The Water Footprint of Staple Crop Trade
under Climate and Policy Scenarios

Supplementary Information

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This document includes supplementary data, methods, and results. Terms, abbreviations and symbols are the same as in the main text.
S1  H08 Model

In this section, we provide additional information on the H08 model. Table S1 lists the 14 global climate models that were used to force the H08 model. Table S2 provides the range of yield shock values by country and crop as output from H08. Table S3 provides the mean shock values by country and crop as output from H08. When H08 output is not available, yield shock values from Hertel et al. (2010) were used. Table S4 highlights the importance of the $Y_{min}$ threshold in calculating the corn yield shock for the USA.

Table S1: List of the 14 global climate models (GCMs) that were used to obtain projections of evapotranspiration and yield in the H08 global hydrology model.

| Number | Global Climate Model            |
|--------|---------------------------------|
| 1      | UKMO-HadGEM1                    |
| 2      | ECHAM5/MPI-OM                   |
| 3      | UKMO-HadCM3                     |
| 4      | GFDL-CM2.1                      |
| 5      | CGCM3.1 (T47)                   |
| 6      | CSIRO Mk3.0                     |
| 7      | CCSM3                           |
| 8      | MIROC3.2 (medres)               |
| 9      | GFDL-CM2.0                      |
| 10     | MRI-CGCM2.3.2                   |
| 11     | CNRM-CM3                        |
| 12     | INM-CM3.0                       |
| 13     | PCM                             |
| 14     | IPSL-CM4                        |
Table S2: Range of yield shocks by country and crop. Starred values indicate that projections from Hertel et al. (2010) were used. Values are reported in percentage terms [%].

| Country         | Maize   | Rice    | Soy      | Wheat   |
|-----------------|---------|---------|----------|---------|
| Albania         | −5, 19*| −5, 19*| −10, 2   |
| Argentina       | [−16, 4]| −19, 9*| −21, 4   | −21, 2  |
| Australia       | [−13, 5]| −5, 19*| −10, 14*| −21, 0  |
| Austria         | −5, 19*| −5, 19*| −17, −2  |
| Bangladesh      | −10, 1 | −10, 4*| −47, 16  |
| Belgium         | −5, 19*| −5, 19*| −39, −10 |
| Bolivia         | [−13, 1]| −5, 0  | −8, 2    | −10, 1  |
| Botswana        | [−22, 16]| −15, 9*| −15, 9*  | −15, 9* |
| Brazil          | [−5, 1] | −6, −1 | −4, 0    | −18, −1 |
| Bulgaria        | −5, 19*| −5, 19*| −14, 0   |
| Canada          | [−100, 116]| −10, 4*| 0, 24*   | −31, 19 |
| Chile           | [−80, −19]| −10, 4*| −10, 4*  | −16, −5 |
| China           | [4, 55]| −7, 0  | 147, 230 | −17, −2 |
| Colombia        | [−4, 0] | −5, −2 | 0, 14*   | 0, 14*  |
| Croatia         | −5, 19*| −5, 19*| −18, −5  |
| Cyprus          | −5, 19*| −5, 19*| −5, 19*  |
| Czech Republic  | −5, 19*| −5, 19*| −45, −3  |
| Denmark         | −5, 19*| −5, 19*| −5, 19*  |
| Ecuador         | [−4, 3]| −6, −1 | −10, 4*  | −10, 4* |
| Estonia         | −5, 19*| −5, 19*| −5, 19*  |
| Finland         | −5, 19*| −5, 19*| −5, 19*  |
| France          | −5, 19*| −5, 19*| −31, −7  |
| Germany         | −5, 19*| −5, 19*| −29, −5  |
| Greece          | [−54, 15]| −5, 19*| −5, 19*  | −13, −5 |
| Hong Kong       | −10, 4*| −10, 4*| −10, 4*  |
| Hungary         | −5, 19*| −5, 19*| −13, −1  |
| India           | [−8, 2]| −4, 0  | −4, 1    | −42, 17 |
| Indonesia       | [−3, 1]| −3, 0  | 0, 14*   | 0, 14*  |
| Iran Islamic Re | [−33, −5]| −5, 9*| −5, 9*   | −11, −2 |
| Ireland         | −5, 19*| −5, 19*| −5, 19*  |
| Italy           | [−12, 19]| −5, 19*| −5, 19*  | −23, −3 |
| Japan           | [−4, 13]| 2, 16* | −20, −1  |
| Latvia          | −5, 19*| −5, 19*| −12, 10  |
| Lithuania       | −5, 19*| −5, 19*| −7, 7    |
| Luxembourg      | [−5, 19]| −5, 19*| −5, 19*  |
| Country               | Values         |
|----------------------|----------------|
| Madagascar           | [-16, 3]       |
| Malawi               | [-3, 0]        |
| Malaysia             | [-15, 1]       |
| Malta                | [-5, 19]       |
| Mauritius            | [-15, 9]       |
| Mexico               | [-8, -1]       |
| Morocco              | [-5, 9]        |
| Mozambique           | [-4, 1]        |
| Netherlands          | [-5, 19]       |
| New Zealand          | [-5, 19]       |
| Nigeria              | [-1, 0]        |
| Pakistan             | [-80, 1]       |
| Peru                 | [-4, 1]        |
| Philippines          | [-9, 2]        |
| Poland               | [-5, 19]       |
| Portugal             | [-25, -2]      |
| Republic of Korea    | [-5, 32]       |
| Romania              | [-100, 14]     |
| Russian Federation   | [-68, 38]      |
| Singapore            | [5, 19]        |
| Slovakia             | [-5, 19]       |
| Slovenia             | [-5, 19]       |
| South Africa         | [-13, 11]      |
| Spain                | [-47, -10]     |
| Sri Lanka            | [-38, 3]       |
| Sweden               | [-5, 19]       |
| Switzerland          | [-5, 19]       |
| Taiwan               | [5, 19]        |
| Tanzania             | [-2, 1]        |
| Thailand             | [-4, 0]        |
| Tunisia              | [-5, 9]        |
| Turkey               | [348, 1240]    |
| Uganda               | [-2, 2]        |
| United Kingdom       | [-5, 19]       |
| United States of America | [15, 116]  |
| Uruguay              | [-10, 2]       |
| Venezuela            | [-9, 0]        |
| Viet Nam             | [-21, -2]      |
| Zambia               | [-1, 1]        |
| Country     | Range 1 | Range 2 | Range 3 | Range 4 |
|------------|---------|---------|---------|---------|
| Zimbabwe   | $[-10, 10]$ | $[-15, 9]^*$ | $[-15, 9]^*$ | $[-63, -26]$ |
Table S3: Mean of yield shocks by country and crop. Starred values indicate that projections from Hertel et al. (2010) were used. Values are reported in percentage terms [%].

