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The impacts of piped water on water quality, sanitation, hygiene and health in rural households of north-western Bangladesh - a quasi-experimental analysis

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Problem Statement

- More than 0.7 billion people (**9% of the world's population**) do not have access to improved drinking water sources (United Nations, 2015).

- **Water quality** at the point of source (POS) and at the point of use (POU) differs because of improper handling with uncleaned container during transportation. Piped water can bridge the gap.

- A proper **water management system** in the household is required along with proper sanitation and hygiene as the health outcomes depend it (Kremer, Leino, Miguel, and Zwane, 2011)

- So, to maintain and develop **human capital**, constant investment in water and sanitation **(WATSAN) infrastructure** is required, along with investment in effecting behavioral and cultural changes.

Problem Statement

- Having **insufficient water** has negative consequences on hygiene behavior, diarrhea and nutritional status of under-five children (van der Hoek, Feenstra, and Konradsen, 2002).

- Installing water filters and building **high-quality piped water systems** with sewer connections are better at reducing **diarrhea** cases than other kinds of intervention (Wolf et al., 2014).

- An adequate amount of water from a **piped water network** allows for more **leisure time and higher productivity** by reducing the burden of water collection Devoto *et al.* (2012)

Research question

To what extent the piped water from the public intervention affect water-sanitation-hygiene and health outcomes of marginalized rural households in north-western Bangladesh.

Contribution of this paper

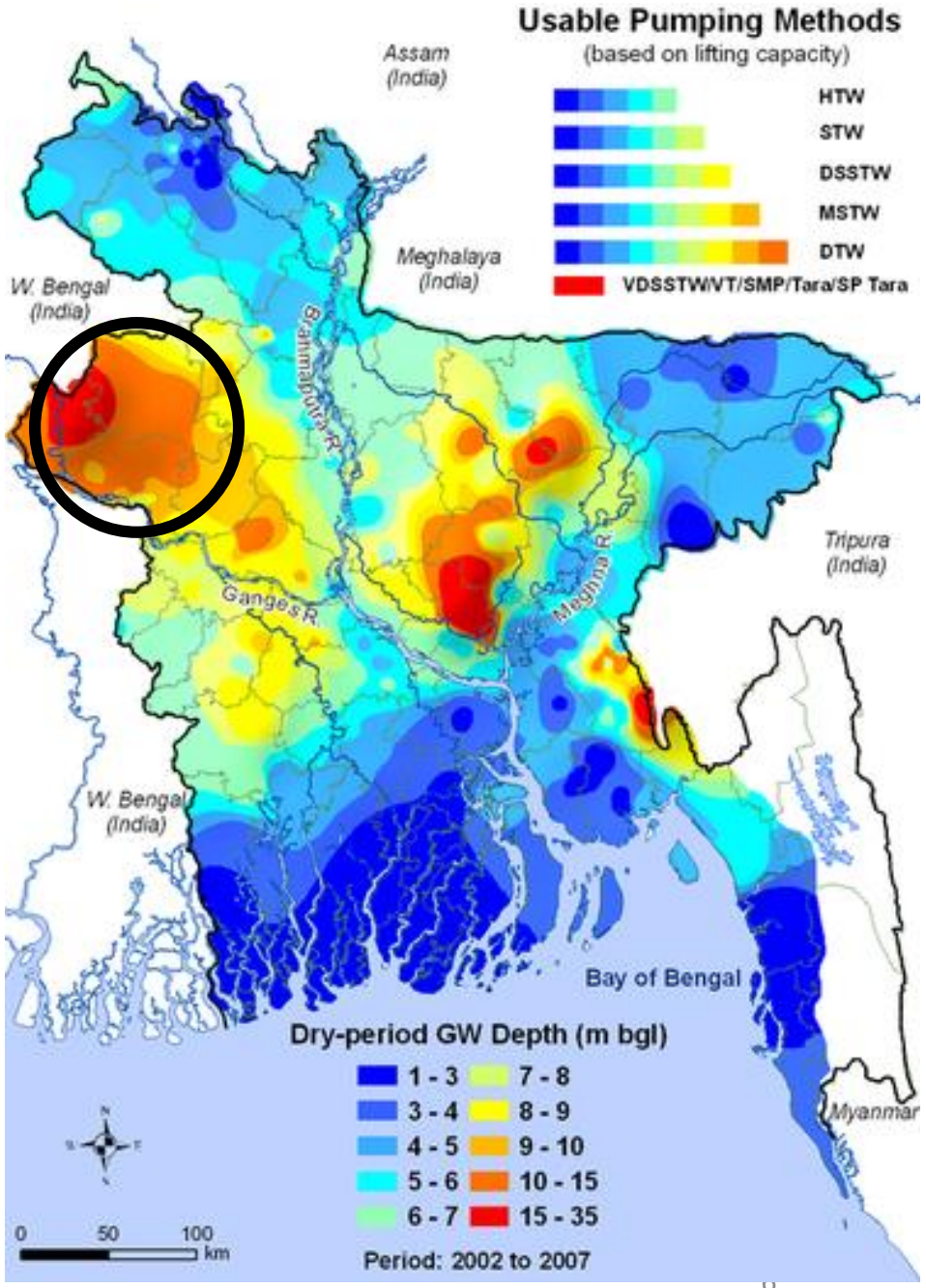
- The impact of piped water on health has been documented in several studies under different conditions (Devoto et al., 2012; Gamper-Rabindran, Khan, and Timmins, 2010; Jalan and Ravallion, 2003; Klasen, Lechtenfeld, Meier, and Rieckmann, 2012).

