Supporting Information

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Table S1. Characteristics of study sites: location of weather stations, and observations included in sample (models without economic variables)

Site	Latitude/longitude	Climatic zone	Years	Villages/districts	Farms	Observations
China (Jinhua, Zhejiang)	29°5′ N/119°47′ E	Subtropics	1998–1999	7	25	91
India (Aduthurai, Tamil Nadu)	11°1′ N/79°29′ E	Tropics (subhumid)	1994–1999	4	37	214
Indonesia (Sukamandi, Java)	6°21′ S/107°40′ E	Tropics (humid)	1995–1999	3	30	159
Philippines (Maligaya, Luzon)	15°23′ N/120°54′ E	Tropics (humid)	1994–1999	4	48	361
Thailand (Suphan Buri, Central Plain)	14°28′ N/100°10′ E	Tropics (subhumid)	1994–1998	3	31	169
Vietnam (Hanoi, Red River Delta)	21°1′ N/105°53′ E	Subtropics	1997–1999	3	24	144
Vietnam (Omon, Mekong Delta)	10°08′ N/105°32′ E	Tropics (subhumid)	1994–1999	8	32	234
Totals	—	—	—	32	227	1,372

Table S2. Characteristics of study sites: means (SDs) of yield, temperature, and solar radiation

		T_{min} (°C)			T_{max} (°C)			Radiation (megajoules·m^{-2}·d^{-1})		
Site	Yield (kg·ha^{-1})	Vegetative	Reproductive	Ripening	Vegetative	Reproductive	Ripening	Vegetative	Reproductive	Ripening
China	6,287.7	22.1	21.1	20.9	30.2	28.7	28.2	13.7	12.5	12.0
	(1,257.3)	(3.6)	(1.0)	(3.9)	(3.7)	(1.2)	(3.6)	(8.5)	(6.8)	(8.6)
India	5,450.5	24.6	23.4	22.7	33.1	31.7	31.6	17.4	17.3	18.3
	(872.8)	(1.3)	(2.2)	(2.1)	(2.9)	(3.0)	(2.2)	(1.8)	(1.6)	(1.5)
Indonesia	4,852.4	24.1	23.5	23.0	31.6	31.3	31.4	17.7	18.0	19.0
	(1,614.2)	(0.7)	(0.8)	(1.0)	(1.1)	(0.9)	(1.0)	(2.7)	(2.3)	(2.9)
Philippines	4,890.5	23.0	22.7	22.7	30.8	31.0	31.8	21.0	22.4	22.3
	(1,858.6)	(1.4)	(1.4)	(1.1)	(1.2)	(1.0)	(1.0)	(3.9)	(3.5)	(3.8)
Thailand	5,056.1	23.4	23.8	23.8	33.3	33.8	34.1	16.7	18.1	18.6
	(923.6)	(2.1)	(1.4)	(1.7)	(1.3)	(1.5)	(2.3)	(1.7)	(1.5)	(1.9)
Vietnam (Hanoi)	5,699.3	21.7	23.7	24.7	27.6	29.5	31.3	13.6	16.7	17.1
	(1,153.8)	(4.7)	(2.7)	(1.1)	(5.7)	(3.4)	(1.1)	(3.9)	(1.3)	(1.3)
Vietnam (Omon)	4,951.1	23.3	23.0	22.8	32.1	31.2	31.1	21.7	21.4	22.2
	(1,362.1)	(1.3)	(1.3)	(1.5)	(1.4)	(1.6)	(1.1)	(3.7)	(3.5)	(3.6)

Values were calculated across all years and seasons in the sample (Table S1). Values for temperature and radiation are shown by rice-growth phase.

Table S3. Correlations among weather variables by rice-growth phase

Phase	Variable	T_{min}	T_{max}	Radiation
Vegetative	T_{max}	0.399 (0.000)	—	—
	Radiation	0.117 (0.000)	0.597 (0.000)	—
	Rainfall	0.034 (0.215)	−0.284 (0.000)	−0.324 (0.000)
Reproductive	T_{max}	0.567 (0.000)	—	—
	Radiation	−0.118 (0.000)	0.396 (0.000)	—
	Rainfall	0.383 (0.000)	−0.053 (0.052)	−0.337 (0.000)
Ripening	T_{max}	0.505 (0.000)	—	—
	Radiation	0.055 (0.043)	0.412 (0.000)	—
	Rainfall	0.358 (0.000)	−0.158 (0.000)	−0.250 (0.000)

To match the regression models, correlations were calculated using residual variation in the variables after demeaning them by farm and site/season-years to remove the fixed effects of unobserved factors unique to each farm or common to all farms at a given site in a given season-year. Number of observations = 1,372. *P* values are in parentheses.