| Country          | Maize | Rice | Soy | Wheat |
|------------------|-------|------|-----|-------|
| Albania          | 7*    | 7*   |     | −6    |
| Argentina        | −3    | −6   | −4  | −5    |
| Australia        | −4    | 7*   | 2*  | −9    |
| Austria          | 7*    | 7*   |     | −8    |
| Bangladesh       | −3    | −3*  | −15 |       |
| Belgium          | 7*    | 7*   |     | −19   |
| Bolivia          | −4    | −1   | −2  | −3    |
| Botswana         | −5    | −3*  | −3* | −3*   |
| Brazil           | −2    | −3   | −3  | −9    |
| Bulgaria         | 7*    | 7*   |     | −7    |
| Canada           | 463   | −3*  | 12* | 5     |
| Chile            | −57   | −3*  | −3* | −9    |
| China            | 45    | −3   | 190 | −9    |
| Colombia         | −2    | −3   | 7*  | 7*    |
| Croatia          | 7*    | 7*   |     | −12   |
| Cyprus           | 7*    | 7*   |     | 7*    |
| Czech Republic   | 7*    | 7*   |     | −10   |
| Denmark          | 7*    | 7*   |     | 7*    |
| Ecuador          | 0     | −2   | −3* | −3*   |
| Estonia          | 7*    | 7*   |     | 7*    |
| Finland          | 7*    | 7*   |     | 7*    |
| France           | 7*    | 7*   |     | −15   |
| Germany          | 7*    | 7*   |     | −13   |
| Greece           | −21   | 7*   | 7*  | −8    |
| Hong Kong        | −3*   | −3*  | −3* |       |
| Hungary          | 7*    | 7*   |     | −8    |
| India            | −2    | −2   | −1  | −20   |
| Indonesia        | −1    | −2   | 7*  | 7*    |
| Iran Islamic Re  | −18   | 2*   | 2*  | −7    |
| Ireland          | 7*    | 7*   |     |       |
| Italy            | 1     | 7*   | 7*  | −13   |
| Japan            | 5     | 9*   |     | −7    |
| Latvia           | 7*    | 7*   |     | 1     |
| Lithuania        | 7*    | 7*   |     | 1     |
| Luxembourg       | 7*    | 7*   |     | 7*    |
| Country              | Change | Δ4  | Δ3  | Δ2  |
|---------------------|--------|-----|-----|-----|
| Madagascar          | -2     | -6  | -3* | -3*|
| Malawi              | -1     | -3* | -3* | -3*|
| Malaysia            | -5     | -3* | -3* | -3*|
| Malta               | 7*     | 7*  | 7*  | 7*  |
| Mauritius           | -3*    | -3* | -3* | -3*|
| Mexico              | -3     | -5  | -3* | -8  |
| Morocco             | 2*     | 2*  | -10 |     |
| Mozambique          | -1     | -2  | -3* | -3*|
| Netherlands         | 7*     | 7*  | -20 |     |
| New Zealand         | 7*     | 2*  | 7*  |     |
| Nigeria             | 0      | 0   | -3* | -3*|
| Pakistan            | -27    | -5* | -3* | -5  |
| Peru                | -3     | -7  | 7*  | -42 |
| Philippines         | -1     | -2  | -3* | -3*|
| Poland              | 7*     | 7*  | -8  |     |
| Portugal            | -11    | 7*  | 7*  | -5  |
| Republic of Korea   | 23     | 12* | 12* |     |
| Romania             | -55    | 7*  | 7*  | -7  |
| Russian Federation  | -15    | 7*  | 7*  | -7  |
| Singapore           | 12*    | 12* | 12* |     |
| Slovakia            | 7*     | 7*  | -8  |     |
| Slovenia            | 7*     | 7*  | -8  |     |
| South Africa        | -3     | -8* | -8* | -6  |
| Spain               | -25    | 7*  | 7*  | -9  |
| Sri Lanka           | -13    | -3* | -3* | -3*|
| Sweden              | 7*     | 7*  | 7   |     |
| Switzerland         | 7*     | 7*  | -9  |     |
| Taiwan              | 12*    | 12* | 12* |     |
| Tanzania            | 0      | -3* | -3* | -6  |
| Thailand            | -1     | -3  | -3* | -3*|
| Tunisia             | 2*     | 2*  | -10 |     |
| Turkey              | 748    | 2*  | 2*  | -6  |
| Uganda              | 0      | -2  | -1  | -3*|
| United Kingdom      | 7*     | 7*  | -19 |     |
| United States of America | 70      | 8  | 39  | -6  |
| Uruguay             | -6     | -4  | -3* | -4  |
| Venezuela           | -3     | -1  | -3* | -3*|
| Viet Nam            | -8     | -4  | -3* | -3*|
| Zambia              | 0      | -3* | -3* | -16 |
| Zimbabwe | −1 | −3* | −3* | −52 |
Table S4: Corn yield change [%] in the United States under different $Y_{min}$ [kg ha$^{-1}$] threshold values.

