*Earth's Future*

Supporting Information for

# Africa Would Need to Import More Maize in the Future Even under 1.5°C Warming Scenario

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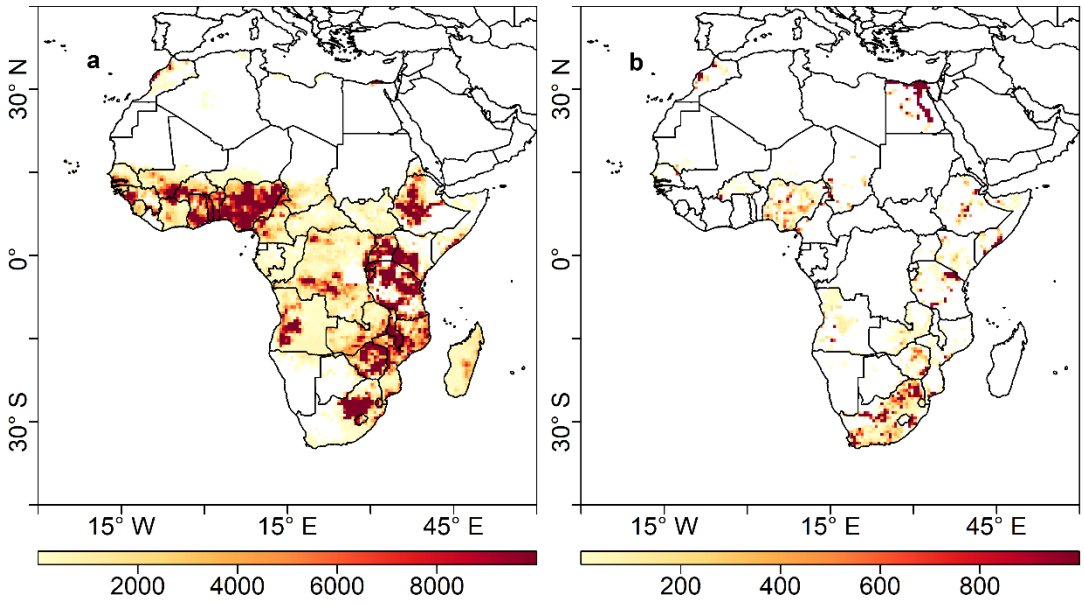


**Figure S1.** Harvested area (ha) for rainfed maize (a) and irrigated maize (b) at a 0.5° resolution in Africa according to SPAM2005 dataset.

