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Economic analysis of domestic water consumption, sewage water disposal and its health impact

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ABSTRACT

We investigate the economic impact of the by-product of rapid urbanization especially focusing on the negative externalities created in the urban ecosystem i.e. contamination of potable water, air pollution, noise pollution, automobile pollution, solid waste and sewage water disposal. Specifically, the domestic water consumption and sewage water disposal are the two variables of interest since these variables have a has a direct bearing on human health but has received scant attention in the literature, so far. Hence, our paper addresses issues like drinking water consumption, quantity disposal of waste water, diseases affected and costs of treatment. Using an intensive field survey, we estimate the loss of opportunity cost for a sample of 140 households. Our result concludes that the provision drinking water and availability of drainage facilities are weakened in the peripheral part of urbanization which associated with high health treatment cost. Moreover, in a slum, even with the proximity of availing these facilities is closer but the socially and economically vulnerable groups are deprived this basic facility.

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1.0 Introduction

All around the world, millions of people lack access to water and other basic services: 20 out of every 100 persons in developing countries have no access to safe drinking water, 50 out of 100 no adequate sanitation and 90 out of 100 have no treatment for their wastewater. In Asia 691 million people (every sixth person in the region), do not have access to safe, sustainable water supplies and almost half the population do not have access to decent sanitation[1]. This situation brings hardship into the daily life of millions of people, constrains their income-earning opportunities and retards the economic growth of the developing world. Environmental degradation is another important consequence of inadequate wastewater treatment, and its implications are suffered disproportionately by the poor, who live in the worst affected areas. Within the poor, it is the most vulnerable groups (women, children and the elderly) who bear most of the costs of under-provision, in terms of time queuing for water at public taps, loss of public spaces or health hazards[2].

Human beings in the form an integral part of urban ecosystems, notwithstanding the equal space within the system, are claimed by non-human such as plants, animals and the pattern of vegetation. The Urban ecosystem is confronted with a host of environmental issues owing to the unprecedented growth of economic activities combined with a lack of proper environmental management. The problems start from the quantity consumption of water, and the amount of wastewater generated, other related issues such as types of waste, current modes of disposal in vogue, dispersing medium, various institutions involved in the drinking water provision and disposal of sewage water will all be taken into account. An attempt will be made to adopt a holistic approach rather than a truncated one to evolve a methodology in solving these issues, and it will help to make water policy. Barring specific rules regarding the consumption of water and disposal of sewage water, there is no comprehensive policy on water management at the national level. Crucial questions such as what is the estimated quantity of consumption and sewage generated from the domestic sector at Coimbatore Corporation? What are the disposal practices of selected households? What are the health impacts of consumption of urban domestic water and improper sewage water disposal? Moreover, how do the households manage all these problems at their level?

2.0 Material and methods

The initial survey was conducted with the help of interview schedule containing all relevant queries. The stratified and proportionate random sampling techniques were employed for selection of wards and the households. Besides, several informal discussions made with the native dwellers to elicit historical information regarding the traditional sources of water, the pattern of water use and quality of water and sewage water disposal. The criteria were adopted to stratify the four selected areas such as 1. Center Part of the city, 2. Peripheral City, 3. Slum in city and 4. A slum in Peripheral to choose 136 households i.e. 2 percentage of the sample household from each ward were sampled for investigation.

3.0 Result and discussion

The present study considered a number variable to discern the water demand at the domestic level. The chosen variables, inter *alia* are drinking, cooking, bathing, washing of clothes, utensil cleaning, personal hygiene, house cleaning, gardening sprinkling at the entrance and other needs. The World Health Organization (WHO) categorizes the supply and access to provide water in four categories. These categories are, (1) no access (water available below 5 lpcd), (2) basic access (average approximately 20 lpcd), (3) inter-mediate access (average approximately 50 lpcd), and (4) optimal access (average of 100-200 lpcd)[3]. The people living in center part are optimal access of domestic water of consumption per day. The average quantity of water used per household in the central part city is 882 liters per day followed by peripheral part of the city 800 liters, the central part of the slum 586 liters, the peripheral part of slum 485 liters, respectively. For drinking and cooking purposes alone, the average requirement per household per day is 17 liters and 32 liters in the central part of the city, 53 liters and 31 liters in the peripheral part of the city, 9 liters and 14 liters in central part slum and 7 liters and 11 liters in the peripheral part of the city, respectively. The requirement of drinking water per household is 29 liters. Out of the total quantity of water consumption for bathing is 266 liters in central part followed by 225 liters in the peripheral part, 196liters in the center part of a slum and 132 liters in peripheral part, respectively (Table 1).