- Deveto et al. (2012) and Klasen et al. (2012) highlighted their work in urban setting and Gamper-Rabindran et al. (2010) worked on only child mortality in Brazil. Jalan and Ravallion (2003) worked in rural setting but ignored the water quality issues.

- This paper studied the health impact of **using piped water** in a **marginalized rural setting** and investigated the **microbiological quality of water and kitchen utensils**, which is a unique aspect of this study.

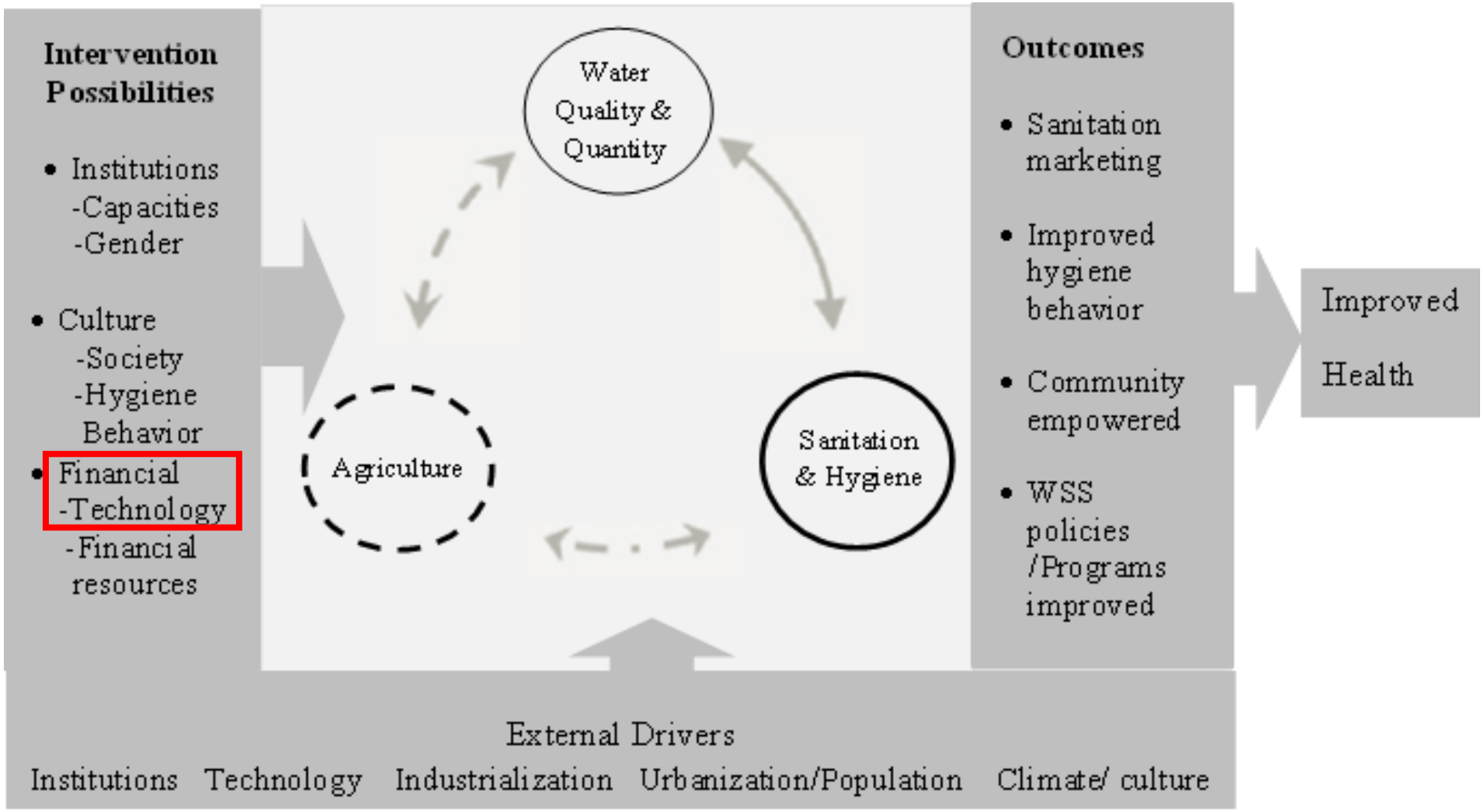
