Running Out of Water: The Prospects for Cities?

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Presented at the UN Conference on “Sustainable Water Management in Cities: engaging stakeholders for effective change and action,” Zaragoza, Spain, December 13-17, 2010

The Bogeymen of Sustainability

Thomas Robert Malthus, (1766-1834)

David Ricardo. (1772-1823)

Malthus postulated a geometric rate of growth of population and an arithmetic growth of land being brought under cultivation and, hence, an arithmetic rate of growth of food production. Malthus predicted widespread famine or violent conflicts to bring food and population into alignment with each other by “misery, war, pestilence, and vice.”

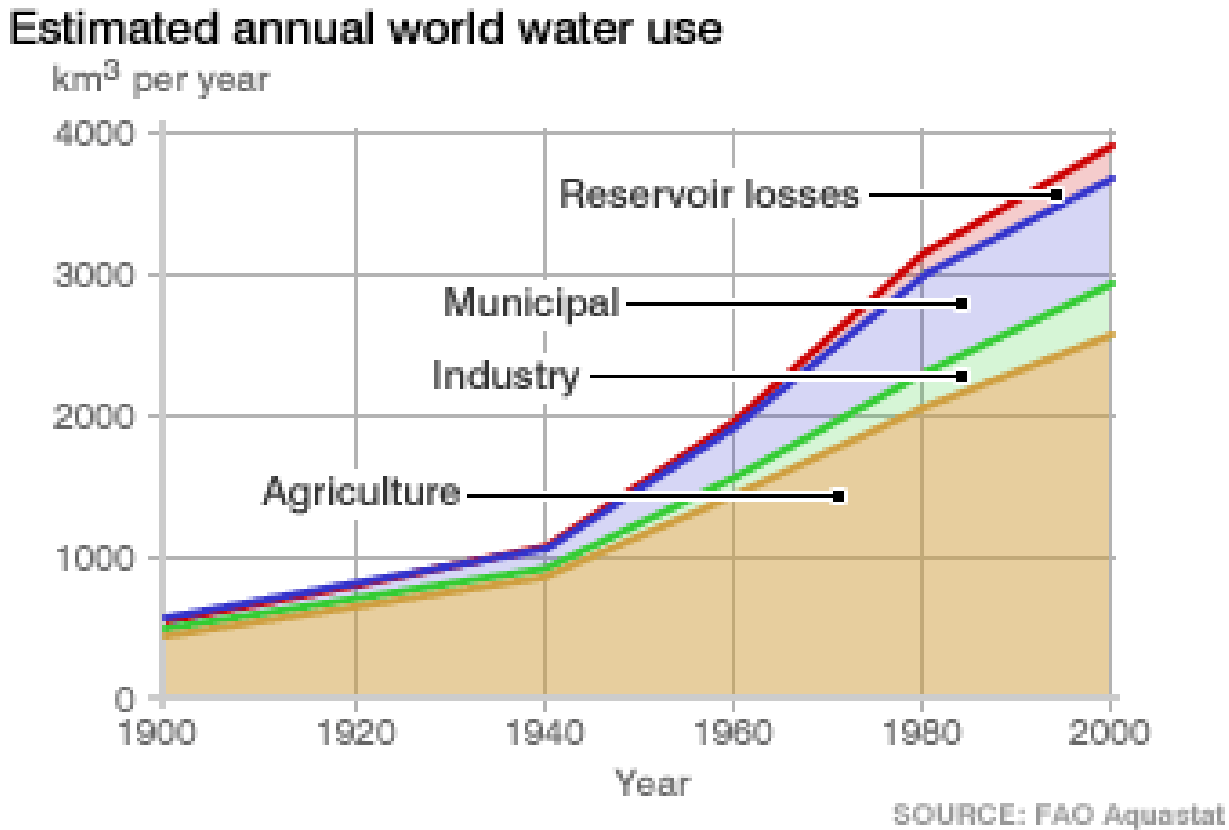
Ricardo articulated “declining returns” on investments in resources (coal and iron ore in his time, water, oil, and gas in our time) whereby the best (least-cost) resources are used first, followed by the next best, and so on. Increasing demand for the resource leads to price increases that will continue to rise until the resource becomes too expensive to use.

These two nineteenth century concepts are at the root of our concern for Sustainable Development.

Cannot talk about urban water without discussing competing uses

Conventional View of Increasing Demand Meeting Fixed Supply

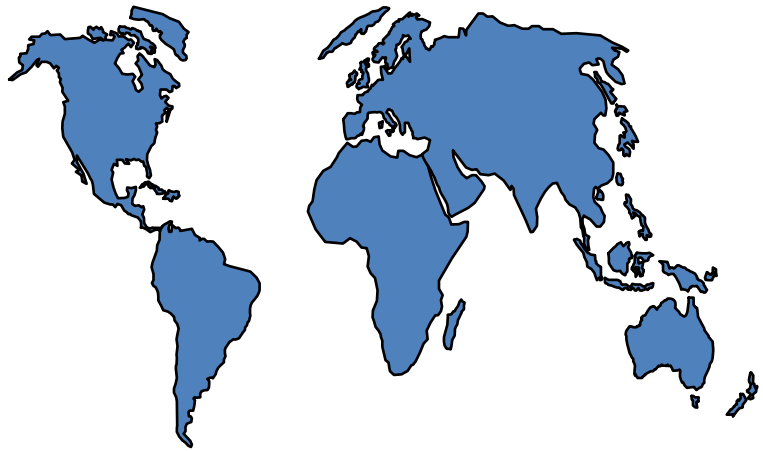
- Since 1900 global population has tripled
- Water use has increased more than six-fold



An old story

Huge needs

- over 1 billion people without safe water, 2 w/o sanitation, 4 w/o sewage treatment
- existing systems are run-down
- Sanitation for 1.2 millions and water for 600,000 additional persons each week over 15 years to meet MDG
- An additional 60 million ha. (+30%) of irrigated land by 2050



No money

➔ fiscal constraints

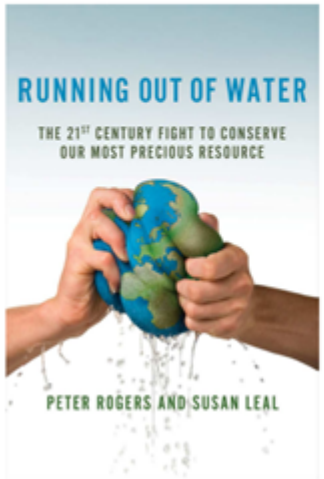
➔ official aid stagnant (< $3bn/yr, WB $1bn)

➔ public utilities unable to self-finance or to carry debt

➔ private investment: a relative trickle so far

what can we do?

Janssens, J., (2003)



RUNNING OUT OF WATER

The Looming Crisis and Solutions to Conserve Our Most Precious Resource

Peter Rogers and Susan Leal

Foreword by Congressman Edward J. Markey

In this ground breaking and forward-looking book, Peter Rogers and Susan Leal give us a sobering perspective on the water crisis—why it's happening, where it's likely to strike, and what puts the worst strain on our supply. They introduce exciting new technologies that can help revolutionize our consumption of water and explain how different areas of the world have taken the helm in alleviating the burden of water shortages. Rogers and Leal also show how it takes individuals at all levels to make this happen, from grassroots organizations who monitor their community's water sources, to local officials who plan years in advance how they will appropriate water, to the national government who can invest in infrastructure for water conservation today. Informed and inspiring, this is a clarion call for action and an innovative look at how we can confront the crisis.

