iFEED crop yield shock rate calibrated statements

Table of Contents

Overview

This document summarises crop yield shock calibrated statements for maize, soybean, potato and groundnut. Results are presented for RCP2.6, and RCP8.5, which are applicable to low and high climate risk scenarios respectively.

See the Appendix for details of the methods used to calculate crop yield shock rates, and the literature summary and rationale for the agreement and robustness assessments.

Malawi

Low climate risk (RCP2.6) / ineffective agricultural policies (LT)

In this scenario, all areas are rainfed and crop varieties are restricted to those used in the baseline climate.

Maize

Calibrated Statement:

Crop yield shocks increase by 101.3% on average (range -12.1 to 302.5%), from approximately 1.6/21 years in the baseline to 3.5/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 3.5/21 years in the future.
This is a mean change of 1.9 years, with range of year change across climate models of -0.2 to 6.5 years; 2/18 climate models are outliers. This becomes a mean change of 1 years, range -0.2 to 4.6 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.6/21 years in the baseline to an average of 1.4/21 years in the future.
This is a mean change of -0.2 years, with range of year change across climate models of -1 to 0.8 years; 1/18 climate models are outliers. This becomes a mean change of 0 years, range -1 to 0.7 years after removing the upper limit outliers.

Soybean

Calibrated Statement:

Crop yield shocks increase by 41.7% on average (range -73.5 to 235.9%), from approximately 1.1/21 years in the baseline to 1.5/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 1.5/21 years in the future.
This is a mean change of 0.4 years, with range of year change across climate models of -0.9 to 2.4 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.1/21 years in the baseline to an average of 1.4/21 years in the future.
This is a mean change of 0.3 years, with range of year change across climate models of -0.4 to 1.3 years; 0/18 climate models are outliers.

Potato

Calibrated Statement:

Crop yield shocks increase by 251.2% on average (range -57.7 to 767%), from approximately 0.5/21 years in the baseline to 1.9/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 1.9/21 years in the future.
This is a mean change of 1.3 years, with range of year change across climate models of -0.4 to 3.6 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 0.5/21 years in the baseline to an average of 1/21 years in the future.
This is a mean change of 0.5 years, with range of year change across climate models of -0.1 to 1.3 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks increase by 97.4% on average (range -12.7 to 484.7%), from approximately 1.5/21 years in the baseline to 3.9/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.5/21 in the baseline to an average of 3.9/21 years in the future.
This is a mean change of 2.3 years, with range of year change across climate models of -0.2 to 9.7 years; 2/18 climate models are outliers. This becomes a mean change of 1 years, range -0.2 to 6.7 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.5/21 years in the baseline to an average of 1.5/21 years in the future.
This is a mean change of 0 years, with range of year change across climate models of -0.9 to 1.1 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / ineffective agricultural policies (LT)

In this scenario, all areas are rainfed and crop varieties are restricted to those used in the baseline climate.

Maize

Calibrated Statement:

Crop yield shocks increase by 174.5% on average (range 63.2 to 368.2%), from approximately 1.6/21 years in the baseline to 5.2/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

High confidence (medium robustness and high agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 5.2/21 years in the future.
This is a mean change of 3.6 years, with range of year change across climate models of 1.1 to 7.9 years; 3/18 climate models are outliers. This becomes a mean change of 3 years, range 1.1 to 5.6 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.6/21 years in the baseline to an average of 1.1/21 years in the future.
This is a mean change of -0.6 years, with range of year change across climate models of -1.5 to 0.7 years; 2/18 climate models are outliers. This becomes a mean change of -1 years, range -1.4 to 0.4 years after removing both upper and lower limit outliers.

Soybean

Calibrated Statement:

Crop yield shocks increase by 28.5% on average (range -80 to 261%), from approximately 1.1/21 years in the baseline to 1.6/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 1.6/21 years in the future.
This is a mean change of 0.5 years, with range of year change across climate models of -1 to 3.3 years; 1/18 climate models are outliers. This becomes a mean change of 0 years, range -1 to 2.8 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.1/21 years in the baseline to an average of 1.3/21 years in the future.
This is a mean change of 0.2 years, with range of year change across climate models of -0.8 to 1.1 years; 0/18 climate models are outliers.

<u>Potato</u>

Calibrated Statement:

Crop yield shocks increase by 479.5% on average (range 133.3 to 1150%), from approximately 0.5/21 years in the baseline to 2.8/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

High confidence (medium robustness and high agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 2.8/21 years in the future.
This is a mean change of 2.3 years, with range of year change across climate models of 0.5 to 4.8 years; 1/18 climate models are outliers. This becomes a mean change of 2 years, range 0.5 to 4.6 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 0.5/21 years in the baseline to an average of 1.4/21 years in the future.
This is a mean change of 0.9 years, with range of year change across climate models of -0.2 to 2 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks increase by 260.4% on average (range -27.8 to 691.5%), from approximately 1.5/21 years in the baseline to 5.6/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.5/21 in the baseline to an average of 5.6/21 years in the future.
This is a mean change of 4 years, with range of year change across climate models of -0.4 to 10.5 years; 1/18 climate models are outliers. This becomes a mean change of 4 years, range -0.4 to 9.8 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.5/21 years in the baseline to an average of 1.1/21 years in the future.
This is a mean change of -0.4 years, with range of year change across climate models of -1.4 to 0.6 years; 0/18 climate models are outliers.

