Supplementary Material

Contents of this File

Tables S1-S10, Text S1 and Table S11

Introduction

The supporting information includes summary statistics, SUR results of DCV effects on climate with different types of crops, estimation results of DCV effects on log recharge using average regional climate variables, total DCV impacts on recharge level based on the SUR results, EDSIM model structure, and crop mix adaptation under transition probability scenario compared to base scenario. All table results here were created simultaneously with the tables in the main paper.

Table S1. Summary Statistics

Variables		Time Period	Mean	SD	Min	Max
DCV	PDO-TAG+WPWP-	1950-2012	0.079	0.270	0.000	1.000
	PDO-TAG-WPWP+		0.143	0.350	0.000	1.000
	PDO+TAG+WPWP-		0.143	0.350	0.000	1.000
	PDO-TAG+WPWP+		0.206	0.405	0.000	1.000
	PDO+TAG+WPWP+		0.127	0.333	0.000	1.000
	PDO+TAG-WPWP-		0.095	0.294	0.000	1.000
	PDO+TAG-WPWP+		0.063	0.244	0.000	1.000
ENSO	El Niño		0.238	0.426	0.000	1.000
	La Niña		0.238	0.426	0.000	1.000
Monthly Climate	Monthly Mean Temperature (°F)		69.192	12.338	43.000	90.000
Variables in San	Monthly Total Precipitation (inch)		2.555	2.543	0.010	18.070
Antonio	Monthly Mean PDSI		-0.112	2.873	-6.680	6.660
Recharge	Log(Monthly Recharge)		10.470	1.055	7.409	13.812
Crop Production	Log(Yield)-Corn	1968-2012	4.256	0.430	2.501	4.857
	Log(Yield)-Cotton		6.443	0.663	4.796	7.281
	Log(Yield)-Oats		3.540	0.413	1.792	4.427
	Log(Yield)-Sorghum-Irr		4.284	0.228	3.807	4.709
	Log(Yield)-Sorghum-Dry		3.844	0.362	2.766	4.512
	Log(Yield)-WinWht-Irr		3.552	0.232	3.025	4.094
	Log(Yield)-WinWht-Dry		3.136	0.359	2.041	3.879
	Log(Acreage)-Corn		8.692	1.277	5.991	10.532
	Log(Acreage)-Cotton		7.873	1.012	5.991	9.699
	Log(Acreage)-Oats		7.222	1.443	4.605	9.903
	Log(Acreage)-Sorghum-Irr		7.732	0.843	5.704	8.896
	Log(Acreage)-Sorghum-Dry		8.786	1.164	5.298	11.035
	Log(Acreage)-WinWht-Irr		7.580	0.929	4.605	9.094
	Log(Acreage)-WinWht-Dry		8.427	1.007	5.298	10.127
Climate Variables	Spring Mean Temperature (°F)		68.854	2.117	64.400	74.660
	Summer Mean Temperature (°F)		83.156	1.722	79.333	87.980
	Fall Mean Temperature (°F)		69.786	1.864	62.500	74.067
	Spring Total Precipitation (inch)		10.987	6.962	1.060	44.670
	Summer Total Precipitation (inch)		11.652	8.617	1.307	61.960
	Fall Total Precipitation (inch)		12.409	9.297	0.736	61.028
	Spring Mean PDSI		0.323	2.283	-4.773	6.127
	Summer Mean PDSI		0.390	2.644	-6.217	6.030
	Fall Mean PDSI		0.519	2.204	-5.540	5.400

Table S2. SUR Results of DCV Effects on Climate (with Crop Yield Function of Corn)