Study Area

- Ground water in the north-western Bangladesh is scarce because of the higher rate of depletion.
- Barindra Multipurpose Development Authority (BMDA), a govt. organization, started initiatives to support irrigation as well as supplying drinking water by establishing deep tube-well in this area.
- Many households in this area have access to piped water in their premises which is claimed as potable water by BMDA.



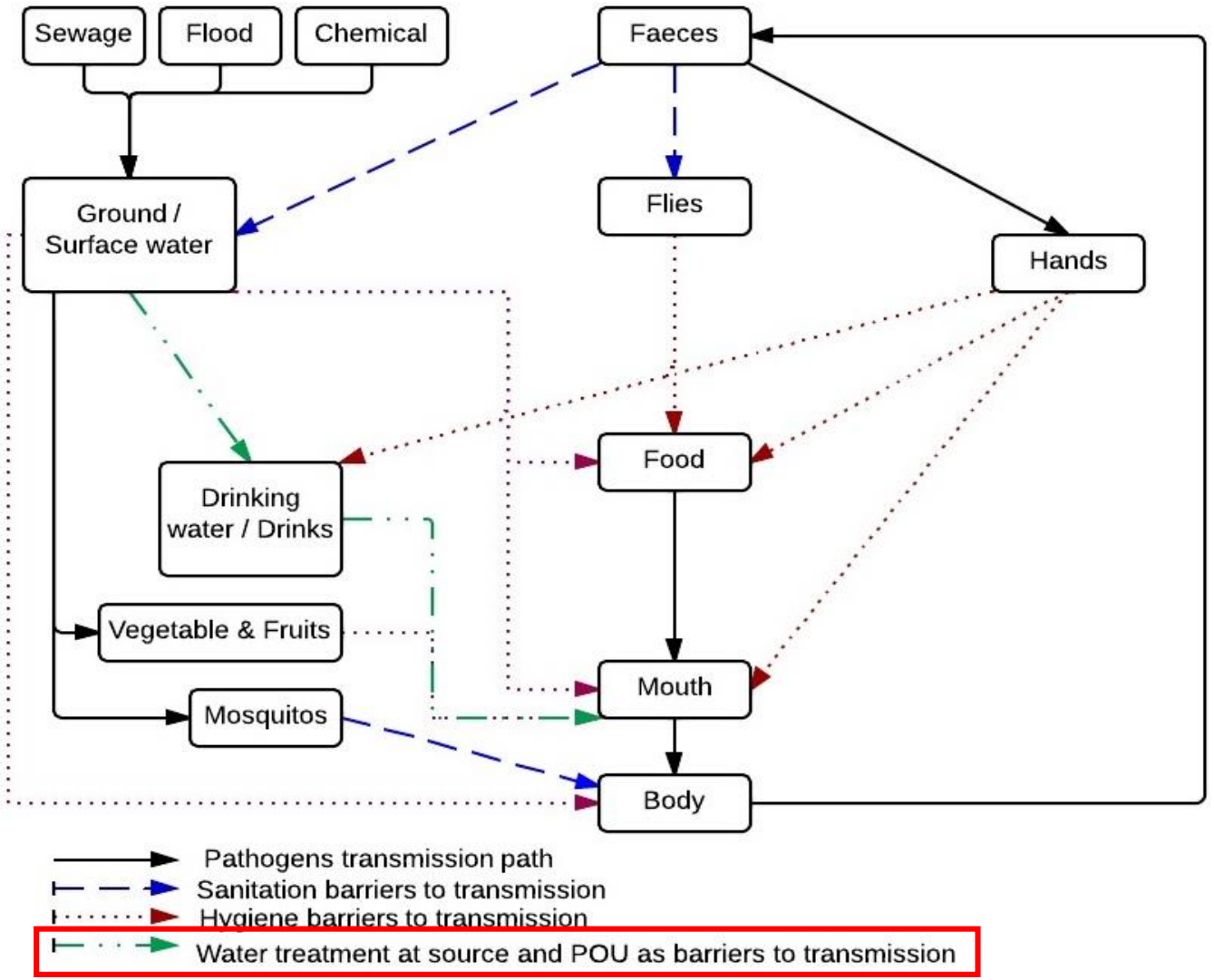
source: Shamsudduha, Taylor, Ahmed, and Zahid (2011)