Low climate risk (RCP2.6) / effective agricultural policies (HT)

In this scenario, all future areas are irrigated and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match historical observed yield percentage increases. Mean yields increase substantially and yield variability would not be expected to increase given the assumptions of this scenario. Therefore, crop yield shocks decrease.

Maize

Calibrated Statement:

Crop yield shocks are reduced from approximately 1.6/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.6 years, with range of year change across climate models of -1.9 to -1.2 years; 0/18 climate models are outliers.

If no technology trend applied:
For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 0.4/21 years in the future.
This is a mean change of -1.3 years, with range of year change across climate models of -1.7 to -0.4 years; 0/18 climate models are outliers.

Soybean

Calibrated Statement:

Crop yield shocks are reduced from approximately 1.1/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.1 years, with range of year change across climate models of -1.9 to -0.6 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.8 to -0.6 years after removing the lower limit outliers.

If no technology trend applied:
For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0.8/21 years in the future.
This is a mean change of -0.3 years, with range of year change across climate models of -1.2 to 1.8 years; 3/18 climate models are outliers. This becomes a mean change of -1 years, range -1.2 to 0.7 years after removing the upper limit outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -97.5% on average (range -100 to -76.6%), from approximately 0.5/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -0.4 years, with range of year change across climate models of -0.9 to -0.1 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 1.9/21 years in the future.
This is a mean change of 1.3 years, with range of year change across climate models of -0.4 to 3.6 years; 0/18 climate models are outliers.

<u>Groundnut</u>

Calibrated Statement:

Crop yield shocks change by -94.8% on average (range -100 to -86.2%), from approximately 1.6/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -1.5 years, with range of year change across climate models of -1.8 to -1.2 years; 0/18 climate models are outliers.

If no technology trend applied:
For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 1.1/21 years in the future.
This is a mean change of -0.5 years, with range of year change across climate models of -1.5 to 1 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / effective agricultural policies (HT)

In this scenario, all future areas are irrigated and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match historical observed yield percentage increases. Mean yields increase substantially and yield variability would not be expected to increase given the assumptions of this scenario. Therefore, crop yield shocks decrease.

Maize

Crop yield shocks are reduced from approximately 1.6/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.6 years, with range of year change across climate models of -1.9 to -1.2 years; 0/18 climate models are outliers.

If no technology trend applied:
For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -1.4 years, with range of year change across climate models of -1.8 to -0.6 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.8 to -0.9 years after removing the upper limit outliers.

Soybean

Calibrated Statement:

Crop yield shocks are reduced from approximately 1.1/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.1 years, with range of year change across climate models of -1.9 to -0.6 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.8 to -0.6 years after removing the lower limit outliers.

If no technology trend applied:
For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0.9/21 years in the future.
This is a mean change of -0.1 years, with range of year change across climate models of -1.5 to 1.6 years; 0/18 climate models are outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -86.4% on average (range -100 to -40.2%), from approximately 0.5/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -0.5 years, with range of year change across climate models of -1 to -0.1 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 2.8/21 years in the future.
This is a mean change of 2.3 years, with range of year change across climate models of 0.5 to 4.8 years; 1/18 climate models are outliers. This becomes a mean change of 2 years, range 0.5 to 4.6 years after removing the upper limit outliers.

Groundnut

Calibrated Statement:

Crop yield shocks change by -95.6% on average (range -100 to -85.3%), from approximately 1.6/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -1.5 years, with range of year change across climate models of -1.8 to -0.9 years; 0/18 climate models are outliers.

If no technology trend applied:
For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 0.5/21 years in the future.

This is a mean change of -1 years, with range of year change across climate models of -1.6 to 0.5 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.6 to -0.3 years after removing the upper limit outliers.

Tanzania

Low climate risk (RCP2.6) / low technology (LT)

In this scenario, irrigation remains the same as the baseline and crop varieties are restricted to those used in the baseline climate.

Maize

Calibrated Statement:

Crop yield shocks increase by 49.3% on average (range -31.4 to 205.7%), from approximately 1.7/21 years in the baseline to 2.9/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 2.9/21 years in the future.
This is a mean change of 1.2 years, with range of year change across climate models of -0.6 to 5 years; 1/18 climate models are outliers. This becomes a mean change of 1 years, range -0.6 to 4 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.7/21 years in the baseline to an average of 1.5/21 years in the future.
This is a mean change of -0.2 years, with range of year change across climate models of -0.9 to 0.4 years; 0/18 climate models are outliers.

Soybean

Calibrated Statement:

Crop yield shocks increase by 10.5% on average (range -56.9 to 133.9%), from approximately 1.2/21 years in the baseline to 1.3/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 1.3/21 years in the future.
This is a mean change of 0.2 years, with range of year change across climate models of -0.7 to 1.3 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.2/21 years in the baseline to an average of 1.6/21 years in the future.
This is a mean change of 0.5 years, with range of year change across climate models of -0.2 to 1.3 years; 0/18 climate models are outliers.

