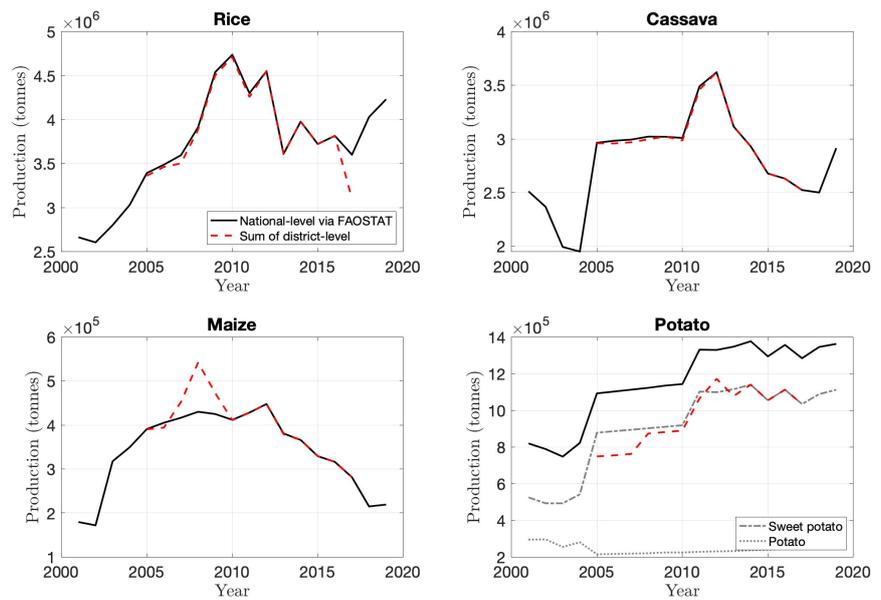
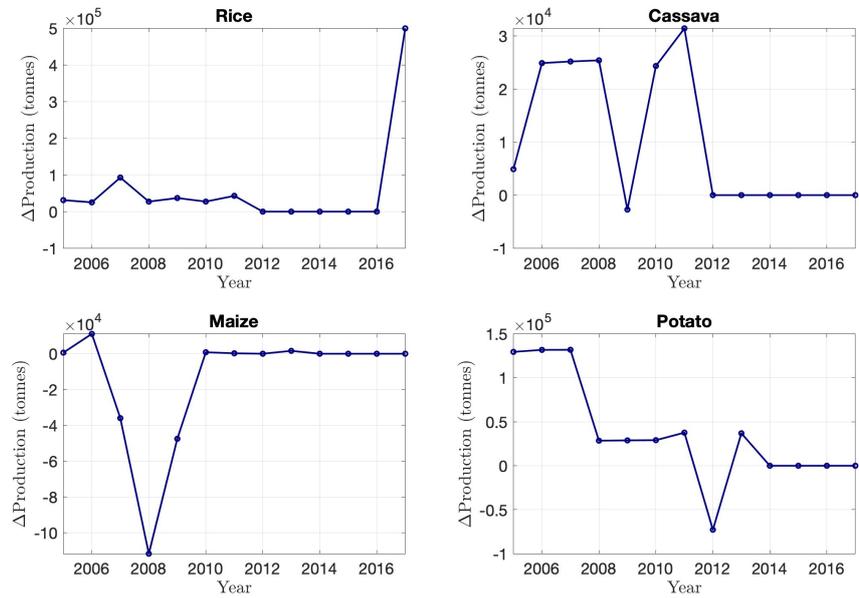


# Supplementary Materials: Retrospective predictions of rice and other crop production in Madagascar using soil moisture and an NDVI-based calendar from 2010-2017

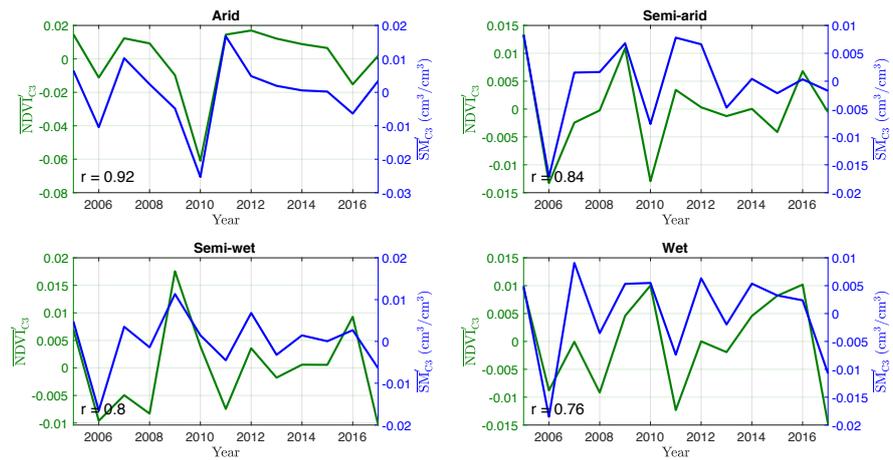
Angela J. Rigden <sup>1</sup><sup>\*</sup>, Christopher Golden <sup>2</sup> and Peter Huybers <sup>1</sup>



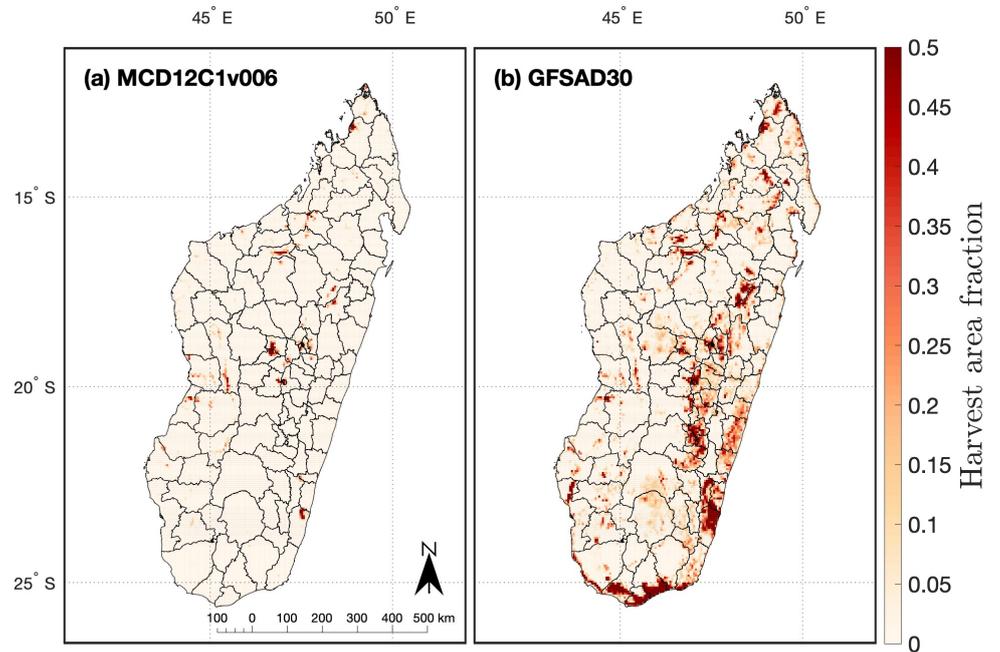
**Figure S1.** National-level production in Madagascar for rice, cassava, maize, and potato estimated by summing district-level statistics (2005 to 2017, dashed line) and from the FAOSTAT (2001 to 2019; solid line). We assume that the district-level potato production represents sweet potatoes, as the magnitude of district-level potato production matches sweet potato production from FAOSTAT. Note that the solid black line in the potato subplot represents the sum of sweet potato and potato from FAOSTAT, while the dashed and dotted gray lines represent sweet potato and potato individually from FAOSTAT.



