Cardiff University
Prifysgol Caerdydd

Water Research Institute
Sefydliad Ymchwil Dŵr

GW4
Water
Security
Alliance

GROUNDWATER FUTURES IN URBAN AFRICA

Cardiff University

14 March 2018

Water Research Institute
Sefydliad Ymchwil Dŵr

Agenda

Water Security Alliance

10.15 Urban Groundwater Use in Tropical Africa – a key factor in enhancing water security?
Stephen Foster,

10.45 Self-supply and resilience: Groundwater Use and Governance in Peri-urban Accra
Jenny Grönwall,

11.15 Introduction CU Water Research Institute and GW4 Water Security Alliance
Isabelle Durance,

11.20 Coffee

11.40 Managing the commons: choices and perceptions of residential users in Lagos Nigeria
Adrian Healy,

12.10 Key Groundwater Challenges for Urban Areas
Helen Bonsor,

12.40 Facilitated discussion

13.10 Lunch and close

URBAN GROUNDWATER USE IN TROPICAL AFRICA

A Key Factor in Enhancing Water Security ?

DR. STEPHEN FOSTER

- IAH Past President (2004-08)
- University College London-Visiting Professor

iah aih 1956 – 2016

UCL

DR. SEAN FUREY

- Swiss Resource Centre & Consultancy for Development

SKAT

DR. ANNE BOUSQUET

- UN Global Water Operators' Partnership Alliance - Barcelona

UN HABITAT FOR A BETTER URBAN FUTURE

THE WATER-SECURITY CONCEPT
attempts at 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'

  Grey & Sadoff, 2007

- in effect balance between 'physical water-resource stress' and 'water-management coping capacity'

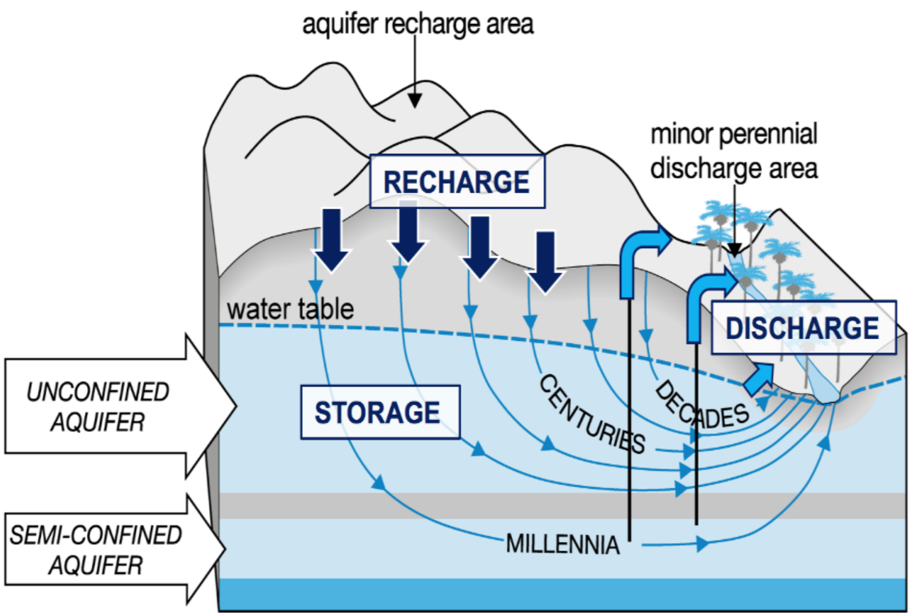
  (with economic development usually being the pathway to enhancing national water security)

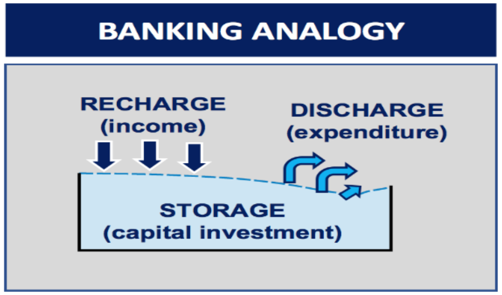
- the 'scale' issue – use at national level too nebulous
- better when referred to specific city (or basin) and to a specific function (like water-supply)

  Foster & MacDonald, 2014

- urban water-supply security will be a function 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

ROLE OF GROUNDWATER IN WATER-SUPPLY SECURITY
vast stocks (storage) but modest fluxes (flows)





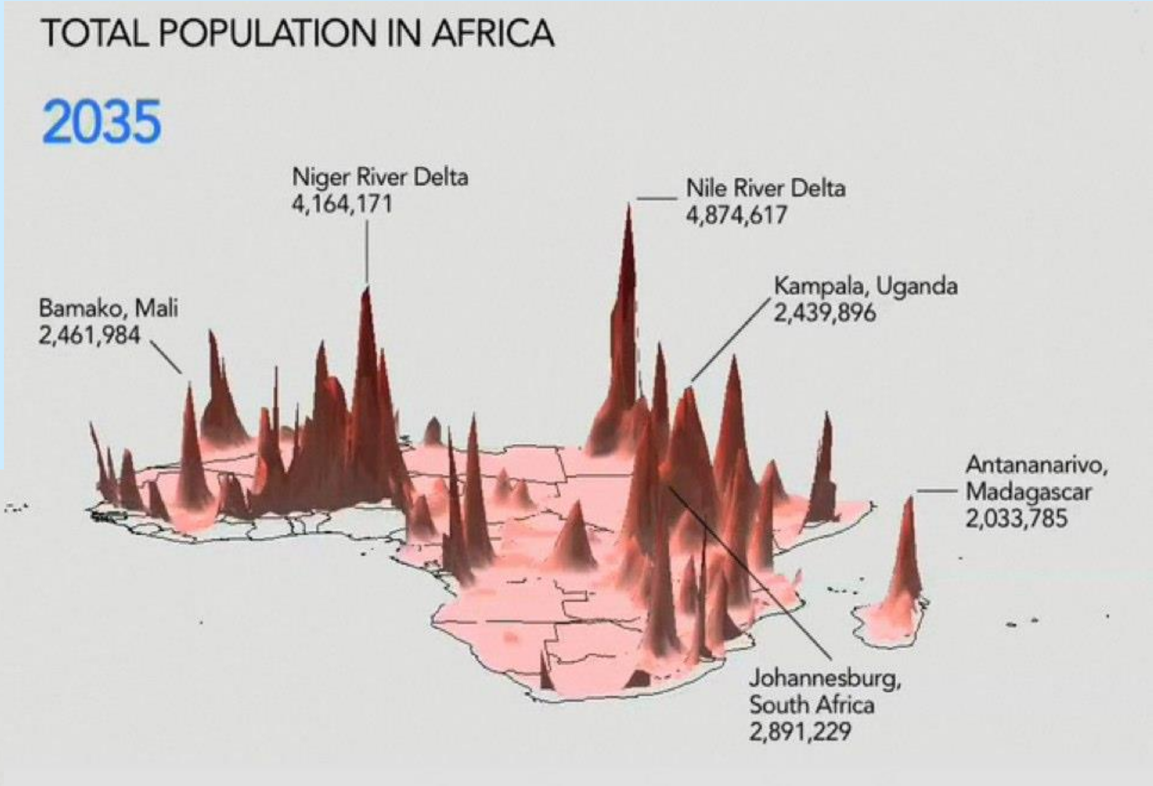
predominant form of global freshwater storage

