S1 Supplementary data and methods

S1.1 ACEA's crop engine outputs

The original AquaCrop-OS can provide annual (at the end of the crop cycle) and daily outputs for crop development, soil water balance, and soil water content. In ACEA, the number of outputs is minimized to reduce the computational time and storage requirements. All output files are stored as MATLAB arrays. The examples of the files are available upon request. The annual outputs include: 1) cumulative GDDs, 2) crop status (mature, immature, dead, not emerged), 3) seeding / anthesis / harvest dates, 4) duration of the growing season (days), 5) dry crop yield (t ha^{-1}), 6) biomass (t ha^{-1}), 7) net irrigation (mm), 8) soil water content (mm) split into three water types (green, blue from irrigation, and blue from capillary rise), 9) crop water use (mm) also split into three water types, 9) water balance components (mm). The daily outputs include: 1) soil water content per compartments (fraction of the compartment depth), 2) water fluxes (mm), 3) crop growth parameters.

S1.2 Changes to AquaCrop-OS code

Several AquaCrop-OS code adjustments were implemented:

1. Tracing of green water, blue water from irrigation, and blue water from capillary rise by tracking soil moisture composition in each soil compartment after any of next water balance-related functions in MATLAB finishes its execution: CheckGroundwaterTable, AOS_Infiltration, AOS_Drainage, AOS_CapillaryRise, AOS_SoilEvaporation, AOS_Transpiration, AOS_GroundwaterInflow.
2. Most of the configuration files are moved from text files into MATLAB arrays.
3. The unnecessary parts of the MATLAB code are commented out (e.g. functions to create text files with outputs).
4. To better simulate water stress processes in rainfed scenarios, some changes to core functions are done. First, we allow crop germination to be automatically triggered if there is a germination delay of more than 30 days. This happens when the topsoil moisture doesn't reach the germination TAW threshold of 20% (default value for all crops). Second, the crop calendar-depended parameters are recalculated if the germination is delayed. This allows the growing season to be extended and growth stages to be shifted according to their GDDs accumulation requirements. Third, we set the first 30 days after germination to be free of water stress-induced senescence. This allows crops to start growing even in arid environments assuming that farmers would use more drought-resistant crop cultivars. Finally, we do not allow canopy cover to go lower than the minimum harvestable 5% until the end of the yield formation. All these changes are also considered in irrigated scenarios. However, the impact on them is neglectable because water availability is not limited. Consequently, the germination is triggered automatically on the next day after planting.

S1.3 Generic maize characteristics

Version of AquaCrop-OS	6
Crop Type (1 = Leafy vegetable, 2 = Root/tuber, 3 = Fruit/grain)	3
Planting method (0 = Transplanted, 1 = Sown)	1
Calendar Type (1 = Calendar days, 2 = Growing degree days)	2
Growing degree/Calendar days from sowing to emergence/transplant recovery	80
Growing degree/Calendar days from sowing to maximum rooting	1400
Growing degree/Calendar days from sowing to senescence	1400
Growing degree/Calendar days from sowing to maturity	1700
Growing degree/Calendar days from sowing to start of yield formation	880
Duration of flowering in growing degree/calendar days (-999 for non-fruit/grain crops)	180
Duration of yield formation in growing degree/calendar days	750
Growing degree day calculation method	3
Base temperature (degC) below which growth does not progress	8
Upper temperature (degC) above which crop development no longer increases	30
Pollination affected by heat stress (0 = No, 1 = Yes)	1
Maximum air temperature (degC) above which pollination begins to fail	40
Maximum air temperature (degC) at which pollination completely fails	45
Pollination affected by cold stress (0 = No, 1 = Yes)	1
Minimum air temperature (degC) below which pollination begins to fail	10
Minimum air temperature (degC) at which pollination completely fails	5
Transpiration affected by cold temperature stress (0 = No, 1 = Yes)	1
Minimum growing degree days (degC/day) required for full crop transpiration potential	12
Growing degree days (degC/day) at which no crop transpiration occurs	0
Minimum effective rooting depth (m)	0.3
Maximum rooting depth (m)	2.3
Shape factor describing root expansion	1.3
Maximum root water extraction at top of the root zone (m3/m3/day)	0.0104
Maximum root water extraction at the bottom of the root zone (m3/m3/day)	0.0026
Soil surface area (cm2) covered by an individual seedling at 90% emergence	6.5
Number of plants per hectare	75000
Maximum canopy cover (fraction of soil cover)	0.96
Canopy decline coefficient (fraction per GDD/calendar day)	0.01
Canopy growth coefficient (fraction per GDD)	0.01245
Crop coefficient when canopy growth is complete but prior to senescence	1.05
Decline of crop coefficient due to ageing (%/day)	0.3
Water productivity normalized for ET0 and C02 (g/m2)	33.7
Adjustment of water productivity in yield formation stage (% of WP)	100
Crop performance under elevated atmospheric CO2 concentration (%)	50
Reference harvest index	0.48
Possible increase of harvest index due to water stress before flowering (%)	0
Coefficient describing positive impact on harvest index of restricted vegetative growth during yield formation	7
Coefficient describing negative impact on harvest index of stomatal closure during yield formation	3
Maximum allowable increase of harvest index above reference value	15
Crop Determinancy (0 = Indeterminant, 1 = Determinant)	1
Excess of potential fruits	50
Upper soil water depletion threshold for water stress effects on affect canopy expansion	0.14
Upper soil water depletion threshold for water stress effects on canopy stomatal control	0.69