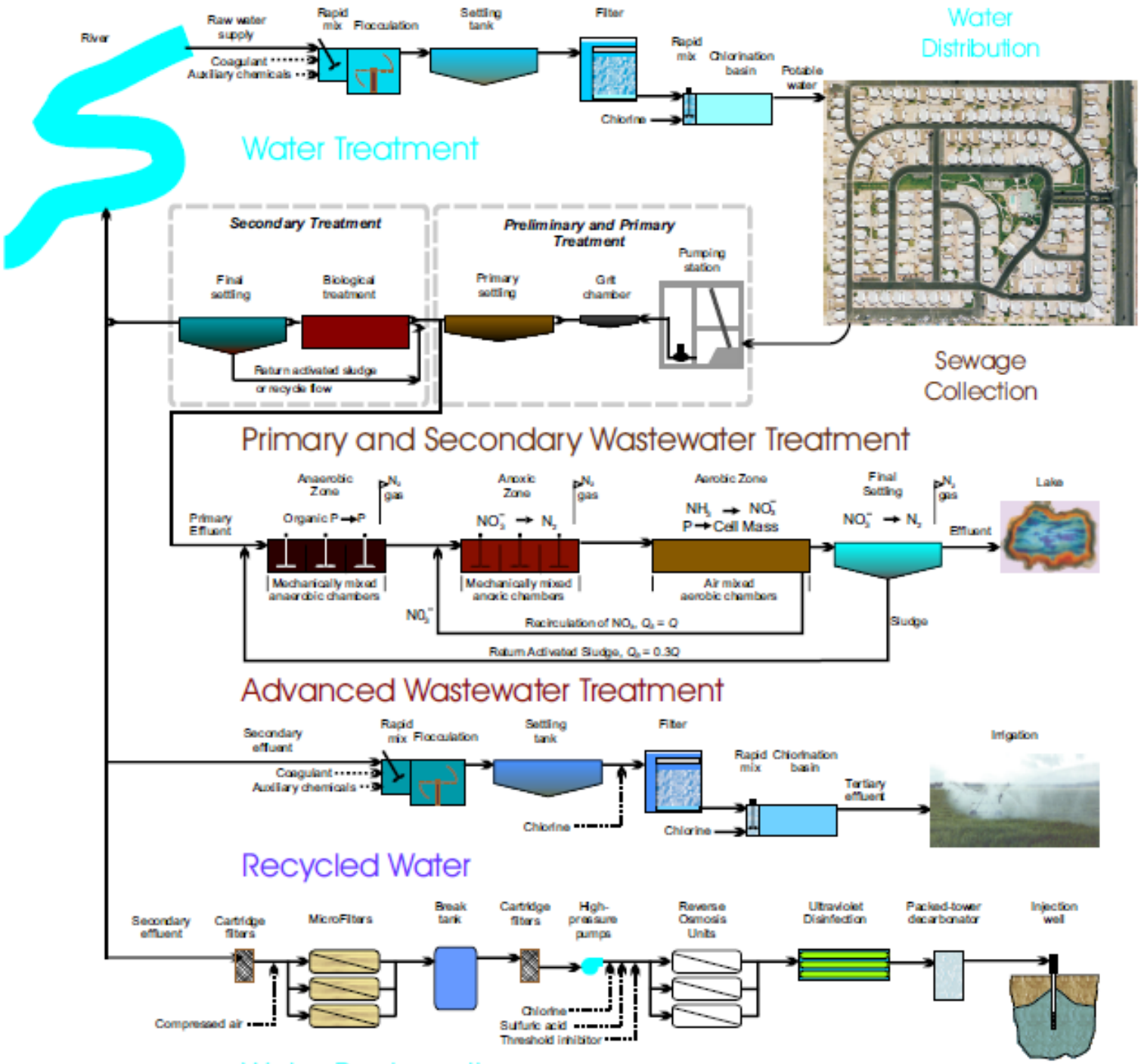
"A call to action as well as a celebration of the progress already under way. *Running Out of Water* offers hope and guidance for getting that crucial job done."**—from the foreword by Congressman Edward J. Markey**
"An admirably clear exposition of the lamentable state of the planet's water. I particularly liked Rogers and Leal's selection of eminently sensible, easily replicable, scalable solutions, and their sense that yes, the water world can be fixed."**—Marq de Villiers, author of Water: The Fate of Our Most Precious Resource**

Running Out of Water: Themes

- Facing a crisis in water due to population, wealth, and changing climate
- Too much Gloom and Doom
- The technologies are already available to improve the efficient use of existing water supplies by:
  - Improved irrigation efficiency
  - Trade of virtual water
  - Moving from conventional wastewater
  - Reuse of water in industry, agriculture, and domestic uses
  - Socially enforced changes in demand

Running Out of Water: Cases

- Recycling wastewater; Orange County, Ca., Singapore, and St Petersburg, Fla
- Improving Agricultural use; Rising City, Nebraska, Imperial Valley, California, and Murray-Darling, Australia
- Public involvement in urban water issues; San Francisco, Ca., innovative urban water supply and sewers in Brazil
- Valuing water the role of economic thinking in managing water resources; the case of Boston Harbor
- Urban wastewater as a resource; San Francisco FOG, East Bay MUD and blood as a resource, Santa Rosa and the Geysers.
- Transboundary conflicts; the Indus as a success story, other major international basins in play, Nile, Ganges, Mekong.
- Bottled water working against improving maintenance and expansion of public systems


River
Raw water supply
Coagulant
Auxiliary chemicals
Rapid mix
Flocculation
Settling tank
Filter
Rapid mix
Chlorination basin
Potable water
Chlorine
Water Treatment
Water Distribution
Secondary Treatment
Final settling
Biological treatment
Return activated sludge or recycle flow
Preliminary and Primary Treatment
Primary setting
Grit chamber
Pumping station
Sewage Collection
Primary and Secondary Wastewater Treatment
Primary Effluent
Anaerobic Zone
Organic P → P
Mechanically mixed anaerobic chambers
Anoxic Zone
Mechanically mixed anoxic chambers
Aerobic Zone
NH3 → NO3
P → Cell Mass
Air mixed aerobic chambers
Final Settling
Effluent
Lake
Recirculation of NOx, Qr = Q
Return Activated Sludge, Qr = 0.3Q
Sludge
Advanced Wastewater Treatment
Secondary effluent
Coagulant
Auxiliary chemicals
Rapid mix
Flocculation
Settling tank
Filter
Chlorine
Rapid mix
Chlorination basin
Tertiary effluent
Irrigation
Recycled Water
Secondary effluent
Cartridge filters
MicroFilters
Break tank
Cartridge filters
High-pressure pumps
Reverse Osmosis Units
Ultraviolet Disinfection
Packed-tower decarbonator
Injection well
Compressed air
Chlorine
Sulfuric acid
Threshold inhibitor