Potato

Calibrated Statement:

Crop yield shocks increase by 329.6% on average (range -11.9 to 826.5%), from approximately 0.5/21 years in the baseline to 2.2/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 2.2/21 years in the future.
This is a mean change of 1.7 years, with range of year change across climate models of 0 to 3.7 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 0.5/21 years in the baseline to an average of 1.2/21 years in the future.
This is a mean change of 0.7 years, with range of year change across climate models of -0.3 to 1.4 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks increase by 41.4% on average (range -50 to 234.8%), from approximately 1.6/21 years in the baseline to 2.8/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 2.8/21 years in the future.
This is a mean change of 1.2 years, with range of year change across climate models of -0.8 to 5.2 years; 2/18 climate models are outliers. This becomes a mean change of 1 years, range -0.8 to 3.8 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.6/21 years in the baseline to an average of 1.5/21 years in the future.
This is a mean change of -0.1 years, with range of year change across climate models of -0.9 to 0.4 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / low technology (LT)

In this scenario, all crop areas are rainfed in future and crop varieties are restricted to those used in the baseline climate.

Maize

Calibrated Statement:

Crop yield shocks increase by 128% on average (range 17.1 to 356%), from approximately 1.7/21 years in the baseline to 4/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

High confidence (medium robustness and high agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 4/21 years in the future.
This is a mean change of 2.3 years, with range of year change across climate models of 0.3 to 6.2 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.7/21 years in the baseline to an average of 1/21 years in the future.
This is a mean change of -0.6 years, with range of year change across climate models of -1.3 to -0.2 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.2 to -0.2 years after removing the lower limit outliers.

Soybean

Calibrated Statement:

Crop yield shocks increase by 28.1% on average (range -43.8 to 97.1%), from approximately 1.2/21 years in the baseline to 1.5/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 1.5/21 years in the future.
This is a mean change of 0.3 years, with range of year change across climate models of -0.6 to 1.4 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.2/21 years in the baseline to an average of 1.5/21 years in the future.
This is a mean change of 0.3 years, with range of year change across climate models of -0.2 to 1 years; 0/18 climate models are outliers.

Potato

Calibrated Statement:

Crop yield shocks increase by 490.3% on average (range 217.6 to 820.4%), from approximately 0.5/21 years in the baseline to 2.8/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

High confidence (medium robustness and high agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 2.8/21 years in the future.
This is a mean change of 2.3 years, with range of year change across climate models of 0.7 to 3.7 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 0.5/21 years in the baseline to an average of 1.7/21 years in the future.
This is a mean change of 1.2 years, with range of year change across climate models of 0.8 to 1.9 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks increase by 125% on average (range -0.3 to 361%), from approximately 1.6/21 years in the baseline to 3.8/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.6/21 in the baseline to an average of 3.8/21 years in the future.
This is a mean change of 2.2 years, with range of year change across climate models of 0 to 5.1 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.6/21 years in the baseline to an average of 1.3/21 years in the future.
This is a mean change of -0.3 years, with range of year change across climate models of -0.8 to 0.2 years; 0/18 climate models are outliers.

Low climate risk (RCP2.6) / high technology (HT)

In this scenario, all future areas are irrigated and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match historical observed yield percentage increases. Mean yields increase substantially and yield variability would not be expected to increase given the assumptions of this scenario. Therefore, crop yield shocks decrease.

Maize

Calibrated Statement:

Crop yield shocks change by -100% on average (range -100 to -99.7%), from approximately 1.7/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0/21 years in the future.

This is a mean change of -1.7 years, with range of year change across climate models of -2 to -1.4 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -2 to -1.4 years after removing the lower limit outliers.

If no technology trend applied:
For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.4/21 years in the future.
This is a mean change of -1.3 years, with range of year change across climate models of -1.7 to -0.8 years; 0/18 climate models are outliers.

Soybean

Calibrated Statement:

Crop yield shocks reduce from approximately 1.2/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.2 years, with range of year change across climate models of -1.4 to -0.8 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 0.5/21 years in the future.
This is a mean change of -0.7 years, with range of year change across climate models of -1.3 to 0.8 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.3 to 0.3 years after removing the upper limit outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -93.6% on average (range -99.2 to -70.7%), from approximately 0.5/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -0.4 years, with range of year change across climate models of -0.7 to -0.2 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 2.2/21 years in the future.
This is a mean change of 1.7 years, with range of year change across climate models of 0 to 3.7 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks change by -94.4% on average (range -98.7 to -86.7%), from approximately 1.7/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -1.6 years, with range of year change across climate models of -1.9 to -1.3 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -1.8 to -1.3 years after removing the lower limit outliers.

If no technology trend applied:
For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 1/21 years in the future.
This is a mean change of -0.7 years, with range of year change across climate models of -1.4 to 0.3 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / high technology (HT)

In this scenario, all future areas are irrigated and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match historical observed yield percentage increases. Mean yields increase substantially and yield variability would not be expected to increase given the assumptions of this scenario. Therefore, crop yield shocks decrease.

Maize

Calibrated Statement:

Crop yield shocks reduce from approximately 1.7/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.7 years, with range of year change across climate models of -2 to -1.4 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -2 to -1.4 years after removing the lower limit outliers.

If no technology trend applied:
For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -1.5 years, with range of year change across climate models of -1.9 to -0.8 years; 4/18 climate models are outliers. This becomes a mean change of -2 years, range -1.8 to -1.2 years after removing both upper and lower limit outliers.

Soybean

Calibrated Statement:

Crop yield shocks reduce from approximately 1.2/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.2 years, with range of year change across climate models of -1.4 to -0.8 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 0.6/21 years in the future.