Upper soil water depletion threshold for water stress effects on canopy senescence	0.69
Upper soil water depletion threshold for water stress effects on canopy pollination	0.8
Lower soil water depletion threshold for water stress effects on canopy expansion	0.72
Lower soil water depletion threshold for water stress effects on canopy stomatal control	1
Lower soil water depletion threshold for water stress effects on canopy senescence	1
Lower soil water depletion threshold for water stress effects on canopy pollination	1
Shape factor describing water stress effects on canopy expansion	2.9
Shape factor describing water stress effects on stomatal control	6
Shape factor describing water stress effects on canopy senescence	2.7
Shape factor describing water stress effects on pollination	1
Vol (%) below saturation at which stress begins to occur due to deficient aeration	5
Number of days lag before aeration stress affects crop growth	3

S1.4 Soil profile selection

In AquaCrop, the soil profile is divided into several compartments (Vanuytrecht et al., 2014). The thickness of a compartment is usually set to a minimum at the top of the soil profile (to increase the accuracy of soil evaporation estimations), and to a maximum at the bottom (where the water interflow is less important). By default, the model suggests using a profile with 12 compartments starting with 10 cm thickness for the first three compartments and reaching 30 cm for the last one. However, recent literature shows that the selection of compartments is task-specific, and thus there is no general rule of thumb (Mkhabela and Bullock, 2012). Therefore, the default 12 compartments setup is simplified. We test three soil profiles in this study (Table S1). A total depth of 3 meters is chosen to cover the maximum root depth of maize. The tests are performed for rainfed maize during 1993-2012 with the initial soil moisture of 50% TAW for the whole soil profile. Following the setup of Chukalla et al. (2015), four climatic zones (arid, semi-arid, semi-humid, humid) and three soil types (real reported soil in literature, sandy loam and silty clay loam) are tested for each soil profile making 36 scenarios in total. No shallow groundwater is considered.

Table S1. Selection of 3 m thick soil profiles for testing in ACEA.

Compartment number	Soil profile 1	Soil profile 2	Soil profile 3
1	0.2	0.1	0.1
2	0.3	0.1	0.1
3	0.5	0.1	0.1
4	0.8	0.3	0.2
5	1.2	0.4	0.2
6		0.6	0.2
7		0.7	0.2
8		0.7	0.2
9			0.2
10			0.2
11			0.2
12			0.2
13			0.3
14			0.3
15			0.3

Soil profile 3 has the highest number of compartments. Therefore, it is set as a benchmark for comparisons with soil profiles 1 and 2. For the comparisons, the T-test function in Excel is used. Consequently, the soil profile with the least difference from the benchmark is optimum. The parameters to compare are the soil moisture at 0.3 and 1 m depths on the crop planting and harvest dates. In total, the comparisons are made for 48 combinations of soil moisture depths with climate and soil scenarios.

According to T-test results, soil profile 1 with five compartments has a significant difference between soil moistures in 79% of the comparisons (38 out of 48) and soil profile 2 with eight compartments in only 12% of the comparisons (6 out of 48). That 12% of comparisons are always for the semi-arid and semi-humid locations at 1 m depth on the harvest date. However, the soil moisture differences in absolute terms are minor and do not affect the crop modelling outputs. Therefore, no further tests are performed and soil profile 2 is selected for further use.

S1.5 Generation of initial soil moisture

Initial soil moisture has a significant impact the crop development, especially in arid and semi-arid climate zones (Rossato et al., 2017). Consequently, it is important to provide accurate water content values when a growing season starts. In our study, we test several scenarios to identify the number of years required to generate realistic soil moisture conditions. The same setup as for the soil profile selection is considered (four climates and three soil types). The soil profile is set to eight compartments and no shallow groundwater is considered.

We see that only the soil water content of the first growing season for an arid location is affected by the initial soil moisture assumptions. Consequently, the crop modelling outputs of the first growing season are inaccurate. Therefore, to analyse the crop modelling results of the year 1986, the simulations need to start in advance. For summer crops it corresponds to a one-year spin-up period and for winter crops it corresponds to two years. To unify the modelling setup, a two-year spin-up period is selected for all crops with a 50% green water TAW on the first day of simulation (1 January 1984).

S1.6 Groundwater level limitation

To avoid crop aeration stress, we lower the minimum groundwater depth to 1 m under the assumption that farmers would drain the area to maximise crop yields. This assumption is validated by simulating rainfed maize production in the Netherlands with groundwater depth limited to 0.5, 1, and 1.5 m. While there is no difference in crop yields with two latter limits, the maize production dropped by 25-30% when the limit is 0.5 m. Moreover, this assumption is supported by literature on the optimal shallow groundwater depth for crop production (Kahlown et al., 2005).

S1.7 Extrapolation of MIRCA2000

To extrapolate the harvest areas at 5 x 5 arc minute resolution around the year 2000 from MIRCA2000 (Portmann et al., 2010), two gridded datasets on the historical cropland are used: HYDE3.2 (Klein Goldewijk et al., 2017) and HID (Siebert et al., 2015). The procedure differs for rainfed and irrigated crops. In our study, we analyse maize production during 1986-2016, so the extrapolation procedure is explained using this crop as an example.

