RECONCILING ENERGY AND FOOD SECURITY

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INTRODUCTION

Achieving food security and energy security are two primary policy aims of international and domestic law. Ironically, the pursuit of energy security can often frustrate efforts to achieve food security. Energy security is the condition of a nation and its citizens having reasonable physical and economic access to sufficient and sustainable energy.[1] Food security is the condition of a nation and its citizens having reasonable physical and economic access to sufficient and sustainable food.[2] These two objectives often collide in the area of agricultural water management. It is in that realm that, frustratingly, the goal of achieving food security most frequently comes into conflict with the ambition to achieve energy security.

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1. Barry Barton et al., *Introduction* to ENERGY SECURITY: MANAGING RISK IN A DYNAMIC LEGAL AND REGULATORY ENVIRONMENT 5 (Barry Barton et al. eds., 2004); *see* Wen-chen Shih, *Energy Security, GATT/WTO, and Regional Agreements*, 49 NAT. RESOURCES J. 433, 436 (2009) (citing U.N. DEV. PROGRAMME, U.N. DEP'T OF ECON. & SOC. AFF., WORLD ENERGY COUNCIL, WORLD ENERGY ASSESSMENT: OVERVIEW 2004 UPDATE, at 42, U.N. Sales No. E.04.III.B.6 (2004), *available at* http://www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/sustainable-energy/world-energy-assessment-overview-2004-update/World%20Energy%20Assessment%20Overview-2004%20Update.pdf).

2. *See, e.g.*, Special Session of the Committee on Agriculture, *Negotiations on WTO Agreement on Agriculture: Proposals by India in the Areas of (i) Food Security, (ii) Market Access, (iii) Domestic Support, and (iv) Export Competition*, ¶ 1, G/AG/NG/W/102 (Jan. 15, 2001), *available at* https://docs.wto.org/dol2fe/Pages/FE_Search/DDFDocuments/48712/Q/G/AG/NGW102.pdf.

For example, food production in India depends heavily upon irrigation.[3] Many of these crops are drought-resistant grain crops like sorghum or millet.[4] However, international and domestic energy demands have rapidly expanded the growth of irrigated sugar cane in India for biofuel production.[5] Unlike drought resistant food crops, biofuel crops are often water intensive.[6] As such, the desire to achieve energy security diverts available land and water resources away from food security, exacerbating conflicts between industries and communities over scarce resources.[7]

This article argues that making "water security" a more predominant policy aim can help reconcile and integrate energy security and food security.[8] Water security is the condition of a nation and its citizens having reasonable physical and economic access to sufficient and sustainable water, combined with acceptable levels of water-related risks (e.g., drought, flood, and water-related plagues).[9]

This article proceeds in three parts. Part I discusses the water/food/energy nexus and explains the relationship between water, food, and energy security. Water, food, and energy are connected for three important reasons: (1) water and energy are mutually embedded in each other's production and development,

3. Mohua Guha & Kamla Gupta, *Water Resources in India: Critical Issues Related to Availability and Sustainable Use*, 25 IASSI Q. 85, 89–92 (2007).

4. *See, e.g.*, Carl E. Pray et al., *Private Research and Public Benefit: The Private Seed Industry for Sorghum and Pearl Millet in India*, 20 RES. POL. 315, 315 (1991).

5. Carey W. King et al., *Coherence Between Water and Energy Policies*, 53 NAT. RESOURCES J. 117, 207 (2013).

6. Ethanol can require as much as 200 times the amount of water used to produce an equivalent amount of petroleum gasoline. Carey W. King & Michael E. Webber, *Water Intensity of Transportation*, 42 ENVTL. SCI. & TECH. 7866, 7869 (2008). A biorefinery that produces 100 million gallons of ethanol annually uses as much water as a town of five thousand people. Roberta F. Mann, *Like Water for Energy: The Water-Energy Nexus Through the Lens of Tax Policy*, 82 U. COLO. L. REV. 505, 521 (2011).

7. Peter G. McCornick et al., *Water-Food-Energy-Environment Synergies and Tradeoffs: Major Issues and Case Studies*, 10 WATER & POL'Y 23, 24 (2008 Supp. 1); *see also* Shelley Ross Saxer, *Managing Water Rights Using Fishing Rights as a Model*, 95 MARQ. L. REV. 91, 99 (2011). Disputes over water resources used in energy production versus food production are often also reflected in political conflicts between urban citizens and rural citizens. Saxer, *supra*, at 99. As such, increasing global urbanization can impact the tension between food and energy security.

8. *See generally* A. Dan Tarlock & Patricia Wouters, *Reframing the Water Security Dialogue*, 20 J. WATER L. 53 (2013) (arguing that a "perfect storm of food, water and energy shortages" is forming and that these issues require a new dialogue on water security).

9. For a discussion of water security, see generally *id.*; David Grey & Claudia W. Sadoff, *Sink or Swim? Water Security for Growth and Development*, 9 WATER POL'Y 545 (2007).

and are in turn deeply embedded in food production;[10] (2) water, food, and energy are important development markers in evaluating global and national economic progress;[11] and (3) water, food, and energy are important sustainability markers in evaluating global and national environmental stewardship.[12]

Part II uses three examples to describe why focusing on energy security or food security often leads to myopic policies that frustrate security aims. The first example describes how the role of biofuel production in achieving energy security has negative implications for food security, due in large part to water management issues. The second example highlights the growing use of hydraulic fracturing techniques (or "fracking") to produce natural gas, and how that technology has impacted water availability and food production. The third example focuses on the use of energy-intensive desalination to treat rivers to salinity levels appropriate for food crop irrigation.

Part III explains the water security paradigm and discusses how this paradigm can reconcile policies that might otherwise conflict when focused narrowly on food or energy. Part III offers two examples of how a shift to the water security paradigm could change the development of natural resource law and policy. The first possible development is to supplement reliance on carbon footprint reporting by both states and corporations as an indicator of environmental management with the reporting of water footprints. The second possible development is to divert subsidies and environmental liability exemptions away from biofuel production and toward policies promoting hydroelectric energy and dam construction.

10. J.A. Allan, *Virtual Water—The Water, Food, and Trade Nexus: Useful Concept or Misleading Metaphor?*, 28 WATER INT'L 4, 9 (2003) [hereinafter *Virtual Water—The Water, Food, and Trade Nexus*]; *see also* J.A. Allan, *Virtual Water—Part of an Invisible Synergy that Ameliorates Water Scarcity*, *in* WATER CRISIS: MYTH OR REALITY 131, 132 (Peter P. Rogers et al. eds., 2006) [hereinafter *Virtual Water—Part of an Invisible Synergy*] (explaining that virtual water is embedded in commodities like food, energy, and clothing).

11. *See* Adam Wagstaff & Mariam Claeson, WORLD BANK, THE MILLENNIUM DEVELOPMENT GOALS FOR HEALTH: RISING TO THE CHALLENGES 8 fig.4 (2004). *See generally* U.N. DEV. PROGRAMME, HUMAN DEVELOPMENT REPORT 2003, MILLENNIUM DEVELOPMENT GOALS: A COMPACT AMONG NATIONS TO END HUMAN POVERTY (2003), *available at* http://hdr.undp.org/sites/default/files/reports/264/hdr_2003_en_complete.pdf.

12. *See* Wagstaff & Claeson, *supra* note 11, at 34 tbl.2.1; *see also* Daniel A. Farber, *Sustainable Consumption, Energy Policy, and Individual Well-Being*, 65 VAND. L. REV. 1479, 1522–24 (2012).

I. THE WATER/FOOD/ENERGY NEXUS

Because of population growth and economic development, the world will need 50% more food, water, and energy by 2030.[13] The challenge of providing adequate food, water, and energy for the world's growing population is aggravated by the advent of global climate change.[14] Addressing this growing demand is the preeminent global challenge of the coming decades, and requires an understanding of the relationship between water, food, and energy.[15] Any policy tool aimed at addressing the sustainable and equitable provision of one of these goods inevitably impacts the sustainability and equitable provision of the others.[16] While the relationship between water, food, and energy is at once both obvious and complex, this part describes three ways in which water, food, and energy policy intersect.

A. *Virtual Water and Embedded Energy in Food Production*

First, water and energy are inextricably linked in public policy debates because each is inherently embedded in the other.[17] Because water is required to produce virtually all goods, the costs associated with water development are embedded in all goods, a

13. U.N. SECRETARY-GENERAL'S HIGH-LEVEL PANEL ON GLOBAL SUSTAINABILITY, RESILIENT PEOPLE, RESILIENT PLANET: A FUTURE WORTH CHOOSING, at 11, U.N. Sales No. E.12.I.2 (2012), *available at* http://www.un.org/gsp/sites/default/files/attachments/GSP_Report_web_final.pdf; *see* Patricia Wouters et al., *Water Security, Hydrosolidarity, and International Law: A River Runs Through It . . .*, 19 Y.B. INT'L ENVTL. L. 97, 98 n.6 (2009) (citing Christine McGourty, *Global Crisis 'to Strike by 2030'*, BBC NEWS (Mar. 19, 2009), http://news.bbc.co.uk/go/pr/fr/-/2/hi/uk_news/7951838.stm (quoting Professor John Beddington, U.K. Government Chief Scientist, who refers to the water stress caused by economic development, population growth, and climate change as the "perfect storm" for a global energy and food crisis)).

14. Robin Kundis Craig, *Adapting Water Federalism to Climate Change Impacts: Energy Policy, Food Security, and the Allocation of Water Resources*, 5 ENVTL. & ENERGY L. & POL'Y J. 183, 217 (2010).

15. *See* Tarlock & Wouters, *supra* note 8, at 54–55; *see also* Elizabeth Burleson, *Energy Revolution and Disaster Response in the Face of Climate Change*, 22 VILL. ENVTL. L.J. 169, 169 (2011); Jenny Sin-hang Ngai, *Energy as a Human Right in Armed Conflict: A Question of Universal Need, Survival, and Human Dignity*, 37 BROOK. J. INT'L L. 579, 580–81 (2012).