This is a mean change of -0.6 years, with range of year change across climate models of -1.3 to 0.2 years; 2/18 climate models are outliers. This becomes a mean change of -1 years, range -1.3 to 0.1 years after removing both upper and lower limit outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -47.2% on average (range -96.3 to 43.7%), from approximately 0.5/21 years in the baseline to 0.3/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 0.3/21 years in the future.
This is a mean change of -0.2 years, with range of year change across climate models of -0.6 to 0.2 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.5/21 in the baseline to an average of 2.8/21 years in the future.
This is a mean change of 2.3 years, with range of year change across climate models of 0.7 to 3.7 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks change by -94.7% on average (range -98.7 to -88.5%), from approximately 1.7/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -1.6 years, with range of year change across climate models of -1.9 to -1.3 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -1.9 to -1.3 years after removing the lower limit outliers.

If no technology trend applied:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.7/21 years in the future.
This is a mean change of -1 years, with range of year change across climate models of -1.5 to -0.4 years; 0/18 climate models are outliers.

Zambia

Low climate risk (RCP2.6) / low market efficacy (LT)

In this scenario, irrigation remains the same as the baseline and crop varieties are restricted to those used in the baseline climate.

Maize

Calibrated Statement:

Crop yield shocks increase by 58.4% on average (range -7.1 to 193.4%), from approximately 1.9/21 years in the baseline to 3.3/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.9/21 in the baseline to an average of 3.3/21 years in the future.
This is a mean change of 1.4 years, with range of year change across climate models of -0.1 to 3.7 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.9/21 years in the baseline to an average of 1.6/21 years in the future.
This is a mean change of -0.3 years, with range of year change across climate models of -0.9 to 0.7 years; 4/18 climate models are outliers. This becomes a mean change of 0 years, range -0.8 to 0.1 years after removing both upper and lower limit outliers.

Soybean
Calibrated Statement:

Crop yield shocks increase by 51.2% on average (range -32.8 to 186.1%), from approximately 1.2/21 years in the baseline to 1.8/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 1.8/21 years in the future.
This is a mean change of 0.6 years, with range of year change across climate models of -0.5 to 2.7 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.2/21 years in the baseline to an average of 1.3/21 years in the future.
This is a mean change of 0.1 years, with range of year change across climate models of -0.6 to 0.9 years; 0/18 climate models are outliers.

<u>Potato</u>

Calibrated Statement:

Crop yield shocks increase by 286.4% on average (range 66.7 to 872.2%), from approximately 0.4/21 years in the baseline to 1.8/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

High confidence (medium robustness and high agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.4/21 in the baseline to an average of 1.8/21 years in the future.
This is a mean change of 1.4 years, with range of year change across climate models of 0.2 to 5 years; 2/18 climate models are outliers. This becomes a mean change of 1 years, range 0.2 to 3.3 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 0.4/21 years in the baseline to an average of 1.2/21 years in the future.
This is a mean change of 0.8 years, with range of year change across climate models of 0.3 to 2.1 years; 2/18 climate models are outliers. This becomes a mean change of 1 years, range 0.3 to 1.3 years after removing the upper limit outliers.

<u>Groundnut</u>

Calibrated Statement:

Crop yield shocks increase by 113.5% on average (range -49.2 to 378.8%), from approximately 1.7/21 years in the baseline to 3.5/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 3.5/21 years in the future.
This is a mean change of 1.8 years, with range of year change across climate models of -0.8 to 6.4 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.7/21 years in the baseline to an average of 1.3/21 years in the future.
This is a mean change of -0.4 years, with range of year change across climate models of -1.1 to 0.4 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / low market efficacy (LT)

In this scenario, all areas are irrigated in the future and crop varieties are restricted to those used in the baseline climate.

<u>Maize</u>

Calibrated Statement:

Crop yield shocks increase by 37.4% on average (range -72.7 to 148.5%), from approximately 1.9/21 years in the baseline to 2.6/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.9/21 in the baseline to an average of 2.6/21 years in the future.
This is a mean change of 0.7 years, with range of year change across climate models of -1.4 to 2.7 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.9/21 years in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -1.7 years, with range of year change across climate models of -2.2 to -1.4 years; 0/18 climate models are outliers.

Soybean

Calibrated Statement:

Crop yield shocks change by -30.4% on average (range -87.8 to 147.9%), from approximately 1.2/21 years in the baseline to 1/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 1/21 years in the future.
This is a mean change of -0.2 years, with range of year change across climate models of -1.2 to 1.8 years; 0/18 climate models are outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.2/21 years in the baseline to an average of 0.4/21 years in the future.
This is a mean change of -0.8 years, with range of year change across climate models of -1.3 to -0.3 years; 0/18 climate models are outliers.

Potato

Calibrated Statement:

Crop yield shocks increase by 507.2% on average (range 126.4 to 1740.1%), from approximately 0.4/21 years in the baseline to 2.3/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock. Increasing yield variability also results in increased crop yield shock.

High confidence (medium robustness and high agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.4/21 in the baseline to an average of 2.3/21 years in the future.
This is a mean change of 1.9 years, with range of year change across climate models of 0.6 to 4.4 years; 1/18 climate models are outliers. This becomes a mean change of 2 years, range 0.6 to 3.9 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 0.4/21 years in the baseline to an average of 2/21 years in the future.