|                  | 100  | 500  | 1,000 |
|------------------|------|------|-------|
| UKMO-HadGEM1     | 69%  | 48%  | 26%   |
| ECHAM5/MPI-OM    | 90%  | 67%  | 42%   |
| UKMO-HadCM3      | 98%  | 74%  | 48%   |
| GFDL-CM2.1       | 60%  | 41%  | 22%   |
| CGCM3.1 (T47)    | 73%  | 52%  | 31%   |
| CSIRO Mk3.0      | 44%  | 26%  | 10%   |
| CCSM3            | 40%  | 23%  | 6%    |
| MIROC3.2 (medres)| 45%  | 27%  | 9%    |
| GFDL-CM2.0       | 97%  | 73%  | 47%   |
| MRI-CGCM2.3.2    | 116% | 85%  | 57%   |
| CNRM-CM3         | 69%  | 49%  | 27%   |
| INM-CM3.0        | 59%  | 40%  | 19%   |
| PCM              | 87%  | 64%  | 40%   |
| IPSL-CM4         | 87%  | 64%  | 40%   |
| Mean             | 73%  | 52%  | 30%   |
| Median           | 71%  | 50%  | 29%   |
| Minimum          | 40%  | 23%  | 6%    |
| Maximum          | 116% | 85%  | 57%   |
S2 GTAP Model

In this section, we provide additional details on the GTAP trade model. Table S5 lists the 76 countries included in the model. Note that some countries are lumped into ‘Rest of World (ROW)’. We have provided the list of countries in ROW in Table S6. The yield shock for ROW was obtained by taking the mean across all ROW countries with projections.
Table S5: Countries in the GTAP trade database.