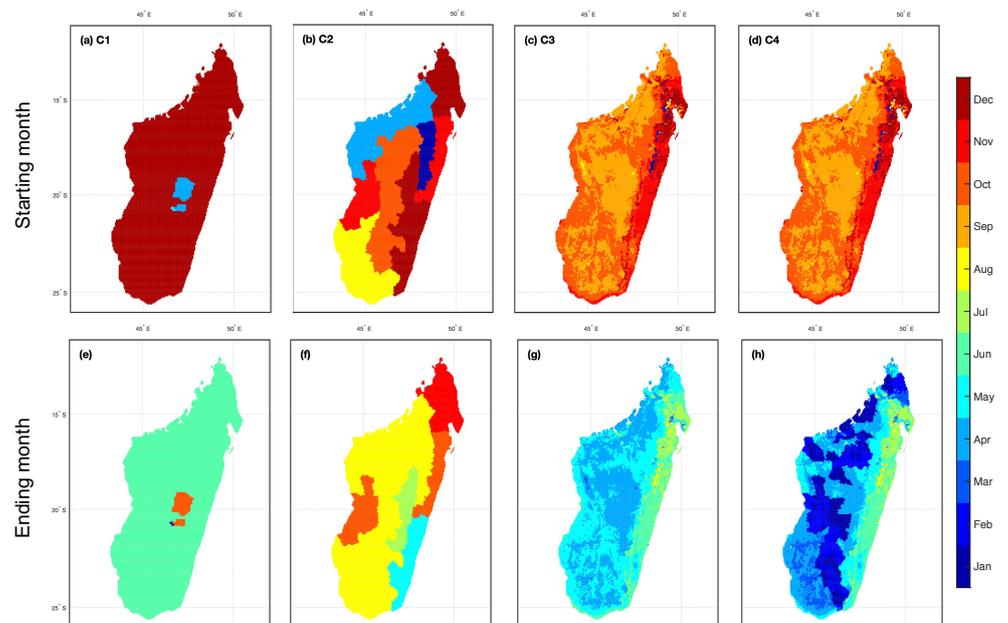
**Figure S2.** The difference in national-level production estimated from district-level statistics and FAOSTAT, such that the line represents FAOSTAT reports minus the sum of district-level reports from 2005 to 2017.



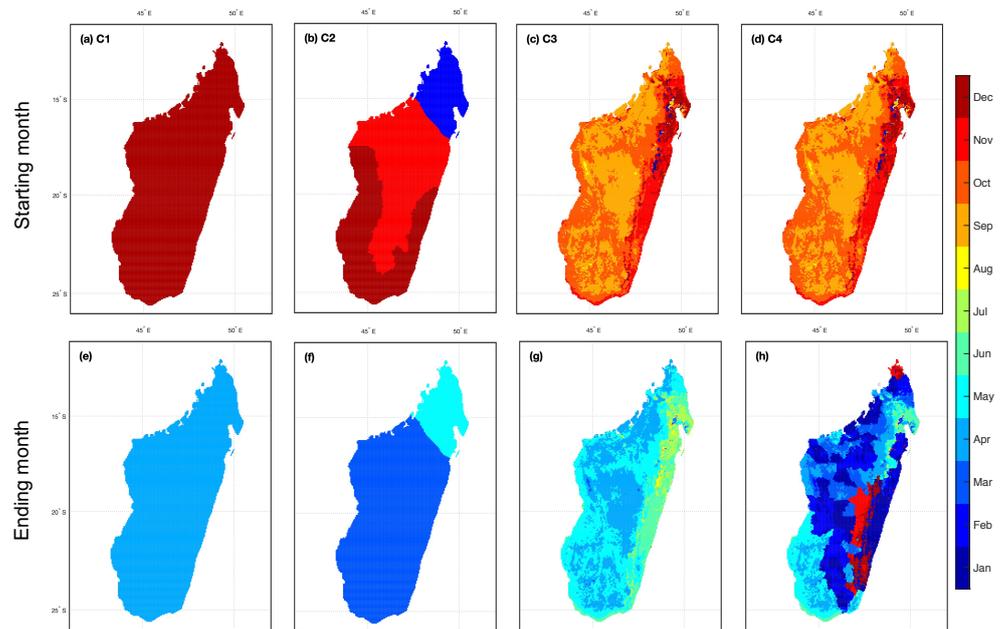
**Figure S3.** Anomalies in NDVI and soil moisture (SM) from 2005 to 2017 in the (a) arid, (b) semi-arid, (c) semi-wet, and (d) wet regions. Anomalies are estimated at the grid box level (0.05-degrees) by removing the linear trend from 2005 to 2017, and averaged to the regional-level for the four climate zones (see Fig. 4 for a map of the four regions).



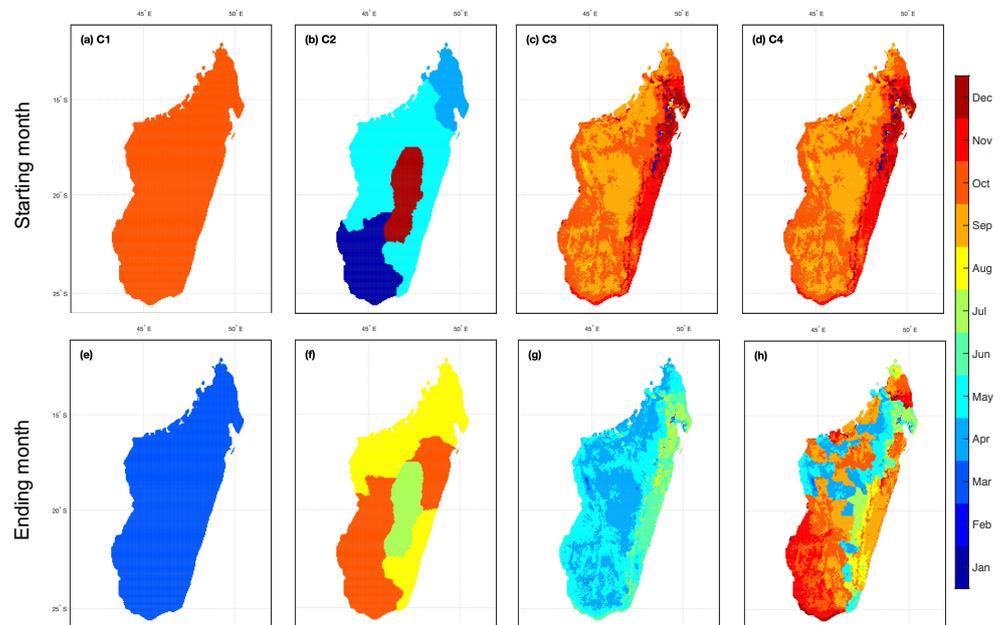
**Figure S4.** Cropland distribution maps from (a) MODIS Terra+ Aqua Combined Land Cover product (MCD12C1v006) [1] and (b) Global Food Security-Support Analysis Data at 30 m (GF-SAD30) dataset [2]. Both data products are re-gridded to a 0.05-degree grid by finding the nearest observation to the 0.05-degree grid box center. For the MCD12C1v006, we use the sum of the “croplands” and “cropland/natural vegetation mosaic” land cover types.



