

Decentralized Small-Scale Water Services in Developing Countries

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The Gloomy Facts

- 1 billion people — or one sixth of the world's population — lack access to safe water
- Over 2 billion are without adequate sanitation
- Between 2 to 4 million deaths a year are attributed to unsafe water, mostly due to water-borne preventable diarrheal diseases
- 90% of those who die from diarrheal diseases are children under 5 in developing countries

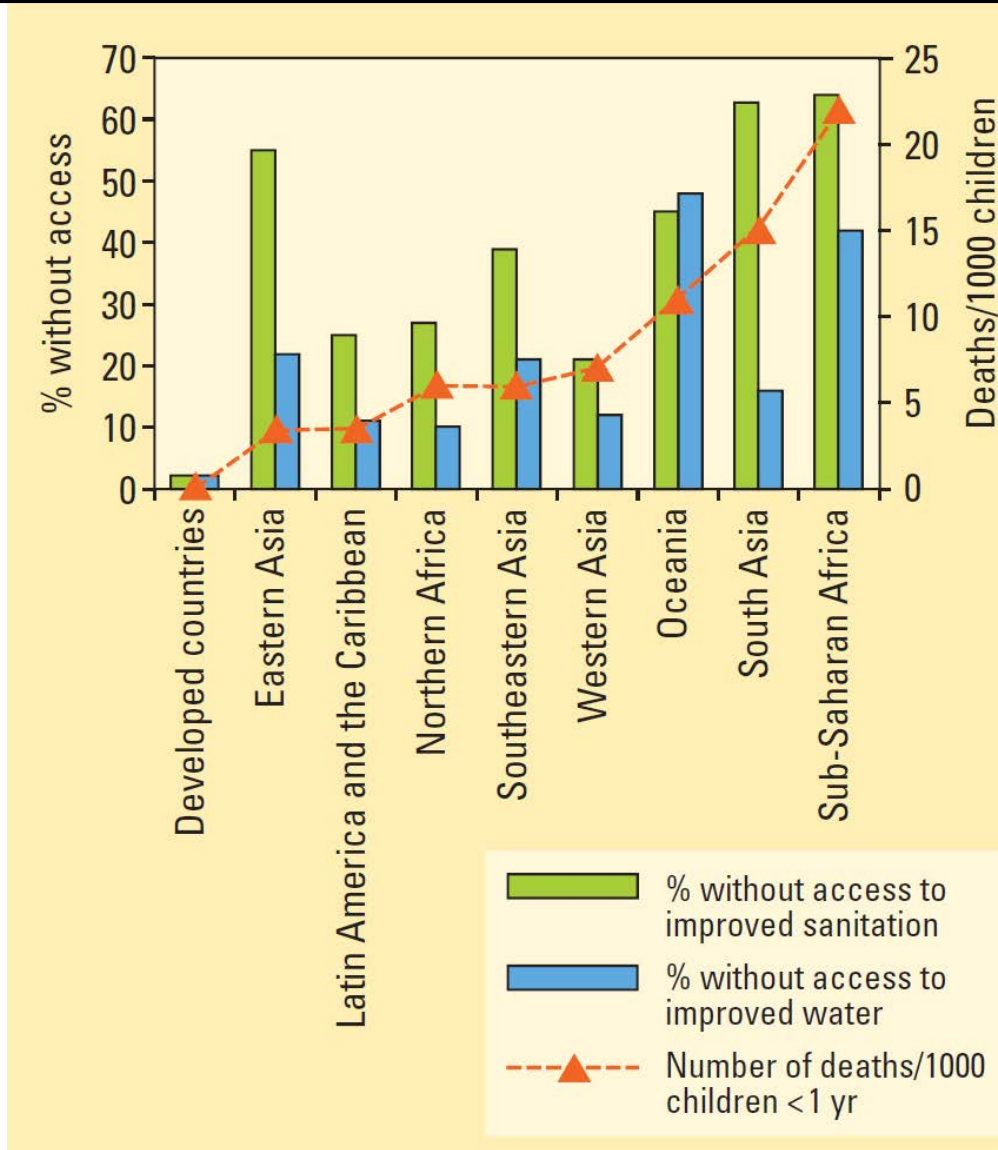
5,000 Children Die from Waterborne Diseases Every Day



WHO/UNICEF, JMP, 2005

“Even when they don’t kill, these diarrhea episodes
can physically and mentally stunt children.”

“Sanitation is the single most important medical advance since 1840”



Montgomery and Elimelech'
Environ. Sci. & Technol. 2007

The UN Millennium Declaration (2000)

- Goal 4: Reduce child mortality
 - By 2015, reduce by two thirds the **mortality rate among children under five**
- Goal 7: Ensure environmental sustainability
 - By 2015, reduce by half the proportion of people without sustainable **access to safe drinking water and sanitation**



We Design for Rural, Low Income Households



<http://sydney.edu.au/vetscience/research>



www.ebmud.com/wastewater/online_tour

Centralized versus Decentralized Solutions?

Mintz et al. *Am. Jour. Public Health*, 1991:

- “Approaches that rely solely on time- and resource-intensive centralized solutions will leave hundreds of millions of people without access to safe water far into the foreseeable future”
- “A radical reorientation toward interventions to support these populations is urgently required.”

Centralized versus Decentralized Solutions?

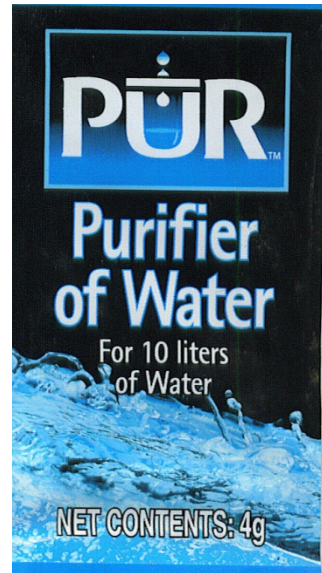
*“Cellular phones and satellite dishes revolutionized the telecommunications industry in developing countries, bypassing the expenditures and delays associated with traditional wire-based systems Similarly new scientific research . . . offers dramatic opportunities to introduce **new decentralized (point-of-use) approaches for improving water quality**”*