	Spring Precipitation	Summer Precipitation	Fall Precipitation	Spring Temperature	Summer Temperature	Fall Temperature	Spring PDSI	Summer PDSI	Fall PDSI
PDO-TAG+WPWP-	14.622*	14.346***	12.028**	-0.076	2.764***	1.178*	-1.035	-1.344	-3.733***
	(7.625)	(5.506)	(5.186)	(1.062)	(0.789)	(0.690)	(0.830)	(1.156)	(1.252)
PDO-TAG-WPWP+	1.153	2.272*	6.505***	-1.436***	0.502	0.390	0.449	0.605	1.020**
	(1.016)	(1.297)	(2.042)	(0.369)	(0.312)	(0.423)	(0.501)	(0.580)	(0.520)
PDO+TAG+WPWP-	3.007**	2.303*	3.179**	-1.651***	-0.289	0.481	0.607	0.595	0.344
	(1.202)	(1.283)	(1.363)	(0.357)	(0.341)	(0.398)	(0.532)	(0.612)	(0.500)
PDO-TAG+WPWP+	7.640***	2.354	0.911	-3.906***	1.178**	0.011	2.941***	1.894**	-0.832
	(2.110)	(2.822)	(2.393)	(0.401)	(0.556)	(0.535)	(0.643)	(0.851)	(0.548)
PDO+TAG+WPWP+	4.900**	9.829***	10.154***	-1.603***	-0.455	0.984**	1.348***	2.187***	2.005***
	(2.363)	(3.371)	(2.434)	(0.362)	(0.454)	(0.429)	(0.494)	(0.600)	(0.543)
PDO+TAG-WPWP-	3.007**	4.295**	11.254***	-1.608***	-0.091	1.421***	1.296**	0.325	-0.442
	(1.351)	(2.095)	(2.559)	(0.467)	(0.316)	(0.398)	(0.511)	(0.605)	(0.478)
PDO+TAG-WPWP+	-2.982**	5.432***	3.434**	-1.376***	-0.405	0.467	-0.779*	-0.512	0.490
	(1.400)	(1.938)	(1.487)	(0.346)	(0.352)	(0.440)	(0.447)	(0.497)	(0.577)
El Niño	2.695***	2.025	4.647**	0.457	-0.026	-0.982***	-0.389	0.697	0.976***
	(0.958)	(1.332)	(1.871)	(0.309)	(0.292)	(0.298)	(0.345)	(0.448)	(0.301)
La Niña	0.295	3.811**	2.301	0.146	-0.641*	0.430	-0.153	0.191	0.335
	(1.318)	(1.642)	(1.557)	(0.248)	(0.345)	(0.354)	(0.323)	(0.439)	(0.387)
Trend	0.642***	0.563**	-0.129	-0.032	0.145***	0.054	-0.006	-0.020	-0.194***
	(0.146)	(0.189)	(0.284)	(0.050)	(0.044)	(0.048)	(0.068)	(0.080)	(0.073)
Trend^2	-0.016***	-0.016***	0.003	0.002*	-0.002**	-0.000	-0.001	-0.001	0.003
	(0.004)	(0.005)	(0.007)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Constant	5.474***	5.558**	8.678***	70.059***	82.077***	68.946***	0.554	0.868	2.415***
	(1.703)	(2.143)	(2.842)	(0.507)	(0.509)	(0.523)	(0.692)	(0.798)	(0.623)
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	217	217	217	217	217	217	217	217	217
R^2	0.265	0.165	0.217	0.495	0.339	0.306	0.265	0.240	0.360

Note: Values in parentheses are heteroskedasticity-robust standard errors using bootstrap with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S3. SUR Results of DCV Effects on Climate (with Crop Yield Function of Cotton)

	Spring Precipitation	Summer Precipitation	Fall Precipitation	Spring Temperature	Summer Temperature	Fall Temperature	Spring PDSI	Summer PDSI	Fall PDSI
PDO-TAG+WPWP-	3.459	1.131	-5.049	0.792	2.322**	1.260	-0.650	-1.033	-3.606**
	(8.971)	(11.889)	(7.025)	(0.979)	(0.949)	(0.911)	(1.082)	(1.616)	(1.728)
PDO-TAG-WPWP+	-0.479	0.458	2.186	-1.734***	0.693*	-0.297	0.429	0.435	0.912
	(2.803)	(4.035)	(2.766)	(0.571)	(0.387)	(0.538)	(0.780)	(0.916)	(0.717)
PDO+TAG+WPWP-	4.019	2.368	0.980	-1.309**	-0.045	0.727	0.694	0.764	-0.336
	(2.971)	(3.557)	(2.500)	(0.564)	(0.472)	(0.558)	(0.851)	(0.939)	(0.769)
PDO-TAG+WPWP+	8.591*	2.800	-1.907	-4.153***	0.749	-0.226	3.643***	2.681**	-0.489
	(4.824)	(8.787)	(3.249)	(0.565)	(0.671)	(0.767)	(1.019)	(1.315)	(0.825)
PDO+TAG+WPWP+	1.534	6.051	8.127**	-1.828***	-0.665	0.706	1.859***	2.596***	1.835**
	(3.246)	(4.917)	(3.951)	(0.531)	(0.460)	(0.597)	(0.566)	(0.726)	(0.808)
PDO+TAG-WPWP-	0.194	-1.841	2.938	-1.803**	-0.287	0.933	1.381*	0.667	-0.422
	(3.143)	(3.794)	(2.394)	(0.828)	(0.479)	(0.665)	(0.779)	(0.930)	(0.682)
PDO+TAG-WPWP+	-9.311***	2.092	4.767	-1.753***	-0.720	0.056	-0.213	0.072	0.531
	(2.311)	(4.373)	(3.900)	(0.454)	(0.470)	(0.665)	(0.626)	(0.725)	(0.909)
El Niño	1.969	3.502	4.690**	0.686	0.283	-0.564	-0.854	-0.057	0.517
	(2.236)	(3.353)	(2.092)	(0.549)	(0.434)	(0.400)	(0.572)	(0.745)	(0.481)
La Niña	-0.036	5.897*	0.101	0.531	-0.304	0.260	-0.822	-0.428	0.023
	(2.448)	(3.558)	(2.756)	(0.450)	(0.490)	(0.536)	(0.652)	(0.755)	(0.606)
Trend	1.362***	0.844*	0.215	-0.004	0.161***	0.071	-0.004	-0.034	-0.215**
	(0.376)	(0.509)	(0.370)	(0.069)	(0.052)	(0.064)	(0.103)	(0.118)	(0.094)
Trend^2	-0.028***	-0.016	-0.003	0.002	-0.002*	-0.001	-0.001	-0.001	0.003
	(0.008)	(0.012)	(0.009)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
Constant	-3.423	-4.596	3.560	69.766***	82.185***	69.372***	0.485	0.509	2.224**
	(4.646)	(7.834)	(3.546)	(0.845)	(0.714)	(0.804)	(1.248)	(1.622)	(1.031)
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	109	109	109	109	109	109	109	109	109
R^2	0.321	0.176	0.244	0.533	0.388	0.305	0.329	0.260	0.330

