Way Down in the Hole: Adaptation to Long-Term Water Loss in Rural India Online Appendix*

David Blakeslee†
Ram Fishman‡
Veena Srinivasan§

July 24, 2019

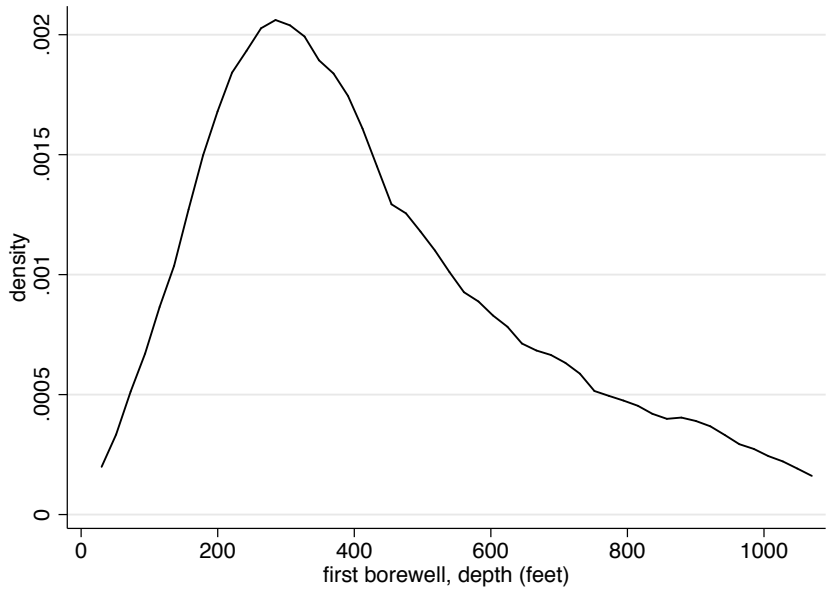
*We thank the editor and two anonymous referees, Shilpa Aggarwal, Tamma Carleton, John Ham, Solomon Hsiang, Avinash Kishore, Deepak Malghan, Reed Walker, and seminar participants at U.C. Berkeley, I.I.M. Bangalore, Cornell University and the Indian School of Business for helpful comments and suggestions. We thank V.S. Prakash, K.V. Raju and G. S. Srinivasa Reddy for their support and insights. We thank the Boris Mints Institute, the International Growth Center and the International Development Research Center, Canada, for funding. We would also like to thank Divakar Naik, Omri Gerlitz, Suraj Jacob, Shruti Korada, Yoav Rothler and Karan Singh for excellent research assistance. The usual disclaimer applies. The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

†New York University (AD), NYUAD Saadiyat Island B2, Abu Dhabi 129188, UAE, david.blakeslee@nyu.edu

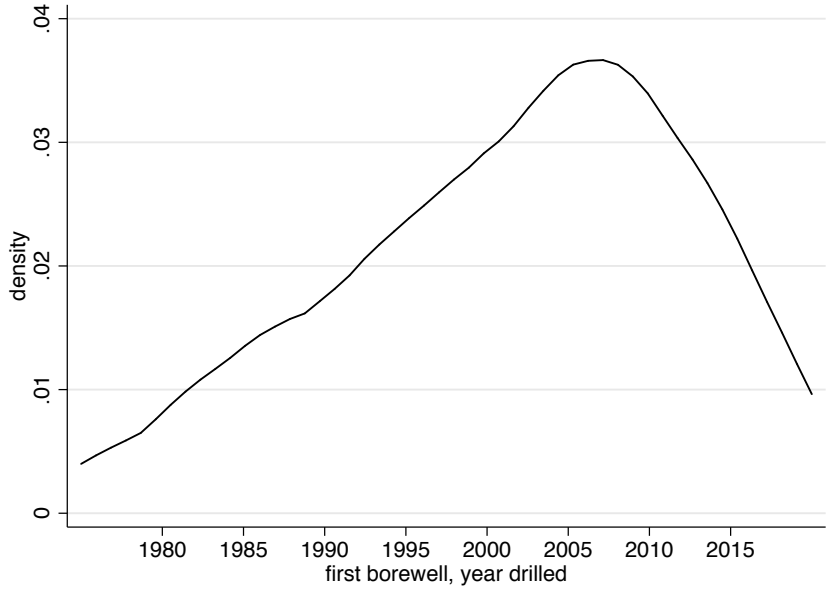
‡Tel Aviv University, Peretz Naftali Building, Chaim Levanon St 30, Tel Aviv-Yafo 6997801, Israel, ramf@tauex.tau.ac.il