For rainfed maize, we firstly extract the rainfed cropland from HYDE3.2 for the time period of 1980-2016. The period before 2000 is reported in 10-year timesteps. Therefore, we interpolate values between 1980 and 2000 to have annual time-series for each grid cell (using scipy.interpolate package in Python). Then we estimate the cropland extent around the year 2000 by taking the average of 1998-2002 (HYDE2000). After, we normalize the historical cropland values to the HYDE2000 value. This allows us to extrapolate MIRCA2000 by assuming that rainfed maize areas experienced the same historical changes as the normalized rainfed cropland (eq. S1). Finally, we take a lower value between the extrapolated MIRCA2000 and original HYDE3.2 values to avoid two outcomes: 1) maize harvest areas being larger than the cropland, and 2) maize harvest areas being more than 0 ha in years when no rainfed cropland is reported.

$$A_{rainfed} = \min\left(MIRCA2000 * \frac{HYDE}{HYDE2000}, \quad HID\right) \tag{S1}$$

For irrigated maize, the procedure is more complex. Firstly, we extract the irrigated cropland from HYDE3.2 for the time period of 1980-2016 and from HID for the time period of 1985-2005. Same as for rainfed, we interpolate the values between 1980 and 2000 in HYDE3.2 and between the whole period in HID as it is reported with 5-year timesteps. Then we use HYDE3.2 to extrapolate HID values until 2016. This is done by multiplying the HID value in 2005 with 2006-2016 values from HYDE3.2 normalized to the year 2005. The next steps are similar to the procedure for rainfed maize but HID values are used instead of HYDE (eq. S2). We prioritise HID dataset as it provides better coherence with globally reported statistics (Siebert et al., 2015).

$$A_{irrigated} = \min\left(MIRCA2000 * \frac{HID}{HID2000}, \quad HID\right) \tag{S2}$$

As a result, each 5 x 5 arc minute grid cell has a historical harvest area of rainfed and irrigated maize production. However, these values may not reflect the official national statistics reported by FAOSTAT (FAOSTAT, 2021). Therefore, we aggregate the extrapolated MIRCA2000 data to the national level and scale it to ensure that the sum of harvest areas (both rainfed and irrigated) within a country is equal to the respective national statistic in a specific year. Note that, due to limitations on data availability, there are no new grid cells with maize production other than reported in MIRCA2000. However, some cells can have production only for several years if the corresponding country does not report it. For example, Denmark started producing maize only in 2010, and thus there were no harvest areas until that year.

S2 Supplementary results

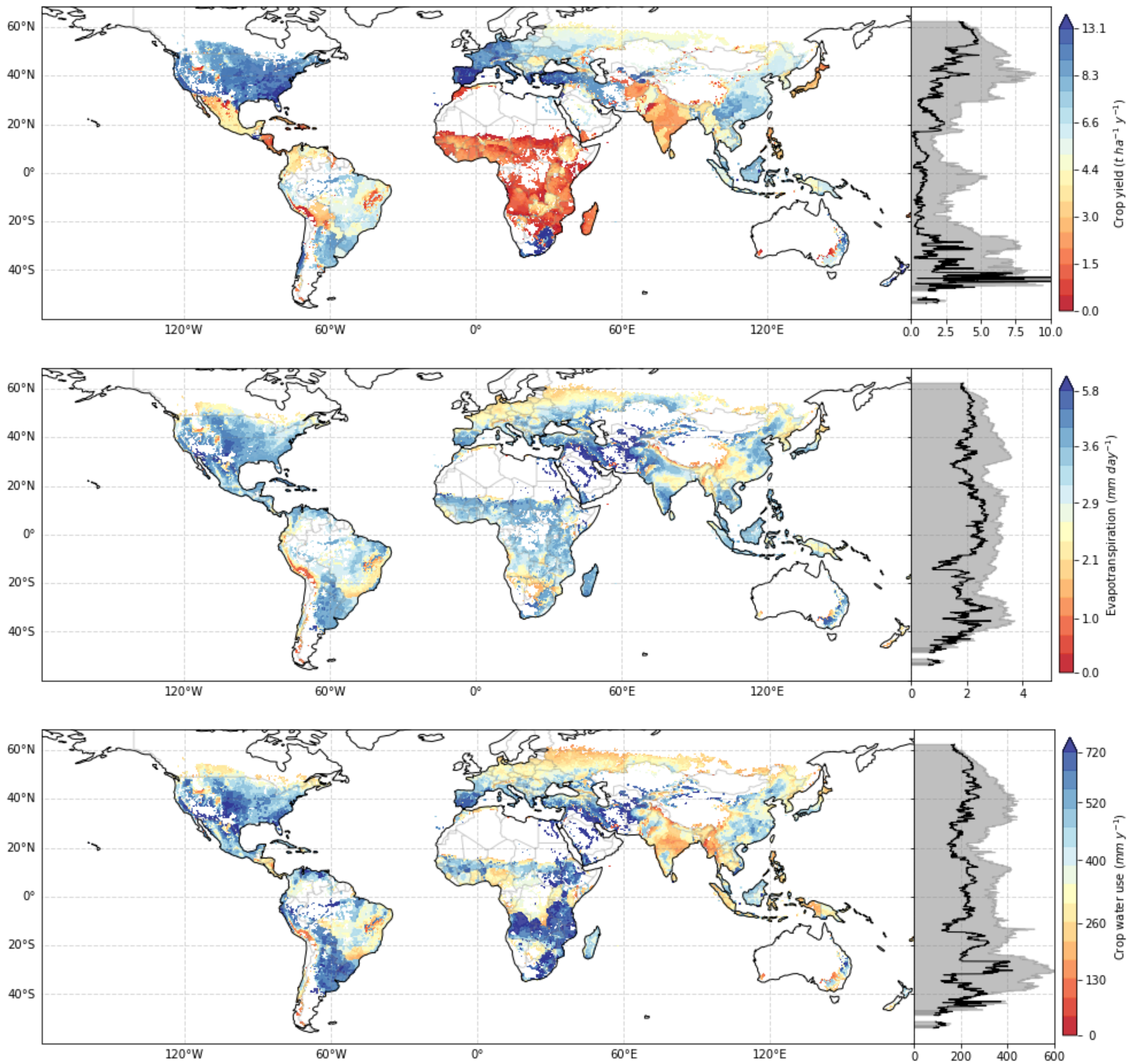

Figure S1: Average maize yields (t ha^{-1} y^{-1}), evapotranspiration (mm day^{-1}), and crop water use (mm y^{-1}) as the average over 2012-2016 at 5 x 5 arc minute resolution. The grey area in the side chart represents the median of all data points along the respective latitude and the black line is the 10 % percentile of them