Conceptual Framework



Source: (Tsegai et al., 2013)

Pathogens transmission path



Source: Author's calibration; adopted from Prüss, Kay, Fewtrell, and Bartram, (2002), and Waddington et al. (2009).

Theory of Change: The impact pathways

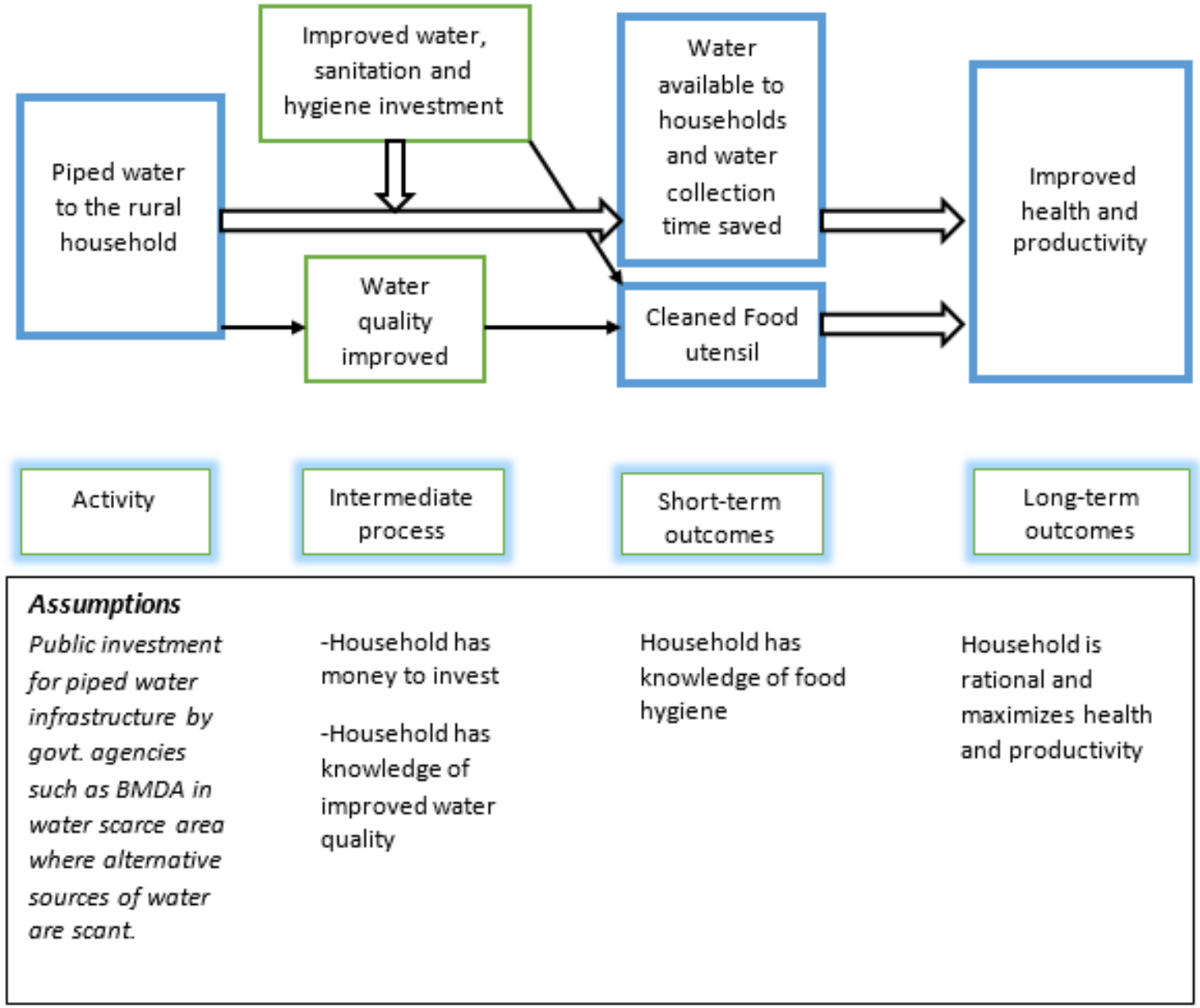


Figure 10: Theory of Change- impact pathways. *Source: Authors' calibration*

Methods and Data

- Two districts of North-western Bangladesh: Rajshahi and Naogaon
- Sampling procedure**: *cluster sampling***
- Two big cluster: BMDA area(389 mouza) and Non-BMDA area (359 mouza)
- 16 villages are taken randomly from BMDA areas and 16 villages are taken from non-BMDA areas.
- A total of 512 households are covered: 256 (BMDA), 256 (non-BMDA)
- Cross section data of 512 households collected in October, 2014.

Identification and estimation technique

- We considered the **actual receipt of piped water** rather than BMDA's intention to supply piped water to households.
- According to this definition**, 186 households** were considered BMDA-treated and **326 households were not considered BMDA-treated**.

Estimation technique

- Mean difference
- Propensity Score Matching
- Sensitivity Analysis (Rosenbaum bounds)

