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THE ROLE OF INTERNATIONAL LAW IN THE FOOD–ENERGY–WATER NEXUS

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ABSTRACT

The current relationship of water, food, and energy is deeply entangled as it functions within different sectors, such as industry and agriculture, the latter of which water is essential for irrigating crops. Similarly, adequate water storage facilities are also required for hydroelectricity generation. Moreover, in many regions, electrical energy is used to operate tube wells for extracting groundwater to irrigate crops for food. Within the intricate nature of the mutual relationship of water, energy, and food, each plays its role in ensuring the security of the others. For instance, both energy security and food security are dependent upon water security, implying a central role of water security in the water–food–energy nexus. This Article will evaluate the mutual relationship of these three securities and the role played by international law in translating the strength of water security, energy security, and food security.

Keywords: Water Security, Food Security, Energy Security, International Water Law, Virtual Water.

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INTRODUCTION

Water, food, and energy security are closely linked.[1] For example, much water has to be used to produce food in the agricultural sector; an estimated eighty percent of worldwide withdrawals of freshwater are consumed in this sector. [2] This indicates a high dependence on water in the food-growing sector.[3] In the same manner, globally, almost ninety percent of energy generation in power plants is "water intensive"[4] and storage works for generating hydropower also require the storage of significant quantities of freshwater,[5] highlighting the high dependence of energy generation on the availability of water.[6] Further, in many regions, groundwater is extracted by using tube wells that run on electricity.[7] This water is used for drinking, cooking, domestic purposes, and irrigating crops.[8] This use of extracted groundwater indicates the bonding of energy with water and food.[9] All three elements—food, water, and

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[1] Rabi H. Mohtar, *An Integrated Sustainability Index for Effective Water Policy*, *in* WATER SECURITY: THE WATER-FOOD-ENERGY-CLIMATE NEXUS 217, 217 (2011).

[2] Int'l Conf. on Water & Env't, *The Dublin Statement on Water and Sustainable Development* (Jan. 26–31, 1992) [hereinafter *Dublin Statement*], https://www.gdrc.org/uem/water/dublin-statement.html.

[3] *Id.*

[4] *See* Irina Bokova, *Forward* to U.N. WATER, 1 THE UNITED NATIONS WORLD WATER DEVELOPMENT REPORT 2014: WATER AND ENERGY at v, v (2014).

[5] Bianca E. Jimenez Cisneros et al., *Freshwater Resources*, *in* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY—PART A: GLOBAL AND SECTORAL ASPECTS 229, 252 (Christopher B. Field et al. eds., 2014); *see also* GUSTAFF OLSSON, WATER AND ENERGY: THREATS AND OPPORTUNITIES 24 (2d ed. 2015).

[6] *See* ROBERT SPEED ET AL., BASIN WATER ALLOCATION PLANNING: PRINCIPLES, PROCEDURES AND APPROACHES FOR BASIN ALLOCATION PLANNING 68 (Susan Curran ed., 2013).

[7] *See* TUSHAAR SHAH ET AL., IRRIGATION MANAGEMENT IN PAKISTAN AND INDIA: COMPARING NOTES ON INSTITUTIONS AND POLICIES 7–8 (2000).

[8] *Id.*

[9] *See* ELOISE M. BRIGGS ET AL., ENVIRONMENTAL LIVELIHOOD SECURITY IN SOUTHEAST ASIA AND OCEANIA: A WATER-ENERGY-FOOD-LIVELIHOODS NEXUS APPROACH FOR SPATIALLY ASSESSING CHANGE 32 (2014).

energy—are deeply linked to each other, establishing a trilateral nexus in today's world.[10]

This Article will include an overview of the interrelated nexus of water, food, and energy. In particular, it will explicate the intricate mutual relationship of water security, food security, and energy security. The next Section will elaborate on the water–energy –food nexus. The third Section will include a discussion of the key principles and recommendations of international law on maintaining adequate global water, food, and energy security. The fourth Section will highlight some of the threats to water security and, in turn, on the nexus of water, food, and energy security in the future. The fifth Section will provide a number of recommendations to mitigate these threats. The Article concludes by providing the overall inferences of the Article, highlighting the fundamental significance of water in the trilateral relationship of food, energy, and water.

I. WHAT IS THE WATER–ENERGY–FOOD NEXUS?

While defining the water–energy–food nexus, this section of the Article will elaborate on the mutual relationship of food, energy, and water. The water–energy–food nexus has become popular in scholarly circles, where it is used to explain the interrelationship of these three securities.[11]

The water–energy–food nexus means the intrinsic mutual relationship among people's water security, food security, and energy security.[12] These three domains have strong interdependencies.[13] For instance, water is essential for the production of food in

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[10] *See* Nikolaus J. Kuhn, *Soil Loss*, *in* THE SOIL UNDERFOOT: INFINITE POSSIBILITIES FOR A FINITE RESOURCE 37, 37 (G. Jock Churchman & Edward R. Landa eds., 2014).

[11] *See generally* Chi Zhang et al., *Water-Energy-Food Nexus: Concepts, Questions and Methodologies*, 195 J. CLEANER PROD. 625 (2018) (discussing the water-energy-food nexus).

[12] *See generally* Paolo D'Odorico et al., *The Global Food-Energy-Water Nexus*, 56 REVS. GEOPHYSICS 456 (2018) (discussing the water-energy-food nexus).

[13] *See id.*

the agricultural sector in terms of irrigating crops.[14] It has been estimated that, globally, approximately eighty percent of freshwater withdrawals are for irrigating crops.[15] This indicates the essential role played by freshwater in ensuring adequate food security for humans.[16]

A number of agrarian countries produce food crops and, in so doing, increase their own food security and the food security of nonagrarian countries through exports.[17] For example, highly populated countries such as China, India, Pakistan, and the United States share almost fifty percent of the entire world's irrigated land.[18] The water used by these agrarian states to irrigate crops ultimately contributes to ensuring the food security of agrarian and nonagrarian countries.[19]

It is pertinent to mention here that, in many regions, groundwater is used to irrigate crops (either instead of or in addition to surface waters).[20] To extract groundwater, tube wells, which use electricity to function, are installed.[21] This groundwater is used for irrigation, drinking, and domestic purposes.[22] The central role played by electrical energy is to extract the groundwater through the tube wells.[23] Thus, here, energy also plays a pivotal role in ensuring people's food security.

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[14] *Dublin Statement*, *supra* note 2.
[15] *Id.*
[16] *Id.*
[17] *See generally* Abdul Rehman et al., *Economic Perspectives of Major Field Crops of Pakistan: An Empirical Study*, *in* 1 PAC. SCI. REV. B: HUMANS. & SOC. SCI., 145 (2015) (discussing field crop economics in Pakistan).
[18] Yatuka Takahasi, *Water Storage, Transport, and Distribution*, *in* U.N. EDUC., SCI. & CULTURAL ORG., WATER STORAGE, TRANSPORT AND DISTRIBUTION: ENCYCLOPEDIA OF LIFE SUPPORT SYSTEMS 1, 11–13 (Yatuka Takahasi ed., 2009).
[19] *See* D'Odorico et al., *supra* note 12, at 488.
[20] *See* SHAH ET AL., *supra* note 7, at 7–8.
[21] *Id.*
[22] *Id.*
[23] *Id.*

In a similar way that energy and water are required to produce food and, thus, to ensure food security,[24] substantial quantities of water are also required to maintain energy security.[25] Electrical energy is employed in the industrial sector and in a number of other fields, including the development of and for consumption in urban areas.[26] The availability of adequate electrical energy is necessary for a nation's sustainable economic development.[27] The energy generated from water is called hydropower or hydroelectricity.[28] Energy generated by these hydroelectric power plants requires significant quantities of water, both for generation and to cool plant machinery.[29] In order to generate hydroelectricity, massive quantities of freshwater are stored in large-capacity dams;[30] this stored water is then allowed to pass through turbines,[31] where the flow of water generates electrical energy.[32] Many countries in the world rely on hydropower as the main source for meeting their energy security.[33] For instance, the United States,[34] India,[35] and China[36] have built a number of dams and reservoirs to generate hydroelectricity to meet their energy-related demands.[37]

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[24] *Dublin Statement*, *supra* note 2.
[25] *See* D'Odorico et al., *supra* note 12, at 479–86.
[26] THÉRÈSE RUDEBECK, CORPORATIONS AS CUSTODIANS OF THE PUBLIC GOOD?: EXPLORING THE INTERSECTION OF CORPORATE WATER STEWARDSHIP AND GLOBAL WATER GOVERNANCE 90 (Claudia Pahl-Wostl & Joyeeta Gupta eds., 2019).
[27] *See* D'Odorico et al., *supra* note 12, at 479–86.
[28] *Id.*
[29] *See* SPEED ET AL., *supra* note 6, at 69.
[30] *See* OLSSON, *supra* note 5.
[31] STEPHEN BUTZ, ENERGY AND AGRICULTURE: SCIENCE, ENVIRONMENT AND SOLUTIONS 133 (2014).
[32] MICHAEL S. HAMILTON, ENERGY POLICY ANALYSIS: A CONCEPTUAL FRAMEWORK 145 (2015).
[33] BUTZ, *supra* note 31, at 133.
[34] *Id.*
[35] Uttam Kumar Sinha, *Towards Riparian Rationality: An Indian Perspective*, *in* CHINA-INDIA RELATIONS: COOPERATION AND CONFLICT 167, 173–75 (Kanti Bajpai, Jing Huang & Kishore Mahbubani eds., 2015).
[36] *Id.*
[37] BUTZ, *supra* note 32l; *see also* Takahasi, *supra* note 19, at 11.