Mintz, et al., *American Journal of Public Health*, 2001, 91:1565

Point-of-Use Methods at the Household Level



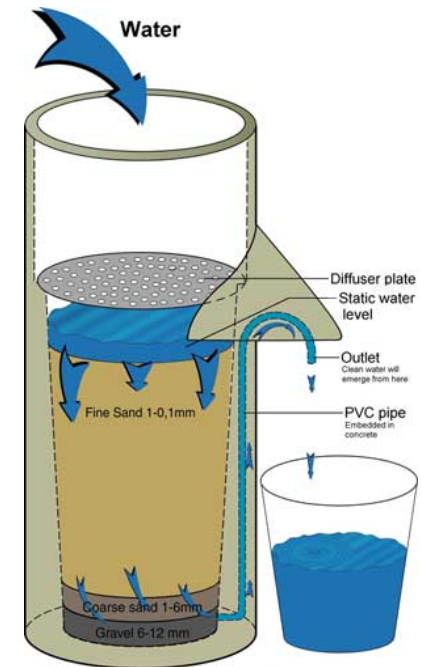
Chlorine



Ceramic Filters

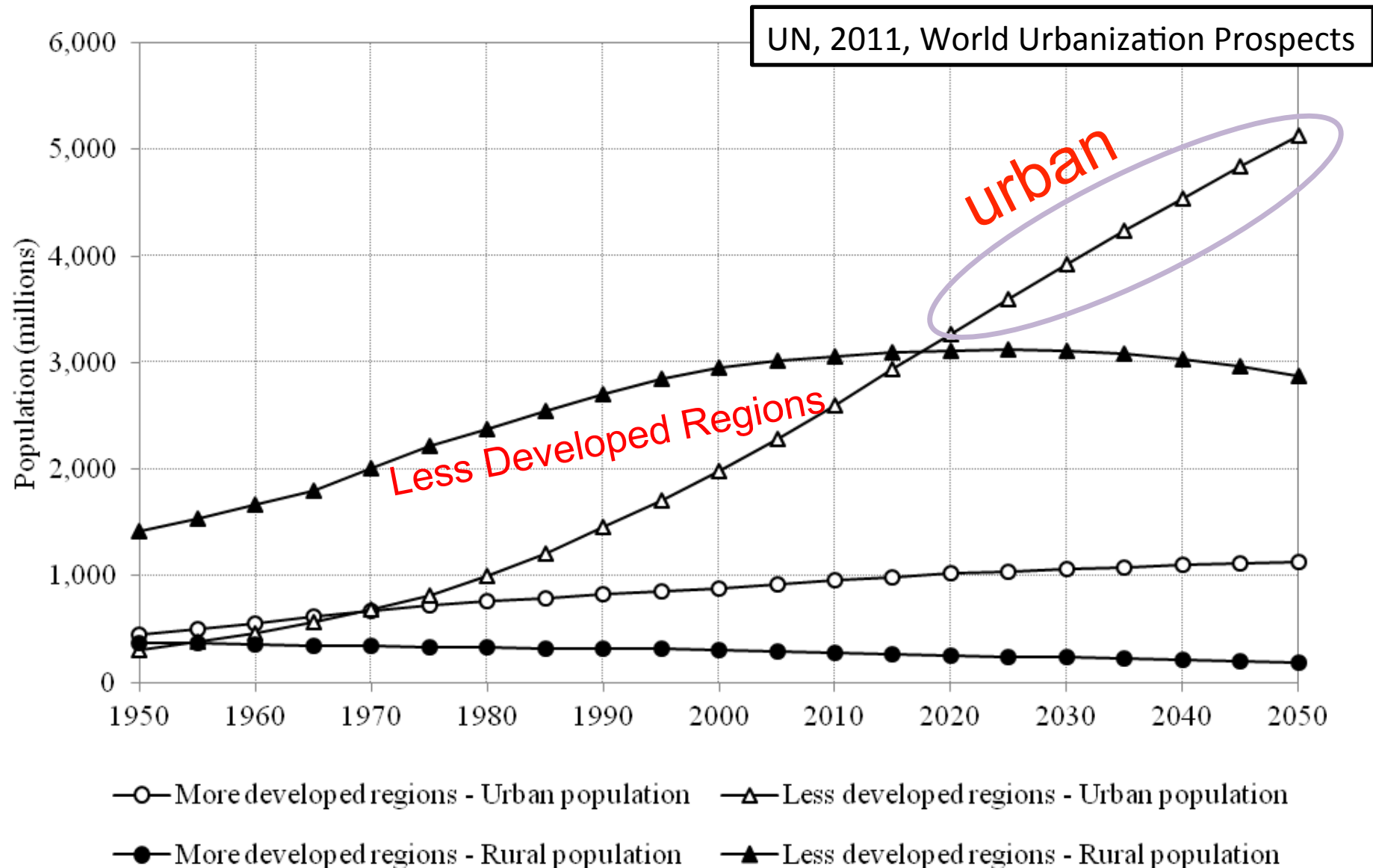


SODIS



Biosand Filter

BUT the World is Rapidly Urbanizing



79% of Urbanites in Low-Income Countries Live in Unplanned Settlements (Slums)

Adapted from WHO/UNICEF, *Joint Monitoring Program*, 2006

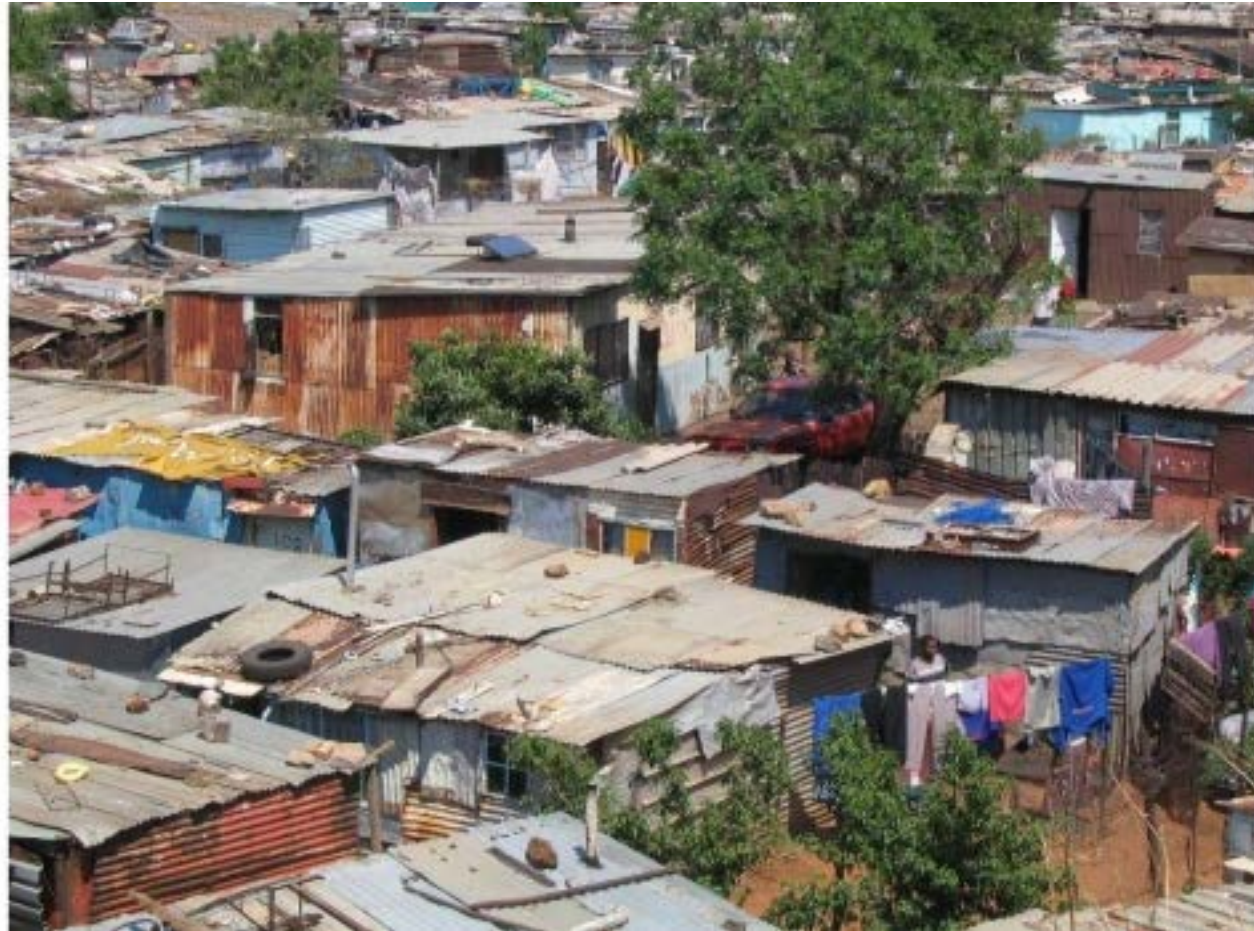


79% of Urbanites in Low-Income Countries Live in Unplanned Settlements (Slums)

Adapted from WHO/UNICEF, *Joint Monitoring Program*, 2006



79% of Urbanites in Low-Income Countries Live in Unplanned Settlements (Slums)



Centralized Systems Fail Systemically in Unplanned Settlements



extreme weather



illegal connections



rapid growth



insufficient pressure, unsafe water



INFORMAL, SMALL-SCALE
WATER SERVICES

MANY PEOPLE IN SLUMS 'PAY' FOR WATER FROM SMALL-SCALE DISTRIBUTORS

INFORMAL SMALL-SCALE WATER SERVICES IN DEVELOPING COUNTRIES: THE BUSINESS OF WATER FOR THOSE WITHOUT FORMAL MUNICIPAL CONNECTIONS