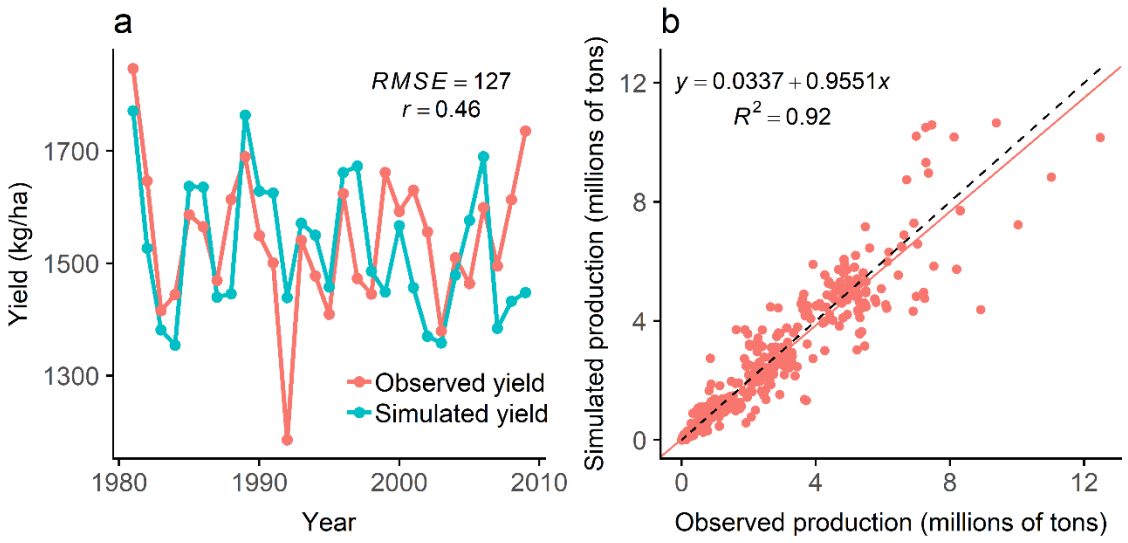


**Figure S2.** Upscaling observed and simulated maize yield (kg/ha) in Africa calculated by the cultivated area and yield in each country (a), the Root Mean Square Error (RMSE, kg/ha) and correlation coefficient (r) are also shown. As well as observed and simulated production (millions of tons) at country level in each year during the whole calibrated period from 1981 to 2009 in Africa (b). The red solid line in panel b represents the linear fitting curve of the observed production and the simulated production, and the black dashed line in panel b represents the 1:1 line of the observed production.

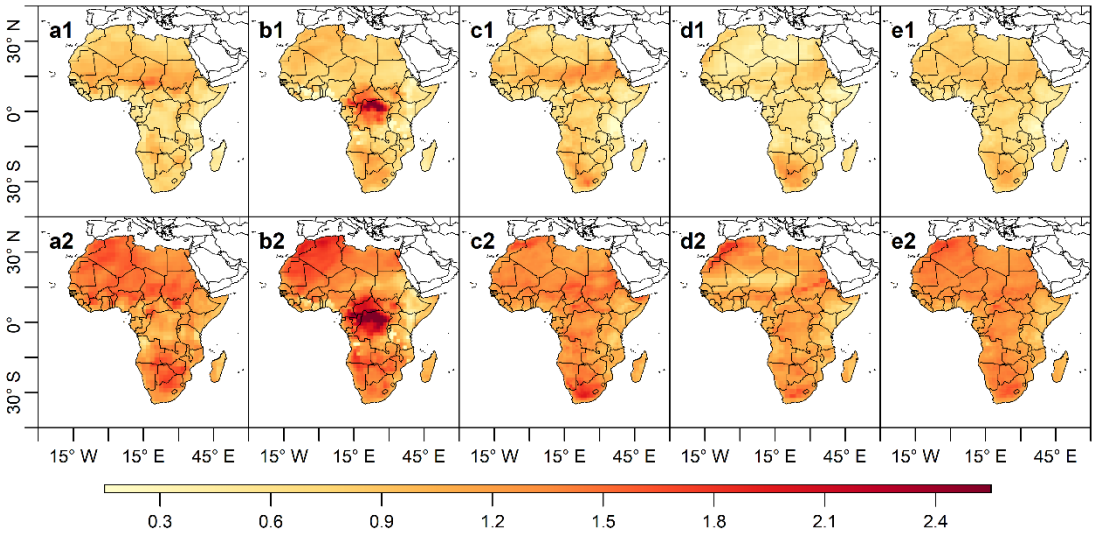


**Figure S3.** Predicted change in daily maximum temperature. Predicted median values of daily maximum temperature change (°C) under 1.5 (a1-e1) and 2.0°C (a2-e2) warming scenarios by ECHAM6-3-LR (a1, a2), MIROC5 (b1, b2), NorESM1-HAPPI (c1, c2), CAM4-2degree (d1, d2), and all the four GCMs (e1, e2), relative to baseline period (2006-2015).

