Does Water Metering Incentivizes Pro Conservation Preferences: A study from Lahore, Pakistan

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Introduction

- Water demand due to population surge is rising especially in urban areas but its availability has greatly suffered because of inefficient regulation

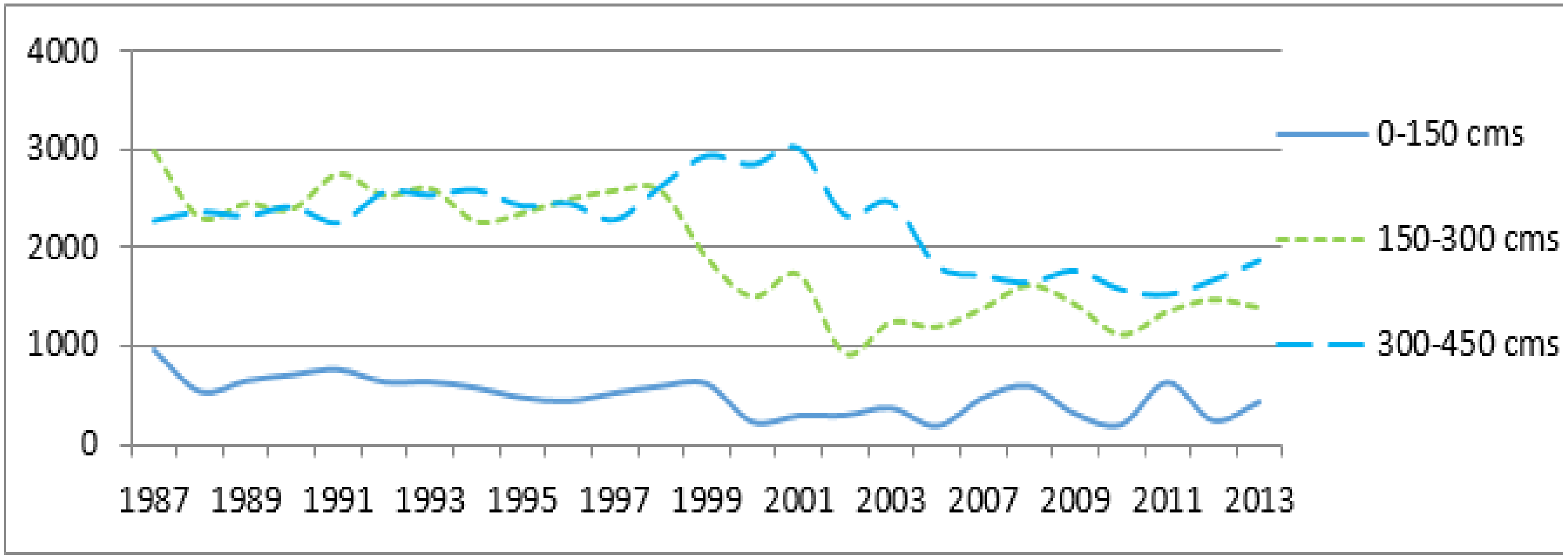
- Efficient distribution of water in cities is a key component of its socio-economic development. However the quality and supply of government-provided water has decreased

- Private suppliers have gained tremendous importance in the water industry

- The fall in underground water tables has also taken place along with these changes in urban centers such as Lahore:

  - water table is depleting by more than 0.5 meter annually. (WWF 2014)
  - Due to disproportionate pumping, the water table depth in the central location of the city has gone below 40 m, and it is estimated that by 2025 the water table depth in most areas will drop under 70m

Trend of water table in Punjab at varying depth levels (in thousand hectares)



Source: Authors' own rendering using various issues of Punjab Development Statistics reports

Problem: With the persistent energy crises, groundwater pumping from excessive depths will be a huge economic burden on Water & Sanitation Agency-Lahore (WASA) and other organizations.

- Pakistan's Commitment to Sustainable Development Goals (SDGs)

- **SDG 6.4** which states:

"By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity…"

Solution: Therefore, there is a need to regulate water use and stop wastage of water.

The goal of this study is to focus on effective demand management for water conservation by estimating difference in consumption as a consequence of metering volumetric use of water.