Summery statistics before matching

Variable	Total (N=512)	Treatment (N=186)	Control (N=326)	P-value (treatment=control)
Household Characteristics				
Age of household head (years)	35.26	35.24	35.27	0.98
Completed years of schooling of household head	4.64	5.73	4.01	0.00
Maximum completed schooling in the household	7.77	8.49	7.36	0.00
Household size	4.72	4.92	4.61	0.05
Household head currently married (dummy)	98%	98%	98%	0.81
Household occupation: wage earning (dummy)	52%	42%	57%	0.00
Household occupation: agriculture (dummy)	57%	59%	56%	0.47
Household occupation: non-agriculture (dummy)	48%	58%	42%	0.00
Total land (in acre)	0.69	0.96	0.54	0.01
Number of Livestock	15.30	19.31	13.02	0.13
Number of cows	1.21	1.24	1.20	0.78
Number of goat	0.92	0.92	0.91	0.93
Number of poultry	9.09	9.67	8.75	0.41
Food expenditure (BDT)	59692.67	65786.71	56215.71	0.00
Non-food expenditure (BDT)	39915.68	49469.15	34464.92	0.00
Household savings (BDT)	36729.38	43737.03	32731.15	0.17
Irrigating households (dummy)	63%	61%	63%	0.62
Sanitation				
Access to improved sanitation (dummy)	68%	75%	63%	0.01
Annual cost for maintaining a toilet (BDT)	258.20	334.25	214.82	0.32

Summery statistics before matching (continue)