16. *See Virtual Water—The Water, Food, and Trade Nexus*, *supra* note 10, at 9; *see also* Robin Kundis Craig, *Hydraulic Fracturing (Fracking), Federalism, and the Water-Energy Nexus*, 49 IDAHO L. REV. 241, 256 (2013).

17. *See* Christopher A. Scott & Martin J. Pasqualetti, *Energy and Water Resources Scarcity: Critical Infrastructure for Growth and Economic Development in Arizona and Sonora*, 50 NAT. RESOURCES J. 645, 648 (2010).

concept called "virtual water."[18] The same is certainly true of "virtual energy." In particular, energy and water have virtual versions of the other embedded in their production, as water treatment and transportation is highly energy-intensive, and the energy industry is one of the largest water consumers in the world.[19]

The water virtually embedded in our food is the amount of water needed to produce a given agricultural commodity.[20] For example, the production of one kilogram of grain requires approximately 1000 liters of water.[21] Virtual water represents a significant portion (around 15%) of the water used and traded throughout the world.[22] Just as virtual water is embedded and exported along with food and other agricultural products, virtual water is embedded in our energy. Water is essential in all parts of the energy sector: it is used as a reactor coolant, to produce steam to turn turbines, in oil and gas production, in the growth of biofuels, and in the mining of coal, uranium, and minerals used in components for wind and solar energy sources.[23] For example, coal

18. *See Virtual Water—The Water, Food, and Trade Nexus*, *supra* note 10, at 5; *see also* Shahbaz Khan & Munir A. Hanjra, *Footprints of Water and Energy Inputs in Food Production—Global Perspectives*, 34 FOOD POL'Y 130, 131 (2008).

19. *See* Peter H. Gleick, *Water and Energy*, 19 ANN. REV. ENERGY & ENV'T 267, 267 (1994).

20. *See Virtual Water—Part of an Invisible Synergy*, *supra* note 10, at 135.

21. WORLD WATER COUNCIL, E-CONFERENCE SYNTHESIS: VIRTUAL WATER TRADE—CONSCIOUS CHOICES 3 (2004), *available at* http://www.waterfootprint.org/Reports/virtual_water_final_synthesis.pdf; *see also* A. Y. Hoekstra & A. K. Chapagain, *Water Footprints of Nations: Water Use by People as a Function of Their Consumption Pattern*, 21 WATER RESOURCES MGMT. 35, 38 (2007).

22. A. Y. Hoekstra, *Virtual Water Trade Between Nations: A Global Mechanism Affecting Regional Water Systems*, IGBP GLOBAL CHANGE NEWS LETTER, June 2003, at 3, *available at* http://www.igbp.net/download/18.5831d9ad13275d51c098000343/1376383092647/NL54.pdf; Alix Gowlland Gualtieri, *Legal Implications of Trade in 'Real' and 'Virtual' Water Resources* 11 (Int'l Envtl. L. Res. Ctr., Working Paper No. 2008-02), *available at* http://www.ielrc.org/content/w0802.pdf.

23. Galan-del-Castillo Elena & Velazquez Esther, *From Water to Energy: The Virtual Water Content and Water Footprint of Biofuel Consumption in Spain*, 38 ENERGY POL'Y 1345, 1349 (2010); King et al., *supra* note 5, at 124–29; M. M. Mekonnen & A. Y. Hoekstra, *The Blue Water Footprint of Electricity from Hydropower*, 16 HYDROLOGY & EARTH SYS. SCI. 179, 179 (2012); Benjamin K. Sovacool, *Running on Empty: The Electricity-Water Nexus and the U.S. Electric Utility Sector*, 30 ENERGY L.J. 11, 17 (2009). *See generally* David B. Spence & Emily Hammond Meazell, *Fuels for Electric Power Generation: Regulatory, Policy, and Economic Pressures*, *in* GLOBAL CLIMATE CHANGE AND U.S. LAW (Michael B. Gerrard & Jody Freeman eds., forthcoming 2d ed.); *Product Water Footprints—Energy*, WATER FOOTPRINT, http://www.waterfootprint.org/?page=files/Water-energy (last visited Feb. 18, 2014).

mining alone uses between fifty and sixty gallons of water for every ton of coal mined.[24]

While the concept of virtual water has taken hold in academic literature and policy development, there is no similar discussion regarding virtual energy. However, the essential attributes of embeddedness and resource scarcity applicable to water development and consumption apply equally to energy development and consumption. Indeed, just as water is essential, and embedded, in energy production and generation, energy is equally essential and embedded in water production and distribution.[25] For example, in California, potable water treatment and distribution accounts for an amount of electricity equivalent to one-third of the electricity used to power all the homes in Southern California.[26] The energy required to run a faucet for five minutes is equivalent to the energy used to power a 60-watt light bulb for fourteen hours.[27]

As water and energy are both embedded in each other, both are similarly embedded in food. Enormous amounts of energy (and the water embedded in that energy) are required to transport water for irrigation. For example, 85% of electricity on farms is used to pump water for irrigation.[28] Thereafter, enormous amounts of energy (and the water embedded in that energy) are required to transport food.[29] As such, any agricultural product (including food and biofuels) contains significant amounts of both virtual water and virtual energy.

The concepts of virtual water and energy are also central to promoting national and international security.[30] In particular, as nations with limited energy or water resources forego development of those resources and instead rely on imports of virtual water and energy from water-rich or energy-rich nations, interna-

24. *See* Bandana Kaur Malik, *Like Water for Energy, and Energy for Water*, ENVTL. & ENERGY STUDY INST. (Aug. 1, 2009), http://www.eesi.org/080109_water_energy.

25. *See, e.g.*, Yuan Zhou & Richard S. J. Tol, *Evaluating the Costs of Desalination and Water Transport*, 41 WATER RESOURCES RES., Mar. 2, 2005, at 2, 4, 9.

26. Malik, *supra* note 24.

27. *Id.*

28. *Id.*

29. *See, e.g.*, Eric Hirst, *Food-Related Energy Requirements*, 184 SCI. 134, 134 (1974); Christopher L. Weber & H. Scott Matthews, *Food-Miles and the Relative Climate Impacts of Food Choices in the United States*, 42 ENVTL. SCI. & TECH. 3508, 3512 (2008).

30. *See, e.g.*, J. Anthony Allan, '*Virtual Water': A Long Term Solution for Water Short Middle Eastern Economies?* (Univ. of London, Sch. of Oriental & Afr. Studies Water Issues Study Group, Working Paper, 1997), *available at* http://www.ciaonet.org/wps/aln02/.

tional trade mitigates scarcity concerns that can otherwise erupt into political instability and violent conflict.[31]

B. *Water, Food, and Energy as Development Markers*

In addition to virtual water and energy in food, the second way in which water, food, and energy security intersect is that the provision of water, food, and energy are important development markers. The quantity, quality, and scope of available energy and water are often used as indicators of national economic development.[32] The United Nations ("UN") established the Millennium Development Goals (MDGs) in 2000, which "provide the road map for reducing poverty and hunger . . . and preserving the environment for future generations."[33] One of the MDGs included halving, by 2015, "the proportion of the population without sustainable access to safe drinking water and basic sanitation [from 1990 levels]."[34] Billions of people live without access to adequate water supplies.[35] Because water treatment and transportation depend so heavily on energy development, the human health crisis arising

31. *See, e.g.*, Frederick Michael Lorenz, *Strategic Water for Iraq: The Need for Planning and Action*, 24 AM. U. INT'L L. REV. 275, 278–79 (2008); Jason J. Morrissette & Douglas A. Borer, *Where Oil and Water Do Mix: Environmental Scarcity and Future Conflict in the Middle East and North Africa*, PARAMETERS, Winter 2004–2005, at 86–87.

32. *See, e.g.*, Daniel D. Bradlow, *A Framework for Assessing Global Economic Governance*, 54 B.C. L. REV. 971, 976–77 (2013); *see also* Declaration on the Right to Development, G.A. Res. 41/128, art. 8, U.N. Doc. A/RES/41/128 (Dec. 4, 1986); United Nations Conference on Environment and Development, Rio de Janeiro, Braz., June 3–14, 1992, *Rio Declaration on Environment and Development*, U.N. Doc. A/CONF.151/26/Rev.1 (Vol. I), Annex I (Aug. 12, 1992) [hereinafter *Rio Declaration*].

33. U.N. DEV. PROGRAMME, WHAT WILL IT TAKE TO ACHIEVE THE MILLENNIUM DEVELOPMENT GOALS? AN INTERNATIONAL ASSESSMENT vi (2010) (presenting, as "complementary strategies," increasing public investments in infrastructure and increasing access to water and energy); *see* United Nations, *Millennium Declaration*, G.A. Res. 55/2, ¶ 19, U.N. Doc. A/Res/55/2 (Sept. 18, 2000); *see also* Katharine A. Van Tassel & Rose H. Goldman, *The Growing Consumer Exposure to Nanotechnology in Everyday Products: Regulating Innovative Technologies in Light of Lessons from the Past*, 44 CONN. L. REV. 481, 489 n.28 (2011) (noting that the following technology-based advancements would significantly advance achievement of MDGs—energy storage, production, and conversion and water treatment and remediation).

34. U.N. DEP'T OF ECON. & SOC. AFFAIRS, THE MILLENNIUM DEVELOPMENT GOALS REPORT 2009, at 45, U.N. Sales No. E.09.I.12 (2009) [hereinafter MILLENNIUM DEVELOPMENT GOALS REPORT 2009]; *Millennium Declaration*, *supra* note 33, at ¶ 19.