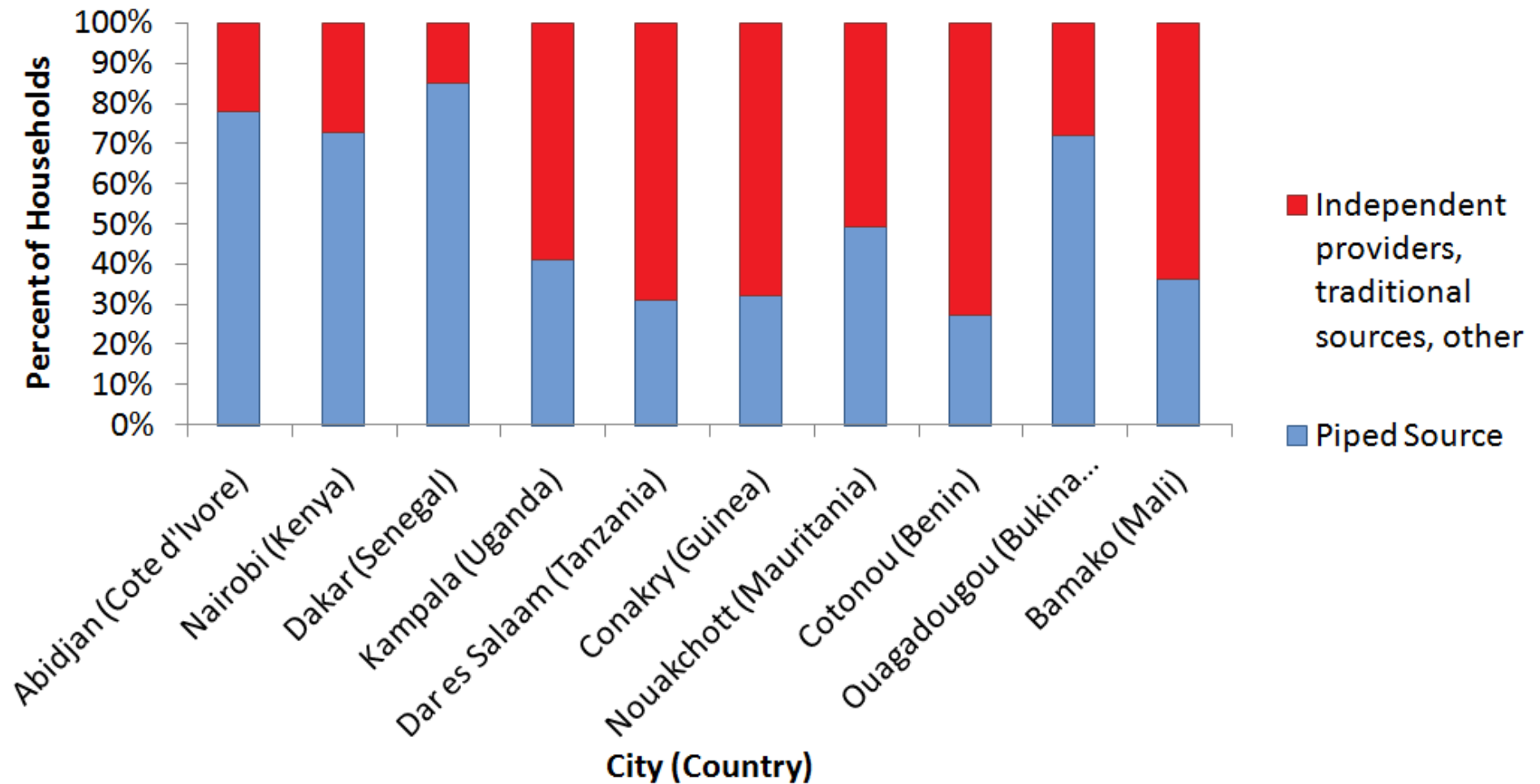
LAURA SIMA AND MENACHEM ELIMELECH

Water and Sanitation-Related Diseases and the Environment: Challenges, Interventions, and Preventive Measures, First Edition.

Edited by Janine M. H. Selendy.

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MANY PEOPLE IN SLUMS 'PAY' FOR WATER FROM SMALL-SCALE DISTRIBUTORS



STUDY OF INFORMAL WATER VENDING SECTOR

Ecological Economics 87 (2013) 137–144



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Analysis

Water flows, energy demand, and market analysis of the informal water sector in Kisumu, Kenya

Laura C. Sima^a, Evan Kelner-Levine^a, Matthew J. Eckelman^b,
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STUDY OF INFORMAL WATER VENDING SECTOR: METHODS



DATA

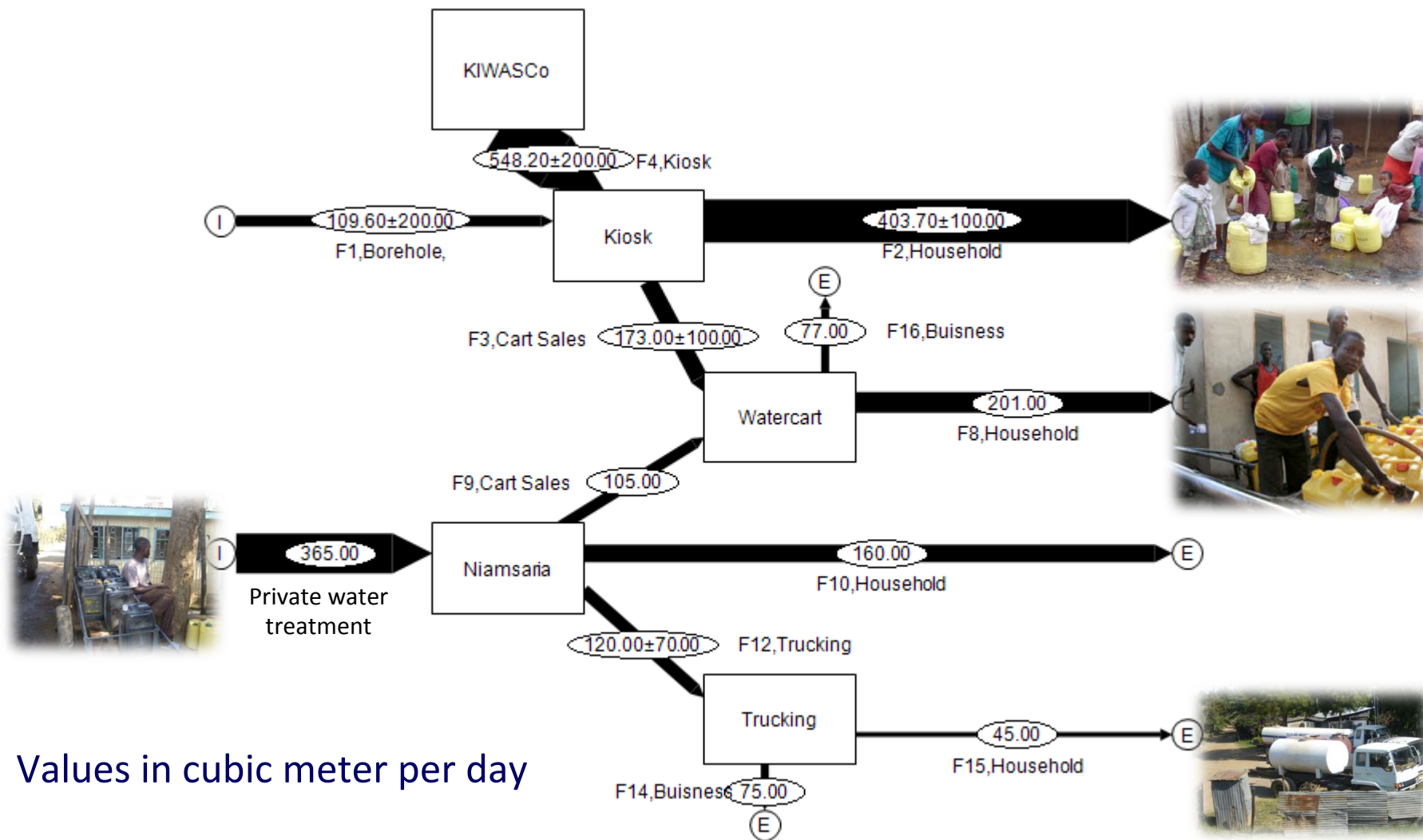
- Interviewer Responses
- Municipal Water Use
- Census Data