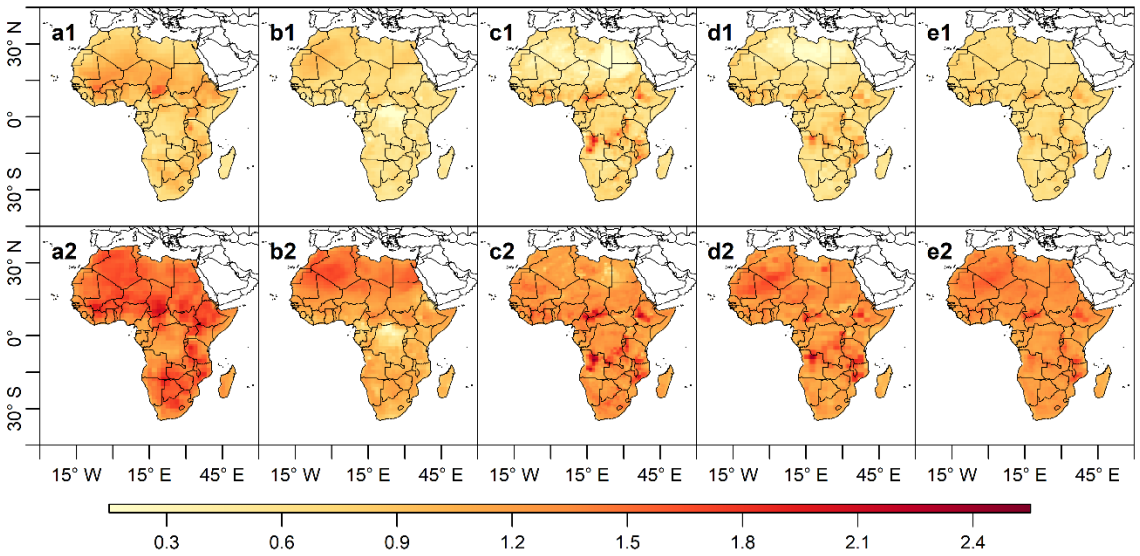


**Figure S4.** Predicted change in daily minimum temperature. Predicted median values of daily minimum temperature change (°C) under 1.5 (a1-e1) and 2.0°C (a2-e2) warming scenarios by ECHAM6-3-LR (a1, a2), MIROC5 (b1, b2), NorESM1-HAPPI (c1, c2), CAM4-2degree (d1, d2), and all the four GCMs (e1, e2), relative to baseline period (2006-2015).

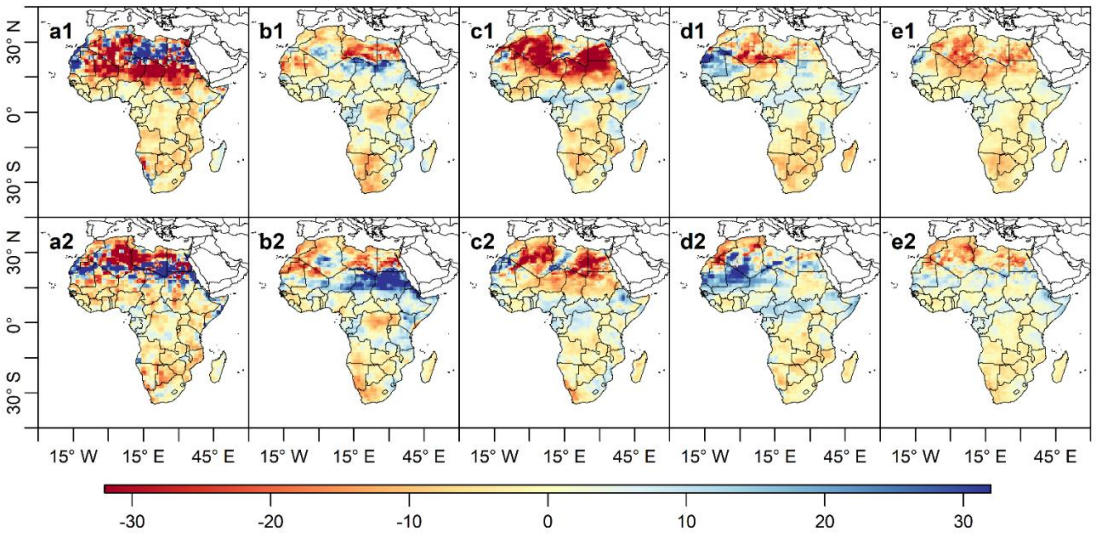


**Figure S5.** Predicted change in daily precipitation. Predicted median values of daily precipitation change (%) under 1.5 (a1-e5) and 2.0°C (a2-e2) warming scenarios by ECHAM6-3-LR (a1, a2) MIROC5 (b1, b2), NorESM1-HAPPI (c1, c2), CAM4-2degree (d1,d2), and all the four GCMs (e1, e2), relative to baseline period (2006-2015).

