A Spatially Detailed Blue Water Footprint of the United States Economy

Supplemental Information

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SI 1.1 Supplemental Tables and Maps – Withdrawal-Based Virtual Water Flows

Table SI-1. U.S. Water Footprint and Virtual Water Statistics (Urban classes Central, Fringe, Medium, Small, Micro, and Non-Core)

Virtual Water Metric	Withdrawal-Based (CU =1)	CU_{max}	CU_{med}	CU_{min}
Water Use – Domestic (Mm^3)	37,566	27,423	4,884	0
Water Use – Non-Domestic (Mm^3)	366,687	200,712	181,773	60,722
Water Use – Total (Mm^3)	404,253	228,135	186,657	60,722
Virtual Water Outflows, VW_{Out} (Mm^3)	362,690	196,857	178,622	59,870
Virtual Water Inflows, VW_{In} (Mm^3)	359,282	190,866	173,931	60,265
Virtual Water Balance, VW_{Bal} (Mm^3)	-3,409	-5,991	-4,691	395
Virtual Water Export, VW_{Export} (Mm^3)	10,671	9,039	7,739	2,653
Virtual Water Import, VW_{Import} (Mm^3)	7,263	3,048	3,048	3,048
Non-Domestic Water Footprint (Mm^3)	363,279	194,722	177,082	61,117
Total Water Footprint (Mm^3)	400,844	222,144	181,966	61,117
Total Water Footprint Per Capita (m^3 $capita^{-1}$)	1,298	720	589	198
Central Water Footprint Per Capita (m^3 $capita^{-1}$)	828	399	282	97
Fringe Water Footprint Per Capita (m^3 $capita^{-1}$)	981	368	250	83
Medium Water Footprint Per Capita (m^3 $capita^{-1}$)	1,705	1,076	936	315
Small Water Footprint Per Capita (m^3 $capita^{-1}$)	1,794	1,139	992	333
Micro Water Footprint Per Capita (m^3 $capita^{-1}$)	1,876	1,169	1,024	345
Non-Core Water Footprint Per Capita (m^3 $capita^{-1}$)	1,927	1,217	1,053	344
Rural to Urban VW Transfers (Mm^3)	114,953	70,648	66,524	22,496
Rural to Rural VW Transfers (Mm^3)	91,682	63,698	60,676	20,614
Urban to Urban VW Transfers (Mm^3)	111,458	39,921	32,338	10,459
Urban to Rural VW Transfers (Mm^3)	33,876	13,551	11,345	3,647