Table S4. Regression results: impacts of weather and economic variables on rice yield (kg·ha^{-1}) for model specifications in Fig. 2

Variables	Model 1: T_{min} only	Model 2: add radiation	Model 3: add T_{max}	Model 4: add rainfall	Model 5: add economic variables
T_{min}: vegetative	−116.0*	−86.08	−172.4†	−158.5†	−185.2†
	(0.078)	(0.154)	(0.011)	(0.027)	(0.011)
T_{min}: reproductive	−40.07	8.916	−5.516	−10.97	20.49
	(0.473)	(0.876)	(0.932)	(0.882)	(0.769)
T_{min}: ripening	−143.8*	−178.3*	−275.4‡	−356‡	−322.4‡
	(0.096)	(0.059)	(0.005)	(0.002)	(0.001)
Radiation: vegetative		−13.71	−85.75†	−98.17†	−106.1‡
		(0.666)	(0.024)	(0.016)	(0.009)
Radiation: reproductive		−0.543	0.458	11.42	27.38
		(0.987)	(0.991)	(0.719)	(0.356)
Radiation: ripening		96.67*	88.65	88.03	109.4†
		(0.060)	(0.150)	(0.111)	(0.038)
T_{max}: vegetative			214.9‡	190.4‡	193.9‡
			(0.000)	(0.002)	(0.001)
T_{max}: reproductive			7.362	−9.373	−22.27
			(0.902)	(0.890)	(0.739)
T_{max}: ripening			79.09	133.2*	124.9*
			(0.247)	(0.065)	(0.087)
Rainfall: vegetative				−0.623	−0.534
				(0.106)	(0.121)
Rainfall: reproductive				0.377	0.311
				(0.624)	(0.685)
Rainfall: ripening				1.325*	1.284†
				(0.087)	(0.040)
ln (farm size)					−779.5‡
					(0.000)
Ratio: rice price/wage					7,073†
					(0.047)
Ratio: rice price/*N* price					348.6
					(0.608)
R^2	0.549	0.554	0.561	0.565	0.600
Observations	1,372	1,372	1,372	1,372	1,248
Number of farms	227	227	227	227	219

All models included fixed effects for farms and site/season-years in addition to the variables shown. Units for explanatory variables: °C for T_{min} and T_{max}, MJ·m^{-2}·d^{-1} for radiation, mm for rainfall, and ha for farm size. Robust *P* values are in parentheses for SEs clustered by village/district.

*$P < 0.1$.

$^{\dagger}P < 0.05$.

$^{\ddagger}P < 0.01$.

Table S5. Regression results: impacts of weather and economic variables on rice yield (kg·ha^{-1}) in Model 5 when excluding either solar radiation or T_{max} during the ripening phase

Variables	Full model (Model 5 in Table S4)	Exclude radiation: ripening	Exclude T_{max}: ripening
T_{min}: vegetative	−185.2†	−200.2‡	−185.9†
	(0.011)	(0.007)	(0.013)
T_{min}: reproductive	20.49	21.91	22.26
	(0.769)	(0.742)	(0.761)
T_{min}: ripening	−322.4‡	−328.8‡	−248.2‡
	(0.001)	(0.000)	(0.006)
Radiation: vegetative	−106.1‡	−126.8‡	−91.83†
	(0.009)	(0.005)	(0.021)
Radiation: reproductive	27.38	15.80	37.45
	(0.356)	(0.589)	(0.208)
Radiation: ripening	109.4†		138.5‡
	(0.038)		(0.002)
T_{max}: vegetative	193.9‡	190.3‡	180.6‡
	(0.001)	(0.003)	(0.001)
T_{max}: reproductive	−22.27	−60.66	−15.50
	(0.739)	(0.360)	(0.817)
T_{max}: ripening	124.9*	209.5‡	
	(0.087)	(0.001)	
Rainfall: vegetative	−0.534	−0.743†	−0.510
	(0.121)	(0.024)	(0.150)
Rainfall: reproductive	0.311	0.0194	0.290
	(0.685)	(0.981)	(0.704)
Rainfall: ripening	1.284†	1.117*	0.922
	(0.040)	(0.065)	(0.114)
ln (farm size)	−779.5‡	−741.8‡	−799.7‡
	(0.000)	(0.000)	(0.000)
Ratio: rice price/wage	7,073†	6,860*	6,823*
	(0.047)	(0.060)	(0.057)
Ratio: rice price/*N* price	348.6	380.1	441.1
	(0.608)	(0.580)	(0.521)
R^2	0.600	0.596	0.598
Observations	1,248	1,248	1,248
Number of farms	219	219	219

All models included fixed effects for farms and site/season-years in addition to variables shown in the table. Units for explanatory variables: °C for T_{min} and T_{max}, MJ·m^{-2}·d^{-1} for radiation, mm for rainfall, and ha for farm size. Robust *P* values are in parentheses for SEs clustered by village/district.

