Open Eyes – Economy Summit
Wroclaw - 24-25 September 2018

Water and Quality of Life in Cities

Uri Shamir
Professor Emeritus
Technion – Israel Institute of Technology
Consultant to the Israeli National Water Authority
Member, Negotiating Team on Water with Israel’s Neighbors
Chair, Technical Advisory Committee, World Water Assessment Program
The Water Hierarchy: from Science to Society

Science: Physical, Chemical, Biological, Environmental, Social

Technology, Engineering, Planning, Economics

Water Sensitive City and Regional Planning (WSP)

Local, National & International Water Governance & Policy

Society
The Water Hierarchy: from Science to Society

- Science: Physical, Chemical, Biological, Environmental, Social
- Technology, Engineering, Planning, Economics
- Water Sensitive City and Regional Planning (WSP)
- Local, National & International Water Governance & Policy
- Society
Water Sensitive Planning (WSP)

Covers water supply, grey and wastewater collection treatment and reuse, rainwater use, stormwater management, landscaping
Population
Uneven distribution of the growth, among countries and within countries

Notably: Countryside → Urban

200 years

> X10
Urban Population (% / total population)

34% / 3,007 B  
1960  57 years  2017

55% / 7,645 B

Urban Population (% of total population)

Israel
92% / 8,9 M

Poland
61% / 38M

48%

1960

57 years

2017

57 years

Israel

Poland

The most densely populated countries (average)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Population</th>
<th>Area (km²)</th>
<th>Density (Pop. per km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Singapore</td>
<td>5,612,300</td>
<td>710</td>
<td>7,905</td>
</tr>
<tr>
<td>2</td>
<td>Bangladesh</td>
<td>165,000,000</td>
<td>143,998</td>
<td>1,146</td>
</tr>
<tr>
<td>3</td>
<td>Taiwan</td>
<td>23,572,415</td>
<td>36,193</td>
<td>651</td>
</tr>
<tr>
<td>4</td>
<td>Lebanon</td>
<td>6,093,509</td>
<td>10,452</td>
<td>583</td>
</tr>
<tr>
<td>5</td>
<td>South Korea</td>
<td>51,635,256</td>
<td>99,538</td>
<td>519</td>
</tr>
<tr>
<td>6</td>
<td>Rwanda</td>
<td>12,001,136</td>
<td>26,338</td>
<td>456</td>
</tr>
<tr>
<td>7</td>
<td>Netherlands</td>
<td>17,250,000</td>
<td>41,526</td>
<td>415</td>
</tr>
<tr>
<td>8</td>
<td>Haiti</td>
<td>11,112,945</td>
<td>27,065</td>
<td>411</td>
</tr>
<tr>
<td>9</td>
<td>India</td>
<td>1,335,500,000</td>
<td>3,287,240</td>
<td>406</td>
</tr>
<tr>
<td>10</td>
<td>Israel</td>
<td>8,900,000</td>
<td>22,072</td>
<td>403</td>
</tr>
<tr>
<td>91</td>
<td>Poland</td>
<td>38,096,850</td>
<td>312,679</td>
<td>122</td>
</tr>
</tbody>
</table>
Water Sources and Uses
Domestic water consumption in developed countries (500-600 litres per capita per day) is about six times greater than in developing countries (60-150 litres per capita per day).
Water abstractions: OECD, Poland, Israel (m3/cap/year) (2002 or latest data)

- **OECD Total**: 900 m³/cap/year
- **Poland**: 300 m³/cap/year
- **Israel**:
  - From natural sources: 125 m³/cap/year
  - With desalination: 189 m³/cap/year

Per capita: average decrease 2016 to 2017 0.4 m³/cap/year, in rural areas 0.7 m³/cap/year
Total decreased by 1.2%, from 1,238.3 hm³ (2016) to 1,223.6 hm³ (2017)
Demand Management
Israel’s per capita water consumption (m³/cap/year)
Including use of treated effluents in agriculture

Source: the late Prof. Yoav Kislev
While >70% of all water supplies go to agriculture, it is imperative to reduce water use for irrigation – while increasing crop yields and crop value.

Therefore: an important component of the national water resources management policy must be efficiency of water use in agriculture → leaving more for the cities & to nature/env.
Israel’s per capita water consumption (m³/cap/year)
Including use of treated effluents in agriculture

Source: the late Prof. Yoav Kislev
Urban per capita water consumption in Israel (m$^3$/cap/year) 1962-2018 & a look ahead

2050: Pop=14 mi → ~ 200 mcn

Poland: 31.8 m$^3$/cap/year

Total national average annual fresh water = 1,100 mcm/year

Desalination capacity in 2018 = 585 mcm/year
Water Distribution Systems Management
Upgrading the Boston primary distribution system

By cleaning and lining the deteriorated pipes

Charles A. Maguire & Assoc., 1968
Water Distribution
Optimal Operation
Optimal operation of the Haifa system