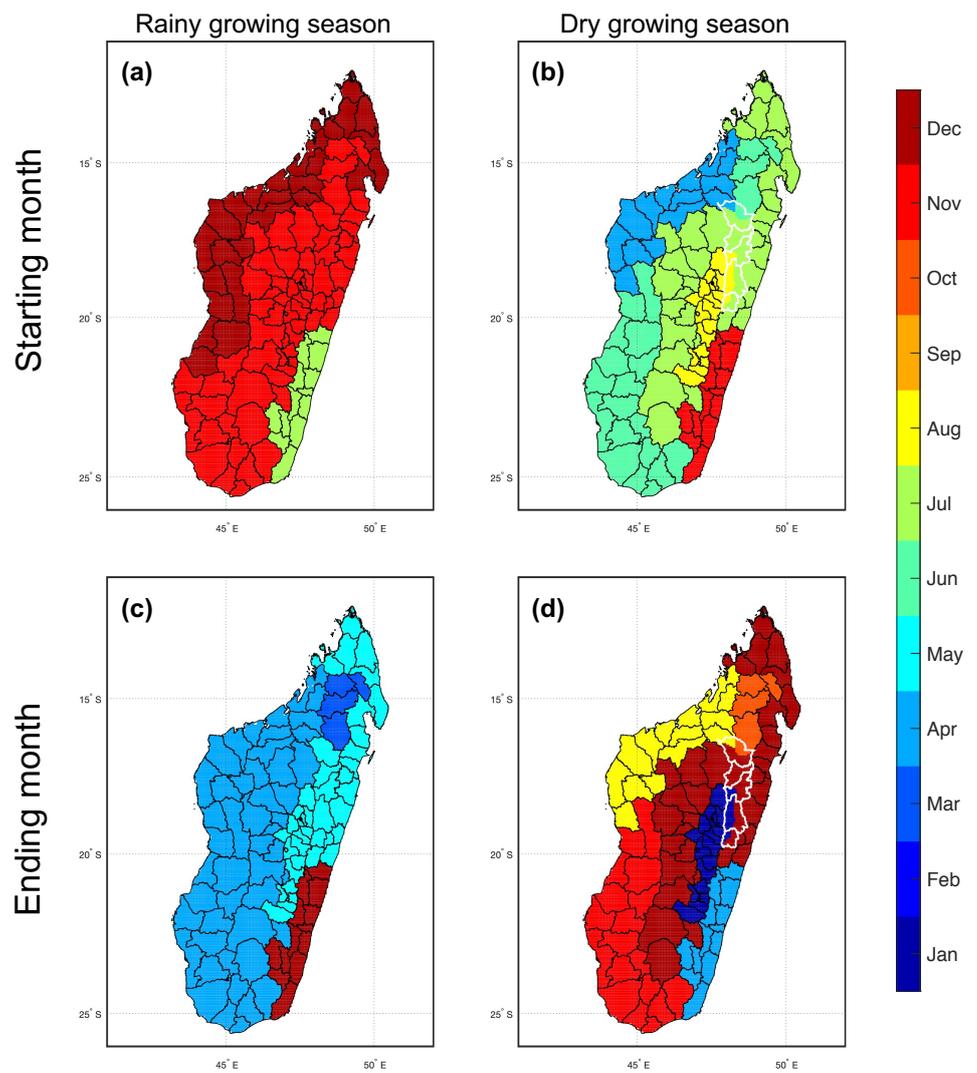
**Figure S5.** Same as Fig. 3 in main text but for cassava. While there may be two growing seasons for cassava specified in a district (see Supplementary Data 1), they always overlap. Thus, the start and end dates plotted above accurately represent the months included in the crop calendar.



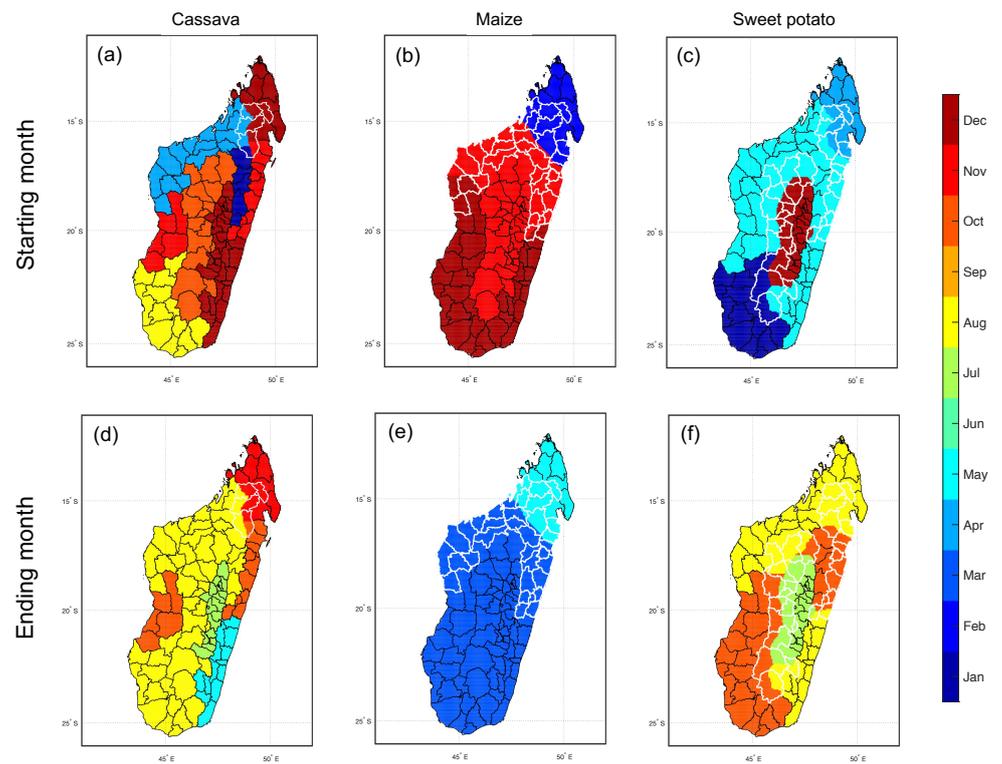
**Figure S6.** Same as Fig. 3 in main text but for maize. Note that there is only one growing season specified for maize for each district (see Supplementary Data 1). Maize is referred to as “Corn, sweet” by the FAO Crop Calendar (C2) database.



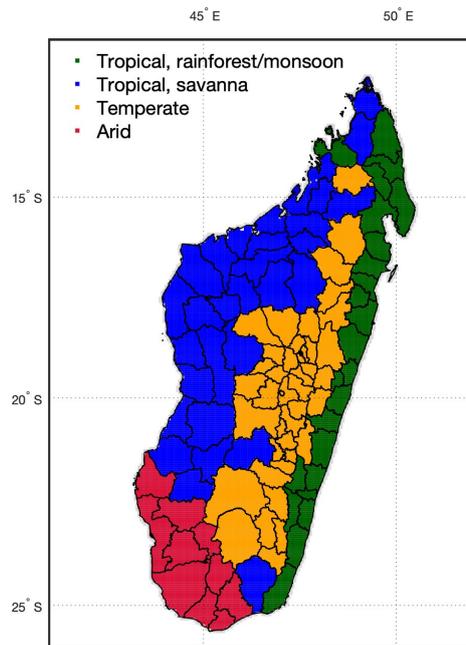
**Figure S7.** Same as Fig. 3 in main text but for sweet potato. While there may be two growing seasons for sweet potato specified in a district (see Supplementary Data 1), they always overlap. Thus, the start and end dates plotted above accurately represent the months included in the crop calendar.