Variable	Total (N=512)	Treatment (N=186)	Control (N=326)	P-value (treatment =control)
Water				
Access to improved drinking water (dummy)	96%	99%	94%	0.00
Annual cost for water (BDT)	231.61	631.61	3.39	0.00
Time spend to collect drinking water in a day (minute)	12.77	8.09	15.46	0.00
Draw water with a mug from jar (dummy)	35%	37%	34%	0.44
Size of the water container (liter)	17.78	23.47	14.54	0.00
100ml drinking water *E.coli* count (cfu)	44.52	50.79	40.93	0.43
E.coli count in the food utensils (cfu)	36.47	25.48	42.77	0.22
Presence of *E. coli* in the 100 ml water (dummy)	78%	75%	80%	0.16
Presence of *E. coli* in food preparing utensils (dummy)	60%	55%	63%	0.06
Disease				
Child diarrhea in last month (percentage) (dummy)	13%	11%	14%	0.24
Annual disease cost for adult (BDT)	4251.14	4702.53	3993.59	0.46
Monthly disease cost for children (BDT)	540.5	577.98	519.13	0.63
Hygiene				
Hand wash with soap after coming from toilet (dummy)	68%	76%	64%	0.01
Hand wash with soap before feeding child (dummy)	3%	5%	2%	0.05
Clean water container with soap (dummy)	26%	32%	22%	0.02
Total soap consumed per month (number, 1 soap =100gr.)	2.31	2.67	2.11	0.00
Per capita soap consumption per month (number)	0.51	0.56	0.48	0.00

Source: Baseline survey, 2014.

Nutritional status by treatment group (unmatched data)

Child anthropometrics by treatment and control households

	Mean (N=569)	Treatment (N=207)	Control (N=362)	P-value
Height-for-age z-score	-1.57	-1.59	-1.56	0.85
Weight-for-age z-score	-1.50	-1.40	-1.56	0.10
Weight-for-height z-score	-0.88	-0.72	-0.97	0.01
BMI z-score	-0.74	-0.59	-0.83	0.02
Stunted	36%	34%	37%	0.48
Severely stunted	10%	10%	10%	0.89
Underweight	32%	27%	36%	0.03
Severely underweight	7%	7%	7%	0.76
Wasted	13%	11%	14%	0.40
Severely wasted	2%	2%	2%	0.87

Source: Baseline survey, 2014.

Impact of access to BMDA piped water on different outcome variables based on Propensity Score Matching

Outcome variables	Nearest-Neighbour Matching[b] (Treatment=186; Control=113)		Stratification Matching (Treatment =185; Control =307)		Kernel Matching[b] (Treatment =186; Control =306)		Regression based nearest-neighboring matching	
	ATT	SE	ATT	SE	ATT	SE	Coefficient	SE
Water-Sanitation facilities								
Access to improved sanitation	0.011	0.06	0.014	0.04	0.018	0.04	0.06	0.06
Access to improved drinking-water	0.065**	0.03	0.059***	0.02	0.059***	0.02	0.05**	0.02
Time to collect drinking water (min/day)	-5.62***	2.04	-5.89***	1.55	-6.034***	1.58	-6.99***	1.89
100ml drinking water E.Coli count (cfu)	-33.19	28.79	2.449	18.59	1.086	17.45	-18.59	24.21
100ml drinking water Coliform count (cfu)	38.00	64.51	35.535	41.91	50.200	36.06	23.83	49.31
E.Coli count in the food utensils (cfu)	11.67	12.78	-7.404	11.51	-10.514	10.77	-12.38	17.99
Coliform count in the food utensils (cfu)	4.703	28.13	-18.415	17.34	-24.052	16.21	2.59	21.40
Distance of drinking water source (meter)	-0.301**	0.12	-0.45***	0.11	-0.471***	0.12	-0.50***	0.13
Drinking water container capacity (liter)	8.72**	3.49	8.732**	3.91	8.556**	3.59	8.48*	4.66
Water cost (BDT)	629.03***	32.90	624.8***	41.98	627.77***	33.73	630.97***	54.52
Hygiene situation								
Hand wash with soap after toilet (%)	-0.032	0.06	0.023	0.04	0.035	0.05	0.08	0.05
Hand wash with soap before feeding child	0.011	0.03	0.035*	0.02	0.032*	0.02	0.05**	0.02
Clean water container with soap	-0.032	0.07	0.030	0.05	0.025	0.05	0.03	0.06
Total soap consumption per month	0.032	0.11	0.142	0.13	0.181	0.11	0.23	0.15
Health outcomes								
Child diarrhoea in last one month (age<59months)	0.016	0.04	-0.007	0.03	-0.010	0.04	0.02	0.04
Cost for illness for adults (BDT)	-300.624	1441.15	-97.27	1165.9	15.097	1061.6	1276.04	1327.9
Cost for illness for children (BDT)	195.086	192.54	69.78	137.04	89.103	157.48	84.03	182.65