Table 1: Distribution of water consumption

Particulars	Central part of city (n_1=44)		Peripheral part of city (n_1=56)		Slums in City (n_1=20)		Slum in peri-pheral (n_1=20)		Total (n_1=140)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Distribution once in a day	3	0	1	0	1	0	10	0	2.91	3.04
Distribution time	24	0	12	0	5	0	3	0	13.49	7.88
Collection Hours	3.18	0.69	1.89	0.5	2.4	0.6	3.81	0.85	2.64	0.96
Drinking purpose	16.84	2.15	53.11	267.08	9.3	1.56	6.78	1.28	28.83	169.22
Cooking purpose	32.39	6.52	30.86	3.92	14.05	4.08	10.6	1.9	26.04	9.96
Bathing	266.41	64.53	225.04	28.43	196.4	44.42	132.45	31.52	220.72	62.35
Washing utensil	98.07	31.17	169.54	140.47	98.85	3	0	1	0	1
Sprinkling at the entrance	22.34	10.28	14.77	4.23	7.68	24	0	12	0	5
Ablutions	69.84	22.09	66.02	21.35	42.2	3.18	0.69	1.89	0.5	2.4
Washing clothes	349.73	76.5	232.84	31.94	213.05	16.84	2.15	53.11	267.08	9.3
Gardening	4.32	28.64	0	0	0	32.39	6.52	30.86	3.92	14.05
Livestock purpose	0	0	0.96	7.22	0	266.41	64.53	225.04	28.43	196.4
Cleaning house	160.73	53.6	53.79	10.11	34.2	98.07	31.17	169.54	140.47	98.85
Total water consumption	882.89	163.63	800.81	306.22	586.41	82.76	485.15	89.15	750.88	260.73

3.1 Regression results -Household demand

At the household more than twenty variables have been identifying which includes predictors: (constant), drinking and cooking, flush out many liter per day, trip, family size, caste, washing cloth, per capita income, room, education year, period of living, type of house, per capita expenditure, value of houses, house service connection, willing to pay money for additional supply of water, operation maintenance cost, septic tanks facility as dummy variable (1-yes, 2-No), water collector (1-male and 2-female), time spent, mode of transport, overflow water, water distribution time, overhead tank location (1.SC packet 2.Non- SC packet). A certain set of variable may be dominant in same wards, while certain others are more influenced in other wards. This can be a hypothetical situation as to which type of variable its influence significantly as a determinant factor is a matter to be taken for hypothesis testing.

Hypothesis–I: Period of living, family size, education, year, type of house (1-Thatched, 2-Tiled, 3-Terraced house), distribution time, water collector, water collection time, mode of transport (1-head load, 2-cycle), flush out the water are they key determinants of per capita consumption of water.

Correlation matrices were applied to understand and shortlist the number of variables, which influence the per capita water consumption at the household level. Out of all variables, period of living, family size, education, year, type of house, distribution time, water collector, water collection time, mode of transport, flush out the water were chosen as variables, those which exhibit a high percentage of correlation was considered for running the regression against per capita consumption.

$$\text{Per Capita Consumption of Domestic Water} = a \pm \beta_1(\text{Family size}) + \beta_2\,(\text{Water distribution time}) + \beta_3\,\text{Water collector (1-Male, 2 Females)} + \varepsilon$$

The regression analysis brings forth the following results. Factors like family size, water collection time and water collector turned out to be significant ($P > \alpha$) (table 1.1). The R square value turns on to be 0.43. This shows that 43 percent of the variation in the dependent variable is explained by the independent variables.