Note: Values in parentheses are heteroskedasticity-robust standard errors using bootstrap with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S4. SUR Results of DCV Effects on Climate (with Crop Yield Function of Oats)

	Spring Precipitation	Summer Precipitation	Fall Precipitation	Spring Temperature	Summer Temperature	Fall Temperature	Spring PDSI	Summer PDSI	Fall PDSI
PDO-TAG+WPWP-	2.388	-2.456	-1.226	0.603	1.970*	0.647	-1.685*	-2.070	-3.545***
	(2.538)	(2.889)	(2.592)	(0.801)	(1.135)	(1.046)	(0.970)	(1.308)	(1.349)
PDO-TAG-WPWP+	-0.134	1.480	3.156**	-1.469***	0.124	0.217	0.425	0.560	0.635
	(0.778)	(1.128)	(1.251)	(0.372)	(0.315)	(0.441)	(0.504)	(0.548)	(0.495)
PDO+TAG+WPWP-	0.679	-0.031	0.574	-1.859***	-0.060	0.512	0.846	0.702	0.229
	(0.839)	(0.911)	(1.073)	(0.373)	(0.323)	(0.404)	(0.515)	(0.580)	(0.492)
PDO-TAG+WPWP+	4.179***	-2.226	-1.333	-4.057***	1.104**	-0.274	2.834***	1.521*	-1.129**
	(1.307)	(2.315)	(1.337)	(0.428)	(0.561)	(0.597)	(0.655)	(0.844)	(0.530)
PDO+TAG+WPWP+	0.231	3.567**	6.209***	-1.667***	-0.148	1.145***	1.514***	2.301***	2.002***
	(1.023)	(1.741)	(1.957)	(0.354)	(0.448)	(0.419)	(0.469)	(0.596)	(0.529)
PDO+TAG-WPWP-	-0.892	-0.608	2.035*	-1.814***	-0.045	1.273***	1.483***	0.539	-0.466
	(0.897)	(1.006)	(1.237)	(0.511)	(0.301)	(0.411)	(0.539)	(0.575)	(0.487)
PDO+TAG-WPWP+	-4.580***	1.361	2.029	-1.567***	-0.328	0.408	-0.677	-0.483	0.304
	(0.879)	(1.499)	(1.668)	(0.325)	(0.357)	(0.482)	(0.416)	(0.504)	(0.676)
El Niño	1.497**	1.853**	1.999**	0.521*	-0.060	-0.759**	-0.180	0.914**	0.755**
	(0.635)	(0.791)	(0.795)	(0.313)	(0.284)	(0.312)	(0.369)	(0.458)	(0.333)
La Niña	-0.598	3.046***	1.029	0.189	-0.262	0.685**	-0.227	0.025	0.174
	(0.655)	(1.031)	(1.405)	(0.277)	(0.330)	(0.325)	(0.340)	(0.428)	(0.379)
Trend	0.299***	-0.026	-0.214	-0.026	0.175***	0.049	-0.054	-0.110	-0.236***
	(0.106)	(0.159)	(0.154)	(0.054)	(0.049)	(0.048)	(0.083)	(0.095)	(0.079)
Trend^2	-0.007***	0.001	0.005	0.002	-0.003**	-0.000	0.001	0.001	0.004*
	(0.003)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Constant	6.686***	7.746***	8.795***	70.065***	81.779***	69.043***	0.660	1.348	2.843***
	(1.175)	(1.654)	(1.889)	(0.516)	(0.513)	(0.570)	(0.734)	(0.858)	(0.661)
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	213	213	213	213	213	213	213	213	213
R^2	0.325	0.141	0.208	0.518	0.264	0.264	0.250	0.218	0.320

Note: Values in parentheses are heteroskedasticity-robust standard errors using bootstrap with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S5. SUR Results of DCV Effects on Climate (with Crop Yield Function of Irrigated Sorghum)

