell, *supra* note 51, at 56. Campbell asserts that:

"In the developing world, even a relatively small climatic shift can trigger or exacerbate food shortages, water scarcity, destructive weather events, the spread of disease, human migration, and natural resource competition. These crises are all the more dangerous because they are interwoven and self-perpetuating: water shortages can lead to food shortages, which can lead to conflict over remaining resources, which can drive human migration, which, in turn, can create new food shortages in new regions." *Id.*

competition for fresh water resources could spur confrontation in an effort to ensure survival.<sup>83</sup> A number of scholars, and even the UN General Secretary, have suggested that water-based, and possibly climate change-related, conflicts have already manifested in places like Darfur.<sup>84</sup>

The Nile River Basin is one area that may be particularly sensitive to climate-induced water scarcity. 95% of the fresh water reaching Egyptian soil originates outside that country's borders, while 86% of the Nile's waters originate in the Ethiopian Highlands where climate change impacts on the El Nino cycle are still unclear.<sup>85</sup> Moreover, United Nations projections for the region indicate that between 2005 and 2050, Egypt's population will expand from 77 million to 129 million, while Ethiopia will grow from 74 million to nearly 174 million.<sup>86</sup>

The overlay of climate change on this already water-stressed region could further aggravate the basin's historically strained relations. According to the IPCC, between 1972 and 1987, the Nile River basin experienced a reduction in runoff of 20% and numerous interruptions in hydropower generation resulting from severe droughts.<sup>87</sup> Moreover, in its First National Communication to the UN Framework Convention on Climate Change, the Egyptian Government stated that by 2050 climate change could deteriorate productive agricultural lands in Egypt to the

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<sup>83</sup> See *Id.* at 60 (asserting that "water scarcity . . . shapes the geopolitical order when states engage in direct competition with neighbors over shrinking water supplies); Michel, *supra* note 73, at 74.

<sup>84</sup> See Mohamed Hamid, *Climate Change in the Arab World: Threats and Responses*, in TROUBLED WATERS, *supra* note 18, at 45, 49. Similarly, UN Secretary General Ban Ki-Moon has argued that the Darfur crisis "grew at least in part from desertification, ecological degradation, and a scarcity of resources, foremost among them water." Ban Ki-moon, *What I Saw in Darfur: Untangling the Knots of a Complex Crisis*, WASH. POST, Sept. 14, 2007, at A13.

<sup>85</sup> Michel, *supra* note 73, at 75; see also Meehl, *supra* note 3, at 780 (explaining that "there are no clear indications at this time regarding future changes in El Niño amplitude in a warmer climate"); THE ARAB REPUBLIC OF EGYPT, INITIAL NATIONAL COMMUNICATION ON CLIMATE CHANGE, 74-5 (1999), available at: <http://unfccc.int/resource/docs/natc/egync1.pdf> [hereinafter Egypt's UNFCCC Report]. But see M. E. Elshamy et al., *Impacts of Climate Change on Blue Nile Flows using Bias-corrected GCM Scenarios*, 13 HYDROL. EARTH SYS. SCI. 551, 562 (2009) (concluding that despite a lack of consensus related to precipitation forecasts for the region, seventeen climate change models applied to river flows of the Blue Nile consistently predicted a rise in temperature of 2-5° C with an accompanying increase in evapotranspiration of 2%-14%, suggesting a substantial decrease in upper Blue Nile flows by the end of the current century).

<sup>86</sup> UN POPULATION DIVISION, WORLD POPULATION PROSPECTS: THE 2008 REVISION (2009), available at <http://esa.un.org/unpp/index.asp?panel=1>.

<sup>87</sup> INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: IMPACTS, ADAPTATION & VULNERABILITY 496-97 (James J. McCarthy et al. eds., 2001), available at [http://www.grida.no/publications/other/ipcc\\_tar/?src=/climate/ipcc\\_tar/wg2/index.htm](http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/index.htm).

extent that the country's production of barley, wheat, maize, sorghum, and soybean will decline between 18% and 27%.<sup>88</sup> A reduction in Egypt's principal source of fresh water could exacerbate that situation and further strain regional tensions.<sup>89</sup>

Similarly, in the eastern Mediterranean, one of the world's most water-scarce regions, experts suggest that climate change will act as a "threat multiplier – exacerbating water scarcity and tensions over water within and between nations linked by hydrological resources, geography, and shared political boundaries."<sup>90</sup> Studies indicate that by 2050, rainfall in the eastern Mediterranean will decline 10%–25%, as compared to current mean values.<sup>91</sup> Coupled with the expected rise in temperature and evaporation, experts assert that average storage volume of surface reservoirs in Israel will fall 25% by the end of the century.<sup>92</sup> Additionally, what rain does arrive will occur in intense rain events that will intensify surface runoff and soil erosion, causing an increase in the sedimentation of reservoirs and channels.<sup>93</sup>

Already, the effort by Israel and Jordan to "find" an additional 50 million cubic meters of potable water for Jordan has fallen by the wayside because of a decline in rainfall in the region.<sup>94</sup> With precipitation projected to fall by an additional 20% or more by the end of the century, evapotranspiration expected to rise by nearly 10%, and the

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<sup>88</sup> See Egypt's UNFCCC Report, *supra* note 85, at 64.

<sup>89</sup> Cf. Michael Klare, *The New Geography of Conflict*, FOREIGN AFF., May-June 2001, at 49, 53-5 (identifying the Nile River Basin as one of several "Possible Flash Point for Regional Conflict" – "where conflict is likely to erupt over access to or the possession of vital" natural resources); James R. Lee, CLIMATE CHANGE AND ARMED CONFLICT 133 (2009) (asserting that "[t]here appears to be an inevitable collision between Egypt's need for water, as a downstream user, and rising needs upstream to satisfy growing populations in . . . Ethiopia. There is simply not enough water to go around . . . The day will come when Egypt will use military force in . . . Ethiopia to guarantee its Nile River water").

<sup>90</sup> Friemuth, L. et al., *Climate Change: A New Threat to Middle East Security*, Prepared for the United Nations Climate Change Conference, Indonesia, Bali (EcoPeace / Friends of the Earth Middle East, December 2007).

<sup>91</sup> See Ragab Ragab & Christel Prudhomme, *Climate Change and Water Resources Management in Arid and Semi-arid Regions*, 81 BIOSYSTEMS ENG'G 3, 17-18 (2002) (reporting that rainfall in the dry summer season will decline 20-25%, and 10-15% during the winter wet period, as compared with current mean values).

<sup>92</sup> See ISRAEL, FIRST NATIONAL COMMUNICATION ON CLIMATE CHANGE 94 (2000), available at: <http://unfccc.int/resource/docs/natc/isrnc1.pdf>. By 2050, the temperature in the region is likely to rise between 2 and 2.75°C. Ragab & Prudhomme, *supra* note 91, at 3.

<sup>93</sup> See ISRAEL, *supra* note 92, at 93-94.

<sup>94</sup> Friemuth, *supra* note 90, at 16; Israel-Jordan Peace Treaty, Annex II, Water Related Matters, available at: [http://www.kinghussein.gov.jo/peace\\_annexII.html](http://www.kinghussein.gov.jo/peace_annexII.html).

continuously growing populations, the region's water stress could escalate in coming years.<sup>95</sup> As the late King Hussein of Jordan stated, water is the one issue "that could drive the nations of this region to war."<sup>96</sup>

Climate variability on international boundaries is another potential consequence of global climate change with security and conflict implications.<sup>97</sup> Floods and droughts, for example, could substantially alter the natural flow routes of rivers, sometimes in sudden avulsive alterations, but often in gradual accretive changes.<sup>98</sup> In areas where rivers and lakes provide the framework for political boundaries, those changes to river routes and lake contours can affect international borders and, as a result, raise tensions over territory as well as access and rights to water resources.<sup>99</sup>

In a similar vein, droughts also could impact international boundaries by depleting waters in transboundary rivers and lakes. The case of Lake Chad is illustrative. Over the past few decades, the lake has drastically shrunk in size and volume as a result of human withdrawals and climatic changes. Because the international boundary is demarcated in relation to the tripoint in the lake where the frontiers of Cameroon, Chad and Nigeria meet, changes to its geographical size affect the tripoint location. The lack of a definitive and stationary border has caused citizens from neighboring countries to cross borders, often

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<sup>95</sup> See Friemuth, *supra* note 90, at 13; Klare, *supra* note 89, *cf* Lee, *supra* note 91 at 136.

<sup>96</sup> See GEORGE MCGOVERN, *THE THIRD FREEDOM: ENDING HUNGER IN OUR TIME* 119 (2001).

<sup>97</sup> See Gleditsch, *supra* note 75, at 365 (describing a number of international conflicts resulting from disputes over "fuzzy" river boundaries).

<sup>98</sup> Avulsion is the abrupt and non-continuous movement of a river caused by natural conditions, such as storms, while accretion is the lateral movement of a river that occurs gradually and continuously over time, as may be caused by natural erosion. See JOHN O'BRIEN, *INTERNATIONAL LAW* 206 (2001).

<sup>99</sup> Under international law, abrupt changes due to storms and other natural phenomena – known as avulsion – do not affect a political boundary, which remains in the old channel. In contrast, gradual and natural changes – termed accretion – can legally increase or decrease a state's territory notwithstanding sovereignty. See *id* at 206. Notwithstanding, while the international law on changes by avulsion and accretion may be settled, it may be an entirely different matter where the changes are induced by climate change. If climate change is indeed a product of human action, there may be grounds to question whether climate change-induced changes to rivers routes constitute accretion. On the one hand, the changes may be described as gradual and natural; on the other, they have an unnatural and indirect source. Similarly, abrupt climate-induced changes may not constitute avulsion where they too have a human origin.

inadvertently, to fish and forage for resources, which has resulted in disputes.<sup>100</sup>

Somewhat reassuring is the work of various scholars suggesting that historically, water has been more often a source of cooperation than of conflict.<sup>101</sup> These studies indicate that, with the exception of Western Europe, arid regions are not less cooperative than other climatic regions of the world.<sup>102</sup> Yet, statistical research and historical analysis do not always provide adequate predictors of human nature. Conventional wisdom suggests that all peoples and nations have breaking points and may resort to violence when faced with significant water depletion and scarcity.<sup>103</sup> Moreover, there is compelling evidence that civilizations can collapse because of resource depletion and environmental and climatic changes.<sup>104</sup>

Ultimately, the challenge of water scarcity coupled with the consequences of climate change could create considerable security problems for nations around the world, especially those already enduring

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<sup>100</sup> See Ernest Waititu, *Diminishing Water Resources Threaten Peace: Scarcity Fosters Conflicts*, WASH. TIMES, May 26, 2009, at A3.

<sup>101</sup> See, e.g., Shira Yoffe et al., *Conflict and Cooperation over International Freshwater Resources: Indicators of Basins at Risk*, 39 J. AM. WATER RESOURCES ASS'N 1109, 1112 (2003) (suggesting that the analysis indicates that between 1948 and 1999, "cooperation over water, including the signing of treaties, far outweighed conflict over water and violent conflict in particular. Of 1,831 events, 28 percent were conflictive (507 events), 67 percent were cooperative (1,228), and the remaining 5 percent were neutral or nonsignificant"); Campbell, *supra* note 51, at 60 (contending that "water wars" are unlikely because "[w]ater does not have the economic value of a globally traded strategic commodity like oil, and to reap significant benefit from a military operation would require capturing an entire watershed, cutting supply to the population currently dependent upon it, and then protecting the watershed and infrastructure from sabotage"); Irna van der Molen & Antoinette Hilderling, *Water: Cause for Conflict or Co-operation?*, 1 ISYP J SCI. & WORLD AFF. 133, 140 (2005) ("water appears to pose a reason for transboundary co-operation rather than for war, often preventing escalation instead of causing it").