35. Malgosia Fitzmaurice, *The Human Right to Water*, 18 FORDHAM ENVTL. L. REV. 537, 538 (2007). The World Resources Institute has estimated that 2.3 billion people live without access to adequate water supplies and 1.1 billion live without safe drinking water. *Id.*

from water stress cannot be addressed without concurrently addressing access to affordable and sustainable energy.[36]

Just as access to water and energy are essential markers of development, access to sufficient food has similarly been relied upon by international non-governmental organizations and by international governance institutions as an indicator of economic development.[37] The UN has promulgated MDGs that call for reducing by half "the proportion of people who suffer from hunger" by 2015.[38] Importantly, because of virtual water and virtual energy embedded in food, using access to sufficient food as an economic indicator inherently necessitates consideration of availability and access to water and energy. Reliance on access to these resources has become a broadly accepted measure of a nation's economic development, replacing more narrow conceptions of development. "[T]he human development approach added value to the conventional economic growth approach by replacing GDP growth with human development indicators such as the provision of food."[39]

The challenge of water-related diseases is closely related to energy and food. Water scarcity impacts food production, with drought leading to famine and resulting in over three million child deaths each year from starvation or malnutrition.[40] More than 6000 children die every day due to water-related diarrheal diseases that aggravate malnutrition and dehydration.[41] Lack of adequate energy supplies and infrastructure preclude effective large-scale water treatment and distribution.[42] This lack of adequate energy for water treatment and distribution leads to un-

36. Adrian J. Bradbrook et al., *A Human Dimension to the Energy Debate: Access to Modern Energy Services*, 26 J. ENERGY & NAT. RESOURCES L. 526, 542 (2008); *see also* Gleick, *supra* note 19, at 269–73.

37. Lillian Aponte Miranda, *The Role of International Law in Intrastate Natural Resource Allocation: Sovereignty, Human Rights, and Peoples-Based Development*, 45 VAND. J. TRANSNAT'L L. 785, 834 n.204 (2012) (citing MARGOT E. SALOMON & ARGUN SENGUPTA, THE RIGHT TO DEVELOPMENT: OBLIGATIONS OF STATES AND THE RIGHTS OF MINORITIES AND INDIGENOUS PEOPLES 6 (2003)).

38. *See* MILLENNIUM DEVELOPMENT GOALS REPORT 2009, *supra* note 34, at 11.

39. MARGOT E. SALOMON & ARJUN SENGUPTA, THE RIGHT TO DEVELOPMENT: OBLIGATIONS OF STATES AND THE RIGHTS OF MINORITIES AND INDIGENOUS PEOPLES 6 (2003).

40. *Nutrition During the First 1,000 Days of Life Crucial for Child Development*, 32 ABA CHILD L. PRAC. 113, 126 (2013).

41. Fitzmaurice, *supra* note 35, at 538.

42. *See* INST. OF MED. OF THE NAT'L ACADS., GLOBAL ISSUES IN WATER, SANITATION, AND HEALTH 2 (2009), *available at* http://www.ncbi.nlm.nih.gov/books/NBK28462/pdf/TOC.pdf.

sanitary conditions and infectious disease outbreaks of water-related pathogens like cholera, typhoid, and malaria.[43] Furthermore, lack of energy for water distribution often results in children—frequently young girls—being unable to attend school and exposed to dangerous environments as they devote themselves to hauling water from remote wells and rivers.[44]

The importance of food, water, and energy as development markers is further illustrated by the growing number of voices arguing for recognition of a human right to food, water, and energy.[45] The interdependent nature of food, water, and energy makes the promotion of any one as a human right effectively the promotion of all three as human rights. Furthermore, the role climate change plays in developing policies related to food, water, and energy invariably ties these human rights arguments to broader issues of sustainability and adaptability.[46] The rhetoric of human rights has become a central component in legal responses to climate change and to policy development in the fields of food, water, and energy security.[47]

43. *See, e.g.*, Ellen J. Lee & Kellogg J. Schwab, *Deficiencies in Drinking Water Distribution Systems in Developing Countries*, 3 J. WATER & HEALTH 109, 112 (2005).

44. JULIE FISHER, WATER SUPPLY AND SANITATION COLLABORATIVE COUNCIL, FOR HER IT'S THE BIG ISSUE: PUTTING WOMEN AT THE CENTRE OF WATER SUPPLY, SANITATION AND HYGIENE 16 (2006), *available at* http://www.unwater.org/downloads/evidencereport_eng.pdf.

45. *See, e.g.*, Sin-hang Ngai, *supra* note 15, at 579, 609 (noting that while access to water is considered "essential for the full enjoyment of life and all human rights" and "at least as important as food," the right to water is "itself dependent upon a right to access to energy services.").

46. *See, e.g.*, Naomi Roht-Arriaza, *"First Do No Harm": Human Rights and Efforts to Combat Climate Change*, 38 GA. J. INT'L & COMP. L. 593, 594 (2010); Elise Aiken, Note, *Energy Justice: Achieving Stability in Oil-Producing African Nations*, 22 COLO. J. INT'L ENVTL. L. & POL'Y 293, 313 (2011) ("Environmental degradation, poor health, the availability of fresh water and food, and human rights are all important social issues tied to poverty that achieving energy justice could help alleviate.").

47. *The Human Right to Water and Sanitation*, G.A. Res. 64/292, U.N. Doc. A/64/L.63/Rev.1, 2–3 (July 26, 2010) [hereinafter 2010 Resolution on the Human Right to Water and Sanitation]; Comm. on Econ., Soc. & Cultural Rights, *Substantive Issues Arising in the Implementation of the International Covenant on Economic, Social and Cultural Rights: General Comment No. 15*, ¶ 28, U.N. Doc. E/C.12/2002/11 (Jan. 20, 2003) [hereinafter *Comment 15*]. Comment 15 states that the right to water "clearly falls within the category of guarantees essential for securing an adequate standard of living" guaranteed under the International Covenant on Economic, Social and Cultural Rights. *Comment 15*, *supra* at ¶ 3; *see* International Covenant on Economic, Social and Cultural Rights art. 11 ¶ 1, *opened for signature* Dec. 19, 1966, 993 U.N.T.S. 3.

C. *Water, Food, and Energy as Sustainability Markers*

The third way that water, food, and energy intersect is the role each plays as a marker of global and national sustainability.[48] Sustainability means the ability of current populations to meet their needs without threatening the ability of future generations to meet their needs at a standard of living comparable to those of current populations.[49] Governments, international governance institutions, and non-profit governmental organizations often use physical and economic access to food, water, and energy as markers of environmental stewardship and sustainable resource management at the corporate, national, and global level.[50]

The interdependent nature of food, water, and energy—as each is embedded in the other—makes the sustainability of one an issue of the sustainability of the others. Water scarcity affects the availability of food and energy, and energy scarcity impacts the availability of food and clean water.[51] As such, the interconnectedness of food, water, and energy through the "virtual water" and "virtual energy" concepts also impacts their respective and relative sustainability.

Furthermore, the sustainability nexus has a strong relationship to the role of food, water, and energy as development markers. As noted above, one of the legal developments arising from the role that food, water, and energy play as development markers is the growing call to recognize each as a human right.[52] To

48. *See* William H.L. Stafford & Alan Brent, *Bioenergy Systems Sustainability Assessment and Management*, 3 RENEWABLE ENERGY L. & POL'Y REV. 205, 205 (2011).

49. U.N. Environmental Programme, Report of the World Commission on Environment and Development, Our Common Future, 14th Sess., June 8–19, 1987, at 54 ¶ 1, U.N. Doc. A/42/427; *see Rio Declaration*, *supra* note 32, at Principle 3.

50. *See, e.g.*, MARTIN C. HELLER & GREGORY A. KEOLEIAN, LIFE CYCLE-BASED SUSTAINABILITY INDICATORS FOR ASSESSMENT OF THE U.S. FOOD SYSTEM 7 (2000); Sara Dillon, *A Farewell to "Linkage": International Trade Law and Global Sustainability Indicators*, 55 RUTGERS L. REV. 87, 98 (2002).

51. *See, e.g.*, King et al., *supra* note 5, at 135; Margaret Sova McCabe & Joanne Burke, *The New England Food System in 2060: Envisioning Tomorrow's Policy Through Today's Assessments*, 65 ME. L. REV. 549, 574–75 (2013).

52. Comm. on Econ., Soc. & Cultural Rights, *Substantive Issues Arising in the Implementation of the International Covenant on Economic, Social and Cultural Rights: General Comment No. 12*, ¶ 1, U.N. Doc. E/C.12/1999/5 (May 12, 1999); Fitzmaurice, *supra* note 35, at 537; Peter Gleick, *The Human Right to Water*, 1 WATER POL'Y 487, 488–89 (1999); Stephen C. McCaffrey, *A Human Right to Water: Domestic and International Implications*, 5 GEO. INT'L ENVTL. L. REV. 1, 7 (1992); Anna F.S. Russell, *International Organizations and Human Rights: Realizing, Resisting or Repackaging the Right to Water?*, 9 J. OF HUM. RTS.

the extent that a human right to food, energy, or water guarantees provision of those goods for free, or at a substantially reduced (and heavily subsidized) cost, such a human right threatens sustainability, because consumers of food, water, and energy do not fully internalize the costs of their consumption and have little incentive to conserve.[53] As food, water, and energy depend upon exhaustible natural resources, polices should encourage conservation of those resources through consumer's cost-internalization.[54]

For example, South Africa was the first nation to recognize a constitutionally guaranteed right to food and water.[55] Under Section 27 of the South African Constitution, "[e]veryone has the right to have access to . . . sufficient food and water."[56] To satisfy the requirements of this right, the city of Johannesburg provided unlimited water to residents at a flat rate.[57] This approach, however, proved unsustainable. Johannesburg delivered one-third of its total water provided to Soweto, but Soweto generated only 1% of Johannesburg's revenue for water services.[58]

The Johannesburg example raises an important point regarding sustainability. In the case of Johannesburg, the underlying exhaustible resource—water—was being consumed at an unsustainable rate. However, too often sustainability is framed narrow-

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1, 3 (2010); Stephen R. Tully, *The Contribution of Human Rights to Universal Energy Access*, 4 NW. J. INT'L HUM. RTS. 518, 525 (2006).

53. *See* Rhett B. Larson, *The New Right in Water*, 70 WASH. & LEE L. REV. 2181, 2228 (2013); *see also* David Zetland, *Water Rights and Human Rights: The Poor Will Not Need Our Charity if We Need Their Water* 6 (Prop. & Env't Research Ctr., Working Paper, Aug. 11, 2011), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1549570 (comparing data on water access before and after enactment of a constitutional right to water in twelve countries, with data from twelve countries lacking a constitutional right to water and finding no impact on improved water access arising from enactment of a constitutional right to water).