§ATREE, Royal Enclave, Srirampura, Jakkur, Bengaluru, Karnataka 560064, India, veena.srinivasan@atree.org

Figure A1: First Borewell, Depth and Year



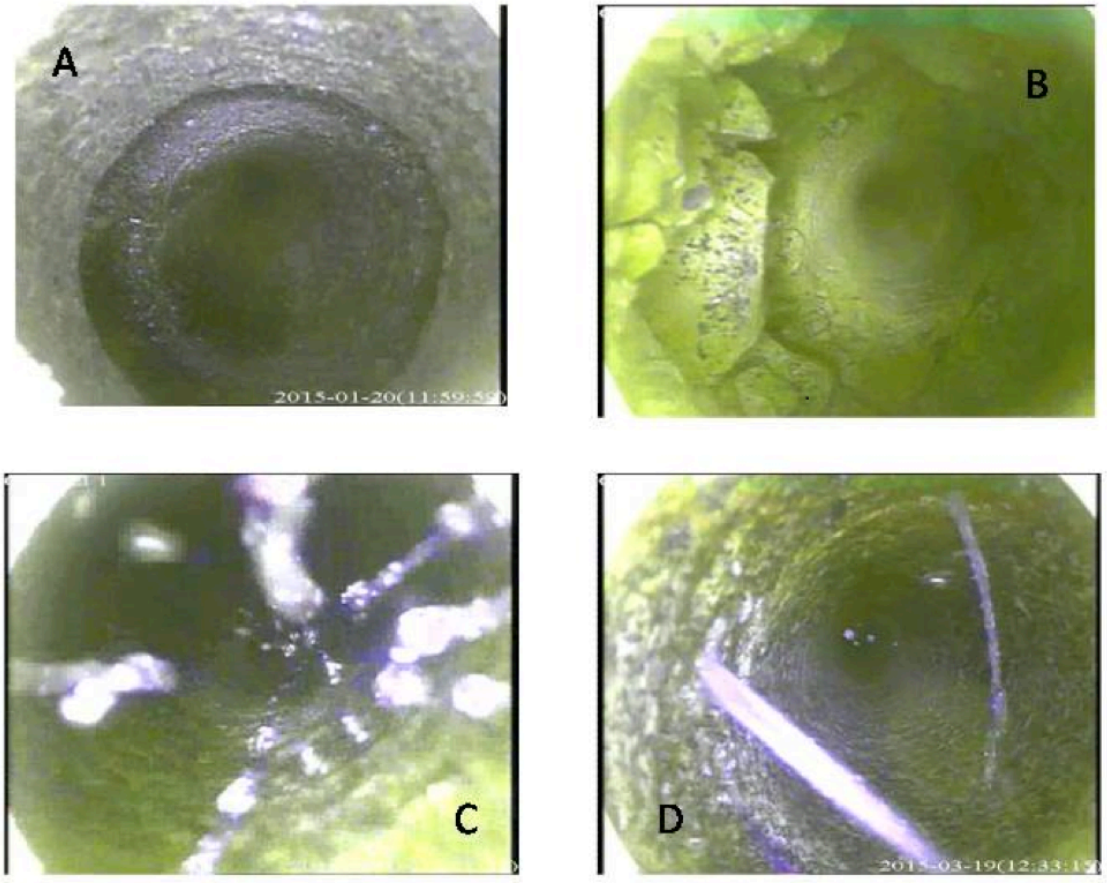
A1.1: Depth



A1.2: Year Drilled

Notes: Figure A1.1 shows the distribution of the depth of the first borewell. Figure A1.2 shows the distribution of the year in which the first borewell was drilled.