Kisumu, Kenya

Analysis

- Material Flow Analysis
- Embedded Energy Calculations

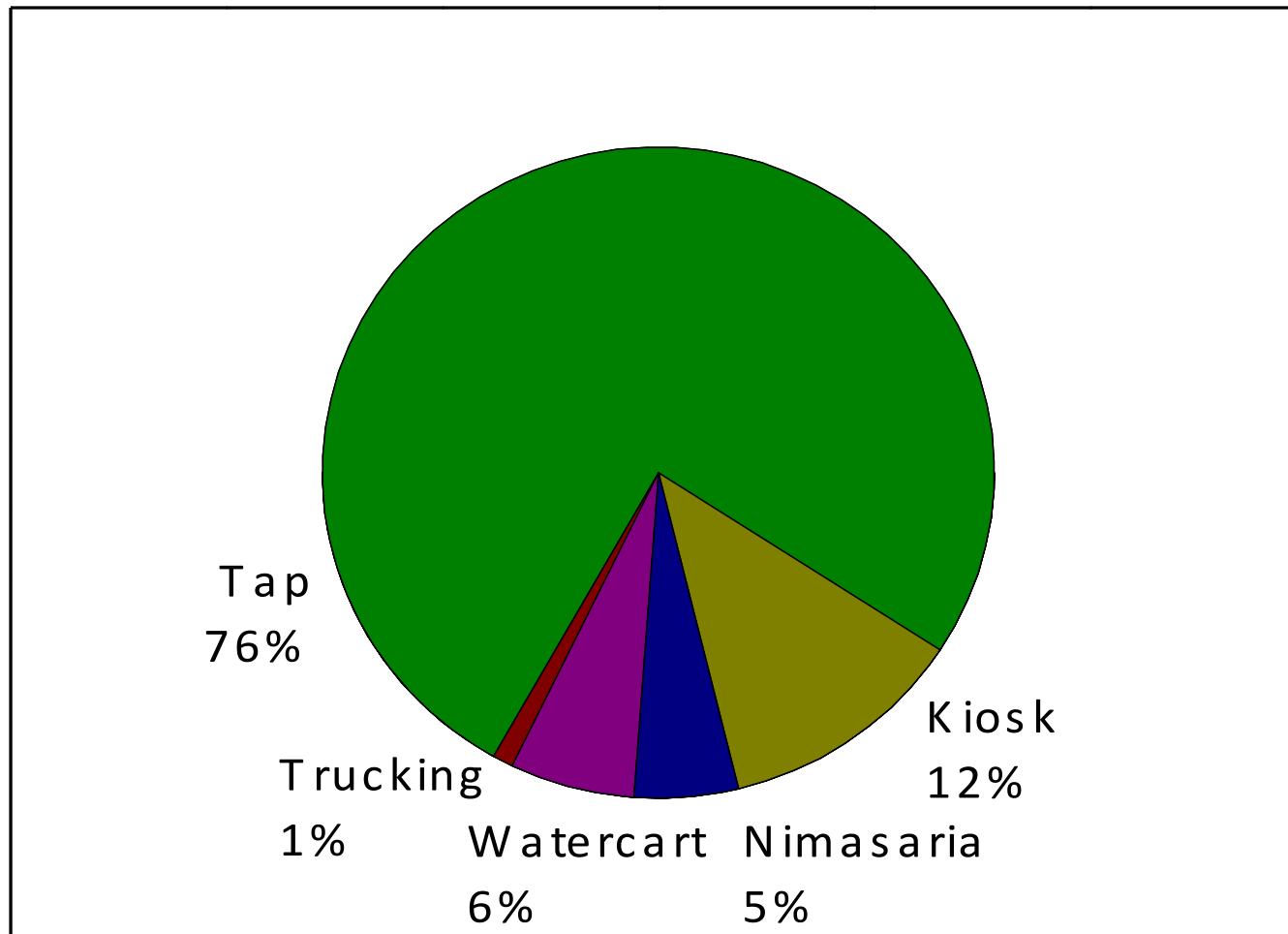
STUDY OF INFORMAL WATER VENDING SECTOR: DISTRIBUTION



Values in cubic meter per day

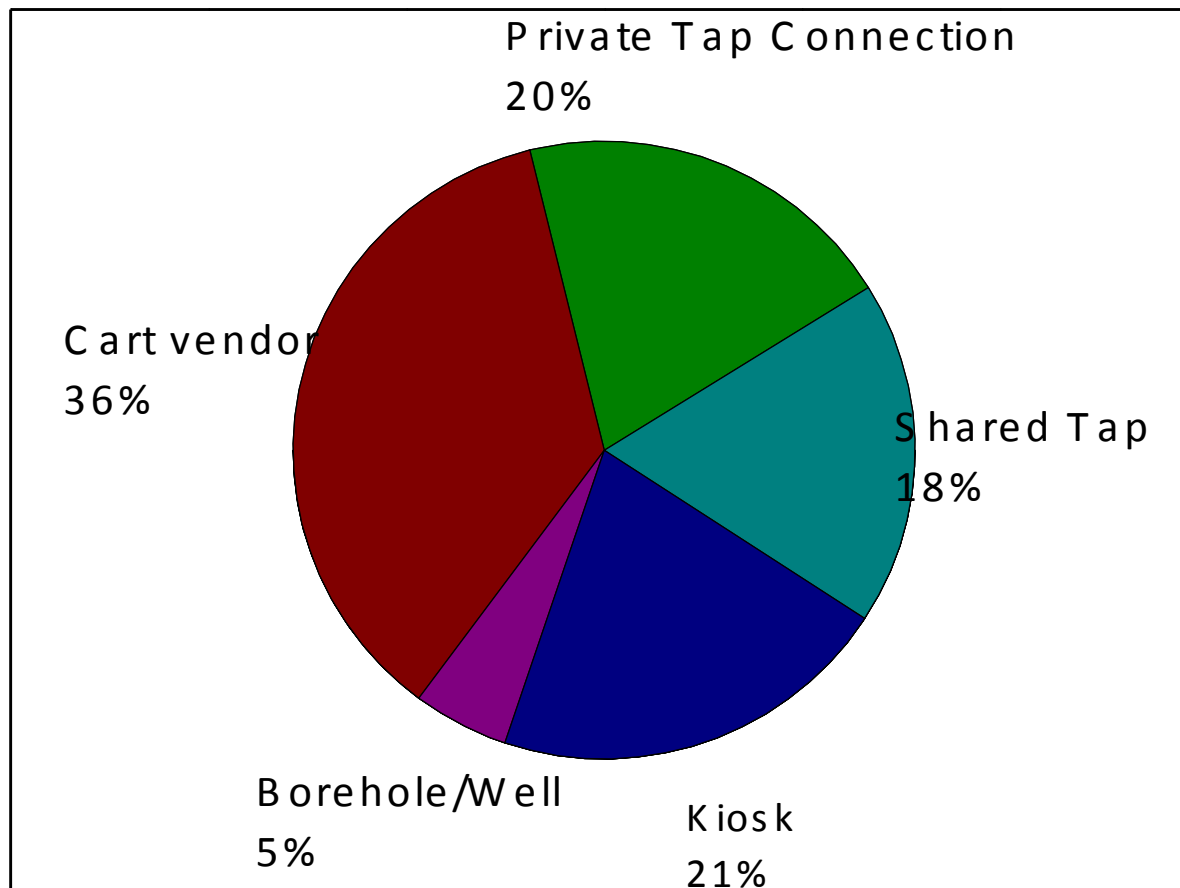
STUDY OF INFORMAL WATER VENDING SECTOR: SCALE

The **volume of water** provided to households by source



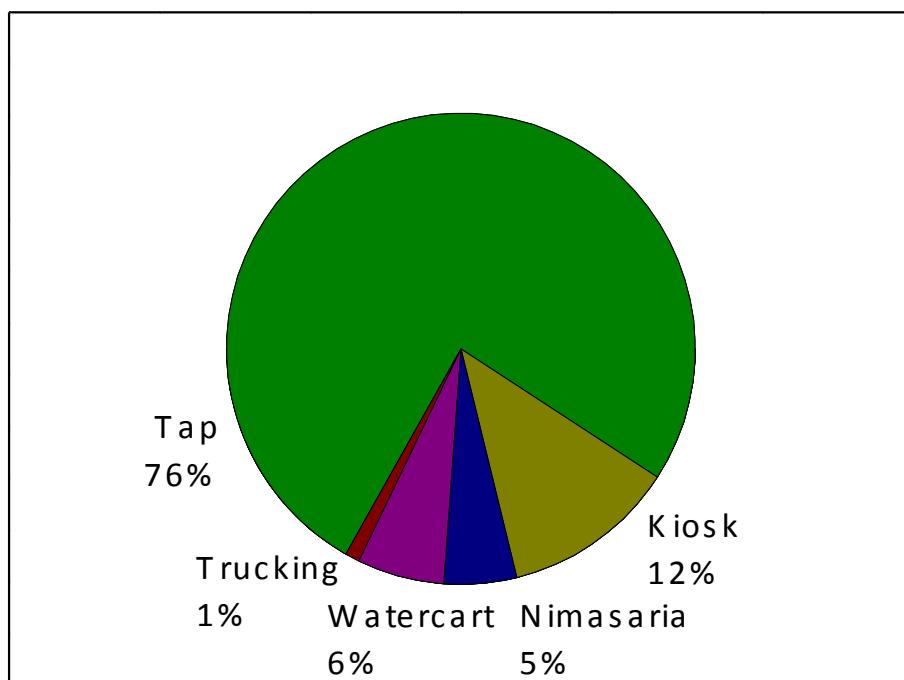
STUDY OF INFORMAL WATER VENDING SECTOR: SCALE

The **per-household water** provided to households by source

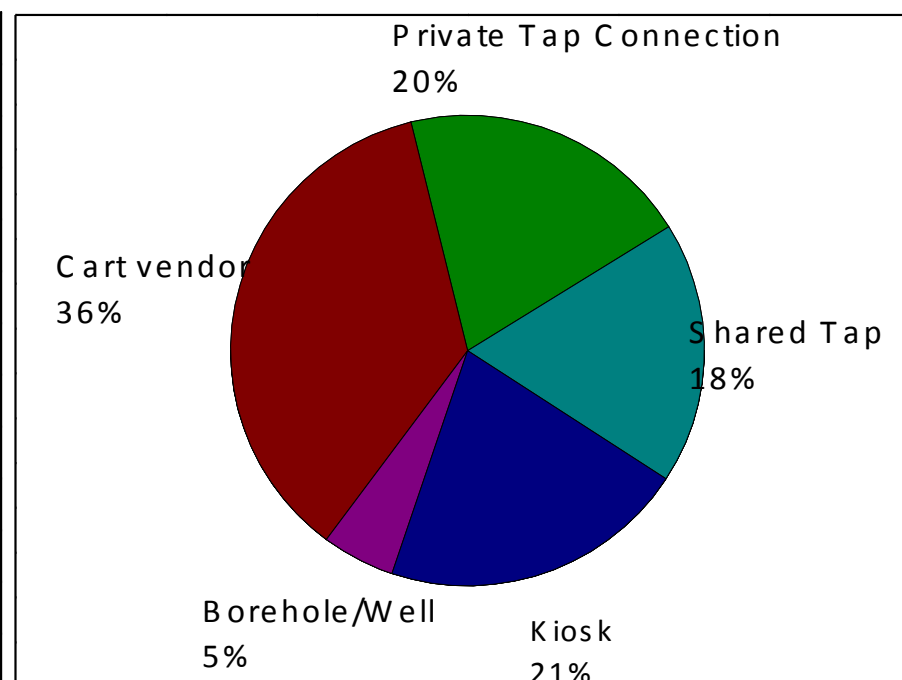


STUDY OF INFORMAL WATER VENDING SECTOR: SCALE

The **volume** of water provided to households by source.



The **per-household water** provided to households by source

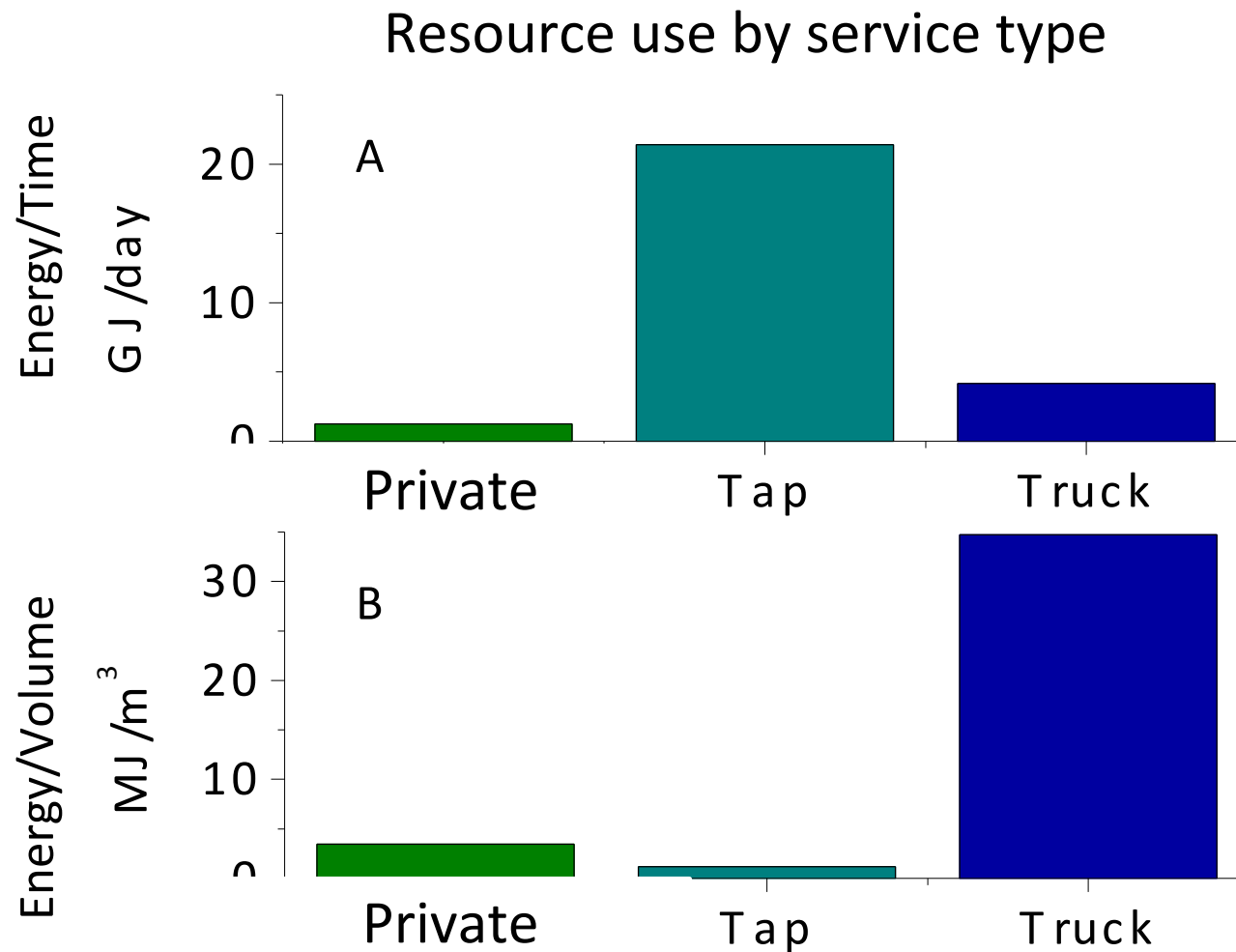


STUDY OF INFORMAL WATER VENDING SECTOR: RESPONDING TO NEEDS

		Kaloleni- Northern	Manyatta	Nyalenda	Nyawita- Migosi	Southern
	Population Density 2009 (residents/Km ²)	7,198	15,501	7,713	10,671	1,760
CENSUS	Population Growth, 1999-2009 (residents/ Km ²)	579	3641	2523	1138	-319
	Price (KSh/20L)	11.4	2.82	2.74	4.16	4.8
DATA	Number of jerrycans waiting to be filled, mean	17.3	24.9	7.88	21.2	6

GATHERING

STUDY OF INFORMAL WATER VENDING SECTOR: ENERGY AND RESOURCE USE



INFORMAL WATER BUSINESSES: CONCLUSIONS

- Small-scale water businesses are financially viable in low-income urban slums.
- Even though they supply a relatively low volume of water, informal businesses supply a significant portion of the population in Kisumu
- Embedded energy use is higher for informal, decentralized distribution than for central, piped distribution.

A solid blue oval shape centered on a white background, containing the text 'WATER REFILL KIOSKS'.