	Spring Precipitation	Summer Precipitation	Fall Precipitation	Spring Temperature	Summer Temperature	Fall Temperature	Spring PDSI	Summer PDSI	Fall PDSI
PDO-TAG+WPWP-	-3.328	-7.764	0.738	1.693	2.712**	2.370	-1.301	-1.224	-3.862**
	(6.519)	(12.665)	(10.300)	(1.286)	(1.115)	(1.441)	(1.624)	(1.882)	(1.853)
PDO-TAG-WPWP+	0.079	9.892*	17.265***	-0.785	0.195	1.652**	-0.645	-0.180	1.171
	(2.971)	(5.080)	(6.280)	(0.682)	(0.356)	(0.762)	(0.773)	(0.823)	(0.878)
PDO+TAG+WPWP-	1.302	5.828	5.387	-1.307**	0.037	0.847	0.258	0.271	0.380
	(3.689)	(3.899)	(4.045)	(0.589)	(0.503)	(0.678)	(0.668)	(0.776)	(0.598)
PDO-TAG+WPWP+	29.036***	33.533	-2.272	-2.853**	-1.230	2.540*	3.058*	5.939***	1.199
	(11.169)	(33.316)	(10.232)	(1.369)	(1.558)	(1.400)	(1.690)	(1.821)	(1.787)
PDO+TAG+WPWP+	7.845	15.868***	20.790***	-1.204**	-0.484	1.653**	0.933	1.810*	2.537***
	(5.007)	(6.132)	(6.452)	(0.564)	(0.582)	(0.695)	(0.751)	(1.026)	(0.893)
PDO+TAG-WPWP-	-1.384	-4.404	8.877*	-1.540*	-0.036	1.525**	1.065	-0.261	-0.294
	(4.497)	(5.100)	(5.070)	(0.861)	(0.537)	(0.656)	(0.817)	(0.924)	(0.758)
PDO+TAG-WPWP+	-9.711***	13.365*	17.544**	-0.996*	-1.046*	0.656	-0.960	-0.005	1.705*
	(3.556)	(6.904)	(7.047)	(0.538)	(0.551)	(0.760)	(0.796)	(0.930)	(1.024)
El Niño	5.581*	1.304	7.814**	0.385	-0.262	-1.200**	-0.095	0.943	1.064**
	(3.150)	(4.630)	(3.570)	(0.549)	(0.456)	(0.579)	(0.531)	(0.712)	(0.442)
La Niña	-3.308	5.620	1.592	-0.390	-0.488	-0.641	0.910	0.963	0.610
	(3.219)	(4.265)	(5.065)	(0.606)	(0.429)	(0.584)	(0.670)	(0.788)	(0.678)
Trend	0.446	-0.989	-0.807	-0.142*	0.205***	-0.054	0.025	0.008	-0.148
	(0.484)	(0.797)	(0.629)	(0.076)	(0.070)	(0.080)	(0.099)	(0.121)	(0.107)
Trend^2	-0.020	0.016	0.016	0.004*	-0.003	0.002	-0.002	-0.003	0.002
	(0.013)	(0.025)	(0.017)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)
Constant	25.698***	25.900***	26.086***	70.595***	81.886***	69.564***	0.488	0.459	1.258
	(4.401)	(6.242)	(6.625)	(0.722)	(0.620)	(0.873)	(0.901)	(1.122)	(0.826)
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	94	94	94	94	94	94	94	94	94
R^2	0.389	0.315	0.316	0.405	0.492	0.307	0.274	0.317	0.383

Note: Values in parentheses are heteroskedasticity-robust standard errors using bootstrap with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S6. SUR Results of DCV Effects on Climate (with Crop Yield Function of Dryland Sorghum)

	Spring Precipitation	Summer Precipitation	Fall Precipitation	Spring Temperature	Summer Temperature	Fall Temperature	Spring PDSI	Summer PDSI	Fall PDSI
PDO-TAG+WPWP-	2.063	-3.297	-7.549	1.420	2.022**	1.419	-1.938*	-0.550	-3.223**
	(8.974)	(7.584)	(7.276)	(0.899)	(0.953)	(1.024)	(1.140)	(1.564)	(1.643)
PDO-TAG-WPWP+	-1.535	9.314***	11.332***	-0.655	0.009	0.744	-1.308**	-0.639	0.841
	(1.937)	(2.766)	(3.934)	(0.440)	(0.292)	(0.496)	(0.508)	(0.598)	(0.641)
PDO+TAG+WPWP-	1.290	2.280	4.088	-1.971***	-0.095	0.433	0.686	0.542	0.681
	(2.124)	(2.081)	(2.679)	(0.340)	(0.319)	(0.422)	(0.468)	(0.524)	(0.451)
PDO-TAG+WPWP+	23.722**	36.613	-10.235	-2.623***	-1.523	1.218	1.925*	5.503***	0.913
	(10.876)	(31.564)	(7.601)	(0.817)	(1.416)	(0.844)	(1.065)	(1.345)	(1.202)
PDO+TAG+WPWP+	1.173	12.795***	15.876***	-1.313***	-0.728*	0.977**	0.511	1.786***	2.088***
	(2.570)	(3.770)	(4.862)	(0.347)	(0.396)	(0.458)	(0.503)	(0.597)	(0.608)
PDO+TAG-WPWP-	-4.306*	-2.080	5.933**	-1.786***	0.058	1.421***	1.242**	0.105	-0.368
	(2.439)	(2.615)	(2.932)	(0.432)	(0.328)	(0.398)	(0.494)	(0.522)	(0.480)
PDO+TAG-WPWP+	-11.497***	7.043**	5.983	-0.952***	-0.681*	0.758	-1.728***	-0.956*	0.492
	(2.233)	(3.349)	(4.150)	(0.351)	(0.375)	(0.463)	(0.507)	(0.577)	(0.612)
El Niño	3.969**	3.259	4.879**	0.287	-0.292	-1.203***	-0.313	1.163***	1.290***
	(1.645)	(2.086)	(2.186)	(0.315)	(0.277)	(0.324)	(0.338)	(0.423)	(0.331)
La Niña	-2.029	2.516	2.496	-0.463	-0.084	0.338	1.249***	0.976*	0.311
	(1.859)	(2.361)	(4.927)	(0.359)	(0.356)	(0.369)	(0.386)	(0.541)	(0.500)
Trend	0.023	-0.789**	-1.164***	-0.087*	0.194***	0.049	0.002	0.002	-0.163**
	(0.263)	(0.394)	(0.425)	(0.045)	(0.047)	(0.056)	(0.069)	(0.082)	(0.070)
Trend^2	-0.008	0.010	0.027**	0.003**	-0.003**	-0.000	-0.001	-0.002	0.003
	(0.007)	(0.012)	(0.012)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Constant	25.300***	26.179***	24.244***	70.901***	81.851***	69.199***	0.336	0.641	1.351**
	(2.938)	(3.874)	(5.308)	(0.468)	(0.478)	(0.664)	(0.635)	(0.725)	(0.650)
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	181	181	181	181	181	181	181	181	181
R^2	0.354	0.298	0.199	0.460	0.382	0.280	0.285	0.290	0.281