<sup>102</sup> See e.g., Yoffe, Wolf, & Giordano, *supra* note 101, at 1119 (noting the absence of a "relationship between climate and water conflict/cooperation in a basin").

<sup>103</sup> See Jaitly, *supra* note 34, at 27. Although based more on his personal experience rather than historical analysis, Ismail Serageldin, former vice president of The World bank and first chair of the Global Water Partnership, bluntly declared in 1995 that "If the wars of this century were fought over oil, the wars of the next century will be fought over water." Philip Hirsch, *Governing Water as a Common Good in the Mekong River Basin: Issues of Scale*, 1 TRANSFORMING CULTURES EJOURNAL 104 (2006), <http://epress.lib.uts.edu.au/journals/index.php/TfC/article/view/256/254>; see also Michel, *supra* note 73, at 76 (quoting former UN Secretary General Boutros Boutros-Ghali when he was yet Egypt's Minister of State for Foreign Affairs as stating that "[t]he next war in the Middle East will be fought over water, not politics").

<sup>104</sup> See generally JOSEPH A. TAINTER, *THE COLLAPSE OF COMPLEX SOCIETIES* 44-45 (1990) (describing generally the link between resources depletion and the collapse of civilizations).

a lack of adequate fresh water resources. The link between water and a nation's security cannot be underestimated. When faced with the threat of demise, it is inevitable that people will fight for their survival and stand against anyone whose actions might challenge their existence. As UN Secretary-General Ban Ki-moon warned in 2007:

The adverse effects of changing weather patterns, such as floods and droughts, and related economic costs, including compensation for lost land, could risk polarizing society and marginalizing communities. This, in turn, could weaken the institutional capacity of the State to resolve conflict through peaceful and democratic means, to ensure social cohesion, and to safeguard human rights.<sup>105</sup>

### III. ADAPTING TO WATER-RELATED IMPACTS OF CLIMATE CHANGE

Climate change will have considerable and unprecedented impacts on the supply, availability, and demand of water resources globally. This, in turn, will have serious effects on people and the environment worldwide. Humanity's ability to tolerate these consequences and to provide some measure of security for its natural surroundings will be directly related to its capacity to respond to the expected changes.

Although mitigation measures are clearly necessary components of any climate change initiative, many of the expected consequences are

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<sup>105</sup> See Ban Ki-moon, U.N. Sec. General, Statement at the Security Council Debate on Energy, Security and Climate (April 17, 2007), *available at*: [http://www.un.org/apps/news/infocus/speeches/search\\_full.asp?statID=79#](http://www.un.org/apps/news/infocus/speeches/search_full.asp?statID=79#). In that same address, during a UN Security Council debate on the impact of climate change on peace and security, the Secretary General also offered "alarming, though not alarmist" examples in which climate change could have implications for peace and security and risk possible conflict:

Extreme weather events and natural disasters, such as floods and drought, increase the risk of humanitarian emergencies, and thus the risk of instability and dislocation.

Migration driven by factors, such as climate change could deepen tensions and conflicts, particularly in regions with large numbers of internally displaced persons and refugees.

Scarce resources, especially water and food, could help transform peaceful competition into violence.

Limited or threatened access to energy is already known to be a powerful driver of conflict. Our changing planet risk making it more so. *Id.*

now inevitable.<sup>106</sup> Hence, any initiative that strives to formulate an adequate response to climate change impacts must include adaptive strategies.<sup>107</sup> Without minimizing the need for mitigation efforts, the remainder of this article will focus on legal and policy approaches nations can and should pursue in order to adapt to the coming changes. These proposals focus on state-to-state initiatives that require bilateral or multilateral implementation rather than solely domestic, unilateral action. They are intended to infuse resilience into and expand the adaptive capacity of the current transboundary water management system as a way to prepare for and respond to the expected, and unexpected, variability of climate change.

The need for resilience and adaptive capacity is a direct outgrowth of the unpredictability, the dynamic nature, and the irreversibility of climate change.<sup>108</sup> The unpredictable character of climate change is manifest in our ongoing inability to formulate clear and constructive projections of the changes currently underway.<sup>109</sup> According to the experts, those changes will continue into the foreseeable future, and beyond, and evidence the pervasive dynamism in store.<sup>110</sup> Moreover, and more ominous, is the extreme improbability of

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<sup>106</sup> See Kundzewicz, *supra* note 20, at 6 (noting that “we are already committed . . . to further warming and corresponding water-related impacts. It is therefore necessary to adapt to changes in the volume, timing and quality of water”).

<sup>107</sup> See Craig 2, *supra* note 16, at 15 (asserting that “Climate change adaptation will be necessary for at least the next several decades, and probably centuries”); UNECE Guidance on Water and Climate Change, *supra* note 60, at 11 (explaining that “[a]daptation to climate change is consequently indispensable and urgent since the climate is already changing in some respects, and mitigation will take too long to show effects”).

Mitigation and adaptation are both important responses to global climate change. The difference between the two actions are described by Craig as: “whereas mitigation efforts focus on shaping human behavior to reduce the ultimate cause of climate change – increased greenhouse gas concentrations in the atmosphere – adaptation strategies must acknowledge the abilities of species, ecosystems, and socio-ecological systems to respond to continuous alterations in baseline conditions.” Craig 2, *supra* note 16, at 15.

<sup>108</sup> See generally R. Craig 1, *supra* note 13, at I.C. (discussing the need for resilience and adaptive capacity as a “new paradigm for environmental and natural resources law in an age of climate change adaptation”).

<sup>109</sup> See J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. REV. 1, 19 (2008) (stating that “[e]ven as we learn more about the highly coupled, tightly interacting processes that comprise the climate, the likelihood is that we will realize with even greater clarity that it is inherently unpredictable”).

<sup>110</sup> P. C. D. Milly et al., *Stationarity Is Dead: Whither Water Management?*, 319 SCIENCE 573 (2008) (arguing that the paradigm of stationarity – “that natural systems fluctuate within an unchanging envelope of variability” – is no longer valid and that a new, dynamic, probabilistic

returning to some level of climatic “normalcy.”<sup>111</sup> Hence, there is tremendous need for an approach that emphasizes flexibility and adaptability and that enhances the adaptive capacity of both humanity and the natural world in response to the ongoing and forthcoming challenges of climate change.<sup>112</sup>

As a first line of consideration, Section A below examines the two contemporary cornerstone principles of international water law, equitable and reasonable utilization and no significant harm, and their applicability to water-related consequences of climate change. Section A concludes that, while important for managing transboundary water resources, the two principles offer little value for developing the type of response needed to confront the challenges of climate change. Rather, in order to meet and overcome the forthcoming challenges and their impacts on global fresh water resources, the international community must embrace fundamental adaptive reforms grounded in cooperation and trust. Sections B, C, and D proffer some of the more important of these reforms: a collaborative administration system, flexible management, and a global approach. Ultimately, this article concludes that governments and the international community will achieve an appropriate and adequate response only by acknowledging the reality that climate change is a global phenomenon that necessitates a collective and coordinated effort.

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approach to managing natural resources is required in order to account for the dynamism of the natural system).

<sup>111</sup> See H. HOLGER ROGNER ET AL., *Introduction, in CLIMATE CHANGE 2007: MITIGATION. CONTRIBUTION OF WORKING GROUP III TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE* 102 (B. Metz et al., eds., 2007), available at [http://www.ipcc.ch/publications\\_and\\_data/publications\\_ipcc\\_fourth\\_assessment\\_report\\_wg3\\_report\\_mitigation\\_of\\_climate\\_change.htm](http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm). “Irreversibility is an important aspect of the climate change issue, with implications for mitigation and adaptation responses. The response of the climate system to anthropogenic forcing is likely to be irreversible over human time scales, and much of the damage is likely to be irreversible even over longer time scales.” *Id.*

<sup>112</sup> According to the IPCC, “adaptive capacity” is described as: “the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies.” See *Climate Change 2007: Impacts, supra* note 19, at 727. Craig asserts that:

[T]he new paradigm for environmental and natural resources law in an era of climate change adaptation must be to increase the natural world’s, human society’s, socio-ecological systems’, and legal institutions’ continuing capacity to adjust to continual transformation. In other words, the overall goal of climate change adaptation law should be to increase humans’, other species’, society’s, and ecosystems’ *adaptive capacity*.

Craig 1, *supra* note 13, at II.C.

### A. A REVIEW OF TRADITIONAL PRINCIPLES OF INTERNATIONAL WATER LAW

Customary international law applicable to transboundary water resources offers a number of principles that are applicable to cross-border water issues. Those include the cornerstone doctrines binding states to an equitable and reasonable utilization of transboundary surface or ground water resources, and ensuring that their activities result in no significant harm to other riparian states. While the first principle affords all riparian states a correlative right to an equitable share of the benefits of a river and mandates that all riparians use the river equitably and reasonably,<sup>113</sup> the second limits a state's sovereign right to use its territory only to the extent that it causes no significant harm to another state.<sup>114</sup> Both principles are intended to prevent conflict and encourage cooperation by providing a normative framework that prescribes how states must act in relation to the use of transboundary waters within their territories, as well as in relation to other riparian states.

Yet, despite the near-universal acceptance for the governance of transboundary waters, the applicability and value of the principles of equitable and reasonable utilization and of no significant harm are limited in the context of climate change. Both principles focus entirely on ensuring the rights of nations rather than on responding to climatic variability; they aid in assessing liability and determining whether one

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<sup>113</sup> See Convention on the Non-Navigational Uses of International Watercourses, G.A. Res. 51/229, Art. 5, U.N. Doc. A/RES/51/229 (May 21, 1997) [hereinafter Watercourses Convention], available at [http://untreaty.un.org/ilc/texts/instruments/english/conventions/8\\_3\\_1997.pdf](http://untreaty.un.org/ilc/texts/instruments/english/conventions/8_3_1997.pdf). See generally STEPHEN C. McCAFFREY, THE LAW OF INTERNATIONAL WATERCOURSES: NON-NAVIGATIONAL USES 384-405 (2nd ed. 2007) (defining the principle of equitable and reasonable use). The principle is regarded as one of the bedrock principles of international water law. See, e.g., McCAFFREY, *supra*, at 404; Gabčíkovo-Nagymaros Project (Hung. v. Slov.), 1997 I.C.J. 7, ¶¶ 78, 85, 147, 150 (Sept. 25); Gabriel Eckstein, *Commentary on the U.N. International Law Commission's Draft Articles on the Law of Transboundary Aquifers*, 18 COLO. J. INT'L ENVTL. L. & POL'Y 537, 563 (2007) [hereinafter Eckstein 2007]; Law of Transboundary Aquifers, G.A. Res. 63/124, art. 4 & 5, U.N. Doc. A/RES/63/124 (Jan. 15, 2009), available at <http://daccessdds.un.org/doc/UNDOC/GEN/N08/478/23/PDF/N0847823.pdf?OpenElement> [hereinafter Law of Transboundary Aquifers].