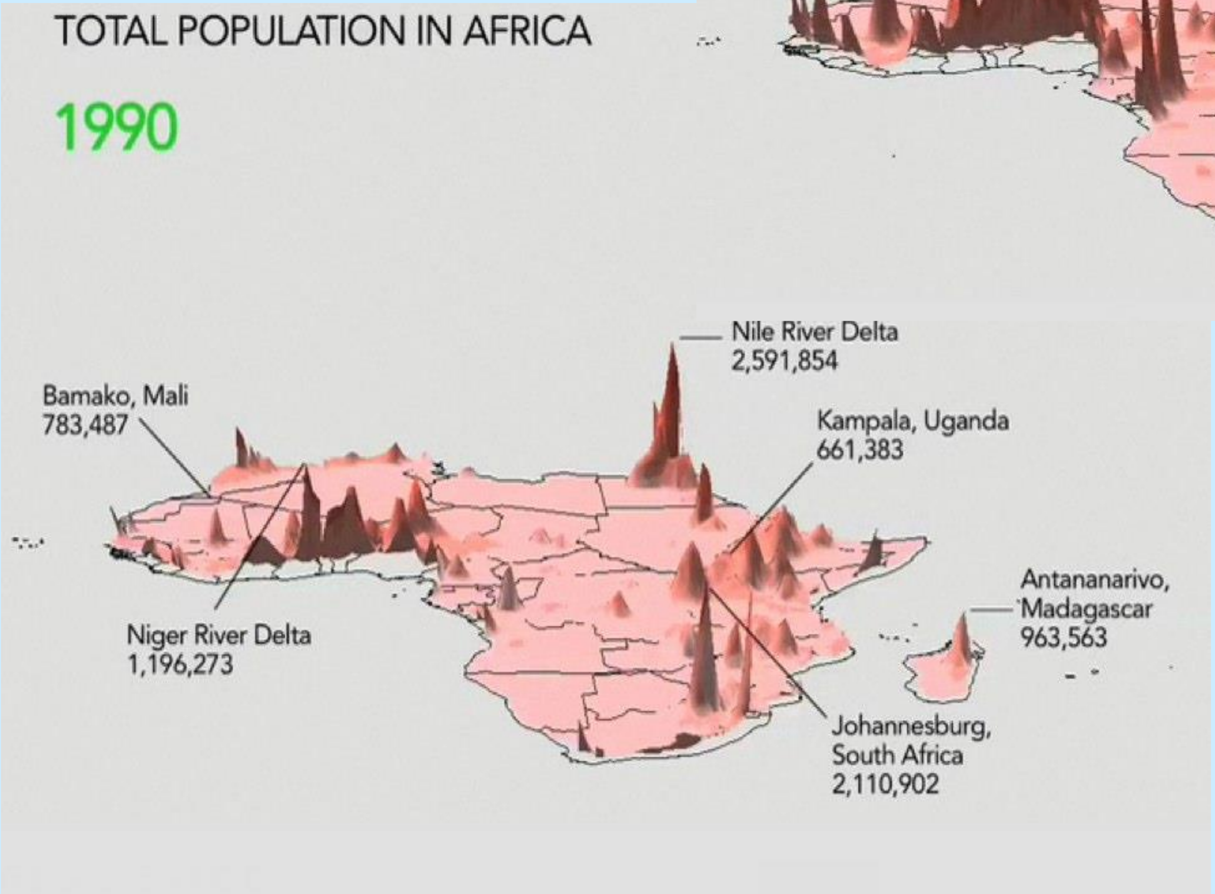
95-97% of 'circulating freshwater' is groundwater – but only 0.03 % of 'groundwater stock' is estimated (on average) to be replenished annually

very large storage means that subsurface 'residence times' are large and 'aquifer memories' long (decades to millennia)

generally high microbiological and (for most part) chemical quality but any pollution occurring can be very persistent and remediation problematic