WATER REFILL
KIOSKS

WATER REFILL STATIONS ARE COMMON

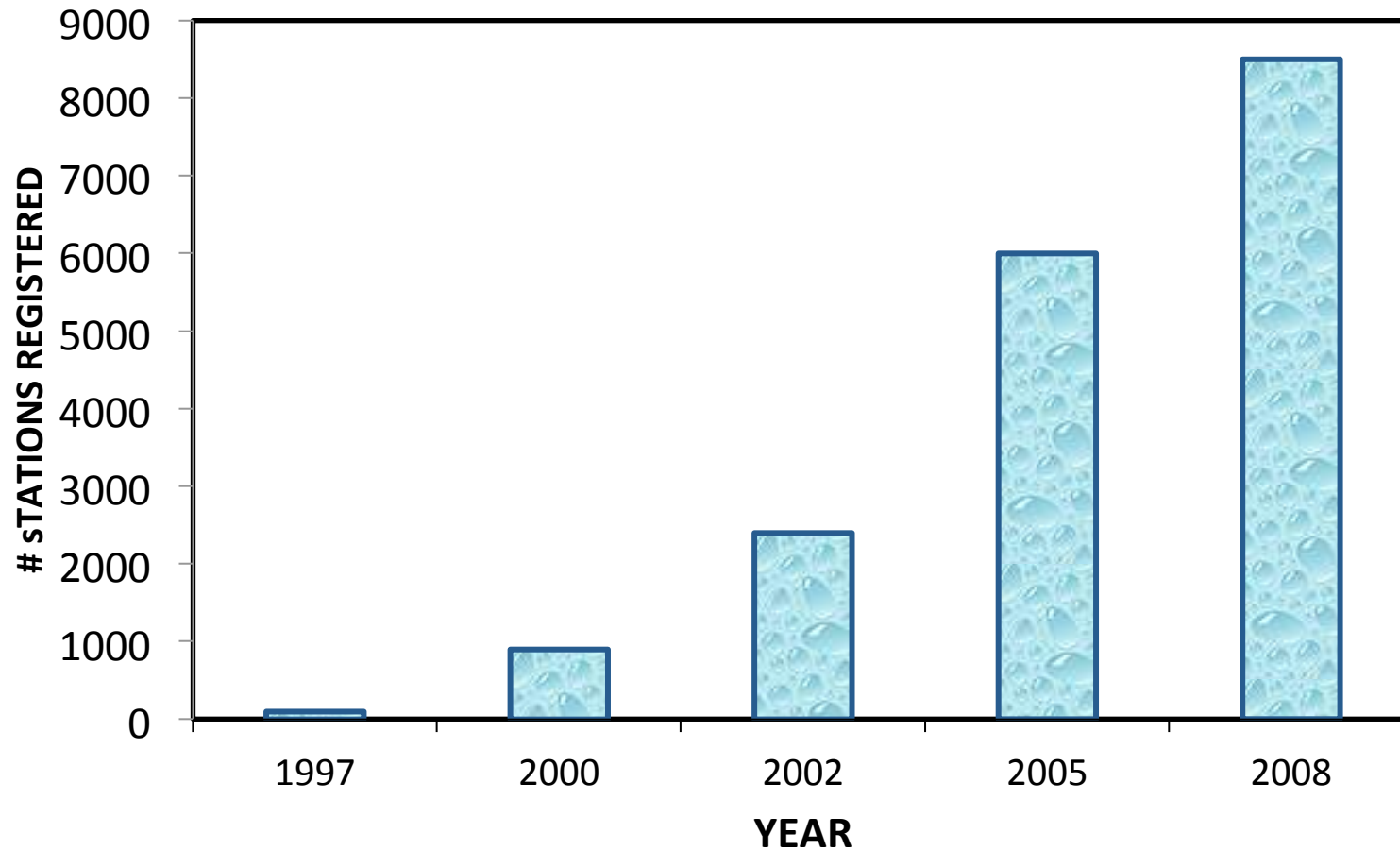


Combined Ultra-filtration/UV
or Reverse Osmosis with Activated Carbon



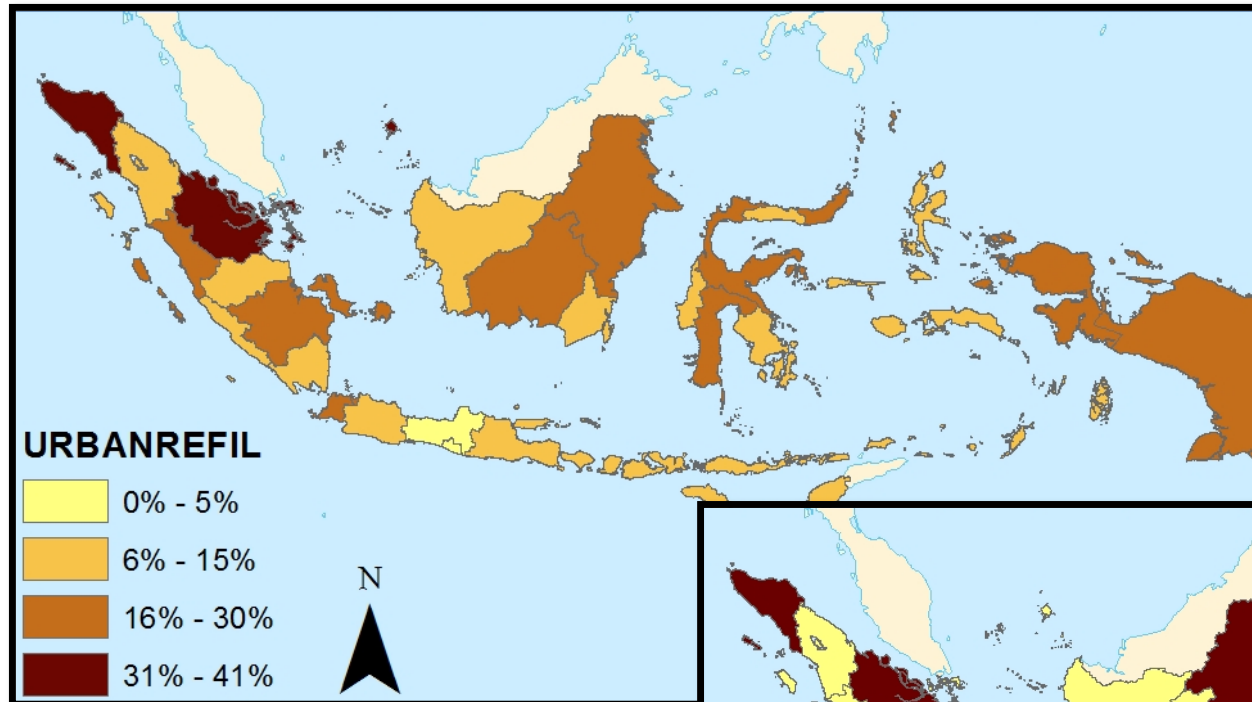
WATER REFILL STATIONS GROWING RAPIDLY

APIMIDO Registry of Refill Stations

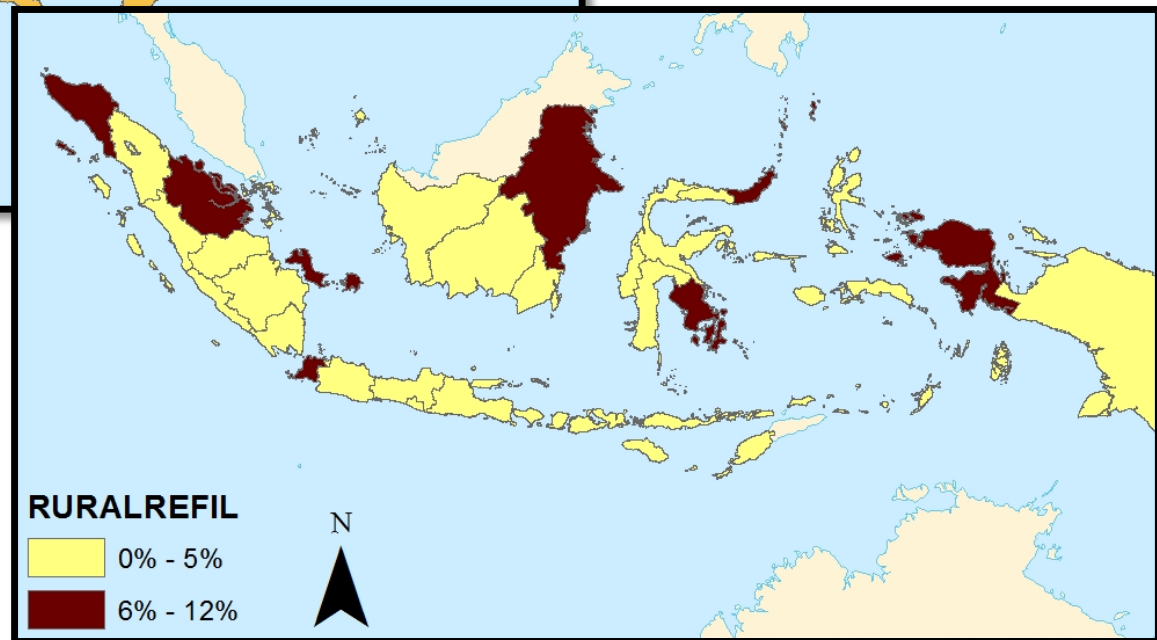


Budi Darmawana, President APIMIDO, July 2009, Water Business Seminar, Nairobi, Kenya.