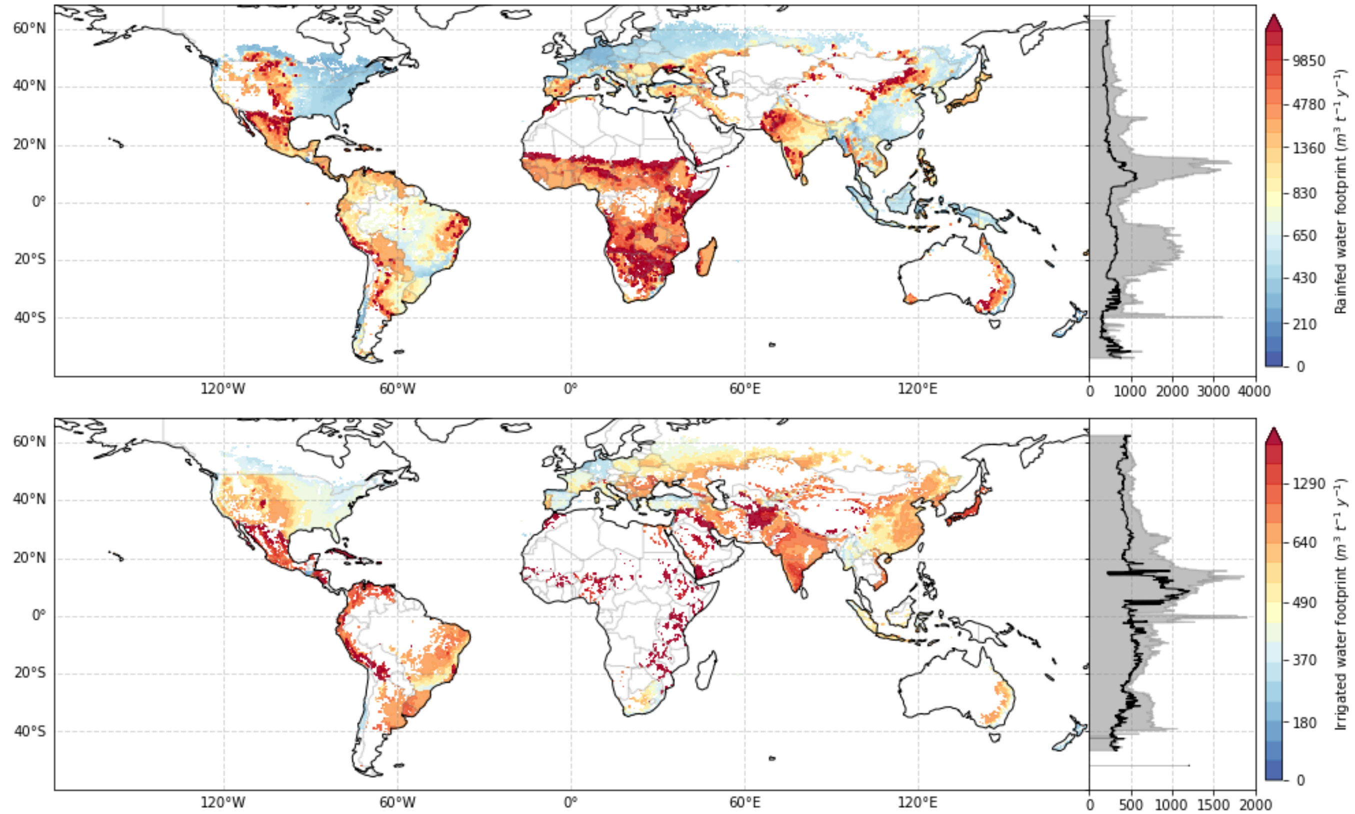

Figure S2: Average unit water footprint of rainfed (top) and irrigated (bottom) maize (m^3 t^{-1} y^{-1}) as the average over 2012-2016 at 5 x 5 arc minute resolution. The grey area in the side chart represents the median of all data points along the respective latitude and the black line is the 10 % percentile of them.

Table S2. National average unit water footprints and production of maize as the average over 2012-2016. WF is water footprint (g - green, bc - blue from capillary rise, bi - blue from irrigation).