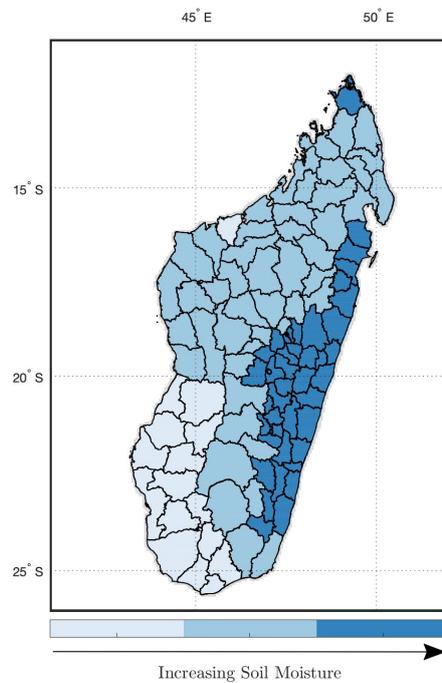
**Figure S8.** Calendar 2 (FAO) for rice in the (a,c) rainy and (b,d) dry growing season, with the top row indicating the mean planting month and the bottom row indicating the mean harvesting month. Districts outlined in white have no reported crop calendar and are filled with the nearest grid box.



**Figure S9.** Calendar 2 (FAO) for (a,d) cassava, (b,e) maize, and (c,f) sweet potato, with the top row indicating the mean planting month and the bottom row indicating the mean harvesting month. Districts outlined in white have no reported crop calendar and are filled with the nearest grid box. Rice is not shown because all districts have reported crop calendars when the rainy, mid, and dry growing seasons are merged.



**Figure S10.** Districts grouped based on the Köppen climate classification scheme [3]. Arid includes BSh (Arid, steppe, hot), tropical rainforest/monsoon includes both Am (Tropical, monsoon) and Af (Tropical, rainforest), tropical savannah includes Aw (Tropical, savannah), and temperate includes Cwa (Temperate, dry winter, hot summer), Cwb (Temperate, dry winter, warm summer), Cfa (Temperate, no dry season, hot summer), and Cfb (Temperate, no dry season, warm summer).



**Figure S11.** Same as Fig. 4 in main text but with three clusters. We refer to the three clusters as “Arid”, “Moderate”, and “Wet”.

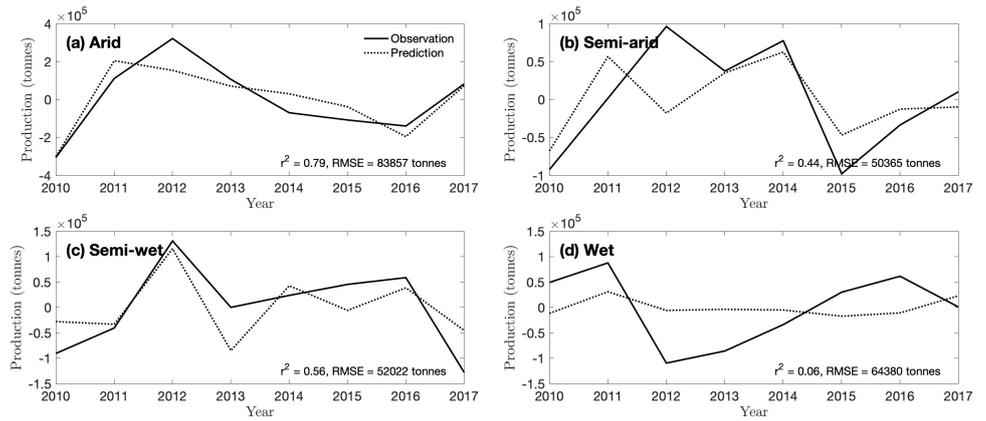


Figure S12. Same as Fig. 5 in main text but for cassava production.

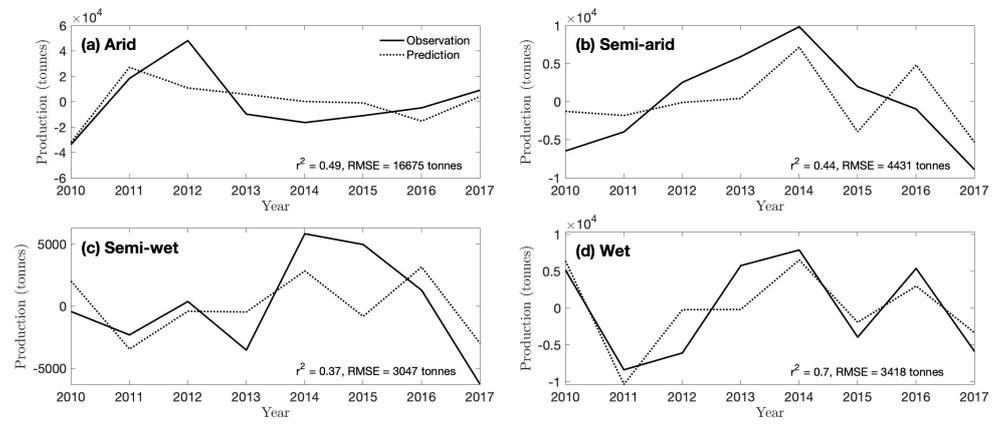


Figure S13. Same as Fig. 5 in main text but for maize production.

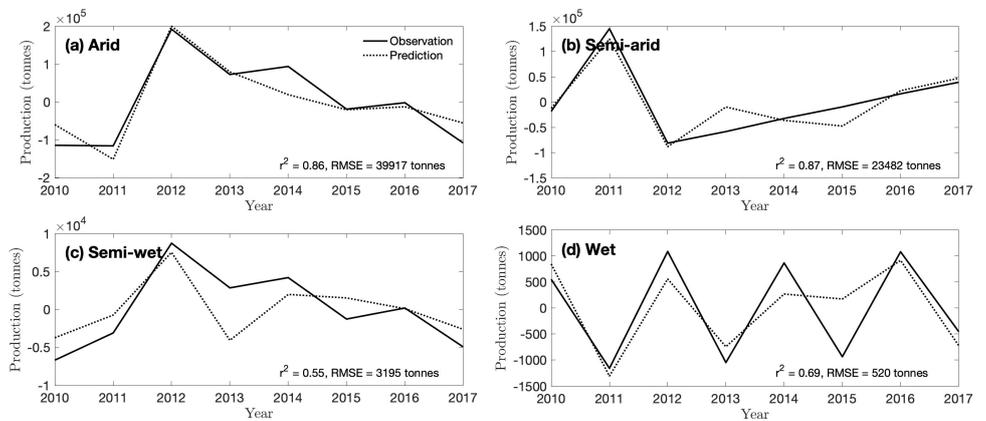


Figure S14. Same as Fig. 5 in main text but for sweet potato production.

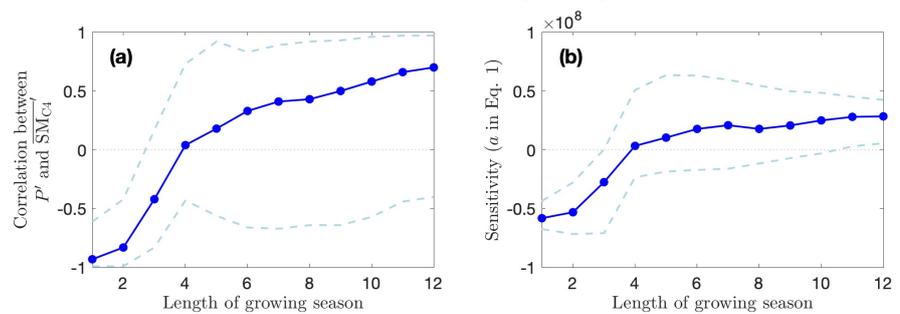
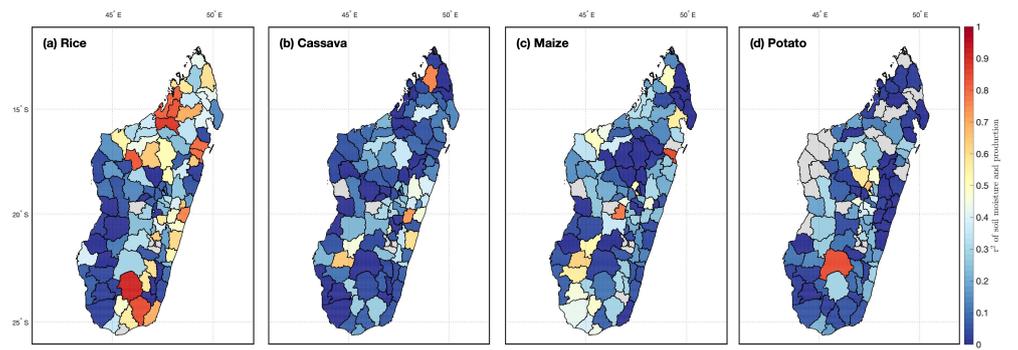


Figure S15. The dependence of the length of the growing season in C4 on (a)  $r$  and (b) the sensitivity coefficient ( $a$ ) when Eq. 1 is applied for sweet potatoes in the semi-arid region. 90% confidence intervals are estimated by bootstrapping the observations with  $10^5$  realizations.