Note: Values in parentheses are heteroskedasticity-robust standard errors using bootstrap with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S7. SUR Results of DCV Effects on Climate (with Crop Yield Function of Irrigated Winter Wheat)

	Spring Precipitation	Summer Precipitation	Fall Precipitation	Spring Temperature	Summer Temperature	Fall Temperature	Spring PDSI	Summer PDSI	Fall PDSI
PDO-TAG+WPWP-	1.490	5.340	-14.767	1.109	1.583	2.671	-1.408	0.040	-3.568*
	(10.148)	(16.986)	(10.495)	(2.111)	(1.623)	(1.876)	(2.101)	(2.615)	(2.084)
PDO-TAG-WPWP+	-0.035	10.142*	16.032**	-1.038	0.192	1.244	-0.811	-0.272	0.942
	(3.130)	(6.140)	(6.294)	(0.777)	(0.465)	(1.102)	(0.858)	(0.940)	(0.883)
PDO+TAG+WPWP-	0.134	-0.795	-0.193	-1.534**	0.200	1.169	-0.154	-0.321	-1.442**
	(3.884)	(6.022)	(5.856)	(0.753)	(0.630)	(0.738)	(0.874)	(1.125)	(0.680)
PDO-TAG+WPWP+	39.513***	82.351***	-5.641	-2.638	-3.394***	2.407	2.343	7.110***	1.628
	(6.234)	(12.386)	(9.266)	(1.681)	(1.164)	(1.737)	(1.693)	(1.776)	(1.599)
PDO+TAG+WPWP+	11.783**	22.720**	8.426	-1.253	-0.911	1.769*	0.577	2.719**	1.704**
	(4.886)	(9.411)	(6.382)	(0.889)	(0.747)	(0.915)	(0.992)	(1.290)	(0.859)
PDO+TAG-WPWP-	-2.713	-6.831	3.070	-1.522	0.646	2.158**	0.615	-0.858	-2.074**
	(4.851)	(6.008)	(6.496)	(1.020)	(0.636)	(0.859)	(0.948)	(1.155)	(0.821)
PDO+TAG-WPWP+	-10.024***	15.750*	14.979**	-1.318	-1.275*	0.860	-0.843	0.299	1.199
	(3.625)	(9.121)	(7.375)	(0.871)	(0.760)	(1.062)	(1.090)	(1.328)	(0.967)
El Niño	8.700***	5.489	7.189*	0.213	-0.639	-1.855***	-0.187	1.223	1.483***
	(3.183)	(4.506)	(3.942)	(0.673)	(0.554)	(0.668)	(0.611)	(0.770)	(0.448)
La Niña	-1.505	0.238	-9.911*	-0.215	-0.117	-0.028	0.761	1.064	-1.209
	(3.747)	(6.980)	(5.889)	(0.811)	(0.702)	(0.791)	(1.002)	(1.377)	(0.822)
Trend	-0.201	-1.314	-2.400***	-0.066	0.259***	0.133	-0.010	-0.013	-0.346***
	(0.525)	(0.834)	(0.737)	(0.105)	(0.099)	(0.124)	(0.138)	(0.177)	(0.114)
Trend^2	-0.004	0.019	0.059***	0.003	-0.004	-0.003	-0.001	-0.003	0.006*
	(0.016)	(0.027)	(0.021)	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)	(0.003)
Constant	27.958***	29.088***	42.286***	70.047***	81.538***	68.291***	0.834	0.829	3.873***
	(5.311)	(8.220)	(7.541)	(1.122)	(0.963)	(1.141)	(1.311)	(1.777)	(1.003)
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	75	75	75	75	75	75	75	75	75
R^2	0.542	0.479	0.433	0.368	0.544	0.446	0.265	0.393	0.518

Note: Values in parentheses are heteroskedasticity-robust standard errors using bootstrap with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S8. SUR Results of DCV Effects on Climate (with Crop Yield Function of Dryland Winter Wheat)