Toilet-to-Tap: Recycling Urban Wastewater

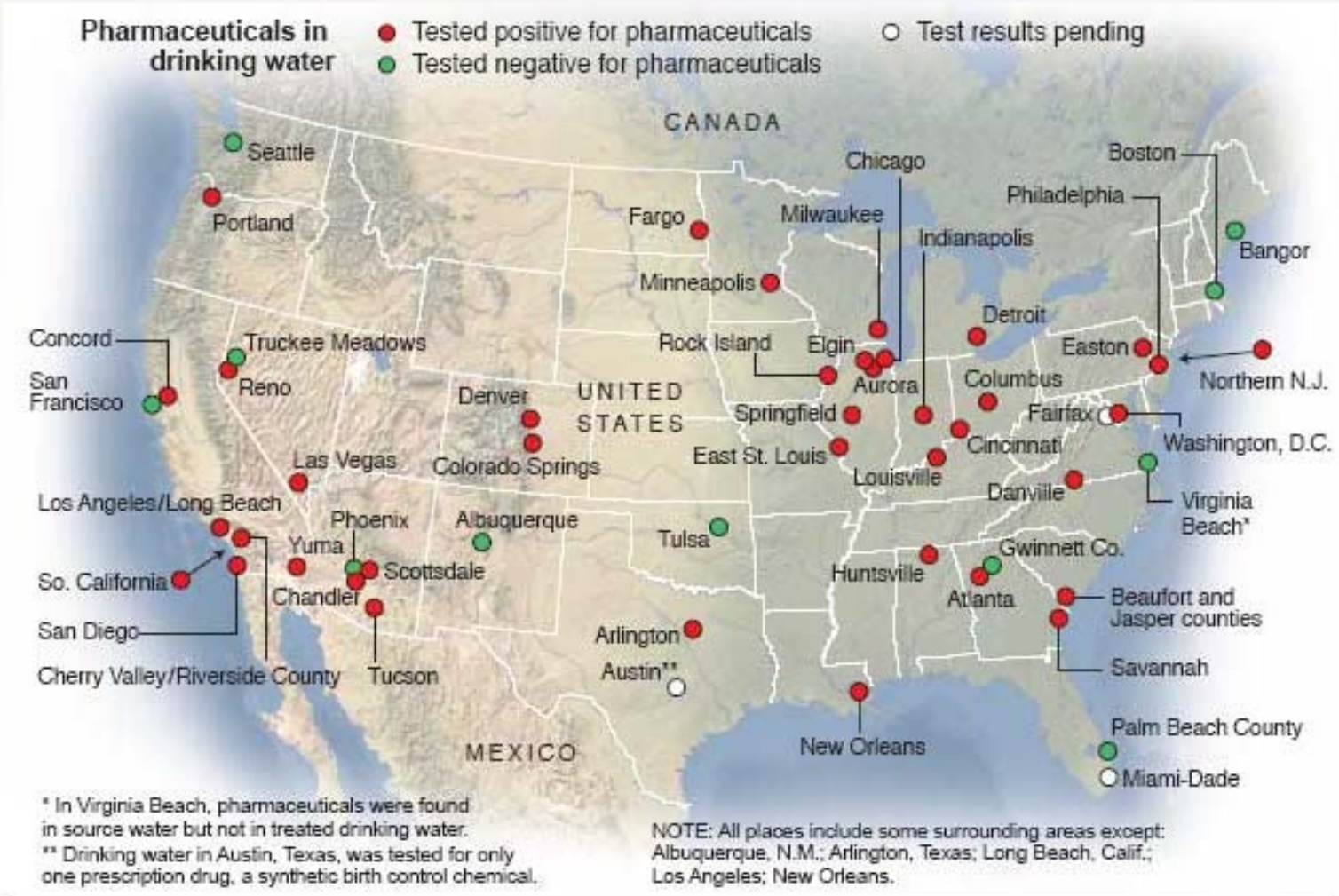
- Singapore NEWater. Classic water security
- Orange County, California (unfortunately provides water for another 500,000 people in the LA area!)
- Many other US urban areas following suit
- Option being taken-up because of competition for additional supplies and increased water quality standards

Recycling wastewater; Orange County, Ca.

- Increasing Demands
  - Population growth, wealth, life-style
- Decreasing Supply
  - Federal Endangered Species Act, restricted pumping out of San Jaoqin Delta
  - Reduced snow melt from N. California
- Increasing Regulation
  - Due to complaints about offshore pollution from long ocean outfall
  - EPA pushing for higher levels of treatment
- The Eureka Moment
  - Move to upgrade treatment—add on—to RO and UV disinfection
  - Produces an additional 70 mgd of potable water at lower cost than importing it from the North
  - Protects endangered species and off-shore water quality
- But there is more…
  - 46 million people in the US are exposed to unregulated chemicals
  - EPA has now promulgated for discussion its Candidate Contaminant List Number 3 (CCL3), proposing to add 116 new contaminants to its existing list of 86—includes pharmaceuticals and endocrine disruptors
  - Possibly the only way to effectively remove these from wastewater streams is by RO
  - Hence, Orange County will be ahead of the regs. others will have to use RO

46 million in U.S. have drugs in drinking water

Testing shows traces of meds in water greater than previously reported



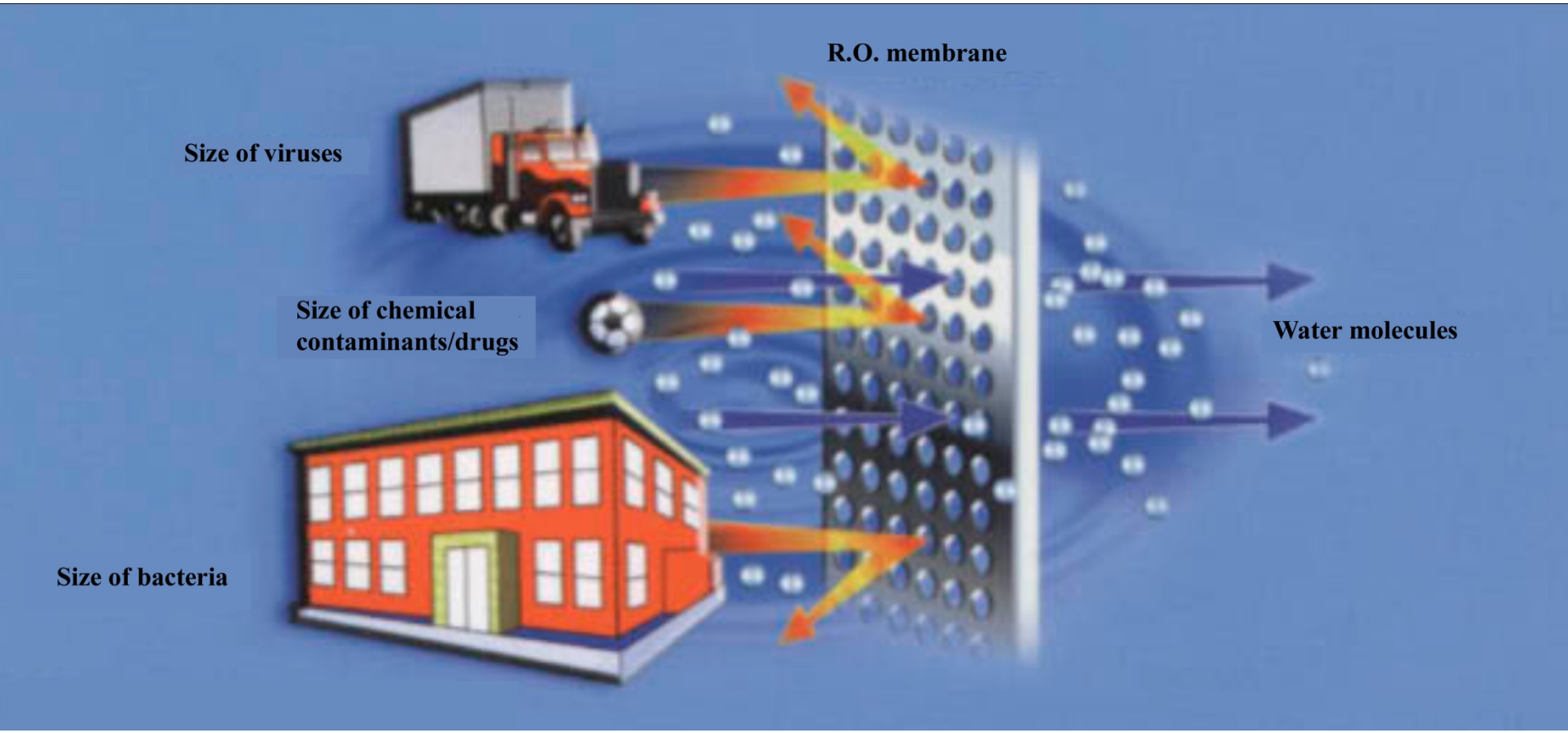
SOURCES: Drinking water providers' responses to Associated Press questions; AP review of scientific literature.

AP

Contaminant Candidate List 3 (CCL 3) EPA site

CCL 3 is a list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, that are known or anticipated to occur in public water systems, and which may require regulation under the Safe Drinking Water Act (SDWA). The list includes, among others, pesticides, disinfection byproducts, chemicals used in commerce, waterborne pathogens, pharmaceuticals, and biological toxins. The Agency considered the best available data and information on health effects and occurrence to evaluate thousands of unregulated contaminants. EPA used a multi-step process to select 116 candidates for the final CCL 3. The final CCL 3 includes 104 chemicals or chemical groups and 12 microbiological contaminants.

