

## SUPPLEMENTAL DATA

*ASCE Journal of Water Resources Planning and Management*

# Valuation and Aspirations for Drip Irrigation in Punjab, Pakistan

Andrew Reid Bell, Patrick S Ward, Muhammad Ashfaq, and  
Stephen Davies

**DOI:** 10.1061/(ASCE)WR.1943-5452.0001181

© ASCE 2019

[www.ascelibrary.org](http://www.ascelibrary.org)

**Table S1. Descriptive statistics of sample households, by district.**

		Attock (Barani; n = 158)		Chakwal (Barani; n = 65)		Layyah (Sandy Desert B; n = 86)		Sahiwal (Northern Irrigated Plain; n = 131)	
		<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Household Information	Age	43.08	11.89	42.66	10.16	45.33	12.38	50.68	11.71
	Female Respondent	0.0063	0.0793	0.0125	0.112	0	0	0.0214	0.145
	Years Formal Education	8.78	5.05	8.062	6.719	8.979	5.687	9.9	4.886
	Literacy (0: No; 1: Somewhat; 2: Yes)	0.849	0.836	1.075	0.925	1.052	0.838	1.207	0.835
	Female HH Members	1.491	1.043	2.25	1.471	2.438	1.568	2.579	1.573
	Male HH Members	2.226	1.031	2.462	1.35	2.76	1.229	3.271	1.822
	Farm Holdings (Acres)	11.73	27.18	8.859	12.09	19.09	21.19	18.61	27.8
Cropping Patterns	Plant Cereals	0.601	0.491	0.605	0.492	0.649	0.48	0.899	0.303
	Plant Vegetables/Melons	0.0127	0.112	0.158	0.367	0	0	0.00725	0.0851
	Plant Fruit and Nuts	0.456	0.5	0.421	0.497	0.457	0.501	0.029	0.168
	Plant Oilseeds	0	0	0	0	0.0319	0.177	0.0725	0.26
	Plant Roots and Tubers	0.0063	0.0796	0	0	0	0	0.13	0.338
	Plant Beverage and Spice Crops	0.0063	0.0796	0	0	0.0106	0.103	0.0145	0.12
	Plant Legumes	0	0	0.0263	0.161	0.149	0.358	0.0217	0.146
	Plant Sugar Crops	0	0	0	0	0.0213	0.145	0.00725	0.0851
	Plant Fiber Crops	0	0	0	0	0.415	0.495	0.543	0.5
Plant Other Crops	0.0127	0.112	0.0132	0.115	0.255	0.438	0.435	0.498	
Constraints	Had to fallow fields due to lack of water	0.459	0.5	0.338	0.476	0.146	0.355	0.0643	0.246

	Avoided drip irrigation due to cost or electricity constraint	0.333	0.473	0.3	0.461	0.385	0.489	0.529	0.501
Water Characteristics	Use canal water	0	0	0	0	0.167	0.375	0.671	0.471
	Use rainwater	0.491	0.501	0.65	0.48	0.0521	0.223	0	0
	Use well	0.371	0.485	0	0	0.417	0.496	0.243	0.43
	Use borehole	0.264	0.442	0.325	0.471	0.406	0.494	0.0786	0.27
	Annual groundwater spending (Rs. 100,000)	1.497	2.739	0.613	1.123	2.316	2.203	2.097	3.877
Drip System Experience	Non-users	0.52	0.50	0.50	0.50	0.63	0.49	0.92	0.27
	New users	0.35	0.48	0.29	0.46	0.17	0.37	0.07	0.26
	Old users	0.14	0.35	0.21	0.41	0.21	0.41	0.01	0.08

**Table S2. Experiences with and perceptions of drip irrigation systems**

System characteristic	Current drip Users		Current non-users		t-test p-value	KS test p-value
	Mean	Standard deviation	Mean	Standard deviation		
Gross installation costs (per acre)	121,162.40	86,788.94	146,194.50	91,591.37	0.002	2.63e <sup>-10</sup>
Subsidy (per acre)	77,208.27	79,511.63	71,889.07	50,741.96	0.188	0.004
Technical/knowledge support offered (years)	1.38	0.58	1.10	0.67	3.87e <sup>-6</sup>	3.61e <sup>-4</sup>
Maintenance support offered (years)	1.29	0.65	1.07	0.68	0.001	8.86e <sup>-4</sup>