	Spring Precipitation	Summer Precipitation	Fall Precipitation	Spring Temperature	Summer Temperature	Fall Temperature	Spring PDSI	Summer PDSI	Fall PDSI
PDO-TAG+WPWP-	-3.791	0.478	-18.217**	1.057	2.403**	2.915**	-2.072	-1.181	-4.670**
	(6.693)	(10.735)	(8.328)	(1.233)	(1.101)	(1.159)	(1.280)	(1.727)	(1.870)
PDO-TAG-WPWP+	-2.143	8.329***	10.031***	-0.381	-0.122	0.876	-1.160**	-0.481	0.556
	(1.940)	(2.989)	(3.820)	(0.487)	(0.360)	(0.587)	(0.537)	(0.632)	(0.648)
PDO+TAG+WPWP-	-0.832	-1.887	0.055	-1.686***	0.225	1.004**	0.985*	0.603	0.389
	(2.547)	(2.433)	(3.185)	(0.403)	(0.359)	(0.414)	(0.592)	(0.689)	(0.555)
PDO-TAG+WPWP+	21.690**	39.371*	-11.774	-1.740*	-2.780***	0.045	1.511	5.617***	0.045
	(9.156)	(21.576)	(7.957)	(0.901)	(0.751)	(1.746)	(1.126)	(1.384)	(1.300)
PDO+TAG+WPWP+	1.999	14.118***	12.982***	-1.027***	-0.523	1.256**	0.624	1.843***	1.896***
	(2.611)	(4.544)	(4.724)	(0.387)	(0.362)	(0.539)	(0.513)	(0.608)	(0.560)
PDO+TAG-WPWP-	-5.018*	-3.907	3.589	-1.607***	0.229	1.747***	1.518***	0.218	-0.538
	(2.648)	(2.906)	(3.117)	(0.492)	(0.341)	(0.468)	(0.547)	(0.594)	(0.460)
PDO+TAG-WPWP+	-11.798***	8.571**	4.479	-0.856**	-0.655*	0.949*	-1.746***	-1.005*	0.130
	(2.217)	(3.671)	(3.788)	(0.378)	(0.396)	(0.495)	(0.495)	(0.564)	(0.646)
El Niño	5.142***	6.410***	5.959***	0.296	-0.457	-1.352***	-0.472	1.127**	1.193***
	(1.718)	(2.470)	(2.247)	(0.346)	(0.310)	(0.372)	(0.421)	(0.529)	(0.366)
La Niña	-2.859	-1.687	-1.854	-0.413	0.188	0.616*	1.408***	0.924	0.290
	(2.230)	(2.794)	(5.038)	(0.318)	(0.350)	(0.369)	(0.437)	(0.612)	(0.535)
Trend	-0.186	-1.191***	-1.825***	-0.051	0.234***	0.146**	0.035	-0.005	-0.209**
	(0.283)	(0.435)	(0.503)	(0.053)	(0.057)	(0.073)	(0.075)	(0.096)	(0.090)
Trend^2	-0.003	0.018	0.048***	0.002	-0.004**	-0.003	-0.001	-0.002	0.004
	(0.008)	(0.014)	(0.014)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Constant	27.583***	30.725***	31.556***	70.416***	81.508***	68.120***	-0.156	0.592	1.837**
	(3.203)	(4.275)	(6.160)	(0.585)	(0.536)	(0.735)	(0.718)	(0.919)	(0.847)
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	173	173	173	173	173	173	173	173	173
R^2	0.376	0.311	0.238	0.428	0.378	0.294	0.289	0.294	0.304

Note: Values in parentheses are heteroskedasticity-robust standard errors using bootstrap with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S9. Estimation Results of DCV Effects on Log Recharge Using Average Regional Climate Variables

	SUR				OLS
	logRecharge	Precipitation	Temperature	PDSI	logRecharge
PDO-TAG+WPWP-	-0.191	0.017	-0.185	-0.805**	-0.003
	(0.149)	(0.316)	(0.433)	(0.384)	(0.094)
PDO-TAG-WPWP+	0.144	0.221	-0.479	0.405	0.008
	(0.126)	(0.255)	(0.370)	(0.339)	(0.073)
PDO+TAG+WPWP-	-0.085	-0.022	-0.483	0.071	-0.102
	(0.123)	(0.241)	(0.388)	(0.314)	(0.071)
PDO-TAG+WPWP+	0.113	0.160	-0.469	0.791**	-0.105
	(0.141)	(0.293)	(0.411)	(0.394)	(0.086)
PDO+TAG+WPWP+	0.863***	0.749**	-0.482	2.345***	0.178**
	(0.141)	(0.322)	(0.378)	(0.346)	(0.074)
PDO+TAG-WPWP-	0.028	-0.094	0.104	0.006	0.042
	(0.141)	(0.290)	(0.370)	(0.314)	(0.094)
PDO+TAG-WPWP+	-0.054	-0.360	-0.302	-0.472	0.115
	(0.165)	(0.301)	(0.428)	(0.353)	(0.094)
El Niño	0.066	0.416**	0.143	0.014	-0.003
	(0.084)	(0.171)	(0.246)	(0.216)	(0.054)
La Niña	-0.007	0.145	0.311	-0.319	0.048
	(0.094)	(0.207)	(0.280)	(0.235)	(0.055)
Trend	0.092***	0.060***	-0.129***	0.264***	0.019**
	(0.010)	(0.020)	(0.032)	(0.027)	(0.007)
Trend^2	-0.001***	-0.001***	0.002***	-0.004***	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Precipitation					0.161***
					(0.015)
Temperature					-0.007
					(0.008)
PDSI					0.239***
					(0.010)
Constant	8.934***	0.542	52.172***	-3.628***	10.075***
	(0.202)	(0.405)	(0.722)	(0.570)	(0.414)
Month fixed effect	Yes	Yes	Yes	Yes	Yes
Number of observations	756	756	756	756	756
R^2	0.242	0.167	0.958	0.245	0.734

Note: Values in parentheses from SUR are heteroskedasticity-robust standard errors using bootstrap and those from OLS are robust standard errors with * significant at 10%, ** significant at 5%, and *** significant at 1%, respectively.