<sup>114</sup> See McCaffrey, *supra* note 113, at 135 at 406-445; Corfu Channel (U.K. v. Alb.), 1949 I.C.J. 4, 22 (Apr. 9); see also Gretta Goldenman, *Adapting to Climate Change: A Study of International Rivers and Their Legal Arrangements*, 17 ECOLOGY L.Q. 741, 779 (1990) (stating that the principle of no harm is part of customary international law); Watercourses Convention, *supra* note 113, at art. 7 (recognizing the principle of no significant harm as a fundamental and substantive principle of international water law); Law of Transboundary Aquifers, *supra* note 113, at art. 6 (recognizing the principle as applying to transboundary ground water resources).

state's actions have infringed on the rights of another. But the two principles do not obligate states to manage their transboundary fresh waters in a way that minimizes climate change consequences and maximizes countries' abilities to respond effectively to this global challenge.

The principle of equitable and reasonable utilization is designed to ensure that each riparian employs only reasonable uses of transboundary waters and obtains an equitable share of the benefits of shared waters. Any use that is unreasonable or that results in an inequitable allocation of the benefits of a transboundary water body constitutes a violation of other riparian states' rights. The no significant harm principle precludes states from taking any action related to transboundary waters that would cause significant harm to the rights and interests of other riparian states.

Neither principle, though, is designed to bring countries together collectively to face the challenges of climate change; neither one seeks to allocate the benefits of and responsibilities for a transboundary fresh water resource in relation to such a challenge. While states may seek to comport their conduct to the principles, that conduct will only prevent violations of the principles rather than truly ameliorate the consequences of climate change.

Moreover, the value of the two principles is limited because the principles are structured to apply *ex post facto*—after a project has been implemented and after a violation is alleged—rather than *ex ante*—prior to or during the implementation of a water-related project. Both principles are generally interpreted as objective criteria, standards that are intended to be assessed impartially and that are immune to agreed-upon derogation. By that very nature, though, these principles become exceptionally difficult to apply *ex ante*. The objective determination of the equitable and reasonable uses of a transboundary watercourse or whether or not a particular project may result in significant harm to another state is, at best, an unworkable exercise. This is especially true where the equity and reasonableness of a water use, as well as the magnitude of the harm, are mere projections. The only possibility for applying the principles objectively *ex ante* is through the use of an impartial third party (e.g., in the context of negotiations over a prospective water project), something that has never occurred.

To achieve true objectivity the principles would have to be employed by an impartial arbiter after a violation is alleged. The

International Court of Justice did exactly that in the *Gabčíkovo-Nagymaros* case when it applied the principle of equitable and reasonable utilization and concluded that Czechoslovakia, in unilaterally diverting the Danube River and “assuming control of a shared resource . . . thereby depriv[ed] Hungary of its right to an equitable and reasonable share of the natural resources of the Danube . . .”<sup>115</sup>

In the context of climate change, though, an *ex post facto* assessment would defeat the very purpose of preventing and minimizing the consequences of climate change. While we are certainly aware that changes are occurring globally, regionally, and locally, we are only now barely beginning to understand the scope, magnitude, and duration of the consequences that will ensue. Only by employing proactive and flexible measures in our approach to climate change will we be able to formulate an adequate response to the looming challenges.

## B. COLLABORATIVE MANAGEMENT

Climate change is a worldwide phenomenon that threatens consequences on a regional and global scale. Individual state action, whether mitigating or adaptive, is unlikely to achieve the scale of relief necessary to diminish the consequences expected from this unprecedented situation. Only a concerted, collaborative, and large-scale effort based on cooperation<sup>116</sup> and an objective of developing resilience and adaptive capacity<sup>117</sup> will produce the strategies and responses needed to meet the oncoming challenge. Anything less is likely to result in disjointed efforts that exacerbate scarcity and water stress regionally and even globally.

A collaborative approach to the management of transboundary waters, as it relates to a nation’s shared fresh water resources, is directly related to the geographic and hydrologic relationship that the nation enjoys with its neighbors. It in no way internationalizes a country’s fresh water resources, but rather reflects the reality that interrelated water resources can best be managed in an integrated and collaborative

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<sup>115</sup> Gabčíkovo-Nagymaros Project, ¶ 85.

<sup>116</sup> Under international law, nations are obligated to cooperate in good faith and to collectively and peacefully seek resolution to disputes and other transboundary challenges. *See, e.g.*, Watercourses Convention, *supra* note 113, at art. 8; Law of Transboundary Aquifers, *supra* note 113, art. 7. Moreover, this principle serves as the foundation upon which to build a collaborative approach that is both concerted and viable. *See infra* Part III.B.

<sup>117</sup> *See supra* note 107-112 and accompanying text.

fashion.<sup>118</sup> Hence, one of the fundamental collaborative reforms that must be adopted by the international community is a basin approach to the management of interrelated transboundary waters.

### 1. A BASIN APPROACH TO WATER MANAGEMENT

Scholars and international organizations have long recognized the basin approach to the management of transboundary waters as the “fulcrum of water resource development.”<sup>119</sup> The paradigm is endorsed by such entities as the The World Bank,<sup>120</sup> the European Union,<sup>121</sup> and the U.N. International Law Commission (UNILC),<sup>122</sup> as well as numerous non-governmental organizations. For example, the influential 1966 Helsinki Rules on the Uses of the Waters of International Rivers, formulated by the International Law Association (ILA), encouraged a holistic, basin-wide approach to water management employing “a geographical area extending over two or more States determined by the

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<sup>118</sup> See generally Muhammad Mizanur Rahaman & Olli Varis, *Integrated Water Resources Management: Evolution, Prospects and Future Challenges*, SUSTAINABILITY: SCI., PRACTICE, & POL’Y, Spring 2005, at 15, <http://ejournal.nbii.org/archives/vol1iss1/0407-03.rahaman.html>; Torkil Jøneh-Clausen & Jens Fugl, *Firming up the Conceptual Basis of Integrated Water Resources Management*, 17 WATER RESOURCES DEV. 501 (2001); Adil Al Radif, *Integrated Water Resources Management (IWRM): An Approach to Face the Challenges of the Next Century and to Avert Future Crises*, 124 DESALINATION 145 (1999).

<sup>119</sup> Ludwig A. Teclaff, *Evolution of the River Basin Concept in National and International Water Law*, 36 NAT. RESOURCES J. 359, 387 (1996) (describing the historical development of the basin approach to transboundary water management).

<sup>120</sup> THE WORLD BANK, WATER RESOURCES MANAGEMENT, 10-11 (1993) (discussing a need for a comprehensive analysis at the river basin level), available at [http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/02/23/000178830\\_98101911251888/Rendered/PDF/multi\\_page.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/02/23/000178830_98101911251888/Rendered/PDF/multi_page.pdf).

<sup>121</sup> See, e.g., Council Directive 2000/EC/60, 2000 O.J. (L 327/1) (EC), available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF> (defining the geographic unit of management as the river basin, and defining the river basin in Article 2(13) as “the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta”); see also DG ENVIRONMENT, EUROPEAN COMMISSION, WATER NOTE 1 – JOINING FORCES FOR EUROPE’S SHARED WATERS (March 2008), available at [http://ec.europa.eu/environment/water/water-framework/pdf/water\\_note1\\_joining\\_forces.pdf](http://ec.europa.eu/environment/water/water-framework/pdf/water_note1_joining_forces.pdf) (noting that “[t]he directive establishes an innovative approach for water management based on river basins, the natural geographical and hydrological units”).

<sup>122</sup> See Gabriel Eckstein, *A Hydrogeological Perspective of the Status of Ground Water Resources Under the UN Watercourses Convention*, 30 COLUMBIA. J. ENVT’L L. 525, 530-538 (2005) [*hereinafter* Eckstein 2005] (describing the evolution of debates in the UNILC’s development of the jurisdictional scope of the 1997 Watercourses Convention, which settled on the basin-like “watercourse” as the geographic unit for managing transboundary fresh water resources).

watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus.”<sup>123</sup>

Despite such broad support, states have not universally embraced the approach. For example, in the early work of the UNILC that eventually led to the development of the 1997 U.N. Convention on the Non-Navigational Uses of International Watercourses (Watercourses Convention),<sup>124</sup> numerous countries objected to the drainage-basin concept as the geographic unit for managing transboundary waters on the grounds that it could be interpreted as an infringement of a nation’s sovereignty.<sup>125</sup> The geographic scope eventually adopted in the Watercourses Convention was the “watercourse,” which was defined as “a system of surface waters and ground waters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus.”<sup>126</sup> While conceptually very similar to the basin approach, the Convention has yet to enter into force, suggesting a possible lack of support for the propositions and principles contained in the treaty, including the watercourse perspective.

The reluctance of some states notwithstanding, the basin approach to managing shared fresh water resources is possibly the most critical aspect of transboundary water management. It is grounded in the doctrine of hydrological unity, which recognizes the interrelationship of all hydraulically linked surface and ground waters within the hydrologic cycle.<sup>127</sup> Moreover, it acknowledges that the “most effective way to use, regulate, manage, and conserve shared water resources is through a comprehensive scheme that takes into account all interrelated water

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<sup>123</sup> INTERNATIONAL LAW ASSOCIATION, REPORT OF THE FIFTY-SECOND CONFERENCE HELD AT HELSINKI, art. II (1967) [hereinafter Helsinki Rules].

<sup>124</sup> Watercourses Convention, *supra* note 113.

<sup>125</sup> Asit K. Biswas, *Management of International Waters: Opportunities and Constraints*, 15 WATER RESOURCES DEV. 429, 438 (1999); *see also* Eckstein 2005, *supra* note 116, at 531-32 & 534-535 (describing the opposition to the basin approach that was founded, in part, in the classical conflict between upstream and downstream states).

<sup>126</sup> Watercourses Convention, *supra* note 113 at art. 2(a).

<sup>127</sup> *See* Yoram Eckstein and Gabriel Eckstein, *Groundwater Resources and International Law in the Middle East Peace Process*, 28 WATER INT’L 154, 159-60 (2003) [hereinafter Eckstein & Eckstein 2003b] (discussing the doctrine of hydraulic unity); *see also* THE WORLD BANK, *supra* note 120, at 40 (noting that “[i]nvestments, policies, and regulations in one part of a river basin or in one sector affect activities throughout the basin”). The doctrine of hydraulic unity is related to the concept of conjunctive use, which concerns the combined use of surface and ground water to optimize resource use and minimize adverse effects of using a single source. *See* C.W. FETTER, APPLIED HYDROGEOLOGY 538-40 (3d ed. 1994) (discussing conjunctive use of surface and ground water).

resources.”<sup>128</sup> As the UNILC noted, “[b]ecause the surface and groundwaters form a system, and constitute by virtue of their physical relationship a unitary whole, human intervention at one point in the system may have effects elsewhere within it.”<sup>129</sup>

The Aral Sea tragedy is but one of many examples in which independent human activity in one region of the basin had disastrous consequences in another part of the basin.<sup>130</sup> In that debacle, under the guidance of the Soviet Union, some of the nations of the sister rivers of the Amu Darya and Syr Darya diverted their waters for agricultural purposes beginning in the middle of the last century.<sup>131</sup> By the 1980s, inflows from the two rivers into the Aral Sea fell by as much as 85%, and in some years, no water passed through the lower reaches of the Amu and Syr Darya rivers.<sup>132</sup> As a result, the Aral Sea—a terminal, inland lake, which relies on the two rivers for its entire inflow—nearly dried out entirely. By the early part of this century, the Aral Sea had lost one-half of its surface area and 75% of its volume causing the lake to split into two lake segments.<sup>133</sup> While recent reforms have witnessed the

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<sup>128</sup> Eckstein & Eckstein 2003b, *supra* note 127, at 159.