URBAN POPULATION
unprecedented growth in population and water demand

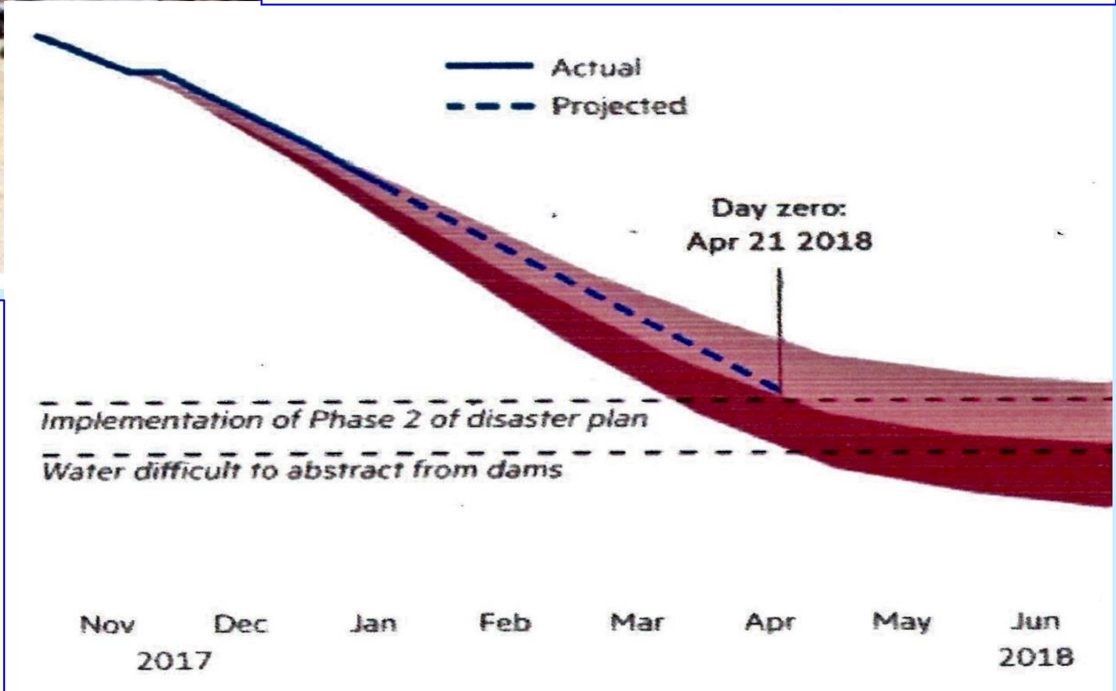




especially West Africa

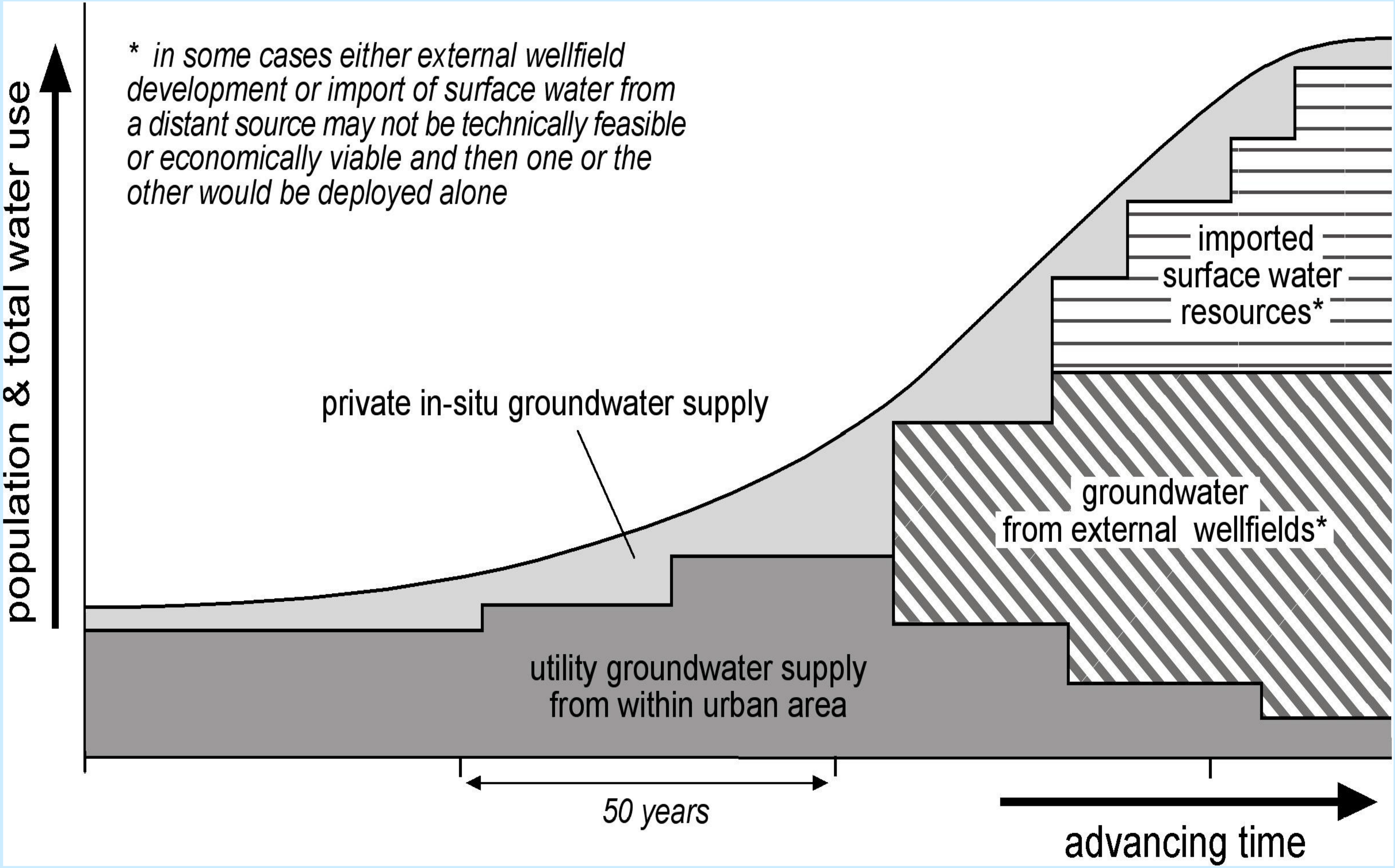
AFRICAN URBAN WATER-SUPPLY CRISIS
Cape Town facing 'Day Zero' sometime March-April 2018

- **surface reservoirs at critical/ disaster level with 3+ million constrained to only 50 lpd/capita**
- **22,000 private boreholes could be used to help 'public good' if effective governance and distribution can be established**



- **'Day Zero' will involve mains shutdown and millions of residents queuing at 200 policed standpipes for 25 lpd/capita**
- **all industry/business to close except for emergency services**

TEMPORAL GROWTH IN URBAN WATER DEMAND
with typical supply-side response



GROUNDWATER USE IN SELECTED AFRICAN CITIES
data for sometime in period 2011-2015

CATEGORY OF CITY	CITY	UTILITY GW USE (Ml/d) (propn)	UTILITY SERVICE LEVEL	PRIVATE GW USE (Ml/d)
Water Utility with Major Groundwater Dependency	Abidjan **	285 (100%)	moderate	some #
	Dakar **	210 (70%)	excellent	minor #
	Arusha	50 (80%)	excellent	minor
	Dodoma **	45 (100%)	good	minor
Water Utility with Conjunctive Resource Use	Addis Ababa	120 (40%)*	moderate	minor #
	Dar-es-Salaam	30 (10%)*	poor	major
	Benin City	45 (50%)	poor	major
Water Utility with Poor Service Levels & Major Private Groundwater Use	Nairobi	30 (5%)	moderate	80-240 #
	Lusaka	135 (45%)	moderate	100-300
	Mombasa	80 (100%)	poor	major

* major new groundwater source under exploration/development

\# cost constructing/equipping private water borehole > US$ 10k

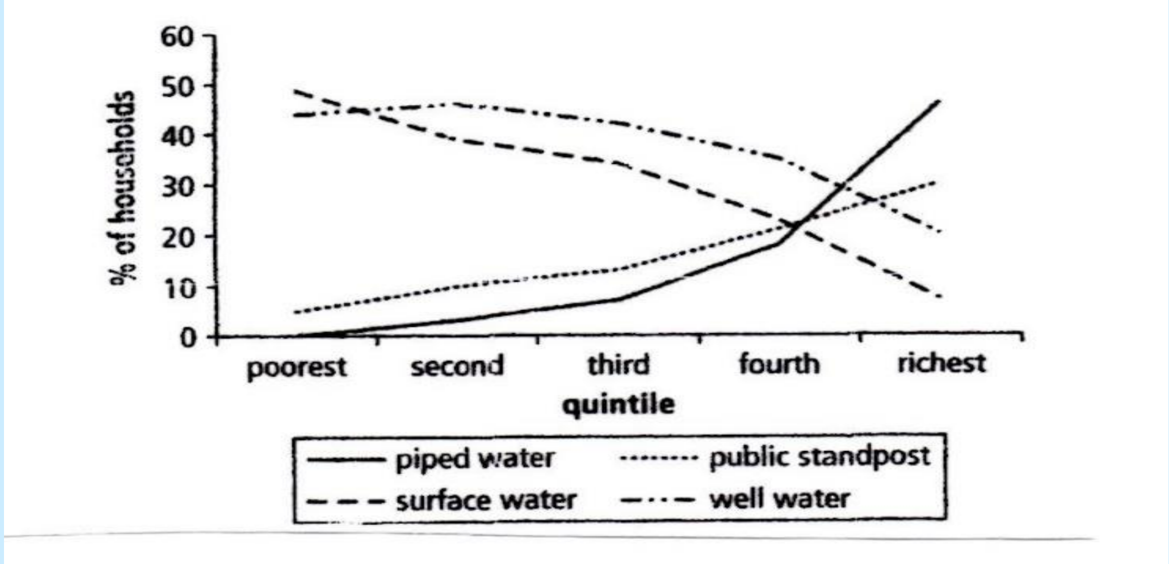
AICD DATA ON EVOLUTION OF WATER-SUPPLY IN AFRICAN CITIES
accessibility and affordability