This is a mean change of 1.6 years, with range of year change across climate models of 0.5 to 2.5 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks increase by 180.7% on average (range -34.8 to 540.7%), from approximately 1.7/21 years in the baseline to 4.6/21 years in the future. This is caused by decreasing mean yields, bringing the yields closer, on average, to the threshold for crop yield shock.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 4.6/21 years in the future.
This is a mean change of 3 years, with range of year change across climate models of -0.5 to 9.5 years; 1/18 climate models are outliers. This becomes a mean change of 3 years, range -0.5 to 8.9 years after removing the upper limit outliers.

When defining crop yield shocks using mean yields in each time period, the number of crop yield shocks changes from an average of 1.7/21 years in the baseline to an average of 0.8/21 years in the future.
This is a mean change of -0.9 years, with range of year change across climate models of -1.5 to 0 years; 0/18 climate models are outliers.

Low climate risk (RCP2.6) / high market efficacy (HT)

In this scenario, all future areas are irrigated and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match historical observed yield percentage increases. Mean yields increase substantially and yield variability would not be expected to increase given the assumptions of this scenario. Therefore, crop yield shocks decrease.

Maize

Calibrated Statement:

Crop yield shocks reduce from approximately 1.9/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.9/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.9 years, with range of year change across climate models of -2.2 to -1.7 years; 0/18 climate models are outliers.

If no technology trend applied:
For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.9/21 in the baseline to an average of 0.4/21 years in the future.
This is a mean change of -1.6 years, with range of year change across climate models of -1.9 to -0.6 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -1.9 to -1 years after removing the upper limit outliers.

Soybean

Calibrated Statement:

Crop yield shocks reduce from approximately 1.2/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.2 years, with range of year change across climate models of -1.7 to -0.9 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 0.8/21 years in the future.
This is a mean change of -0.4 years, with range of year change across climate models of -1.3 to 1.5 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.3 to 0.8 years after removing the upper limit outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -98.3% on average (range -100 to -84.6%), from approximately 0.4/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.4/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -0.4 years, with range of year change across climate models of -0.8 to -0.1 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.4/21 in the baseline to an average of 1.8/21 years in the future.
This is a mean change of 1.4 years, with range of year change across climate models of 0.2 to 5 years; 2/18 climate models are outliers. This becomes a mean change of 1 years, range 0.2 to 3.3 years after removing the upper limit outliers.

Groundnut

Calibrated Statement:

Crop yield shocks change by -92.7% on average (range -99.1 to -77%), from approximately 1.7/21 years in the baseline to 0.2/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -1.5 years, with range of year change across climate models of -1.8 to -0.9 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -1.8 to -1 years after removing the upper limit outliers.

If no technology trend applied:
For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 1.1/21 years in the future.
This is a mean change of -0.6 years, with range of year change across climate models of -1.4 to 0.8 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / high market efficacy (HT)

In this scenario, all future areas are irrigated and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match historical observed yield percentage increases. Mean yields increase substantially and yield variability would not be expected to increase given the assumptions of this scenario. Therefore, crop yield shocks decrease.

<u>Maize</u>

Calibrated Statement:

Crop yield shocks change by -99.9% on average (range -100 to -99.4%), from approximately 1.9/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.9/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.9 years, with range of year change across climate models of -2.2 to -1.7 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -2.2 to -1.7 years after removing the lower limit outliers.

If no technology trend applied:
For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.9/21 in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -1.7 years, with range of year change across climate models of -2 to -1.2 years; 0/18 climate models are outliers.

<u>Soybean</u>

Calibrated Statement:

Crop yield shocks reduce from approximately 1.2/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -1.2 years, with range of year change across climate models of -1.7 to -0.9 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.2/21 in the baseline to an average of 1/21 years in the future.
This is a mean change of -0.2 years, with range of year change across climate models of -1.2 to 1.8 years; 0/18 climate models are outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -82.3% on average (range -97.4 to -24.5%), from approximately 0.4/21 years in the baseline to 0.1/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.4/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -0.3 years, with range of year change across climate models of -0.8 to 0.2 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.4/21 in the baseline to an average of 2.3/21 years in the future.
This is a mean change of 1.9 years, with range of year change across climate models of 0.6 to 4.4 years; 1/18 climate models are outliers. This becomes a mean change of 2 years, range 0.6 to 3.9 years after removing the upper limit outliers.

Groundnut

Calibrated Statement:

Crop yield shocks change by -94.5% on average (range -98.6 to -89.7%), from approximately 1.7/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.1/21 years in the future.

This is a mean change of -1.6 years, with range of year change across climate models of -1.9 to -1.2 years; 1/18 climate models are outliers. This becomes a mean change of -2 years, range -1.9 to -1.3 years after removing the upper limit outliers.

If no technology trend applied:
For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.7/21 in the baseline to an average of 0.7/21 years in the future.
This is a mean change of -1 years, with range of year change across climate models of -1.4 to -0.3 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.4 to -0.3 years after removing the upper limit outliers.

South Africa

Low climate risk (RCP2.6) / low land reform (LT)

In this scenario, irrigation remains the same as the baseline and crop varieties are restricted to those used in the baseline climate. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match approximately half the increases seen historically. Mean yields increase substantially, helping to reduce future crop yield shock rates.