| Number | Country Name           | Number | Country Name       |
|--------|------------------------|--------|-------------------|
| 1      | Albania                | 39     | Malta             |
| 2      | Argentina              | 40     | Mauritius         |
| 3      | Australia              | 41     | Mexico            |
| 4      | Austria                | 42     | Morocco           |
| 5      | Bangladesh             | 43     | Mozambique        |
| 6      | Belgium                | 44     | Netherlands       |
| 7      | Bolivia                | 45     | New Zealand       |
| 8      | Botswana               | 46     | Nigeria           |
| 9      | Brazil                 | 47     | Pakistan          |
| 10     | Bulgaria               | 48     | Peru              |
| 11     | Canada                 | 49     | Philippines       |
| 12     | Chile                  | 50     | Poland            |
| 13     | China                  | 51     | Portugal          |
| 14     | Colombia               | 52     | Republic of Korea |
| 15     | Croatia                | 53     | Romania           |
| 16     | Cyprus                 | 54     | Russian Federation|
| 17     | Czech Republic         | 55     | Singapore         |
| 18     | Denmark                | 56     | Slovakia          |
| 19     | Ecuador                | 57     | Slovenia          |
| 20     | Estonia                | 58     | South Africa      |
| 21     | Finland                | 59     | Spain             |
| 22     | France                 | 60     | Sri Lanka         |
| 23     | Germany                | 61     | Sweden            |
| 24     | Greece                 | 62     | Switzerland       |
| 25     | Hong Kong              | 63     | Taiwan            |
| 26     | Hungary                | 64     | Tanzania          |
| 27     | India                  | 65     | Thailand          |
| 28     | Indonesia              | 66     | Tunisia           |
| 29     | Iran Islamic Re        | 67     | Turkey            |
| 30     | Ireland                | 68     | Uganda            |
| 31     | Italy                  | 69     | United Kingdom    |
| 32     | Japan                  | 70     | United States of America |
| 33     | Latvia                 | 71     | Uruguay           |
| 34     | Lithuania              | 72     | Venezuela         |
| 35     | Luxembourg             | 73     | Viet Nam          |
| 36     | Madagascar             | 74     | Zambia            |
| 37     | Malawi                 | 75     | Zimbabwe          |
| 38     | Malaysia               | 76     | ROW               |
Table S6: List of countries in the ‘Rest of World (ROW)’ in the GTAP database.

| Number | Country            |
|--------|--------------------|
| 1      | Mongolia           |
| 2      | Cambodia           |
| 3      | Laos               |
| 4      | Nepal              |
| 5      | Afghanistan        |
| 6      | Paraguay           |
| 7      | Costa Rica         |
| 8      | Guatemala          |
| 9      | Honduras           |
| 10     | Nicaragua          |
| 11     | Panama             |
| 12     | El Salvador        |
| 13     | Belize             |
| 14     | Jamaica            |
| 15     | Dominican Republic |
| 16     | Norway             |
| 17     | Poland             |
| 18     | Kyrgyzstan         |
| 19     | Azerbaijan         |
| 20     | Georgia            |
| 21     | Kuwait             |
| 22     | Saudi Arabia       |
| 23     | Egypt              |
| 24     | Cameroon           |
| 25     | Ghana              |
| 26     | Senegal            |
| 27     | Namibia            |
S3 Value of food trade

Table S7 presents some of the most significant price changes under the trade liberalization scenario. Japan and China’s imports are some of the most dramatic changes under the trade liberalization scenario. We present changes in imports in percentage terms for Japan in Table S8 and China in Table S9.

Table S7: Local price change under trade policy liberalization (free on board, % change).

| Commodity     | Argentina | Australia | Brazil | Japan | South Korea | USA |
|---------------|-----------|-----------|--------|-------|-------------|-----|
| Rice          | 1.4       | 25.1      | 0.5    | -13.1 | -46.7       | 25.1|
| Wheat         | 1.9       | 1.1       | 0.7    | -11.4 | -13.8       | 1.4 |
| Maize         | 1.6       | 2.6       | 0.9    | -6.6  | -24.5       | 1.3 |
| Other grains  | 1.0       | 0.9       | 0.5    | -5.0  | -14.1       | 1.1 |
| Soybeans      | 2.8       | 0.8       | 1.5    | -5.0  | -44.2       | 1.3 |

Table S8: Japan’s % change in imports from this country.

| Commodity | Australia | Canada | China | USA   |
|-----------|-----------|--------|-------|-------|
| Rice      | 348.7     | 9.4    | 1926.0| 1552.3|
| Wheat     | 68.6      | 55.1   | 0.8   | 143.5 |
| Maize     | 37.1      | 17.1   | -6.6  | 2.4   |

Table S9: China’s % change in imports from this country.

| Commodity  | Argentina | Brazil | USA  |
|------------|-----------|--------|------|
| Soybeans   | 280.3     | 412.0  | 16.7 |

The value [$USD] of aggregate crop trade across scenarios is provided in Fig S1. In the baseline there is approximately $30.2 billion worth of staple crop trade. If all policy barriers to trade are removed (free trade scenario), this rises by 31% to $39.6 billion worth of trade. The increase in trade occurs because of new opportunities for spatial arbitrage. Removing trade barriers lowers prices in importing countries, and raises prices in exporting countries.

If, by contrast, only the yield shocks occur, then there is also an increase in the value of trade relative to the baseline. In particular, the value of trade rises by 17.5%, to $35.5 billion worth of trade, on average. With greater supply, there tends to be a lower price for importers, leading to increased imports.

If trade liberalization and the climate scenarios occur simultaneously, the two effects compound each other, increasing trade by 48.7% over the baseline to an average $44.9 billion worth of trade. The scenario with both trade liberalization and yield shocks exhibits more
uncertainty than does the scenario with trade liberalization alone. This is due to the range of yield outcomes across the 14 climate change scenarios. Note that this uncertainty is offset by the large increase in trade that would occur with trade liberalization.