Reverse Osmosis in layman's terms



Source. PUB, Singapore.

Improving Agricultural use; Rising City, Nebraska

- Farmer Glock
  - 77-year old farmer and his wife farm 700 plus acres of irrigated crops
  - Moved up technology ladder from furrow, to spray, to center pivots
- Center Pivots
  - Typically irrigate quarter section (180 acres)
  - Capital costs less than US$100,000
  - Allow for multiple cropping in same field
  - Avoids costly land levelling
  - Applies fertilizer and other chemicals without clogging
  - Can be completely controlled with a lap-top computer
- Actual Performance
  - two thirds reduction in water use and a doubling of crop yield
- Global implications
  - Good example of existing technology with widespread application
  - Just one example of many water saving technologies

Managing Water by Pricing?

Valuing water and the role of economic thinking in managing water resources: Boston Harbor

- 2.1 million in MWRA service area
- 1973 demand reached 300 mgd and exceeded the safe-yield of the system
- In 1986 $3.8 billion WWTP completed and an average water and sewer bill was $116/hh/yr
- By 2008 the bill had risen to $1,132 /hh/year and system demand had declined to 200 mgd
- Pricing works!

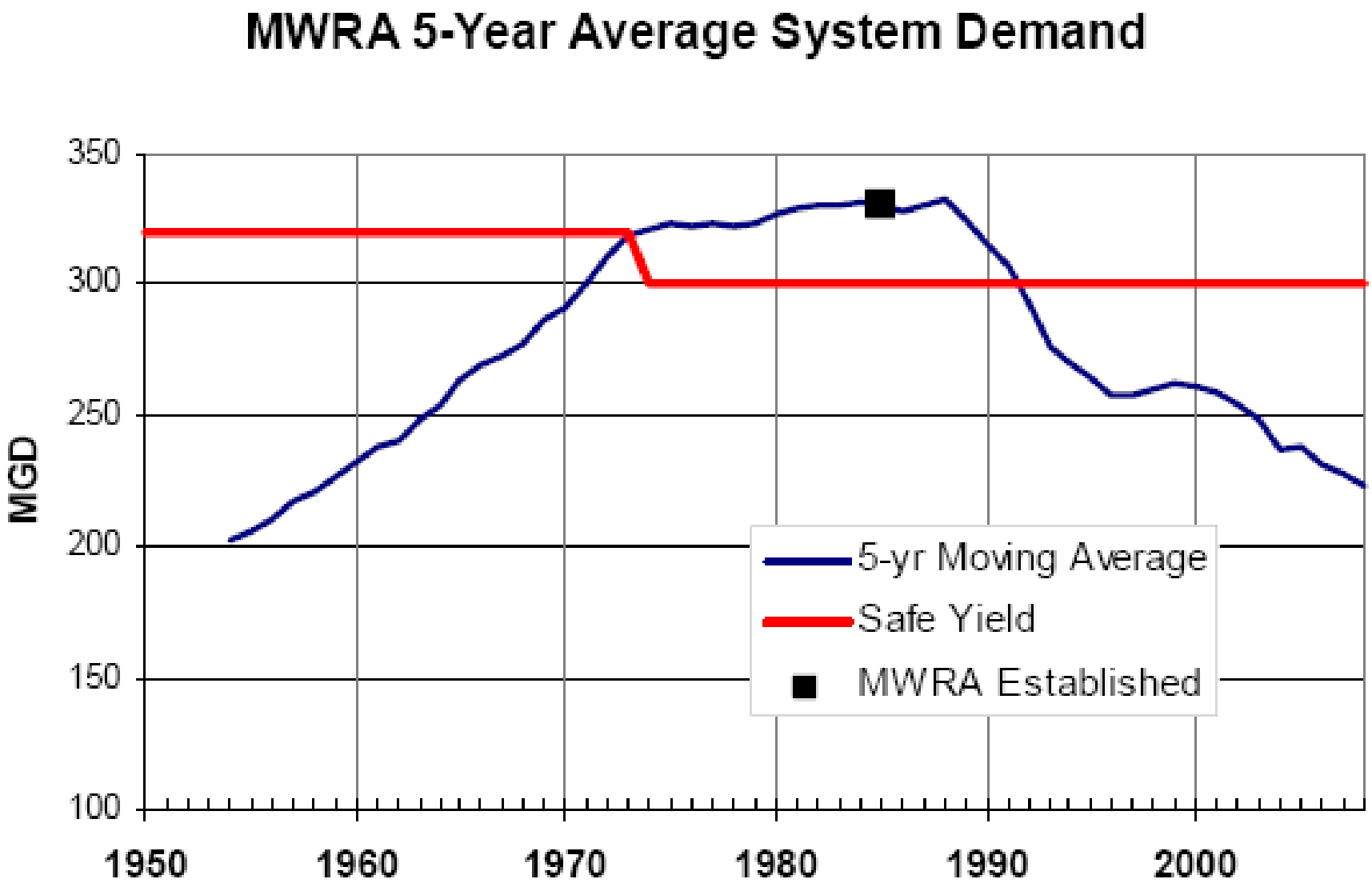
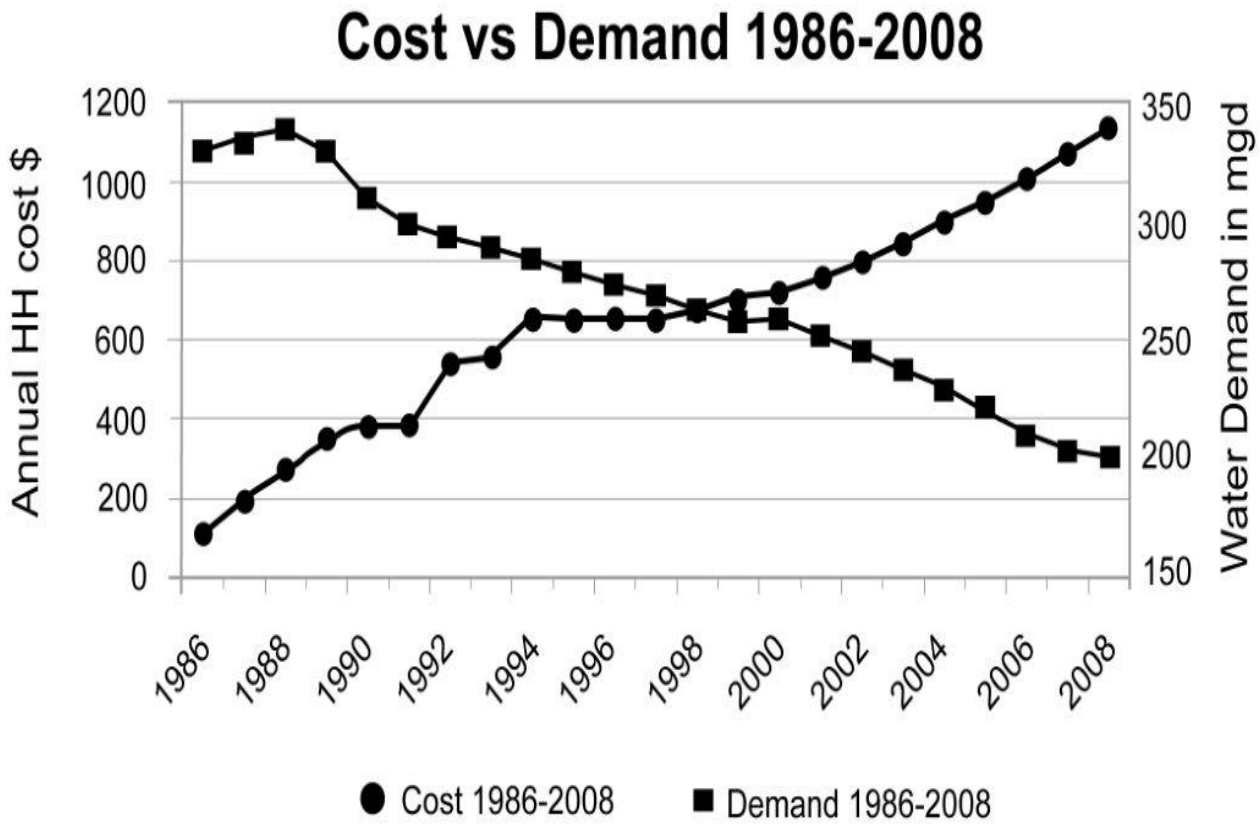