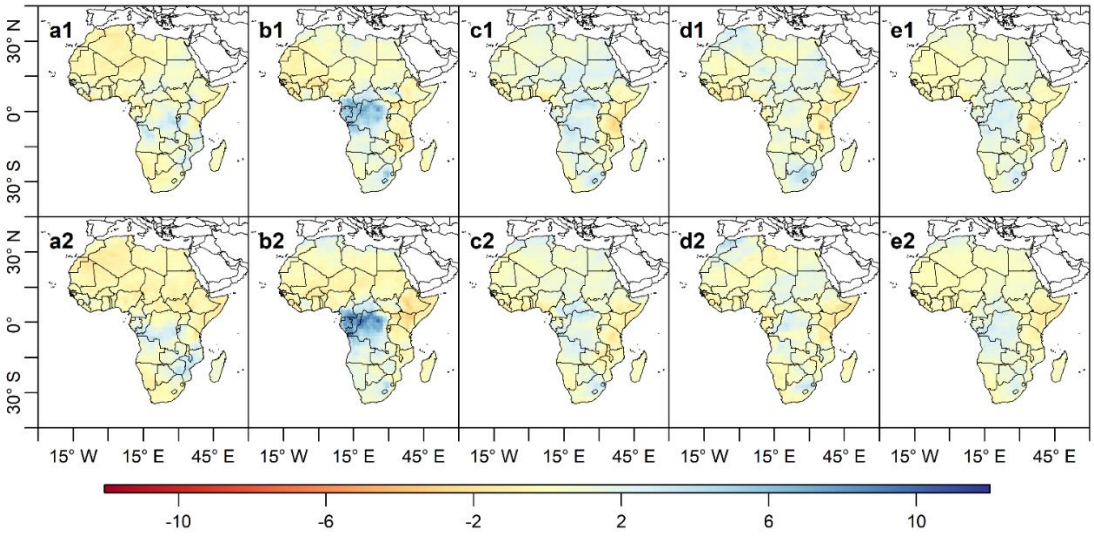


**Figure S6.** Predicted change in daily average downward shortwave radiation flux. Predicted median values of daily average downward shortwave radiation flux change (%) under 1.5 (a1-e1) and 2.0°C (a2-e2) warming scenarios by ECHAM6-3-LR (a1, a2), MIROC5 (b1, b2), NorESM1-HAPPI (c1, c2), CAM4-2degree (d1, d2), and all the four GCMs (e1, e2), relative to baseline period (2006-2015).

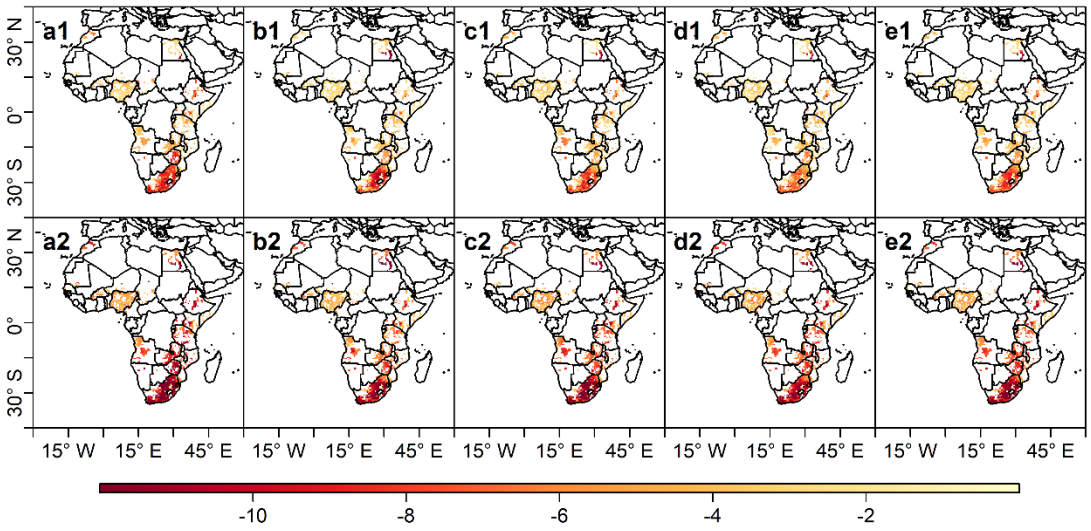


**Figure S7.** Predicted change in growth duration (%) for irrigated maize, with taking the $CO_2$ effect into account. Predicted median change in growth duration (%) for irrigated maize during 2106-2115 under 1.5 (a1-e1) and 2.0°C (a2-e2) warming scenarios by ECHAM6-3-LR (a1, a2), MIROC5 (b1, b2), NorESM1-HAPPI (c1, c2), CAM4-2degree (d1, d2), and all the four GCMs (e1, e2), relative to baseline period (2006-2015).