Table 1.1: Regression –LPCD

Variables	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.
	β	SE	β		
Constant	215.250	64.343		3.345	0.001
Period of living	0.797	0.761	0.089	1.047	0.297
Family size	-41.307	8.582	-0.383	-4.813	0.000**
Education year	0.747	0.577	0.110	1.295	0.198
Type of house	8.216	10.971	0.060	0.749	0.455
Distribution time	6.863	1.719	0.774	3.992	0.000**
Water collector	27.105	10.354	0.384	2.618	0.010*
Collection hours	-3.914	10.362	-0.056	-0.378	0.706
Mode of transport	-9.704	17.065	-0.089	-0.569	0.571
Flush out the water	-4.378	3.324	-0.203	-1.317	0.190
R2	0.43				

**at 1 percent level of significance and * 5 % level of significance

To understand the implications of the results a detailed discussion is necessary. A crucial factor, which is inversely related to water consumption, was the family size. As family size increases the resultant total consumption goes up, but the per capita consumption comes down. This is due to water requirement for other domestic uses, does not vary regardless of the number of persons in a household. For instance, water sprinkling at entrance used for cooking, house cleaning, upkeep of livestock, washing clothes and bathing may not increase commensurately with the increase in family size.

The variable, water distribution time, which refers to the number of hours water is distributed for domestic use at the household level, has come out positive and statistically significant. The positive sign explains that the increase in hours of distribution per day leads to increase in water consumption. During the field survey, it was observed that in water availability is more the number hours distributed. The water collector as a variable came out positive and significant at 5 percent level.

The per capita consumption of water for all purposes per day works out to be 19.7 liters and for drinking, the per capita LPCD is 3.9 liters. The per capita consumption for drinking and cooking declined from moving from the central part of city to city in peripheral, slum in central and slum in peripheral respectively. The per capita consumption of water in the central part of the city is 4.7 liters followed by 4.6 liters in peripheral city, 2.5liters in a slum in central part of the city and 1.9liters in slum peripheries, respectively. The reason being in area requirement of water for other purposes could not be captured as respondents resorted to direct spot such assets for use. While in central part of city, water use for other purposes could be gauged as the respondents bring home the water for use of all purposes (Table 2).

Table 2: Distribution of per capita consumption water

Particulars	Central part of city		Peripheral part of city		Slums in City		Slum in peripheral		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Drinking	4.7	09	4.6	09	2.5	.5	1.9	.6	3.9	1.4
Cooking	9.0	2.0	8.1	1.3	3.7	1.0	3.0	1.1	7.0	2.8
Bathing	73.2	18.1	58.9	10.9	51.2	8.0	36.1	8.2	59.0	17.8
Washing utensil	27.1	8.6	44.3	35.5	26.2	8.1	18.3	6.5	32.6	25.2
Sprinkling at the entrance	6.1	2.7	3.9	1.4	2.0	.6	3.8	1.6	4.3	2.3
Ablution	19.3	5.9	17.3	6.3	11.1	2.6	9.3	2.7	15.9	6.5
Washing clothes	96.6	24.2	61.0	12.3	56.1	8.7	55.2	8.4	70.6	24.0
Gardening	1.1	7.2	.0	.0	.0	.0	.0	.0	.3	4.0
Cleaning house	6.3	2.1	2.0	.5	1.3	.3	1.2	.4	3.1	2.5
LPCD	24.4	44.5	200.3	46.8	154.0	20.3	13.9	17.1	19.7	56.0

Regarding the break-up details of per capita of water used per day for different domestic purposes, for drinking it is 3.9 cooking it is 7 liters, for bathing it is 59 liters, for utensil cleaning 32.6liters, for washing clothes 70.6 liters, for house cleaning 3.1, for sprinkling house entrance 4.3, and the rest goes for personal hygiene etc.

Table 3: Quantity of sewage water disposal (percentage)

Particulars		Central part of city ($n_{1=44}$)		Peripheral part of city ($n_{1=56}$)		Slums in City ($n_{1=20}$)		Slum in peripheral ($n_{1=20}$)		Total ($n_{=140}$)	
To use toilet with free of cost	Not agree	0	0	85.7	55.2	95.0	21.8	100	23	62.1	100
	Not willing	100	83	14.3	15.1	5.0	1.9	0	0	37.9	100
Total		100	31.4	100	40	100	14.3	100	14.3	100	100
No of times flush out	1 trip	70.5	24.4	100	44.1	100	15.7	100	15.7	90.7	100
	2 trip	29.5	100	0	0	0	0	0	0	9.3	100
Total		100.00	31.4	100	40	100	14.3	100	14.3	100	100
Toilet waste gets in to	Open ditch	0	0	78.6	100	0	0	100	0	31.4	100
	Corporation drainage	100	45.8	21.4	12.5	100	20.8	0	20.8	68.6	100
Total		100	31.4	100	40	100	14.3	100	14.3	100	100
Waste water from bathing and utensil cleaning	Statistics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
	Bathing	232	69.1	177	26	232	34.6	60.3	9.4	185.4	72.1
	Utensil cleaning	188.43	95.07	80.07	7.73	80	11.47	72.55	13.22	113.04	74.1
Sewage disposal	TSWD	750.46	139.09	680.69	260.29	498.45	70.34	412.37	75.78	638.25	221.62
	PSWD	206.87	37.82	177.81	68.48	130.94	17.29	112.1	14.5	170.86	59.36