Figure A2: Borewell images



Notes: Figure A2 shows images taken from four borewells in the study area. A: Dry fracture in bedrock. B: Cavity formed in a fracture, now dried up. C: Fracture with cavity below the water level. D: Water-bearing shallow fracture, spout cascading down the well.

Table A1: Balance w.r.t. Borewell Characteristics

	All BWs	First BW			
	Number	Log Depth	Log Cost	Flow	Imm. Fail
	(1)	(2)	(3)	(4)	(5)
HH Head					
Hindu	-0.110 [0.300]	-0.096 [0.079]	0.081 [0.176]	-0.089 [0.283]	-0.144 [0.131]
Non-Marginal Caste	0.336 [0.143]	-0.004 [0.031]	-0.026 [0.065]	-0.038 [0.089]	0.018 [0.058]
Male	0.191 [0.122]	-0.070 [0.037]	-0.102 [0.059]	-0.086 [0.070]	0.071 [0.052]
Age	-0.003 [0.004]	-0.001 [0.001]	0.001 [0.002]	-0.000 [0.003]	0.001 [0.002]
Literate	0.184 [0.119]	-0.019 [0.030]	-0.066 [0.054]	0.058 [0.070]	-0.011 [0.051]
Education - none	-0.185 [0.119]	0.019 [0.030]	0.069 [0.055]	-0.064 [0.070]	0.011 [0.051]
Education - primary	-0.026 [0.158]	-0.027 [0.048]	0.004 [0.094]	0.037 [0.096]	-0.038 [0.082]
Education - secondary	0.217 [0.150]	0.002 [0.046]	-0.100 [0.066]	0.129 [0.092]	0.047 [0.078]
Education - post-secondary	0.067 [0.142]	-0.023 [0.036]	-0.048 [0.053]	-0.048 [0.074]	0.040 [0.056]
Number Children					
Aged 6-11	0.159 [0.065]	0.022 [0.016]	-0.009 [0.025]	-0.004 [0.030]	-0.000 [0.027]
Aged 12-18	0.125 [0.089]	0.026 [0.015]	-0.016 [0.026]	-0.022 [0.035]	0.006 [0.024]
Adult Sons	0.191 [0.125]	-0.044 [0.037]	-0.051 [0.057]	-0.116 [0.069]	0.070 [0.052]
Assets (at time 1st BW Drilled)					
Seed Drill	0.089 [0.149]	0.025 [0.040]	-0.002 [0.064]	-0.132 [0.074]	0.084 [0.063]
Tractor	1.284 [0.853]	0.077 [0.076]	0.129 [0.134]	-0.099 [0.175]	0.023 [0.125]
Thresher	1.536 [0.638]	-0.230 [0.272]	-0.164 [0.544]	-0.265 [0.245]	0.061 [0.407]
Motorcycle	0.315 [0.206]	0.034 [0.053]	0.021 [0.074]	0.023 [0.095]	-0.011 [0.069]
Inherited Land (acres)	0.065 [0.013]	-0.007 [0.003]	-0.014 [0.004]	-0.002 [0.005]	0.004 [0.004]
Agriculture (at time 1st BW Drilled)					
Cash Crops	-0.153 [0.148]	0.039 [0.036]	-0.015 [0.066]	-0.108 [0.073]	-0.034 [0.063]
Irrigation	0.089 [0.149]	0.025 [0.040]	-0.002 [0.064]	-0.132 [0.074]	0.084 [0.063]
Village F.E.	Yes	Yes	Yes	Yes	Yes
First-BW Year-Drilled F.E.	Yes	Yes	Yes	Yes	Yes

Note: Household characteristics and household drilling history. Each column reports estimates from a separate regression of the total number of borewells drilled (Column (1)) and characteristics of the first borewell (depth, cost, initial flow in mm, and whether the well had failed immediately, Columns (2)–(5)) on household characteristics indicated in the left column. All specifications include village fixed effects and fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.