54. King et al., *supra* note 5, at 118.

55. S. AFR. CONST., 1996 ch. 2, § 27; *see also* Andrew L. Magaziner, *The Trickle Down Effect: The Phiri Water Rights Application and Evaluating, Understanding, and Enforcing the South African Constitutional Right to Water*, 33 N.C. J. INT'L L. & COM. REG. 509, 510 (2008).

56. S. AFR. CONST., 1996 ch. 2, § 27.

57. *Mazibuko v. City of Johannesburg* 2010 (3) BCLR 239 (CC) at ¶ 11 (S. Afr.), *available at* http://www.saflii.org/za/cases/ZACC/2009/28.pdf.

58. *Id*. at ¶ 12 (noting that "the rate of payment of municipal water bills was less than 10%); COALITION AGAINST WATER PRIVATISATION ET AL., THE STRUGGLE AGAINST SILENT DISCONNECTIONS: PREPAID METERS AND THE STRUGGLE FOR LIFE IN PHIRI, SOWETO 6 (2004), http://www.citizen.org/documents/Phiri.pdf (noting that the lack of cost recovery for water services in Phiri was a major contributing factor to Johannesburg's decision to explore new methods for water distribution in Soweto); *see also* Larson, *supra* note 53, at 2211.

ly in terms of conservation of natural resources. In the case of food, water, and energy, resource sustainability is closely related to economic sustainability.[59] Water treatment and distribution and energy generation and transmission are both extremely capital-intensive industries.[60] The infrastructure necessary to generate and transmit electricity and to treat and transport water requires significant investments that necessitate full-cost recovery in order to maintain infrastructure, credit-worthiness, and attract capital.[61] A human rights approach to energy and water, therefore, frustrates economic sustainability when it interferes with full cost recovery.

Additionally, distribution of water and transmission of electricity typically involve natural monopolies.[62] As such, regulatory rate-setting is typically employed to avoid monopolistic pricing.[63] Combining guaranteed provision of energy or water in connection with a human right, with centralized rate-setting powers, raises the potential for large general subsidies to energy and water sectors due to political pressure to keep rates low.[64] Low rates result

59. *See* RESILIENT PEOPLE, RESILIENT PLANET, *supra* note 13, at 11.

60. *See, e.g.*, John Briscoe, *The Financing of Hydropower, Irrigation and Water Supply Infrastructure in Developing Countries*, 15 WATER RESOURCES DEV. 459, 460, 462 (1999); Klaus W. Grewlich, *International Regulatory Governance of the Caspian Pipeline Policy Game*, 29 J. ENERGY & NAT. RESOURCES L. 87, 106 (2011); Camille Pannu, *Drinking Water and Exclusion: A Case Study from Calif. Central Valley*, 100 CALIF. L. REV. 223, 237, 268 (2012).

61. *See, e.g.*, Fed. Power Comm'n v. Hope Natural Gas Co., 320 U.S. 591, 603 (1944) (noting that cost-recovery "should be sufficient to assure confidence in the financial integrity of the enterprise, so as to maintain its credit and to attract capital"); *see also* Jersey Cent. Power & Light Co. v. Fed. Energy Regulatory Comm'n, 730 F.2d 816, 818 (D.C. Cir. 1984).

62. Bruce Pardy, *The Dark Irony of International Water Rights*, 28 PACE ENVTL. L. REV. 907, 918 (2011); David B. Spence, *Can Law Manage Competitive Energy Markets?*, 93 CORNELL L. REV. 765, 767–68 (2008). Natural monopolies occur when a single firm is able to provide a good or service to a market at a lower average cost than multiple firms because of large economies of scale or network economies. *See* WILLIAM W. SHARKEY, THE THEORY OF NATURAL MONOPOLY 54–55 (1982). Economies of scale occur when the average cost of production declines over the entire range of production for the industry. Daniel F. Spulber & Christopher S. Yoo, *Access to Networks: Economic and Constitutional Connections*, 88 CORNELL L. REV. 885, 915 (2003). Network economies occur when a single firm is able to more efficiently operate than multiple firms because it is better able to coordinate interdependent aspects of an industry's operations or because it is able to process information more efficiently. *See id.* at 914–16.

63. *See Hope Natural Gas*, 320 U.S. at 595, 600–01*; see also* Bluefield Water Works & Improvement Co. v. Pub. Serv. Comm'n, 262 U.S. 679, 683, 690 (1923); *see also* George L. Priest, *The Origins of Utility Regulation and the "Theories of Regulation" Debate*, 36 J.L. & ECON. 289, 295–96 (1993).

64. *See* MICHAEL J. ROUSE, INSTITUTIONAL GOVERNANCE AND REGULATION OF WATER

in cost-externalization by consumers, and no incentive to conserve energy or water.[65] The subsidies and low rates are then passed on to food, because water and energy are embedded in their virtual forms. Technological innovation, increasing reliance on renewable energy, and distributed generation could change the economics of food, water, and energy provision, eliminating some of the concerns associated with capital-intensive natural monopolies.[66]

II. THE CONFLICTING AIMS OF FOOD AND ENERGY SECURITY

As discussed above, it is often impossible to address food, water, or energy independently. They are inherently intertwined because of the virtual nature of water and energy, and the role water, food, and energy play as indicators of economic development and sustainability. The failure to integrate food, water, and energy policies, by narrowly considering each separately, often results in inconsistent measures that enhance security of one at the expense of the others. This part provides three examples of how the failure to integrate food, water, and energy policies often aggravates development and sustainability challenges.

SERVICES: THE ESSENTIAL ELEMENTS 38, 40–41, 45, 47, 135 (2007).

65. *See* Robert Glennon, *Water Scarcity, Marketing, and Privatization*, 83 TEX. L. REV. 1873, 1882–84 (2005) (arguing that generally subsidizing water leads to inefficient water use); Barton H. Thompson, Jr., *Water as a Public Commodity*, 95 MARQ. L. REV. 17, 24–25 (2011) (noting efforts to charge "the full cost of delivered water" and trends towards improved water valuation). *See generally* NORMAN MYERS & JENNIFER KENT, PERVERSE SUBSIDIES: HOW TAX DOLLARS CAN UNDERCUT THE ENVIRONMENT AND THE ECONOMY (2001) (discussing the negative effects of general subsidies on water management and other sectors).

66. Gary H. Wolff et al., *Private Sector Participation in Water Services: Through the Lens of Stockton*, 57 HASTINGS L.J. 1323, 1341 (2006). As they relate to energy, the first and third assertions (capital intensity and natural monopolies) have been true for most of modern history. *See* Spence, *supra* note 62, at 767. However, these assertions for energy may become increasingly inapplicable as "distributed energy sources" (photovoltaic solar cells and small wind turbines) become increasingly accessible and viable. *See, e.g.*, Patrick Parenteau & Abigail Barnes, *A Bridge Too Far: Building Off-Ramps on the Shale Gas Superhighway*, 49 IDAHO L. REV. 325, 349–52 (2013); Matt Rivera & John Roach, *Out of Darkness: Solar Power Sheds a Little Light on Powerless Communities*, NBC NEWS (Aug. 11, 2013, 5:12 PM), http://www.nbcnews.com/technology/out-darkness-solar-power-sheds-little-light-powerless-communities-6C10867721 (describing the increasing use of solar panels to provide evening light to families in the Navajo nation and in rural areas of Africa).

A. *Biofuel Production, Water Management, and Food Security*

One obvious way in which food, water, and energy policies intersect is in the production of biofuels. Arable land formerly used to produce food is often converted into energy crops (usually corn, palm oil, soy, or sugar cane) used to produce bioethanol or biodiesel.[67] Because biofuels are renewable energy sources with a relatively low carbon footprint, biofuel production forms an important part of the energy security policies of many nations.[68]

However, biofuel production raises significant food and water security issues. The conversion of food crops to energy crops reduces the food supply and increases food prices, and it impacts water management, as drought-resistant, water-efficient food crops are replaced with drought-sensitive, water-intensive energy crops.[69] China and India, the world's two largest producers—and consumers—of many agricultural goods, already face serious water-related limitations on agricultural production.[70] Yet both nations have initiated programs to increase biofuel production and exports, often by converting water-efficient food crops, like millet and sorghum, to water-intensive energy crops such as palm oil.[71] Production of soy-based biofuels can consume more water per unit of energy than conventional petroleum production and refining.[72] Nonetheless, increasing demand for biofuels has led Argentina to shift from food production to soy production for biodiesel with

67. *See* Arthur J. Ragauskas et al., *The Path Forward for Biofuels and Biomaterials*, 311 SCI. 484, 487–88 (2006).

68. *Id*. at 484.

69. *See, e.g.*, High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, June 3–5, 2008, *Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required*, ¶¶ 9, 19–24, U.N. Doc. HLC/08/INF/1 (Apr. 2008) [hereinafter *Soaring Food Prices*]; *see also* Steven Sexton et al., *Food Versus Fuel: How Biofuels Make Food More Costly and Gasoline Cheaper*, AGRIC. & RESOURCE ECON. UPDATE, Sept.–Oct. 2008, at 1–2.

70. Charlotte de Fraiture et al., *Biofuels and Implications for Agricultural Water Use: Blue Impacts of Green Energy*, 10 WATER POL'Y 67, 68, 71 (2008 Supp. 1); *see* U.S. INT'L TRADE COMM'N, PUBLICATION NO. 4219, CHINA'S AGRICULTURAL TRADE: COMPETITIVE CONDITIONS AND EFFECTS ON U.S. EXPERTS xv (2011); *India: Issues and Priorities for Agriculture*, WORLD BANK (May 17, 2012), http://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities.

71. *See* de Fraiture et al., *supra* note 70, at 68, 70–71.