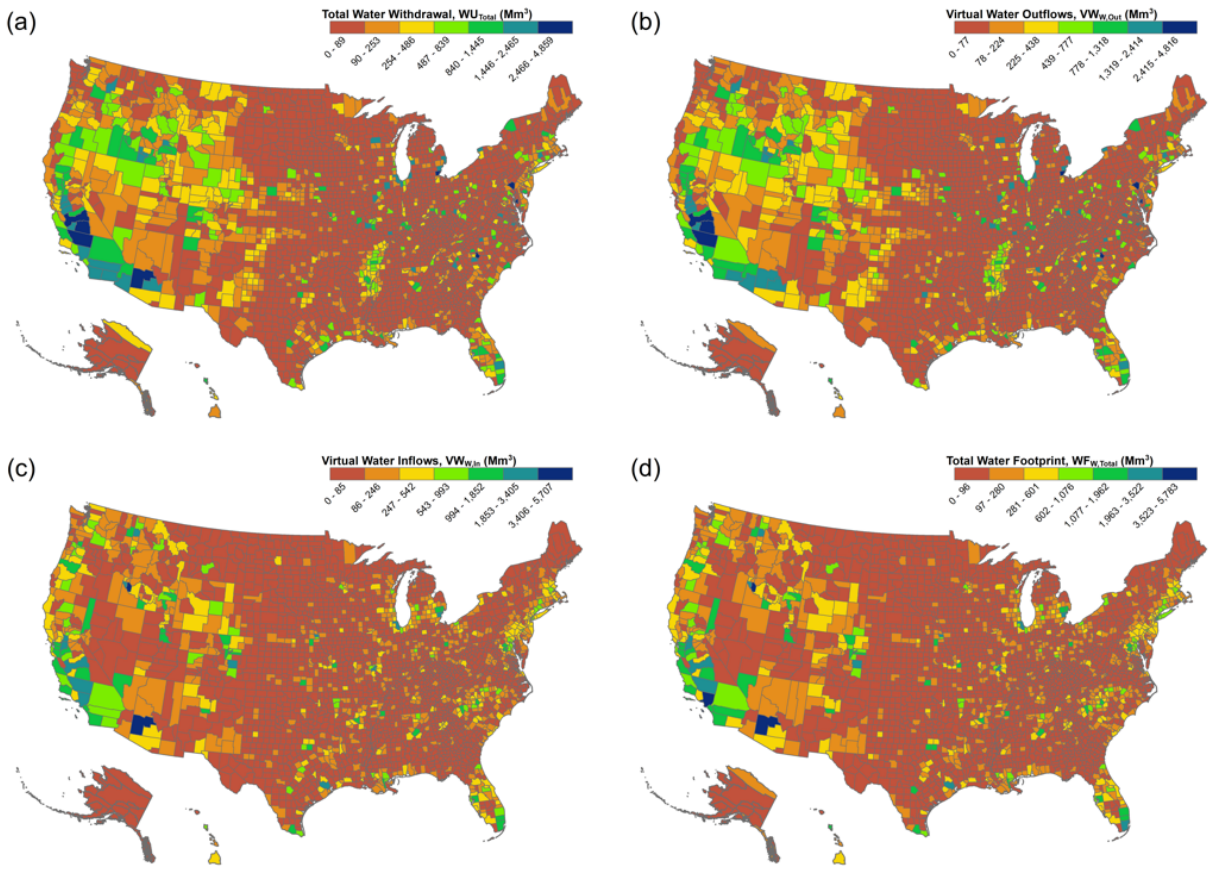

Figure SI-1. (a) Total water withdrawals by county in the U.S. (b) Virtual water outflows from U.S. are concentrated in the western United States, particularly where irrigated agriculture is located, in addition to the High Plans, Mississippi Embayment, and south Florida. (c) Virtual water inflows are concentrated in Western U.S. cities, Western U.S. agricultural counties, metropolitan regions in the Eastern U.S., and in particular where a city also serves as a regional distribution center or has prominent food processing industry (Little Rock and Northwestern Arkansas, Chicago and Houston). (d) Annual Withdrawal-Based (*CU = 1*) Water Footprint, F_{Total} [Mm^3], for U.S. Counties. Detailed economic sector-level water footprint maps and tables are in the Supplemental Information.