Foster & Briceño-Garmendia, 2010
and Banerjee et al, 2017

REGIONAL AVERAGE URBAN WATER-SUPPLY ACCESSIBILITY

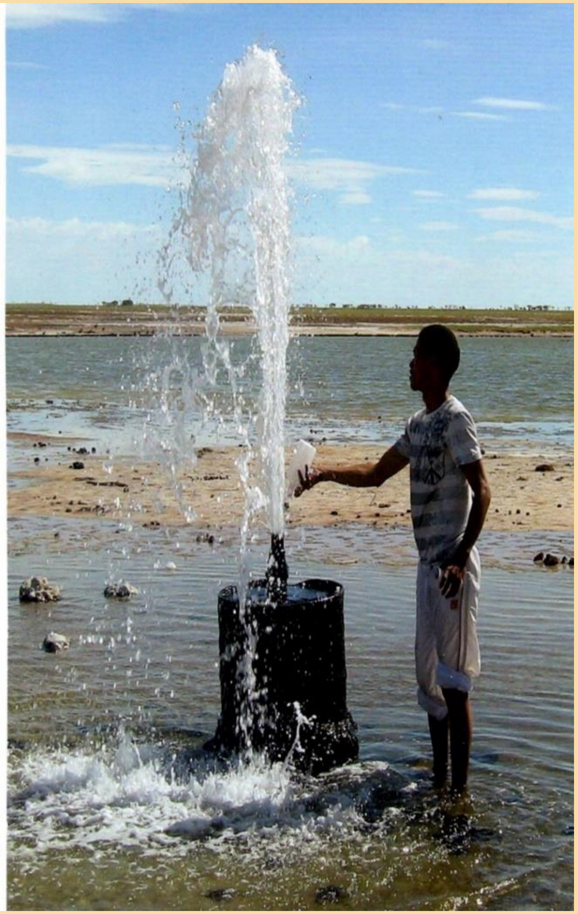
PERIOD	*PIPED-SUPPLY*	*WATERWELLS (boreholes/ dugwells)*	*STAND-POSTS*
1990-95	**50%**	**20%**	**29%**
1995-2000	**43%**	**21%**	**25%**
2000-2005	**39%**	**24%**	**24%**

REGIONAL AVERAGE URBAN WATER-SUPPLY AFFORDABILITY



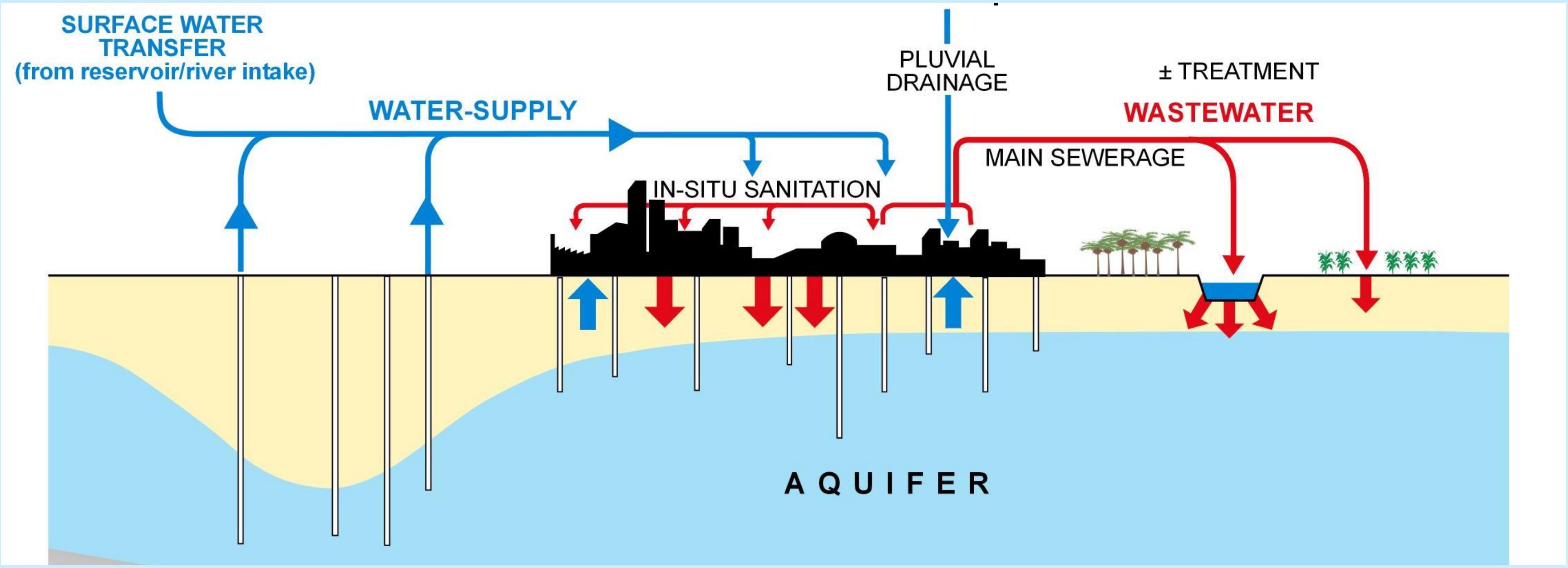
WATER-UTILITIES AND GROUNDWATER
critical resource for improving physical water-supply security