If sufficient water is not maintained in the dams, there may not be enough potential energy stored by the water to adequately spin the turbines, which, as a result, causes a shortage of electrical energy.[38] Such a situation harms a nation's energy security and, in turn, economic security.[39] Moreover, there is also a potential harm to food security in certain regions; agrarian regions that use groundwater to irrigate crops may not be able to meet the water demands for irrigating their crops if they receive shortages in electricity.[40] Here, the relationship between water security, energy security, and food security becomes so inextricably intrinsic, each affecting the other symbiotically.[41]

II. INTERNATIONAL WATER LAW AND THE NEXUS OF WATER, FOOD, AND ENERGY

International water law has provided guidance for maintaining water, food, and energy security. Some of its rules directly instruct states to ensure people's water and food security, while other principles indirectly refer to maintaining energy and water security. This Section will describe some of the instructions provided by international water law to states for maintaining food, energy, and water security.

A. The Protection of Vital Human Needs

International water law gives particular attention to the fulfillment of "vital human needs" in relation to the procurement of water.[42] In particular, the Berlin Rules on Water Resources recom-

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[38] *See* CISNEROS ET AL., *supra* note 5, at 251; HAMILTON, *supra* note 32, at 145.
[39] *See* D'Odorico et al., *supra* note 12, at 480 (discussing an example of shortage of water and resulting harm to energy and economic security in India).
[40] *See* SHAH, *supra* note 7, at 7.
[41] *See* Damilola Olawuyi, *Sustainable Development and the Water-Energy-Food Nexus: Legal Challenges and Emerging Solutions*, 103 ENV'L SCI. & POL'Y 1, 1 (2020).
[42] Int'l L. Assoc., *Berlin Rules on Water Resources*, art. 3 (2004) [hereinafter *Berlin Rules*], http://www.cawater-info.net/library/eng/l/berlin_rules.pdf; *see also*

mended state parties to ensure the provisioning of vital human needs related to the availability of water.[43] The Berlin Rules describe the meaning of "vital human needs" in relation to freshwater as: "'Vital human needs' means waters used for immediate human survival, including drinking, cooking, and sanitary needs, as well as water needed for the immediate sustenance of a household."[44]

1. The Essential Nexus Between Water and Food

The text of the Berlin Rules specifically mentions "cooking" as an element of vital human needs related to freshwater availability.[45] This directly highlights the significance of the relationship between the procurement of water and food security.[46] Water is necessary for cooking and growing food, the latter through the irrigation of crops.[47] Crops cannot grow without sufficient freshwater.[48] Here, the Berlin Rules and Dublin Statement combine to highlight the significance of freshwater in provisioning food for humans.[49] Considering this connection the Berlin Rules directs state parties to ensure that freshwater be allocated first for fulfilling "vital human needs."[50] That is, freshwater has to be allocated first for drinking and food procurement purposes, and then for other ventures:[51] "In determining an equitable and reasonable use, States shall first allocate waters to satisfy vital human needs."[52]

If water is allocated first to the agricultural sector, the crops that prepare food for humans should be given priority over non–food

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Asit K. Biswas, *United Nations Water Conference Action Plan: Implementation Over the Past Decade*, 4 WATER RES. DEV. 148 (1988).

[43] *Berlin Rules*, *supra* note 42, art. 17.

[44] *See id.* art. 3.

[45] *Id.*

[46] *Id.*

[47] *See id.*; *Dublin Statement*, *supra* note 2.

[48] See Olawuyi, *supra* note 42, at 3.

[49] *Id.*

[50] *See Berlin Rules*, *supra* note 42, art. 14.

[51] *Id.*

[52] *Id.*

producing crops such as cotton.[53] In practice, this means fields of rice, wheat, etc., which employ large quantities of freshwater,[54] should receive water first, then the remaining freshwater can be directed to other crops, like cotton, or other sectors, like industry or electricity generation.

2. The Nexus between Energy and Food

The rule to protect vital human needs is also applicable to the energy–food nexus. For instance, groundwater is used to irrigate crops in many regions.[55] This water is extracted through the tube wells that run on electricity.[56] Therefore, it can be asserted that electrical energy contributes to ensuring water for the agricultural sector and, ultimately, to the production of food.[57] Similarly, following the Berlin Rules, the availability of water to the energy sector is limited by the amount of water necessary for the production of food.[58] This affirms the strong relationship between energy and food. Energy is necessary for fulfilling vital human needs, in the production of food, and the production of food directly relates to the water available for the production of energy.[59]

B. The Human Right to Water and Basic Needs

The strong mutual connection of water with food is further endorsed in the Berlin Rules, which states: "Every individual has a right of access to sufficient, safe, acceptable, physically accessible, and affordable water to meet that individual's vital human needs."[60]

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[53] *Id.*
[54] Tony Allen, *The Concept of Virtual Water*, ENI.COM (Mar. 20, 2020), https://www.eni.com/en-IT/low-carbon/concept-ofvirtualwater.html#:~:text=Virtual%20water%20is%20the%20water,produce%20a%20ton%20of%20beef.
[55] See SHAH, *supra* note 7, at 7–8.
[56] *Id.*
[57] *Id.*
[58] *Id.*; *see also* Olawuyi, *supra* note 41, at 1.
[59] *Berlin Rules*, *supra* note 43, art. 3.
[60] *Id.* art. 17.

Here, the right to access water has been endorsed, with special attention given to ensuring the fulfillment of "vital human needs."[61] As elucidated earlier, vital human needs include water and food; therefore, the right to access water indirectly endorses the nexus between water and food.[62] This nexus is also endorsed in Agenda 21 and in the Mar del Plata Action Plan.[63] Chapter Agenda 21 describes the right to access water in these words: "[A]ll peoples, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs."[64]

Here, again, the right to access to water is endorsed, with the particular goal of ensuring the fulfillment of basic needs.[65] The term "basic needs" used here reflects "vital human needs," which include water for drinking, food production, and sanitation.[66] As food is a vital element of "vital human needs" or "basic needs," Agenda 21 indirectly endorses the inherent strong relationship between food and the availability of water.[67] Furthermore, Agenda 21 specifically instructs state parties that the right to access water for the fulfillment of basic needs has to be provisioned for every human being without bias:[68] "States shall ensure the implementation of the right of access to water on a non-discriminatory basis."[69]

Thus, no state party is allowed to deny this right to any human being in any circumstance.[70] It can also be inferred that no state can be denied access to water or to using it for irrigating crops

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[61] *Id.*
[62] *Id.* art. 13.
[63] *See* U.N. Conference on Environment & Development, *Agenda 21*, ch. 18, U.N. Doc. A/CONF.151/26/Rev.1 (Vol. 1), annex II (June 3–14, 1992) [hereinafter *Agenda 21*].
[64] *Id.*; *see* also U.N. Water Conf., *Mar del Plata Action Plan*, U.N. Doc. E/CONF.70/29 (Mar. 14–25, 1977).
[65] *See Agenda 21*, *supra* note 63, ch. 18.
[66] *See Berlin Rules*, *supra* note 43, art. 3.
[67] *See Agenda 21*, *supra* note 63, ch. 18.
[68] *Id.*
[69] *Id.*
[70] *Id.*

or for constructing water dams for energy generation purposes.[71] Hence, here, the right to water also translates into the right to acquire food or to produce energy from water.