#	Country	FAOSTAT code	Production (10^6 t y^{-1})	Harvested area (10^3 ha y^{-1})	WF_g	WF_{bc}	WF_{bi}	Unit WF (m^3 t-1 y^{-1})	Change in unit WF (relative to 1986-1990)	Change in WF of production (relative to 1986-1990)
					(% of unit WF)					
1	USA	231	346.5	34435.0	86.6%	3.9%	9.5%	485.3	-28.5%	37%
2	China	41	233.0	39523.5	82.2%	2.7%	15.1%	623.0	-29.9%	102%
3	Brazil	21	75.4	15057.7	99.7%	0.0%	0.2%	643.2	-62.0%	19%
4	Argentina	9	32.0	4674.0	91.7%	7.6%	0.7%	813.9	-48.3%	103%
5	Ukraine	230	26.3	4432.3	96.1%	1.8%	2.2%	593.1	-33.3%	244%
6	Mexico	138	24.1	7155.5	90.5%	0.4%	9.0%	1243.8	-45.9%	9%
7	India	100	23.7	9197.6	93.8%	0.4%	5.9%	973.8	-48.0%	52%
8	Indonesia	101	20.0	3969.6	98.5%	0.2%	1.2%	573.5	-60.4%	27%
9	France	68	14.9	1691.7	95.4%	0.5%	4.1%	463.3	-16.3%	0%
10	Canada	33	13.2	1383.1	92.3%	7.1%	0.6%	377.7	-32.2%	39%
11	Russian Federation	185	12.0	2461.2	90.1%	7.7%	2.2%	590.2	-40.1%	23%
12	South Africa	202	11.7	2553.6	95.6%	0.0%	4.4%	885.8	-67.0%	-59%
13	Nigeria	159	10.1	6388.8	99.3%	0.4%	0.2%	1835.3	-15.0%	80%
14	Romania	183	10.0	2583.9	95.6%	4.1%	0.3%	950.0	-16.5%	7%
15	Egypt	59	7.9	1039.9	1.0%	0.0%	99.0%	973.4	-32.5%	30%
16	Italy	106	7.8	828.9	81.7%	1.7%	16.6%	460.5	-13.3%	10%
17	Ethiopia	238	7.8	2751.3	96.4%	0.1%	3.5%	1785.3	-45.5%	158%
18	Philippines	171	7.4	2563.1	98.8%	1.2%	0.0%	867.8	-60.5%	-35%
19	Hungary	97	7.2	1156.6	90.3%	9.6%	0.1%	628.9	-5.8%	4%
20	United Republic of Tanzania	215	6.1	4014.4	99.3%	0.1%	0.6%	3797.8	-11.5%	114%
21	Serbia	272	5.9	1006.9	86.7%	13.0%	0.2%	718.3	-27.1%	-15%
22	Turkey	223	5.8	660.6	84.8%	0.3%	14.9%	394.3	-47.3%	42%
23	Viet Nam	237	5.2	1164.3	97.5%	0.3%	2.2%	780.8	-67.2%	148%
24	Pakistan	165	5.1	1182.0	78.1%	0.1%	21.9%	693.2	-64.9%	52%
25	Thailand	216	4.7	1111.3	97.1%	2.9%	0.0%	621.5	-44.4%	-34%
26	Germany	79	4.6	475.3	96.4%	3.5%	0.1%	328.2	-20.4%	154%
27	Spain	203	4.5	401.8	53.7%	0.0%	46.3%	421.9	-36.8%	-17%
28	Paraguay	169	4.1	947.0	99.7%	0.3%	0.0%	1196.2	-55.7%	456%
29	Poland	173	3.9	620.0	98.5%	1.2%	0.4%	470.0	-13.6%	1612%
30	Kenya	114	3.7	2166.9	99.9%	0.1%	0.1%	2254.0	13.1%	58%
31	Malawi	130	3.3	1676.3	99.0%	1.0%	0.0%	3097.7	-42.5%	34%
32	Zambia	251	2.9	1059.9	99.8%	0.1%	0.1%	2217.1	-26.9%	42%
33	Uganda	226	2.7	1076.8	99.7%	0.3%	0.0%	1182.0	-49.7%	191%
34	Bulgaria	27	2.5	441.8	99.5%	0.5%	0.1%	674.7	-28.0%	-6%
35	Democratic People's Republic of Korea (North)	116	2.2	538.8	96.4%	0.0%	3.6%	787.3	33.1%	-22%
36	Nepal	149	2.1	884.8	98.9%	0.6%	0.5%	998.3	-39.4%	24%
37	Democratic Republic of the Congo	250	2.0	2591.8	99.9%	0.1%	0.0%	3412.7	10.0%	143%
38	Austria	11	2.0	204.4	97.7%	2.3%	0.0%	330.7	-13.9%	4%
39	Venezuela (Bolivarian Republic of)	236	2.0	552.2	91.3%	0.9%	7.8%	1333.6	-40.2%	3%
40	Mali	133	2.0	789.2	99.9%	0.0%	0.1%	1944.8	-40.9%	458%
41	Cameroon	32	2.0	1071.9	99.5%	0.3%	0.2%	1640.6	3.1%	434%
42	Bangladesh	16	1.9	279.9	95.0%	5.0%	0.0%	375.4	-86.0%	8513%
43	Greece	84	1.9	174.8	66.0%	0.0%	33.9%	415.2	-0.3%	-12%
44	Guatemala	89	1.8	867.3	99.1%	0.1%	0.8%	208.9	-38.8%	-8%
45	Croatia	98	1.8	271.2	92.8%	7.1%	0.0%	624.4	-32.4%	-35%
46	Ghana	81	1.8	969.6	99.4%	0.6%	0.0%	1756.1	-33.3%	83%
47	Myanmar	28	1.7	455.0	96.5%	2.1%	1.4%	422.6	-58.2%	223%
48	Colombia	44	1.7	520.5	97.2%	2.6%	0.2%	1145.9	-55.1%	-23%
49	Peru	170	1.6	496.0	83.5%	0.1%	16.4%	963.0	-37.4%	18%
50	Burkina Faso	233	1.6	848.4	100.0%	0.0%	0.0%	2710.4	-45.1%	311%
51	Iran (Islamic Republic of)	102	1.6	227.8	18.9%	0.1%	81.1%	795.2	-38.2%	1560%
52	Angola	7	1.5	1560.9	100.0%	0.0%	0.0%	6046.9	-68.4%	93%
53	Mozambique	144	1.5	1646.1	99.4%	0.3%	0.4%	6498.1	-61.8%	57%
54	Ecuador	58	1.4	438.9	95.2%	0.0%	4.7%	1332.3	-69.9%	-9%
55	Chile	40	1.4	125.3	49.0%	0.0%	51.0%	317.5	-28.7%	31%
56	Republic of Moldova	146	1.4	468.6	92.6%	0.1%	7.3%	1362.4	52.9%	151%
57	Lao People's Democratic Republic	120	1.4	233.0	100.0%	0.0%	0.0%	525.2	-75.3%	593%
58	Slovakia	199	1.3	205.3	85.1%	13.7%	1.2%	575.9	-14.2%	116%
59	Benin	53	1.3	983.4	99.2%	0.8%	0.0%	2351.3	-37.8%	117%
60	Bolivia (Plurinational State of)	19	1.0	418.4	99.1%	0.2%	0.7%	1773.3	-35.2%	50%