Maize

Calibrated Statement:

Crop yield shocks increase by 16.3% on average (range -22.7 to 53.9%), from approximately 0.7/21 years in the baseline to 0.8/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.8/21 years in the future.
This is a mean change of 0.1 years, with range of year change across climate models of -0.1 to 0.4 years; 0/18 climate models are outliers.

If no technology trend applied:
For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 1.3/21 years in the future.
This is a mean change of 0.6 years, with range of year change across climate models of 0.2 to 1.2 years; 0/18 climate models are outliers.

Soybean

Calibrated Statement:

Crop yield shocks increase by 17.5% on average (range -9 to 55.5%), from approximately 0.9/21 years in the baseline to 1/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 1/21 years in the future.
This is a mean change of 0.1 years, with range of year change across climate models of -0.1 to 0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 1.5/21 years in the future.
This is a mean change of 0.6 years, with range of year change across climate models of 0.2 to 1.2 years; 4/18 climate models are outliers. This becomes a mean change of 1 years, range 0.3 to 0.9 years after removing both upper and lower limit outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -62.6% on average (range -87.7 to -17.5%), from approximately 0.7/21 years in the baseline to 0.3/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.3/21 years in the future.
This is a mean change of -0.5 years, with range of year change across climate models of -0.7 to -0.1 years; 1/18 climate models are outliers. This becomes a mean change of 0 years, range -0.7 to -0.2 years after removing the upper limit outliers.

If no technology trend applied:
For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 2.3/21 years in the future.
This is a mean change of 1.6 years, with range of year change across climate models of 0.6 to 2.4 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks increase by 8.6% on average (range -27.6 to 66.5%), from approximately 1.1/21 years in the baseline to 1.2/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 1.2/21 years in the future.
This is a mean change of 0.1 years, with range of year change across climate models of -0.3 to 0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 1.5/21 years in the future.
This is a mean change of 0.4 years, with range of year change across climate models of -0.1 to 0.9 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / low land reform (LT)

In this scenario, all future areas are irrigated and crop varieties are restricted to those used in the baseline climate. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match approximately half the increases seen historically. Mean yields increase substantially, helping to reduce future crop yield shock rates.

Maize

Calibrated Statement:

Crop yield shocks change by -90% on average (range -96.7 to -74.5%), from approximately 0.7/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.1/21 years in the future.

This is a mean change of -0.6 years, with range of year change across climate models of -0.8 to -0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.6/21 years in the future.
This is a mean change of -0.1 years, with range of year change across climate models of -0.5 to 0.4 years; 1/18 climate models are outliers. This becomes a mean change of 0 years, range -0.5 to 0.3 years after removing the upper limit outliers.

Soybean

Calibrated Statement:

Crop yield shocks change by -99.3% on average (range -100 to -98.2%), from approximately 0.9/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 0/21 years in the future.
This is a mean change of -0.9 years, with range of year change across climate models of -1.2 to -0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 0.3/21 years in the future.
This is a mean change of -0.6 years, with range of year change across climate models of -0.9 to -0.3 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -0.9 to -0.3 years after removing the lower limit outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -22.5% on average (range -75.3 to 66.3%), from approximately 0.7/21 years in the baseline to 0.6/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.6/21 years in the future.
This is a mean change of -0.2 years, with range of year change across climate models of -0.6 to 0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 3.6/21 years in the future.
This is a mean change of 2.8 years, with range of year change across climate models of 1.4 to 4.8 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks change by -86.4% on average (range -93.4 to -74.1%), from approximately 1.1/21 years in the baseline to 0.2/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -0.9 years, with range of year change across climate models of -1.2 to -0.6 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -1.2 to -0.6 years after removing the upper limit outliers.

If no technology trend applied:
For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0.5/21 years in the future.
This is a mean change of -0.6 years, with range of year change across climate models of -0.9 to -0.2 years; 0/18 climate models are outliers.

Low climate risk (RCP2.6) / high land reform (HT)

In this scenario, irrigation remains the same as the baseline and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match approximately half the increases seen historically. Mean yields increase substantially, helping to reduce future crop yield shock rates.

Maize

Calibrated Statement:

Crop yield shocks increase by 8.9% on average (range -27.3 to 30.6%), from approximately 0.7/21 years in the baseline to 0.8/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.8/21 years in the future.
This is a mean change of 0.1 years, with range of year change across climate models of -0.2 to 0.2 years; 0/18 climate models are outliers.

If no technology trend applied:
For maize, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 1.1/21 years in the future.
This is a mean change of 0.4 years, with range of year change across climate models of 0.1 to 0.7 years; 0/18 climate models are outliers.

<u>Soybean</u>

Calibrated Statement:

Crop yield shocks increase by 17.5% on average (range -9 to 55.5%), from approximately 0.9/21 years in the baseline to 1/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 1/21 years in the future.
This is a mean change of 0.1 years, with range of year change across climate models of -0.1 to 0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 1.5/21 years in the future.
This is a mean change of 0.6 years, with range of year change across climate models of 0.2 to 1.2 years; 4/18 climate models are outliers. This becomes a mean change of 1 years, range 0.3 to 0.9 years after removing both upper and lower limit outliers.

<u>Potato</u>

Calibrated Statement:

Crop yield shocks change by -62.6% on average (range -87.7 to -17.5%), from approximately 0.7/21 years in the baseline to 0.3/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.3/21 years in the future.
This is a mean change of -0.5 years, with range of year change across climate models of -0.7 to -0.1 years; 1/18 climate models are outliers. This becomes a mean change of 0 years, range -0.7 to -0.2 years after removing the upper limit outliers.