Elevations - sea-level to +500 m with ~100 pressure zones

Shamir & Salomons, JWRPM, 2008
Optimal operation of the Haifa system

Shamir & Salomons
2008
Reduced model for optimization of operation

Detailed Model
867 nodes, 987 pipes

Shamir & Salomons
2008
Reduced model for optimization of operation

Detailed Model
867 nodes, 987 pipes

Reduced Model
77 nodes, 92 pipes

Shamir & Salomons, JWRPM, 2008
Comparison of results of reduced and full model

Level at Tank 12 - Reduced vs. Full Model

Pressure at Node 93 - Reduced vs. Full Model

Shamir & Salomons, JWRPM, 2008
Water Distribution Cyber Protection
Technologies for Water Systems
A System for the Monitoring and Protection of Hydrants

https://www.youtube.com/watch?v=yWJb0V3KgNE
The device is based on an electronic bracelet which is easily installed on the hydrant, requires no special training, and is relatively inexpensive compared to existing solutions. The solution creates an “identity card” for each municipal hydrant allowing the hydrants’ activities to be monitored.
The system assesses the amount of water flowing from the hydrant. It also enables real-time detection of the hydrant’s activities when fluids are flowing from or penetrating into the hydrant.
Each hydrant is equipped with a “smart bracelet” that communicates wirelessly with the municipal command center, mapping the hydrants scattered throughout the city. Warnings can be sent to a mobile phone by means of an app.
Real Time information:
Location of the hydrant, Flow out, Flow in

In continuous contact with the management software
and thru it, the municipal headquarters
HydroSpin

Electric generators using in-pipe flow, for powering probes, monitors, transmitters and data loggers

http://www.h-spin.com/solutions/
Floods and Flood Damages
EU annual damage cost ($10^6$ Euro)

Source: European Environment Agency
Number of global natural disasters, 1980-2015

Moody’s Investor Service, 28 November 2016
https://www.eenews.net/assets/2016/11/30/document_cw_01.pdf
Stormwater Management

Other terms, not exactly the same objectives
LID = Low Impact Development (USA)
WSUD = Water Sensitive Urban Design (Australia)
SUDS = Sustainable Drainage Systems (UK)
Stormwater Management

While the objectives are location-specific the list of “soft/green” and “hard/grey” Best Management Practices (BMPs) are similar
The new stormwater paradigm: it is a resource, not merely a nuisance & threat

Four groups of objectives, to be addressed simultaneously and synergistically:

- Hydrological: added water supplies, flood control
- Economic: lower flood damages, lower system costs
- Environmental: enhanced environmental amenities
- Social: advance social norms and awareness, engage the community

The mix/balance of objectives is location specific: climate, precipitation, soils, land cover, built areas, receiving waters, economics, social norms, for example:

- Protect quality in the receiving waters - stream, river, lake, sea, groundwater
- Add water for on-site uses – irrigation, landscaping, groundwater recharge
- Mitigate downstream flooding damages by reducing runoff discharge

Best Management Practices (BMPs):

- BMPs I: urban land use practices - spatial planning, placement and design of open spaces and roads, follow the natural hydrology
- BMPs II: land cover design: pervious sidewalks and roads, green roofs, pervious gardens, modified topography, depressions, raingardens, vegetation
- BMPs III: constructed facilities

Regional WSP: Catchment area master plan, delineation of floodplains, urban-regional coordination

Legal and statutory frameworks

Enabling:

- Training the relevant professionals in the spirit of WSP and interdisciplinary cooperation
- Economic incentives
- Public–Civic Partnerships (PCPs) and public–private partnerships (PPPs)
BMPs
Best Management Practices
Real Time Control (RTC) of urban drainage systems

Use the storage capacity of the drainage system to control the outflows
Using remotely controlled gates, under operational optimization software
The performance of the RTC system was evaluated by calculating the reduction in overflow volumes using rain events over the last 10 years. RTC was applied to a full hydrodynamic model setup on 9 pumping stations; furthermore, gates were installed in 7 basins. Control functions were implemented based on total inflow to the wastewater treatment plant, water levels in the basins and in critical parts of the systems. The study showed a potential for up to 40% reduction in discharge volumes to the Kolding River.

http://documents.irevues.inist.fr/handle/2042/32575
Land use planning

Original plan of the neighborhood (280,000 m²)
Re-location of buildings & open public spaces

Building upstream – Open spaces downstream

Natural streams
Micro: green and grey BMPs in private and public spaces
Nashville, Tennessee, US: ~4,000 m³ captured annually and used to irrigate the park

Three study areas were selected to perform simulation of stormwater management with the possibilities of eco modernization of the grey infrastructure. The districts represent urban structures typical for the whole city.