61	El Salvador	60	0.9	295.8	99.5%	0.4%	0.1%	878.0	-30.7%	8%
62	Zimbabwe	181	0.8	1192.8	97.6%	0.0%	2.4%	6135.2	112.6%	-13%
63	Portugal	174	0.8	101.6	56.4%	0.1%	43.6%	595.6	-65.6%	-56%
64	Bosnia and Herzegovina	80	0.8	188.1	98.0%	2.0%	0.0%	852.8	-6.3%	-20%
65	Togo	217	0.8	677.3	99.5%	0.5%	0.0%	2838.5	-25.5%	165%
66	Côte d'Ivoire	107	0.8	381.0	99.8%	0.2%	0.0%	1768.9	-62.8%	-37%
67	Czechia	167	0.7	96.3	99.4%	0.6%	0.0%	411.2	-33.7%	16%
68	Belarus	57	0.7	135.6	97.6%	2.1%	0.4%	538.8	-28.8%	2%
69	Guinea	90	0.7	564.5	100.0%	0.0%	0.0%	3640.7	-21.2%	489%
70	Cambodia	115	0.7	152.7	91.5%	8.5%	0.0%	609.4	-77.0%	206%
71	Belgium	255	0.7	63.2	93.3%	6.7%	0.0%	302.9	-20.9%	1068%
72	Kazakhstan	108	0.6	121.3	32.9%	0.0%	67.1%	954.9	-28.5%	8%
73	Kyrgyzstan	113	0.6	96.6	64.8%	0.0%	35.2%	505.2	-55.3%	139%
74	Honduras	95	0.6	338.5	99.1%	0.5%	0.4%	1535.8	-13.8%	1%
75	Uruguay	234	0.5	108.8	99.2%	0.3%	0.5%	1127.6	-73.1%	58%
76	Rwanda	184	0.5	251.7	100.0%	0.0%	0.0%	1452.2	-34.6%	223%
77	Australia	10	0.4	62.7	59.1%	0.1%	40.9%	590.1	-49.6%	-1%
78	Uzbekistan	235	0.4	37.5	15.9%	0.0%	84.1%	523.9	-62.2%	-59%
79	Iraq	103	0.4	111.2	11.7%	0.2%	88.1%	1564.5	-46.0%	129%
80	Nicaragua	157	0.4	339.5	99.0%	0.3%	0.7%	1895.9	22.4%	95%
81	Chad	39	0.4	322.7	89.9%	5.4%	4.7%	3190.1	-25.5%	1111%
82	Cuba	49	0.4	167.5	89.3%	0.0%	10.7%	1710.7	-52.1%	122%
83	Albania	3	0.4	55.0	84.8%	0.0%	15.2%	640.3	-41.3%	-23%
84	Madagascar	129	0.4	219.1	99.8%	0.2%	0.0%	2460.3	-40.4%	38%
85	Slovenia	198	0.3	38.7	96.5%	3.4%	0.1%	475.8	-44.5%	-44%
86	Afghanistan	2	0.3	141.8	13.8%	0.0%	86.2%	2712.1	-12.3%	-46%
87	Haiti	93	0.3	351.0	99.6%	0.1%	0.3%	2953.2	2.0%	47%
88	Georgia	73	0.3	116.4	96.7%	1.9%	1.4%	1348.8	41.9%	62%
89	Senegal	195	0.2	159.7	99.2%	0.0%	0.8%	2586.8	-19.1%	51%
90	Sri Lanka	38	0.2	65.1	98.0%	2.0%	0.0%	845.8	-68.3%	90%
91	New Zealand	156	0.2	19.5	98.4%	0.0%	1.6%	290.1	-23.6%	3%
92	Azerbaijan	52	0.2	36.7	34.4%	0.0%	65.6%	798.6	-33.3%	204%
93	Tajikistan	208	0.2	15.7	26.6%	0.0%	73.4%	433.9	-63.4%	7%
94	South Sudan	277	0.2	222.7	86.8%	0.2%	13.0%	6745.3	-31.5%	23880%
95	Burundi	29	0.2	125.0	100.0%	0.0%	0.0%	1390.3	-5.7%	-7%
96	Netherlands	150	0.2	12.6	73.6%	26.1%	0.3%	274.0	-15.1%	1360%
97	Switzerland	211	0.2	14.8	99.8%	0.2%	0.0%	290.1	-13.7%	-38%
98	Syrian Arab Republic	212	0.1	40.4	17.3%	0.0%	82.7%	2016.3	-46.3%	-28%
99	North Macedonia	154	0.1	31.5	95.2%	0.1%	4.7%	870.5	-22.5%	-20%
100	Panama	166	0.1	58.8	99.3%	0.7%	0.0%	1316.2	-38.6%	-21%
101	Somalia	201	0.1	133.4	52.6%	0.0%	47.4%	5347.7	50.0%	-43%
102	Central African Republic	37	0.1	101.4	100.0%	0.0%	0.0%	3440.1	-1.8%	55%
103	Israel	105	0.1	4.2	28.1%	0.0%	71.9%	204.5	-37.2%	-33%
104	Morocco	143	0.1	139.7	45.5%	0.2%	54.2%	4056.6	23.5%	-62%
105	Timor-Leste	176	0.1	46.0	100.0%	0.0%	0.0%	1805.4	-44.6%	-8%
106	Lithuania	126	0.1	14.6	95.7%	4.3%	0.0%	416.1	-48.3%	252%
107	Eswatini	209	0.1	65.5	99.7%	0.0%	0.3%	4308.7	-11.2%	-28%
108	Namibia	147	0.1	31.1	64.8%	0.0%	35.2%	1386.1	-48.6%	99%
109	Republic of Korea (South)	117	0.1	15.9	100.0%	0.0%	0.0%	669.1	-3.4%	-33%
110	Bhutan	18	0.1	24.2	100.0%	0.0%	0.0%	832.8	-70.6%	-50%
111	Lesotho	122	0.1	101.1	100.0%	0.0%	0.0%	5750.0	24.4%	-29%
112	Malaysia	131	0.1	9.8	99.1%	0.9%	0.0%	586.4	-75.5%	-46%
113	Belize	23	0.1	19.9	97.9%	0.5%	1.6%	952.8	0.0%	58%
114	Denmark	54	0.1	10.0	95.3%	2.1%	2.5%	378.1	0.0%	0%
115	Yemen	249	0.1	43.4	25.0%	0.0%	75.0%	3603.6	62.3%	63%
116	Turkmenistan	213	0.1	37.8	5.6%	0.0%	94.4%	5152.7	184.8%	30%
117	Sudan	276	0.0	35.5	22.9%	0.0%	77.1%	4941.1	-63.1%	-38%
118	Saudi Arabia	194	0.0	7.7	3.4%	0.0%	96.6%	1322.6	-7.9%	1010%
119	Gabon	74	0.0	27.5	99.2%	0.8%	0.0%	2054.2	-2.0%	88%
120	Dominican Republic	56	0.0	25.7	98.9%	1.1%	0.0%	2488.5	1.9%	-15%
121	Jordan	112	0.0	0.9	100.0%	0.0%	0.0%	12.2	-31.9%	407%
122	Niger	158	0.0	24.4	92.2%	0.0%	7.8%	2378.1	-54.7%	193%
123	Gambia	75	0.0	36.9	100.0%	0.0%	0.0%	4011.7	38.9%	196%
124	Sierra Leone	197	0.0	29.2	99.8%	0.2%	0.0%	3530.5	14.0%	189%
125	Botswana	20	0.0	54.8	100.0%	0.0%	0.0%	11119.8	88.9%	53%
126	Eritrea	178	0.0	20.0	100.0%	0.0%	0.0%	2266.2	-50.7%	8%
127	Kuwait	118	0.0	1.0	1.4%	0.0%	98.6%	683.2	-1.5%	969%
128	Armenia	1	0.0	3.1	99.8%	0.2%	0.0%	405.9	-63.2%	4%