*$P < 0.1$.

$^{\dagger}P < 0.05$.

$^{\ddagger}P < 0.01$.

Table S6. Equality tests for regression parameters in Models 4 and 5 in Table S4

Null hypothesis	*P* values	
	Model 4	Model 5
Equality across rice-growth phases		
T_{min}: vegetative = T_{min}: reproductive	0.117	0.020
T_{min}: vegetative = T_{min}: ripening	0.041	0.114
T_{min}: reproductive = T_{min}: ripening	0.012	0.007
T_{min} equal for all three phases	0.038	0.022
Radiation: vegetative = radiation: reproductive	0.013	0.001
Radiation: vegetative = radiation: ripening	0.012	0.003
|Radiation: vegetative| = radiation: ripening	0.870	0.957
Radiation: reproductive = radiation: ripening	0.144	0.115
Radiation equal for all three phases	0.026	0.002
T_{max}: vegetative = T_{max}: reproductive	0.038	0.019
T_{max}: vegetative = T_{max}: ripening	0.467	0.353
T_{max}: reproductive = T_{max}: ripening	0.198	0.189
T_{max} equal for all three phases	0.108	0.048
Rainfall: vegetative = rainfall: reproductive	0.185	0.248
Rainfall: vegetative = rainfall: ripening	0.044	0.020
Rainfall: reproductive = rainfall: ripening	0.238	0.205
Rainfall equal for all three phases	0.125	0.062
Equality within growth phases		
|T_{min}: vegetative| = T_{max}: vegetative	0.577	0.899
|T_{min}: ripening| = T_{max}: ripening	0.031	0.037

Table S7. Regression results: impacts of weather and economic variables on rice yield (kg·ha^{-1}) for models that included T_{ave} instead of T_{min} and T_{max}

Variables	T_{ave} only	Add radiation	Add rainfall	Add economic variables
T_{ave}: vegetative	−22.64	43.29	31.74	10.05
	(0.778)	(0.395)	(0.558)	(0.876)
T_{ave}: reproductive	−115.0†	−38.22	−54.31	−34.26
	(0.045)	(0.556)	(0.441)	(0.562)
T_{ave}: ripening	−45.77	−153.9	−163.4*	−142.9
	(0.578)	(0.119)	(0.083)	(0.109)
Radiation: vegetative		−12.43	−27.95	−30.32
		(0.687)	(0.311)	(0.347)
Radiation: reproductive		18.70	19.03	28.22
		(0.614)	(0.495)	(0.291)
Radiation: ripening		121.1†	118.3†	142.5‡
		(0.036)	(0.027)	(0.004)
Rainfall: vegetative			−0.820†	−0.689†
			(0.036)	(0.039)
Rainfall: reproductive			−0.126	−0.119
			(0.851)	(0.856)
Rainfall: ripening			0.435	0.469
			(0.538)	(0.433)
ln (farm size)				−816.1‡
				(0.000)
Ratio: rice price/wage				7,199†
				(0.050)
Ratio: rice price/*N* price				559.2
				(0.418)
R^2	0.545	0.551	0.554	0.589
Observations	1,372	1,372	1,372	1,248
Number of farms	227	227	227	219

All models included fixed effects for farms and site/season-years in addition to variables shown in the table. Units for explanatory variables: °C for T_{min} and T_{max}, MJ·m^{-2}·d^{-1} for radiation, mm for rainfall, and ha for farm size. Robust *P* values are in parentheses for SEs clustered by village/district.

*$P < 0.1$.

$^{\dagger}P < 0.05$.

$^{\ddagger}P < 0.01$.