C. The No-Harm Principle

The no-harm principle has essential significance in international law.[72] According to this principle, no party can use a transboundary watercourse in such a way that results in harm being caused to another party.[73] For instance, if a water storage work in one riparian state risks extracting large quantities of water from a transboundary watercourse and harming the natural flow or quality of water in that watercourse basin in another riparian state, then that extraction could cause harm[74] and is not allowed under international water law unless the necessary changes to its designs are carried out to mitigate that harm.[75]

1. Accessing Water for Irrigation

According to the no-harm principle, if a state party is using the transboundary freshwater resource to irrigate crops for food production or to meet vital human needs such as drinking, cooking, and sanitation, then its coriparian state cannot use the same watercourse in such a manner that harms the former's access to

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[71] *Id.*

[72] *See* Edith Hödl, *Legislative Framework for River Ecosystem Management on International and European Level*, *in* RIVERINE ECOSYSTEM MANAGEMENT: SCIENCE FOR GOVERNING TOWARDS A SUSTAINABLE FUTURE 325, 329 (Stefan Schmutz & Jan Sendzimir eds., 2018).

[73] *See id.*

[74] *See* U.N. Econ. Comm'n Eur., *Convention on the Law of the Non-Navigational Uses of International Watercourses*, art. 7 (May 21, 1997) [hereinafter *Watercourses Convention*], https://treaties.un.org/doc/Treaties/1998/09/19980925%2006-30%20PM/Ch_XXVII_12p.pdf; *Berlin Rules*, *supra* note 42, art. 12.

[75] *See Berlin Rules*, *supra* note 42, art. 12; *Watercourses Convention*, *supra* note 74, art. 7.

water.[76] This principle is particularly applied on riparian states to prevent them from engaging in any activity that risks harm to another.[77] The 1997 UN Watercourses Convention specifically imposes an obligation on state parties to cause no significant harm to the residents of their coriparian states in their use of transboundary freshwater resources.[78] This obligation is expressed as: "Watercourse states shall, in utilizing an international watercourse in their territories, take all appropriate measures to prevent the causing of significant harm to other watercourse states."[79]

It is pertinent to mention here that almost eighty percent of freshwater withdrawal on earth is consumed by the agricultural sector, primarily for irrigating crops to producing food.[80] Thus, it can be asserted that almost every riparian state is using the water from its transboundary watercourses in the agricultural sector to produce food. This use must cause no harm, as per the no-harm principle of international water law,[81] because any hindrance to accessing freshwater will also harm states' food security.[82] This depicts the inherent nexus of food with water, which is protected by international water law through the application of the no-harm rule to the nexus.[83]

International water law has also advised states to also ensure that their water extraction endeavors cause no harm to the environment.[84] The Berlin Rules particularly highlights this: "States shall take all appropriate measures to prevent or minimize environmental harm."[85]

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[76] *See* Hödl, *supra* note 72, at 329.
[77] *See Watercourses Convention*, *supra* note 74, art. 17.
[78] *See id.*
[79] *See id.*
[80] *See Dublin Statement*, *supra* note 2.
[81] *See* Hödl, *supra* note 72, at 329.
[82] *See generally Dublin Statement*, *supra* note 2 (large quantities of freshwater are required in agriculture for growing food).
[83] *See* Hödl, *supra* note 72, at 329.
[84] *See Berlin Rules*, *supra* note 42, art. 8.
[85] *Id.*

Minimization of environmental harm is necessary to preserve the fauna and flora of the environment, which is dependent on such water resources.[86] In addition, international water law also advises states to cause no harm to the natural flow or quality of water in river basins.[87]

2. Storing Water for Energy Generation

Hydropower generation requires the availability of large sums of water,[88] which states extract to store in a reservoir to produce electricity, as well as for additional purposes, such as cooling plant machinery.[89] The no-harm principle also applies to riparian states here.[90] A pertinent application of this rule has been followed in the Agreement on Cooperation for Sustainable Development of the Mekong River multilateral treaty,[91] where China, being an upper riparian state from its energy generation projects pursued on the Mekong River,[92] is bound to cause no harm to its lower riparian neighbors.[93] The parties to this agreement, the lower riparian states to China on the Mekong River, are Thailand, Cambodia, Laos, Myanmar, and Vietnam.[94] Another agreement, signed among them in 2002, has been accepted by China and, since then, China has also

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[86] *See id.* art. 3 (explanation of what is included in "environment").
[87] *See Watercourses Convention*, *supra* note 74, art. 7; *see also Berlin Rules*, *supra* note 42, art. 12.
[88] P. K. NAG, POWER PLANT ENGINEERING 28 (3d ed. 2008); *see also* SPEED ET AL., *supra* note 6, at 68.
[89] *See* Olsson, *supra* note 5, at 24.
[90] *See* Hödl, *supra* note 72, at 329 (discussing that the no-harm principle is an obligation applicable on all riparian states).
[91] Waseem Ahmad Qureshi, *The Indus Basin: Water Cooperation, International Law and The Indus Waters Treaty*, 26 MICH. ST. INT'L L. REV. 43, 75 (2017).
[92] Stina Hansson et al., *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, *in* POLITICS AND DEVELOPMENT IN A TRANSBOUNDARY WATERSHED: THE CASE OF THE LOWER MEKONG BASIN 10 (Joakim Öjendal et al. eds., 2011).
[93] *See* Hödl, *supra* note 72, at 329.
[94] *See* Qureshi, *supra* note 91, at 75.

been bound to share information regarding the usage and flow of the Mekong River in its territory.[95]

Similarly, the Indus Waters Treaty also follows the no-harm principle in apportioning water between the upper riparian India and the lower riparian Pakistan.[96] Pakistan has objected to a number of Indian dams, prominently the Baglihar and Kishanganga Dams, which caused it harm in terms of significant reductions of water flows in the Chenab and Jhelum Rivers in its territory.[97] The Neelum River faced a threat of severe water shortage due to the Kishanganga Dam, which threatened the water and food security of the people nearby.[98] Notably, in addition to reducing the flow of water in its rivers, Pakistan also faced a water shortage in its major hydropower generation dams, including the Tarbela and Mangla Dams, and suffered significant harm from the reduction of freshwater to irrigate its croplands.[99] Therefore, it took the Baglihar Dam dispute to the International Court of Arbitration in 2005[100] and the Kishanganga Dam dispute to The Hague's Permanent Court of Arbitration in 2011.[101] In its judgment in 2013, the International Court of Arbitration ordered India to make modifications in the design of its Baglihar Dam to release an additional nine cusecs of

[95] PHILIPPE SANDS ET AL., PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW 337 (2012).

[96] LESLIE-ANNE DUVIC-PAOLI, THE PREVENTION PRINCIPLE IN INTERNATIONAL ENVIRONMENTAL LAW 149 (2018).

[97] *See* A. K. CHATURVEDI, WATER: A SOURCE FOR FUTURE CONFLICTS 164 (2013).

[98] *Id*. at 164.

[99] *See* MATTHEW ZENTNER, DESIGN AND IMPACT OF WATER TREATIES: MANAGING CLIMATE CHANGE 140 (2011); *see also* F. Naz, *Water: A Cause of Power Politics in South Asia, in* WATER AND SOCIETY II 101, 105 (C. A. Brebbia, ed., 2013).

[100] Kristina Roic et al., *The Ebb and Flow of Water Conflicts: A Case Study of India and Pakistan, in* IMAGINING INDUSTAN: OVERCOMING WATER INSECURITY IN THE INDUS BASIN 49, 55 (Zafar Adeel & Robert G. Wirsing eds., 2016).

[101] Patricia Wouters, *'Dynamic Cooperation'—The Evolution of Transboundary Water Cooperation, in* WATER AND THE LAW: TOWARDS SUSTAINABILITY 13, 52 (Michael Kidd et al. eds., 2014).

water to Pakistan's river basins.[102] The Permanent Court of Arbitration allowed India to construct the Kishanganga Dam, with some restrictions such as preventing it from "using drawdown flushing for sediment control."[103] The Permanent Court of Arbitration also prevented India from constructing any additional run-of-the-river dam on the western rivers.[104] The purpose of applying restrictions on the Indian dams was to minimize the harm that these dams were causing to Pakistan.[105] Here, the imminence of harm to Pakistan's hydropower generation and agricultural sector by the water storage works of the upper riparian India[106] highlights the nexus among water, energy, and food. In this example, India's water storage works negatively affected the generation of energy and the production of food in Pakistan.[107]

As is evident from the Baglihar and Kishanganga Dam disputes between India and Pakistan, because of the strong nexus of water and energy, states' pursuit of hydropower from fresh watercourses can harm the natural flow of watercourses in their coriparian states.[108] International water law helps to prevent this harm by advising riparian states to make the necessary alterations to the designs of their hydropower water storage works to ensure that no harm is caused to their coriparian neighbors,[109] and the UN Watercourses Convention also advises state parties to compensate the latter for

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[102] *See* Ashok Swain, *Water Insecurity in the Indus Basin: The Costs of Cooperation*, *in* IMAGINING INDUSTAN: OVERCOMING WATER INSECURITY IN THE INDUS BASIN 37, 40 (Zafar Adeel & Robert G. Wirsing, eds., 2016).