- allows 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



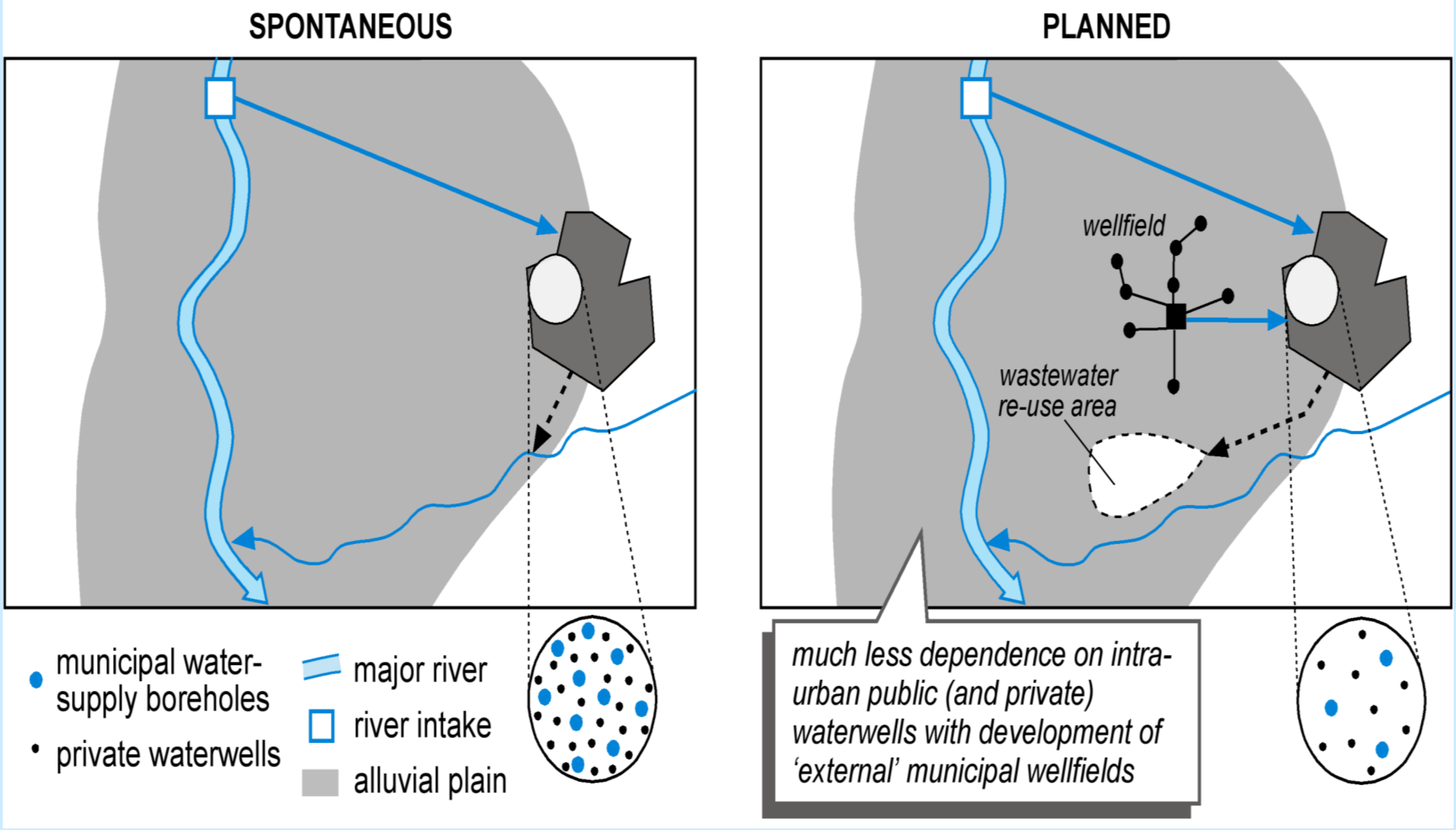
URBANISATION & GROUNDWATER
intimate but often unrecognised relationship

- impact of urbanisation on groundwater and groundwater impacts on urban infrastructure much better understood over past 15 years



- important differences according to :
  - hydrogeology – especially confined/uncofined aquifers
  - water-supply and sanitation arrangements
- in reality impacts are now 'predictable' but still 'rarely predicted'
- HOWEVER–very scanty information on groundwater USE dynamics in/for urban areas (scale, dependency and modes)

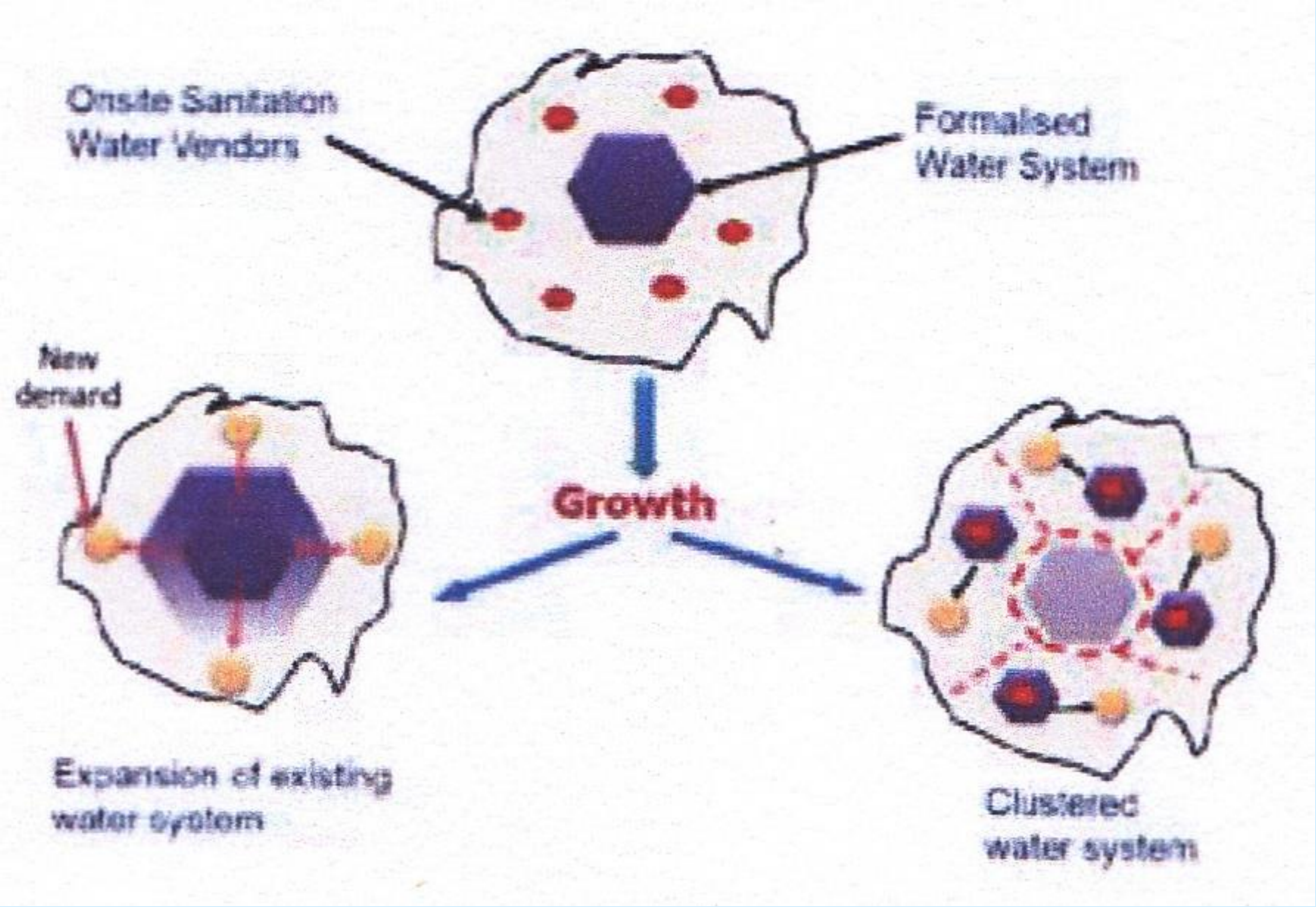
CONJUNCTIVE USE & MANAGEMENT OF RESOURCES
key to urban water-supply security