Table S8. Marginal effects of weather variables expressed per SD: regression model that included economic variables

Variable	Growth phase	SD based on residual variation	Marginal effect (kg·ha^{-1} per SD)
T_{min}	Vegetative	0.42 °C	−78.6
	Ripening	0.54 °C	−174.4
Radiation	Vegetative	1.17 MJ·m^{-2}·d^{-1}	−124.1
	Ripening	0.90 MJ·m^{-2}·d^{-1}	98.2
T_{max}	Vegetative	0.63 °C	122.9
	Ripening	0.55 °C	69.0
Rainfall	Ripening	53.3 mm	68.4

Marginal effects are shown only for weather variables whose estimated regression parameters were significant at $P < 0.1$ (see Model 5 in Table S4) and were calculated by multiplying regression parameters by the SDs of the corresponding weather variables. SDs refer to residual variation after removing variation explained by fixed effects for farms and site/season-years.

Table S9. Quadratic model: significance of linear and quadratic terms, marginal effects, and turning points

		P values of variables					
Variable	Growth phase	Linear	Quadratic	Joint	Marginal effect	Turning point	Impact when variable exceeds turning point
T_{min}	Vegetative	0.004	0.002	0.000	−225.4	21.5 °C	Yield falls
	Reproductive	0.263	0.262	0.527	25.3	22.7 °C	Yield rises
	Ripening	0.985	0.792	0.001	−343.4	*	Yield falls
Radiation	Vegetative	0.262	0.108	0.084	−77.5	12.8 MJ·m^{-2}·d^{-1}	Yield falls
	Reproductive	0.059	0.022	0.015	29.7	17.5 MJ·m^{-2}·d^{-1}	Yield rises
	Ripening	0.816	0.816	0.062	107.4	*	Yield rises
T_{max}	Vegetative	0.001	0.000	0.000	139.6	29.9 °C	Yield rises
	Reproductive	0.977	0.988	0.730	−56.5	7.7 °C	Yield falls
	Ripening	0.232	0.299	0.144	122.9	37.3 °C	Yield falls
Rainfall	Vegetative	0.387	0.589	0.335	−0.66	768 mm	Yield rises
	Reproductive	0.120	0.208	0.290	0.84	341 mm	Yield falls
	Ripening	0.109	0.515	0.049	1.80	548 mm	Yield falls

Model also included economic variables and fixed effects for farms and site/season-years. Significance of individual variables was based on robust SEs clustered by villages/districts; joint significance of linear and quadratic terms was determined using *F* tests. Marginal effects were calculated at means of the weather variables and can be compared with parameter estimates for the corresponding weather variables in Model 5 in Table S4. An asterisk denotes a monotonic function over the range of positive values.

Table S10. Observed weather trends at the end of the 20th century at study sites by quarter of the year

	T_{min} (°C·decade^{-1})				T_{max} (°C·decade^{-1})				Surface radiation (%·y^{-1})			
Site	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
China	0.62*	0.53*	0.15	0.28	0.58	0.72*	0.04	0.32	−0.09%	0.21%	−0.59%	0.25%
India	0.19	0.10	0.26	0.39*	0.39*	0.09	0.42*	0.30*	0.31%	0.16%	0.43%*	−0.18%
Indonesia	0.39*	0.19	0.22*	0.23*	0.13	0.05	0.11	0.05	−0.24%*	−0.15%	−0.17%	−0.10%
Philippines	0.55*	0.36*	0.24*	0.25*	0.05	−0.17	0.02	0.12	−0.51%*	−0.36%*	−0.15%	−0.23%
Thailand	0.63*	0.00	0.10	0.12	0.16	−0.06	0.38*	0.28*	−0.35%*	−0.30%*	−0.40%*	−0.18%
Vietnam (north)	0.59*	0.44*	0.10	0.21	0.13	−0.38	0.00	0.23	−0.21%	−0.25%	−0.65%*	0.18%
Vietnam (south)	0.03	−0.28*	−0.32*	−0.34*	0.27	0.11	0.46*	0.38*	−0.50%*	−0.22%	−0.29%	−0.10%

DJF, December to February; MAM, March to May; JJA, June to August; SON, September to November. Time periods for estimating trends: temperature, 1979–2004; radiation, 1983–2004.
*Trends that were significant at $P < 0.05$.