72. Shannon L. Ferrell et al., *The Future of Agricultural Law: A Generational Shift*, 18 DRAKE J. AGRIC. L. 107, 127 (2013); *see also* DIANA GLASSMAN ET AL., WORLD POL'Y INST., THE WATER-ENERGY NEXUS: ADDING WATER TO THE ENERGY AGENDA 7 (2011), http://www.worldpolicy.org/sites/default/files/policy_papers/THE%20WATER-ENERGY%20NEXUS_0.pdf.

significant environmental impacts.[73] Brazil has become one of the world's largest producers and exporters of water-intensive, sugar cane-based biofuels—but at a huge ecological cost.[74] Brazil's growing biofuel industry has accelerated deforestation, which causes increased nutrient and organic pollution to rivers from agricultural runoff.[75]

In the case of biofuels, energy security is perhaps too often given precedence over food security. In exchange for domestically grown, renewable energy or the economic advantages of exporting in-demand biofuel products, many nations sacrifice sustainable food production. Exports of biofuels effectively export water supplies in the form of virtual water. The result is often not only water scarcity and contamination, but rising food prices.[76] Spikes in food prices are a common source of political instability, as evidenced by the role of food costs in the recent "Arab Spring" uprisings in the Middle East and North Africa.[77]

B. *Hydraulic Fracturing, Water Management, and Food Security*

Biofuels are not the only energy crop presenting challenges to water management in emerging countries. Some farmers, for example, grow crops that support hydraulic fracturing in natural gas production.[78] Fracking involves the injection of fluids into the substratum, which fractures shale formations and releases otherwise inaccessible natural gas.[79] The United States has vast nat-

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73. Julia Tomei & Paul Upham, *Argentinean Soy-Based Biodiesel: An Introduction to Production and Impacts*, 37 ENERGY POL'Y 3890, 3891, 3895 (2009).

74. José Goldemberg, Suani Teixeira Coelho & Patricia Guardabassi, *The Sustainability of Ethanol Production from Sugarcane*, 36 ENERGY POL'Y 2086, 2091 (2008).

75. *Id.*

76. *See Fuel Subsidies: Is There an Impact on Food Supply and Prices?: Hearing Before the S. Comm. on Homeland Sec. & Governmental Affairs*, 110th Cong. 12–13 (2008) (testimony of Mark W. Rosegrant, Ph.D., Director, Env't & Prod. Tech. Div., Int'l Food Policy Research Inst.); *Soaring Food Prices*, *supra* note 69, at ¶¶ 9, 19–24; Amela Ajanovic, *Biofuels Versus Food Production: Does Biofuels Production Increase Food Prices?*, 36 ENERGY 2070, 2074 (2011); Donald Mitchell, *A Note on Rising Food Prices* 4 (The World Bank Dev. Prospects Grp., Policy Research Working Paper No. 4682, 2008), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1233058.

77. *See, e.g.*, Sarah Johnstone & Jeffrey Mazo, *Global Warming and the Arab Spring*, *in* THE ARAB SPRING AND CLIMATE CHANGE 15, 15–17 (2013); George Joffé, *The Arab Spring in North Africa: Origins and Prospects*, 16 J. N. AFR. STUD. 507, 510 (2011).

78. Gardiner Harris, *In Tiny Bean, India's Dirt-Poor Farmers Strike Gas-Drilling Gold*, N.Y. TIMES, July 17, 2012, at A1.

79. *See* Dianne Rahm, *Regulating Hydraulic Fracturing in Shale Gas Plays: The Case of Texas*, 39 ENERGY POL'Y 2974, 2974 (2011).

ural gas reserves in shale formations, and that natural gas burns cleaner, with lower greenhouse gas emissions than coal or petroleum.[80] Electric generation using natural gas also avoids the regulatory and ecological miasma associated with coal ash waste disposal.[81] As a result, natural gas lies at the heart of the United States' energy security policy.[82] Fracking is also a growing natural gas exploration technique in many parts of the world.[83]

Fracking is, by itself, typically an extremely water-intensive form of hydrocarbon production.[84] Fracking at a single well site can require as much as thirteen million gallons of water.[85] Additionally, fracking, like biofuel production, has water quality implications just as significant as its water supply implications. Fracking fluid often contains hazardous substances, including benzene and formaldehyde.[86] While injectate into shale formations likely does not impact underground sources of drinking water, fault drilling or well installation can result in groundwater contamination.[87]

Fracking, however, raises many of the same food security issues as biofuel production. Fracking fluid frequently contains an emulsifier produced from the seed of the guar plant.[88] The rapid expansion of fracking in the United States and other countries has resulted in a rising demand for guar, with the international

80. *Id.*; *see also* James M. Inhofe & Frank Fannon, *Energy and the Environment: The Future of Natural Gas in America*, 26 ENERGY L.J. 349, 352 (2005).

81. *See* Spence & Hammond Meazell, *supra* note 23, at 4, 26, 36 (discussing the environmental benefits of electric generation using natural gas).

82. *See* Inhofe & Fannon, *supra* note 80, at 350, 388 (discussing the need to balance environmental and energy concerns).

83. *See* Jonathan A. Lesser, *Energy and the Environment: A Fractured Europe Debates Fracking*, 29 NAT. GAS & ELECTRICITY 31, 31 (2013).

84. *See* Kundis Craig, *supra* note 16, at 252–54.

85. HEATHER COOLEY & KRISTINA DONNELLY, PAC. INST., HYDRAULIC FRACTURING AND WATER RESOURCES: SEPARATING THE FRACK FROM THE FICTION 15 (2012), *available at* http://www.pacinst.org/wp-content/uploads/2013/02/full_report35.pdf.

86. ROBERT B. JACKSON ET AL., CTR. ON GLOBAL CHANGE, RESEARCH AND POLICY RECOMMENDATIONS FOR HYDRAULIC FRACTURING AND SHALE-GAS EXTRACTION 3 (2011); Chris Mooney, *The Truth About Fracking*, 305 SCI. AM. 80, 84 (2011), *available at* http://www.nature.com/scientificamerican/journal/v305/n5/full/scientificamerican1111-80.html.

87. Mooney, *supra* note 86, at 84; *see also* David C. Holzman, *Methane Found in Well Water Near Fracking Sites*, 119 ENVTL. HEALTH PERSP. A289, A289 (2011), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3222989/.

88. Ahmad Bahamdan, Hydrophobic Guar Gum Derivatives Prepared by Controlled Grafting Processes for Hydraulic Fracturing Applications, 4–6 (Aug. 2005) (unpublished Ph.D. dissertation, Louisiana State University), *available at* http://etd.lsu.edu/docs/available/etd-06022005-225849/.

price of guar seed rising from $4 per kilogram to $30 per kilogram in an eighteen-month period.[89] Thousands of acres of crops formerly used for food production have been converted to the production of guar in India and Pakistan.[90] As with palm oil and sugar cane, guar may be a less drought-resilient and more water-intensive crop than many of the food crops it replaces.[91]

Conversion of land from food to energy production has far-reaching impacts on water management. This conversion often precludes the use of efficient irrigation techniques. For example, water-efficient irrigation techniques, like the use of drip irrigation or center-pivot irrigation, are often appropriate for food crops, but inappropriate for the biofuel crops that replace them.[92]

From pollution to food price increases, the transition from growing food to "growing" energy presents serious challenges to food security and water management. Where this transition increases water consumption and the export of virtual water, energy crop production aggravates water-related conflicts. Such conflicts arise as increased water demand strains legal and regulatory regimes aimed at mediating or resolving disputes over shared and scarce water resources. Furthermore, converting land to growing water-intensive energy crops makes the population more vulnerable to drought conditions, which are likely to become increasingly common in many parts of the world as a result of global climate change.[93]

89. Hilary Hylton, *Why the U.S. Fracking Industry Worries About the Weather in India*, TIME (July 17, 2012), http://world.time.com/2012/07/17/why-the-u-s-fracking-industry-worries-about-the-weather-in-india/.

90. *Id.*

91. *Compare* W.L. Alexander, D.A. Bucks & R.A. Backhaus, *Irrigation Water Management for Guar Seed Production*, 80 AGRONOMY J. 447, 447–53 (1988) (describing irrigated water amounts necessary for guar seed production), *with* M.O.A. Fawusi & A.A. Agboola, *Soil Moisture Requirements for Germination of Sorghum, Millet, Tomato, and Celosia*, 72 AGRONOMY J. 353, 353–57 (1980) (describing irrigated water amounts necessary for sorghum and millet).

92. Kenneth G. Cassman, *Ecological Intensification of Agriculture and Implications for Improved Water and Nutrient Management*, *in* FERTIGATION PROCEEDINGS: SELECTED PAPERS AT THE JOINT INTERNATIONAL SYMPOSIUM ON FERTIGATION 23, 29, 32 (Patricia Imas ed., 2005), *available at* http://www.ipipotash.org/en/publications/detail.php?i=269.

93. *See, e.g.*, Cynthia Rosenzweig et al., *Climate Change and Extreme Weather Events—Implications for Food Production, Plant Diseases, and Pests*, 2 GLOBAL CHANGE & HUM. HEALTH 90, 90, 102 (2001).

C. *Desalination, Irrigation, and Energy Security*

Energy and crop irrigation are invariably connected; not only as water is increasingly used to irrigate energy crops like guar, but also through the energy required to treat contaminated water, or develop new water supplies, for irrigation purposes. One particularly energy-intensive means of increasing the availability of irrigation water is the use of desalination.[94] Desalination can represent the sacrifice of energy security in the name of food security, and it can also provide a locus for disputes over shared water resources.[95]

For example, the apportionment of water from the Colorado River and the river's water quality have long been sources of dispute between the United States and Mexico.[96] Increasing crop irrigation within the Colorado River Basin has resulted in contamination of the river from significant runoff containing fertilizer salts.[97] The salinity levels at the headwaters of the Colorado are less than fifty parts per million ("ppm").[98] But because of irrigation runoff, the Colorado River crosses the United States/Mexico border with salinity at an environmentally toxic level exceeding 1200 ppm.[99]

The elevated salinity of the Colorado River has caused significant diplomatic issues between the United States and Mexico because of damage from saline-contaminated waters used to irrigate crops in northern Mexico.[100] This challenge is aggravated during

94. *See* Sabine Lattemann & Thomas Höpner, *Environmental Impact and Impact Assessment of Seawater Desalination*, 220 DESALINATION 1, 10 (2008); *see also* G.L. Meerganz von Medeazza, *'Direct' and Socially-Induced Environmental Impacts of Desalination*, 185 DESALINATION 57, 61 (2005).