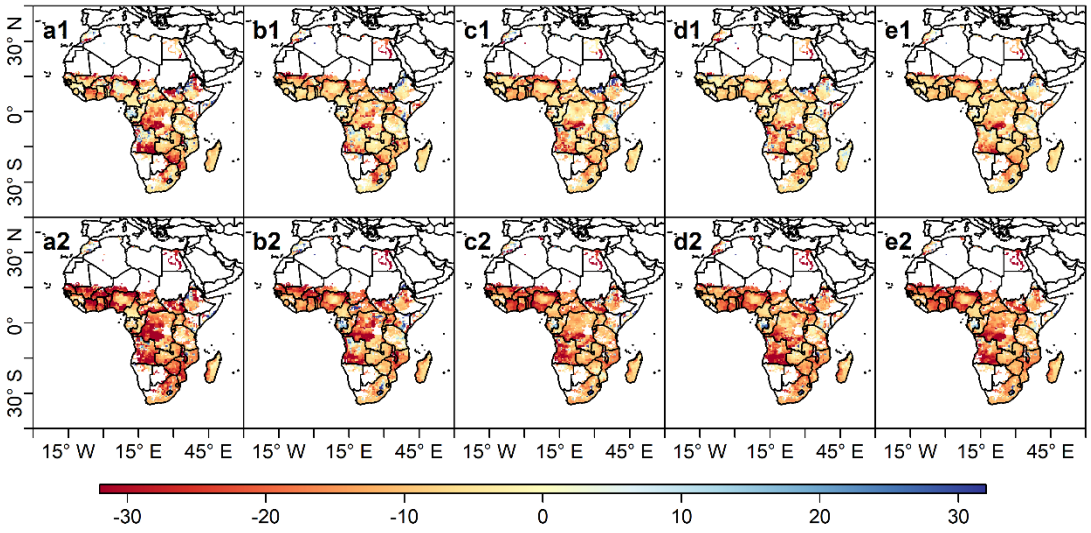


**Figure S8.** Predicted yield change (%) for maize, without taking the $CO_2$ effect into account. Predicted median change (%) in yield for maize during 2106-2115, under 1.5 (a1-e1) and 2.0°C (a2-e2) warming scenarios by ECHAM6-3-LR (a1, a2), MIROC5 (b1, b2), NorESM1-HAPPI (c1, c2), CAM4-2degree (d1, d2), and all the four GCMs (e1, e2), relative to baseline period (2006-2015).