Literature Review

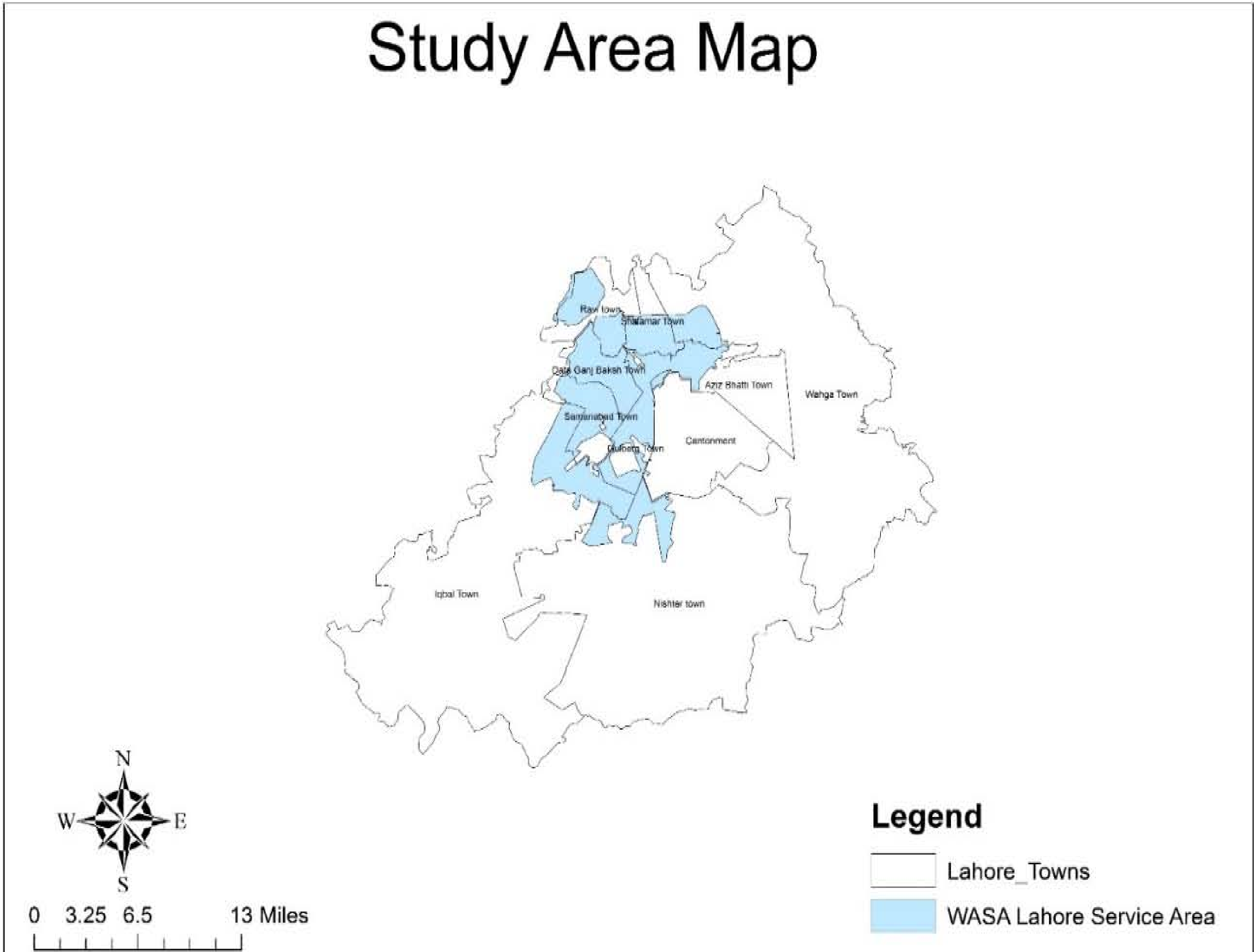
- Supplying water incurs cost that varies with the attitudes and consumption patterns. This state of affairs presents a practical example of (Jhele & Reny's, 2000) succinct definition of moral hazard whereby "a principal has a stake in the action taken by an agent, but the agent's action cannot be observed by the principal

- Abdel Khaleq & Dziegielewski, (2006) presents proposal for water demand policy of Jordan.
- Rationalize water use along with ground water management policy.
- How to manage water demand and recover cost?
  - Universal Metering
  - 20% reduction in water demand

- Panagopoulos (2014) and Garcia & Reynaud (2004) proposes increasing block prices
- Boyle et all. (2013) Metering thus can satisfy sustainable urban water management objectives

Giuliani A. (2015) & Ribeiro, R. et all (2015)

- water metering can reduce the need for labor cost for meter reading
- water loss prevention measures
- Utilities on the other hand can also use water consumption data and can get support for increasing operation efficiency



Source: Authors own rendering using GIS

Data

- Data on water consumption taken from Water & Sanitation Agency (WASA) Lahore
- Panel Data ranges from 2000-2015
- Variables:

Account Number	Period Number	Consumer Billed	Water Charges	Ward Number	Area of House

Town wise Distribution of water meters in Lahore

Town Name	Number of Meters	Percentage of Meters
Allama Iqbal	118145	18
Gunj Buksh	131111	20
Nishter (Marla)	76246	11
Nishter (Ferrule)	25059	4
Ravi	175686	26
Shalamar	108471	16
Aziz Bhatti	34671	5
Total	**669,389**	**100**

Source: Authors' own rendering using data from WASA Lahore.