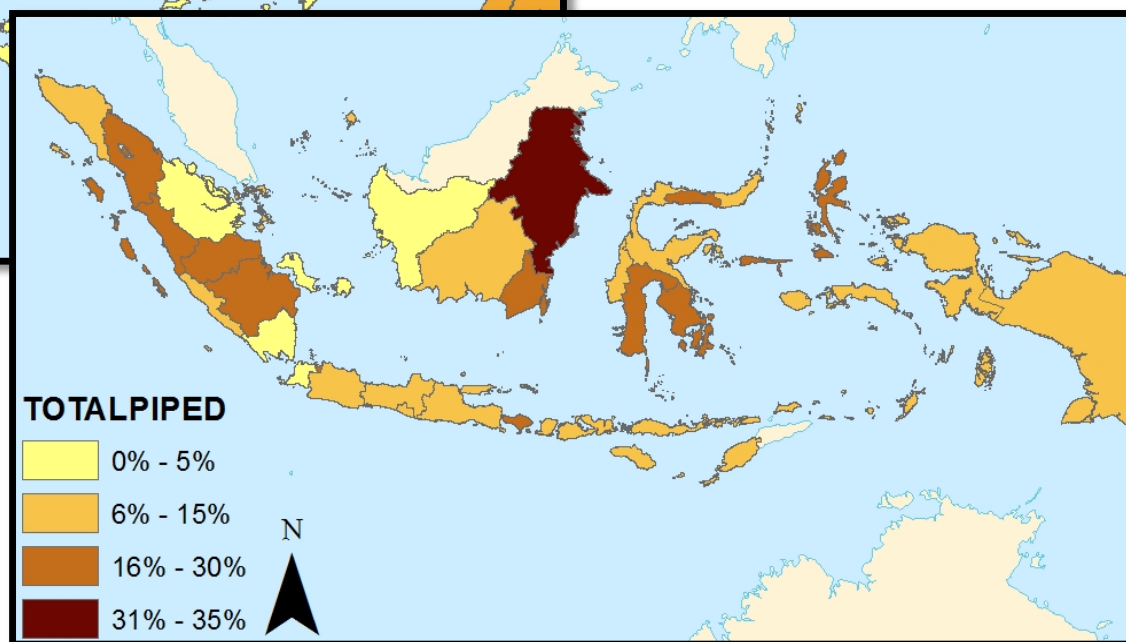
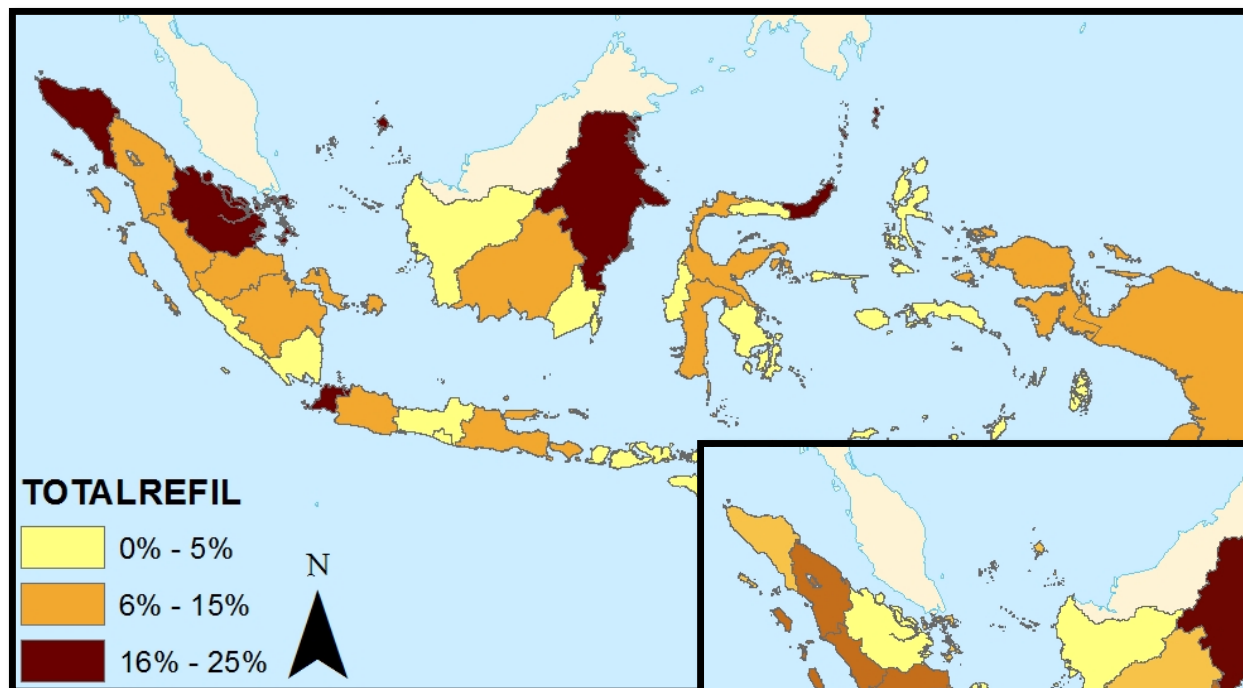
WATER REFILL STATIONS MORE PREVALENT IN URBAN THAN RURAL AREAS



SUSENAS, 2010



WATER REFILL STATION ALMOST AS POPULAR AS PIPED WATER IN SOME PROVINCES



SUSENAS, 2010

LONGITUDINAL DIARRHEA AND REFILL STATIONS

Am. J. Trop. Med. Hyg., 87(6), 2012, pp. 979–984

doi:10.4269/ajtmh.2012.12-0224

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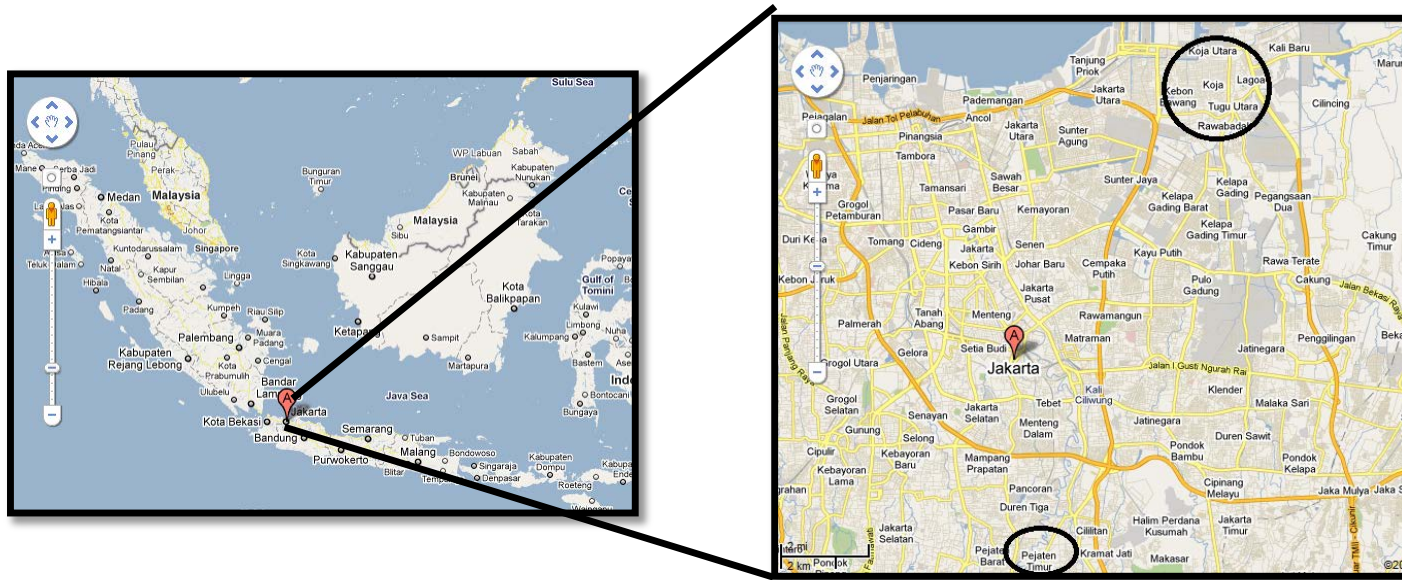
Relationship between Use of Water from Community-Scale Water Treatment Refill Kiosks and Childhood Diarrhea in Jakarta

Laura C. Sima, Mayur M. Desai, Kathleen M. McCarty, and Menachem Elimelech*

Department of Chemical and Environmental Engineering, Yale University, New Haven, Connecticut; School of Public Health, Yale University, New Haven, Connecticut

LONGITUDINAL DIARRHEA AND REFILL STATIONS: METHODS

Kelurahan Koja (North) and
Kelurahan Pejaten Timur (South), Jakarta, Indonesia



1000 children between 1-5 years old
Low or middle-low income families
Selected from government records

Sima et. al, American Journal of Tropical Medicine and Hygiene, 2012













LONGITUDINAL DIARRHEA AND REFILL STATIONS: METHODS

1. Baseline Survey

- Socioeconomic and environmental survey
- Direct nutrition measures (weight, height)