Table A2: Borewell Failure

	First Borewell Failed (binary)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Age First BW	0.127	0.103		0.118	0.088	
	[0.024]	[0.029]		[0.024]	[0.028]	
Log Depth First BW	0.080	0.049	0.054			
	[0.034]	[0.047]	[0.050]			
Log Cost First BW				-0.025	-0.044	-0.047
				[0.024]	[0.028]	[0.029]
HH Head Literate	-0.013	-0.024	-0.023	0.001	-0.025	-0.025
	[0.038]	[0.036]	[0.038]	[0.038]	[0.036]	[0.037]
HH Head Age	0.000	-0.001	-0.000	0.000	-0.001	-0.000
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
HH Head Non-Marginal Caste	0.045	0.016	0.012	0.055	0.017	0.014
	[0.039]	[0.042]	[0.044]	[0.038]	[0.042]	[0.043]
Inherited Land (acres)	-0.002	0.002	0.002	-0.004	0.001	0.001
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
R-squared	0.059	0.193	0.239	0.055	0.195	0.242
N	892	891	876	892	891	876
Village F.E.		Yes	Yes		Yes	Yes
First-BW Year-Drilled F.E.			Yes			Yes

Note: Estimated correlates of first borewell failure. Each column reports estimates from a separate regression of an indicator of first borewell failure on the variables indicated in the left column. Columns (2), (3), (5), and (6) include village fixed effects, and Columns (3) and (6) include fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.

Table A3: Borewell Failure (Well Census)

	Borewell Failed	
	(1)	(2)
Number of Sources	-0.068	-0.063
	[0.024]	[0.024]
Log Age	0.259	0.222
	[0.023]	[0.030]
Log Depth		-0.081
		[0.043]
Constant	0.277	0.494
	[0.081]	[0.140]
R-squared	0.212	0.237
N	434	434

Note: Estimates of a regression of a binary indicator of borewell failure on the number of sources intercepted by the well. The sample consists of a census of all operational and failed borewells in a cluster of villages in the study region. See section 3.2 for details. Error terms are assumed to be iid. Standard errors in brackets.

Table A4: Borewell Failure and Labor Reallocation by Gender

	Control Mean	Impact of BW Failure	
	(1)	(2)	(3)
Panel A: Fraction of Adult Males (Dry Season)			
Working on Own Farm	0.634	-0.112	-0.114
		[0.030]	[0.031]
Working Off-Farm, Agriculture	0.165	0.065	0.068
		[0.031]	[0.030]
Working Off-Farm, Non-Agriculture	0.070	0.056	0.059
		[0.021]	[0.023]
Not Working	0.080	0.029	0.040
		[0.015]	[0.014]
Non-Migrant Working Outside Village	0.083	0.031	0.028
		[0.019]	[0.020]
Semi-Permanent Migrant (Annual)	0.012	0.020	0.021
		[0.008]	[0.009]
Panel B: Fraction of Adult Females (Dry Season)			
Working on Own Farm	0.370	-0.065	-0.077
		[0.032]	[0.033]
Working Off-Farm, Agriculture	0.078	0.056	0.059
		[0.023]	[0.023]
Working Off-Farm, Non-Agriculture	0.014	0.022	0.025
		[0.008]	[0.010]
Not Working	0.108	0.012	0.012
		[0.017]	[0.018]
Non-Migrant Working Outside Village	0.028	0.016	0.015
		[0.010]	[0.011]
Semi-Permanent Migrant (Annual)	0.006	0.005	0.006
		[0.005]	[0.006]
Village F.E.		Yes	Yes
First-BW Year-Drilled F.E.			Yes

Note: This table shows the estimated impacts of first borewell failure on outcomes indicated at the leftmost column. Each estimate is derived from a separate regression. Column (1) gives the mean level of the outcome variable in households that drilled a borewell and did not experience a first-borewell failure. Columns (2) and (3) report estimates of the coefficient α_2 in specification 1. All regressions include controls for household head literacy, age, caste, and the amount of inherited land, as well as village fixed effects. Column (3) includes fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.