Source: Authors' calculation. [b] represent Bootstrapping 50 times. Matching variables are: *Household savings, food expenditure, non-food expenditure, number of livestock, number of cow, number of goat, number of poultry, total land, wage earning households, agricultural household, non-agricultural household, age of household head, education of household head, household size, electricity, distance from road, distance from big market, distance from health center, distance from town.* note: *** p<0.01, ** p<0.05, * p<0.1

Impact of access to piped water on child growth based on Propensity Score Matching

Child health outcome	Nearest-Neighbour Matching[b] (Treatment=205; Control=132)		Stratification Matching[b] (Treatment=205; Control=324)		Kernel Matching[b] (Treatment=205; Control=324)		Regression based nearest-neighboring matching	
	ATT	SE	ATT	SE	ATT	SE	Coefficient	SE
Height-for-age z-score	-0.037	0.18	-0.057	0.12	-0.072	0.14	-0.047	0.12
Weight-for-age z-score	0.048	0.14	0.116	0.11	0.105	0.10	0.179*	0.10
Weight-for-height z-score	0.085	0.15	0.191**	0.10	0.187**	0.08	0.278**	0.12
Stunted (dummy)	-0.013	0.06	0.002	0.05	-0.001	0.05	-0.037	0.05
Severely Stunted (dummy)	0.027	0.04	0.013	0.03	0.014	0.02	-0.001	0.03
Underweight (dummy)	-0.02	0.06	-0.074**	0.04	-0.069**	0.03	-0.095**	0.04
Severely underweight (dummy)	-0.005	0.03	-0.001	0.03	0.001	0.02	0.007	0.02
Wasted (dummy)	-0.02	0.04	-0.024	0.03	-0.018	0.03	-0.024	0.03
Severely wasted (dummy)	0.02	0.02	0.013	0.01	0.012	0.01	0.006	0.01

Source: Authors' calculation. [b] represent Bootstrapping 50 times. Matching variables are: *Presence of E. coli in the 100 ml water, Presence of E. coli in food preparing utensils, Total soap consumed per month, Hand wash with soap after coming from toilet, Hand wash with soap before feeding child, Percentage of child diarrhoea in last month, Household savings, food expenditure, non-food expenditure, number of livestock, number of cow, number of goat, number of poultry, total land, wage earning households, agricultural household, non-agricultural household, age of household head, education of household head, household size, electricity, distance from road, distance from big market, distance from health center, distance from town.*

note: *** p<0.01, ** p<0.05, * p<0.1

Summary

- BMDA piped water infrastructure had a positive impact on **access to improved water** and significantly reduced the **distance traveled** for and **time spent on collecting** drinking water.

- However, we found **no improvement in the drinking water quality**, which was measured by the extent of fecal contamination (*E. coli* count per 100 ml of water) at the point of use.

- The hygiene status of **food utensils also did not show any improvement**; food utensils were tested positive for *E. coli* in both the control and treatment group.

- The BMDA intervention clearly improved hygiene behavior: the percentage of households practicing **handwashing with soap before feeding children** was higher among the treated households.

Summary

- The treated households also owned larger water containers. This implies that the intervention has had a clear impact on the **quantity of water** used for household purposes.

- We did not find evidence of immediate health benefits, such as decreased **diarrhea** incidence of in under-five children.

- **Longer-term health impacts** of access to piped water were observed in child anthropometrics. In particular, **weight-for-age and weight-for-height** z-scores of under-five children were improved.

- There is also evidence that the percentage of **underweight children** was reduced significantly due to piped water use.

Policy implication

- Overall, the BMDA piped water project has been a success because the state supplies water to some marginalized households in rural areas, where water availability is low.

- Access to piped water generated much benefit for water availability and time saving as well as health benefit specially for under five children.

- We recommend that the government should expand the piped water network to other marginalized communities.

Thank you