Table S10. Total DCV Impacts on Recharge Level Based on the SUR Results (% Change)

	PDO-TAG-WPWP-	PDO-TAG+WPWP-	PDO-TAG-WPWP+	PDO+TAG+WPWP-	PDO-TAG+WPWP+	PDO+TAG+WPWP+	PDO+TAG-WPWP-	PDO+TAG-WPWP+
Recharge	-14.75	-14.75	-14.75	-14.75	-14.75	102.03	-14.75	-14.75

Note: The total DCV effects are calculated based on estimated parameters that have 90% or greater statistical significance.

Text S1. EDSIM Model Structure

EDSIM simulates agricultural, municipal, and industrial water use and also irrigated versus dryland cropping versus use of land for livestock grazing, livestock herd size, pumping lift, pumping cost, aquifer elevation, and spring flow. The model optimizes the consumers and producers surplus as discussed in McCarl and Spreen (1980). That approach simulates the economic allocation of water to profit maximizing agricultural producers and cost minimizing consumers subject to technical and legislatively imposed environmentally related pumping limits. The following equation (S1) shows the objective function with DCV information.

$$
\begin{aligned}
Max: & -\sum_{p}\sum_{z} irrcost_{z} IRRLAND_{pz} - \sum_{p}\sum_{z} sprinkcost_{p} FURRTOSPK_{pz} \\
& + \sum_{d} prob\_DCV_{d} \sum_{r/d} prob_{r/d} \left(\sum_{p}\sum_{z}\sum_{c}\sum_{s} irrincome_{rcsd} IRRPROD_{pzrcsd} \right. \\
& + \sum_{p}\sum_{c} dryincome_{rcd} DRYPROD_{prcd} \\
& - \sum_{p}\sum_{z}\sum_{m} AGPUMPCOST_{pzrd} AGWATER_{pzrmd} \\
& + \sum_{p}\sum_{z}\sum_{l} liveincome_{rld} LIVEPROD_{pzrld} \\
& - \sum_{p}\sum_{z} grasscost_{rd} GRASSUSE_{pzrd} \\
& + \sum_{p}\sum_{m} \int_{0}^{MUN_{prm}} mp_{prmd}(MUN_{prmd}) dMUN_{prmd} \\
& + \sum_{p}\sum_{m} \int_{0}^{IND_{prm}} ip_{prmd}(IND_{prmd}) dIND_{prmd} \\
& \left. - \sum_{p}\sum_{m} MIPUMPCOST_{prd}(MUN_{prmd} + IND_{prmd}) \right)
\end{aligned}
\tag{S1}
$$

First line of equation (S1) contains the cost of maintaining developed irrigable land (*IRRLAND*) and the cost of converting furrow land to sprinkler land (*FURRTOSPK*) in a county (p) and lift zone (z). Probability of the DCV phases is represented by $prob\_DCV_d$, which is calculated based on DCV phase combination (d), and $prob_{r|d}$ is the probability of a recharge state r given a DCV phase combination d. The first three items in bracket depict the net revenue from crop production, which is crop net income (*irrincome*, *dryincome*) times production acreage (*IRRPROD*, *DRYPROD*) by county, lift zone, crops (c), and irrigation strategy (s) minus agricultural pumping cost (*AGPUMPCOST*) multiplied by agricultural water use (*AGWATER*) by county, lift zone, and month (m). The fourth and fifth items in bracket represent

net revenue of livestock production, which equals to livestock net income per animal unit (*liveincome*) multiplied by livestock production (*LIVEPROD*) by county, lift zone, and livestock type (*l*) less per acre cost of grassland maintenance (*grasscost*) multiplied by the amount of grassland used by livestock (*GRASSUSE*) by county and lift zone under recharge state and DCV phase combination. The last three lines represent the net benefit of water use in Municipal and Industrial sectors (M&I), which includes the area under the M&I demand curves minus the M&I pumping cost (*MIPUMPCOST*) times the amount of water demanded in the M&I sectors (*MUN* and *IND*) by county and month.

Constraints on land conversion are defined so the land conversion has to be done before knowledge of the DCV state applying to all states. Only one way conversions are permitted. Irrigated land use (*IRRLAND*) could not exceed the initial irrigated land available less the irrigated land converted to dryland and grassland. Likewise, grassland use (*GRASSUSE*) is limited to the available initial grassland plus the land converted to grassland from irrigated land. Grassland has no conversion possibilities.

DCV information is primarily used in three ways in the EDSIM model. First, the eight combinations of DCV phases and corresponding DCV phase probabilities are applied. Second, data on DCV impacts on crop yields are used to define the state of nature dependent yields. Data on DCV impacts on corn, cotton, and oats are used for both irrigated and dryland practices. Additionally, impact data for dryland sorghum are applied as proxy for other dryland crops, excluding corn, cotton, oats, and winter wheat. Average DCV impact data for irrigated corn, cotton, oats, sorghum, and winter wheat under each DCV phase combination are used for all other irrigated crops. Third, the adaptation of crop mix and livestock mix is examined in detail under different DCV phase combinations.