[103] *See* Bjørn-Oliver Magsig, *The Indus Waters Treaty: Modernizing the Normative Pillars to Build a More Resilient Future*, *in* IMAGINING INDUSTAN: OVERCOMING WATER INSECURITY IN THE INDUS BASIN 69, 79 (Zafar Adeel & Robert G. Wirsing eds., 2016).

[104] *Id.*

[105] *Id.* at 80.

[106] *Id.*

[107] *See* ZENTNER, *supra* note 99, at 140; *see also* Naz, *supra* note 99, at 105.

[108] *See* ZENTNER, *supra* note 99, at 140.

[109] *Watercourses Convention*, *supra* note 74, arts. 7 & 17.

any losses that their water utilization–related endeavors may cause to their people:[110]

> Where significant harm nevertheless is caused to another watercourse State, the States whose use causes such harm shall, in the absence of agreement to such use, take all appropriate measures, having due regard for the provisions of articles 5 and 6, in consultation with the affected State, to eliminate or mitigate such harm and, where appropriate, to discuss the question of compensation.[111]

As in the situation described above, international water law also advises riparian states to cooperate to implement joint engineering works so that the harm to the lower riparian state can be reduced without compromising on the benefits for the upper riparian state.[112]

D. The Duty to Cooperate

International water law imposes a duty on state parties to cooperate to ensure the sustainable provisioning of freshwater resources for their people.[113] This principle is applicable to all riparian states accessing water for food production or for hydropower generation purposes.[114]

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[110] *See id.* art. 7.
[111] *Id.*
[112] ALISTAIR RIEU-CLARKE ET AL., TRANSBOUNDARY WATER GOVERNANCE AND CLIMATE CHANGE ADAPTATION: INTERNATIONAL LAW, POLICY GUIDELINES AND BEST PRACTICE APPLICATION 42 (2015); s*ee also Watercourses Convention*, *supra* note 74, art. 27.
[113] *Watercourses Convention*, *supra* note 74, art. 5.
[114] *See id*.

1. Using Water for Food Production

Sustainable provisioning of freshwater to people will ultimately result in ensuring sufficient food security for the people.[115] To do so, international water law recommends that states develop and protect their freshwater resources.[116] This recommendation is provided in the UN Watercourses Convention: "Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection and development thereof, as provided in the present convention."[117]

According to Campbell, the protection here refers to protecting watercourses from natural disasters such as floods and droughts.[118] It can also refer to shielding natural aquifers from pollution.[119] Both natural and manmade disasters pose threats to water security and, in turn, to people's food security by harming the water available for irrigation.[120] Droughts can dry out natural aquifers, while the floods can cause siltation of freshwater and can also destroy crops, resulting in harming people's water and, in turn,

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[115] *See* FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, WATER FOR SUSTAINABLE FOOD AND AGRICULTURE: A REPORT FOR THE G20 PRESIDENCY OF GERMANY 2 (2017) [hereinafter FAO].

[116] *Watercourses Convention*, *supra* note 74, art. 5.

[117] *Id.*

[118] James R. Campbell, *Human Health Threats and Implications for Regional Security in Southeast Asia*, *in* HUMAN SECURITY: SECURING EAST ASIA'S FUTURE 173, 174 (Benny Teh Cheng Guan ed., 2012).

[119] *Id.*

[120] Madhavi Malalgoda Ariyabandu et al., *Do Disasters Discriminate? A Human Security Analysis of the Impact of the Tsunami in India, Sri Lanka and of the Kashmir Earthquake in Pakistan*, *in* FACING GLOBAL ENVIRONMENTAL CHANGE: ENVIRONMENTAL, HUMAN, ENERGY, FOOD, HEALTH AND WATER SECURITY CONCEPTS 1215, 1215 (Hans Günter Brauch et al. eds., 2009); *see also* Philippe Gourbesville, *Smart Water Solutions for Water Security: From Concept to Operational Implementation*, *in* WATER SECURITY AND THE SUSTAINABLE DEVELOPMENT GOALS 47, 48 (Hyoseop Woo et al. eds., 2019).

food security.[121] Likewise, pollution also threatens the availability of freshwater for the fulfillment of vital human needs.[122] Unclean water, when consumed for drinking, cooking, or sanitation purposes, can spread serious diseases in humans such as diarrhea and typhoid.[123] In certain regions, arsenic has been identified in freshwater.[124] Drinking such polluted water can also cause some of the deadliest diseases, including cancer.[125] Unfortunately, the most common cause of water pollution in many regions is the dumping of untreated hazardous industrial chemical waste directly into rivers and other open aquifers.[126] As a result, that water becomes toxic and cannot be used to meet vital human needs.[127] Thus, both types of disasters—manmade, such as pollution, and natural disasters, such as droughts and floods—risk harming people's water and food security.[128]

As natural disasters do not respect geographical borders between states, international water law advises states to cooperate to mitigate the environmental threats that loom over food and water security.[129] This advice has been particularly vocalized in Articles 34 and 35 of the Berlin Rules.[130] Article 34 advises state parties to cooperate to mitigating the threats of floods,[131] while Article 35 recommends that state parties cooperate to reduce the severity of droughts.[132]

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121 Gourbesville, *supra* note 120, at 48.
122 BJØRN-OLIVER MAGSIG, INTERNATIONAL WATER LAW AND THE QUEST FOR COMMON SECURITY 30 (2015).
123 H. Ahmad & Sanjeev Sinha, *Cyclosporiasis: An Emerging Potential Threat for Water Contamination*, *in* WATER AND HEALTH 179, 179 (Prati Pal Singh & Vinod Sharma eds., 2013).
124 DAVID B. RESNIK, ENVIRONMENTAL HEALTH ETHICS 142 (2012).
125 *Id.*
126 INTERNATIONAL MONETARY FUND, BANGLADESH: POVERTY REDUCTION STRATEGY PAPER 183 (2013) [hereinafter BANGLADESH: POVERTY REDUCTION].
127 *Id.*
128 *Id.*; *see also* Gourbesville, *supra* note 120, at 48.
129 *See Berlin Rules*, *supra* note 42, arts. 34 & 35.
130 *Id.*
131 *Id.*
132 *Id.*

Cooperation among riparian states can be established by the implementation of joint and well-coordinated cross-border approaches by riparian states to mitigate the threats of natural and man-made disasters.[133] International water law especially advises state parties to establish joint committees comprising water management experts from both states.[134] Such committees of experts should monitor the quantity and quality of the flow of water in watercourses[135] and facilitate the exchange of information among riparian states about the flow of water.[136] The regular exchange of such information will help the committees to forecast any perceived threats from natural disasters such as droughts or floods in the future.[137] A significant drop or increase in the quantity of flow of water can indicate droughts or floods situation in the watercourse, respectively,[138] though those changes can also result from a significant reduction or increase in precipitation rates.[139]

On the other hand, assessing the quality of the flow of water by setting quality standards can provide information about pollution and the presence of substances that are hazardous to crops.[140] The joint committees can notify the relevant authorities of either or both states of any change in the quality or quantity of watercourses,[141] then the relevant authorities can implement timely measures to

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[133] *Id.*
[134] Christina Leb, *The Significance of the Duty to Cooperate for Transboundary Water Resources Management under International Water Law*, *in* ROUTLEDGE HANDBOOK OF WATER LAW AND POLICY 247, 255 (Alistair Rieu-Clarke et al. eds., 2013).
[135] *See Dublin Statement*, *supra* note 2.
[136] *See Berlin Rules*, *supra* note 42, art. 56; *Watercourse Convention*, *supra* note 74, art. 9.
[137] *Watercourse Convention*, *supra* note 74, art. 9.
[138] *Id*.
[139] *See, e.g.*, Gabriel Eckstein, *Water Scarcity, Conflict, and Security in a Climate Change World: Challenges and Opportunities for International Law and Policy*, 27 WIS. INT'L L.J. 409, 411 (2010).
[140] *See Berlin Rules*, *supra* note 42, art. 28; *Watercourse Convention*, *supra* note 74, art. 21.
[141] *See Berlin Rules*, *supra* note 42, art. 56; *Watercourse Convention*, *supra* note 74, art. 9.

ensure a good-quality flow of water for irrigating crops.[142] In particular, they can make timely precautionary arrangements in the event of forecasts of natural disasters.[143] This will ensure the protection of adequate water and food security for the people of both riparian states.[144] Hence, cooperation among riparian states through joint committees would prove vital for protecting people's food and water security.[145]