Figure 1 – MWRA Reservoir Withdrawals


Cost vs Demand 1986-2008
Annual HH cost $
Water Demand in mgd
1200
1000
800
600
400
200
0
350
300
250
200
150
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Cost 1986-2008
Demand 1986-2008

Brazilia Sewering the Favelas

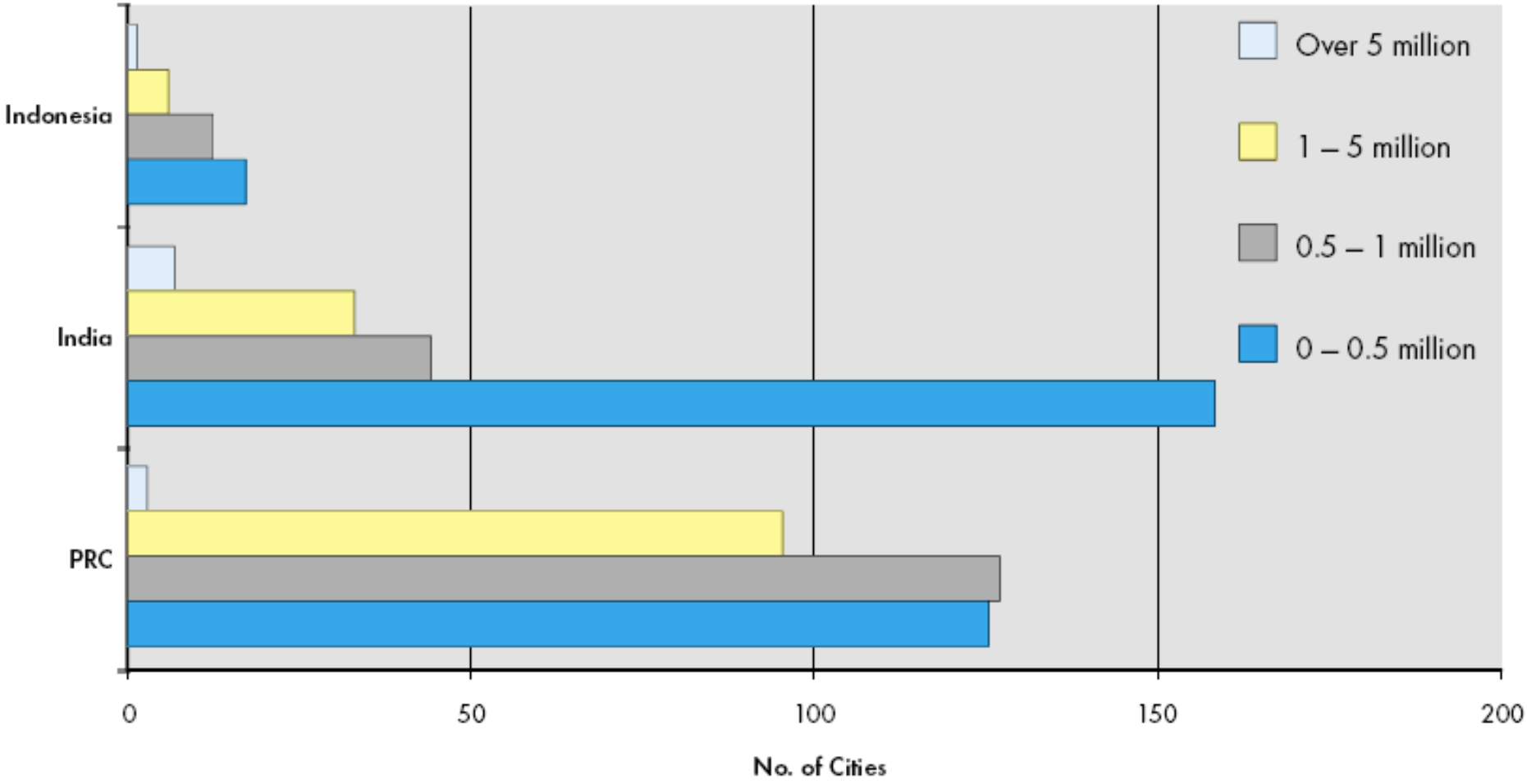
- In 1980 Jose Carlos Melo developed a low cost solution to urban wastewater collection. Called the *condominial system*, it was 10% technology and 90% community outreach!
- Brazilia 1990s, community education of half-million residents ; 5,000 public meetings attended by more than 57,000 residents, eventually 100% of favelas' residents participated

Karachi: Sewering Orangi

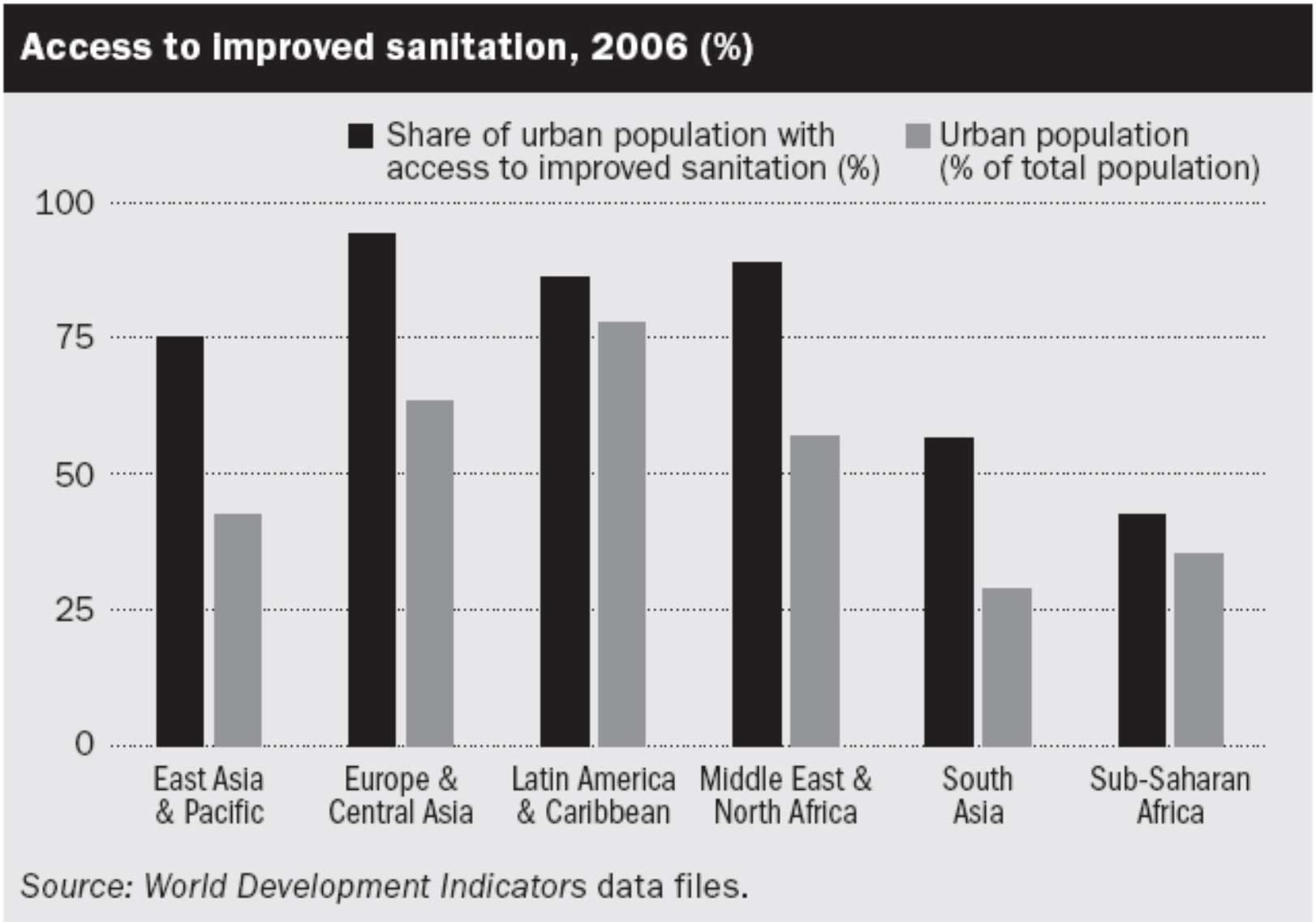
- Orangi, probably the largest informal settlement in Asia.
- Based on Melo’s condominial system in 1980s the sewer system was self-funded, self-administered, and self-maintained.
- By early 1990swas able to provide sewer service to over 600,000 residents

HOW DOES IT LOOK FOR ASIA?