**Table S3. Percentage of farmers currently growing various crops.**

	Cereals	Vegetables and Melons	Fruits and Nuts	Oilseeds	Roots and Tubers	Beverage and Spice	Legume	Sugarcane	Fiber Crops	Other Crops
Attock (n=158)	0.601	0.013	0.456	0	0.006	0.006	0	0	0	0.013
Chakwal (n=65)	0.677	0.046	0.492	0	0	0	0	0	0	0.015
Layyah (n=86)	0.663	0	0.500	0	0	0	0.105	0.023	0.430	0.279
Sahiwal (n=131)	0.908	0	0.031	0.061	0.107	0.008	0.015	0.008	0.550	0.450
Total	0.716	0.011	0.343	0.018	0.034	0.005	0.025	0.007	0.248	0.195

**Table S4 Percentage of farmers indicating aspirations to increase cultivation of various crops.**

	Cereals	Vegetables and Melons	Fruits and Nuts	Oilseeds	Roots and Tubers	Beverage and Spice	Legume	Sugarcane	Fiber Crops	Other Crops
Attock (n=158)	0.032	0.013	0.620	0.006	0	0.063	0	0	0	0
Chakwal (n=65)	0.046	0.185	0.508	0.015	0	0	0	0	0	0
Layyah (n=86)	0.012	0.105	0.407	0.093	0	0.128	0.012	0	0.023	0
Sahiwal (n=131)	0.366	0.321	0.038	0.153	0.137	0.458	0.160	0	0.008	0
Total	0.130	0.148	0.389	0.068	0.041	0.184	0.050	0	0.007	0

**Table S5. Percentage of farmers indicating an aspiration to reduce cultivation of various crops.**

	Cereals	Vegetables and Melons	Fruits and Nuts	Oilseeds	Roots and Tubers	Beverage and Spice	Legume	Sugarcane	Fiber Crops	Other Crops
Attock (n=158)	0.089	0	0.006	0	0	0	0	0	0	0
Chakwal (n=65)	0.031	0	0	0	0	0	0	0	0	0
Layyah (n=86)	0.023	0	0	0	0	0	0	0	0	0
Sahiwal (n=131)	0.275	0	0	0	0.008	0	0	0	0.038	0
Total	0.123	0	0.002	0	0.002	0	0	0	0.011	0

**Table S6. Proportion of sample farmers reporting different agricultural aspirations across any two choice scenarios**

	Choice 1	Choice 2	Choice 3	Choice 4	Choice 5
Choice 1					
Choice 2	0.198				
Choice 3	0.222	0.195			
Choice 4	0.235	0.200	0.214		
Choice 5	0.248	0.212	0.197	0.202	
Choice 6	0.206	0.203	0.193	0.187	0.159



**Table S7. Correlates with estimated conditional marginal utilities**

	(1A)	(1B)	(2A)	(2B)	(3A)	(3B)	(4A)	(4B)	(5A)	(5B)
VARIABLES	MU coverage area	MU coverage area	MU Cost (negative)	MU Cost (negative)	MU subsidy	MU subsidy	MU maintenance support	MU maintenance support	MU knowledge support	MU knowledge support
Constant	-0.132	-0.214	- 3.662* **	- 3.952* **	3.377* **	3.447* **	0.150	0.140	0.506* **	0.588* **
Non-user x Attock	- 0.029 5	- 0.0574	- 0.0079 1	- 0.0107	0.0022 2	- 0.0318	0.180**	0.192**	-0.0283	-0.0780
New user x Attock	0.155	0.0516	- 0.0650	- 0.0947	0.0619	- 0.0127	0.117	0.0888	-0.0728	-0.119
Old user x Attock	0.349 ***	0.229* *	1.403* **	1.329* **	-0.249	-0.323	0.139	0.115	- 0.198* *	- 0.256* **
Non user x Chakwal	0.032	0.015	0.276	0.312	0.315*	0.293	-0.0613	-0.0655	-0.110	-0.154
New user x Chakwal	0.550 ***	0.456* **	1.747* **	1.892* **	0.818* **	0.640* **	0.0889	0.0329	-0.112	-0.117
Old user x Chakwal	0.483 ***	0.297* **	1.382* **	1.297* **	0.415	0.210	0.151	0.103	-0.0887	-0.106
Non user x Layyah	- 0.171 **	- 0.188* *	- 0.709* *	- 0.659* *	0.161	0.146	0.0105	-0.0334	0.154* *	0.118*
New user x Layyah	0.438 ***	0.347* **	0.997* *	0.926* *	0.742* **	0.706* **	0.0834	0.0272	-0.0667	-0.0946
Old user x Layyah	0.231 **	0.107	0.561	0.458	-0.151	0.0740	0.153*	0.0744	0.111	0.0967