129	Mauritania	136	0.0	20.2	93.2%	0.0%	6.8%	5555.5	51.0%	708%
130	Papua New Guinea	168	0.0	2.2	99.1%	0.9%	0.0%	608.1	-67.4%	133%
131	Costa Rica	48	0.0	5.8	98.6%	1.4%	0.0%	1499.9	-3.9%	-88%
132	Congo	46	0.0	13.4	99.0%	1.0%	0.0%	3192.9	-12.7%	-40%
133	Guinea-Bissau	175	0.0	7.0	99.6%	0.4%	0.0%	3718.9	-5.7%	-36%
134	Libya	124	0.0	1.5	70.2%	0.0%	29.8%	85.7	-54.1%	-32%
135	Guyana	91	0.0	2.9	98.9%	1.1%	0.0%	2081.5	-20.1%	21%
136	Trinidad and Tobago	220	0.0	1.5	99.6%	0.4%	0.0%	1584.5	46.4%	69%
137	Lebanon	121	0.0	0.9	100.0%	0.0%	0.0%	582.9	-59.4%	-45%
138	Montenegro	273	0.0	0.6	99.2%	0.8%	0.0%	776.2	-20.8%	-99%
139	Jamaica	109	0.0	2.3	100.0%	0.0%	0.0%	3524.8	-5.8%	-19%
140	Algeria	4	0.0	0.7	99.7%	0.3%	0.0%	793.4	-49.7%	-31%
141	Luxembourg	256	0.0	0.2	100.0%	0.0%	0.0%	411.4	6.0%	-78%
142	Qatar	179	0.0	0.1	2.3%	0.0%	97.7%	558.9	9.8%	1047%
143	Fiji	66	0.0	0.3	100.0%	0.0%	0.0%	1110.5	-16.9%	-49%
144	Bahamas	12	0.0	0.1	90.1%	9.9%	0.0%	447.8	-82.1%	-84%
145	Mauritius	137	0.0	0.1	90.6%	0.0%	9.4%	454.9	-46.7%	-93%
146	Japan	110	0.0	0.1	98.8%	0.9%	0.3%	1272.7	-16.4%	-84%
147	Suriname	207	0.0	0.0	99.6%	0.4%	0.0%	1633.0	-38.0%	-82%
148	Djibouti	72	0.0	0.0	10.8%	0.0%	89.2%	2967.6	-20.3%	59%

Table S3. Annual average global maize simulation outputs and water footprints during 1986-2016. CWU is crop water use and WF is unit water footprint (g - green, bc - blue from capillary rise, bi - blue from irrigation).