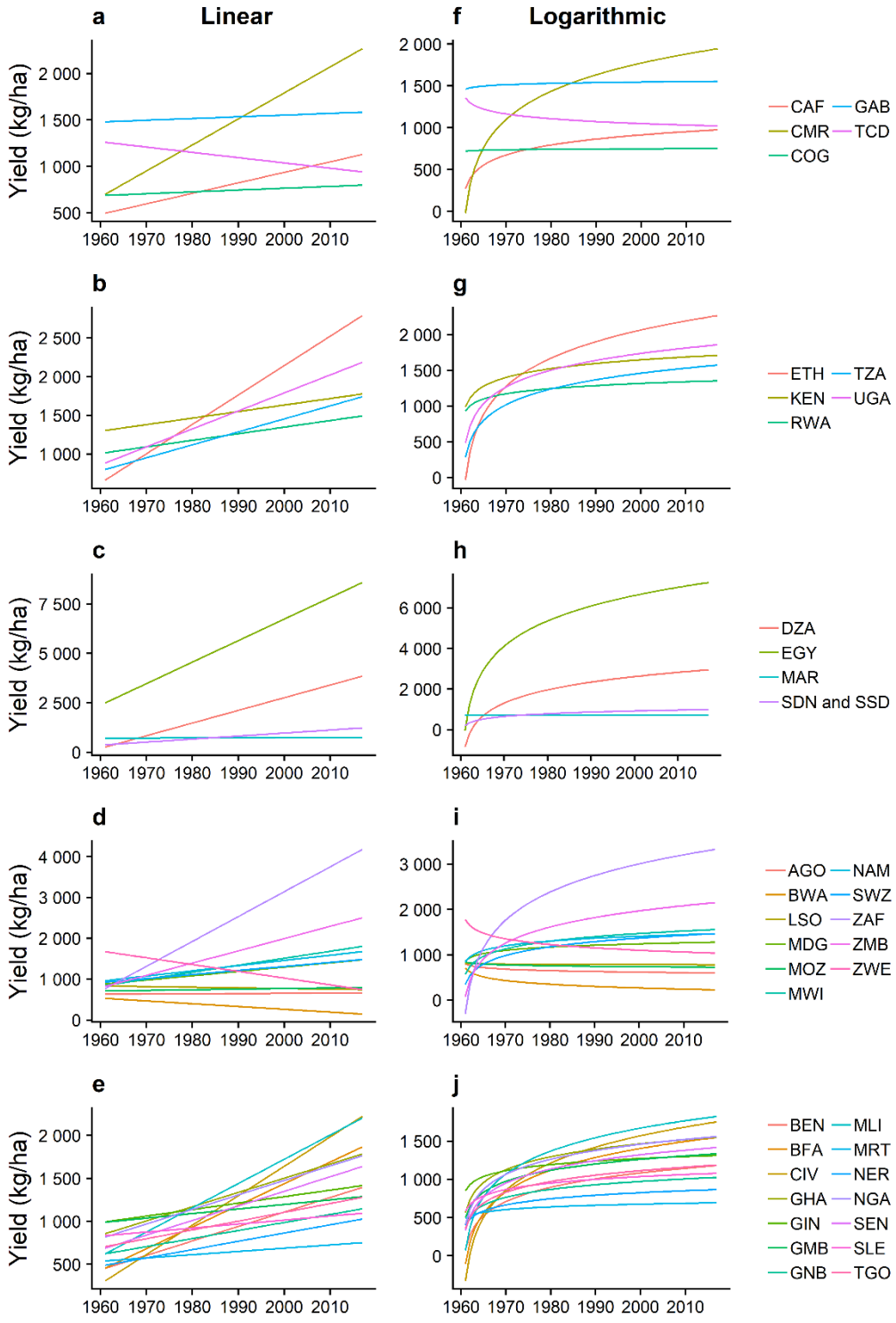


**Figure S9.** Linear regression curve (Left) and logarithmic regression curve (Right) in the Central Africa (a,f), Eastern Africa (b,g), Northern Africa (c,h), Southern Africa (d,i) and Western Africa (e,j).

**Table S1.** The coefficients (*a,b*) for the linear regression and logarithmic regression, and coefficients of determination ($R^2$) for the linear regression and logarithmic regression for maize yield (kg/ha) from 1961 to 2017 in every country.