**Figure S16.** The district-level relationships between anomalies in soil moisture and production of (a) rice, (b) cassava, (c) maize, and (d) sweet potato using growing season calendars based on mean planting and harvesting dates from C1.

**Table S1.** Same as Table 2 but with 95% confidence intervals rather than 90%.

Calendar 1					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.83 (0.56-0.97)	0.94 (0.77-0.98)	0.67 (-0.05-0.95)	0.73 (-0.52-0.95)	0.56 (-0.24-0.92)
Cassava	0.76 (0.19-0.95)	0.24 (-0.41-0.82)	0.46 (-0.28-0.94)	-0.24 (-0.96-0.55)	0.72 (0.25-0.95)
Maize	0.66 (0.02-0.92)	-0.04 (-0.72-0.74)	0.31 (-0.59-0.76)	0.15 (-0.74-0.79)	0.65 (-0.07-0.97)
Potato	0.25 (-0.54-0.95)	0.49 (-0.64-0.95)	0.45 (-0.26-0.89)	0.54 (-0.32-0.9)	0.65 (0-0.95)
Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.78 (0.46-0.96)	0.94 (0.75-0.98)	0.77 (0.27-0.94)	0.77 (-0.77-0.93)	0.69 (0.08-0.93)
Cassava	0.87 (0.49-0.97)	0.3 (-0.54-0.81)	0.47 (-0.34-0.96)	-0.19 (-0.95-0.59)	0.8 (0.24-0.98)
Maize	0.51 (-0.32-0.92)	0.19 (-0.9-0.8)	0.93 (0.74-0.99)	0.57 (-0.42-0.92)	0.47 (-0.5-0.89)
Potato	0.03 (-0.75-0.97)	0.78 (-0.47-0.99)	-0.05 (-0.92-0.88)	0.74 (-0.01-0.98)	0.49 (-0.17-0.98)
Calendar 3					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.73 (0.32-0.96)	0.91 (0.65-0.98)	0.94 (0.78-0.98)	0.85 (-0.3-0.96)	0.89 (0.38-0.98)
Cassava	0.88 (0.6-0.97)	0.49 (-0.45-0.86)	0.75 (0.1-0.97)	-0.24 (-0.95-0.79)	0.92 (0.64-0.99)
Maize	0.7 (0.11-0.93)	0 (-0.7-0.73)	0.38 (-0.64-0.85)	0.57 (-0.33-0.93)	0.93 (0.65-0.99)
Potato	0.29 (-0.58-0.98)	0.43 (-0.74-0.97)	0.74 (-0.22-0.99)	0.65 (-0.42-0.97)	0.68 (-0.08-0.97)
Calendar 4					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.74 (0.39-0.96)	0.95 (0.77-0.99)	0.95 (0.85-0.99)	0.93 (0.64-0.97)	0.9 (0.44-0.98)
Cassava	0.89 (0.65-0.97)	0.66 (-0.49-0.96)	0.75 (0.09-0.97)	-0.24 (-0.96-0.78)	0.92 (0.63-0.99)
Maize	0.7 (0.13-0.93)	0.66 (-0.04-0.95)	0.61 (-0.17-0.89)	0.84 (0.41-0.96)	0.93 (0.65-0.99)
Potato	0.93 (0.8-1)	-0.93 (-1- -0.49)	0.74 (-0.21-0.99)	0.83 (0.29-0.97)	0.81 (0.18-0.98)

**Table S2.** Same as Table 2 but showing  $r^2$  values (rather than  $r$ ) with the out-of-sample  $r^2$  ( $r_{\text{out}}^2$ ) in the parentheses (rather than the 90% confidence interval).  $r_{\text{out}}^2$  is calculated as,  $r_{\text{out}}^2 = 1 - \text{SSR}/\text{SST}$ , where SSR is the residual sum of squares and SST is the total sum of squares. When calculating the SSR out-of-sample, residuals are estimated from predictions generated out-of-sample, i.e. using all the data except that specific year.

Calendar 1					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.68 (0.52)	0.89 (0.72)	0.45 (0.13)	0.53 (0.21)	0.32 (-0.26)
Cassava	0.58 (0.16)	0.06 (-0.61)	0.21 (-0.47)	0.06 (-0.72)	0.52 (0.01)
Maize	0.43 (0.12)	0 (-0.72)	0.1 (-0.43)	0.02 (-0.71)	0.42 (-0.19)
Potato	0.06 (-0.68)	0.24 (-1.03)	0.2 (-0.08)	0.29 (-0.08)	0.42 (-0.22)
Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.61 (0.44)	0.88 (0.73)	0.59 (0.35)	0.59 (0.38)	0.48 (0.12)
Cassava	0.76 (0.52)	0.09 (-0.82)	0.22 (-0.56)	0.04 (-0.73)	0.63 (0.17)
Maize	0.26 (-0.1)	0.04 (-0.78)	0.86 (0.78)	0.33 (-0.08)	0.22 (-0.39)
Potato	0 (-1.31)	0.61 (0.13)	0 (-0.9)	0.55 (0.35)	0.24 (-0.55)
Calendar 3					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.53 (0.32)	0.84 (0.65)	0.94 (0.89)	0.77 (0.52)	0.82 (0.62)
Cassava	0.78 (0.61)	0.24 (-0.67)	0.51 (0.07)	0.06 (-1)	0.84 (0.69)
Maize	0.49 (0.23)	0 (-0.7)	0.14 (-0.46)	0.3 (-0.16)	0.86 (0.69)
Potato	0.08 (-0.74)	0.18 (-1.02)	0.52 (0)	0.5 (0.25)	0.45 (-0.06)
Calendar 4					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.54 (0.37)	0.91 (0.8)	0.94 (0.89)	0.79 (0.69)	0.82 (0.62)
Cassava	0.79 (0.63)	0.44 (0.09)	0.51 (0.07)	0.18 (-0.54)	0.84 (0.69)
Maize	0.49 (0.23)	0.44 (-0.03)	0.37 (-0.05)	0.67 (0.49)	0.86 (0.69)
Potato	0.86 (0.78)	0.87 (0.74)	0.52 (0.21)	0.73 (0.61)	0.66 (0.34)

**Table S3.** Same as Table 2, but using a generic cropland mask for all four crops from the Global Food Security-Support Analysis Data at 30 m (GFSAD30) dataset [2]. Grid boxes are included if they have cropland fractional areas greater than 0.025.