Table S11. Projected changes in decadal means of weather variables between 1991–2000 and 2091–2100 at study sites by quarter of the year

	T_{min} (°C)				T_{max} (°C)				Surface radiation (MJ·m^{-2}·d^{-1})			
Site	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
China	3.00	1.29	1.96	3.44*	3.77	1.58	2.08	3.01	−0.07	0.11	−0.50	−2.85
India	2.16*	3.56	3.58	3.09	2.08	4.16	4.39	3.36	1.40	−6.99	−7.64	−7.84
Indonesia	2.27*	2.43*	2.46*	2.48*	2.00	2.03	2.11	2.40	−11.88	−3.82	−8.33	−6.28
Philippines	2.97*	3.31*	3.28*	3.13*	0.32	3.03	3.24	2.79	−28.62	−16.94	−15.30	−16.38
Thailand	2.16*	3.46*	3.20*	2.96*	1.37	3.25	3.08	2.62	−8.86	−14.97	−15.43	−17.76
Vietnam (north)	1.83*	2.25	2.84*	2.98*	1.28	2.40	2.72	2.46	−7.93	−13.50	−9.40	−4.00
Vietnam (south)	2.06*	3.02*	2.92*	2.80*	1.17	2.95	2.75	2.60	−8.00	−16.61	−10.43	−11.91

Projections are from climate simulations conducted for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. They refer to scenario A1B, which was the scenario used in the report's regional climate projections, and were generated by the Geophysical Fluid Dynamics Laboratory (GFDL) model.

*Cases where T_{min} is projected to increase more than T_{max}.

Table S12. Regression results: alternative specifications of fixed effects

Variables	FE: farm, site/season-year	RE: farm, FE: site/season-year	FE: site/season-year only	FE: farm only	FE: none
T_{min}: vegetative	−185.2†	−170.3†	−155.4*	−89.92	−92.68
	(0.011)	(0.015)	(0.091)	(0.290)	(0.276)
T_{min}: reproductive	20.49	35.71	83.42	−9.133	4.890
	(0.769)	(0.652)	(0.395)	(0.912)	(0.953)
T_{min}: ripening	−322.4‡	−373.0‡	−381.6‡	−160.7	−92.82
	(0.001)	(0.000)	(0.004)	(0.112)	(0.368)
Radiation: vegetative	−106.1‡	−132.0‡	−147.6‡	−53.84*	−95.75‡
	(0.009)	(0.000)	(0.000)	(0.050)	(0.001)
Radiation: reproductive	27.38	11.27	−1.203	−3.644	−11.84
	(0.356)	(0.705)	(0.972)	(0.913)	(0.819)
Radiation: ripening	109.4†	133.9†	188.5†	46.77	71.30*
	(0.038)	(0.024)	(0.013)	(0.182)	(0.096)
T_{max}: vegetative	193.9‡	215.5‡	231.2‡	147.4†	150.2†
	(0.001)	(0.000)	(0.000)	(0.034)	(0.048)
T_{max}: reproductive	−22.27	6.851	29.86	−77.87	−99.67
	(0.739)	(0.914)	(0.680)	(0.348)	(0.288)
T_{max}: ripening	124.9*	98.73	−2.296	75.98	4.097
	(0.087)	(0.251)	(0.984)	(0.448)	(0.967)
Rainfall: vegetative	−0.534	−0.842†	−1.010†	−0.836*	−1.549‡
	(0.121)	(0.036)	(0.046)	(0.053)	(0.000)
Rainfall: reproductive	0.311	0.256	0.256	−1.662†	−1.176*
	(0.685)	(0.689)	(0.708)	(0.019)	(0.085)
Rainfall: ripening	1.284†	1.089	0.576	−0.973	−1.365
	(0.0403)	(0.138)	(0.526)	(0.294)	(0.172)
ln (farm size)	−779.5‡	−228.7†	−167.4*	−742.4‡	−201.1*
	(0.000)	(0.016)	(0.059)	(0.002)	(0.073)
Ratio: rice price/wage	7,073†	7,813†	7,794†	359.6	861.3
	(0.047)	(0.014)	(0.024)	(0.819)	(0.566)
Ratio: rice price/*N* price	348.6	857.2	1,442*	645.5†	366.2
	(0.608)	(0.212)	(0.069)	(0.030)	(0.287)
R^2	0.600	—	0.512	0.294	0.224
Observations	1,248	1,248	1,248	1,248	1,248
Number of farms	219	219	219	219	219

Model in first column is the same as Model 5 in Table S4 and is included for reference. FE, fixed effects; RE, random effects, included in just the second model. Units for explanatory variables: °C for T_{min} and T_{max}, MJ·m^{-2}·d^{-1} for radiation, mm for rainfall, and ha for farm size. Robust *P* values are in parentheses for SEs clustered by village/district.

*$P < 0.1$.

$^{\dagger}P < 0.05$.

$^{\ddagger}P < 0.01$.