Figure 2: City Size for Capital Cities and Urban Agglomerations



ADB, Asian Water Development Outlook 2007, p. 28



World Bank, Little Green Data Book, 2009.

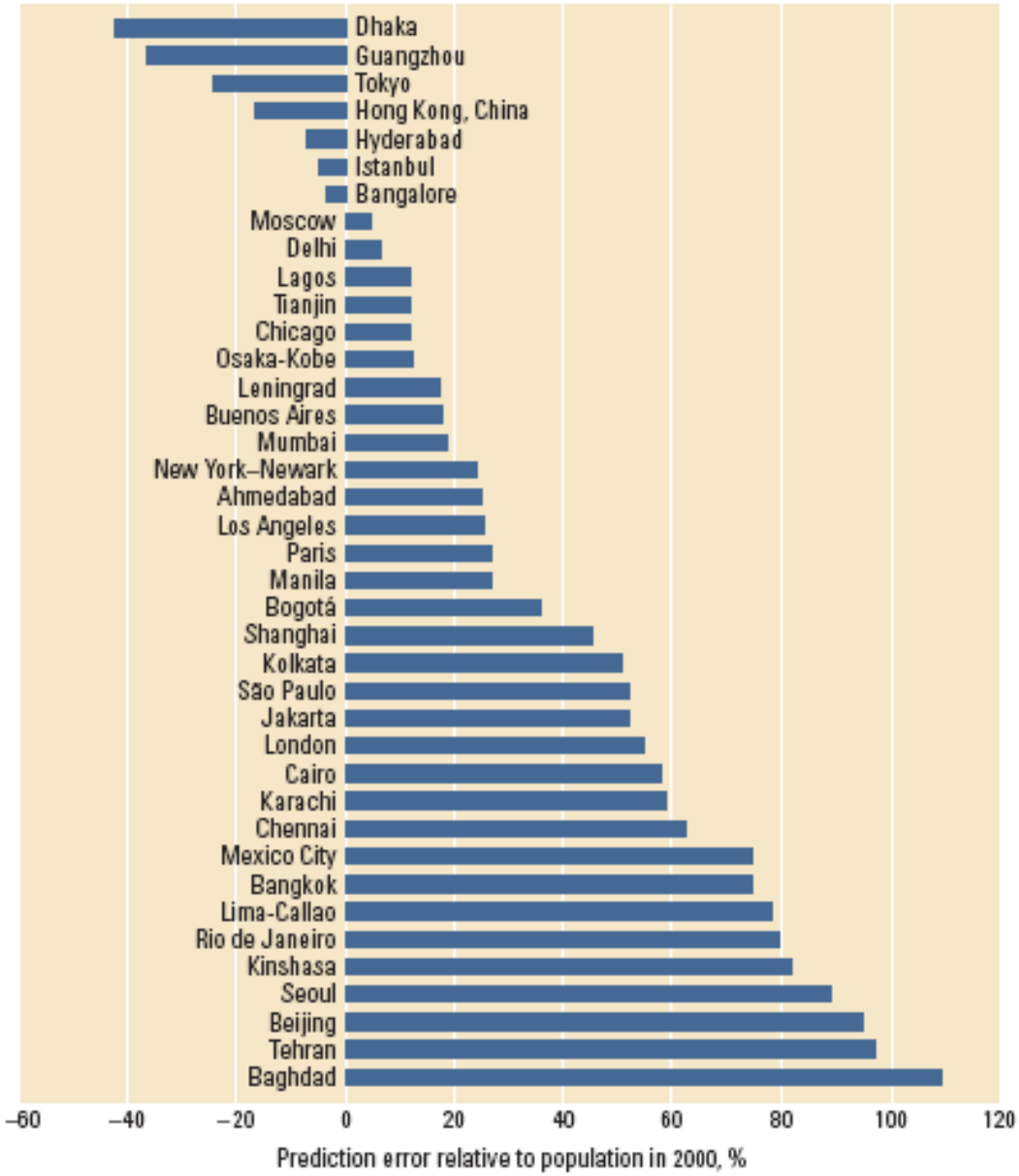
McKINSEY STUDIES (2009)

China and India dominate all discussions on resource use in the 21st century

Problems with Forecasts: A Cautionary Tale

Over and Under predictions 1974 to 2000 as a Percentage of the year 2000 Population

Figure 7.1 The growth of cities has been grossly overestimated



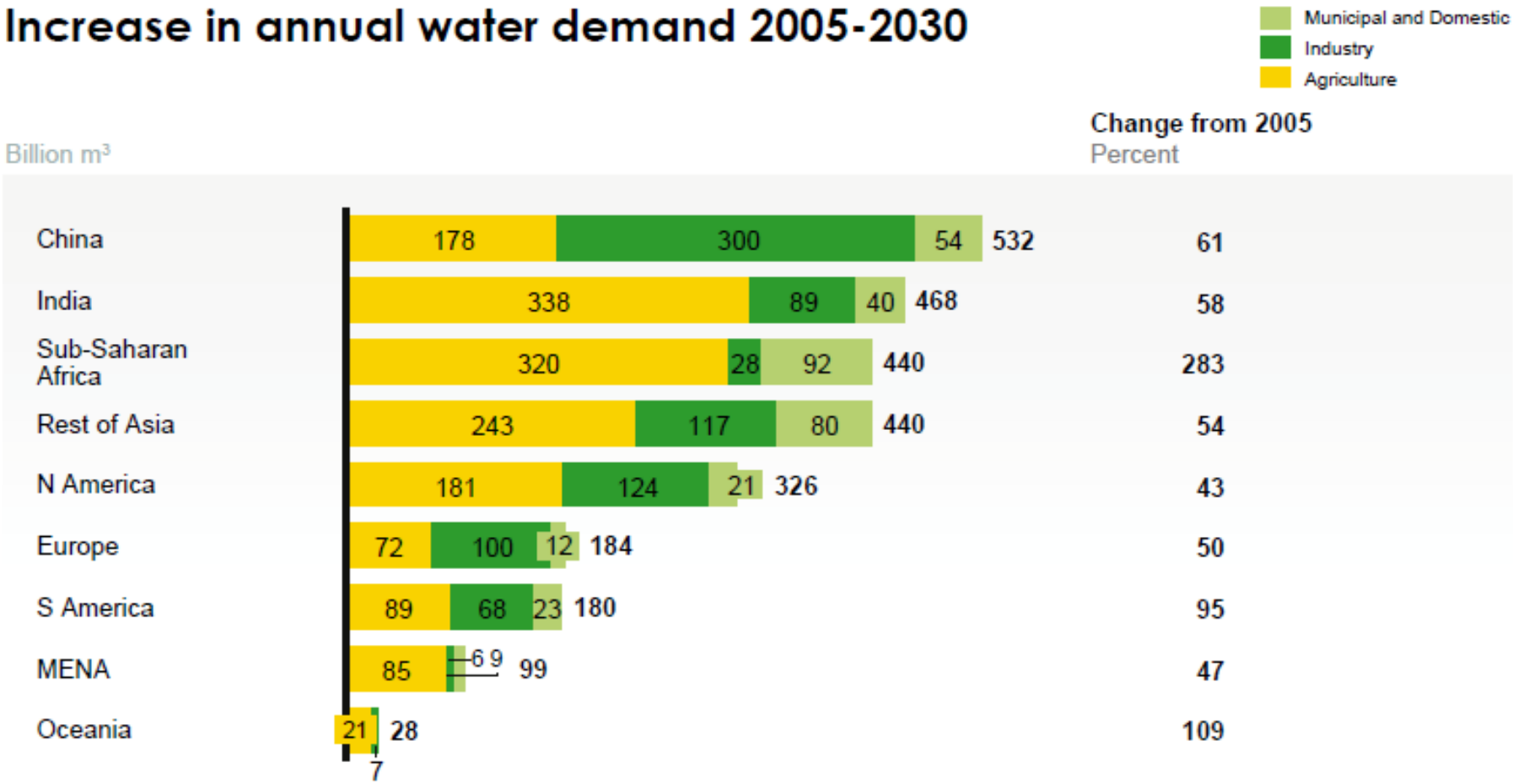
Source: Satterthwaite 2007.