TSWD-Total Sewage Water Disposal, PSWD- Per Capita Sewage Water Disposal

Source: Primary Data, [] Figures in parentheses are row wise percentage and () Figures in parentheses are indicated column wise percentage

Wastewater is another dimension from human settlements in urban areas. Both policy variables cannot be discussed independently. Therefore, a special attention is paid to find out the solution of urban waste water disposal also. The fundamental approaches to these issues state that the quantity of waste water disposal requires an integral solution. Present paper address to issues like quantity of sewage water disposal is presented in table 3. Wastewater disposal has been a common phenomenon since the early days. However, with increasing urban population, changing lifestyles and industrialization, the quality of wastewater has deteriorated over the years and hence requires treatment before it can be released for any purpose. Since, wastewater is an expensive process; many of them have not been able to treat their wastewater to appropriate levels by the households. While the lack of wastewater treatment to household levels before use is a major problem. 90 percent of the people are taking bathing at once in a day and the rest of them are taking twice a day. About 62 percent of households were agreeing to do some expense to treat their wastewater. About 78.6 percent of toilet waste water was going to open ditch in the peripheral part of city rest of waste water goes to corporation drainage. In general, the waste water gets into the corporation drainage in central part of the city. In contrast, the majority of waste water gets into the open space due to non-availability of drainage facility in the peripheral area, and even it is available in the slum in central part not properly maintained. Surprisingly, the majority of corporation fourth-grade employeee is residing in the slum in the central part. An average 85 percent domestic water consumption is released as waste water without any treatment. This is lead to have the more water-based disease.

3.2 Sewage water disposal

The regression model predicts the influence factors with sewage water disposal. Theoretically, a large number of variables are determined sewage water disposals such as health impact (1-Yes 0-No), Family size, Type of house, Cast, Per capita Income, Period of living, Toilet facility within your house, Education year, Value of houses and Willingness to pay improved drainage facility. It may not be necessary that all variables are their influence on the sewage water disposal. A certain set of the variable may be dominant in same wards, while certain others are more influenced in other wards. This can be a hypothetical situation as to which type of variable its influence significantly as a determinant factor is a matter to be taken for hypothesis testing.

Hypothesis –II: family size, type of house, cast, per capita income, period of living, toilet facility within your house, education year, value of houses, per capita expenditure, willingness to pay, over head tank capacity, availability of house service connection, time spent, willingness to pay for improvement and location are they key factors determinant to urban sewage water disposal. The variables mentioned in hypotheses are highly correlated with sewage water disposal. The high correlated variable is taken into consideration for running regression model.

$$\text{Sewage Water Disposal} = a \pm \beta_1 \text{Location} + \beta_1 \text{Family size} + \varepsilon$$
$$\text{Sewage Water Disposal} = 292.5 - 26.3_{\text{(Location)}} - 28.11_{\text{(FS)}} + \text{Residual}$$

Table 3.1: Regression –Sewage water disposal

Variables	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.
	β	SE	β		
Constant	292.516	35.802		8.170	0.000
Location	-26.265	5.449	0-.447	-4.820	0.000**
Caste	0.074	4.761	0.001	0.016	0.988
Period of living	0.516	.646	0.068	0.798	0.426
Family size	-28.109	7.078	-0.307	-3.971	0.000**
Education year	0.527	0.452	0.092	1.164	0.246
Value of houses	0.0000093		0.083	0.973	0.332
R^2					0.41

a: Dependent Variable: Sewage Water Disposal ** significant at 1 % level

The continuing efforts have been taken by central, and state government failed to provide safe drinking water and adequate sanitation services to all the sections of people. The most severe consequence of this failure results the high rate of mortality among young children from preventable water-related diseases. The pollutant discussed above adversely impacts on the environment. Bad quality of water is resulting in health threats. The major health concern is related to the quality of water and food which already exposed to some environmentally related problems. Safe drinking water, adequate sanitation, and unpolluted water bodies are essential ingredients for healthy and productive society.