Year	Rainfed systems					Irrigated systems					Yield scaling factor	Weighted average				
	Harvested area (10^6 ha y^{-1})	Simulated yield (t ha^{-1} y^{-1})	CWU (mm y^{-1})	WF_g (m^3 t^{-1} y^{-1})	WF_{bc}	Harvested area (10^6 ha y^{-1})	Simulated yield (t ha^{-1} y^{-1})	CWU (mm y^{-1})	WF_g (m^3 t^{-1} y^{-1})	WF_{bi}		Actual yield (t ha^{-1} y^{-1})	WF_g (m^3 t^{-1} y^{-1})	WF_{bc}	WF_{bi}	Unit WF
1986	109.6	12.91	381.2	1040.5	27.6	22.3	14.06	439.6	697.3	323.2	27.6%	3.67	972.4	22.1	64.1	1058.6
1987	107.7	12.40	379.0	1136.6	33.9	22.4	13.95	438.4	721.5	333.4	26.2%	3.38	1048.9	26.8	70.5	1146.1
1988	107.9	12.36	374.3	1163.7	43.5	22.2	13.84	430.2	680.7	345.9	26.3%	3.27	1057.9	34.0	75.8	1167.6
1989	109.2	12.94	379.0	1086.8	32.9	22.7	14.00	432.2	646.4	332.5	27.1%	3.55	992.6	25.9	71.1	1089.6
1990	108.1	12.53	381.9	1062.5	28.8	23.0	14.03	442.9	651.7	314.5	28.2%	3.66	972.2	22.5	69.1	1063.8
1991	110.3	12.52	378.9	1031.4	31.5	23.4	13.93	444.1	621.7	306.6	29.1%	3.76	940.3	24.5	68.2	1032.9
1992	112.9	12.21	357.0	959.7	30.7	23.8	14.10	432.0	596.5	286.5	29.1%	3.76	877.6	23.8	64.8	966.1
1993	108.1	12.42	372.1	1012.9	26.1	23.5	14.10	426.9	594.9	270.9	29.2%	3.79	916.1	20.1	62.7	998.9
1994	113.6	12.89	376.4	956.9	27.9	24.8	13.92	439.0	611.3	297.9	29.6%	3.98	881.9	21.9	64.7	968.4
1995	110.7	12.31	370.3	974.4	28.9	25.2	13.90	429.8	590.7	286.1	29.9%	3.87	884.4	22.1	67.1	973.6
1996	112.4	13.36	382.3	924.4	27.3	27.1	14.18	414.8	581.3	243.0	30.6%	4.19	844.6	20.9	56.5	922.0
1997	113.6	13.28	384.8	916.8	27.7	27.3	13.98	445.7	584.1	285.0	31.2%	4.26	839.2	21.3	66.4	926.9
1998	110.3	13.06	380.7	888.4	22.8	28.5	13.92	423.5	571.9	252.5	32.2%	4.36	811.9	17.3	61.0	890.2
1999	108.5	13.03	386.3	883.2	27.9	28.9	14.03	437.1	566.8	257.8	32.7%	4.44	803.8	20.9	64.7	889.4
2000	109.0	12.80	377.9	875.0	29.4	28.0	13.95	447.5	515.9	329.7	33.1%	4.37	786.2	22.1	81.5	889.8
2001	108.7	13.04	385.1	876.6	27.0	28.7	13.98	445.2	537.6	297.9	33.3%	4.46	792.1	20.2	74.2	886.6
2002	108.4	12.41	385.6	884.0	28.0	29.2	14.00	452.7	518.7	322.6	34.2%	4.44	790.4	20.8	82.7	893.9
2003	114.4	12.64	380.5	864.5	24.3	30.2	14.18	437.8	499.1	292.4	34.6%	4.51	771.1	18.1	74.7	863.9
2004	115.9	13.28	386.0	797.4	20.7	31.7	14.33	435.6	518.5	232.6	35.8%	4.92	726.8	15.5	58.9	801.1
2005	116.0	12.63	390.7	837.0	23.2	32.3	13.91	445.9	509.3	260.2	36.4%	4.79	750.7	17.1	68.5	836.3
2006	115.3	12.92	384.1	816.9	23.8	33.3	13.80	436.3	502.2	254.0	36.4%	4.8	732.5	17.4	68.2	818.0
2007	124.2	12.79	387.1	795.8	27.6	35.2	13.99	430.9	490.1	230.9	37.8%	4.95	714.4	20.3	61.5	796.1
2008	128.5	13.48	396.0	779.8	22.1	35.3	14.15	431.9	497.2	221.3	37.4%	5.14	708.7	16.5	55.7	780.9
2009	124.0	13.08	384.8	758.2	22.3	35.6	14.08	441.4	488.5	235.7	38.2%	5.16	687.2	16.4	62.1	765.7
2010	127.4	13.02	387.9	775.0	19.0	37.4	13.76	424.8	500.4	212.7	38.7%	5.1	702.4	13.9	56.3	772.6
2011	133.6	13.04	389.8	754.1	22.5	38.4	13.92	429.9	472.1	221.0	39.5%	5.25	679.9	16.6	58.1	754.7
2012	140.3	11.94	372.8	799.7	30.9	40.3	13.87	440.8	436.8	265.9	40.4%	4.85	695.3	22.0	76.5	793.8
2013	145.9	12.96	385.4	720.5	22.1	41.9	13.77	432.3	472.0	214.2	41.2%	5.39	655.9	16.3	55.7	727.9
2014	144.5	13.26	386.1	700.7	18.5	42.0	14.17	433.9	444.9	221.7	41.3%	5.59	633.8	13.7	58.0	705.5
2015	145.0	12.77	380.2	683.8	20.0	46.5	13.95	427.1	444.7	213.2	42.6%	5.61	616.8	14.4	59.8	690.9
2016	149.8	12.71	381.2	695.0	18.1	46.9	13.65	423.5	475.7	181.5	43.0%	5.56	634.5	13.1	50.1	697.6

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