Table A5: Individual Assets

	Control Mean	Impact of BW Failure	
	(1)	(2)	(3)
Number of Asset			
Cattle	1.728	-0.301	-0.297
		[0.160]	[0.179]
Bicycle	0.531	-0.074	-0.070
		[0.041]	[0.044]
Motorcycle	0.609	-0.028	-0.027
		[0.044]	[0.045]
Car	0.036	0.004	0.006
		[0.016]	[0.015]
Refrigerator	0.173	-0.077	-0.078
		[0.027]	[0.028]
TV	0.887	-0.030	-0.009
		[0.027]	[0.026]
Gold (ounces)	32.024	-20.816	-22.983
		[8.204]	[9.214]
Village F.E.		Yes	Yes
First-BW Year-Drilled F.E.			Yes

Note: This table shows the estimated impacts of first borewell failure (Columns 2 and 3) on outcomes indicated at the leftmost column. "Cattle" is the aggregation of bullocks, buffloes, and cows. Each estimate is derived from a separate regression. Column (1) gives the mean level of the outcome variable in households that drilled a borewell and did not experience a first-borewell failure. Columns (2) and (3) report estimates of the coefficient α_2 in specification 1. All regressions include controls for household head literacy, age, caste, and the amount of inherited land, as well as village fixed effects. Column (3) includes fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.

Table A6: Controlling for Borewell Characteristics

	Impact of BW Failure			
	Benchmark	First Borewell Controls		
	(1)	(2)	(3)	(4)
Fraction of HH Members (Dry Season)				
Working on Own Farm	-0.104	-0.101	-0.095	-0.089
	[0.025]	[0.027]	[0.028]	[0.029]
Working Off-Farm, Agriculture	0.064	0.065	0.055	0.055
	[0.021]	[0.022]	[0.022]	[0.022]
Working Off-Farm, Non-Agriculture	0.042	0.042	0.041	0.038
	[0.014]	[0.014]	[0.014]	[0.014]
Not Working	0.029	0.028	0.024	0.025
	[0.014]	[0.014]	[0.015]	[0.015]
Non-Migrant Working Outside Village	0.028	0.027	0.028	0.025
	[0.014]	[0.015]	[0.015]	[0.015]
Semi-Permanent Migrant (Anuual)	0.014	0.014	0.017	0.017
	[0.007]	[0.008]	[0.007]	[0.008]
Income (1,000 Rs.)				
On-Farm	-14.083	-15.322	-12.473	-12.223
	[6.325]	[6.672]	[6.786]	[6.870]
Off-Farm	12.182	11.474	12.217	11.869
	[6.017]	[6.313]	[6.398]	[6.672]
Total	-1.900	-3.848	-0.256	-0.355
	[9.500]	[9.826]	[10.359]	[10.387]
Village F.E.	Yes	Yes	Yes	Yes
First-BW Year-Drilled F.E.	Yes	Yes	Yes	Yes
Log BW Depth	No	Yes	No	Yes
Log BW Cost	No	No	Yes	Yes

Note: Estimated impacts of first borewell failure on outcomes indicated at the leftmost column. Each estimate is derived from a separate regression (the coefficient α_2 in specification 1). Column (1) reports estimates from the benchmark standard specficiation. Column (2) controls for the depth of the first borewell, Column (3) controls for the cost of the first borewell, and Column (4) controls for both. All regressions include controls for household head literacy, age, caste, and the amount of inherited land, as well as village fixed effects and fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.