Water is an essential for mankind and its quality decides the health of the people in general poor in particular. However, about 1.1 billion people have lack of access to an improved drinking water supply globally. About 4 billion people have suffering diarrheal disease and about 1.8 million people died per year due to water borne and water based disease. The children are more vulnerable to get waterborne and water based.[4] The quality of water distribution and waste water disposal are directly bearing to human health. About 56 percent of respondent households is expressed that they are affected either water borne or water based diseases. Waterborne diseases include those where transmission occurs by drinking contaminated water. These include most of waterborne diseases such the diarrheal diseases caused by bacteria (1.4 percent in the central part of the city) and typhoid. Evidence suggests that waterborne disease contributes to rates of diseases not detected or reported explicitly as outbreaks. Water-based diseases come from hosts that live-in water or require water for part of their life cycle.

These diseases are usually passed to humans when they drink contaminated water or use it for any other consumption. The most widespread examples in this category are Chikungunya and skin diseases. Most of the people tanking are the treatment of allopathic medicine (40 percent), and 2.3 percent are expressed from Siddha. Among the victims, 35.7 percent being hit by Chikungunya and the rest are affected by diarrhea typhoid and skin. Twenty-nine percent of the victims approached government hospitals for treatment and the rest of them resorted to private hospitals. The medical expenses for both diseases spent about Rs. 136 per annum towards medical expenses table 4.

Table 4: Impact of waterborne and water-based disease

Locations	Waterborne and water-based disease					Type of Treatment				Treatment Cost				Statistics	Treatment cost
	None	Diarrhea	Chikungunya	Skin diseases	Total	English	Siddha	None	Total	Private	Government	Clinic	Total		
Central part of city	33	2	9		44	10		34	44	10			44.00	Mean	255.6
	[75]	[4.5]	[20.5]		[100]	[22.7]		[77.3]	[100]	[22.7]			10.06	N	44.00
	(43.4)	(100)	(18.0)	-	(31.4)	(17.9)	-	(77.4)	(31.4)	(100)	-	-	70.27	SD	536.92
Peripheral part of city	24		32		56	25	4	27	56		22	8	56.00	Mean	97.23
	[42.9]	-	[57.1]		[100]	[44.6]	[7.1]	[48.2]	[100]		[39.3]	[14.3]	9.22	N	56.00
	(31.6)	-	(64)	-	40	(44.6)	(100)	(88.3)	(40)	-	(53.7)	(80)	63.50	SD	122.6
Slum in City	13		7		20	7		13	20		5	2	20.00	Mean	31.50
	[65]		[35]		[100]	[35]		[65]	[100]		[25]	[10]	8.13	N	20.00
	(17.1)	-	(14)	-	(14)	(12.5)	-	(22.8)	(14.3)	-	(12.2)	(20)	50.00	SD	45.54
Slum in peripheral	6		2	12	20	14		6	20		14		20.00	Mean	90.00
	[30]		[10]	[60]	[100]	[70]		[30]	[100]		[70]		15.89	N	20.00
	(7.9)	-	(4)	(100)	14.3	(25)	-	(10.5)	(14.3)	-	(34.1)	-	64.82	SD	75.39
Total	76	2	50	12	140	56	4	57	140	10	41	10	140.0	Mean	136.6
	[54.3]	[1.4]	[35.7]	[8.6]	[100]	[40]	[2.9]	[57.1]	[100]	[7.1]	[29.3]	[7.1]	12.34	N	140.0
	(100)	(100)	(100)	100	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	SD	321.2

Source: Primary Data, [ ] Figures in parentheses are row-wise percentage and ( ) Figures in parentheses are indicate column wise percentage.

4.0 Conclusions

Water as a renewable natural resource, which incidentally has no substitute, gets allocated across sectors like agriculture, industry and domestic use. According to 2011, cases although the domestic sector requires less than 10 percent of the total in countries, one-fourth of the population is deprived of access to potable water, and 15 per cent has with covered with proper sanitation. This is achieved by conducting case studies of Coimbatore Corporation under selected with a sample of 140 households to enable to discern the actual problems at the grass root level and to suggest measures for improving the existing system. The provision drinking water and availability of drainage facilities are weakened in the peripheral part which associated with high health treatment cost. In a slum in the central part, even proximity availing of the facility is closer but not proper.

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