Utility Maximization Framework

WASA

- *Net* benefit function for WASA

$$b_t(h_t, x_t) = b_t(h_t) - c_t\ (h_t, x_t)$$

Where by the costs are increasing in extraction $\left(\frac{\partial c_t}{\partial h_t} > 0\right)$ and decreasing in stock size $\left(\frac{\partial c_t}{\partial x_t} < 0\right)$

Individuals

- **Case I**

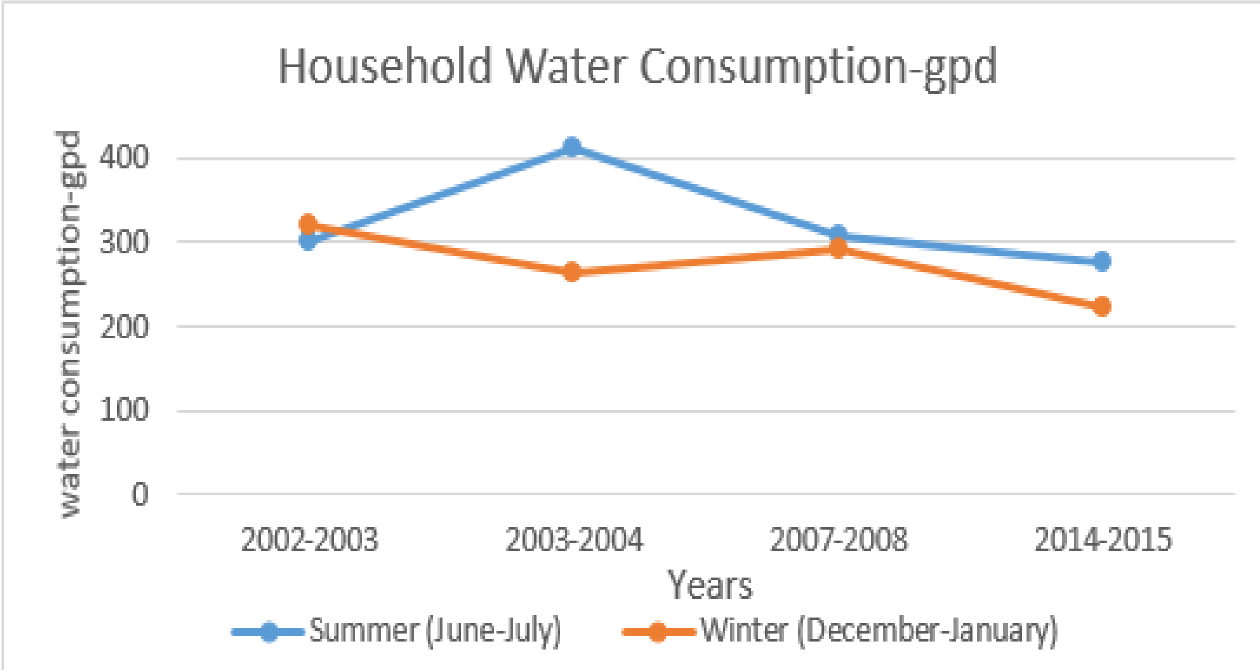
$$U = f(w, w')$$
$$C = p_w + p_{w'} w'$$
$$p_w = \bar{p}_w$$

- **Case II**

$$U = f(w, w')$$
$$Cost = p_w w + p_{w'} w'$$

Where relevant price slab is determined by the quantity of water consumed

$$p_w = \begin{cases} p_{w1} & 0 < w < 5000 \\ p_{w2} & 5001 < w < 10000 \\ p_{w3} & w > 10000 \end{cases}$$
$$where\ p_{w1} < p_{w2} < p_{w3}$$



Source: Author's own rendering using data from WASA-Lahore

S.No	Plot size	Average Per Month
1.	1.0 to 5 Marla	10,000 Gallons
2.	5.1 to 10 Marla	15,000 Gallons
3.	10.1 to 20 Marla	20,000 Gallons
4.	20.1 to 02 Kanal	25,000 Gallons
5.	2.1 and above	30,000 Gallons

Source: Taken from WASA website

Methodology & Econometric specification:

$$y_{it} = premetered_{treat} + postmetered(I)_{treat} + postmetered(II)_{treat} + premetered_{comp} + potmetered(I)_{comp} + postmetered(II)_{comp}$$

Period	Premetered		Post metered-Tier I		Post metered-Tier II	
Description	Post-metered, prebilled	Post-metered, first bill	Post-metered, second bill	Post-metered, third bill	Post-metered, fourth bill	Post-metered, fifth bill
Length of time	Varied	60 days or one billing cycle	60 days or one billing cycle	60 days or one billing cycle	60 days or one billing cycle	60 days or one billing cycle

