Groundwater – rational use to enhance urban water security under global change

Lead researcher: Dr. Stephen Foster, IAH past Pres. and , visiting Pr., University College London
Dr. Sean Furey, Swiss Resource Centre & Consultancy For Development
Dr. Anne Bousquet, Regional Coordinator for Africa and Asia, GWOPA-UN-Habitat
OUTLINE OF THE PRESENTATION

1) Introducing UPGro

2) Water security and ground water resources
   - Concept of water security
   - Role of groundwater in water security

3) Self-supply boom – current trends in use of ground water
   - Urban growth unprecedented and growth of water demand
   - Typical “supply” response
   - Africa regional evolution of type of supply
   - Causes and consequences of the self-supply boom (Rich and Poor people)
   - Advantages of using groundwater resources for the utilities/ water security

4) How to enhance water security through ground water use
   - Example of conjunctive use of ground and surface with loop of reuse
   - What should be done to optimize use of ground water in the utilities’ perspective (to enhance source security)
   - Mapping the sources of pollution of the aquifers (Risks and hazards assessment)
   - What should be done to regulate and optimize; policy implications, role of the utilities
1) INTRODUCING UPGro

Unlocking the Potential of Groundwater for the Poor (UPGro), a 7-year international research programme (2013-2020)

Focus on improving the evidence base around groundwater availability and management in sub-Saharan Africa (SSA) to enable developing countries and partners to use groundwater in a sustainable way in order to benefit the poor.

UPGro is funded by:

UPGro Knowledge Broker charged with facilitating the uptake of the research findings into policy and practice.
Diverse groundwater

2012: first quantitative continent-wide maps of aquifer storage and potential published

- 0.66 million km$^3$ of storage (not all available for abstraction)
The Consortium Projects (2015-19)

Working in Benin, Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Niger, Nigeria, South Africa, Tanzania, Uganda

+ research commissioned on ground water use and urban utilities =>Stephen Foster

Upgro.org
2) WATER SECURITY AND GROUND WATER RESOURCES

DEFINITION

• ‘Availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with and acceptable level of water-related risks to people, environments and economies’*

• The ‘scale’ issue – use at national level too nebulous better when referred to specific city (or basin) and to a specific function (like water-supply)**

• Urban water-supply security assessed in terms of:
  accessibility – in effect availability and continuity
  affordability – cost especially for lowest income quintile
  acceptability – safety as regards quality
  sustainability – susceptibility to decline/vulnerability to pollution

*Grey & Sadoff, 2007  ** Foster & MacDonald, 2014
ROLE OF GROUNDWATER IN WATER-SUPPLY SECURITY
vast stocks (storage) but modest fluxes (flows)

Predominant form of global freshwater storage

95-97% of ‘circulating freshwater’ = groundwater – but only 0.03 % of ‘groundwater stock’ replenished annually

Very large storage means= subsurface ‘residence times’ large and ‘aquifer memories’ long (decades to millennia) high microbiological and chemical quality

But any pollution can be very persistent and remediation problematic
Unprecedented growth in urban population and water demand, especially West Africa.
TEMPORAL GROWTH IN URBAN WATER DEMAND
with typical supply-side response

* In some cases either external wellfield development or import of surface water from a distant source may not be technically feasible or economically viable and then one or the other would be deployed alone.

private in-situ groundwater supply

utility groundwater supply from within urban area

imported surface water resources*

groundwater from external wellfields*

advancing time

50 years
EVOLUTION OF WATER-SUPPLY SOURCES IN AFRICAN CITIES: ACCESSIBILITY AND AFFORDABILITY *

Regional average urban water-supply accessibility

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>PIPED-SUPPLY</th>
<th>WATERWELLS (boreholes/dugwells)</th>
<th>STAND-POSTS</th>
<th>SURFACE WATER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-1995</td>
<td>50%</td>
<td>20%</td>
<td>29%</td>
<td>6%</td>
</tr>
<tr>
<td>1995-2000</td>
<td>43%</td>
<td>21%</td>
<td>25%</td>
<td>5%</td>
</tr>
<tr>
<td>2000-2005</td>
<td>39%</td>
<td>24%</td>
<td>24%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Regional average urban water-supply affordability

* Sources: World Bank AICD + Foster & Briceño-Garmendia, 2010, and Banerjee et al, 2017
**GROUNDWATER USE IN SELECTED AFRICAN CITIES**