2. Daily Monitoring with “Diaries”

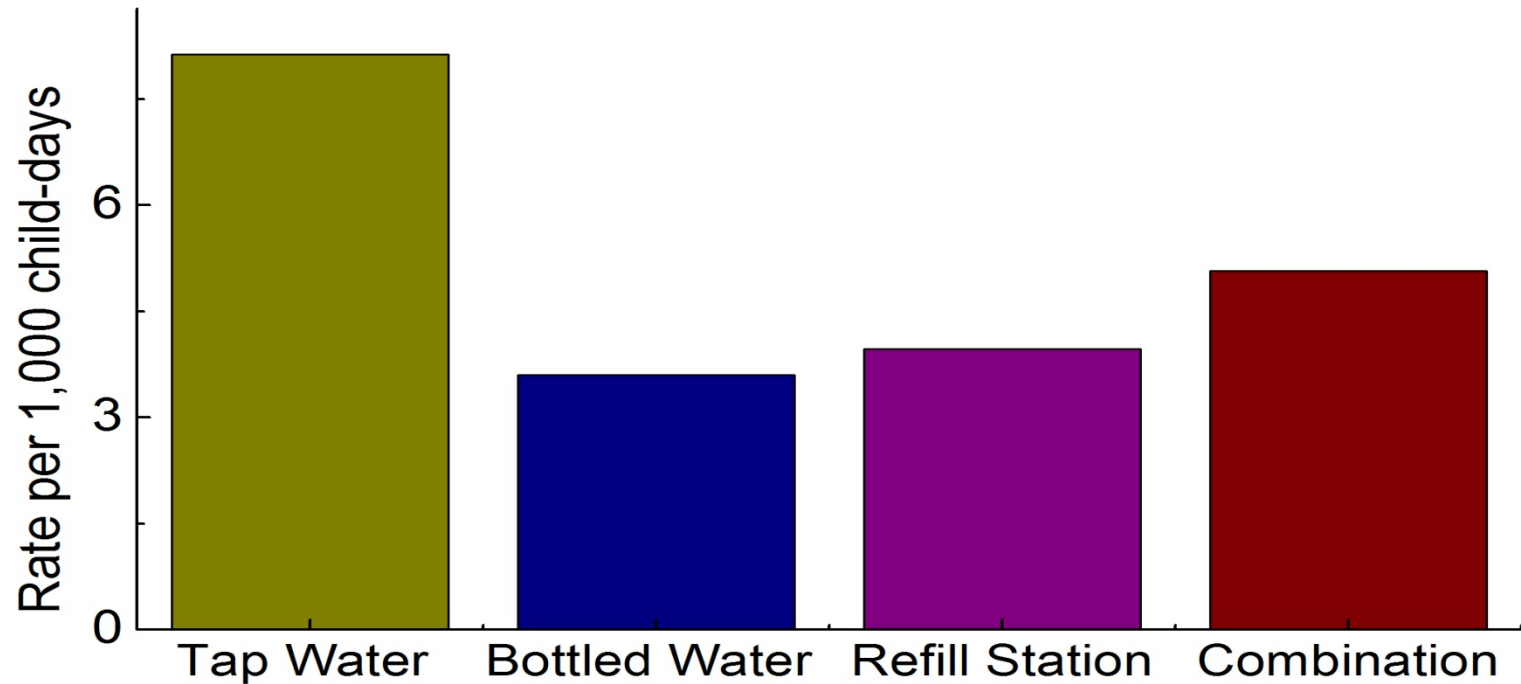
	SUMUR	PAM	AIR ISI ULANG	AIR DALAM KEMASAN	DIMASAK/REBUS
SENIN					
SELASA					

	Tinja Normal	Diare				Dengan darah dan/atau lendir
Senin 14/02						
Selasa						

DISTRIBUTION OF SOCIO-DEMOGRAPHIC AND SANITATION FACTORS IN NORTHERN SLUM AREA

	Tap Water n = 142	Bottled Water n = 64	Water Kiosk n = 148	Combination n = 146
Household is below poverty line	70%	46%	59%	52%
Head of household's education level				
Less than primary school	41%	20%	23%	18%
Completed primary school	36%	22%	32%	35%
Secondary school or greater	23%	58%	45%	47%
Household sanitation facilities				
Private Improved	26%	55%	42%	48%
Shared/Public Improved	63%	39%	41%	40%
Unimproved	11%	5%	17%	12%

DIARRHEA RATES BY WATER SOURCE IN NORTHERN SLUM



Unadjusted rate ratio

1.00

0.44 *

0.49*

0.63

Adjusted rate ratio

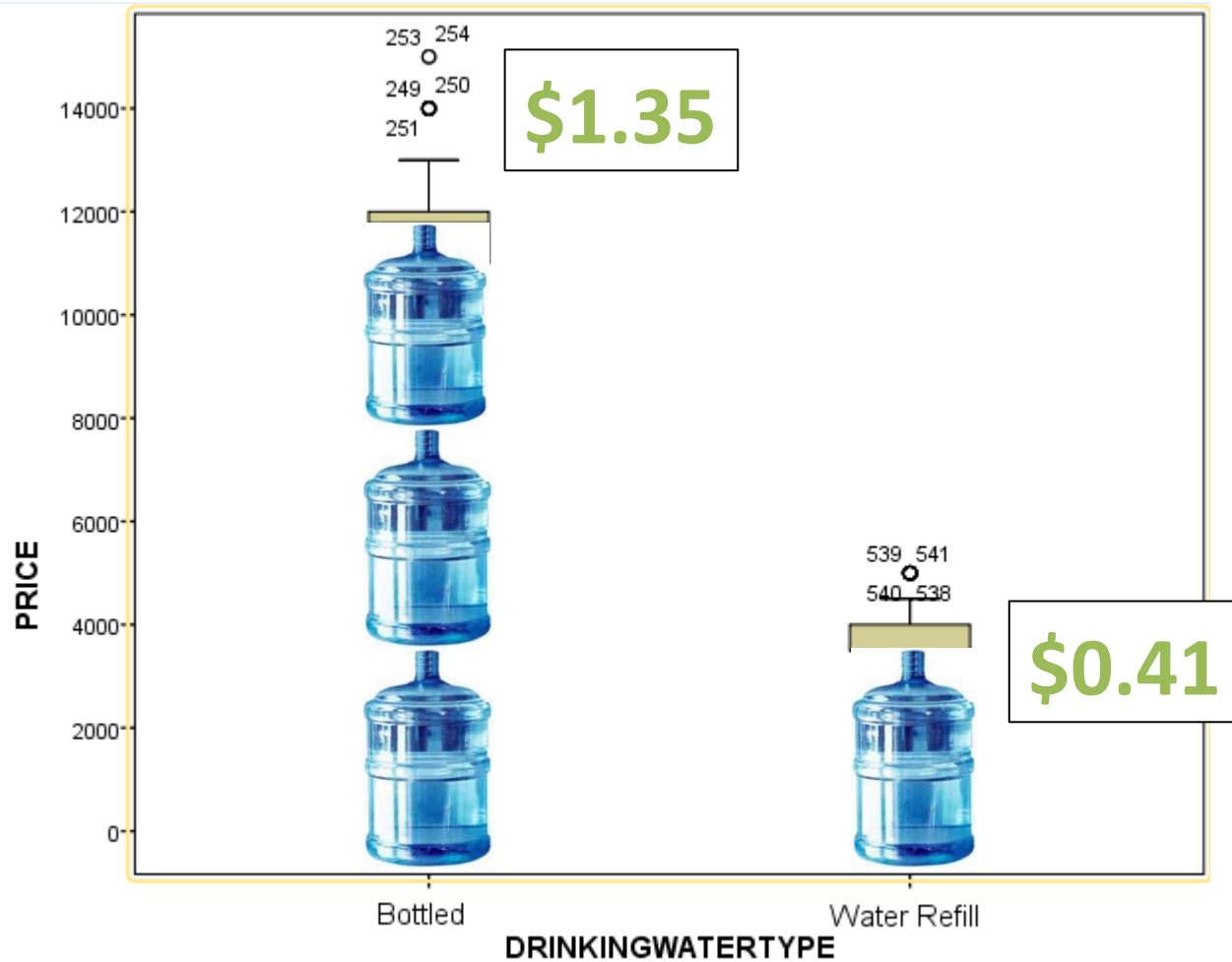
1.00

0.45*

0.49*

0.61

OUTLOOK OF WATER REFILL INDUSTRY



Sima et. al, *American Journal of Tropical Medicine and Hygiene*, 2012

WATER REFILL KIOSKS: CONCLUSIONS

- Water refill kiosks associated with relative risk reduction of diarrhea similar to bottled water.
- Both water bottle use and refill station use contributed to >50% reduction in longitudinal disease prevalence amongst children 1-5.
- These impacts may be context-specific. Water quality improvements only reduce transmission of disease tied to dirty water; they cannot reduce disease transmission from other sources.

OVERALL CONCLUSIONS

- A wide variety of small-scale businesses supply water to areas where government supplies and natural sources are unavailable.
- Water refill stations in Jakarta not only supply water, but supply treated water to lower income households in slums. These higher quality water source improvements are associated with a reduced diarrhea risk of as much as 50% — a reduction similar to that of bottled water consumption.
- Considering the size and scope of these businesses, little work has been done to understand them. Assumptions that these businesses are inherently opportunistic and supply low quality water may be unwarranted.