| Country Name | Abbreviation | Zones | $y = ax + b$ | | | $y = a\ln(x) + b$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | *a* | *b* | $R^2$ | *a* | *b* | $R^2$ |
| Algeria | DZA | NA | 64.0293 | 199.0866 | 0.4976 | 941.1494 | -856.6060 | 0.3144 |
| Angola | AGO | SA | 0.5312 | 629.9943 | 0.0015 | -49.3432 | 798.0987 | 0.0389 |
| Benin | BEN | WA | 16.8321 | 435.5440 | 0.9225 | 271.3574 | 83.9138 | 0.7012 |
| Botswana | BWA | SA | -6.8417 | 537.3487 | 0.2468 | -118.1314 | 704.5155 | 0.2152 |
| Burkina Faso | BFA | WA | 25.2110 | 430.0044 | 0.7957 | 409.4825 | -106.0880 | 0.6139 |
| Cameroon | CMR | CA | 28.0005 | 671.8886 | 0.6730 | 486.2315 | -20.8213 | 0.5936 |
| Central Africa Republic | CAF | CA | 11.3033 | 484.2370 | 0.3620 | 173.3604 | 275.5394 | 0.2491 |
| Chad | TCD | CA | -5.6908 | 1265.4405 | 0.0546 | -82.8840 | 1356.9050 | 0.0339 |
| Congo | COG | CA | 1.9732 | 686.4021 | 0.0661 | 7.5051 | 720.4006 | 0.0028 |
| Côte d'Ivoire | CIV | WA | 34.2216 | 272.0891 | 0.8041 | 514.3634 | -327.2661 | 0.5313 |
| Egypt | EGY | NA | 108.7147 | 2386.3445 | 0.9160 | 1803.3529 | -41.6992 | 0.7372 |
| Ethiopia | ETH | EA | 37.9951 | 623.9249 | 0.6892 | 569.8325 | -37.6578 | 0.4534 |
| Gabon | GAB | CA | 1.8502 | 1478.7888 | 0.2535 | 22.8628 | 1461.6911 | 0.1132 |
| Gambia | GMB | WA | 5.3182 | 984.4283 | 0.0670 | 207.1010 | 497.7483 | 0.2973 |
| Ghana | GHA | WA | 16.5784 | 839.5637 | 0.6755 | 244.2794 | 564.3740 | 0.4289 |
| Guinea | GIN | WA | 7.5381 | 986.4271 | 0.4057 | 113.8298 | 852.7683 | 0.2706 |
| Guinea-Bissau | GNB | WA | 9.3623 | 612.6534 | 0.5765 | 149.7774 | 420.6488 | 0.4315 |
| Kenya | KEN | EA | 8.4342 | 1296.2591 | 0.2953 | 178.5542 | 988.2855 | 0.3871 |
| Lesotho | LSO | SA | -1.5447 | 832.6551 | 0.0120 | -8.5577 | 814.3427 | 0.0011 |
| Madagascar | MDG | SA | 10.5443 | 873.8831 | 0.3404 | 102.1624 | 863.5100 | 0.0935 |
| Malawi | MWI | SA | 17.0707 | 830.1311 | 0.4162 | 244.2705 | 569.2472 | 0.2492 |
| Mali | MLI | WA | 28.2407 | 593.6977 | 0.5949 | 433.8632 | 70.0163 | 0.4106 |
| Mauritania | MRT | WA | 3.7864 | 535.7581 | 0.1207 | 51.0225 | 487.6674 | 0.0641 |
| Morocco | MAR | NA | 0.4162 | 713.2231 | 0.0007 | 3.1298 | 715.6073 | 0.0001 |
| Mozambique | MOZ | SA | 1.5175 | 708.8385 | 0.0087 | -29.1965 | 843.2008 | 0.0094 |
| Namibia | NAM | SA | 12.7243 | 950.4567 | 0.2471 | 152.2118 | 848.4169 | 0.1034 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Niger | NER | WA | 9.5899 | 479.8722 | 0.2824 | 115.2200 | 401.4135 | 0.1192 |
| Nigeria | NGA | WA | 16.9175 | 800.2340 | 0.6783 | 284.5687 | 410.1975 | 0.5613 |
| Rwanda | RWA | EA | 8.5093 | 1007.6408 | 0.0946 | 104.3754 | 931.4037 | 0.0416 |
| Senegal | SEN | WA | 16.9803 | 670.5110 | 0.4009 | 267.4501 | 335.2703 | 0.2908 |
| Sierra Leone | SLE | WA | 4.6728 | 828.2575 | 0.0591 | 121.9251 | 586.4512 | 0.1177 |
| South Africa | ZAF | SA | 60.8552 | 708.3497 | 0.6503 | 898.1035 | -306.1796 | 0.4142 |
| Sudan and South Sudan | SDN and SSD | NA | 15.2103 | 364.4809 | 0.3959 | 195.6302 | 200.1710 | 0.1915 |
| Eswatini | SWZ | SA | 9.8595 | 917.8669 | 0.1283 | 277.9251 | 343.7082 | 0.2981 |
| Togo | TGO | WA | 10.2366 | 695.6409 | 0.4414 | 204.6662 | 359.1286 | 0.5161 |
| Uganda | UGA | EA | 23.2525 | 860.3788 | 0.6864 | 339.8609 | 482.9447 | 0.4289 |
| United Republic of Tanzania | TZA | EA | 16.7884 | 783.3324 | 0.3194 | 318.4531 | 284.6913 | 0.3361 |
| Zambia | ZMB | SA | 29.9899 | 794.4065 | 0.6267 | 513.6792 | 74.4478 | 0.5377 |
| Zimbabwe | ZWE | SA | -16.5688 | 1689.8505 | 0.3010 | -182.1953 | 1773.1894 | 0.1065 |

**Table S2.** The ratio of maize supply to demand under different warming scenarios (+1.5°C, +2.0°C), population growth scenarios (SSP1, SSP2), and climate change with constant technology development trend (C & NT), linear technology development trend (C & T (linear)), logarithmic technology development trend (C & T (logarithmic)), and if there is no climate change or technology development (NC & NT) in Africa.