<sup>129</sup> *Report of the International Law Commission on the Work of its Forty-Sixth Session*, [1994] 2 Y.B. INT'L L. COMM'N, 90, ¶ 4, U.N. Doc A/49/10.

<sup>130</sup> The Aral Sea is a salt-water lake situated along the borders of Uzbekistan and Kazakhstan and was once the world's fourth largest inland body of water. 1 THE NEW ENCYCLOPEDIA BRITANNICA, MICROPEDIA 514 (15th ed 2005).

<sup>131</sup> See Max Spoor, *The Aral Sea Basin Crisis: Transition and Environment in Former Soviet Central Asia*, 29 DEV. AND CHANGE 409, 410 (1998) (noting the significance of agriculture in decisions to divert and continue diverting the Amu Darya and Syr Darya rivers).

<sup>132</sup> See *id.* at 418 (discussing the drop of inflow from the two Darya rivers into the Aral Sea from 45-55 km<sup>3</sup> annually in 1960, an average of 7 km<sup>3</sup> by the early 1980s).

<sup>133</sup> See Ilan Greenberg, *A Vanished Sea Reclaims its Form in Central Asia: Aral Dam Project Surpasses Expectations*, INT'L HERALD TRIB., Apr. 6, 2006, at 2; Ragab & Prudhomme, *supra* note 91, at 24. Another byproduct of the depletion of the Aral Sea is the release of salts stored in the bed of the lake that were exposed as the waters receded. As the waters vanished, the salts, which are now laced with herbicides, pesticides, and other chemicals from modern agricultural practices, became exposed to the elements and were blown throughout Central Asia poisoning the land. See Tom Bissell, *Eternal Winter: Lessons of the Aral Sea Disaster*, HARPER'S MAG., Apr. 1, 2002, at 41; Spoor, *supra* note 131, at 410. By 2001, the United Nations had estimated that salinization of soils had damaged 46 percent of Uzbekistan's irrigated lands. Sabrina Tavernise & David L. Stern, *Old Farming Habits Leave Uzbekistan a Legacy of Salt*, N.Y. TIMES, June 15, 2008, at A6. As a result of the depleted lake and salt damage, the region's fishing industry collapsed, disease rates soared, the land became untenable, summer temperatures spiked (due to the loss of heat absorption that the Sea previously provided), and of the 178 animal species that had historically been found in the Aral Sea region, only 38 survive today. Bissell, *supra* note Bissell, at 41; Martin Fletcher, *The Return of the Sea*, TIMES (LONDON), June 23, 2007, at 48.

revitalization of the northern lake,<sup>134</sup> the larger southern section continues to wither due to the unsustainable and destructive activities of the upstream states.<sup>135</sup>

By following a holistic, basin approach to the management of a transboundary watercourse, countries of each basin will be better able to respond to the challenges of climate change and avoid similar ecological disasters. They will be able to formulate and coordinate both short-term and long-term strategies, as well as develop local, national, and basin-level priorities for managing the shared waters. They will also be able to develop plans for alternative scenarios that best prepare them for the possible consequences of climate change. Ultimately, basin countries will not only gain the ability to pool their resources to maximize the benefits of the shared waters, they will also gain the ability to collectively shoulder the expected burdens of climate change.

Certainly, such an approach could be construed as an affront to sovereignty, especially where one or more nations is expected to bear a larger share of the costs, or where greater benefits might accrue to some but not to all nations in the basin. Notwithstanding the slight to nationhood, such will be the price for minimizing the consequences of climate change that any one country suffers and for maximizing the benefits that each country derives from the watercourse.<sup>136</sup>

In regions expecting prolonged and substantial droughts, such as those in the sub-tropics and mid-latitudes, basin states should work together to expand opportunities for capturing what little rainfall does arrive. Such cooperation could include programs and technologies for harvesting rainwater as well as for diverting and managing runoff.<sup>137</sup> Basin states should also collectively explore means for producing new water, such as through desalination technologies,<sup>138</sup> as well as enhancing storage potential by constructing new and expanding existing

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<sup>134</sup> Greenberg, *supra* note 133, at 2; Fletcher, *supra* note 133, at 48.

<sup>135</sup> See Fletcher, *supra* note 133, at 48; Tavernise & Stern, *supra* note 133.

<sup>136</sup> Cf. Vivekanandan and Nair, *supra* note 18, at 10 (discussing the need to develop burden- and benefit-sharing mechanisms).

<sup>137</sup> See generally Troy Payne & Janet Neuman, *Remembering Rain*, 37 ENVTL. L. 105 (2007).

<sup>138</sup> See Ragab & Prudhomme, *supra* note 91, at 31 (suggesting various “innovative solutions” for the expected problems associated with climate change, including desalination techniques).

reservoirs,<sup>139</sup> developing aquifer storage and recovery opportunities,<sup>140</sup> and exploring other possibilities.

In contrast, countries that share basins that are likely to see an increase in precipitation, such as those in the tropical regions and higher latitudes, could band together to manage the expected flood waters through diversion schemes, protection and enhancement of wetlands designed to absorb naturally large volumes of water, and staggered dams to minimize the destructive effects of massive deluges. Of course, scientists expect regions, such as the Mekong and the Vistula river basins, to endure the extremes of both floods and dry spells depending on the season.<sup>141</sup> It is imperative for countries in these parts of the world, particularly those that are less developed and have fewer resources, to work along with their basin neighbors toward collective action.

## 2. JOINT INSTITUTIONAL MECHANISMS

Institutional mechanisms have been installed in numerous transboundary river basins around the world for the purpose of managing and allocating shared waters, coordinating development and conservation activities, and protecting aquatic environments for human and environmental health.<sup>142</sup> Yet, in comparison with the number of

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<sup>139</sup> See IPCC Technical Paper, *supra* note 1, at 12 (contending that many states may find it beneficial to increase storage behind dams because of the expected increase in the variability of temporal runoff resulting from climate change).

<sup>140</sup> Aquifer storage and recovery refers to the use of existing aquifers to store large quantities of water for use when other sources are unavailable. This storage technique, in many cases, is more preferable to water storage in surface reservoirs as dams and reservoirs, the traditional means for water storage, tend to have high rates of evaporation, sediment accumulation, environmental consequences, and other costs. Additionally, the decreasing availability of suitable sites for dam projects, coupled with the enormous construction costs and the limited lifespan, indicate that subsurface storage of fresh water may be a preferable solution in many parts of the world, especially those that are water-scarce and drought-plagued. See Herman Bouwer, *Integrated Water Management: Emerging Issues and Challenges* 45 AGRIC WATER MGMT 217, 220 (2000) (discussing the costs and benefits associated with surface and underground storage of water). See generally S.R. Barnett et al., *Aquifer Storage and Recharge: Innovation in Water Resources Management*, 47 AUSTL J. OF EARTH SCI. 13 (2000) (describing successful use of aquifer storage and recovery for stormwater and treated sewerage effluent, previously regarded as waste).

<sup>141</sup> See *supra* note 31-32 and accompanying text.

<sup>142</sup> See generally Stephen Schwebel, *Third Report on the Law of the Non-navigational Uses of International Watercourses*, U.N. Doc. A/CN.4/348, reprinted in 2(1) Y.B. Int'l L. Comm'n 175-180 (1982), A/CN.4/SER.A/1982/Add.1 (discussing the widespread use and support for "permanent institutional machinery" for the management of transboundary watercourses) and Stephan C. McCaffrey, *Sixth Report on the Law of the Non-Navigational Uses of International Watercourses*, U.N. Doc. A/CN.4/427 (1990), reprinted in [1990] II Y.B. Int'l L. Comm'n 41-

transboundary surface and ground water resources found on the planet, coordinated management of shared waters is still an uncommon occurrence.<sup>143</sup> The result has been significant inefficiencies in the management and conservation of shared waters, as well as occasional conflicts, which, in turn, has detrimentally impacted economic development, the environment, human health, and international relations.<sup>144</sup>

*a. Benefits of Joint Institutional Mechanisms*

Although there is no ideal model for managing an international watercourse, lake, or aquifer, the development of a joint institutional mechanism can provide unique benefits and opportunities for enhancing the ability of basin riparians to respond to climate variability. Most directly, the ability of riparian states to collectively shoulder the financial and resource burdens of research, preventative measures, emergency response, and development projects clearly supports the institutionalization of a collaborative approach to the management of shared water resources. Such a mechanism could also benefit participating states by creating an institution with the dexterity and capacity to respond to the needs of the basin in meeting the challenges

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52, U.N. Doc. A/CN.4/SER.A/1990/Add.1 (Part 1) [*hereinafter* McCaffrey's Sixth Report] (supplementing Schwebel's Third Report).

<sup>143</sup> Of the world's 263 international watercourses, 60% (158 transboundary river basins) have no cooperative management framework. Moreover, of the 105 international basins that employ some type of water management institutions, less than 20% of those basins with more than three riparians have multilateral agreements involving all of the riparians. See UN ENVIRONMENTAL PROGRAMME, ATLAS OF INTERNATIONAL FRESHWATER AGREEMENTS 7 (2002); see also McCaffrey's Sixth Report, *supra* note 142, at 43, ¶5 (referring to a 1979 list, compiled by the Secretariat of the United Nations, that identified 90 bipartite and multipartite commissions concerned with the non-navigational uses of international watercourses). And of the 273 known transboundary aquifers worldwide, only one has such a framework – the Genevese Aquifer, See Convention relative a la protection, a l'utilisation, a la realimentation et au suivi de la Nappe Souterraine Franco-Suisse du Genevois, 1 January 2008, available at <http://www.internationalwaterlaw.org/documents/regionaldocs/2008Franko-Swiss-Aquifer.pdf> (original French), and <http://www.internationalwaterlaw.org/documents/regionaldocs/2008Franko-Swiss-Aquifer-English.pdf> (unofficial English translation) – while two others have a basic data sharing agreements. See Eckstein & Eckstein 2003a, *supra* note 14, at 227 (explaining that the Genevese Aquifer agreement between France and Switzerland is the only international agreement that directly addresses a transboundary aquifer).

<sup>144</sup> See THE WORLD BANK, *supra* note 120, at 38 (stating that “coordinated management of international river basins is still rare, resulting in economic losses, environmental degradation, and international conflict”).

posed by climate change. By coordinating and collaborating together via a single entity, the parties will be able to generate more data and information, enhance their collective expertise in basin characteristics and management, and develop a cadre of managers and experts who have a unique knowledge of the particular basin. In so doing, they will also enhance their ability to respond to changing climatic conditions, such as extreme droughts and flood events, and to meet the needs of the region.<sup>145</sup>

*b. Structure of Joint Institutional Mechanisms*

The mere creation of a joint institutional mechanism is unlikely to result in all of the benefits and promises of such a system. The success of such entities will be greatly dependent on three chief factors: (1) the extent and scope of authority assigned to the institution; (2) the degree of flexibility afforded the institution in its operation, planning, and project implementation; and (3) the financial and other support provided to the institution by the riparian governments.