If no technology trend applied:
For potato, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 2.3/21 years in the future.
This is a mean change of 1.6 years, with range of year change across climate models of 0.6 to 2.4 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks increase by 5.2% on average (range -28.9 to 57%), from approximately 1.1/21 years in the baseline to 1.1/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 1.1/21 years in the future.
This is a mean change of 0.1 years, with range of year change across climate models of -0.3 to 0.4 years; 0/18 climate models are outliers.

If no technology trend applied:
For groundnut, RCP2.6, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 1.3/21 years in the future.
This is a mean change of 0.3 years, with range of year change across climate models of -0.1 to 0.7 years; 0/18 climate models are outliers.

High climate risk (RCP8.5) / high land reform (HT)

In this scenario, all future areas are irrigated and crop varieties have adapted to mitigate growing season duration reduction due to warming. Technology trends have also been assumed that increase average yields substantially compared to the baseline period, to match approximately half the increases seen historically. Mean yields increase substantially, helping to reduce future crop yield shock rates.

Maize

Calibrated Statement:

Crop yield shocks change by -93.7% on average (range -97.3 to -85.4%), from approximately 0.7/21 years in the baseline to 0.1/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.1/21 years in the future.
This is a mean change of -0.7 years, with range of year change across climate models of -0.8 to -0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For maize, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -0.5 years, with range of year change across climate models of -0.6 to -0.3 years; 0/18 climate models are outliers.

Soybean

Calibrated Statement:

Crop yield shocks change by -99.3% on average (range -100 to -98.2%), from approximately 0.9/21 years in the baseline to 0/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 0/21 years in the future.

This is a mean change of -0.9 years, with range of year change across climate models of -1.2 to -0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For soybean, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.9/21 in the baseline to an average of 0.3/21 years in the future.
This is a mean change of -0.6 years, with range of year change across climate models of -0.9 to -0.3 years; 1/18 climate models are outliers. This becomes a mean change of -1 years, range -0.9 to -0.3 years after removing the lower limit outliers.

Potato

Calibrated Statement:

Crop yield shocks change by -22.5% on average (range -75.3 to 66.3%), from approximately 0.7/21 years in the baseline to 0.6/21 years in the future.

Medium confidence (medium robustness and medium agreement)

Underlying Results:

For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 0.6/21 years in the future.
This is a mean change of -0.2 years, with range of year change across climate models of -0.6 to 0.5 years; 0/18 climate models are outliers.

If no technology trend applied:
For potato, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 0.7/21 in the baseline to an average of 3.6/21 years in the future.
This is a mean change of 2.8 years, with range of year change across climate models of 1.4 to 4.8 years; 0/18 climate models are outliers.

Groundnut

Calibrated Statement:

Crop yield shocks change by -85.4% on average (range -94.8 to -70.3%), from approximately 1.1/21 years in the baseline to 0.2/21 years in the future.

Low confidence (medium robustness and low agreement)

Underlying Results:

For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0.2/21 years in the future.
This is a mean change of -0.9 years, with range of year change across climate models of -1.2 to -0.6 years; 4/18 climate models are outliers. This becomes a mean change of -1 years, range -1.2 to -0.7 years after removing both upper and lower limit outliers.

If no technology trend applied:
For groundnut, RCP8.5, the number of years with yields below the baseline threshold for yield shock changes from an average of 1.1/21 in the baseline to an average of 0.4/21 years in the future.
This is a mean change of -0.7 years, with range of year change across climate models of -1 to -0.4 years; 0/18 climate models are outliers.

Appendix 1: methods and literature

<u>Methods used for crop yield shock rates:</u>

Crop yield shock can, in general, be said to occur when yields are below the value needed for a farmer to break even on costs. The threshold for crop yield shock is therefore econometric, and it is impossible to calculate without detailed economic analysis. Yield thresholds chosen using yield statistics serve as a proxy for econometric crop yield shock. We have used two parallel methods to calculate yield thresholds. The first method uses the same threshold in both baseline and future; the second uses a changing threshold that is dependent on the mean yield in each time period.

The first method uses a threshold that is equal to mean yield in the baseline minus 1.5 standard deviations in the baseline – this is referred to as the “baseline threshold crop yield shock method” in the rest of this Appendix, since it uses a fixed definition in the baseline and future of what is considered to be a low-yielding year. See below for averages across grid cells and climate models of all baseline thresholds used.

The second method uses the same threshold in the baseline but a different threshold in the future, which is mean yield in the future minus 1.5 standard deviations in the baseline. We refer to this as “future threshold crop yield shock method”, since increasing crop yield shock using this metric will more specifically be caused by increasing yield variability, rather than mean yield losses – i.e. this metric measures the years in both baseline and future that are considered to be especially low, given mean yield levels in each time period.

Baseline threshold crop yield shocks often increase in iFEED projections on average for all crops and RCPs for the low / ineffective tech / markets / policy scenarios. However, future threshold crop yield shocks sometimes increase and sometimes decrease in these cases. When future threshold crop yield shocks increase also, this shows that the variability of yields is increasing. With no change or a decrease in future threshold crop yield shock, it is the change in mean yields that is causing increased crop yield shock.