Calendar 1					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.8 (0.5-0.95)	0.96 (0.85-0.99)	0.68 (0.15-0.91)	0.66 (-0.28-0.88)	0.68 (0.19-0.9)
Cassava	0.79 (0.38-0.92)	0.26 (-0.3-0.77)	0.56 (-0.1-0.94)	-0.22 (-0.85-0.54)	0.74 (0.16-0.95)
Maize	0.58 (0.05-0.89)	0.02 (-0.65-0.6)	0.46 (-0.3-0.74)	0.05 (-0.73-0.68)	0.67 (0.17-0.94)
Potato	0.31 (-0.29-0.89)	0.58 (-0.39-0.91)	0.37 (-0.3-0.84)	0.54 (-0.05-0.87)	0.77 (0.38-0.98)
Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.75 (0.38-0.93)	0.95 (0.77-0.98)	0.69 (0.29-0.9)	0.83 (-0.51-0.93)	0.76 (0.4-0.89)
Cassava	0.9 (0.71-0.97)	0.33 (-0.31-0.77)	0.59 (-0.17-0.94)	-0.17 (-0.82-0.55)	0.78 (0.06-0.98)
Maize	0.44 (-0.22-0.87)	0.27 (-0.8-0.78)	0.98 (0.92-0.99)	0.6 (-0.24-0.93)	0.46 (-0.48-0.78)
Potato	0.08 (-0.61-0.95)	0.79 (-0.12-0.99)	-0.02 (-0.96-0.84)	0.77 (0.26-0.97)	0.37 (-0.23-0.81)
Calendar 3					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.7 (0.31-0.93)	0.89 (0.55-0.97)	0.88 (0.51-0.97)	0.86 (0.3-0.94)	0.86 (0.41-0.96)
Cassava	0.89 (0.73-0.96)	0.55 (-0.09-0.85)	0.77 (0.39-0.93)	-0.25 (-0.83-0.6)	0.87 (0.31-0.98)
Maize	0.61 (0.19-0.9)	0.13 (-0.54-0.63)	0.39 (-0.34-0.8)	0.58 (-0.17-0.91)	0.88 (0.7-0.97)
Potato	0.29 (-0.41-0.96)	0.52 (-0.52-0.95)	0.82 (0.38-0.96)	0.67 (0.13-0.95)	0.81 (0.33-0.96)
Calendar 4					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.72 (0.33-0.93)	0.96 (0.81-0.99)	0.95 (0.9-0.98)	0.93 (0.58-0.97)	0.98 (0.94-0.99)
Cassava	0.9 (0.78-0.96)	0.69 (-0.09-0.95)	0.77 (0.27-0.96)	-0.25 (-0.83-0.62)	0.9 (0.26-0.99)
Maize	0.61 (0.18-0.89)	0.76 (0.31-0.95)	0.54 (-0.15-0.84)	0.84 (0.5-0.97)	0.9 (0.6-0.99)
Potato	0.92 (0.76-0.98)	-0.91 (-0.99- -0.52)	0.82 (0.39-0.96)	0.85 (0.59-0.97)	0.85 (0.48-0.98)

**Table S4.** Same as Table 2, but using a generic cropland mask for all four crops from the MODIS Terra+Aqua Combined Land Cover product (MCD12C1v006) [1]. For all crops, 0.05-degree grid boxes are included if they exceed a cropland fractional area of 0.025.

Calendar 1					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.77 (0.36-0.94)	0.85 (0.38-0.89)	0.54 (-0.02-0.85)	0.32 (-0.27-0.77)	0.53 (-0.04-0.84)
Cassava	0.44 (-0.34-0.85)	0.01 (-0.49-0.64)	0.47 (-0.18-0.85)	0.1 (-0.78-0.88)	0.54 (0-0.83)
Maize	0.47 (-0.25-0.87)	-0.1 (-0.92-0.53)	0.56 (-0.16-0.82)	-0.2 (-0.73-0.49)	0.52 (-0.03-0.81)
Potato	0.05 (-0.69-0.75)	0.48 (-0.43-0.85)	0.41 (-0.19-0.82)	0.65 (0.23-0.88)	0.34 (-0.22-0.81)
Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.7 (0.17-0.92)	0.88 (0.68-0.95)	0.5 (-0.05-0.84)	0.89 (0.67-0.96)	0.59 (0.08-0.85)
Cassava	0.45 (-0.5-0.86)	0.1 (-0.49-0.67)	0.63 (-0.15-0.9)	0.15 (-0.59-0.78)	0.55 (-0.04-0.89)
Maize	0.31 (-0.47-0.82)	0.07 (-0.52-0.66)	0.96 (0.84-0.99)	0.44 (-0.27-0.79)	0.15 (-0.8-0.52)
Potato	0.06 (-0.82-0.76)	0.54 (-0.36-0.94)	0.3 (-0.59-0.98)	0.55 (-0.15-0.85)	0.42 (-0.12-0.89)
Calendar 3					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.65 (0.12-0.91)	0.5 (-0.52-0.81)	0.83 (0.42-0.97)	0.94 (0.73-0.98)	0.8 (0.21-0.98)
Cassava	0.56 (-0.11-0.9)	0.23 (-0.51-0.74)	0.66 (0.08-0.9)	-0.15 (-0.72-0.57)	0.32 (-0.33-0.81)
Maize	0.42 (-0.36-0.9)	-0.1 (-0.9-0.47)	0.37 (-0.41-0.74)	0.54 (-0.22-0.91)	0.64 (0.2-0.96)
Potato	0.11 (-0.77-0.78)	0.56 (-0.59-0.89)	0.59 (0.07-0.88)	0.81 (0.37-0.95)	0.68 (0.22-0.86)
Calendar 4					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	-0.89 (-0.98- -0.65)	0.79 (0.42-0.86)	0.9 (0.78-0.96)	0.94 (0.73-0.98)	0.89 (0.67-0.96)
Cassava	0.56 (-0.11-0.91)	0.3 (-0.49-0.81)	0.79 (0.38-0.95)	0.26 (-0.55-0.89)	-0.61 (-0.93-0.17)
Maize	0.42 (-0.36-0.9)	0.22 (-0.3-0.71)	0.52 (-0.16-0.92)	0.85 (0.54-0.97)	0.78 (0.46-0.97)
Potato	0.43 (-0.34-0.83)	-0.71 (-0.97-0.14)	0.6 (0.06-0.91)	0.9 (0.67-0.96)	0.71 (0.29-0.89)

**Table S5.** Same as Table 2, but only for rice in Calendar 2. Results are shown for the merged seasons (as in main text), the rainy season, and the dry season. Note that there are 35 districts that have mid-season rice (see Supplemental Data 1). While this mid-season rice is included in the “merged” growing season, we do not estimate the relationship between soil moisture and production anomalies in this mid-season separately because it is defined for only a small region of Madagascar.

Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice (merged)	0.78 (0.5-0.93)	0.94 (0.81-0.97)	0.77 (0.38-0.92)	0.77 (-0.45-0.91)	0.69 (0.22-0.9)
Rice (rainy)	0.75 (0.45-0.93)	0.94 (0.75-0.97)	0.79 (0.39-0.93)	0.7 (-0.57-0.9)	0.69 (0.11-0.9)
Rice (dry)	0.74 (0.21-0.94)	0.85 (0.54-0.93)	0.58 (-0.28-0.93)	0.79 (-0.09-0.95)	0.58 (-0.13-0.9)

**Table S6.** Same as Table 2, but with climate-zones defined by the Köppen climate classification scheme [3]

Calendar 1					
	Arid	Temperate	Savannah	Rainforest	National
Rice	0.78 (0.46-0.9)	0.23 (-0.41-0.72)	0.97 (0.89-0.98)	0.81 (0.1-0.95)	0.56 (-0.1-0.88)
Cassava	0.68 (0.06-0.91)	0.86 (0.63-0.94)	0.63 (-0.08-0.96)	0.48 (-0.41-0.79)	0.72 (0.37-0.92)
Maize	0.66 (0.28-0.89)	-0.56 (-0.93-0.04)	0.68 (0.25-0.86)	0.03 (-0.68-0.81)	0.65 (0.13-0.95)
Potato	0.24 (-0.4-0.91)	-0.48 (-0.65-0.49)	0.71 (-0.07-0.96)	0.09 (-0.47-0.71)	0.65 (0.11-0.92)
Calendar 2					
	Arid	Temperate	Savannah	Rainforest	National
Rice	0.72 (0.49-0.88)	0.56 (-0.11-0.85)	0.96 (0.84-0.98)	0.63 (-0.36-0.88)	0.69 (0.21-0.9)
Cassava	0.82 (0.34-0.95)	0.87 (0.62-0.94)	0.63 (0.03-0.96)	0.61 (-0.22-0.85)	0.79 (0.41-0.97)
Maize	0.52 (-0.02-0.89)	0.5 (-0.27-0.87)	0.73 (0.45-0.86)	0.07 (-0.69-0.81)	0.47 (-0.36-0.84)
Potato	0.01 (-0.68-0.94)	0.48 (-0.37-0.94)	0.79 (-0.16-0.97)	-0.49 (-0.86-0.26)	0.49 (-0.1-0.96)
Calendar 3					
	Arid	Temperate	Savannah	Rainforest	National
Rice	0.68 (0.35-0.89)	0.86 (0.43-0.96)	0.8 (0.4-0.92)	0.88 (0.7-0.94)	0.88 (0.57-0.96)
Cassava	0.84 (0.43-0.95)	0.93 (0.74-0.96)	0.48 (-0.2-0.9)	0.54 (-0.51-0.86)	0.92 (0.73-0.98)
Maize	0.71 (0.39-0.9)	0.4 (-0.4-0.88)	0.45 (-0.25-0.88)	0.04 (-0.65-0.82)	0.93 (0.7-0.99)
Potato	0.28 (-0.44-0.97)	-0.41 (-0.86-0.22)	0.75 (0.12-0.97)	0.16 (-0.4-0.72)	0.68 (0.05-0.94)
Calendar 4					
	Arid	Temperate	Savannah	Rainforest	National
Rice	-0.69 (-0.96-0.3)	0.86 (0.45-0.96)	0.92 (0.6-0.97)	0.89 (0.67-0.97)	0.89 (0.57-0.98)
Cassava	0.9 (0.67-0.98)	0.95 (0.84-0.99)	0.71 (0.12-0.96)	0.75 (0.23-0.95)	0.92 (0.73-0.98)
Maize	0.71 (0.39-0.9)	0.87 (0.6-0.96)	-0.51 (-0.91-0.26)	-0.39 (-0.81-0.36)	0.93 (0.7-0.99)
Potato	0.93 (0.84-0.99)	-0.61 (-0.92-0.47)	0.78 (-0.18-0.96)	-0.29 (-0.81-0.55)	0.81 (0.37-0.97)

**Table S7.** Same as Table 2, but with climate-zones defined using three clusters instead of four. We refer to the three clusters as “Arid”, “Moderate”, and “Wet”.

Calendar 1				
	Arid	Moderate	Wet	National
Rice	0.81 (0.45-0.94)	0.84 (0.46-0.95)	0.61 (-0.15-0.85)	0.56 (-0.09-0.88)
Cassava	0.76 (0.28-0.92)	0.61 (-0.11-0.91)	0.78 (0.31-0.96)	0.72 (0.37-0.92)
Maize	0.66 (0.19-0.89)	0.32 (-0.22-0.81)	-0.19 (-0.7-0.5)	0.65 (0.14-0.94)
Potato	0.25 (-0.39-0.91)	0.47 (-0.66-0.86)	0.36 (-0.21-0.69)	0.65 (0.11-0.92)
Calendar 2				
	Arid	Moderate	Wet	National
Rice	0.73 (0.31-0.97)	0.83 (0.47-0.92)	0.82 (-0.22-0.96)	0.69 (0.22-0.9)
Cassava	0.87 (0.57-0.96)	0.76 (0.36-0.95)	0.8 (0.39-0.99)	0.8 (0.43-0.97)
Maize	0.5 (-0.15-0.88)	0.68 (0.2-0.89)	0.64 (-0.42-0.9)	0.47 (-0.36-0.84)
Potato	0.03 (-0.66-0.94)	0.78 (-0.1-1)	0.74 (0.29-0.92)	0.49 (-0.09-0.96)
Calendar 3				
	Arid	Moderate	Wet	National
Rice	0.73 (0.42-0.93)	0.88 (0.56-0.93)	0.93 (0.44-0.99)	0.89 (0.57-0.96)
Cassava	0.88 (0.66-0.96)	0.79 (0.5-0.95)	0.71 (0.07-0.94)	0.92 (0.73-0.98)
Maize	0.7 (0.27-0.9)	0.36 (-0.15-0.72)	0.62 (-0.15-0.95)	0.93 (0.7-0.99)
Potato	0.29 (-0.43-0.97)	0.41 (-0.58-0.93)	0.45 (-0.18-0.76)	0.68 (0.04-0.94)
Calendar 4				
	Arid	Moderate	Wet	National
Rice	0.73 (0.42-0.93)	0.95 (0.56-0.97)	0.96 (0.88-0.99)	0.9 (0.58-0.98)
Cassava	0.89 (0.71-0.96)	.81 (0.52-0.95)	0.71 (0.07-0.94)	0.92 (0.74-0.98)
Maize	0.7 (0.27-0.9)	0.54 (-0.1-0.88)	0.93 (0.81-0.98)	0.93 (0.7-0.99)
Potato	0.93 (0.82-0.99)	-0.89 (-0.99- -0.39)	0.81 (0.44-0.94)	0.81 (0.38-0.97)

**Table S8.** Same as Table 2, but with the minimum crop-specific fractional harvested area [4] set to 0.01 rather than 0.001.

Calendar 1					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.83 (0.63-0.96)	0.98 (0.92-0.99)	0.71 (0.2-0.92)	0.75 (-0.17-0.92)	0.71 (0.22-0.92)
Cassava	0.77 (0.33-0.92)	0.21 (-0.35-0.74)	0.41 (-0.2-0.86)	-0.23 (-0.94-0.41)	0.77 (0.37-0.93)
Maize	0.69 (0.34-0.91)	-0.51 (-0.83-0.27)	0.07 (-0.65-0.71)	0 (-0.75-0.64)	0.49 (-0.16-0.85)
Potato	0.23 (-0.42-0.9)	0.23 (-0.4-0.76)	0.53 (-0.16-0.84)	0.59 (-0.03-0.87)	0.72 (0.17-0.96)
Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.8 (0.6-0.93)	0.97 (0.86-0.99)	0.78 (0.38-0.91)	0.74 (-0.46-0.91)	0.79 (0.38-0.91)
Cassava	0.88 (0.6-0.97)	0.26 (-0.39-0.7)	0.42 (-0.2-0.85)	-0.19 (-0.84-0.44)	0.83 (0.25-0.97)
Maize	0.53 (0.06-0.9)	-0.43 (-0.83-0.14)	0.72 (0.21-0.93)	0.59 (-0.35-0.93)	-0.02 (-0.87-0.46)
Potato	0.01 (-0.67-0.95)	0.47 (-0.45-0.94)	0.14 (-0.63-0.85)	0.65 (-0.07-0.92)	0.54 (-0.02-0.94)
Calendar 3					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.75 (0.41-0.94)	0.94 (0.79-0.98)	0.93 (0.81-0.98)	0.84 (0.29-0.94)	0.92 (0.75-0.96)
Cassava	0.89 (0.7-0.96)	0.47 (-0.15-0.81)	0.67 (0.15-0.91)	-0.21 (-0.86-0.65)	0.92 (0.48-0.99)
Maize	0.72 (0.38-0.89)	-0.51 (-0.78-0.25)	0.18 (-0.52-0.78)	0.59 (-0.15-0.92)	0.49 (-0.32-0.81)
Potato	0.27 (-0.42-0.97)	0.41 (-0.49-0.97)	0.55 (-0.33-0.97)	0.69 (0.12-0.97)	0.74 (0.05-0.96)
Calendar 4					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.77 (0.43-0.95)	0.97 (0.9-0.99)	0.96 (0.89-0.99)	0.9 (0.49-0.95)	0.96 (0.89-0.99)
Cassava	0.9 (0.66-0.98)	0.6 (-0.05-0.91)	0.74 (0.31-0.94)	-0.21 (-0.88-0.63)	0.93 (0.56-0.99)
Maize	0.72 (0.37-0.89)	-0.57 (-0.8-0.03)	0.45 (-0.17-0.86)	0.82 (0.42-0.96)	0.73 (0.29-0.97)
Potato	0.89 (0.69-0.99)	0.55 (-0.25-0.88)	0.68 (-0.07-0.92)	0.85 (0.54-0.97)	0.77 (0.25-0.96)