1) Authority

Nations are typically reluctant to undermine their sovereignty by delegating decision-making authority to a supranational entity.<sup>146</sup> This is particularly evident in the absolutist position that most countries have adopted with regard to natural resources located within their territory. For example, the United Nations General Assembly resolution on Permanent Sovereignty over Natural Resources asserts that every nation enjoys complete sovereignty over all natural resources found within its jurisdiction.<sup>147</sup> The thought that a nation would be willing to relinquish some aspect of that dominion is absurd to many national governments.

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<sup>145</sup> See Frank G.W. Jaspers, *Institutional Arrangements for Integrated River Basin Management*, 5 WATER POL'Y 77, 81-83 (2003) (discussing several justifications for integrating transboundary river basin management); see also generally Claudia Sadoff & David Grey, *Beyond the River: the Benefits of Cooperation on International Rivers*, 4 WATER POL'Y 389 (2002) (describing and analyzing the benefits derived from cooperation over international rivers).

<sup>146</sup> Nations are especially reluctant to relinquish or diminish their right to fresh water resources within their jurisdiction because "[l]ivelihoods and life itself depend on the volume and quality of available water, making water scarcity and water securities a concern of every country." Vivekanandan & Nair, *supra* note 18, at 2.

<sup>147</sup> Permanent Sovereignty over Natural Resources, G.A. Res. 1803 (XVII), 17 U.N. GAOR Supp. No. 17, U.N. Doc. A/5217 (Dec. 14, 1962). Pertinent paragraphs of the Declaration provide:

Notwithstanding this traditional view of countries' natural resources, there is a growing consensus among nations that transboundary water resources should no longer be determined by notions of sovereignty, but rather "by a positive spirit of cooperation and effective interdependence."<sup>148</sup> Moreover, there is much to be said about the nature of water that characterizes the substance as different from other natural resources and that diminishes the right of States to take an absolutist position.<sup>149</sup> This is most evident in the universal rejection of the international water law principles of absolute territorial sovereignty<sup>150</sup> and absolute territorial integrity,<sup>151</sup> both of which have long been

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1. The right of peoples and nations to permanent sovereignty over their natural wealth and resources must be exercised in the interest of their national development and of the well-being of the people of the State concerned.

5. The free and beneficial exercise of the sovereignty of peoples and nations over their natural resources must be furthered by the mutual respect of States based on their sovereign equality.

7. Violation of the rights of peoples and nations to sovereignty over their natural wealth and resources is contrary to the spirit and principles of the Charter of the United Nations and hinders the development of international co-operation and the maintenance of peace. *Id.*

<sup>148</sup> Green Cross International, National Sovereignty and International Watercourses 18 (2000), *available at* [http://webworld.unesco.org/water/wwap/pccp/cd/pdf/background\\_documents/national\\_sovereignty%20international\\_watercourses\\_2000.pdf](http://webworld.unesco.org/water/wwap/pccp/cd/pdf/background_documents/national_sovereignty%20international_watercourses_2000.pdf); Salman M.A. Salman, *The United Nations Watercourses Convention Ten Years Later: Why Has its Entry into Force Proven Difficult?* 32 WATER INT'L, 1, 12 (2007).

<sup>149</sup> *See generally* Peter Gleick, *The Human Right to Water*, 1 WATER POL'Y 5, 487 (1999) (arguing that access to water resources is a natural human right), *available at* [http://www.waterlaw.org/bibliography/articles/general/Gleick-Human\\_Rt\\_Water-1999.pdf](http://www.waterlaw.org/bibliography/articles/general/Gleick-Human_Rt_Water-1999.pdf); U.N. Econ. & Soc. Council [ECOSOC], Committee on Econ., Soc., and Cultural Rights, *Substantive Issues Arising in the Implementation of the International Covenant on Economic, Social and Cultural Rights*, ¶ 2, U.N. Doc. E/C.12/2002/11 (Jan. 20, 2003) (interpreting the International Covenant on Economic, Social and Cultural Rights to include a human right to water that "entitles everyone to sufficient, affordable, physically accessible, safe and acceptable water for personal and domestic uses"). As a human right, the obligation to provide water would be rather incompatible with profit-based operations that are typically employed in the extraction of other natural resources. *See* Eckstein & Eckstein 2003a, *supra* note 14 at 251-256 (comparing rights to water in non-recharging aquifers with rights to other fluidic natural resource like oil and gas).

<sup>150</sup> *See* McCaffrey, *supra* note 113, at 125 (asserting that the principle of absolute territorial sovereignty has been rejected by nations and scholars in international water law and politics). The principle of absolute territorial sovereignty posits that states have the right to unrestrained use of fresh water resources found within their territory, regardless of the transboundary consequences of such use. *See id.* at 113-14 (describing the principle in the context of the Harmon Doctrine).

<sup>151</sup> *See id.* at 133 (noting that the principle of absolute territorial integrity has been abandoned by scholars and the international community). The principle of absolute territorial integrity suggests that lower riparian states have the right to the undiminished and continuous flow of a river flowing into their territory from upper riparian states. *See id.* at 126.

abandoned by scholars and nations.<sup>152</sup> In their stead emerged the doctrine of limited territorial sovereignty<sup>153</sup> and the notion that transboundary fresh water resources must be used equitably and reasonably in relation to other riparians.<sup>154</sup> Arguably, these limitations on sovereignty are rooted in the unique, life-giving quality of water that make cooperation over its management so singularly important. Water, after all, is fundamental to life.

Hence, while there certainly may be appropriate limitations on the extent to which riparian nations might empower a joint supranational institution, the ability of the institution to carry out its mandate successfully will greatly depend on the degree of authority it receives.<sup>155</sup> At the very least, such authority should include jurisdiction over the entire hydrographic basin—all hydraulically-related fresh water resources in the basin<sup>156</sup>—and encompass the mandate to engage all basin riparians in ongoing dialogue, produce and exchange relevant data and information,<sup>157</sup> and coordinate activities designed to prevent and mitigate the impacts of climate change. Ideally, such authority would also include the responsibility to assess and identify the most effective

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<sup>152</sup> See *id.* at 125-26 and 133 (noting that these principles “deny that sovereignty entails duties as well as rights”).

<sup>153</sup> See *Id.* at 135 (describing the principle of limited territorial sovereignty as “the prevailing theory”). The principle of limited territorial sovereignty posits that a state’s sovereignty is limited by its obligation not to use its territory in a way that causes significant harm to other states. This doctrine has been more fully articulated in the form of the principle of no significant harm. See *supra* Part III.A.

<sup>154</sup> See McCaffrey, *supra* note 113, at 384-405; 1997 Watercourses Convention, *supra* note 113, at art. 5. The principle of equitable and reasonable use entitles each riparian state to a reasonable and equitable share in the beneficial uses of an international water resource. Essentially, the principle is a utilitarian concept employing a cost-benefit analysis that attempts to maximize the beneficial uses of limited water resources while minimizing the burdens. See Eckstein 2007, *supra* note 113, at 563-564 (defining the principle in the context of transboundary ground water resources).

<sup>155</sup> See THE WORLD BANK, *supra* note 120, at 45 (“River basin organizations can be an effective means for coordination when they have adequate authority and financial autonomy”).

<sup>156</sup> Itay Fischendler, *Legal and Uninstitutional Adaptation to Climate Uncertainty: A Study of International Rivers*, 6 WATER POL’Y 1, 3 (2004) (asserting that “Joint institutions will have greater flexibility to mitigate crisis situations if they are given control over the different parts of the hydrologic cycle, including allocation of surface water, groundwater and water quantity”); cf. E. Feitelson, *The Upcoming Challenge: Transboundary Management of the Hydraulic Cycle*, 123 WATER, AIR, AND SOIL POLLUTION 533, 547 (2000) (discussing the need for institutions at all levels of government, including international, that would be empowered to address increasingly complex transboundary water issues).

<sup>157</sup> See *infra* note 161-163 (discussing the obligation to exchange data and information) and 164-166 (discussing the obligation to monitor).

preventative and mitigatory measures and to craft the appropriate steps that each basin state must take to implement such measures.

Although the International Boundary and Water Commission (IBWC) operating on the Mexico-United States border does not have an explicit mandate to address climate change issues, it is an example of a supranational institution that enjoys an advanced level of authority and that has considerable success in pursuing its responsibilities. Composed of both a Mexican and an American section, the IBWC exercises its collaborative mandate and commitments through decisions called Minutes.<sup>158</sup> These Minutes are transmitted to the respective governments and, if neither denied by either nation within 30 days nor requiring an affirmative approval, become binding commitments.<sup>159</sup> Among other things, the IBWC has been entrusted with the following duties: investigating, planning, constructing, operating, and maintaining joint water projects, such as stream-gauging stations, storage dams and reservoirs, and hydroelectric power plants; protecting land along the Rio Grande from floods with levees and floodway projects; and settling disputes between the states over the interpretation or application of the treaty authorizing the IBWC.<sup>160</sup>

Another noteworthy basin commission with considerable authority and a history of success is the Organization for the Development of the Senegal River, known by its French acronym as OMVS.<sup>161</sup> In addition to having full legal personality, the OMVS has supranational character that allows it to plan, construct, operate, and maintain jointly-owned water projects even if located fully within one of the member states. It also has authority to develop strategy for the entire basin, and to reallocate periodically the river's water based on changes in

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<sup>158</sup> See Treaty relating to the Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande, art. 7, U.S.-Mex., February 3, 1944, 59 Stat. 1219 [hereinafter Rio Grande Treaty].

<sup>159</sup> See *id.* at art. 25; see also Alberto Szekely, *How to Accommodate an Uncertain Future into Institutional Responsiveness and Planning: The Case of Mexico and the United States*, 33 NAT. RESOURCES J. 397, 398 (1993).

<sup>160</sup> See Rio Grande Treaty, *supra* note 158, at arts. 2, 5-9, 12, 13, 23, 25; see also U.N. Educational, Scientific, and Cultural Organization [UNESCO], Institutions for International Freshwater Management, *Technical Documents in Hydrology No. 3*, 33-34 (2003) (prepared by S. Burchi and M. Spreij) [hereinafter Burchi & Sprechi].

<sup>161</sup> OMVS is the acronym for Organisation pour la Mise en Valeur du Fleuve Sénégal. The OMVS is composed of the West African nations of Guinea, Mali, Mauritania, and Senegal. The Senegal River originated in Guinea, flows northward through Mali, and then forms the border between Mauritania and Senegal as it makes its way west toward the Atlantic Ocean.

flow and availability of water in the river as well as the changing needs of the member states.<sup>162</sup>

## 2) Flexibility and Agility

To meet the challenges of climate change and to function efficiently, joint water management organizations require a flexible mandate that allows them to adapt their operations, planning, and implementation activities to changing conditions. As noted by the IPCC, while scientists are confident that global climatic changes will affect water resources worldwide, they are unable to provide precise predictions at the regional and local scales.<sup>163</sup> For example, some climate change models suggest that certain transboundary watercourses, such as the Rhine, Congo, and Indus river basins, should expect an increase in both precipitation and temperature. While the former is likely to result in more flood events, the latter could intensify evapotranspiration resulting in an increase in the frequency of droughts.<sup>164</sup>

The resulting uncertainty in predicting whether the basin should expect floods, droughts, or other climatic impacts in any given season creates considerable planning complications for the basin states and, especially, for joint water management organizations. As a result, joint institutional mechanisms must not be hampered with procedures and obligations that would constrain their ability to quickly and adeptly respond to dynamic climatic changes. Moreover, they must escape the paradigm of stationarity and develop alternative probabilistic approaches that can better respond to the variability of climate change and ensure that any negative impacts are minimized and managed.<sup>165</sup> Such approaches can incorporate flexible management systems that allow the

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<sup>162</sup> See U.N., WORLD WATER DEVELOPMENT REPORT 1: WATER FOR PEOPLE, WATER FOR LIFE, *Pilot Case Studies: A Focus on Real-World Examples, Senegal River Basin – Guinea, Mali, Mauritania, Senegal* 447, 458 (2003); Burchi and Spreij, *supra* note 160, at 14-17.