The value of crop-specific trade across scenarios is provided in Fig S2. This allows for a breakdown of the aggregate figures provided above. In percentage terms, the trade liberalization policy scenario (free trade) has the greatest impact on rice. Should all tariffs and subsidies be eliminated, there would be an approximately 300% growth in rice trade value. This increase is followed by trade value increases of 15% for soy, 11% for wheat, and 5% for corn. The successively lower increases are due to lower initial trade distortions or barriers for these commodities. Rice is a particularly sensitive food commodity in a number of countries, and countries have erected high import barriers so as to protect domestic producers from foreign competition.

There is also an increase in trade value due to yield effects. This is largest for wheat (23.9%), followed by corn (17.5%), rice (14.7%), and finally by soy (2.2%). When the policy change is combined with the yield effects, the trade value effect for all commodities except for soy are intensified. This is especially true for rice, which has a mean 325% increase in trade value over the baseline value.
| Base Policy Yield All |
|----------------------|
| 3                    |
| 3.2                  |
| 3.4                  |
| 3.6                  |
| 3.8                  |
| 4                    |
| 4.2                  |
| 4.4                  |
| 4.6                  |
| 4.8                  |

Figure S1: The aggregate value [USD$] of staple crop trade across scenarios.
Figure S2: Crop-specific value [USD$] trade across scenarios. Note that the wheat trade exhibits the highest value, followed by rice.
S4  Mass of food trade

An alternative means of evaluating the scenarios is through physical quantities. The mass [metric tons] of aggregate crop trade across scenarios is provided in Fig S3. In the base scenario, the mass of trade in the four commodities is approximately 260 million metric tons. When tariffs and subsidies are eliminated, prices for most importers fall, leading to a rise in the mass of agricultural trade. Under full trade liberalization trade rises by 33.4% to 346 million tons. The mass of food trade increases across all climate scenarios. Globally, yields increase, which decreases the price and leads to more agricultural trade. The rise under the climate scenarios is more modest than under trade liberalization, however, climbing 10.6% to 287 million tons.

If both the policy and climate scenarios prevail, there is a much larger (46.0%) rise in physical quantities, quite similar to the change in value (48.7%). The difference is due to the price changes for individual commodities that additionally influence the change measured in value terms. As with trade values, there is also considerable uncertainty regarding the potential increase in the physical mass of trade. However, the mass of food trade clearly increases as compared with the baseline.

The mass [metric tons] of crop-specific trade across scenarios is provided in Fig S4. Under most of the scenarios there is a positive change in trade volume for all crops, but rice experiences by far the largest proportionate change in the case of the trade liberalization scenario, as well as the combined trade liberalization and climate change scenario. As mentioned above, this is due to the existing high policy barriers to rice trade that exist at present. While trade volumes generally increase under the yield change scenarios, there is a potential decrease in trade volume with some of the climate change scenarios, for the case of corn and wheat.
Figure S3: The aggregate mass [metric tons] of staple crop trade across scenarios. The aggregate food trade mass is driven by wheat.
Figure S4: Crop-specific mass [metric tons] trade across scenarios. Note that rice does not show increases under the climate-only scenario, but is most impacted under the free trade scenario.
S5  Water footprint of food trade

Here, we provide additional water footprint results. Specifically, we map changes in net total virtual water trade by scenario in Fig S5. Additionally, we rank the top net virtual water traders in Tables S10 and S11.
Figure S5: Maps of changes in net total virtual water trade [km$^3$] for each country from the baseline scenario to the (A) policy only, (B) climate change only, and (C) climate change and policy scenario. Warm shades indicate reductions in net trade, while cool shades show positive changes to net trade. Countries that are shaded white indicates that model results are not available. Note that the ranges on the color bars are different across scenarios.
Table S10: Top net virtual water traders [km$^3$] across scenarios.

| Positive Baseline Policy Yield All | Country | Volume | Country | Volume | Country | Volume | Country | Volume | Country | Volume |
|-----------------------------------|---------|--------|---------|--------|---------|--------|---------|--------|---------|--------|
| Rank                              |         |        |         |        |         |        |         |        |         |        |
| 1                                 | USA     | 62.56  | USA     | 79.47  | USA     | 87.76  | USA     | 102.97 |
| 2                                 | Argentina | 41.46  | Argentina | 46.53  | Canada | 58.62  | Canada | 57.80  |
| 3                                 | Brazil  | 33.37  | Brazil  | 44.05  | Argentina | 38.34  | Argentina | 31.31  |
| 4                                 | Canada  | 27.25  | Canada  | 31.01  | Brazil  | 26.49  | Brazil  | 21.09  |
| 5                                 | Australia | 13.68  | Australia | 15.94  | Australia | 9.51  | Australia | 10.78  |
| 6                                 | France  | 6.13   | India   | 6.29   | France  | 3.12   | France  | 4.16   |
| 7                                 | India   | 5.76   | France  | 5.42   | Pakistan | 2.59  | Pakistan | 1.72  |
| 8                                 | Russia  | 3.06   | Russia  | 3.96   | Russia  | 2.44   | Russia  | 1.67   |
| 9                                 | Pakistan | 3.06   | Thailand | 3.32  | Hungary  | 1.60   | Hungary  | 1.52  |
| 10                                | Hungary | 2.55   | Hungary | 2.75   | India  | 1.52   | India  | 1.13   |