Cereals	0.007 26		- 0.0555		0.231* *		0.0240		0.130* **	
Vegetables and melons	- 0.090 5		0.335		- 0.470* *		-0.0994		0.111	
Fruits and nuts	-0.121		-0.101		- 0.0205		-0.0130		0.0474	
Oilseeds	0.107		0.537		0.258		0.104		-0.0246	
Fiber crops	- 0.134 **		-0.321		- 0.240* *		-0.0419		-0.0430	
Would grow more cereals		0.237* **		0.798* **		0.138		- 0.162** *		0.108*
Would grow more vegetables and melons		0.0979 *		0.0585		0.159		0.0379		-0.0663
Would grow more fruits and nuts		0.261* **		0.514* **		0.160* *		-0.00634		0.0251
Would grow more oilseeds		0.0230		0.226		- 0.454* *		0.131*		-0.0549
Would substitute vegetables and melons for cereals		- 0.0305		-0.406		0.279		- 0.272** *		0.0475
Would substitute fruits and nuts for cereals		- 0.0378		-0.106		0.339* *		-0.0801		0.0261
Would substitute oilseeds for cereals		0.0138		-0.739		0.955* **		-0.126		0.0637

Would substitute beverages and spices for cereals		0.112		0.333		0.442**		0.00479		-0.234**
Land fallowed because of dry conditions	0.0928*	0.0884*	0.309*	0.334*	0.222*	0.170*	-0.00730	-0.0194	0.0343	0.0252
Irrigation limited because of cost or unreliable electricity	0.208***	0.133**	0.630**	0.457**	0.273**	0.221**	0.0836*	0.0936*	-0.00819	-0.00395
Water source: canal	0.115	0.104	0.653*	0.578*	0.248	0.281*	0.0714	0.115*	-0.154*	-0.155*
Water source: rainfed	-0.168**	-0.148*	-0.301	-0.303	-0.120	0.0355	-0.0204	-0.00261	-0.154*	-0.0867
Water source: tubewell	0.0681	0.0677	0.654*	0.660*	0.0314	0.0744	0.125*	0.135*	-0.197**	-0.153*
Water source: borehole	0.108	0.128*	0.545*	0.581*	0.245	0.310*	-0.0207	-0.0107	-0.140*	-0.0905
Groundwater cost	-0.0006	-0.00631	-0.00335	-0.0108	0.0301	0.0226	-0.00332	-0.000334	0.00598	0.00458
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	465	465	465	465	465	465	465	465	465	465
R-squared	0.220	0.292	0.179	0.220	0.248	0.271	0.112	0.141	0.106	0.107
AIC	440.4	401	1673	1655	1018	1009	308.5	299.3	379.8	385.5
BIC	564.7	537.7	1797	1792	1142	1146	432.8	436	504.1	522.2

Notes: \*\*\* significant with 1 percent probability of Type I error; \*\* significant with 5 percent probability of Type I error; \* significant with 10 percent probability of Type I error. Standard errors adjusted for clustering at the district level.

Table S8: P-values for Wald tests of differences in regression coefficients for drip experience, by district.

		<b>Coverage</b>	<b>Cost</b>	<b>Subsidy</b>	<b>Maintenance Support</b>	<b>Knowledge Support</b>
<b>Attock</b>	<i>Non- and New</i>	Same (p = 0.1822)	Same (p = 0.7724)	Same (p = 0.8939)	Same (p = 0.184)	Same (p = 0.6256)
	<i>Non- and Old</i>	Increasing (p = 0.0058)	Increasing (p = 0.0036)	Same (p = 0.2194)	Same (p = 0.4607)	Decreasing (p = 0.0146)
	<i>New and Old</i>	Same (p = 0.0577)	Increasing (p = 0.0012)	Same (p = 0.2094)	Same (p = 0.7946)	Same (p = 0.1204)
<b>Chakwal</b>	<i>Non- and New</i>	Increasing (p = 0)	Increasing (p = 0)	Increasing (p = 0.0442)	Same (p = 0.4371)	Same (p = 0.7163)
	<i>Non- and Old</i>	Increasing (p = 0.0101)	Increasing (p = 0.0095)	Same (p = 0.7988)	Same (p = 0.1091)	Same (p = 0.6836)
	<i>New and Old</i>	Same (p = 0.0784)	Same (p = 0.0559)	Same (p = 0.117)	Same (p = 0.5191)	Same (p = 0.9096)
<b>Layyah</b>	<i>Non- and New</i>	Increasing (p = 0)	Increasing (p = 0.0003)	Increasing (p = 0.0106)	Same (p = 0.5344)	Decreasing (p = 0.0185)
	<i>Non- and Old</i>	Increasing (p = 0.0061)	Increasing (p = 0.014)	Same (p = 0.2149)	Same (p = 0.1267)	Same (p = 0.8826)
	<i>New and Old</i>	Decreasing (p = 0.0334)	Same (p = 0.3069)	Decreasing (p = 0.0016)	Same (p = 0.6289)	Same (p = 0.1163)