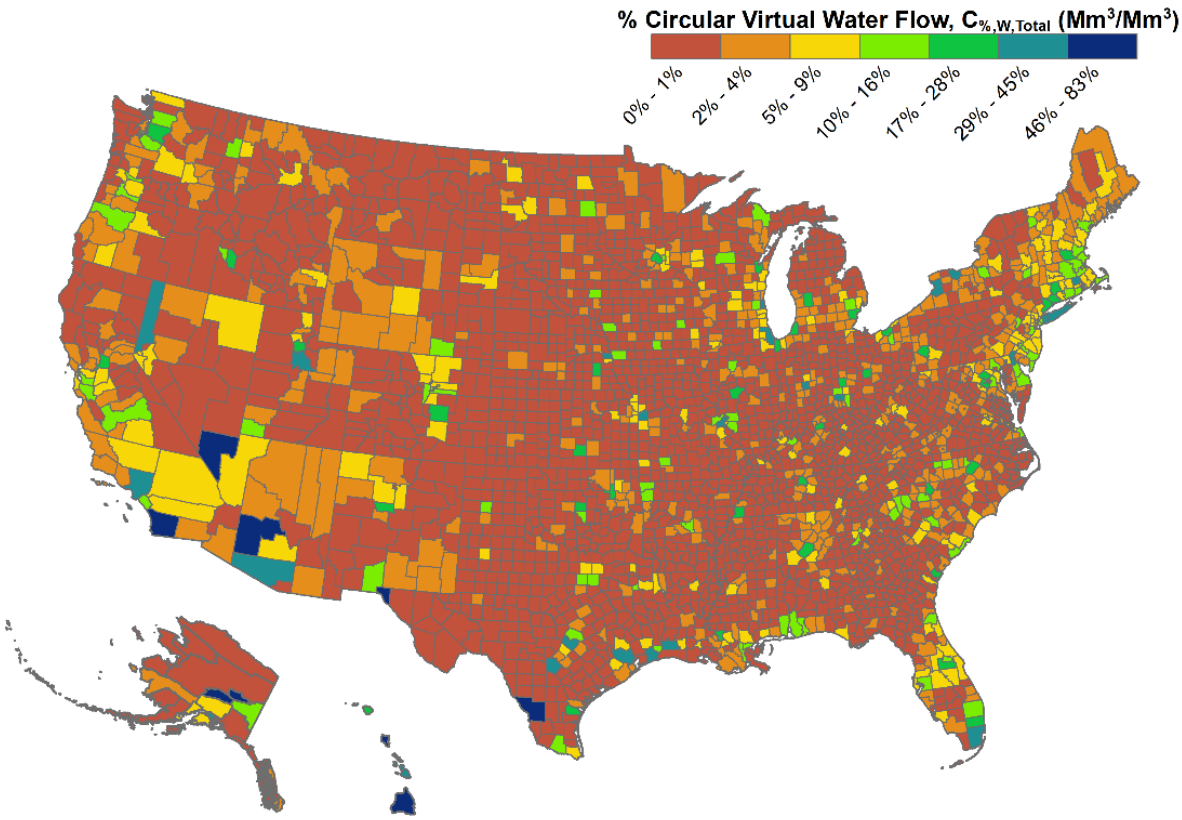

Figure SI-2. Circular virtual water flows (*CU = 1*), or virtual water flows that originate and terminate within the same county.

Table SI-2. Virtual Water Transfers Between Urban and Rural Areas (Mm^3)

Urban/Rural Classification	← Urban Rural →							
↓ Rural Urban →	Central	Fringe	Medium	Small	Micro	Non-Core	VW_{In}	$VW_{Balance}$
Central	12,025	13,303	11,994	7,642	9,391	8,264	62,618	34,395
Fringe	6,299	15,238	10,811	8,180	12,289	10,462	63,280	17,886
Medium	5,750	7,636	28,402	14,336	20,417	23,973	100,513	28,796
Small	1,516	3,477	8,452	8,543	10,899	14,215	47,101	-3,653
Micro	1,713	3,469	7,366	7,130	13,026	14,068	46,772	-26,904
Non-Core	919	2,272	4,692	4,923	7,655	11,222	31,684	-50,521
VW_{Out}	28,222	45,394	71,717	50,754	73,676	82,205	351,969	–

Table SI-3. U.S. Virtual Water Exports and Imports to and Balances with World Regions

Region	Value (M$)	Weight (kilotons)	Virtual Water Export (Mm^3)	% SW	% GW
Canada	252,368	167,912	2,114	57 %	43 %
Mexico	187,431	158,946	2,326	46 %	54 %
Rest of Americas	160,636	86,228	1,033	66 %	34 %
Europe	290,591	92,719	1,008	58 %	42 %
Africa	27,917	41,804	506	37 %	63 %
Southwest & Central Asia	81,977	40,680	471	49 %	51 %
Eastern Asia	274,579	157,361	2,645	62 %	38 %
Southeast Asia & Oceania	60,341	29,775	567	60 %	40 %
Total	**1,335,840**	**775,425**	**10,670**	**56 %**	**44 %**

SW – Surface Water; GW– Groundwater

Region	Value (M$)	Tons (kilotons)	Virtual Water Import (Mm^3)	% SW	% GW
Canada	294,227	293,707	1,897	—	—
Mexico	250,132	121,896	912	—	—
Rest of Americas	155,880	213,653	1,175	—	—
Europe	411,859	174,366	1,248	—	—
Africa	59,898	123,660	227	—	—
Southwest & Central Asia	106,500	149,927	361	—	—
Eastern Asia	680,927	130,236	1,042	—	—
Southeast Asia & Oceania	73,213	30,629	400	—	—
Total	**2,032,637**	**1,238,074**	**7,263**	**—**	**—**

Region	Value Balance (M$)	Ton Balance (kilotons)	Virtual Water Balance (Mm^3)	% SW	% GW
Canada	41,859	125,795	-217	—	—
Mexico	62,701	-37,050	-1,414	—	—
Rest of Americas	-4,756	127,425	142	—	—
Europe	121,268	81,647	240	—	—
Africa	31,981	81,856	-279	—	—
Southwest & Central Asia	24,523	109,247	-110	—	—
Eastern Asia	406,348	-27,125	-1,603	—	—
Southeast Asia & Oceania	12,872	854	-167	—	—
Total	**696,797**	**462,649**	**-3,407**	**—**	**—**