| | | C & NT | C & T (linear) | C & T (logarithmic) | NC & NT |
|---|---|---|---|---|---|
| Baseline period (2006-2015) | | 0.60 (0.57,0.63) | 0.72 (0.70,0.76) | 0.65 (0.62,0.68) | 0.60 (0.57,0.63) |
| 1.5°C warming scenario (2106-2115) | SSP1 | 0.33 (0.31,0.34) | 0.87 (0.84,0.88) | 0.45 (0.42,0.46) | 0.36 (0.34,0.38) |
| | SSP2 | 0.21 (0.20,0.22) | 0.55 (0.54,0.56) | 0.29 (0.27,0.29) | 0.23 (0.22,0.24) |
| 2.0° C warming scenario (2106-2115) | SSP1 | 0.31 (0.29,0.32) | 0.85 (0.83,0.86) | 0.43 (0.41,0.44) | 0.36 (0.34,0.38) |
| | SSP2 | 0.20 (0.19,0.21) | 0.54 (0.53,0.55) | 0.27 (0.26,0.28) | 0.23 (0.22,0.24) |

* 5th and 95th percentile values are given in the parentheses.

**Table S3.** Change in the ratio of maize supply to demand at country level in major maize producing countries taking into account climate change impact with different technology development (constant (C & NT), linear (C & T (linear)), logarithmic (C & T (logarithmic))), and change in that ratio without taking consideration of climate change or technology development (NC & NT), under SSP1 and SSP2 national population projections, 1.5°C warming scenario, respectively. Better represents the ratio of maize supply to demand is projected to increase, while worse represents the ratio is projected to decrease under different scenarios, relative to the baseline period (2006-2015). The blue value represents that ratio is less than 1.0 in 2106-2115.

| | SSP1 (+1.5°C) | SSP2 (+1.5°C) |
|---|---|---|
| | C & NT | |
| Ⅱ: Worse | Angola, Benin, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, South Africa, Uganda, United Republic of Tanzania, Zambia, Zimbabwe | Angola, Benin, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, South Africa, Uganda, United Republic of Tanzania, Zambia, Zimbabwe |
| | C & T (linear) | |
| Ⅰ: Better | Benin, Cameroon, Ethiopia, Ghana, South Africa, Uganda, Zambia | Cameroon, Ethiopia, South Africa |
| Ⅱ: Worse | Angola, Egypt, Kenya, Malawi, Mozambique, Nigeria, United Republic of Tanzania, Zimbabwe | Angola, Benin, Egypt, Ghana, Kenya, Malawi, Mozambique, Nigeria, Uganda, United Republic of Tanzania, Zambia, Zimbabwe |
| | C & T (logarithmic) | |
| Ⅰ: Better | Ethiopia, South Africa | |
| Ⅱ: Worse | Angola, Benin, Cameroon, Egypt, Ghana, Kenya, Malawi, Mozambique, Nigeria, Uganda, United Republic of Tanzania, Zambia, Zimbabwe | Angola, Benin, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, South Africa, Uganda, United Republic of Tanzania, Zambia, Zimbabwe |
| | NC & NT | |
| Ⅱ: Worse | The same as C & NT | |

**Table S4.** The same as table S3, but for 2.0℃ warming scenario.

| | SSP1 (+2.0°C) | SSP2 (+2.0°C) |
|---|---|---|
| | C & NT | |
| Ⅱ: Worse | Angola, Benin, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, South Africa, Uganda, United Republic of Tanzania, Zambia, Zimbabwe | Angola, Benin, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, South Africa, Uganda, United Republic of Tanzania, Zambia, Zimbabwe |
| | C & T (linear) | |
| Ⅰ: Better | Benin, Cameroon, Ethiopia, Ghana, South Africa, Zambia | Cameroon, Ethiopia, South Africa |
| Ⅱ: Worse | Angola, Egypt, Kenya, Malawi, Mozambique, Nigeria, Uganda, United Republic of Tanzania, Zimbabwe | Angola, Benin, Egypt, Ghana, Kenya, Malawi, Mozambique, Nigeria, Uganda, United Republic of Tanzania, Zambia, Zimbabwe |
| | C & T (logarithmic) | |
| Ⅰ: Better | Ethiopia, South Africa | |
| Ⅱ: Worse | Angola, Benin, Cameroon, Egypt, Ghana, Kenya, Malawi, Mozambique, Nigeria, Uganda, United Republic of Tanzania, Zambia, Zimbabwe | Angola, Benin, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, South Africa, Uganda, United Republic of Tanzania, Zambia, Zimbabwe |
| | NC & NT | |
| Ⅱ: Worse | The same as C & NT | |