UTILITY URBAN GROUNDWATER SUPPLIES
measures to enhance source security

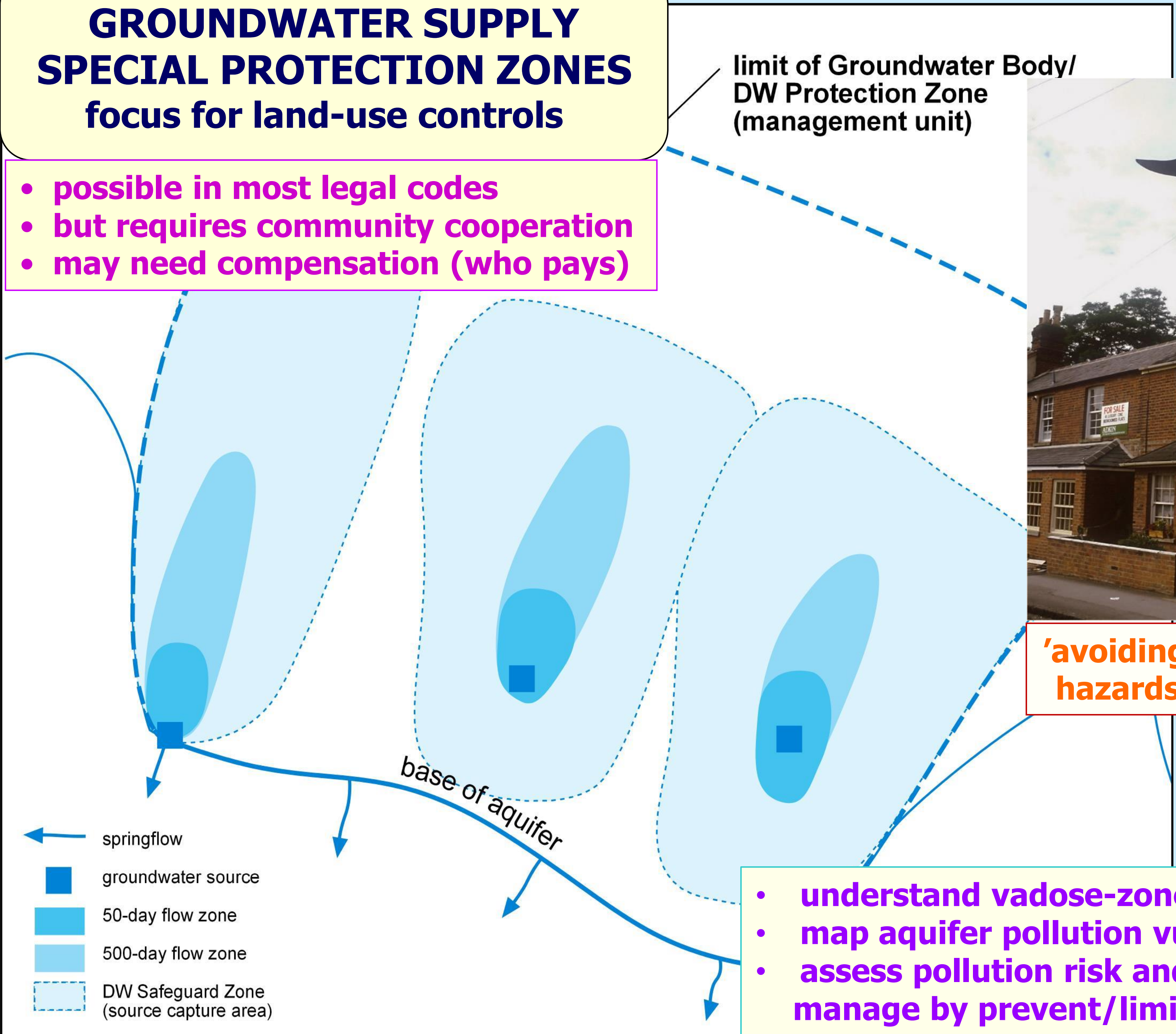
- develop **protected external municipal wellfields** (with agreement between urban and rural municipalities involved on land-use controls)
- establish **municipal waterwell protection zones** (to take advantage of parkland and prevent generation of polluting discharges)
- **prioritise mains sewerage**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

DECENTRALISED URBAN WATER-SERVICES
'closed-loop paradigm' to cope with rapid urban expansion



GROUNDWATER SUPPLY SPECIAL PROTECTION ZONES
focus for land-use controls

- possible in most legal codes
- but requires community cooperation
- may need compensation (who pays)



'avoiding unexpected hazards from above'

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

PRIVATE URBAN GROUNDWATER USE
causes and consequences of 'self-supply boom'

- '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
- open-access to groundwater cannot be regarded as 'pro-poor' since reduces revenue of water utilities
- need for systematic study of hydrogeologic dynamics, engineering economics and sociologic impact
  (only limited work in districts of Accra, Lusaka & Lagos)

PRIVATE URBAN SELF-SUPPLY FROM GROUNDWATER
policy implications

- massive private domestic self-supply reality – can distort utility water operations with major implications for finance/investment
- 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
- what management measures should be taken : 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 ?

URBAN WATER-SUPPLY IN AFRICA
ways forward on enhancing security

- 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)

DR. STEPHEN FOSTER

www.DrStephenFoster.com
www.ResearchGate.net/Stephen_Foster11

www.un-igrac.org/gwmate
www.worldbank.org/gwmate
www.groundwatergovernance.org
www.gwp.org/toolkit/groundwater
www.iah.org/learning-resources/strategic-overviews
www.groundwateruk.org/our-hidden-asset
www.iucn.org/resources/publications/spring

Self-supply and resilience

Groundwater Use and Governance in Peri-Urban Accra

Dr Jenny Grönwall

Groundwater Futures in Urban Africa | Cardiff | March 14, 2018

SIWI

Water supply systems developed and maintained largely or wholly by households,
typically relying on low-cost technologies and user investments
to extract water from hand-dug or drilled wells

(adapted from Workneh and Sutton 2008, MacCarthy, Annis et al. 2013)

Self-supply, definition

Self-supply – how?