2. Using Water for Energy Generation

International water law also imposes a duty on riparian states to cooperate over the utilization of water for hydropower generation from their mutual transboundary watercourses.[146] For this purpose, international water law advises states to exchange information regarding water storage works planned or under construction.[147] This information can enable them to analyze the nature and extent of the harm posed by that water storage work.[148] International water law has directed riparian states to establish joint bodies to monitor the flow and quantity of water in river basins.[149] Such joint monitoring could estimate and thus mitigate any potential harm of a hydropower water storage work.[150] The design could then be modified.[151] This can be seen in the treatment of the Baglihar Dam, where India

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[142] *See Berlin Rules*, *supra* note 42, art. 28.
[143] *See Berlin Rules*, *supra* note 42, art. 56; *see also* Leb, *supra* note 134, at 252.
[144] *See Berlin Rules*, *supra* note 42, art. 56
[145] *See id.*; *see also* Leb, *supra* note 134, at 252.
[146] *Watercourse Convention*, *supra* note 74, art. 5 (the duty to cooperate is applied on all kinds of endeavors initiated by the states in their pursuits of accessing and utilizing their transboundary shared freshwater resources).
[147] *Id.* art. 11.
[148] *Id.* arts. 7 & 17.
[149] Convention on the Protection and Use of Transboundary Watercourses And International Lakes art. 9, Mar. 17, 1992, 1936 U.N.T.S. 269.
[150] Watercourse Convention, *supra* note 74, at arts. 7 & 17.
[151] *Id.* art. 12.

was asked by the International Court of Arbitration to modify its design during construction.[152]

In short, cooperation among riparian states in the sharing of one or more transboundary watercourses can mitigate the harm of the states' water utilization activities.[153] That cooperation can lead to the establishment of peaceful relations among the states, facilitating the equitable and reasonable utilization of their transboundary shared watercourses among them.[154]

E. The Principle of Reasonable and Equitable Utilization of Fresh Water

The principle of reasonable and equitable utilization of transboundary freshwaters is one of the most vital elements of international water law.[155] This principle has been made obligatory on all riparian states by the UN Watercourses Convention: "Watercourse states shall in their respective territories utilize an international watercourse in an equitable and reasonable manner."[156]

This principle is applicable to all water-related endeavors that riparian states may carry out, whether related to food production or energy generation.[157]

1. Application to the Water–Food Nexus

The reasonable and equitable utilization of transboundary freshwaters requires that vital human needs be realized as the first priority of the freshwater.[158] This is echoed in the Berlin Rules: "In

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[152] See Swain, *supra* note 102, at 40.
[153] *Watercourse Convention*, *supra* note 74, art. 7.
[154] *Id.* art. 17.
[155] *See* Hödl, *supra* note 72, at 329; *see also* DINARA ZIGANSHINA, PROMOTING TRANSBOUNDARY WATER SECURITY IN THE ARAL SEA BASIN THROUGH INTERNATIONAL LAW 92 (2014).
[156] *Watercourse Convention*, *supra* note 74, art. 5.
[157] *Id.*
[158] *See Berlin Rules*, *supra* note 42, art. 14.

determining an equitable and reasonable use, States shall first allocate waters to satisfy vital human needs."[159]

The inherent meaning of this principle is that riparian states sharing one or more transboundary watercourse are advised to share the water equitably[160] and utilize their share of the water reasonably, which means satisfying vital human needs first.[161] The meeting of vital human needs will ensure adequate water security and food security for humans, which further implies the relationship between water security and food security in international law. Likewise, international water law's principle of reasonable and equitable utilization appears to safeguard food and water security.[162] It suggests that a riparian state cannot deprive another of its due share of the water in the transboundary watercourse. Thus, it appears to protect people's water security[163] and, in turn, food security.[164]

However, determining what is a reasonable and equitable share of water from a common transboundary watercourse for each riparian state is another challenge that needs to be assessed.[165] For this purpose, the instructions in Article 13 of the Berlin Rules can be taken into account; these recommend that riparian states consider all factors in determining an equitable and reasonable share of water for each riparian state.[166] It mentions the "geographic, hydrographic, hydrological, hydrogeological, climatic, ecological, and other natural features" of the water aquifer to be studied, in addition to evaluating the "socio-economic needs" of the people who rely on the aquifer.[167] It specifically requires the "minimization of environment harm" in establishing plans to allocate an equitable share for

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[159] *Id.*
[160] *Watercourse Convention*, *supra* note 74, art. 5.
[161] *See Berlin Rules*, *supra* note 42, art. 14.
[162] *See* ZIGANSHINA, *supra* note 155, at 92.
[163] *Id.*
[164] This is because the principle of reasonable and equitable utilization necessarily requires the fulfillment of vital human needs for its implementation on a watercourse. *See Berlin Rules*, *supra* note 42, art. 14.
[165] *Id*. art. 13.
[166] *See id*. art. 13.
[167] *See id*. art. 13.

each riparian state[168] and highlights the need to inculcate "sustainability" in those plans.[169] It also recommends that state parties evaluate the significance of each factor and give additional consideration to it in terms of its capacity to affect people's well-being.[170] Here, well-being can imply people's water security and, in turn, food security, because the reasonable and equitable allocation of water will result in provisioning sufficient water for the fulfillment of vital human needs.[171] In effect, this again highlights the inherent nexus between water and food security.

2. Application to the Water–Energy Nexus

The principle of equitable utilization, as explained above, mandates an equitable and reasonable apportionment of one or more transboundary watercourses among riparian states.[172] Once vital human needs are met by the use of freshwater, riparian states can allocate water for hydropower generation.[173] Nonetheless, this allocation of water must also follow the principle of equitable utilization, meaning that both states should get an equitable share of the remaining water resources to use for energy generation.[174] Here again, the recommendations provided in Article 13 of the Berlin Rules can be considered.[175] Population plays an important role in justifying the allocation of a larger share of water to the riparian state with the higher population, because the energy-related needs of its population will be greater.[176] A similar rule can be applied for determining an equitable share for irrigating crops.[177] These rules affirm the inherently strong nexus among water, energy, and

[168] *See id*.
[169] *See id*.
[170] *See id*.
[171] *See id*. arts. 3 & 14.
[172] *See* Hödl, *supra* note 72, at 329.
[173] *See Berlin Rules*, *supra* note 42, art. 14.
[174] *See* Hödl, *supra* note 72, at 329.
[175] *See Berlin Rules*, *supra* note 42, art. 13.
[176] *Id.*
[177] *See id.*

food.[178] Likewise, international water law appears to endorse this nexus through the implementation of its equitable utilization principle among riparian states in apportioning their transboundary watercourses.

F. The Example of Nonconsumptive Use of Water

Nonconsumptive use implies the use of river water that brings no harm to the original flow of water in the river basin,[179] in particular not causing a blockage in the flow of water in the river basin.[180] The term "nonconsumptive use" is used in the text of the Indus Waters Treaty,[181] which restricts India and Pakistan from using each other's rivers for consumptive purposes.[182] Nonetheless, both are allowed to use rivers of each other for agricultural and hydropower generation.[183]

The Indus Waters Treaty, signed in 1960, equitably apportioned the water of the Indus River Basin between the two countries.[184] The Indus River basin comprises six river tributaries: the Ravi, Jhelum, Chenab, Sutlej, Beas, and Indus Rivers.[185] Of these six tributaries, the Indus Waters Treaty allocated the three eastern tributaries—the Beas, Ravi, and Sutlej—to the upper riparian country, India, for its unrestricted use.[186] The treaty also allowed the lower riparian state, Pakistan, to use the three western tributaries—the Jhelum, Chenab, and Indus—for its unrestricted use.[187] However, because the eastern tributaries also pass through Pakistan and the western tributaries reach Pakistan after passing

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[178] *Id.*
[179] *See* Indus Waters Treaty art. I, Sep. 19, 1960, 1962 U.N.T.S. 126.
[180] *Id.*
[181] *Id.*
[182] *See id.* arts. II & III.
[183] *Id.*
[184] LUDWIK A. TECLAFF, THE RIVER BASIN IN HISTORY AND LAW 163–64 (Albert H. Garretson ed., 2012).
[185] *Id.*
[186] *Id.*
[187] *Id.*

through Indian territory,[188] the Indus Waters Treaty allowed both countries to use each other's tributaries for domestic and nonconsumptive purposes.[189] Nonetheless, the use of those tributaries for agricultural and hydropower generation is exclusively allowed to both countries to pursue.[190] For instance, Pakistan can use the water of the eastern tributaries for agricultural and hydropower generation,[191] and India can do likewise from Pakistan's western river tributaries.[192] However, such use must not cause any harm to the natural flow of water in those tributaries.[193]

Allowing the use of each other's river tributaries for agricultural purposes will ensure adequate food security, because agricultural use takes priority in the utilization of the Indus Basin's water.[194] This fulfills the central condition of international water law, that vital human needs be fulfilled as the first priority in accessing water.[195] This affirms the intrinsic relationship between the provisioning of water (from river tributaries) and the production of food (via agriculture). This relationship cannot be harmed because the bilateral treaty allowed both riparian states to take of water for agricultural purposes.[196] Hydropower energy presents a similar case, indicating an inherent nexus between water and energy that has been endorsed in the Indus Waters Treaty.[197]

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[188] *See* Malcolm Cooper, *River Tourism in the South Asian Subcontinent*, *in* RIVER TOURISM 23, 25–26 (Bruce Prideaux and Malcolm Cooper eds., 2009).
[189] *See* Indus Water Treaty, *supra* note 179, arts. II & III.
[190] *Id*. art. I.
[191] *See id.* arts. II & IV.
[192] *See id.* art. III.
[193] *See id.* art. IV.
[194] This is because the Indus Waters Treaty allows each country to use water from the other's rivers for agricultural purposes. *See id.* arts. II, III & IV.
[195] *See Berlin Rules*, *supra* note 42, arts. 3 & 14.
[196] *See* Indus Water Treaty, *supra* note 179, arts. II & III.
[197] *See id.* arts. I & II.