<sup>163</sup> IPCC Technical Paper, *supra* note 1, at 167 (stating that “[p]rojections of future precipitation, soil moisture and runoff at regional scales are subject to substantial uncertainty”).

<sup>164</sup> See Yukiko Hirabayashi et al., *Global Projections of Changing Risks of Floods and Droughts in a Changing Climate*, 53 HYDROLOGICAL SCI. J. 754, 769 (2008).

<sup>165</sup> “[S]tationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning.” Milly, *supra* note 110, at 573 (suggesting that the paradigm of stationarity – “the idea that natural systems fluctuate within an unchanging envelope of variability – is no longer valid, especially in light of “the magnitude and ubiquity of the hydroclimatic change apparently now under way” and recommends a dynamic, probabilistic approach for managing and optimizing water systems).

institutions to adapt their mechanisms, activities, and policies in response to changes on the ground. This type of adaptive management style is discussed further below.<sup>166</sup>

### 3) Financial and Other Support

An especially noteworthy aspect of a joint institutional mechanism that requires attention pertains to the financial and related support provided to the institution. Regardless of the authority granted to an institution, the absence of financial and other mechanisms to support and sustain the institution's activities can render the institution ineffective and irrelevant. Hence, to ensure that a joint water management mechanism can produce the expected benefits and promises, it must have the appropriate resources to carry out its mandate. This includes both financial and human resources as well as the political capital necessary to carry out policies and implement projects that may be unpopular but necessary. Accordingly, governmental support by all of the basin riparians must be secured and assured in order to allow the institution to formulate and implement effectively its responsibilities.

### 3. EXCHANGE OF DATA AND INFORMATION

The obligation to exchange data and information on a regular basis is critical to the sound management of transboundary waters.<sup>167</sup> Absent such an exchange, it becomes impossible for basin states or basin institutions to manage water uses, formulate basin-wide policies, or take measures to minimize floods, droughts, and pollution. That imperative has been codified in numerous international instruments concerning transboundary fresh water resources and has been recognized in various international fora.<sup>168</sup> This imperative is also well recognized in the

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<sup>166</sup> See *infra* note 179-187, and accompanying text.

<sup>167</sup> See THE WORLD BANK, *supra* note 120, at 43 (asserting that "inadequate and unreliable data constitute a serious constraint to developing and implementing a country's water resource strategy and to managing water effectively"); Vivekanandan & Nair, *supra* note 18, at 12.

<sup>168</sup> For a extensive list of agreements incorporating the principle, see Stephen McCaffrey, *Fourth Report on the Law of the Non-navigational Uses of International Watercourses*, 2 Y.B. INT'L L. COMM'N 205, 210 n.28 (1988) [hereinafter McCaffrey's Fourth Report]. See also See also Ludwik A. Teclaff & Eileen Teclaff, *Transboundary Groundwater Pollution: Survey and Trends in Treaty Law*, in INTERNATIONAL GROUNDWATER LAW 77, 110 (Teclaff & Utton eds., 1981) (asserting that "[t]here is no longer any question that modern treaty practice incorporates the duty

climate change context because of its variable nature and the considerable gaps that remain in knowledge, especially on the local and regional levels.<sup>169</sup>

While the type of data and information that must be exchanged is most often left to the negotiations of basin riparians, in the context of climate change and transboundary watercourses, relevant information includes scientific and technical data related to climatic conditions in the basin, the watercourse itself, and the surrounding basin environment.<sup>170</sup> Additionally, such data and information also includes knowledge of the populations and ecosystems that depend on the watercourse, current and planned water uses, and management activities including regulatory actions and conservation measures.<sup>171</sup>

A corollary to the obligation to regularly exchange data and information is the duty to monitor changing conditions related to transboundary waters.<sup>172</sup> In order to have the necessary data and information, such data and information must be generated in a consistent manner so as to provide a clear picture of the nature of the watercourse, especially in the context of climate change. Moreover, because climate change is a dynamic and long-term phenomenon, it is necessary to continuously develop and collect the data and information so that the ongoing climatic consequences on the watercourse are recorded and

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to exchange information” in the context of transboundary water agreements); Law of Transboundary Aquifers, *supra* note 113, at art. 8.

<sup>169</sup> See generally UNECE Guidance on Water and Climate Change, *supra* note 60, at 47-55 (discussing the need for information and monitoring in the climate change context).

<sup>170</sup> See UNECE Guidance on Water and Climate Change, *supra* note 60, at 52 (describing the climate change-related information needed to include meteorological data, hydrological data, morphological data, water quality data, and statistics related to these elements).

<sup>171</sup> Article 9(1) of the 1997 Watercourses Convention provides that “watercourse States shall on a regular basis exchange readily available data and information on the condition of the watercourse, in particular that of a hydrological, meteorological, hydrogeological and ecological nature and related to the water quality as well as related forecasts.” Watercourses Convention, *supra* note 113, at art. 9(1). Article 8(1) of the General Assembly Resolution on the Law of Transboundary Aquifers states that “aquifer States shall, on a regular basis, exchange readily available data and information on the condition of their transboundary aquifers or Aquifer systems, in particular of a geological, hydrogeological, hydrological, meteorological and ecological nature and related to the hydrochemistry of the aquifers or aquifer systems, as well as related forecasts.” Law of Transboundary Aquifers, *supra* note 113, at art. 8(1). See UNECE Guidance on Water and Climate Change, *supra* note 60, at 52.

<sup>172</sup> See Stephen Stec & Gabriel E. Eckstein, *Of Solemn Oaths and Obligations: The Environmental Impact of the ICJ’s Decision in the Case Concerning the Gabčíkovo-Nagymaros Project*, 8 Y.B. OF INT’L ENV’T L. 41, 48 (1997); see also, Law of Transboundary Aquifers, *supra* note 113, at art. 13.

examined.<sup>173</sup> Accordingly, basin states must be engaged in the continuous development, collection, and exchange of the relevant characteristics and conditions related to the transboundary watercourse.<sup>174</sup>

A chief concern for the management of a transboundary basin is that all basin States harmonize the methodologies, techniques, procedures, assumptions, and technologies—collectively known as metadata<sup>175</sup>—used in the generation and processing of data and information. This concern is based on the reality that there can be more than one approach or instrumentation available to assess a particular basin characteristic, such as river flow rates, chemical composition, extent of hydraulic connection between surface and ground waters, and dependent populations and ecosystems.<sup>176</sup> At times, the metadata can produce disparate results because of the multitude of factors and assumptions that go into the process of assessing the characteristic. Moreover, due to differences in education, training, experience, and preferences, the professionals employed by states producing data for a transboundary watercourse will often use different methodologies and procedures and focus on different characteristics of the basin. As a result, the data and information produced may be incompatible and, at

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<sup>173</sup> See Craig 1, *supra* note 13, at 30-31 (advocating for a principle of “Monitor[ing] and Study[ing] Everything” related to climate change).

<sup>174</sup> Former Vice-President of the International Court of Justice, Judge Weeramantry, proposed that the duty to monitor is better styled as a principle of continuing environmental impact assessment that can only be accomplished through the regular exchange of data and information. See *Gabčíkovo-Nagymaros Project (Hung. v. Slov.)*, 1997 I.C.J. 88 (Sept. 25) (Separate Opinion of Vice-President Weeramantry).

<sup>175</sup> The United States Geological Survey (USGS) describes metadata as consisting “of information that characterizes data. Metadata are used to provide documentation for data products. In essence, metadata answer **who, what, when, where, why**, and **how** about every facet of the data that are being documented.” United States Geological Survey, <http://geology.usgs.gov/tools/metadata/tools/doc/faq.html#q1.1> (emphasis in original) (last visited Feb. 12, 2009). This description relies on the definition and standard proffered for metadata by the Federal Geographic Data Committee (FGDC), an interagency committee that promotes the coordinated development, use, sharing, and dissemination of geospatial data on a national basis. FGDC defines metadata as “. . . a file of information . . . which captures the basic characteristics of a data or information resource. It represents the who, what, when, where, why and how of the resource.” Federal Geographic Data Committee, <http://www.fgdc.gov/metadata> (last visited 2/12/09).

<sup>176</sup> See Eckstein 2007, *supra* note 113, at 581. See also Gabriel Eckstein, *Protecting A Hidden Treasure: The U.N. International Law Commission and the International Law of Transboundary Ground Water Resources*, 5 SUSTAINABLE DEV. L. & POL’Y 5, 10 (2005) (discussing the problems of exchanging data and information that is incompatible or otherwise unusable by other aquifer States).

worst, may be useless for establishing cross-border, baseline characteristics in the basin and for the ongoing monitoring and assessing of subsequent changes.<sup>177</sup>

Accordingly, the harmonization of metadata among basin riparians is an imperative that must be addressed early in any collaborative effort related to climate change.<sup>178</sup> Although such technicalities may seem trivial for politicians and decision-makers, the lack of synchronized methodologies, techniques, procedures, assumptions, and technologies can undermine the collaborative approach sought and needed for responding to the threat of climate change. Moreover, an agreement on harmonization can serve as a basis upon which to build stronger basin relationships and further collaborative climate change action.

### C. FLEXIBILITY IN MANAGEMENT

While there is near-universal consensus that climate change will affect global water resources, in many cases significantly, modern science is still unable to identify precise consequences at specific locations. As a result, effective legal and policy responses to climatic impacts—both mitigation and adaptation—are difficult at best and often based on educated guesses.<sup>179</sup> Accordingly, to meet the challenges posed by climate change, nations must embrace a new paradigm of flexibility in management, one that allows mechanisms, plans, and policies to adapt in response to changes on the ground.<sup>180</sup> Moreover, they need to formulate

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<sup>177</sup> See Eckstein 2007, *supra* note 113, at 578 and 582-83 (discussing the problems of exchanging data and information, in the context of transboundary aquifers, that is incompatible or otherwise unusable by other aquifer States); UNECE Guidance on Water and Climate Change, *supra* note 60, at 65 (explaining that “[t]he use of different scenarios and GCMs by neighbouring countries could lead to differences in climate and impact projections, possibly leading to contradictory adaptation measures”).

<sup>178</sup> Cf. UNECE Guidance on Water and Climate Change, *supra* note 60, at 54 and 65 (discussing the need to coordinate and harmonize the generation of data).

<sup>179</sup> Joseph Arvai et al., *Adaptive Management of the Global Climate Problem: Bridging the Gap Between Climate Research and Climate Policy*, 78 CLIMATIC CHANGE 217, 217 (2006).