- MDG 7c achieved? Not at disaggregated level
    - Uneven development;
    - Urban SSA behind rest of the world (JMP 2017: 46/85%);
    - 55% of urban population in SSA live in informal, unplanned settlements

- Piped networks = modern infrastructure ideal
- … but *inadequate* (piped & public) water 'services' or entirely detached, *unconnected* areas prevail

→ informal, unplanned urban areas poorly provided

Self-supply – why?

SIWI

→ 269M urban dwellers depend on wells as principal source

(IIED 2010, global figure; great variation between SSA countries)

- ‘Community-based’ supply – *or ‘self-supply’*
  - Shallow aquifers, dug wells → poor quality ⇒ health & safety problems – *if no / sub-standard treatment*

Self-supply – why? *cont’d*

SIWI

The “capacity of a system to
absorb disturbance and reorganize
while undergoing change

so as to still retain essentially the same *function*,
structure and feedbacks, and therefore identity,

[i.e.], the capacity to change
in order to maintain the same identity”

Folke et al. (2010) Resilience thinking: integrating resilience

Social-ecological resilience, definition

A resilient household is one that can
self-supply from different water sources

to increase or maintain its capability to cope with stress,

with respect to quantity (access, availability) as well as quality issues (health and safety)

...so as to still retain essentially the same *function*

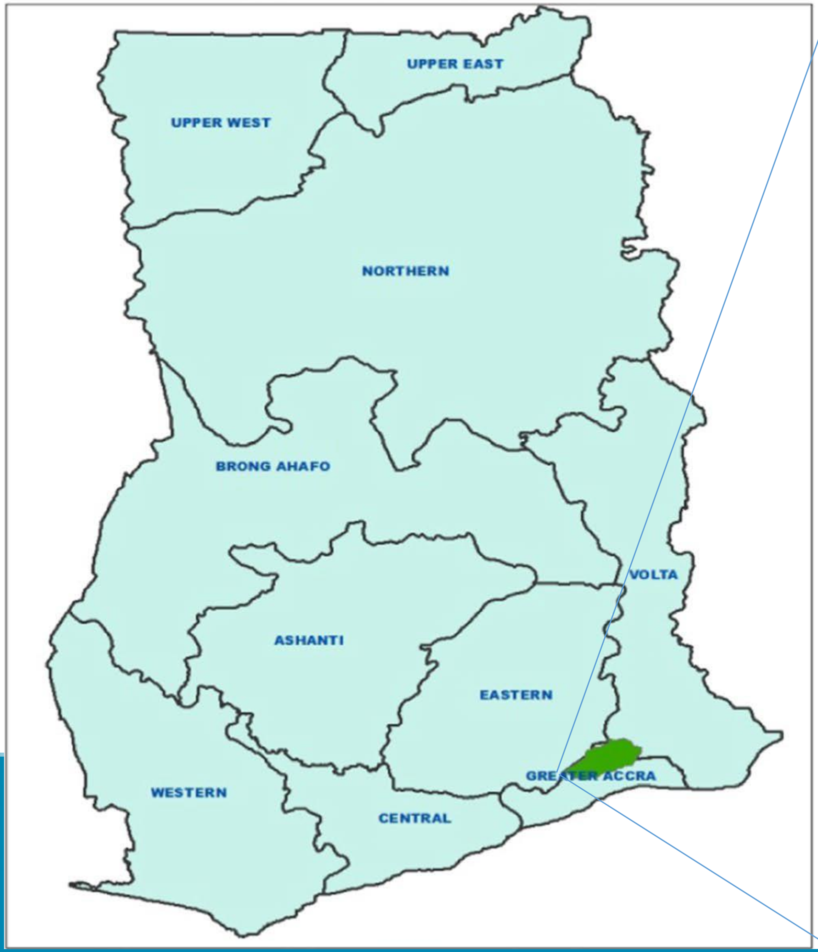
Grönwall & Oduro-Kwarteng 2018

S–E Resilience *at household level*

Dodowa, peri-urban Accra

- Low-income township (~12,000 residents)
- N-W outskirts of Greater Accra, 30 km from coast
- Akwapim–Togoland mt range
- Weathered & fractured quartzite & gneiss + sandstone

GHANA MAP



MAP OF SHAI-OSUDOKU DISTRICT
SHOWING DODOWA

Water sources

Fig. 1. Main water source

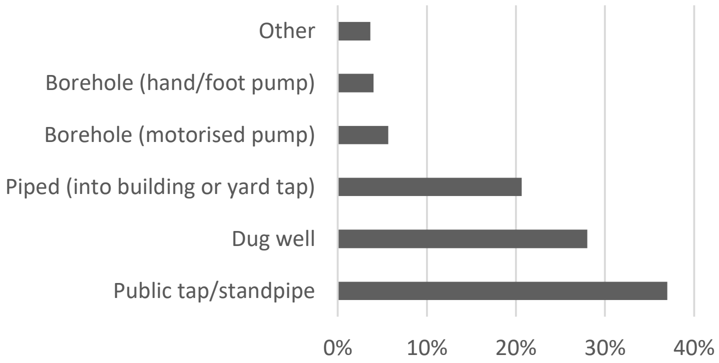
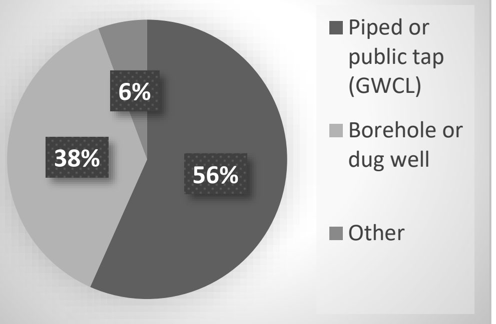


Fig. 2. Provider



Residents in Dodowa were fully relying on GW
[6 utility boreholes + 6 District Assembly boreholes + private boreholes + self-supply
(+ locally packaged water)]
until Kpong Expansion Projects end-2014

Shift due to

- policy intervention to achieve MDG 7c:
  Loans → infrastructure investments;
  +300,000m^3/day surface water
- Taste & quality issues?