| Negative Baseline Policy Yield All | Country | Volume | Country | Volume | Country | Volume | Country | Volume |
|-----------------------------------|---------|--------|---------|--------|---------|--------|---------|--------|
| Rank                              |         |        |         |        |         |        |         |        |
| 1                                 | Japan   | -22.25 | Japan   | -54.42 | Japan   | -32.10 | Japan   | -32.10 |
| 2                                 | Iran    | -15.08 | Korea   | -21.40 | Iran    | -16.16 | Mexico  | -15.38 |
| 3                                 | China   | -14.01 | Iran    | -14.87 | Mexico  | -12.87 | Iran    | -15.10 |
| 4                                 | Mexico  | -10.88 | Mexico  | -11.01 | Spain   | -10.75 | Netherlands | -10.93 |
| 5                                 | Netherlands | -10.87 | Netherlands | -10.95 | Netherlands | -10.74 | China   | -10.74 |
| 6                                 | Spain   | -9.43  | Italy   | -9.56  | Italy   | -10.13 | Spain   | -10.62 |
| 7                                 | Italy   | -8.83  | Spain   | -9.42  | Korea   | -6.43  | Italy   | -9.36  |
| 8                                 | Philippines | -5.78  | Philippines | -5.88  | Indonesia | -6.23  | Indonesia | -6.65  |
| 9                                 | Korea   | -5.77  | Morocco | -5.86  | Philippines | -5.51  | UK  | -5.65  |
| 10                                | Indonesia | -5.76  | Indonesia | -5.82  | UK  | -4.86  | Korea   | -5.50  |
Table S11: Top net blue virtual water traders [km$^3$] across scenarios.

| Positive Baseline Country | Volume | Policy Country | Volume | Yield Country | Volume | All Country | Volume |
|---------------------------|--------|----------------|--------|--------------|--------|-------------|--------|
| Rank                      |        |                |        |              |        |             |        |
| 1                         | USA    | 9.96           | USA    | 14.54        | USA    | 12.08       | USA    |
| 2                         | Pakistan | 3.28            | China  | 5.17         | Pakistan | 2.82          | Pakistan |
| 3                         | India  | 1.72           | Pakistan | 2.75      | Argentina | 1.53          | Argentina |
| 4                         | Argentina | 1.67           | India  | 1.88         | China   | 1.32         | Canada  |
| 5                         | Australia | 1.19          | Argentina | 1.81    | Canada   | 1.18         | Australia |
| 6                         | Canada  | 0.58           | Australia | 1.77     | Australia | 0.85         | India   |
| 7                         | Morocco | 0.37           | Thailand | 1.03     | India    | 0.61         | China   |
| 8                         | Uruguay | 0.20           | Canada  | 0.68        | Morocco  | 0.36         | Morocco |
| 9                         | Thailand | 0.16           | Uruguay | 0.27       | Uruguay  | 0.15         | Uruguay |
| 10                        | Russia  | 0.12           | Brazil  | 0.25        | Thailand | 0.09         | Turkey  |

| Negative Baseline Country | Volume | Policy Country | Volume | Yield Country | Volume | All Country | Volume |
|---------------------------|--------|----------------|--------|--------------|--------|-------------|--------|
| Rank                      |        |                |        |              |        |             |        |
| 1                         | Japan  | -2.27          | Japan  | -10.82       | Japan  | -2.96       | Japan  |
| 2                         | Mexico | -1.30          | Korea  | -4.40        | Mexico | -1.23       | Mexico |
| 3                         | UK     | -0.87          | Mexico  | -1.25     | UK     | -0.95       | UK     |
| 4                         | Philippines | -0.85       | Italy  | -0.98       | Italy  | -0.81       | Netherlands |
| 5                         | Korea  | -0.73          | UK     | -0.91        | Korea  | -0.72       | Italy  |
| 6                         | Italy  | -0.70          | Philippines | -0.86   | Netherlands | -0.67       | Spain  |
| 7                         | Indonesia | -0.66        | Indonesia | -0.67     | Philippines | -0.65       | Indonesia |
| 8                         | Netherlands | -0.50        | Spain  | -0.53        | Spain  | -0.64       | Korea  |
| 9                         | Malaysia | -0.48         | Netherlands | -0.51   | Indonesia | -0.55       | Philippines |
| 10                        | Iran   | -0.45          | Belgium | -0.45   | Malaysia | -0.46       | Malaysia |
S6  Global water savings