Note: Comparison of predictions in 1974 with estimates of city populations in 2000. Bar indicates the extent to which the city population was overpredicted in 1974 relative to its size in 2000. A negative number indicates that a city size was greater in 2000 than predicted.

WDR 2009, p. 199

Exhibit 5

Increase in annual water demand 2005-2030



SOURCE: 2030 Water Resources Global Water Supply and Demand model; baseline agricultural production based on IFPRI IMPACT-WATER base case

China's Urban Growth until 2025

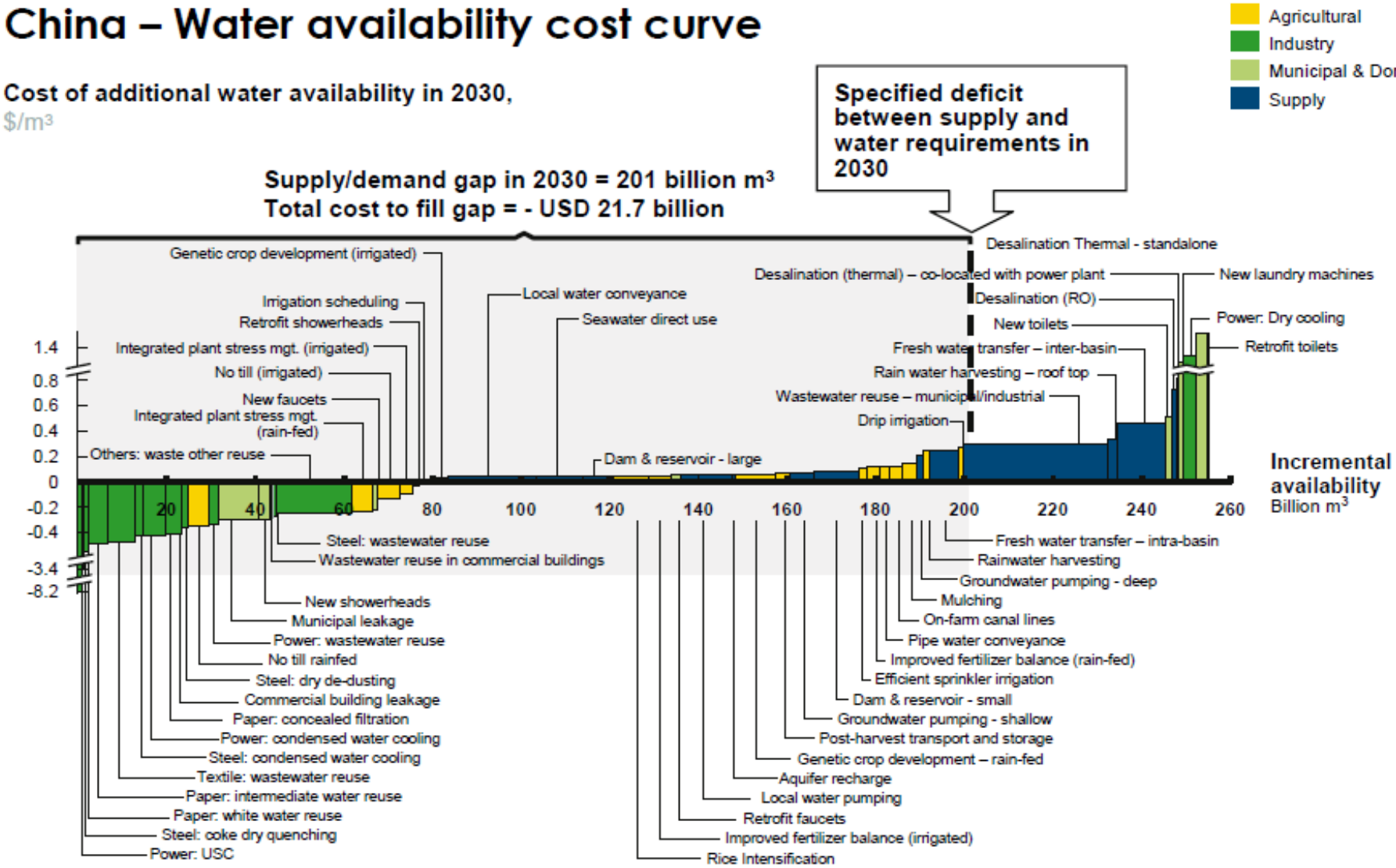
- 350 million people added to urban population
- One billion urban dwellers
- 221 cities with more than one million people
- Five billion square meters of road paved
- Forty billion square meters of floor space built
- 50,000 skyscrapers; equivalent 10 New Yorks
- 170 mass-transit systems built
- GDP increased by a factor of 5

McKinsey Global institute, Preparing for China's Urban Billion, McKinsey & Company, 2009, frontispiece.

$20 bills lying on the ground!