95. *See* Rhett B. Larson, *Innovation and International Commons: The Case of Desalination Under International Law*, 2012 UTAH L. REV. 759, 761–62, 764–66 (2012).

96. *See* Robert W. Adler, *Restoring the Environment and Restoring Democracy: Lessons from the Colorado River*, 25 VA. ENVTL. L.J. 55, 81 (2007). *See generally* Jennifer Pitt et al., *Two Nations, One River: Managing Ecosystem Conservation in the Colorado River Delta*, 40 NAT. RESOURCES J. 819, 833–34, 836–41 (2000).

97. *See* Edward Lohman, *Yuma Desalting Plant: 2003*, SOUTHWEST HYDROLOGY, May/June 2003, at 20.

98. *Id.*

99. *See id.*

100. *See* Herbert Brownell & Samuel D. Eaton, *The Colorado River Salinity Problem with Mexico*, 69 AM. J. INT'L L. 255, 255–56 (1975); *see also* Lynne Lewis Bennett, *The Integration of Water Quality into Transboundary Allocation Agreements: Lessons from the Southwestern United States*, 24 AGRIC. ECON. 113, 120–21 (2000) (noting that saline water has caused damage to more than 63% of crops in northern Mexico that rely on Colorado

drought conditions when there is less water to dilute salt concentrations, as illustrated during the extreme drought of the early 1960s when salinity levels in the Colorado River at the United States/Mexico border reached 2500 ppm, with devastating impacts to Mexican farmers in the basin.[101] Mexico formally protested the United States' upstream management of salinity levels, arguing that those levels made the water unusable and thus constituted a violation of the United States' obligations under the 1944 Rivers Treaty.[102]

In an effort to resolve the dispute, the United States agreed to maintain the salinity levels of the Colorado River at the Mexican border at just over the salinity levels behind the United States Imperial Dam on the Colorado River.[103] To maintain this salinity level, Congress passed the Colorado River Basin Salinity Control Act, authorizing the construction (at a cost of $245 million in 1974) and operation of a desalination plant in Yuma, Arizona for the express purpose of lowering the salinity levels in the Colorado.[104]

However, operation of the Yuma desalination plant has been sporadic, largely because of the energy expenses associated with operating the plant.[105] Unlike fracking or biofuel production, where energy security is implemented in a way inconsistent with food security, the Yuma desalination plant implements an energy-intensive technology for the purpose of protecting food-producing crops. In each instance, however, water quality is threatened. Just as fracking fluid can contaminate groundwater,

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River water for irrigation, with annual damages to farmers reaching in excess of $300 million per year); Francisco Oyarzabal-Tamargo & Robert A. Young, *International External Diseconomies: The Colorado River Salinity Problem in Mexico*, 18 NAT. RESOURCES J. 77, 88 (1978).

101. Bennett, *supra* note 100, at 121.

102. *See* Treaty Between the United States of America and Mexico Respecting Utilization of Waters of the Colorado and Tijuana Rivers of the Rio Grande, U.S.-Mex., Feb. 3, 1944, 59 Stat. 1219 [hereinafter 1944 Rivers Treaty]; *see also* Brownell & Eaton, *supra* note 100, at 256. The treaty imposes an obligation on the United States to deliver a certain quantity, but not necessarily a certain quality, of Colorado River water at the border. *See* 1944 Rivers Treaty, *supra*, art. 10(a), 59 Stat. at 1237.

103. *See* 1944 Rivers Treaty, *supra* note 102, arts. 12(d) & 15, 59 Stat. at 1241; International Boundary and Water Comm'n, Minute 242, Aug. 30, 1973, *available at* http://www.ibwc.gov/Treaties_Minutes/Minutes.html.

104. Colorado River Basin Salinity Control Act, Pub. L. No. 93-320, 88 Stat 266, 269–70 (1974).

105. *See* Lohman, *supra* note 97, at 21; *see also* TAYLOR O. MILLER ET AL., THE SALTY COLORADO 75 (1986).

and runoff and erosion from biofuel production can contaminate rivers, the disposal of brine wastes from desalination plants can have significant environmental impacts.[106]

The point of friction, therefore, between policies aimed at achieving energy security and those aimed at food security is often management of both water quantity and water quality. To harmonize these two policy aims, and avoid resource-related conflicts and human health problems, the security paradigm must shift away from food and energy, and toward water security.

III. WATER SECURITY AS AN INTEGRATED POLICY PARADIGM

As discussed above, the failure to integrate energy security and food security presents difficult policy choices and often puts these policy aims at odds. However, policies implemented to achieve food or energy security need not be inconsistent. The point at which food security and energy security often intersect is water management.[107] Therefore, water security can effectively integrate both food and energy security. This part first describes what the water security paradigm is, and then discusses two ways in which shifting to a water security paradigm would harmonize the often discordant relationship between food security and energy security.

A. *Defining the Water Security Paradigm*

The water security paradigm integrates much of food security and energy security because managing water inherently manages food and energy, given the degree to which virtual water is embedded in both. However, despite the fact that the water security paradigm integrates much of food and energy security, it is nevertheless different from both forms of security in fundamental and important ways.

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106. *See* Nicos X. Tsiourtis, *Desalination and the Environment*, 141 DESALINATION 223, 228–33 (2001); *see also* Hisham M. Ettouney et al., *Evaluating the Economics of Desalination*, CHEMICAL ENGINEERING PROGRESS, Dec. 2002, at 32, 33–34.

107. Of course, food and energy security interests compete in other ways as well, including land use, government spending, investments in research and development, and for political attention. *See generally* Robert H. Abrams & Noah D. Hall, *Framing Water Policy in a Carbon Affected and Carbon Constrained Environment*, 50 NAT. RESOURCES J. 3 (2010); Petra Hellegers et al., *Interactions Between Water, Energy, Food and Environment: Evolving Perspectives and Policy Issues*, 10 WATER POL'Y 1 (2008 Supp. 1).

First, water is inherently different than food and energy because only water is water. This means that, while there are many kinds of food and many sources of energy, there is no substitute for water.[108] While diversification of food production or energy sources is an important component of food and energy security, there is no diversification option in water law.

Second, water has a unique socio-cultural role.[109] Uranium and natural gas are rarely if ever used in religious ceremonies, and you do not see children playing during the summer by squirting each other with petroleum or in the winter by throwing coal. The unique socio-cultural role of water often impacts its value and pricing as an economic good and commodity—because it falls for free out of the sky and runs freely in rivers, and because it is so intertwined with culture through recreation and religion, water is often undervalued.[110]

Third, food security and energy security are primarily concerned with adequacy of provision—getting enough of both to everyone. Indeed, the central concern of food and energy security is how to manage scarcity.[111] Water security, on the other hand, is as much about managing excess as it is about managing scarcity.[112] Too much water (floods) can be catastrophic, and too much water in the wrong place, or with elevated concentrations of the wrong constituents (toxins or pathogens), can be equally catastrophic.[113]

The water security paradigm moves water to center stage as the one resource that is embedded in the production and distribution of all others.[114] The water security paradigm encourages states to pursue alternative sources of energy and food for which

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108. *See, e.g.*, JOHN P. SMOL, POLLUTION OF LAKES AND RIVERS: A PALEOENVIRONMENTAL PERSPECTIVE 1 (2d ed. 2008).

109. *See generally* Rhett B. Larson, *Water, Worship, and Wisdom: Indigenous Traditional Ecological Knowledge and the Human Right to Water*, 19 ILSA J. INT'L & COMP. L. 43 (2012); Rhett B. Larson, *Holy Water and Human Rights: Indigenous Peoples' Religious-Rights Claims to Water Resources*, 2 ARIZ. J. ENVTL. L. & POL'Y 81 (2011).

110. *See* Larson, *supra* note 53, at 2220–21.

111. *See, e.g.*, CLAIRE SCHAFFNIT-CHATTERJEE, THE GLOBAL FOOD EQUATION: FOOD SECURITY IN AN ENVIRONMENT OF INCREASING SCARCITY 4 (Stefan Schneider ed., 2009); Mary Jane Angelo, *Corn, Carbon, and Conservation: Rethinking U.S. Agricultural Policy in a Changing Global Environment*, 17 GEO. MASON L. REV. 593, 594–95 (2010); S. Scott Gaille, *Allocation of International Petroleum Licenses to National Oil Companies: Insights from the Coase Theorem*, 31 ENERGY L.J. 111, 114 (2010).

112. *See* Grey & Sadoff, *supra* note 9, at 558.

113. *Id.* at 547, 560.

114. *Id.* at 546–47.

they have a comparative advantage in production, rather than risk their own water security in an attempt to secure food and energy security. For example, water-poor states will seek to develop water-efficient food products and import water-intensive food products (like rice), which effectively imports virtual water.[115]

Additionally, the water security paradigm deals frankly with water as a market commodity.[116] Undervalued water, whether for sociocultural reasons or political reasons, presents the greatest threat to conservation and sustainable food and energy production.[117] The water security paradigm requires that water consumers internalize the costs of their water consumption, which will require agriculture and energy—the two largest water consumers—to move toward water-efficient means of production and distribution.

At first glance, full cost recovery and effective pricing of water services can appear regressive and to possess disproportionate impact on the poor. However, large general subsidies to the water sector typically benefit the energy and agricultural industries the most, because they are the largest water consumers.[118] Furthermore, in developing countries, the rich are typically those connected to a treated water distribution system, and thus benefit from water subsidies.[119] The poor often obtain water either from remote, contaminated sources or buy water from water vendors at a cost twenty-five times more than the rates paid by those connected to the system.[120] Rather than large general subsidies that benefit the agricultural and energy industries, directed subsidies to indigent water consumers (something akin to food stamps) paid

115. *See* A.Y. Hoekstra & P.Q. Hung, *Globalisation of Water Resources: International Virtual Water Flows in Relation to Crop Trade*, 15 GLOBAL ENVTL. CHANGE 45, 46 (2005); M. Dinesh Kumar & O.P. Singh, *Virtual Water in Global Food and Water Policy Making: Is There a Need for Rethinking?*, 19 WATER RESOURCES MGMT. 759, 763 (2005).