Table A7: Robustness Test: Alternative Time Controls

	Impact of BW Failure			
	First BW Year-Drilled Controls:			
	Year F.E.		5-Year Intervals	
	(1)	(2)	(3)	(4)
Fraction of HH Members (Dry Season)				
Working on Own Farm	-0.104	-0.112	-0.099	-0.108
	[0.025]	[0.029]	[0.025]	[0.026]
Working Off-Farm, Agriculture	0.064	0.032	0.057	0.053
	[0.021]	[0.024]	[0.019]	[0.021]
Working Off-Farm, Non-Agriculture	0.042	0.058	0.038	0.043
	[0.014]	[0.015]	[0.013]	[0.014]
Not Working	0.029	0.034	0.026	0.024
	[0.014]	[0.019]	[0.013]	[0.014]
Non-Migrant Working Outside Village	0.028	0.037	0.029	0.029
	[0.014]	[0.018]	[0.013]	[0.015]
Semi-Permanent Migrant (Annual)	0.014	0.019	0.013	0.010
	[0.007]	[0.008]	[0.006]	[0.006]
Income (1,000 Rs.)				
On-Farm	-14.083	-17.639	-15.947	-14.746
	[6.325]	[6.892]	[6.126]	[5.808]
Off-Farm	12.182	18.635	9.284	11.719
	[6.017]	[7.754]	[5.652]	[5.830]
Total	-1.900	0.996	-6.663	-3.027
	[9.500]	[9.863]	[8.772]	[8.165]
Village F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes			
District F.E. X Year F.E.		Yes		
5-Year Bins			Yes	
District F.E. X 5-Year Bins				Yes

Note: Estimated impacts of first borewell failure on outcomes indicated at the leftmost column. Each estimate is derived from a separate regression (the coefficient α_2 in specification 1). Columns (1), (3), and (5) give the estimates when including, respectively, fixed effects for the year in which the first borewell was drilled, the log age of the first borewell, and fixed effects for 5-year bins in which the first borewell was drilled. Columns (2), (4), and (6) include interactions of the district fixed effects with the above three controls for the year in which the first borewell was drilled. All specifications include controls for household head literacy, age, caste, and inherited land; as well as village fixed effects. Error terms are assumed to be clustered at the village level.

Table A8: Robustness Test: Immediate and Non-Immediate Failures

	Impact of BW Failure		
		Failed Borewell Sample:	
	Benchmark	Non-Immed.	Immediate
	(1)	(2)	(3)
Fraction of HH Members (Dry Season)			
Working on Own Farm	-0.104	-0.086	-0.117
	[0.025]	[0.033]	[0.029]
Working Off-Farm, Agriculture	0.064	0.053	0.068
	[0.021]	[0.024]	[0.030]
Working Off-Farm, Non-Agriculture	0.042	0.039	0.037
	[0.014]	[0.016]	[0.017]
Not Working	0.029	0.025	0.045
	[0.014]	[0.019]	[0.018]
Non-Migrant Working Outside Village	0.028	0.027	0.027
	[0.014]	[0.017]	[0.018]
Semi-Permanent Migrant (Annual)	0.014	0.013	0.012
	[0.007]	[0.005]	[0.011]
Income (1,000 Rs.)			
On-Farm	-14.083	-15.810	-11.470
	[6.325]	[7.879]	[7.085]
Off-Farm	12.182	7.693	14.461
	[6.017]	[6.261]	[10.263]
Total	-1.900	-8.118	2.991
	[9.500]	[9.914]	[13.639]
Village F.E.	Yes	Yes	Yes
First-BW Year-Drilled F.E.	Yes	Yes	Yes
Num of First-BW Failures	582	347	240
Num of First-BW Non-Failures	305	305	305

Note: Estimated impacts of first borewell failure on outcomes indicated at the leftmost column. Each estimate is derived from a separate regression (the coefficient α_2 in specification 1). Column (1) gives the benchmark estimates derived from the entire sample. Column (2) restricts the sample of failed first borewells only to those which did not fail within the first year; and column (3) restricts the sample of failed first borewells only to those which did fail within the first year. All specifications include controls for household head literacy, age, caste, and inherited land; as well as village fixed effects and fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.