data for sometime in period 2011-2015

<table>
<thead>
<tr>
<th>CATEGORY OF CITY</th>
<th>CITY</th>
<th>UTILITY GW USE (ML/d) (propn)</th>
<th>UTILITY SERVICE LEVEL</th>
<th>PRIVATE GW USE (ML/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Utility with Major Groundwater Dependency</strong></td>
<td>Abidjan **</td>
<td>285 (100%)</td>
<td>moderate</td>
<td>some #</td>
</tr>
<tr>
<td></td>
<td>Dakar **</td>
<td>210 (70%)</td>
<td>excellent</td>
<td>minor #</td>
</tr>
<tr>
<td></td>
<td>Arusha</td>
<td>50 (80%)</td>
<td>excellent</td>
<td>minor</td>
</tr>
<tr>
<td></td>
<td>Dodoma **</td>
<td>45 (100%)</td>
<td>good</td>
<td>minor</td>
</tr>
<tr>
<td></td>
<td>Kabwe</td>
<td>40 (100%)</td>
<td>good</td>
<td>minor</td>
</tr>
<tr>
<td></td>
<td>N’Djamena **</td>
<td>35 (100%)</td>
<td>poor</td>
<td>some #</td>
</tr>
<tr>
<td><strong>Water Utility with Conjunctive Resource Use</strong></td>
<td>Addis Ababa</td>
<td>120 (40%)*</td>
<td>moderate</td>
<td>minor #</td>
</tr>
<tr>
<td></td>
<td>Dar-es-Salaam</td>
<td>30 (10%)*</td>
<td>poor</td>
<td>major</td>
</tr>
<tr>
<td></td>
<td>Benin City</td>
<td>45 (50%)</td>
<td>poor</td>
<td>major</td>
</tr>
<tr>
<td><strong>Water Utility with Poor Service Levels &amp; Major Private Groundwater Use</strong></td>
<td>Nairobi</td>
<td>30 (5%)</td>
<td>moderate</td>
<td>80-240 #</td>
</tr>
<tr>
<td></td>
<td>Lusaka</td>
<td>135 (45%)</td>
<td>moderate</td>
<td>100-300</td>
</tr>
<tr>
<td></td>
<td>Mombasa</td>
<td>80 (100%)</td>
<td>poor</td>
<td>major</td>
</tr>
</tbody>
</table>

* major new groundwater source under exploration/development  
** modern supply system deploying external wellfield(s)  
# cost constructing/equipping private water borehole > US$ 10k
CAUSES AND CONSEQUENCES OF THE SELF-SUPPLY BOOM (RICH AND POOR PEOPLE)

• Coping strategy’ for confronting poor water-utility service coverage and/or reliability
• High cost of constructing/equipping water-supply boreholes means only affordable by high-income quintile
• Poorer households have to resort (where feasible) to shallow handpump dugwells with poor sanitary completion which are more vulnerable to pollution
• Private borehole use likely to be perpetuated long-term as cost-reduction strategy
• Massive private domestic self-supply reality – can distort utility water operations with major implications for finance/investment
• Open-access to groundwater cannot be regarded as ‘pro-poor’ since reduces revenue of water utilities
• Could be regarded as reducing demand on (and recovering leakage from) utility water-supply and very good practice for ‘secondary uses’
• ‘Banning’ such practice too simplistic (unrealistic and impractical), except where it poses major public health or environmental hazard
• Need for systematic study of hydrogeologic dynamics, engineering economics and sociologic impact (only limited work in districts of Accra, Lusaka & Lagos)
WHY TAPPING INTO THE POTENTIAL OF GROUND WATER RESOURCES

• allow phased investment in supply expansion at much lower capital cost (avoiding advanced treatment)
• suitability located and constructed groundwater sources provide supply security against drought and pollution
• basis for providing a high level of water-supply reliability and continuity
• but requires proactive involvement in resource management and quality protection
Recommendations on management of the aquifers:
Enhance recharge, reduce pollution load, improve construction standards for private wells and in-situ sanitation, advise users on potential hazards, charge or regulate groundwater use(?)
UTILITIES’ INVOLVEMENT, RECOMMENDATIONS:

• Proactively integrate utility and private investment

• Coordinate piped and non-piped service provision

• Develop utility involvement and capacity for groundwater resource management and protection

• Establish utility low-income user support units for:
  - construction/operation of community stand-post boreholes
  - advisory/registration services for private waterwell users (with appropriate charging especially if generating sewer discharge)
CONJUNCTIVE USE & MANAGEMENT OF RESOURCES
key to urban water-supply security

SPONTANEOUS

PLANNED

- municipal water-supply boreholes
- private waterwells

major river
river intake
alluvial plain

wellfield
wastewater re-use area

much less dependence on intra-urban public (and private) waterwells with development of ‘external’ municipal wellfields
RECOMMENDATIONS (ctd)

Measures to enhance the source security

- develop protected external municipal wellfields (with agreement between urban and rural municipalities involved on land-use controls)
- establish municipal waterwell protection zones (to take advantage of parkland and prevent generation of polluting discharges)
- prioritise main sewerage in densely-populated zones and limit population density of new unsewered zones
- undertake groundwater pollution hazard assessments and reduce dependence on vulnerable municipal waterwells
GROUNDWATER POLLUTION PROTECTION
‘avoiding unexpected hazards from above’

- understand vadose-zone attenuation
- map aquifer pollution vulnerability
- assess pollution risk and manage by prevent/limit measures
THANK YOU!
MERCI!

WWW.GWOPA.ORG
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