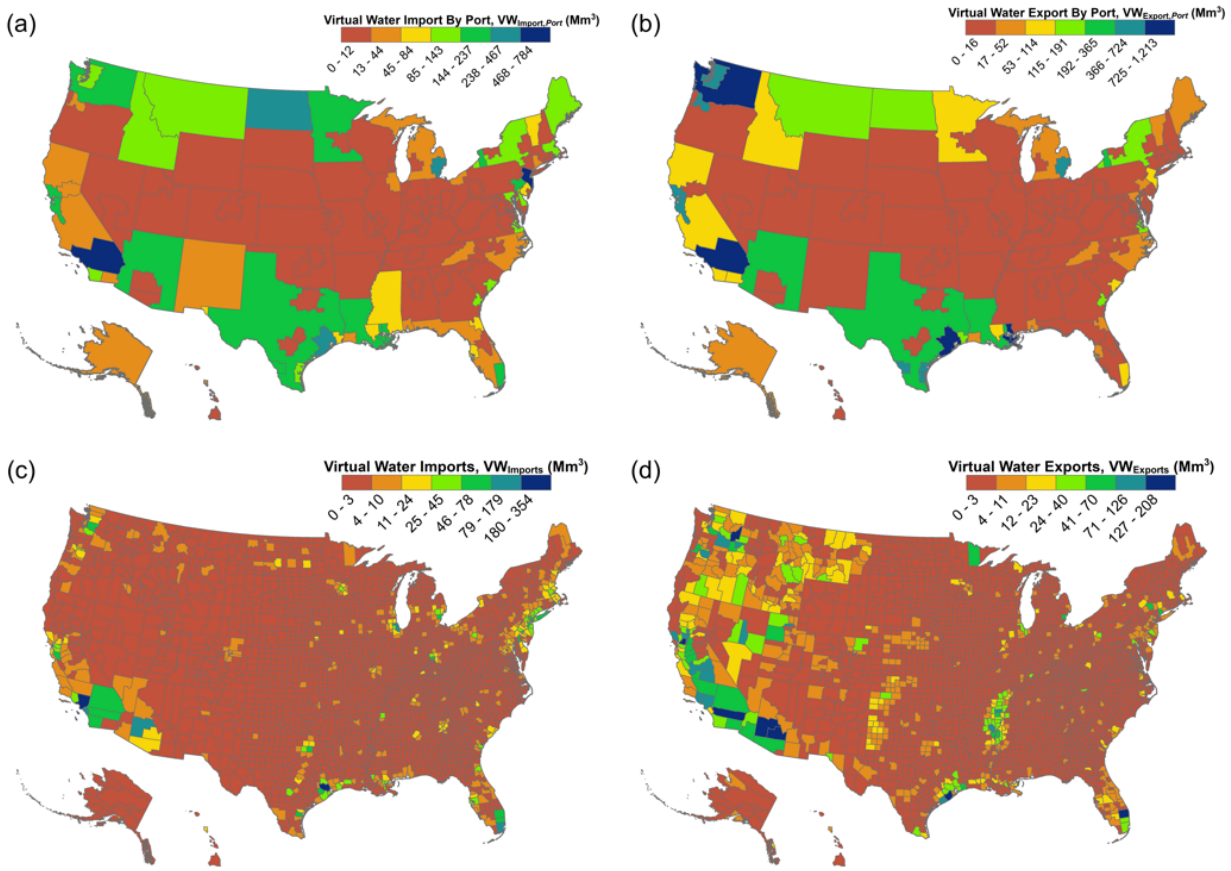

Figure SI-3. (a) The ports through which the majority of U.S. virtual water imports (*CU = 1*) enter the U.S. market are primarily Los Angeles and New York and also Houston and Detroit (FAZ's used for port boundaries). However, land borders with Canada and Mexico are also import to U.S. virtual water import. (b) The ports through which the majority of U.S. virtual water exports (*CU = 1*) enter the global market are located in natural hazard prone areas along the West Coast, Texas Gulf Coast, and Eastern Seaboard. (c) Cities such as Los Angles, Phoenix, Houston, New York City, Miami, Dallas, Seattle, and the San Francisco Bay area are the major destinations of U.S. virtual water imports (*CU = 1*). (d) U.S. virtual water exports (*CU = 1*) originate from California's Central Valley; Southern California and Southwest Arizona; the Columbia River Basin and the Pacific Northwest; Central Nevada and Northwest Utah; the Ogallala Aquifer region of the Midwest; the Texas Gulf Coast; the Mississippi Embayment; and South Florida. (d) The ports through which the majority of U.S. virtual water exports (*CU = 1*) enter the global market are located in natural hazard prone areas along the West Coast, Texas Gulf Coast, and Eastern Seaboard.