G. The Domains of Human Security and the Nexus of Food Security, Energy Security, and Water Security

The water–energy–food nexus can also be observed through the lens of human security.[198] The concept of human security includes seven separate dimensions: economic, food, health, environmental, personal, community, and political security.[199] Here, energy security can be regarded as the fundamental element of economic security, because the availability of sufficient energy is necessary for industrial and technological development.[200]

Countries export products manufactured by industry and, in turn, earn export revenue,[201] and agrarian countries irrigate crops and produce food, which they export to nonagrarian countries to fulfill the latter's food security-related needs.[202] Agrarian countries also contribute to their own food security by consuming the food they produce and to their economic security by exporting surplus food.[203] For exports, both the industrial and agricultural sectors require significant water for their surplus goods production.[204] The industrial sector requires electricity, which is produced through hydropower mechanisms, employing large amount of freshwater, and it needs sufficient water in the manufacturing processes of certain industrial products.[205] For example, the garment industry consumes a massive amount of water.[206] A single pair of jeans

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198 OSCAR A. GÓMEZ & DES GASPER, HUMAN SECURITY: A THEMATIC GUIDANCE NOTE FOR REGIONAL AND NATIONAL HUMAN DEVELOPMENT REPORT TEAMS 2 (2013).
199 *Id.*
200 *See* Eric Abokyi et al., *Consumption of Electricity and Industrial Growth in the Case of Ghana*, J. ENERGY, 2018, at 1–3, https://www.hindawi.com/journals/jen/2018/8924835.
201 *See* ROGER TIMINGS, BASIC MANUFACTURING 2 (3d ed. 2004).
202 *See* Rehman et al., *supra* note 17, at 145–58.
203 *Id.*
204 *See* SPEED ET AL., *supra* note 6, at 68.
205 *Id.*
206 RUDEBECK, *supra* note 26, at 90.

requires around 3,500 liters of water for its manufacture.[207] Thus, water becomes an integral part of a nation's food and energy security and, then, economic security.[208]

H. The Concept of Virtual Water

The concept of virtual water is especially employed when explaining the nexus between food, water, and energy.[209] Virtual water represents the water used in the production of food (via irrigating crops) and the generation of hydropower.[210] The use of freshwater by the agricultural and energy sectors is much larger than in the domestic sector.[211]

1. Virtual Water Affirming the Food and Water Nexus

As per an estimate, up to five thousand liters of freshwater are required to produce one kilogram of rice, two thousand liters to produce one kilogram of soya,[212] and one thousand three hundred tons to produce one ton of wheat crop.[213] The water used in producing this food is called "virtual water," which affirms the presence of an intrinsic nexus between food and water.[214] As per an estimate, the agricultural sector consumes the biggest share of earth's freshwater resources, to produce food for humanity.[215] According to the estimates provided in the Action Agenda of the Dublin Statement, withdrawals by the agricultural sector use up to eighty percent

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207 *Id.*
208 *See Dublin Statement*, *supra* note 2.
209 Allen, *supra* note 54.
210 *Id.*
211 *See* FAO, *supra* note 115, at 2.
212 IVO ŠLAUS, *Grand Societal Global Threats and Challenges*, *in* TRANSFORMING OUR WORLD: NECESSARY, URGENT, AND STILL POSSIBLE 38, 48 (Ivo Šlaus ed., 2020).
213 Allen, *supra* note 54.
214 *Id.*
215 *See Dublin Statement*, *supra* note 2.

of freshwater extraction on earth.[216] Food cannot be grown without sufficient water for crops.[217] As per another estimate, around eighty percent of the total cropland worldwide is rainfed[218] and sixty percent of the total food produced on earth via agriculture is dependent on rainfed lands.[219] These stats strongly affirm the deep nexus between water and food.

2. Virtual Water Explaining the Water and Energy Nexus

Similar to water's use in the agricultural sector, the significant amount of water consumed in the production of energy,[220] and then in industry,[221] is regarded as virtual water.[222] It has been estimated that, globally, ninety percent of energy generation relies on freshwater.[223] This use includes the direct generation of hydropower from water and the use of water for cooling power plant machinery, which includes not just hydropower but also coal and nuclear energy.[224] This indicates the high dependence of the energy generation sector on the availability of freshwater.[225]

The concept of virtual water affirms that every unit of energy produced from water involves water,[226] as does each industrial item[227] and every unit of food.[228] This concept further

[216] *Id.*
[217] *See* Olawuyi, *supra* note 41, at 1.
[218] *See Water, Food and Energy*, UN WATER, https://www.unwater.org/water-facts/water-food-and-energy (last visited Nov. 11, 2020).
[219] *Id.*
[220] *See* SPEED ET AL., *supra* note 6, at 68.
[221] RUDEBECK, *supra* note 26, at 90.
[222] Allen, *supra* note 54.
[223] Bokova, *supra* note 4, at v.
[224] SPEED ET AL., *supra* note 6, at 68.
[225] *Id.*
[226] Allen, *supra* note 54.
[227] RUDEBECK, *supra* note 26, at 90.
[228] *See* ŠLAUS, *supra* note 212, at 48.

highlights the importance of water in the nexus of water, energy, and food.[229]

There is a profoundly interconnected nexus among water, food, and energy[230] and the concept of virtual water provides an additional viewpoint in determining the central role that water has within that nexus.[231] Virtual water helps to highlight that central role, as it helps to quantify the water that is added in the processes of producing food and energy.[232] Specifically, because irrigating crops[233] and hydropower generation consume large quantities of water,[234] water plays a central role in the water–food–energy nexus.[235] It follows that water security also leads to food security and energy security.[236] International law has indirectly endorsed this view through international water law principles such as the no-harm principle,[237] the principle of equitable utilization,[238] and the duty to cooperate.[239] Likewise, the human right to water[240] contributes to ascertaining the nexus between water and food.[241]

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[229] Allen, *supra* note 54.
[230] *See* Olawuyi, *supra* note 41, at 1; *see also* D'Odorico et al., *supra* note 12, at 456.
[231] Allen, *supra* note 54.
[232] *Id.*; *see also* RUDEBECK, *supra* note 26, at 90.
[233] Allen, *supra* note 54.
[234] SPEED ET AL., *supra* note 6, at 68.
[235] D'Odorico et al., *supra* note 12, at 456.
[236] *Id.*
[237] *See* Hödl, *supra* note 72, at 329; *see also Watercourses Convention*, *supra* note 74, art. 7.
[238] *See* Hödl, *supra* note 72, at 329; *see also Watercourses Convention*, *supra* note 74, art. 5.
[239] *Watercourses Convention*, *supra* note 74, art. 5.
[240] *See Agenda 21*, *supra* note 63, ch. 18; *see also Watercourses Convention*, *supra* note 74, art. 17.
[241] This is in accordance with Article 3 of the Berlin Rules on Water Resources, which mandates that the provisioning of water must ensure the fulfillment of "vital human needs" as the first priority. *See Berlin Rules*, *supra* note 43, art. 3. As vital human needs also include access to food, the nexus between food and water is endorsed indirectly through Article 3 of the Berlin Rules. *Id.*

III. THE WATER–FOOD–ENERGY NEXUS IN THE FUTURE

Taking from the intrinsic relationship among water, food, and energy security,[242] the future trends foresee that balancing water's role in the water–food–energy nexus will continue in order to meet the human demands of economic and food security. However, there are concerns around the nexus in the future, primarily due to the growing scarcity of freshwater resources on earth.[243] A major concern is the decline in rainfall due to climate change, which is causing a shortage of water in river basins and, especially, in natural aquifers.[244] People residing in many water-scarce regions, such as Baluchistan Province in Pakistan, depend on these natural aquifers to meet their demands related to water and food.[245] Hence, their vital human needs are being threatened because of the declining availability of freshwater in the natural aquifers, especially in subtropical and mid-latitude regions.[246] Likewise, riparian states are also seeing an increased number of disputes over accessing and utilizing their shared watercourses despite the water sharing treaties.[247] Disputes have been raised by India against China, claiming that the latter's massive water storage dams threaten the former's water and food security.[248] In particular, China's construction of dams on the Brahmaputra River in its territory may result in an acute scarcity of water in the Indian basin of this river.[249] Scholars have warned of a

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[242] *See* Olawuyi, *supra* note 41, at 1; *see also* D'Odorico et al., *supra* note 12, at 456.