**Table S9.** Same as Table 2, but with the minimum crop-specific fractional harvested area [4] set to 0.025 rather than 0.001.

Calendar 1					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.83 (0.64-0.96)	0.97 (0.89-1)	0.76 (0.33-0.93)	0.74 (-0.19-0.92)	0.84 (0.51-0.94)
Cassava	0.74 (0.25-0.91)	0.02 (-0.51-0.71)	0.39 (-0.21-0.87)	-0.22 (-0.94-0.41)	0.61 (-0.26-0.93)
Maize	0.7 (0.21-0.88)	-0.39 (-0.82-0.36)	0.01 (-0.74-0.77)	-0.03 (-0.77-0.63)	0.33 (-0.36-0.74)
Potato	0.42 (-0.24-0.88)	NA	0.39 (-0.18-0.8)	0.52 (-0.21-0.87)	0.32 (-0.21-0.74)
Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.8 (0.61-0.93)	0.94 (0.72-0.99)	0.8 (0.44-0.92)	0.73 (-0.5-0.9)	0.85 (0.48-0.94)
Cassava	0.86 (0.52-0.96)	0.06 (-0.53-0.57)	0.42 (-0.2-0.86)	-0.19 (-0.82-0.44)	0.47 (-0.39-0.89)
Maize	0.61 (0.15-0.84)	-0.19 (-0.7-0.46)	0.69 (0.04-0.92)	0.61 (-0.32-0.94)	-0.17 (-0.77-0.37)
Potato	0.09 (-0.59-0.96)	NA	-0.16 (-0.74-0.48)	0.7 (0.07-0.92)	0.42 (-0.18-0.82)
Calendar 3					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.79 (0.49-0.96)	0.9 (0.61-0.98)	0.91 (0.75-0.97)	0.84 (0.3-0.94)	0.89 (0.57-0.96)
Cassava	0.88 (0.63-0.96)	0.31 (-0.43-0.72)	0.68 (0.14-0.92)	-0.19 (-0.88-0.61)	0.37 (-0.46-0.83)
Maize	0.72 (0.18-0.89)	-0.33 (-0.75-0.63)	0.12 (-0.57-0.63)	0.59 (-0.15-0.92)	0.11 (-0.59-0.64)
Potato	0.33 (-0.35-0.95)	NA	0.53 (0.09-0.84)	0.61 (-0.12-0.95)	0.54 (-0.12-0.85)
Calendar 4					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.79 (0.49-0.96)	0.95 (0.78-0.99)	0.97 (0.9-0.99)	0.9 (0.51-0.95)	0.99 (0.94-0.99)
Cassava	0.88 (0.64-0.96)	0.34 (-0.48-0.95)	0.72 (0.3-0.93)	-0.19 (-0.88-0.6)	-0.54 (-0.84- -0.02)
Maize	0.74 (0.34-0.89)	-0.43 (-0.75-0.31)	0.41 (-0.21-0.84)	0.82 (0.42-0.96)	-0.55 (-0.88- -0.01)
Potato	0.86 (0.57-0.96)	NA	0.53 (0.09-0.84)	0.8 (0.39-0.97)	0.58 (-0.03-0.89)

**Table S10.** Same as Table 2, but without weighting soil moisture grid boxes by the district's average (2010-2017) production.

Calendar 1					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.84 (0.6-0.94)	0.9 (0.72-0.94)	0.7 (0.16-0.94)	0.73 (-0.24-0.9)	0.4 (-0.31-0.82)
Cassava	0.66 (0.07-0.9)	0.21 (-0.36-0.77)	0.56 (-0.15-0.94)	-0.24 (-0.87-0.48)	0.68 (-0.02-0.92)
Maize	0.66 (0.21-0.88)	-0.12 (-0.67-0.62)	0.68 (-0.16-0.86)	0.44 (-0.59-0.95)	0.69 (0.14-0.94)
Potato	0.19 (-0.5-0.84)	0.52 (-0.6-0.9)	0.44 (-0.09-0.8)	0.38 (-0.41-0.82)	0.57 (-0.39-0.82)
Calendar 2					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.78 (0.51-0.93)	0.91 (0.75-0.96)	0.83 (0.5-0.97)	0.66 (-0.49-0.91)	0.53 (-0.11-0.86)
Cassava	0.76 (0.31-0.91)	0.32 (-0.27-0.78)	0.59 (-0.36-0.91)	-0.18 (-0.85-0.54)	0.75 (0.06-0.96)
Maize	0.51 (-0.12-0.88)	0.04 (-0.78-0.65)	0.73 (-0.1-0.9)	0.6 (-0.34-0.96)	0.54 (-0.33-0.87)
Potato	-0.04 (-0.71-0.78)	0.65 (-0.35-0.98)	0.28 (-0.64-0.99)	0.7 (0.17-0.91)	0.46 (-0.19-0.86)
Calendar 3					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	0.71 (0.34-0.93)	0.86 (0.46-0.92)	0.94 (0.78-0.98)	0.84 (0.01-0.94)	0.68 (0.01-0.91)
Cassava	0.79 (0.33-0.93)	0.47 (-0.14-0.82)	0.74 (0.16-0.94)	-0.24 (-0.84-0.75)	0.8 (0.09-0.96)
Maize	0.71 (0.31-0.9)	-0.09 (-0.66-0.56)	0.6 (-0.57-0.81)	0.61 (-0.15-0.97)	0.88 (0.55-0.98)
Potato	0.23 (-0.53-0.92)	0.45 (-0.57-0.95)	0.63 (-0.06-0.94)	0.51 (-0.15-0.95)	0.87 (0.37-0.98)
Calendar 4					
	Arid	Semi-arid	Semi-wet	Wet	National
Rice	-0.73 (-0.89-0.05)	0.93 (0.76-0.96)	0.94 (0.78-0.98)	0.93 (0.6-0.96)	0.78 (0.17-0.96)
Cassava	0.79 (0.33-0.93)	0.56 (-0.06-0.95)	0.74 (0.14-0.94)	-0.24 (-0.84-0.75)	0.8 (0.09-0.96)
Maize	0.71 (0.29-0.9)	0.69 (0.13-0.93)	0.81 (0.6-0.93)	0.85 (0.46-0.96)	0.88 (0.55-0.98)
Potato	0.92 (0.84-0.99)	-0.97 (-1- -0.88)	0.63 (-0.06-0.94)	0.65 (0.1-0.9)	0.87 (0.37-0.98)

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