<sup>180</sup> See UNECE Guidance, *supra* note 13, at 6. One of the main messages of the UNECE Guidance document is that:

“Adaptation needs to be flexible. This is required by the uncertainties which exist about the direction and nature of change the climate is causing in hydrological systems. Interventions chosen should be flexible enough to deliver maximum benefits under a range of conditions instead of being designed for what are thought to be the ‘most likely’ future conditions. If

approaches that explicitly consider a dynamic and unpredictable environment.<sup>181</sup>

## 1. ADAPTIVE MANAGEMENT

To achieve the new paradigm of flexibility, basin states must create an environment and a transboundary regulatory structure that fosters the adoption and implementation of an adaptive management approach to the administration of transboundary waters. Adaptive management is a decision-making framework for governing water resources that incorporates uncertainty into the planning process.<sup>182</sup> It is a process of experimentation that, rather than testing hypotheses in a stilted laboratory setting, implements its trials in the real world.<sup>183</sup> Fundamentally, adaptive management necessitates both feedback and updated information, both of which are dependent on a monitoring and review process.<sup>184</sup>

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conditions change again, or if the changes prove different from those expected today, the measures taken should be capable of changing in step.”

*Id.* See also International Conference on Freshwater, Bonn, F.R.G, Dec. 3-7 2001, *Water—A Key to Sustainable Development: Recommendation for Action 1*, 7 available at <http://www.earthsummit2002.org/ic/freshwater/Bonn%20Recommendations.pdf> (last visited Feb. 18, 2009) (stating that “Decision-making mechanisms under uncertainty should ensure flexibility to respond to both rapid onset disasters and long-term changes to water resources”).

<sup>181</sup> See Milly, *supra* note 110, and accompanying text.

<sup>182</sup> Carl Bruch, *Adaptive Water Management: Strengthening Laws and Institutions to Cope with Uncertainty in WATER MANAGEMENT IN 2020 AND BEYOND* 91-92 (Asit K. Biswas, & Cecilia Tortajada, eds. 2009); J.B. Ruhl, *Regulation by Adaptive Management – Is It Possible?*, 7 MINN. J.L. SCI. & TECH. 21, 28-30, 38 (2005).

<sup>183</sup> In other words, adaptive management entails a continuous iterative management process that endeavors to learn through a process of trial and error and that adjusts its policies and actions in response to changes in circumstances and new information. Bruch, *supra* note 182, at 91; Arvai, *supra* note 179, at 218; UNECE Guidance, *supra* note 13, at 6.

<sup>184</sup> See Vivekanandan & Nair, *supra* note 18, at 9 (discussion the need for “the continuous and dynamic adjustment of management practices through monitoring and feedback mechanisms”); Ruhl, *supra* note 182, at 28-30, 38. Monitoring, in the context of assessing the implementation and effectiveness of a law, would require the periodic examination of various indicators related to the operationalization of the law, such as the process of implementing the law, the intended and unintended effects of the law, the extent to which the law achieved the targeted goals, the reasons why the law achieved or failed to achieve the targeted goals, the social, economic, and other costs associated with the operationalization of the law, and others. Likewise, there would be a need to continuously assess the underlying data upon which the law was established, which, in the context of climate change, would entail monitoring changes in weather patterns, precipitation levels, river flows, environmental impacts, and a host of other climate-related factors. Thereafter, the results of the two monitoring regimes would be reviewed in relation to the current law, and the law would be modified with the goal of improving its ability to achieve its targeted goals. Bruch, *supra* note 182, at 99-100.

In the context of legal frameworks, institutional mandates, or management practices, adaptive management entails the acceptance and incorporation of uncertainty into laws, regulations, policies, and action plans through the institutionalization of the trial and error process.<sup>185</sup> This means that any legal framework applicable to a transboundary river or aquifer must incorporate language and simple procedures allowing for periodic changes to the objectives, rights, and obligations defined in the instrument. This will allow the agreement to operate dynamically in relation and in response to new information. Likewise, any institutional mechanism authorized to operate on or manage a transboundary fresh water resource must have the capacity and authority to quickly respond to new data and information and to alter its activities, responsibilities, and objectives.

Understandably, implementing adaptive management in a transboundary context could prove difficult, not least because it would require governments and policymakers to admit to and learn from failures and mistakes in a very public process.<sup>186</sup> It also could face obstacles where the costs associated with the implementation of an experimental and adaptive approach to planning may be regarded as overly burdensome in political and social contexts, as well as in economic terms.<sup>187</sup> Moreover, implementation of adaptive management may be frustrated by the lack of accommodating domestic and transboundary legal regimes that allow flexibility in management decisions.<sup>188</sup>

Nonetheless, in light of the uncertainty of climate change, adaptive management may be one of the few viable methodologies for responding to the variability of climate change. Clearly, such an approach requires a revised political perspective in which governments and policymakers, as well as the citizenry, adopt a long-term time horizon that emphasizes a process of learning and improving policies and

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<sup>185</sup> A law, for example, would be construed as provisional to the extent that it is based on the best available or most recent evidence. Since such evidence is never complete or devoid of uncertainty, the law would be subject to periodic modification in response to an assessment of its implementation and effectiveness, as well as to new information related to the underlying data upon which it is founded. Bruch, *supra* note 182, at 93.

<sup>186</sup> Certainly, such public exposure to scrutiny would make any elected or appointed official wish to distance themselves from such management schemes. Arvai, *supra* note 179, at 218.

<sup>187</sup> Arvai, *supra* note 179, at 220.

<sup>188</sup> *Cf.* Craig 2, *supra* note 16, at 16 (discussing some of the obstacles to the implementation of adaptive management in domestic US law).

management, rather than one concerned with ideology and political gain.<sup>189</sup> Additionally, there is a strong case to be made that over the longer term, adaptive management will result in lower societal costs, especially given that inaction could prove disastrous.<sup>190</sup>

## 2. NEEDS OVER RIGHTS

In order for a flexible approach to succeed, basin states must also reassess their relationship to the basin and their neighbors, and pursue an allocation and management strategy from a needs-based approach rather than a rights-based perspective.<sup>191</sup> In contrast to a rights-based approach, which relies on the inherent right of each riparian state to obtain some measure of the benefits of a transboundary watercourse,<sup>192</sup> a needs-based approach begins the allocation analysis by assessing the minimum requirements of each state based on established and agreed-upon criteria.<sup>193</sup>

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<sup>189</sup> See generally John Dernbach, *Navigating the U.S. Transition to Sustainability: Matching National Governance Challenges with Appropriate Legal Tools*, 44 TULSA L.J. 93 (2009).

<sup>190</sup> See UNECE Guidance, *supra* note 13, at 10 (noting that “Adaptation may be costly, but it is much more cost-effective to start it now, because costs will be much higher once the effects of climate change are irreversible”); Arvai, *supra* note 179, at 221.

<sup>191</sup> See Aaron T. Wolf, *From Rights to Needs: Water Allocations in International treaties*, in, MANAGEMENT OF SHARED GROUNDWATER RESOURCES: THE ISRAELI-PALESTINIAN CASE WITH AN INTERNATIONAL PERSPECTIVE 133, 137-38 (E. Feitelson & M. Haddad eds., 2000) (discussing a shift in which treaty negotiating is becoming more needs rather than rights-based); see also Meena Palaniappan & Peter H. Gleick, *Peak Water*, in THE WORLD’S WATER: 2008-2009, at 13 (Peter H. Gleick ed., 2009) (articulating the ‘soft path’ approach to water management as moving toward a demand oriented management regime under which rather “than seek endless sources of new supply, the soft path matches water services to the scale of the users’ needs, and it takes environmental and social concerns into account to ensure that basic human needs and the need of the natural world are both met”); Oliver M Brandes, *At a Watershed: Ecological Governance and Sustainable Water Management in Canada*, 16 J. ENV. L. & PRAC. 79, 83-84 (2005) (advocating “. . .for a shift from supply-oriented to demand-oriented water management [that] emphasizes the need to manage people in the watershed and not the watershed itself” and an approach that emphasizes health watersheds as a prerequisite to water management rather than managing the watershed as an adjunct of the water supply).

<sup>192</sup> The principles of absolute territorial sovereignty and absolute territorial integrity are extreme examples of a rights approach to water management and allocation. See *supra* notes 150-51, and accompanying text. Though the principle of equitable and reasonable utilization is a more balanced methodology, it nonetheless is focused on the inherent rights of each state to some measure of the benefits of a transboundary watercourse. See *supra* note 154.

<sup>193</sup> See Wolf, *supra* note 191, at 137-38, 140-141 (describing various examples where minimum requirements for specific needs were articulated for purposes of negotiating agreements, including water for agricultural and irrigation needs, per capita consumption, and existing uses).

The notion of “vital human needs” articulated in Article 10 of the Watercourses Convention may be a valid point of departure.<sup>194</sup> It has been interpreted as referring to “sufficient water to sustain human life, including both drinking water and water required for production of food in order to prevent starvation.”<sup>195</sup> Any water or benefits remaining after such needs are met can then be allocated based on an agreed-upon legal mechanism or in accordance with a basin plan formulated to respond to the possible consequences of climate change. Such an approach requires that basin states quantify their present needs to the watercourse and, as discussed above, exchange that information.<sup>196</sup> Of course, given that populations grow and needs change over time, such assessment will require periodic updates and the distribution of basin benefits may have to be readjusted.

The chief benefit of such an approach lies in the paradigm’s emphasis on quantifying claims based on justified needs rather than on legal rights, which often can exceed available water resources. A needs-based approach to the allocation of a transboundary watercourse, especially in regions of scarcity, like the Middle East, could lessen unnecessary complications related to inchoate claims of right and abstract principles of law and allow parties to negotiate from concrete, fact-based positions. This, in turn, will allow the basin states to prioritize allocations and uses of the basin’s waters, and to manage the watercourse based on agreed-upon schemes for addressing climate change conditions.

As in the basin approach to the management of transboundary waters, this paradigm entails a relinquishment of sovereignty to the extent that riparian states must forego, at least initially, their inherent right to the equitable and reasonable use of the watercourse.<sup>197</sup> The same sovereignty arguments, however, presented in the discussion on the basin approach<sup>198</sup> and on the authority afforded to a joint water management institution apply equally to the diminution of sovereignty resulting from this paradigm shift.<sup>199</sup> Moreover, the benefits derived from such an approach, particularly those related to the minimization of disputes and

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<sup>194</sup> Watercourses Convention, *supra* note 113, at Art. 10(2).

<sup>195</sup> U.N. Gen. Assembly, 51st Sess., Sixth Comm., *Convention on the Law of the Non-Navigational Uses of International Watercourses: Report of the Sixth Committee Convening as the Working Group of the Whole*, ¶ 8, U.N. Doc. A/51/869 (Apr. 11, 1997).

<sup>196</sup> *See supra* notes 167-75 and accompanying text.

<sup>197</sup> *See supra* notes 118-41 and accompanying text.

<sup>198</sup> *See supra* notes 125-127 and accompanying text.

<sup>199</sup> *See supra* notes 146-54 and accompanying text.

the flexibility ingrained in the planning system, are likely to far outweigh any disadvantages related to sovereignty.

#### D. PRIORITIZING ADAPTATION

To date, much of the discussion surrounding climate change has focused on mitigation, in some cases, to the exclusion of adaptation. This is evident in the emphasis of both the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the Bali Action Plan on binding targets for reducing greenhouse gas emissions.<sup>200</sup> While mitigation is certainly a critical component of national and international climate change policy, many of the expected consequences of climate change are inevitable. This is especially evident in the context of global fresh water resources. Accordingly, states and the international community must expand their focus to include adaptive strategies as part of the overall climate change approach.