[243] *See* WORLD ECONOMIC FORUM, THE GLOBAL RISKS REPORT 2019, at 12 (14th ed. 2019) (compiling information on growing water scarcity) [hereinafter GLOBAL RISKS REPORT 2019].

[244] *See* Eckstein, *supra* note 139, at 411.

[245] *See* M. A. Kahlown et al., *Use of Saline Water for Vegetable Production in Dryland of Lal Sohanra Biosphere Reserve, Pakistan, in* UNESCO, SUSTAINABLE MANAGEMENT OF MARGINAL DRYLANDS 79, 79–80 (2007).

[246] *See* Eckstein, *supra* note 139, at 411.

[247] *See* Roic et al., *supra* note 100, at 55.

[248] Jonathan Holslag, *Assessing The Sino-Indian Water Dispute*, 64 J. INT'L AFFS. 19, 19–20 (2011).

[249] *Id.*

possible war between these two countries over accessing a larger share of their shared watercourses.[250]

Similar to the disputes between India and China, Pakistan has also raised numerous objections over the latest Indian water storage works, claiming that they threaten Pakistan's water, food, and energy security.[251] This places India in a precarious position, as India becomes the middle riparian between China and Pakistan; it is an upper riparian to Pakistan and a lower riparian to China.[252] Moreover, India depends highly on the rivers it shares with China and Pakistan to irrigate its food crops and produce its electricity.[253] All three countries also have nuclear weapons,[254] so any harsh escalation of disputes—either between China and India or between India and Pakistan—can invoke nuclear war, which may have a deadly impact on the peace and security of the region.[255] Because of the importance of water within the nexus, a threat to water resources between these three countries may become a threat to the peace and security in that region.[256]

Another threat that underlies the water–food–energy nexus is pollution in fresh watercourses.[257] For example, the throwing of untreated industrial waste by factories in many regions directly into fresh watercourses is making those watercourses polluted and unsuitable to be used for drinking, domestic, and agricultural purposes,[258] and is contributing to an artificial shortage of water.[259]

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[250] *Id.*
[251] *See* Roic et al., *supra* note 100, at 55.
[252] Uttam Kumar Sinha, *Towards Riparian Rationality: An Indian Perspective*, *in* CHINA-INDIA RELATIONS: COOPERATION AND CONFLICT, ch. 9 (Kanti Bajpai et al. eds., 2015) (ebook).
[253] *Id*.
[254] HOWARD J. WIARDA & ESTHER M. SKELLEY, THE CRISIS OF AMERICAN FOREIGN POLICY: THE EFFECTS OF A DIVIDED AMERICA 243 (2006).
[255] CHRISTOPHER J. CUBBAGE & DAVID J. BROOKS, CORPORATE SECURITY IN THE ASIA-PACIFIC REGION: CRISIS, CRIME, FRAUD, AND MISCONDUCT 4–5 (2012).
[256] *See* Holslag, *supra* note 248, at 20.
[257] *See Dublin Statement*, *supra* note 2.
[258] INTERNATIONAL MONETARY FUND, *supra* note 126, at 183.

Additionally, as the world's population is growing massively, the per capita availability of freshwater is decreasing and existing freshwater resources are undergoing increasing stress.[260] Consequently, a number of countries are moving from being water-scarce to being water-stressed,[261] increasing demands to extract additional water to irrigate more lands for the agricultural sector to produce more food.[262] The pace of increase in population even indicates that there will be additional two to three billion people on earth within the next thirty years,[263] which will further decrease the per capita availability of freshwater.[264]

The stress on water resources will also be exacerbated by the industrial sector, which will require additional water to compensate for the growing industrial demands; the world is increasingly turning toward industrialization and material development.[265] It is estimated that water withdrawals for energy generation and industrial manufacturing may increase by twenty percent, because more water will be required for cooling purposes to increase the efficiency of plants.[266] At present, almost forty-three percent of water in

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[259] *See Dublin Statement*, *supra* note 2; *see also* Alberto Boretto & Lorenzo Rosa, *Reassessing the Projections of the World Water Development Report*, NPJ CLEAN WATER, 2019, at 1, 15.

[260] *Id. See generally* Cornelius Okello et al., *Impact of Population Growth and Climate Change on the Freshwater Resources of Lamu Island, Kenya*, 2015 WATER 1264 (2015) (discussing the population's effect on the availability of freshwater resources).

[261] *See* Shaheen Akhtar, *Emerging Challenges to Indus Waters Treaty: Issues of Compliance & Transboundary Impacts of Indian Hydroprojects on the Western Rivers*, INST. REG'L STUD. 10 (2010), http://www.irs.org.pk/f310.pdf.

[262] SANDRA POSTEL, LIQUID ASSETS: THE CRITICAL NEED TO SAFEGUARD FRESHWATER ECOSYSTEMS 38–39 (Lisa Mastny ed., 2005).

[263] These estimates are provided by the United Nations. *See Growing at a Slower Pace, World Population is Expected to Reach 9.7 Billion in 2050 and Could Peak at Nearly 11 Billion Around 2100*, U.N. Dep't Econ. & Soc. Affs. (June 17, 2019), https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html.

[264] *See* POSTEL, *supra* note 262, at 38–39.

[265] *See Water, Food and Energy*, *supra* note 218.

[266] *Id.*

Europe is consumed for such cooling purposes.[267] This estimated increase highlights the high future demand for water in energy generation.[268] However, the growing scarcity of water poses a challenge for meeting such demands for energy in the future.[269]

IV. RECOMMENDATIONS TO ENSURE AN ADEQUATE WATER SECURITY FOR ENERGY AND FOOD IN THE FUTURE

It is recommended that states should cooperate in devising sustainable policies to ensure adequate water security so that the resultant vital human needs related to water will be satisfied in all regions.[270] This will ensure sufficient food security and, later, adequate energy security for the people. Obstacles to water security such as the emerging scarcity of water should be tackled sustainably.[271] A notable recommendation is the implementation of integrated water management schemes.[272] Riparian states can coordinate to implement integrated water management schemes, not only to equitably utilize, but also to preserve and develop their shared water resources sustainably.[273] Such schemes entail the integration of all freshwater resources so as to preserve and utilize them sustainably,[274] and can allow states to first allocate sufficient water to satisfy vital human needs and then allocate water for other endeavors such as agriculture and industry; enabling states to preserve and use water resources sustainably.[275] This is possible because integrated water management schemes give states control over managing and allocating water to any sector they like,[276] ensuring that

[267] *Id.*
[268] *Id.*
[269] *See* Boretto & Rosa, *supra* note 259, at 15.
[270] *Watercourses Convention*, *supra* note 74, art. 5.
[271] Anatole Boute, *The Water-Energy-Climate Nexus Under International Law: A Central Asian Perspective*, 5 MICH. J. ENV'T & ADMIN. L. 371, 408 (2016).
[272] *See Dublin Statement*, *supra* note 2.
[273] *See id.*; *see also* Leb, *supra* note 134, at 252; *Berlin Rules*, *supra* note 42, art. 3.
[274] *See Berlin Rules*, *supra* note 42, art. 3.
[275] *See id.*; *see also Dublin Statement*, *supra* note 2.
[276] *See Berlin Rules*, *supra* note 42, art. 3; *Dublin Statement*, *supra* note 2.

water-related needs and the resulting food- and energy-related demands for water can be satiated effectively, without compromising on vital human needs or causing any harm to coriparian states.[277]

Conversely, certain conditions in the river basins, such as erosion, siltation, saltation, and droughts, threaten individuals' water and food security.[278] Considering this, international water law also recommends that state parties carry out joint or individual measures to remove such conditions.[279] Specifically, the UN Watercourses Convention includes this recommendation:

> Watercourse states shall, individually and, where appropriate, jointly, take all appropriate measures to prevent or mitigate conditions related to an international watercourse that may be harmful to other watercourse states, whether resulting from natural causes or human conduct, such as flood or ice conditions, water-borne diseases, siltation, erosion, saltwater intrusion, drought or desertification.[280]