Exhibit 24

China – Water availability cost curve



SOURCE: 2030 Water Resources Group

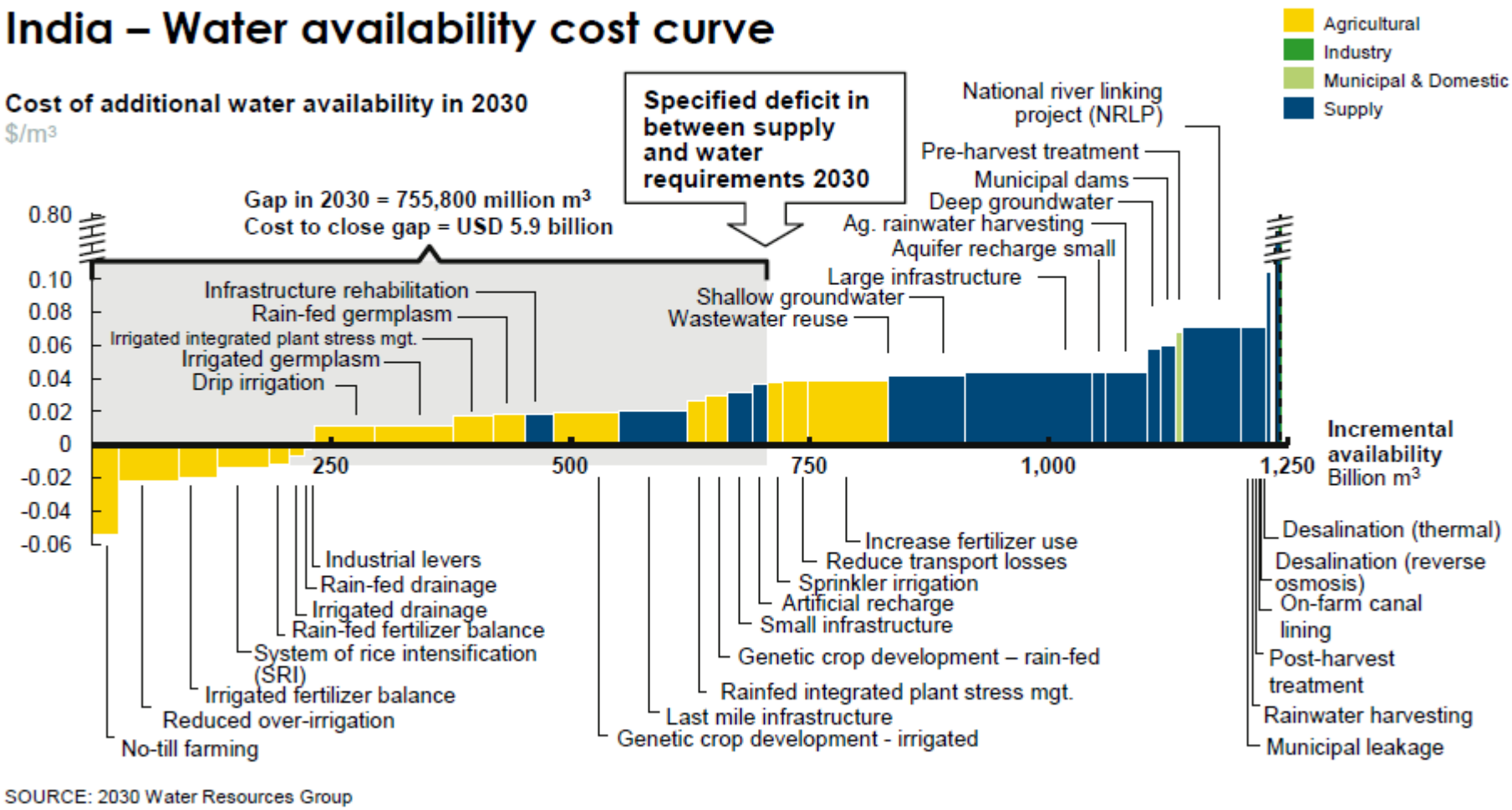
INDIA

India's Urban Growth until 2030

- 350 million people added to urban population
- 590 million urban dwellers
- 68 cities with more than one million people
- 700-900 million square meters of road paved
- 2.5 billion square meters of floor space built
- $1.2 trillion expenditures to meet needs
- 20-times kms of metros subways of last decade
- GDP increased by a factor of 5

More $20 bills lying on the ground!

Exhibit V

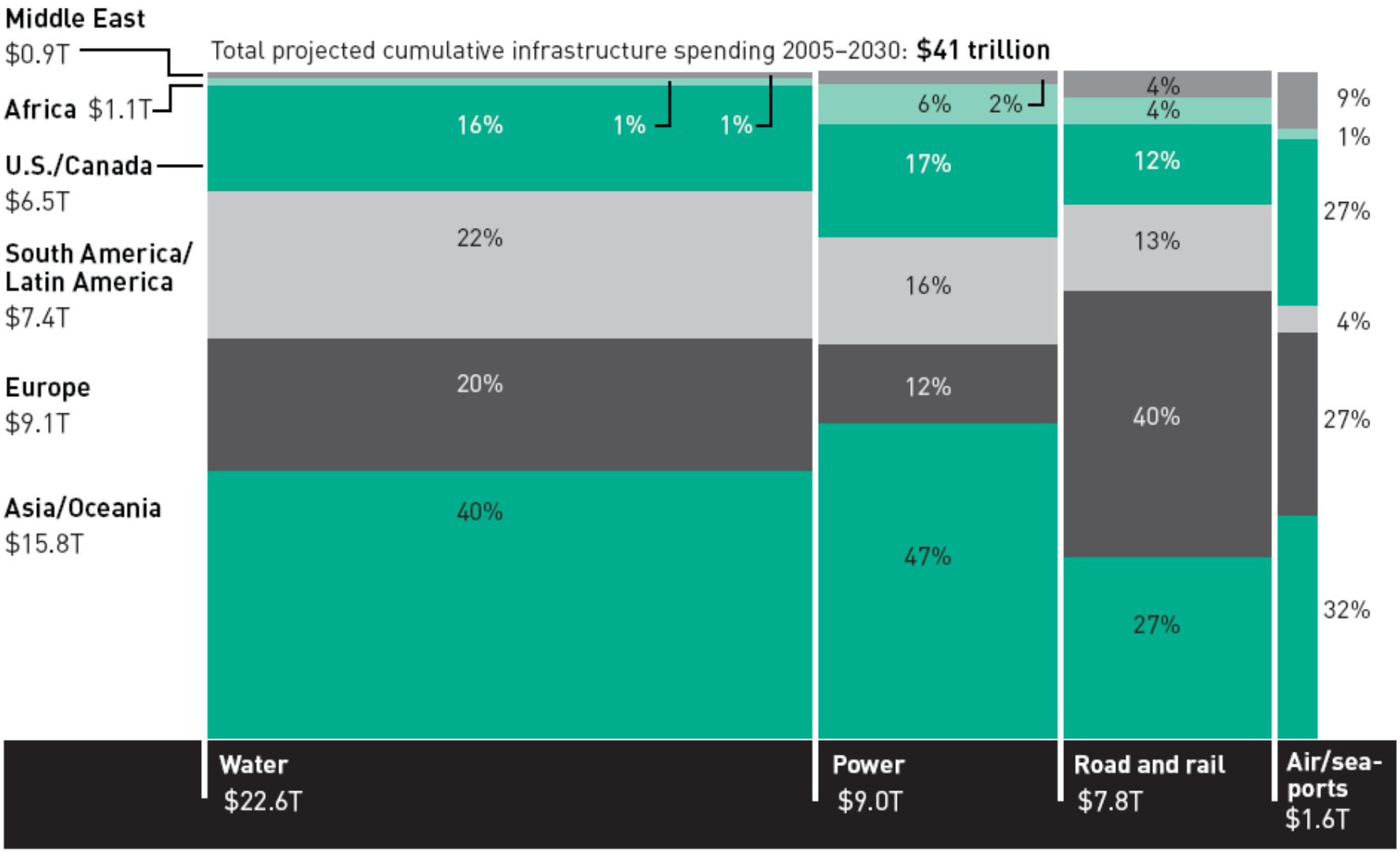


SOURCE: 2030 Water Resources Group

The Infrastructure Challenge: How Large Is It Really?

Exhibit 1: **The Infrastructure Challenge**

Percentages of total projected cumulative infrastructure investment needed during the next 25 years to modernize obsolescent systems and meet expanding demand, broken down by region (rows) and sector (columns).



Source: Booz Allen Hamilton, Global Infrastructure Partners, World Energy Outlook, Organisation for Economic Co-operation and Development (OECD), Boeing, Drewry Shipping Consultants, U.S. Department of Transportation

The Infrastructure Challenge: How Large Is It Really?

- The $22.6 trillion global need for all types of water infrastructure from 2005 until 2030 seems like a daunting number, but really how large is it compared with the global GDP and expenditures in other social sectors?

- It turns out to be about 1.5% of annual global GDP, or about $120 per capita.

- Global spending on health amounted to 4.3% of global GDP in 2005.

Current Financial Disaster is Crying out for Government Investment in Infrastructure

- Water and Sewer looks like a good place to invest.
- The Cadmus Group (August 2008) estimated that $1 invested in water and sewer infrastructure increases Gross Domestic Product in the long run by $6.35 (9.7% rate of return).
- One job in water and sewer infrastructure creates 3.68 jobs in the national economy to support that job.
- They claim that these are larger than for highways.

It’s not about technology—it’s about political leadership!

- In all the cases considered the path to resolution of water crises does not require new technologies
- We already have in place all the technology that we need
- What is missing is political and technical leaders who are willing to take risks
- We can beat Ricardo; can we beat Malthus?

The Romans Ignored The AD 202 GAO Report!

Source: InfoRoma, 2004. www.inforoma.it

DEFERRED MAINTENANCE?