##### 1. INCORPORATING ADAPTATION INTO DEVELOPMENT

Development today is no longer the mere pursuit of economic growth, social progress, knowledge, or simply a better life. With climate change impacts augmenting existing nuisances and placing new obstacles in the way of the human experience, development today necessarily involves adapting to the new realities. The developmental question is no longer limited to “what can be done to advance humanity,” but rather now encompasses “how can we maintain and ensure human lives under changing environmental conditions.” This is true in both the developed and developing world, but is an especially harsh reality for peoples and nations who lack the resources and abilities to formulate appropriate adaptive strategies.

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<sup>200</sup> See Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 11, 1997, 2303 U.N.T.S. 148, [hereinafter Kyoto Protocol] available at [http://unfccc.int/essential\\_background/kyoto\\_protocol/items/1678.php](http://unfccc.int/essential_background/kyoto_protocol/items/1678.php); U.N. Framework Conv. on Climate Change, Conf. of the Parties, *Report of the Conference of the Parties on Its Thirteenth Session*, U.N. Doc. FCCC/CP/2007/6/Add.1 (Mar. 14, 2008) (adopting Bali Action Plan at 3) available at <http://www.unisdr.org/eng/risk-reduction/climate-change/docs/Bali-Action-plan.pdf>.

Accordingly, all nations must “do development differently.”<sup>201</sup> This requires governments to incorporate strategies into all of their development activities that facilitate adaptation to climatic variability and climate change.<sup>202</sup> Fundamentally, this means using a climate change lens through which they consider new proposals, projects, and objectives. It also requires states and the international community to adopt new policies, laws, and domestic funding mechanisms to facilitate the integration of adaptation strategies into development campaigns, investment plans, and the educational system. For example, drought and water resource planning should be mandated in all regions expected to succumb to growing water scarcity conditions as a result of climate change. Moreover, such planning should be incorporated into all new municipal, industrial, and agricultural improvement and expansion projects in order to ensure that existing and projected new water resources are adequate to meet the short and long-term needs of people and the environment.

Understandably, many nations, especially those in the developing world, lack the domestic capacity and resources to undertake such a significant alteration to their development practices. Moreover, many of these countries are most vulnerable to climatic variability and changes due to their geography, topography, and lack of local fresh water resources. As a result, they are susceptible to the so-called “snowball effect” where the lack of capacity to alter their approach exacerbates their vulnerability and worsens the consequences. Accordingly, an international effort must be established to support those most vulnerable to climate change, possibly under the auspices of a global climate change support program (discussed below),<sup>203</sup> which would allow them to achieve the same objectives as those with the capacity to adapt.

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<sup>201</sup> See U.N. Development Programme, *Adaptation to Climate Change – Integrating Adaptation Into Development*, <http://www.undp.org/climatechange/adapt/mainstream.html> (last visited 6/23/09) (using the “do development differently” language).

<sup>202</sup> This is the approach adopted by the members of the Organization for the Economic Co-operation and Development nations in 2006. See Org. for Econ. Co-operation and Dev. [OECD], *Dev. and Env'tl. Ministers of OECD Member Countries, Declaration on Integrating Climate Change Adaptation into Development Co-operation* (Apr. 4, 2006), available at <http://www.oecd.org/dataoecd/44/29/36426943.pdf>; see also OECD, *Members of the Development Assistance Committee at the DAC High Level Meeting, Statement of Progress on Integrating Climate Change Adaptation into Development Co-operation* (May 21, 2008), available at <http://www.oecd.org/dataoecd/44/53/40909509.pdf>.

<sup>203</sup> See *infra* notes 204-11 and accompanying text.

For example, new funding opportunities should be crafted, and existing funding mechanisms should be modified, to incorporate adaptive strategies into all development funding activities. This means incorporating line-items and resources for climate change vulnerability studies, adaptation strategizing, adaptation capacity building, and adaptation implementation projects as components of financed development activities. In appropriate cases, such components should be made obligatory by the donor agencies and funding institutions as part of the development strategy pursued by the recipient.

## 2. A GLOBAL APPROACH TO ADAPTATION

While climate change will impact different regions in disparate ways, climate change is a global phenomenon that will likely have a measurable impact in every corner of the planet. Many of the regions and nations around the world, however, are already experiencing considerable difficulty in responding to and planning for the expected changes. One of the principal difficulties in formulating an adequate response to climate change is a lack of adequate knowledge and resources, factors that are inextricably intertwined. Numerous countries, in both the developed and developing worlds, have a dearth of data and information needed to make climate change-related planning decisions. Many of these same countries cannot produce the necessary information; they either lack the human capital or the resources necessary to carry out the required studies, or both.

A global approach to climate change adaptation entails international collaborative empowerment, which is the creation of opportunities to allow all nations to be able to meet the present and forthcoming challenges.<sup>204</sup> This approach includes the development of a global climate change support program (GCCSP) to facilitate information development and cooperation.

A GCCSP is critical to ensuring that all nations have the opportunity to prepare adequately for the coming challenges. While such a program would encompass all climate change-related data and

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<sup>204</sup> Ostensibly, adaptation is already recognized as a component of the United Nations Framework Convention on Climate Change. Among others, Article 4(1)(d) of the Convention requires parties to “cooperate in preparing for adaptation to the impacts of climate change . . .” United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107, 31 I.L.M. 849, 1220 [hereinafter UNFCCC].

information needs, in the context of climate change-related water issues, it would provide assistance to countries in need in three main ways. First, it will facilitate the provision of data and information relevant to each country and region. It could do this by compiling all of the available studies and information for specific regions and countries and disseminating it as needed.

Next, the GCCSP will seek and develop opportunities for generating additional data to fill in gaps in knowledge. This could be accomplished by facilitating collaborative efforts among researchers and institutions within and outside the particular region or country. The program also would secure and provide grants to support the production of new information, either through such collaborative efforts or by directly engaging experts to undertake needed studies.<sup>205</sup>

Finally, the GCCSP should engage basin states in discussions and exchanges, facilitate cooperative efforts to undertake needed research, and develop and coordinate plans designed to respond to the challenges of climate change. The GCCSP will also encourage the formalization of such cooperation through the development of bilateral and multilateral agreements and institutional mechanisms, such as those discussed above.<sup>206</sup>

As an international endeavor, such a program will have to be structured either within an existing intergovernmental organization or as an independent entity. Existing organizations whose mandate may be adaptable to undertake these additional responsibilities may include the United Nations Environmental Program<sup>207</sup> or the United Nations Educational, Scientific, and Cultural Organization,<sup>208</sup> with the support from UN-Water.<sup>209</sup> As for an independent approach, given that models

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<sup>205</sup> Article 4(4) of the UNFCCC provides that “developed country Parties and other developed Parties . . . shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects.” *Id.* at art. 4(4).

<sup>206</sup> See *supra* notes 142-168, and accompanying text.

<sup>207</sup> The United Nations Environmental Program already has a focus on climate change. See UNEP – Climate Change at <http://www.unep.org/climatechange/> (last visited June 22, 2009).

<sup>208</sup> See United Nations Economic, Scientific, and Cultural Organization – Homepage, <http://www.unesco.org/> (last visited June 22, 2009).

<sup>209</sup> UN-Water is an inter-agency mechanism that was created in 2003 by the United Nations High Level Committee on Programmes. See UN-Water Website, <http://www.unwater.org> (last visited Apr. 17, 2009). Its purpose is to “strengthen[] coordination and coherence among UN entities dealing with issues related to all aspects of freshwater and sanitation.” While the entity’s focus is on the UN system’s various agencies, it may be well positioned to expand its mission to encompass regional and national needs given its wealth of information, its experience in

of effective international organizations are not lacking, there is no need to describe the makeup of the organization. In either scenario, though, the creation of a GCCSP will entail a secretariat responsible for managing and implementing the three responsibilities. It will also require the creation of a mechanism for securing funding from the international community, potentially from both public and private sources, which might be rolled into the existing Adaptation Fund apparatus under the Kyoto Protocol,<sup>210</sup> or modeled on the Global Environment Facility (GEF).<sup>211</sup>

Regardless of the structure of this global support system, it is imperative that it be established sooner than later. In order to ensure that all countries and all people have the tools and knowledge to prepare adequately for the coming changes to fresh water resources, both locally and globally, the entire global community must embrace a cooperative and supportive approach to provide aid to those who need it. By empowering nations through collaborative exchange, provision of information, and resources support, the international community will ensure that all nations are able to rise to the challenges already manifesting through climatic variability and which are exacerbating global, regional, and local water scarcity and stress.

#### IV. CONCLUSION

Regardless of whether climate change has anthropogenic origins, the human species will seek to acclimatize itself to its surroundings and,

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generating and coordinating research efforts, and its ability to coordinate efforts within the UN system. *See id.* (follow "About UN-Water" hyperlink).

<sup>210</sup> *See* United Nations Framework Convention on Climate Change, Adaptation Fund, available at [http://unfccc.int/cooperation\\_and\\_support/financial\\_mechanism/adaptation\\_fund/items/3659.php](http://unfccc.int/cooperation_and_support/financial_mechanism/adaptation_fund/items/3659.php) (last visited Dec. 7, 2009). The Adaptation Fund was created to provide funding for adaptation projects and programmes in developing country that are especially vulnerable to the adverse effects of climate change and that are Parties to the Kyoto Protocol. *Id.* The Kyoto Protocol is a protocol or supplemental agreement to the United Nations Framework Convention on Climate Change. It was adopted on 11 December 1997 and entered into force on 16 February 2005. *See* Kyoto Protocol, *supra* note 200.

<sup>211</sup> The GEF is a global partnership that includes most of the world's nations, various international institutions, non-governmental organizations, and the private sector. Its mission is assist nations, particularly those in the developing world, to address global and local environmental issues by providing grants in six focal areas: biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. *See generally* Global Environmental Facility, [http://www.gefweb.org/interior\\_right.aspx?id=50](http://www.gefweb.org/interior_right.aspx?id=50) (last visited Apr. 17, 2009).

to the extent possible, its surroundings to people's needs and wants. Human adaptation to climate change, in fact, is inevitable, but not because of exuberant and idealistic longing to better the human condition. Rather, it will emerge out of necessity, a response grounded in humanity's survival mechanisms, as well as out of people's self-interest and their desire to ensure and improve their lives and lifestyles.

The vital question that remains to be answered is: "How should we proceed?" Although many of the effects of climate change described in this article are likely unavoidable, how governments and human society respond to those consequences is not inevitable. The path chosen, though, could have grave and long-lasting implications for future generations and for this planet. While some options are likely to enrich peoples' lives and allow for a harmonious adaptation process, others could produce disastrous results in terms of social and political discord, human suffering, and a decayed environment. Accordingly, it is critical that governments, international organizations, and civil society approach the threat of climate change carefully, seriously, and collectively, but also urgently. Moreover, the international community must accept the reality that climate change is a global phenomenon that necessitates a collective and coordinated response, and that principles of sovereignty over territory and natural resources must yield to that reality.

The global community has been in a water crisis for many years. Yet, the coming changes in climatic patterns, precipitation rates, and rising temperatures present unprecedented challenges to people, communities, nations, and the environment in ways that have never been witnessed by humans on this planet. These changes will have a lasting imprint on cultures, traditions, and lifestyles throughout the globe and will challenge humanity's ability to adapt. Unless nations and peoples can overcome sovereign differences and ideologies, unless we can cooperate and coordinate our efforts in response to this global phenomenon, we will condemn our children and our world to an arduous and uncertain future.