116. *See* Saxer, *supra* note 7, at 96 (noting that "[t]he price that water districts pay for water should reflect the uncertainty of the resource from year to year, as well as the need to support the infrastructure necessary to deliver the water that is available for allocation").

117. *See, e.g.*, Janet E. McKinnon, *Water to Waste: Irrational Decisionmaking in the American West*, 10 HARV. ENVTL. L. REV. 503, 508 (1986); *see also* Nels Johnson et al., *Managing Water for People and Nature*, 292 SCI. 1071, 1072 (2001).

118. Larson, *supra* note 53, at 2231–32; *see also* S. Sharma, *Water Markets Exclude the Poor*, *in* THE VALUE OF NATURE—ECOLOGICAL POLITICS IN INDIA 142 (S. Kothari et al. eds., 2003); ROUSE, *supra* note 64, at 45–47.

119. *See* ROUSE, *supra* note 64, at 45, 47.

120. *Id.* at 47.

for by increased block-tariffs (i.e., water rates that increase on consumption increases) facilitate equitable distribution of water, full cost recovery, and water conservation in the energy and agricultural sectors.[121] Remaining in an energy security or food security paradigm could aggravate issues of conservation and equity by retaining large general water subsidies for irrigation and power generation.

The water security paradigm not only integrates the scarcity concerns driving food and energy security, it also integrates the productive and destructive power of water. Droughts have obvious impacts on food and energy security. However, floods have similar impacts in their disruption of roads, transmission lines, crops, and other critical infrastructure.[122] Such impacts range from flooded dirt roads that prevent rural crops from reaching the market, to the ecological disaster at Fukushima's nuclear power plant in the wake of a major typhoon.[123] This integration is essential because water variability is the most critical issue arising from global climate change, and the most important part of climate change adaptation is resiliency to water variability in energy and food production.[124]

A move toward the water security paradigm will influence how law and policy is developed with respect to food and energy. Because water is so highly embedded in both food and energy, the water security paradigm presents opportunities to harmonize the otherwise often discordant aims of policies aimed at food and energy security. At the same time it addresses the challenges presented by both droughts and floods.[125] While shifting to a water

121. *See id*. at 47, 49; *see also* GABRIEL A. BITRÁN & EDUARDO P. VALENZUELA, WATER SERVICES IN CHILE: COMPARING PRIVATE AND PUBLIC PERFORMANCE 3 (2003), *available at* http://openknowledge.worldbank.org/bitstream/handle/10986/11303/261260viewpoint.pdf?; D. Whittington, *Municipal Water Pricing and Tariff Design: A Reform Agenda for South Asia*, 5 WATER POL'Y 61, 71–72 (2003).

122. *See* Grey & Sadoff, *supra* note 9, at 551, 560.

123. *See, e.g.*, Lincoln L. Davies, *Beyond Fukushima: Disasters, Nuclear Energy, and Energy Law*, 2011 BYU L. REV. 1937, 1942–43 (2011); Carlo Del Ninno et al., *Public Policy, Markets and Household Coping Strategies in Bangladesh: Avoiding a Food Security Crisis Following the 1998 Floods*, 31 WORLD DEV. 1221, 1222 (2003).

124. *See* Lenny Bernstein et al., *Synthesis Report*, *in* CLIMATE CHANGE 2007: CONTRIBUTION OF WORKING GROUPS I, II, AND III TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 50–52 (2007); Charles J. Vorosmarty et al., *Global Water Resources: Vulnerability from Climate Change and Population Growth*, 289 SCI. 284–87 (2000). *See generally* Barry Smit et al., *An Anatomy of Adaptation to Climate Change and Variability*, 45 CLIMACTIC CHANGE 223 (2000).

125. *See* Grey & Sadoff, *supra* note 9, at 547, 560.

security paradigm could have far-reaching legal and policy implications, this part presents two possible implications of the paradigm shift for reconciling food and energy security.

B. *From Reporting Carbon Footprints to Reporting Water Footprints*

The first possible implication of a shift to the water security paradigm is to supplement reliance on carbon footprints as the main indicia of environmental stewardship with greater reliance on water footprints. Because of the role greenhouse gas emissions play in climate change, monitoring, reporting, and reducing those emissions (particularly in the form of carbon dioxide equivalent [CO2e]) has played a central role in the mitigation of anthropogenic climate change.[126] By extension, the measuring, reporting, and reducing of "carbon footprints" (or the amount of CO2e emitted to produce a given product or provide a given service) has become the aim of policymakers and the sine qua non of good environmental stewardship.[127] The centrality of carbon footprints has been one of the major policy features of both food and energy security.[128]

Focus on carbon footprints, however, is narrow and fails to integrate other aspects of sustainability. Carbon footprints often do not integrate the environmental concerns associated with low-carbon energy sources, like nuclear energy, solar and wind energy, or biofuels.[129] Arguably, carbon footprints do not fully integrate the environmental impacts of industries associated with power generation, like mining or oil and gas exploration and extraction, including fracking.[130] Carbon footprints also fail to include the environmental impacts of climate change mitigation

126. *See, e.g.*, *Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule*, 75 Fed. Reg. 31,514, 31,516 (June 3, 2010) (codified in various sections at 40 C.F.R. pts. 51, 52, 70, and 71); Kyoto Protocol to the United Nations Framework Convention on Climate Change arts. 3, 7 & 8, *opened for signature* Mar. 16, 1998, 2303 U.N.T.S. 162.

127. *See, e.g.*, Christopher L. Weber & H. Scott Matthews, *Quantifying the Global and Distributional Aspects of American Household Carbon Footprint*, 66 ECOLOGICAL ECON. 379, 380, 387 (2008).

128. *See, e.g.*, Mark Harvey & Sarah Pilgrim, *The New Competition for Land: Food, Energy, and Climate Change*, 36 FOOD POL'Y 540, 541 (2011).

129. Alexis Laurent et al., *Limitations of Carbon Footprint as Indicator of Environmental Sustainability*, 46 ENVTL. SCI. & TECH. 4100, 4105–06 (2012).

130. *Id.*

measures, like geologic carbon sequestration, "green" building codes, smart grids, or hybrid cars.[131]

For example, a state seeks to implement policies to reduce its carbon footprint. It replaces one coal-fired power plant with a nuclear power plant, photovoltaic solar cell arrays, and a wind farm. The state retrofits another coal-fired power plant to operate on natural gas (which emits less carbon than coal), and engages in geologic carbon sequestration to mitigate the emissions from its use of natural gas. It passes a green building code to improve energy efficiency and decrease energy consumption, and provides subsidies to encourage the purchase of hybrid cars or cars using biofuels. These efforts would likely significantly reduce the state's carbon footprint.[132]

But that reduction would tell the state little of the environmental impacts from all of the mining of silicon, copper, gold, tungsten, and other minerals to build the components of solar cells, wind turbines, "green" buildings, hybrid cars, or smart grids.[133] It would tell the state little of the water used as a reactor coolant in the nuclear power plant, to grow biofuels, or used in the fracking operations to provide natural gas.[134] It would tell the state little of the impacts of nuclear waste disposal.[135] It would tell the state little of possible contamination of groundwater from geologic carbon sequestration.[136]

131. *See, e.g.*, Adam Harmes, *The Limits of Carbon Disclosure: Theorizing the Business Case for Investor Environmentalism*, 11 GLOBAL ENVTL. POL. 98 (2011); Sarah E. Light, *NEPA's Footprint: Information Disclosure as a Quasi-Carbon Tax on Agencies*, 87 TUL. L. REV. 511, 564 (2013); Michael P. Vandenbergh & Mark A. Cohen, *Climate Change Governance: Boundaries and Leakage*, 18 N.Y.U. ENVTL. L.J. 221, 271 (2010).

132. *See generally* Committee Report, *Report of the Legislation Committee*, 33 ENERGY L.J. 617 (2012); Marc B. Mihaly, *Recovery of a Lost Decade (or is it Three?): Developing the Capacity in Government Necessary to Reduce Carbon Emissions and Administer Energy Markets*, 88 OR. L. REV. 405 (2009).

133. *See, e.g.*, Laurent et al., *supra* note 129, at 4104–06; RESNICK INST., CRITICAL MATERIALS FOR SUSTAINABLE ENERGY APPLICATIONS 4 (Neil Fromer, Roderick G. Eggert & Jack Lifton eds., 2011).

134. *Cf.* P.W. Gerbens-Leenes et al., *The Water Footprint from Biomass: A Quantitative Assessment and Consequences of an Increasing Share of Bio-Energy in Energy Supply*, 68 ECOLOGICAL ECON. 1052, 1058 (2009) (comparing the water footprint through the energy supply chain for several sources, including coal, natural gas, uranium, solar, and wind).

135. *See generally* Alex Funk & Benjamin K. Sovacool, *Wasted Opportunities: Resolving the Impasse in United States Nuclear Waste Policy*, 34 ENERGY L.J. 113 (2013).

136. *Cf.* Elizabeth J. Wilson, *Regulating the Ultimate Sink: Managing the Risks of Geologic CO_2 Storage*, 37 ENVTL. SCI. & TECH. 3476, 3476–77 (2003) (describing potential risks associated with geologic carbon sequestration, including contamination of subsurface wa-

If the state relied on water footprints as an additional measure of environmental performance, it would have a clearer picture of the overall environmental impacts of its policies.[137] Because of the water embedded in energy production, the water footprint would capture many of the same environmental issues as those captured by the carbon footprint.[138] And the water footprint would also incorporate other environmental impacts. For example, accounting for the virtual water embedded in the natural gas produced through fracking and used in the generation of nuclear energy would tell us more about the environmental impacts and sustainability of natural gas and nuclear power.[139] The virtual water embedded in minerals mined to support renewable energy and used to grow biofuels would provide more information on the sustainability of those policies.[140] Water contaminated through mining, nuclear waste disposal, deforestation to support biofuel production, or geologic carbon sequestration would similarly provide information on environmental impacts not otherwise captured by the carbon footprint.[141]

The water security paradigm would establish effective monitoring and reporting of water footprints—incorporating virtual water up through the chain of production and transfer—as the new sine qua non of integrated and transparent reporting of environmental stewardship and sustainability. Because of the water embedded in energy, and particularly when combined with reporting carbon footprints, the water footprint would still capture impacts

ters).