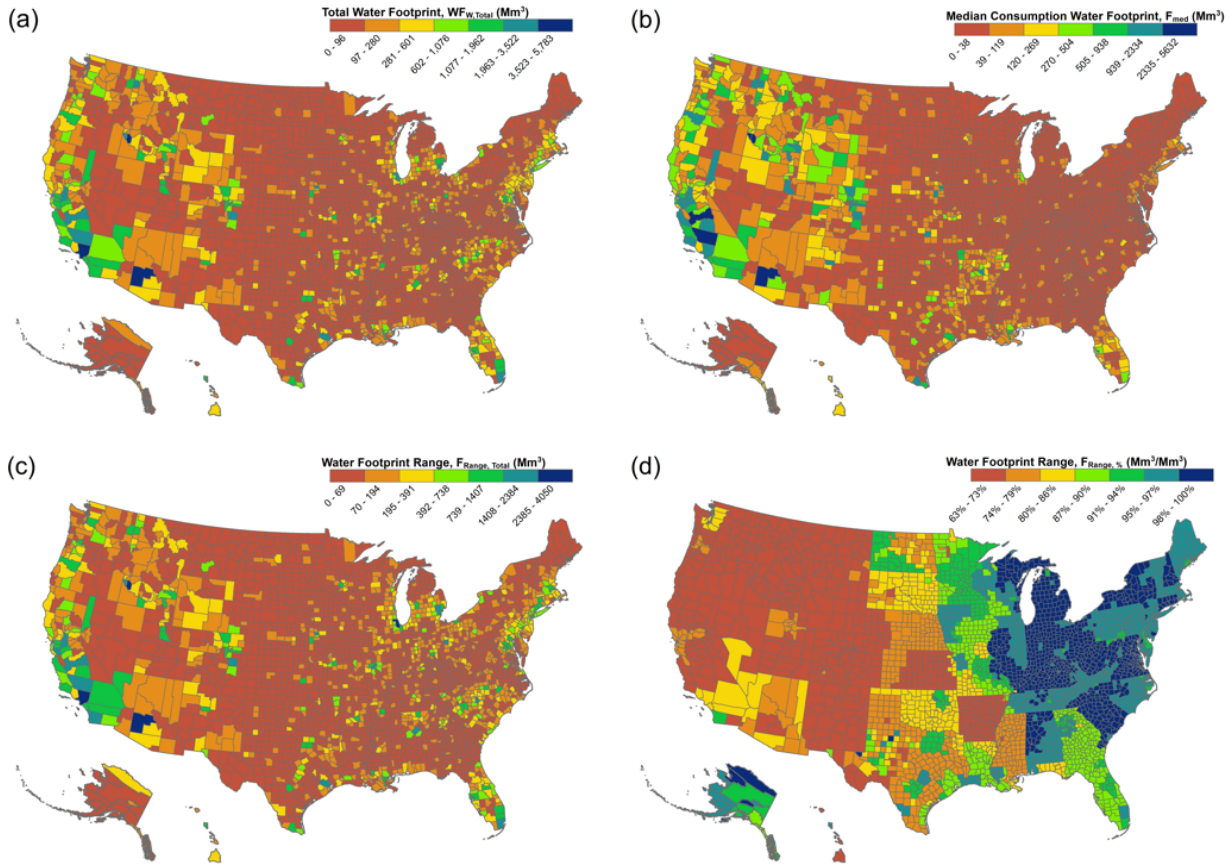

Figure SI-4. (a) The annual withdrawal-based (*CU = 1*) water footprint, F_{Total} [Mm^3], for U.S. Counties. (b) The annual consumption-based (CU_{med}) water footprint, $F_{Total,med}$ [Mm^3], for U.S. Counties. The minimum scenario was constructed applying minimum sector-level consumption coefficients. (c) The annual average water footprint, $F_{Average}$ [Mm^3], for U.S. Counties. $F_{Average}$ is taken as the average water footprint of the withdrawal-based (*CU = 1*) and three consumption-based scenarios (CU_{max}, CU_{med}, CU_{min}). (d) The range of uncertainty in water footprint, F_{Range} [Mm^3], for U.S. Counties. F_{Range} is computed as the range between the highest and lowest water footprints of the withdrawal-based and three consumption-based scenarios. Absolute water footprint uncertainties are highest in the west, but relative uncertainties are highest in the east.

SI 1.4 Supplemental Data

Supplemental data is located in the included spreadsheet.