Definitions of evaluation periods

Flowchart defining treatment and comparison groups

Population of single-family (5 Marla Houses) residences to be metered	Residences divided into cohorts based on meter installation date and ward number	Cohorts chosen for analysis if premetered period < 3 months	Treatment Group
Population of single-family (5 Marla Houses) residences already metered	Households divided into cohorts to match treatment cohort date of meter installation and ward number	Households geocoded and matched with treatment cohort locations	Comparison Group

Wichman, Taylor, & von Haefen, (2016) Need to contrrol for factors when looking at water usage

Spatial Mapping of treatment household of Allama Iqbal Town

Spatial Mapping of Control household of Allama Iqbal Town

Regression Results

Variables	Allama Iqbal	Ganj Baksh	Aziz Bhatti	Nishtar	Ravi	Shalamar
Premetered_treatment	150.7513***	1,098.9673***	323.0714**	201.7594**	184.7756***	295.8405***
	0	0	0.042	0.013	0	0.003
Postmetered_tier I_treatment	102.5207***	1,073.5078***	252.2844	216.3280***	90.5312***	284.4311***
	0	0	0.104	0.003	0.009	0.005
Postmetered_tier II_treatment	109.6855***	1,073.8044***	227.7448	131.6305***	71.4385**	278.6320***
	0	0	0.138	0.004	0.038	0.006
Premetered_comparison	125.5286***	115.5542***	275.2788**	161.3499**	183.3362***	285.1629***
	0	0	0.016	0.027	0	0.004
Postmetered_tier I comparison	100.7870***	108.7681***	284.3015**	220.5213***	154.1494***	284.9359***
	0	0	0.018	0.003	0	0.005
Postmetered_tier II_comparison	122.4546***	110.7118***	306.5596**	165.2676***	184.7975***	286.1957***
	0	0	0.011	0.003	0	0.005
Mean_Temperature	4.9602***	2.5295**	2.5541*	-0.7102	2.6728**	2.2657***
	0	0.014	0.075	0.791	0.024	0
Number of Observations	1,536	483	216	174	102	2,298
R^2	0.931	0.96	0.933	0.928	0.951	0.939
Robust pvalues reported						
*** p<0.01, ** p<0.05, * p<0.1						

Overall Findings:

- Unmetered households in Allama Iqbal Town, Aziz Bhatti Town, Nishtar Town-Marla, Ravi Town and Shalamar Town used more water than metered households.
- In Allama Iqbal Town, unmetered households used an average of 20% (25 gpd) more water than similar metered households.
- In Aziz Bhatti Town, unmetered households used an average of 17% (48 gpd) more water than similar metered households.
- In Nishtar Town-Marla, unmetered households used an average of 25% (41 gpd) more water than did similar metered households.
- In Ganj Buksh Town, unmetered households used an average of 847% (983 gpd) more water than did similar metered households.
- In Ravi Town, unmetered households used an average of 1% (2 gpd) more water than did similar metered households.
- In Shalamar Town, unmetered households used an average of 25% (10 gpd) more water than did similar metered households.

Results Summary

	Allama Iqbal	Aziz Bhatti	Ganj Baksh	Nishtar	Ravi	Shalamar
Unmetered average monthly consumption per household-gpd	151	323	1099	202	185	295
Metered average monthly consumption per household-gpd	126	275	116	161	183	285
Difference between unmetered and metered households-%	20	17	847	25	1	25
Short Term Meter Impacts-Reduction after four months of metering-%	15	25	2	23	35	4
Longer term meter impacts-Reduction after six months of metering-%	26	39	2	37	63	6

Using the data on water metering for the largest metropolitan city of Punjab our results shows that water metering results in **17 %** reduction in the use of residential water demand in the short run and this reduction in water demand rises to **29%** in the long run, these results are based on data from 2000-2015.

Conclusion and Policy Recommendation

- Water is precious and scarce, and therefore to ensure its conservation water metering may be done in urban areas.
- Water Meter installation impacts positively on residential water conservation efforts and should be helpful in planning a water utility's conservation program.
- Pakistan has committed to achieving SDGs. In order to achieve SDG-6 (Clean Water and Sanitation) water metering may play an important role.
- Government may use water metering to conserve water. Additional income generated as a result of volumetric use of water can be used to improve water infrastructure and to provide sustainable public investment for sustainable cities and communities (SDG-11).
- Better water infrastructure results in provision of clean drinking water and this can prevent from many water borne diseases, thus helping in achieving SDG-3 (Good health and wellbeing) also.
- Poor households may face problems of installing meters this can be countered by reimbursements of metering costs within stipulated time, such example was given by H. Chen, Z.F. Yang (2009) where costs were reimbursed within five years

Thank You!