Table A9: Heterogeneous Effects by Local Economic Development

	Impact of BW Failure		
	Development		
	Low	High	Difference
	(1)	(2)	(3)
Children Aged 6–11			
Fraction Enrolled	0.016	0.220	0.204
	[0.081]	[0.078]	[0.113]
Fraction Working	-0.004	0.000	0.004
	[0.010]	[0.000]	[0.011]
Children Aged 12–18			
Fraction Enrolled	-0.063	-0.160	-0.097
	[0.053]	[0.077]	[0.093]
Fraction Working	0.017	0.150	0.133
	[0.046]	[0.063]	[0.078]
Village F.E.	Yes	Yes	Yes
First-BW Year-Drilled F.E.	Yes	Yes	Yes

Note: Estimated impacts of first borewell failure on outcomes indicated at the leftmost column, segregated by local rates of economic development. Each estimate is derived from a separate regression. Column (1) reports estimates of the coefficient α_2 in specification 1 limiting the sample to villages in which fewer than 171 individuals work for firms with 15 or more employees within 5 kilometers ("low development"); and in Column (2) to villages with more than 171 individuals working for such firms ("high development"). Column (3) reports the coefficient for an interaction term of first-borewell failure and a dummy indicating high development areas, where the sample includes all villages. All regressions include controls for household head literacy, age, caste, and the amount of inherited land, which are interacted with the high-development indicator in the Column (3) regressions. All regressions also include village fixed effects and fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.

Table A10: Heterogeneous Effects by Local Groundwater Situation

	Impact of BW Failure		
	BW Failure Rate		
	High	Low	Difference
	(1)	(2)	(3)
Fraction of HH Members (Dry Season)			
Working on Own Farm	-0.139	-0.080	0.059
	[0.035]	[0.035]	[0.049]
Working Off-Farm, Agriculture	0.054	0.066	0.013
	[0.026]	[0.037]	[0.045]
Working Off-Farm, Non-Agriculture	0.049	0.045	-0.004
	[0.019]	[0.019]	[0.027]
Not working	0.013	0.030	0.017
	[0.024]	[0.015]	[0.028]
Non-Migrant Working Outside Village	0.047	0.019	-0.028
	[0.021]	[0.020]	[0.029]
Semi-Permanent Migrant (Annual)	0.009	0.025	0.015
	[0.006]	[0.014]	[0.015]
Income (1,000 Rs.)			
On-Farm	-18.034	-20.051	-2.016
	[9.148]	[8.929]	[12.735]
Off-Farm	16.542	9.432	-7.110
	[10.782]	[6.521]	[12.554]
Total	-1.492	-10.619	-9.127
	[14.591]	[11.526]	[18.525]
Village F.E.	Yes	Yes	Yes
First-BW Year-Drilled F.E.	Yes	Yes	Yes

Note: Estimated impacts of first borewell failure on outcomes indicated at the leftmost column, segregated by local rates of economic development. Each estimate is derived from a separate regression. Column (1) reports estimates of the coefficient α_2 in specification 1 limiting the sample to villages in which more than 57% of households ever drilled a borewell lacked an operational borewell at the time of the survey ("high failure"); and in Column (2) to villages in which less than 57% lacked an operational borewell ("low failure"). Column (3) reports the coefficient for an intection term of first-borewell failure and a dummy indicating low-failure areas, where the sample includes all villages. All regressions include controls for household head literacy, age, caste, and the amount of inherited land, which are interacted with the low-failure indicator in the Column (3) regressions. All regressions also include village fixed effects and fixed effects for the year in which the first borewell was drilled. Error terms are assumed to be clustered at the village level. Standard errors in brackets.