137. *See, e.g.*, A.K. Chapagain & S. Orr, *An Improved Water Footprint Methodology Linking Global Consumption to Local Water Resources: A Case of Spanish Tomatoes*, 90 J. ENVTL. MGMT. 1219, 1227 (2009).

138. *Cf. Virtual Water—The Water, Food, and Trade Nexus*, *supra* note 10, at 5 ("Virtual water is the water needed to produce agricultural commodities. The concept could be expanded to include the water needed to produce non-agricultural commodities."). The water footprint links production impacts—environmental, economic, and political—with the "consumption base." Chapagain & Orr, *supra* note 137, at 1219; *Virtual Water—The Water, Food, and Trade Nexus*, *supra* note 10, at 5.

139. *See* King et al., *supra* note 5, at 118–19; Sovacool, *supra* note 23, at 17.

140. Gerbens-Leenes et al., *supra* note 134, at 1052.

141. *See* FOOD & AGRIC. ORG., THE STATE OF FOOD AND AGRICULTURE 64 (2008); Gerald F. Hess, *Hanford: Cleaning Up the Most Contaminated Place in the United States*, 38 ARIZ. L. REV. 165, 179, 180 (1996); John F. Seymour, *Hardrock Mining and the Environment: Issues of Federal Enforcement and Liability*, 31 ECOLOGY L.Q. 795, 821–23 (2004); Wilson, *supra* note 136, at 3476–77; *cf.* A. B. Kersting et al., *Migration of Plutonium in Ground Water at the Nevada Test Site*, 397 NATURE 56, 59 (1999) (concluding that models only accounting for "sorption and solubility" may underestimate the ability of plutonium to migrate in groundwater).

of carbon emissions on global climate change and encourage energy conservation and climate change mitigation measures.[142] The water footprint would also provide necessary information on sustainability issues arising from increased consumption attributable to population growth and economic development.[143] Furthermore, water footprints would provide a better understanding of how countries could face water insecurity through virtual water exports. For example, guar production may improve energy security in nations with fracking operations and may frustrate food security in nations replacing food crops with guar. The water footprint will capture this tension, but will also provide necessary information on whether guar exports have the net effect of achieving water security in one nation at the expense of water security in another.

C. *Water Security, Dams, and Hydroelectric Energy*

In addition to placing water footprint monitoring and reporting at the center of sustainability policies, the water security paradigm could also change attitudes about the role of dams in society. Dams are the paradigmatic example of the food, water, and energy nexus.

Imagine a society with widespread adult illiteracy, thousands of deaths each year from malaria and floods, most living on subsistence farming, and a life expectancy of fifty-three years. This may sound like an impoverished nation, but this in fact describes Tennessee in the early 1930s before the construction of forty-two large dams comprising the Tennessee Valley Authority ("TVA").[144] The dams provided electricity that promoted industry, safety, education, and efficiency in that region.[145] The dams provided water storage for times of drought and flood control mechanisms.[146] TVA

142. *See supra* note 138 and accompanying text.

143. A. Ertug Ercin & Arjen Y. Hoekstra, *Water Footprint Scenarios for 2050: A Global Analysis*, 64 ENV'T INT'L 71, 71–72 (2014).

144. *See* Grey & Sadoff, *supra* note 9, at 553; *see also* W.J. Cosgrove, *Water for Growth and Security*, *in* WATER CRISIS: MYTH OR REALITY 40 (Peter P. Rogers et al. eds., 2006).

145. *See generally* WORLD BANK, TECHNICAL PAPER NO. 416, COMPREHENSIVE RIVER BASIN DEVELOPMENT: THE TENNESSEE VALLEY AUTHORITY (Barbara A. Miller & Richard B. Reidinger eds., 1998).

146. *See id*. at 43–44, 52, 58–59.

transformed the region from one hampered by its hydrology to one that had harnessed its hydrology.[147]

The development of large dams has fallen into disfavor in many policy circles, for understandable and compelling reasons.[148] Large dams are expensive to build, maintain, and operate, can have devastating effects on a watershed's ecology, can displace communities, and can result in catastrophic failures.[149] However, one potential advantage of a shift to the water security paradigm will be a more considerate approach to balancing the obvious and serious costs of large dams against their equally obvious and significant benefits.[150] France, one of the lowest carbon-emitting developed countries in the world, has achieved a low-carbon energy industry by developing 97% of its hydroelectric capacity, with a total capacity of 26,000 MW from hydroelectric power.[151] Compare that to Africa, which has greater hydroelectric potential than Europe, but has developed only 5% of that potential.[152] In the Colorado River Basin in the United States Sonoran Desert, the river has about 1400 days of storage behind dams, allowing these arid regions to irrigate crops and feed livestock even during prolonged droughts.[153] Compare that to the Indus River in South Asia, which has only thirty days of storage, despite supporting huge populations with high water variability.[154] In North America, dams have over 6000 m^3 per capita of reservoir capacity to respond to floods, while Ethiopia and Morocco have less than 40 m^3 and 550 m^3 per capita, despite being wracked by floods.[155]

The aims of food security are to secure consistent and predictable production of crops and livestock resilient to drought conditions.[156] The aims of energy security are to secure a sustainable, renewable, and low-carbon source of predictable and consistent

147. *See id.* at 7; Grey & Sadoff, *supra* note 9, at 553.

148. *See* WORLD COMM'N ON DAMS, DAMS AND DEVELOPMENT: A NEW FRAMEWORK FOR DECISION-MAKING 15–17 (2000) (providing an overview of the problems associated with large dams).

149. *Id.* at 15–17, 39; *see also* PATRICK MCCULLY, SILENCED RIVERS: THE ECOLOGY AND POLITICS OF LARGE DAMS 24–31, 42 (1996).

150. *See* Grey & Sadoff, *supra* note 9, at 564.

151. *Id.* at 554.

152. *Id.* at 554–55 & fig.4.

153. *Id.* at 553.

154. *Id.*

155. *Id.*

156. *See supra* note 2 and accompanying text.

energy.[157] These aims are furthered by the development of large dams. However, despite the security synergies inherent in large dam construction, there has been a decreasing social and political acceptance of large dams for the reasons discussed above. A shift to the water security paradigm would reemphasize the benefits of large dam development, because it would integrate the productive capacity of water with storage concerns inherent in food security, the renewable, low-carbon power concerns in energy security, and it would introduce considerations of flood control and the destructive capacity of water.

CONCLUSION

The water security paradigm focuses on achieving a sustainable quantity and quality of water, thereby maximizing the constructive power of water to develop food and energy, while minimizing the destructive power of water in instances of drought, flood, and plague. Moving to a water security paradigm is fundamentally about achieving equitable resource distribution, because the poor suffer disproportionately from both droughts and floods.[158] Indeed, water presents something of a "chicken or egg" challenge to development. Is it the hydrologic condition of a state or region that determines its political and economic stability, or does economic and political stability allow states and regions to overcome their hydrologic condition? Put another way: Are droughts and floods caused by nature, or by the failure of society to adapt to nature? On the one hand, many countries with "difficult hydrologic legacies" (i.e., areas with absolute water scarcity like deserts or low-lying regions with seasonal heavy rainfalls) typically deal with political and economic instability, arguably attributable to "bad hydrology."[159] On the other hand, as noted above, in the Tennessee Valley (an area with a difficult hydrologic legacy of floods) and in other areas of absolute water scarcity (like the Australian Outback or the Sonoran Desert in the Southwest-

157. *See supra* note 1 and accompanying text.

158. *See, e.g.*, Enrique R. Carrasco & Alison K. Guernsey, *The World Bank's Inspection Panel: Promoting True Accountability Through Arbitration*, 41 CORNELL INT'L L.J. 577, 586 (2008); Robert R.M. Verchick, *Disaster Justice: The Geography of Human Capability*, 23 DUKE ENVTL. L. & POL'Y F. 23, 42–43 (2012).

159. *See* Tarlock & Wouters, *supra* note 8, at 53, 56; *see also* Grey & Sadoff, *supra* note 9, at 569 ("Water security has always been a societal priority—in its absence people and economies have remained vulnerable and poor.").

ern United States), political and economic stability has allowed states to overcome the bounds placed on them by their otherwise difficult hydrologic legacies. In a sense, political and economic stability have allowed states to simulate the conditions of good hydrology.

Thus, the tension created by water insecurity may not necessarily be conflict over shared, scarce resources, but instead may be managing the migration pattern that has typified human history and pre-history—people move to follow water. Today, we see this pattern as large groups of immigrants leave areas of water insecurity (either because of a difficult hydrologic legacy or because of a society's failure to adapt) to areas of water security (either because of a good hydrologic legacy or an effective simulation of that legacy due to political and economic stability). The greatest investment nations can make in managing immigration will be to achieve global water security.

That achievement is elusive, not only because of the "chicken or egg" relationship between water and development, but because it may be difficult to know when water security is achieved. A central question at the heart of food, water, and energy security is: "How much"? With water, the answer cannot be "enough to stay alive." There are only two kinds of people on earth—people with enough water to stay alive and dead people. Every living person on earth has access to at least some water. The real question of security is: "How much to achieve what standard of living"? The water security paradigm has the potential to integrate and harmonize security aims in both food and energy, but still must answer this fundamental question. Despite the need to answer fundamental questions of measuring outcomes, the water security paradigm will play an important role in guiding how law and policy reconcile the challenges of providing sustainable food and energy to a growing population in the face of climate change.