A constraint is imposed on crop mixes following McCarl (1982). The crop mix constraint is defined in equation (S2). Cropland use (*CROPROD*) is a convex combination of historical crop mixes (*cropmixdata*) for crops (*c*) and mix possibilities (*x*) in county (*p*). Different crop mixes could be chosen depending on knowledge of DCV phase and phase strength information. Following Fernandez et al. (2016), we discuss three cases here. The first is the base scenario case in which crop mix is selected without DCV information. The second is the transition probability case for which we know the DCV information for today and have a set of transition probabilities as in Appendix Table A1 in the main paper relative to the possibility of occurrence of each of the eight states in the next year. The last is the perfect information case for which both DCV phase combination and phase strength information are known in advance and transition probabilities for the possibilities in the following year are also known.

$$\sum_s CROPPROD_{pzrcsd} = \begin{cases} \sum_x cropmixdata_{pcx} CROPMIX_{px} \;\; without\ DCV\ information,\ \ for\ all\ p,z,r,c,d \\ \sum_x cropmixdata_{pcx} CROPMIX_{pxd} \;\; with\ DCV\ information,\ \ for\ all\ p,z,r,c,d \\ \sum_x cropmixdata_{pcx} CROPMIX_{pxrd} \;\; with\ DCV\ and\ phase\ strength\ information,\ \ for\ all\ p,z,r,c,d \end{cases} \quad \text{(S2)}$$

We also impose a livestock mix constraint on the mix of historical animal numbers across species. This is structured in the same way as the crop mix constraint with three cases defined. Other constraints cover pumping cost, aquifer elevation, spring flow determination, and maximum pumping allowed as in McCarl et al. (1999). For example, both ending water level and springflow level are a function of recharge, initial water level, and total water use (*AGWATER+MUN+IND*).

Table S11. Crop Mix Adaptation under Transition Probability Scenario Compared to Base Scenario (% Change)

	Base (10^3 acres)	PDO-TAG-WPWP-	PDO-TAG+WPWP-	PDO-TAG-WPWP+	PDO+TAG+WPWP-	PDO-TAG+WPWP+	PDO+TAG+WPWP+	PDO+TAG-WPWP-	PDO+TAG-WPWP+
	Without a 400 000 acre-feet pumping limit								
Corn	*46.98*	5.47	-35.83	-15.95	9.75	-11.11	9.20	-0.72	5.04
Cotton	*9.44*	-36.01	-51.20	-43.54	-12.03	-37.03	-32.68	-18.68	-40.11
Hay	*3.30*	-10.87	11.84	-22.07	-11.53	-5.00	-25.58	-4.33	-27.88
Oats	*1.74*	13.33	13.85	-18.28	3.10	43.16	7.87	8.62	12.70
Peanuts	*2.23*	13.04	16.09	2.60	5.60	-0.72	9.10	16.94	12.28
Sorghum	*9.43*	35.90	5.42	14.79	9.47	95.79	28.65	31.99	41.72
Winter Wheat	*2.92*	50.94	65.40	6.37	5.89	126.86	19.32	14.46	23.50
Cabbage	*2.00*	0.00	0.00	-0.10	-0.10	0.10	0.00	0.10	0.00
Carrot	*10.66*	0.00	0.00	-0.10	-0.10	0.09	0.00	0.09	0.00
Watermelon	*0.84*	16.43	12.38	-3.10	3.69	2.50	-0.24	10.48	1.43
	With a 400 000 acre-feet pumping limit								
Corn	*31.31*	6.70	-25.94	-19.09	30.62	-1.92	14.48	-26.89	-10.45
Cotton	*0.51*	260.55	126.04	313.81	307.69	290.53	175.94	761.54	386.00
Hay	*3.43*	-13.27	-1.17	-30.95	-6.62	-24.18	-6.91	-18.47	-26.75
Oats	*3.20*	-11.36	-6.16	-12.98	16.05	49.25	-6.91	-38.11	-16.58
Peanuts	*2.03*	15.53	27.71	-14.35	8.68	-17.85	23.67	-18.44	0.79
Sorghum	*9.33*	31.22	33.08	21.17	76.73	195.89	30.35	-1.18	30.76
Winter Wheat	*8.02*	-30.95	-12.40	-38.90	37.01	29.72	-17.88	-33.69	-35.25
Cabbage	*2.00*	0.00	0.00	-0.10	-0.10	0.10	0.00	0.10	0.00
Carrot	*10.66*	0.00	0.00	-0.10	-0.10	0.09	0.00	0.09	0.00
Watermelon	*0.83*	9.64	9.16	-22.17	5.54	-23.37	18.31	-28.92	-9.88

Note: Due to space consideration, we did not report irrigated land and dryland crop production separately.

Literature Cited

McCarl BA (1982) Cropping activities in agricultural sector models: a methodological proposal. Am J Agric Econ 64:768–772 doi:10.2307/1240588

McCarl BA, Spreen TH (1980) Price endogenous mathematical programming as a tool for sector analysis. Am J Agric Econ 62:87–102 doi:10.2307/1239475

McCarl BA, Dillon CR, Keplinger KO, Williams RL (1999) Limiting pumping from the Edwards Aquifer: an economic investigation of proposals, water markets, and spring flow guarantees. Water Resour Res 35:1257–1268 doi:10.1029/1998WR900116