**Table 1. Runoff indices according to the Polish norm**

<table>
<thead>
<tr>
<th>Types of surfaces</th>
<th>Runoff index</th>
</tr>
</thead>
<tbody>
<tr>
<td>The roof's slope &gt;15</td>
<td>1.00</td>
</tr>
<tr>
<td>The roof's slope &lt;=15</td>
<td>0.80</td>
</tr>
<tr>
<td>Roof covered with gravel</td>
<td>0.50</td>
</tr>
<tr>
<td>Garden on the rooftop</td>
<td>0.30</td>
</tr>
<tr>
<td>Impervious surfaces</td>
<td>0.90</td>
</tr>
<tr>
<td>Impervious pavements</td>
<td>0.60</td>
</tr>
<tr>
<td>Permeable pavements, alleys, backyards</td>
<td>0.50</td>
</tr>
<tr>
<td>Playgrounds, sport fields</td>
<td>0.25</td>
</tr>
<tr>
<td>Gardens</td>
<td>0.10–0.15</td>
</tr>
<tr>
<td>Parks</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Source: own elaboration according to PN-92/B-01707.

**Table 3. Drained area (ha) – multifamily housing district – scenario I – now**

<table>
<thead>
<tr>
<th>Types of surfaces</th>
<th>Runoff index x area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofs (sloping &gt; 15)</td>
<td>2.25</td>
</tr>
<tr>
<td>Roofs (sloping &lt;= 15)</td>
<td>2.35</td>
</tr>
<tr>
<td>Parking lots</td>
<td>8.82</td>
</tr>
<tr>
<td>Sport fields</td>
<td>0.35</td>
</tr>
<tr>
<td>Green areas</td>
<td>24.6</td>
</tr>
<tr>
<td>Total</td>
<td>48.26</td>
</tr>
</tbody>
</table>

Source: own elaboration according to PN-92/B-01707.

**Table 4. Drained area (ha) – multifamily housing district – scenario II – the alternative option**

<table>
<thead>
<tr>
<th>Types of surfaces</th>
<th>Runoff index x area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofs (sloping &gt; 15)</td>
<td>2.25</td>
</tr>
<tr>
<td>Gardens on the rooftops</td>
<td>2.34</td>
</tr>
<tr>
<td>Parking lots</td>
<td>1.40</td>
</tr>
<tr>
<td>Sport fields</td>
<td>0.35</td>
</tr>
<tr>
<td>Green areas</td>
<td>24.6</td>
</tr>
<tr>
<td>Total</td>
<td>42.86</td>
</tr>
</tbody>
</table>

Source: own elaboration according to PN-92/B-01707.

- **Total runoff volume** = \( \sum \text{(areas x Runoff Indices)} \)
- **Objective** = reduce total runoff volume
- **Recommendations**: use SUDS/LID concepts and methods to change the Runoff Index of planned developed areas, including: green roofs, permeable pavements and backyards, \( \rightarrow \) Permeable \( \geq \) 50% of total area
Built BMPs: Biofilter + Infiltration wells

Winter: bio-filtering of runoff from 3 km²
Summer: nitrate removal from adjacent wells with 150 mg/l

Figure 1. The dual operation stormwater biofilter, Kfar-Sava, Israel.

By: Dr. Yaron Zinger, Monash University and JNF
Built BMPs: underground storage
Built BMPs: underground storage

Tokyo: Underground stormwater retention reservoir
In 1760 King Yeongjo established regulations for protecting and regulating the Cheonggyecheon River

Seoul, South Korea
In the early 20\textsuperscript{th} century, immigrants from the countryside settled on the river banks and used it for washing → pollution and very low flows
Rebirth of the Cheonggyecheon River in Seoul

In the early 20th century, immigrants from the countryside settled on the river banks and used it for washing → pollution and very low flows

Today’s population 10 million
More than in New York
In the 1970s this sewage canal was converted into a major highway
Rebirth of the Cheonggyecheon River in Seoul

A 10 km central two-level highway through the entire city
In 2003/2004 the highway was demolished and removed.
In 2005 the river was re-born, day-lighted
Messages
Messages

- All socially motivated urban water management should be based on solid science.
- The Water Hierarchy connects from Science to Society through technology and all levels of governance.
- Demand Management is the first and most important component of urban and regional water resources management, using technologies, laws, regulations, education.
- Agriculture-To-Urban water transfer is an important water policy.
Technologies have a central and increasing role to play, combining hardware and software.

Water Sensitive Planning (WSP) encompasses more than stormwater management: it includes use of rainwater and greywater, water supply, wastewater treatment/reuse.

It also connects the city to the regional scale as a common stormwater-shed.

Other approaches have partially different objectives but often the same/similar implementation means.
The Water Hierarchy: from Science to Society

- Science: Physical, Chemical, Biological, Environmental, Social
- Technology, Engineering, Planning, Economics
- Water Sensitive City and Regional Planning (WSP)
- Local, National & International Water Governance & Policy
- Society
Thank you