In this section, we present additional results on the global water savings (GWS) of staple crop trade. Specifically, we plot total GWS of aggregate crop trade in Fig S6. We present total GWS by crop and scenario in Fig S7. In Fig S8 we map changes in total GWS by country and scenario. Fig S9 maps changes in link-level total GWS. Table S14 lists the links that save and lose the most water under the ‘Baseline’ and ‘All’ scenarios.
Figure S6: Global water savings across scenarios. Note that aggregate global water savings is highest under climate change when free trade is enabled.
Figure S7: Crop-specific global water savings across scenarios. Note that rice and soy exhibit large water-efficiency gains in trade under free trade policies.
Figure S8: Maps of changes in total global water savings [km$^3$] for each country from the baseline scenario to the (A) policy only, (B) climate change only, and (C) climate change and policy scenario. Warm shades indicate negative changes to global water savings, while cool shades show positive changes to global water savings. Countries that are shaded white indicates that model results are not available. Note that the ranges on the color bars are different across scenarios.
Table S12: Top contributors to total global water savings [km^3] across scenarios.

| Positive | Baseline | Policy | Yield | All  |
|----------|----------|--------|-------|------|
| Rank     | Country  | Volume | Country | Volume | Country | Volume | Country | Volume |
| 1        | USA      | 30.91  | USA    | 37.38  | USA    | 64.92  | USA    | 73.94  |
| 2        | Canada   | 28.96  | Canada  | 36.83  | Canada  | 41.56  | Canada  | 50.75  |
| 3        | Argentina| 22.98  | Argentina| 26.25  | Argentina| 23.56  | Argentina| 25.15  |
| 4        | France   | 14.40  | France  | 14.73  | France  | 16.08  | Australia| 13.27  |
| 5        | Australia| 9.75   | Australia| 12.91  | Australia| 10.44  | France  | 13.23  |
| 6        | Germany  | 4.65   | China   | 8.29   | Germany  | 7.28   | China   | 8.37   |
| 7        | South Africa| 3.34 | Germany | 5.35 | South Africa | 3.64 | Germany | 5.85 |
| 8        | China    | 1.60   | South Africa| 3.45 | China    | 2.85   | Turkey  | 4.10   |
| 9        | UK       | 0.92   | Turkey  | 1.58   | Turkey  | 2.77   | South Africa|       |
| 10       | Hungary  | 0.90   | Hungary | 1.27 | Sweden   | 2.09   | Denmark | 3.15   |

| Negative | Baseline | Policy | Yield | All  |
|----------|----------|--------|-------|------|
| Rank     | Country  | Volume | Country | Volume | Country | Volume | Country | Volume |
| 1        | Brazil   | -4.98  | Thailand| -1.94 | Brazil  | -6.20  | Thailand| -2.95  |
| 2        | Morocco  | -0.77  | Pakistan| -0.95 | Pakistan| -1.71  | Brazil  | -2.89  |
| 3        | Pakistan | -0.63  | Morocco | -0.73 | Morocco | -0.74  | Pakistan| -1.28  |
| 4        | India    | -0.34  | India   | -0.41 | India   | -0.69  | Morocco | -0.74  |
| 5        | Russia   | -0.23  | Malaysia| -0.35 | Portugal| -0.17  | India   | -0.72  |
| 6        | Portugal | -0.18  | Tunisia | -0.18 | Botswana| -0.13  | Malaysia| -0.64  |
| 7        | Botswana | -0.09  | Uruguay | -0.17 | Mauritius| -0.09  | Korea   | -0.23  |
| 8        | Mauritius| -0.08  | Portugal| -0.17 | Russia  | -0.06  | Portugal| -0.18  |
| 9        | Greece   | -0.07  | Greece  | -0.08 | Tanzania| -0.05  | Botswana| -0.11  |
| 10       | Indonesia| -0.06  | Indonesia| -0.07 | Mozambique| -0.04  | Tanzania| -0.10  |
| Positive Baseline Policy Yield All | Positive Baseline Policy Yield All |
|-----------------------------------|-----------------------------------|
| Rank | Country | Volume | Country | Volume | Country | Volume | Country | Volume |
| 1    | Argentina | 10.21 | Argentina | 12.77 | USA | 20.74 | USA | 24.05 |
| 2    | Brazil | 8.25 | Brazil | 11.60 | Canada | 11.04 | Canada | 12.47 |
| 3    | USA | 7.96 | USA | 10.80 | Argentina | 9.68 | Argentina | 11.52 |
| 4    | Canada | 6.48 | Canada | 7.66 | France | 6.12 | Brazil | 9.26 |
| 5    | France | 5.17 | France | 4.46 | Brazil | 6.10 | China | 5.29 |
| 6    | Australia | 3.09 | Australia | 4.12 | Australia | 3.06 | France | 4.74 |
| 7    | Germany | 1.22 | China | 3.71 | Turkey | 1.92 | Australia | 4.09 |
| 8    | Hungary | 0.82 | Germany | 1.21 | Germany | 1.92 | Turkey | 2.83 |
| 9    | South Africa | 0.61 | Hungary | 0.99 | China | 1.61 | Germany | 1.45 |
| 10   | Turkey | 0.43 | Turkey | 0.71 | Hungary | 0.77 | Hungary | 0.87 |