Mitigating the threats of a natural disaster, such as preventing siltation and saltwater intrusion of transboundary freshwater resources, can enable riparian states to make available an adequate flow of freshwater for irrigation and the satisfaction of vital human needs.[281] In effect, this will protect the food security of the people of both the upper and lower riparian states;[282] shielding freshwater resources

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[277] *See Berlin Rules*, *supra* note 42, art. 3; *Dublin Statement*, *supra* note 2.
[278] *See Watercourses Convention*, *supra* note 74, art. 27.
[279] *Id.*
[280] *Id.*
[281] *See id.*; *see also* RIEU-CLARKE ET AL., *supra* note 112, at 42.
[282] This is because the protection of water will ensure provisioning of adequate water for the fulfillment of vital human needs. *See Berlin Rules*, *supra* note 42, art. 3.

from threat of natural disaster will result in protecting people's food security, which reflects the strong nexus of water with food.[283]

Another specific recommendation is to identify and evaluate the regions with the highest vulnerability to water and food insecurity.[284] The people residing in such regions should be approached and helped accordingly to meet their vital human needs.[285] Programs such as the United Nations Trust Fund for Human Security (UNTFHS) can be imitated by states themselves to locate vulnerable regions in their territory.[286] The UNTFHS discovers and keeps track of vulnerable regions[287] and attempts to install localized policies and strategies in those regions to enhance people's food and water security.[288] This program has been pursued in some regions in Peru, Egypt, and Pakistan, where the local communities were equipped by the Fund's team with the necessary localized assistance to raise their water, food, and, in turn, human security.[289] The extension of such programs on a global scale can result in mitigating the threats related to food and water security in vulnerable regions.[290]

V. CONCLUSION

Water, food, and energy have an intrinsic relationship.[291] For instance, water is necessary for irrigating crops and, thus, for growing food.[292] The concept of virtual water further endorses the

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[283] *See* Gourbesville, *supra* note 120, at 48; *see also* D'Odorico et al., *supra* note 12, at 456.
[284] *Why Invest in the UNTFHS?*, U.N. TR. FUND HUM. SEC., https://www.un.org/humansecurity/wp-content/uploads/2018/04/UN-Trust-Fund-for-Human-Security.pdf (last visited November 11, 2020).
[285] *Id.*
[286] *Id.*
[287] *Id.*
[288] *Id.*
[289] *Id.*
[290] *Id.*
[291] *See* Allen, *supra* note 54.
[292] *Id.*

nexus of water with food and energy:[293] one kilogram of rice requires five thousand liters of water[294] and one ton of wheat uses one thousand three hundred tons of water.[295] Similarly, huge quantities of water are also required for hydropower generation, indicating the nexus of water with energy.[296] On the other hand, in many regions, groundwater is extracted by using tube wells, which run on electricity.[297] Such water is used for drinking purposes and irrigating crops.[298] This points to the nexus of energy with food. Food, energy, and water security are deeply linked to one another.[299] The connection among the three is inherent and undeniable.[300] Further, the role of water is central in the nexus of water, energy, and food, because water security leads to food and energy security.[301]

International water law includes some principles that appear to directly and indirectly safeguard the water–food–energy nexus. In relation to freshwater alone, international water law comprises the 2004 Berlin Rules on Water Resources, the 1997 UN Watercourses Convention, the 1992 UNECE Convention, the 1992 Agenda 21, the Dublin Statement, and bilateral and multilateral treaties on the apportionment of freshwater resources among riparian states.[302] The prominent rules and principles of these conventions (such as the no-harm principle,[303] the equitable and reasonable utilization princi-

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[293] *Id.*
[294] *See* ŠLAUS, *supra* note 212, at 48.
[295] *See* Allen, *supra* note 54.
[296] *See* NAG, *supra* note 88, at 28.
[297] *See, e.g.*, SHAH ET AL., *supra* note 7, at 7–8.
[298] *Id.*
[299] D'Odorico et al., *supra* note 12, at 456; *see also* Olawuyi, *supra* note 41, at 1.
[300] Olawuyi, *supra* note 41, at 1.
[301] D'Odorico et al., supra note 12, at 456.
[302] Contemporary international water law also includes the law of the sea, but here we are only focusing on the domain of freshwater. In that particular domain, we will not include the law of the sea in international water law. *See* ANTOINETTE HILDERING, INTERNATIONAL LAW, SUSTAINABLE DEVELOPMENT AND WATER MANAGEMENT 45–48 (2004) (discussing historic and contemporary international water law).
[303] *See* Hödl, supra note 72, at 329; *see also Watercourses Convention*, *supra* note 74, art. 7.

ple,[304] the duty to cooperate,[305] the human right to water,[306] the requirement to fulfill vital human needs,[307] and the nonconsumptive usage rule[308]) are directed toward protecting adequate water security for riparian states.[309] These rules indirectly endorse the water–food nexus by mandating the satisfaction of vital human needs as the first priority of water.[310] Likewise, the energy–food nexus also prioritizes "vital human needs"[311] and the rules support the water–energy nexus by advising states to cooperate and cause no harm to each other in their construction of large water storage works.[312]

Unfortunately, the existing role of water in its nexus with food and energy is presently threatened by the mounting scarcity of water.[313] The ongoing rapid increase in population and water pollution can be regarded as the main factors contributing to reducing the per capita availability of freshwater.[314] Climate change is also resulting in a significant reduction of rainfall in many regions,[315] which is causing a decline in the natural flow of freshwater in river basins and other natural aquifers.[316] Consequently, the availability of water for irrigation and hydropower generation is declining in

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[304] *See* Hödl, supra note 72, at 329; *see also Watercourses Convention*, *supra* note 74, art. 5.
[305] *Watercourses Convention*, *supra* note 74, art. 5.
[306] *See Agenda 21*, *supra* note 63, ch. 18; *see also Berlin Rules*, *supra* note 42, art. 17.
[307] *See Berlin Rules*, *supra* note 42, art. 14.
[308] *See* Indus Water Treaty, *supra* note 179, art. I.
[309] *See* HILDERING, *supra* note 302, at 47–48.
[310] *See Berlin Rules*, *supra* note 42, art. 3.
[311] This is because the water can only be used to generate energy after allocating sufficient water for the fulfillment of vital human needs. *See Berlin Rules*, *supra* note 42, art. 14.
[312] *Watercourses Convention*, *supra* note 74, art. 5.
[313] GLOBAL RISKS REPORT 2019, *supra* note 243, at 12.
[314] UNESCO, THE UNITED NATIONS WORLD WATER DEVELOPMENT REPORT 2019: LEAVING NO ONE BEHIND 1–3 (2019); *see also* Boretto & Rosa, *supra* note 259, at 15.
[315] *See* Eckstein, *supra* note 139, at 411.
[316] *Id.*; *see also* Kahlown et al., *supra* note 245, at 79–80.

subtropical and mid-latitude regions.[317] Additionally, because of the growing scarcity of freshwater, there is a fear of growing tensions among states that may start competing for access to and a larger share of the water in international watercourses.[318]

To mitigate these concerns, it has been recommended in this Article that riparian states should cooperate to preserve, sustainably use, and develop their existing freshwater resources.[319] In particular, states are advised to pursue integrated water management schemes,[320] which can provide them with additional control in allocating freshwater to their desired sectors, minimizing the wastage of water.[321] Likewise, as industrial pollution in the fresh watercourses is making such watercourses unsuitable for drinking purposes and food production,[322] it is suggested that the removal of pollution and the implementation of strict policies against the spreading of pollution may aid in restoring such water resources to be used for vital human needs.[323] The implementation of these recommendations sustainably can lead to enhanced water security,[324] which will further contribute to strengthening people's food and energy security by reducing water scarcity and protecting the existing water resources to be used for irrigation and hydropower generation.[325]

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317 *See* Eckstein, *supra* note 139, at 411.
318 Howard M. Wachtel, *Water Conflicts and International Water Markets*, *in* WATER RESOURCES IN THE MIDDLE EAST: ISRAEL-PALESTINIAN WATER ISSUES—FROM CONFLICT TO COOPERATION 147, 148 (Hillel Shuval & Hassan Dweik eds., 2007).
319 *Watercourses Convention*, *supra* note 74, art. 5.
320 *See Dublin Statement*, *supra* note 2.
321 *Id.*; *see also Berlin Rules*, *supra* note 42, art. 3.
322 *See* BANGLADESH: POVERTY REDUCTION, *supra* note 126, at 183; *see also Dublin Statement*, *supra* note 2.
323 *See Dublin Statement*, *supra* note 2.
324 *Id.*
325 *See Dublin Statement*, *supra* note 2