For each calibrated statement, if an increase in baseline threshold crop yield shocks is reported, the underlying causes of crop yield shock increase is also reported, depending on whether future threshold crop yield shocks also increase:

- If future threshold crop yield shocks increase on average, both mean yield decreases and variability increases are cited as causes of crop yield shock increase.
- If future threshold crop yield shocks do not change or decrease on average, then increasing crop yield shock is due to mean yields decreasing.

Baseline years are the 21 years from 1990-2010, future years are the 21 years from 2040-2060.

Simulations are rainfed, and assume adaptation of planting windows and varieties (this is considered autonomous adaptation, as these are the varieties available in the baseline climate).

<u>Robustness assessment:</u>
Medium robustness is selected for all scenarios and countries. Between 0 and 3 climate model projections are outliers in all cases, which means medium or highly robust with respect to climate model uncertainty in all cases; however, there is some uncertainty associated with crop model parameterisation also (e.g CO2 and response to duration, which differ across crop models; and only one crop model was run here). Therefore, the robustness assessment has been downgraded to “medium”.

<u>Literature summary and agreement assessment rationale:</u> Of the studies that report changes to crop yield variability or crop yield shock / failure rates, most project increases, although there are some exceptions, usually arising due to uncertainty in rainfall projections (e.g. see Parkes et al. 2015). Most typically crop variability (and therefore, yield shocks / failures) are projected to increase but some studies suggest that decreases in variability are possible (see for example the Challinor et al. 2014 meta-analysis). Therefore, if all projections in iFEED shows an increase in baseline threshold crop yield shocks in terms of number of years, high agreement is selected. If the iFEED ranges overlap with 0 / show a decrease in crop yield shock rate in some cases, medium agreement is selected. If all projections indicate a decrease in crop yield shock, low agreement is selected.

- Jones and Thornton, 2009, this study uses these methods: “*Yield shock rate of the primary growing season*: This is the yield shock rate of the longest (average) growing season, which may not necessarily correspond to the traditional “long-rains” season in bimodal environments. A season is defined as “failed” if, in any year, it never starts (as defined above), or if there are fewer than 50 growing days, or if more than 30% of the days within a season proper (that has started and ended) are stress (non-growing) days.” i.e. generic rainy season yield shock rate, not crop-specific. But increases projected for yield shock rate in the majority of agricultural systems. E.g. 18-30% yield shock rate increase in rainfed mixed arid-semi-arid systems.

- Thornton et al. 2011 projects primary season yield shock rate to increase for all of SSA apart from central Africa. Almost 50% yield shock rate in parts of southern Africa.
- Parkes et al. 2015, reduced groundnut crop yield shock rates in west Africa. Severe crop yield shock rate reduces from c. 1 to c. 0.6.
- Parkes et al. 2018, increased crop yield shock rates for maize, sorghum and millet.
- Challinor et al. 2014, crop variability likely to increase with climate change. A range of projections though, with some studies suggest variability could decrease.
- Stuch et al. 2020, "year-to-year variability of yield increases over a majority of the harvested areas"
- Ahmed et al. 2015, yield variability increasing in West Africa.
- Betts et al. 2018, increasing drought, wet days and high temperatures in most of southern Africa.
- Gaup et al. 2020, Increasing risk of global multiple crop yield shocks.

References:

1. Jones and Thornton, 2009, Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change, Environmental Science and Policy
2. Thornton et al. 2011, Agriculture and food systems in sub-SaharanAfrica in a 4◦C+world, Phil. Trans. R. Soc.
3. Parkes et al. 2015, Crop yield shock rates in a geoengineered climate: impact of climate change and marine cloud brightening, ERL.
4. Parkes et al. 2018, Projected changes in crop yield mean and variability over West Africa in a world 1.5 K warmer than the pre-industrial era, Earth Sys. Dynam.
5. Challinor et al. 2014, A meta-analysis of crop yield under climate change and adaptation, Nature Climate Change
6. Stuch et al. 2020, Projected climate change impacts on mean andyear-to-year variability of yield of key smallholdercrops in Sub-Saharan Africa, Climate and Development
7. Ahmed et al., 2015, Potential impact of climate change on cereal crop yieldin West Africa, Climate Change
8. Abera et al. 2018, Simulating the impact of climate change on maize production in Ethiopia, East Africa, Environmental Systems Research
9. Betts et al. 2018, Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5°C and 2°C global warming with a higher-resolution global climate model, P. Trans. R. Soc.
10. Gaup et al., 2020, Changing risks of simultaneous global breadbasket yield shock, Nature Climate Change

Crop yield shock thresholds used for baseline threshold method (all in kg/ha):

[1] "maize"
[1] "Zambia"
[1] "mean threshold across climate models for maize for RCP2.6 is 1139.08066424226"
[1] "mean threshold across climate models for maize for RCP8.5 is 1142.91063606883"
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[1] "groundnut"
[1] "Malawi"
[1] "mean threshold across climate models for groundnut for RCP2.6 is 389.727272721449"
[1] "mean threshold across climate models for groundnut for RCP8.5 is 385.093047686635"
[1] "mean base yield across climate models for groundnut for RCP2.6 is 540.298738298738"
[1] "mean base yield across climate models for groundnut for RCP8.5 is 539.511803011803"
[1] "mean 1.5sd across climate models for groundnut for RCP2.6 is 150.57146557729"
[1] "mean 1.5sd across climate models for groundnut for RCP8.5 is 154.418755325168"