| Negative Baseline Policy Yield All | Negative Baseline Policy Yield All |
|-----------------------------------|-----------------------------------|
| Rank | Country | Volume | Country | Volume | Country | Volume | Country | Volume |
| 1    | Pakistan | -0.86 | Pakistan | -1.20 | Pakistan | -2.77 | Pakistan | -2.24 |
| 2    | India | -0.68 | India | -0.74 | India | -0.60 | India | -0.59 |
| 3    | Morocco | -0.53 | Morocco | -0.46 | Morocco | -0.51 | Morocco | -0.47 |
| 4    | Thailand | -0.19 | Uruguay | -0.14 | Uruguay | -0.07 | Thailand | -0.15 |
| 5    | Uruguay | -0.08 | Thailand | -0.09 | Thailand | -0.06 | Uruguay | -0.11 |
| 6    | Indonesia | -0.05 | Indonesia | -0.06 | Portugal | -0.03 | Korea | -0.09 |
| 7    | Chile | -0.03 | Chile | -0.03 | Indonesia | -0.02 | Indonesia | -0.04 |
| 8    | Portugal | -0.02 | Portugal | -0.02 | Korea | -0.01 | Portugal | -0.03 |
| 9    | Greece | -0.02 | Greece | -0.02 | Venezuela | -0.01 | Sri Lanka | -0.01 |
| 10   | Peru | -0.01 | Sri Lanka | -0.02 | Mozambique | -0.01 | Venezuela | -0.01 |
Figure S9: Maps of changes in link-level total global water savings [km$^3$] from the baseline scenario to the climate change and policy scenario. (A) Blue links indicate positive changes to global water savings, while (B) red links illustrate negative changes in global water savings.
Table S14: Top 10 links that save and lose the most water under the ‘Baseline’ and ‘All’ scenarios for aggregate crop trade. All values are in km³. Note that ‘Export’ refers to the country of export and ‘Import’ refers to the country of import. ‘ROW’ indicates ‘Rest of World’.

| Positive Baseline |  | All |  |  |
|------------------|-----------------|-----------------|-----------------|-----------------|
| Rank             | Volume          | Export          | Import          | Volume          | Export          | Import          |
| 1                | 12.5            | Canada          | Venezuela       | 19.9            | USA             | Japan           |
| 2                | 10.9            | Argentina       | Brazil          | 18.5            | Canada          | Venezuela       |
| 3                | 7.7             | USA             | Japan           | 16.2            | USA             | ROW             |
| 4                | 7.6             | France          | Morocco         | 13.4            | Canada          | Morocco         |
| 5                | 5.2             | Brazil          | China           | 10.4            | Argentina       | Brazil          |
| 6                | 5.1             | USA             | Venezuela       | 7.9             | USA             | Mexico          |
| 7                | 4.4             | Canada          | Morocco         | 7.4             | Canada          | ROW             |
| 8                | 4.3             | Argentina       | Morocco         | 6.2             | USA             | Venezuela       |
| 9                | 3.2             | Germany         | Morocco         | 5.9             | USA             | Morocco         |
| 10               | 3.1             | Argentina       | Peru            | 5.5             | France          | Morocco         |

| Negative Baseline |  | All |  |  |
|------------------|-----------------|-----------------|-----------------|-----------------|
| Rank             | Volume          | Export          | Import          | Volume          | Export          | Import          |
| 1                | -3.3            | Brazil          | Spain           | -3.1            | Brazil          | Iran            |
| 2                | -3.2            | Brazil          | Iran            | -2.1            | Brazil          | Spain           |
| 3                | -1.6            | Brazil          | Netherlands     | -2.0            | USA             | Spain           |
| 4                | -1.0            | Brazil          | Italy           | -1.9            | Thailand        | Korea           |
| 5                | -1.0            | Brazil          | Germany         | -1.8            | USA             | Italy           |
| 6                | -1.0            | USA             | Spain           | -1.3            | Brazil          | Netherlands     |
| 7                | -0.9            | USA             | Italy           | -1.0            | Canada          | UK              |
| 8                | -0.9            | Argentina       | Spain           | -0.9            | Argentina       | Chile           |
| 9                | -0.9            | Argentina       | Chile           | -0.8            | Thailand        | Italy           |
| 10               | -0.7            | Brazil          | France          | -0.8            | Brazil          | Italy           |

References

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