GW dependence: the big transition

SIWI

At time of field study: Intermittent & irregular piped supply

→ people must still rely on several sources

→ people still depend on GW

Relative to in Accra proper, better off *because they can self-supply* from own or someone else's well

GW dependence, cont'd

Ghana Water Company, Ltd. (GWCL)

- Domestic tariffs
- Cost for new connection (road-cutting, pipe-laying) estimated on case-by-case basis; GH¢150,000 (ca. USD 33,833)(2006)

Category	**Price** GH¢/m^3/m
Domestic ('lifeline tariff') 0-5 m^3	2.98 (0.67 USD)
Domestic >5 m^3	5.07 (1.14 USD)
Public standpipe	3.35 (0.76 USD)

Utility water pricing

Competition over scarce GW

- Gentrification of Dodowa township
  - Poor HHs v. richer? No signs of impact on water table (yet)
- Mineral water companies
  - Packaged water production (3 sites); total abstraction ~450 m^3/day? → total pressure on local aquifers = negligible

- IF city planners & utility resume pumping GW fr Dodowa → incr. pressure

Rainwater harvesting? Yes

90% of HH respondents

(Managed) Aquifer Recharge? No

- HH collecting for direct use only
- Mineral water companies never reflected over need to recharge; "our boreholes always yield water"

No one has a comprehensive picture of the abstraction situation in Dodowa, or elsewhere in Greater Accra

Prevention is better than cure…

Dodowa HHs are coping through combining different sources, for different purposes...

Planning for status quo or the new normal?

GW is invisible, unmanaged, undervalued

Resilience—how long?

Governance for improved resilience

- Recognize the importance of conjunctive use
- Plan for enhanced buffer capacity based on diversification
- Build resilience thinking into governance regimes
- Raise end users' resilience: RWH/MAR, PoU treatment?

Thank you!

jenny.gronwall@siwi.org

SIWI

Managing the commons: choices and perceptions of residential users in Lagos Nigeria

Adrian Healy
Cardiff University
Healya2@cardiff.ac.uk

S. Allan, G. Bristow, Y. Bukar; S. Capstick, K. Danert, I. Goni, A. MacDonald, M. Tijani, S. Theis; K. Upton, L. Whitmarsh

A pilot study: Building Resilience

- Three locations:
  - Lagos
  - Borno State (Maiduguri)
  - Nasarawa State (around Lafia)

Water point analysis

Interviews with community groups

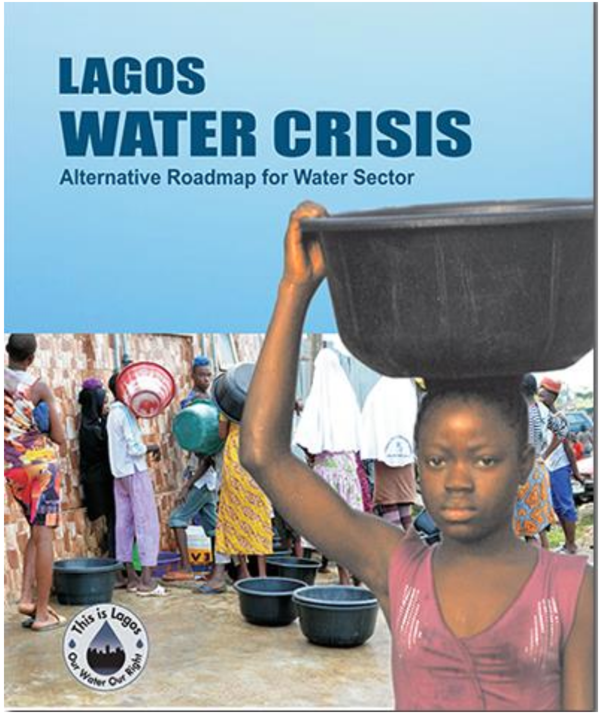
Interviews with households

- Survey of 500 Households in Lagos
- Global survey of 115 water professionals

Groundwater

- crucial to meeting rising demands for domestic water supplies
- a powerful resource for more equitable development

A water crisis



Source: ERACTION, 2017

UN expert calls for budget plans to tackle “unacceptable” water crisis in Lagos

December 2016

Cape Town: preparation of a Water Resilience Plan

Augmented supply

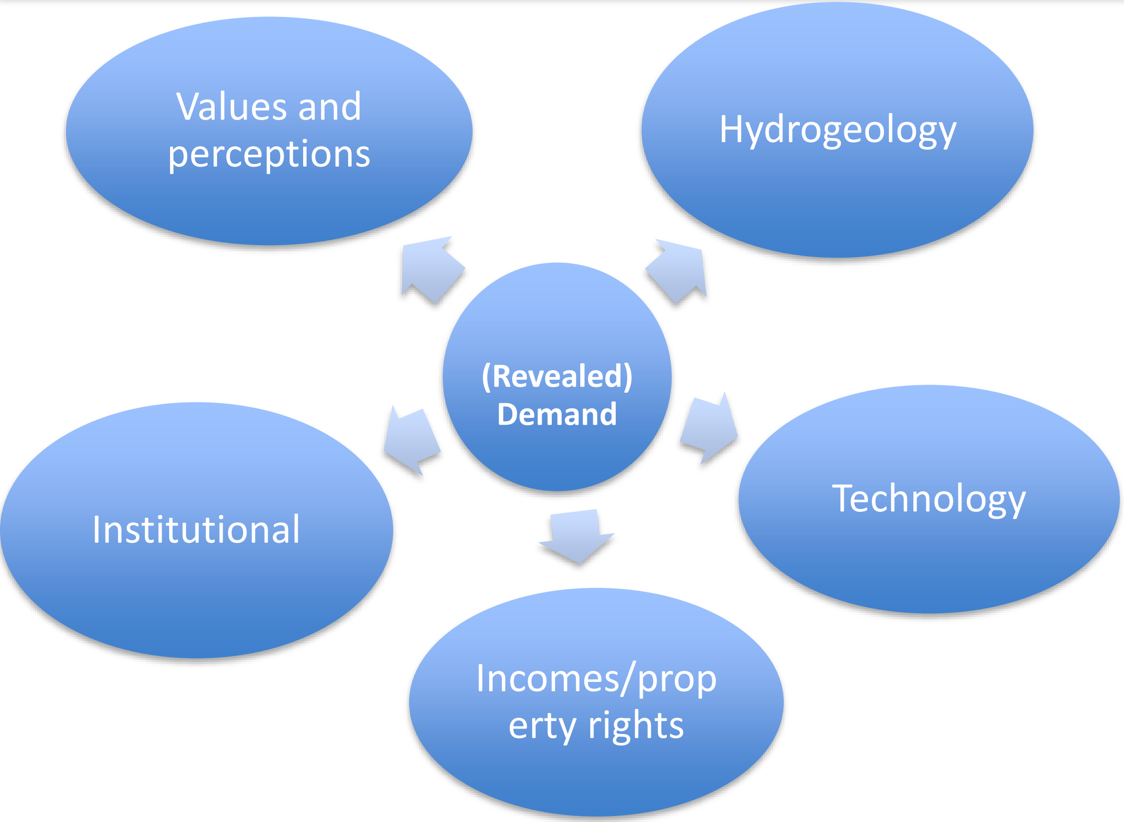
- Households increasingly investing in their own secure supplies
- Individual supplies often augment publicly provided water supply

51% of households owned their own borehole

36% of households shared a borehole with other families

For c.33% of households access to public water supply is primary source

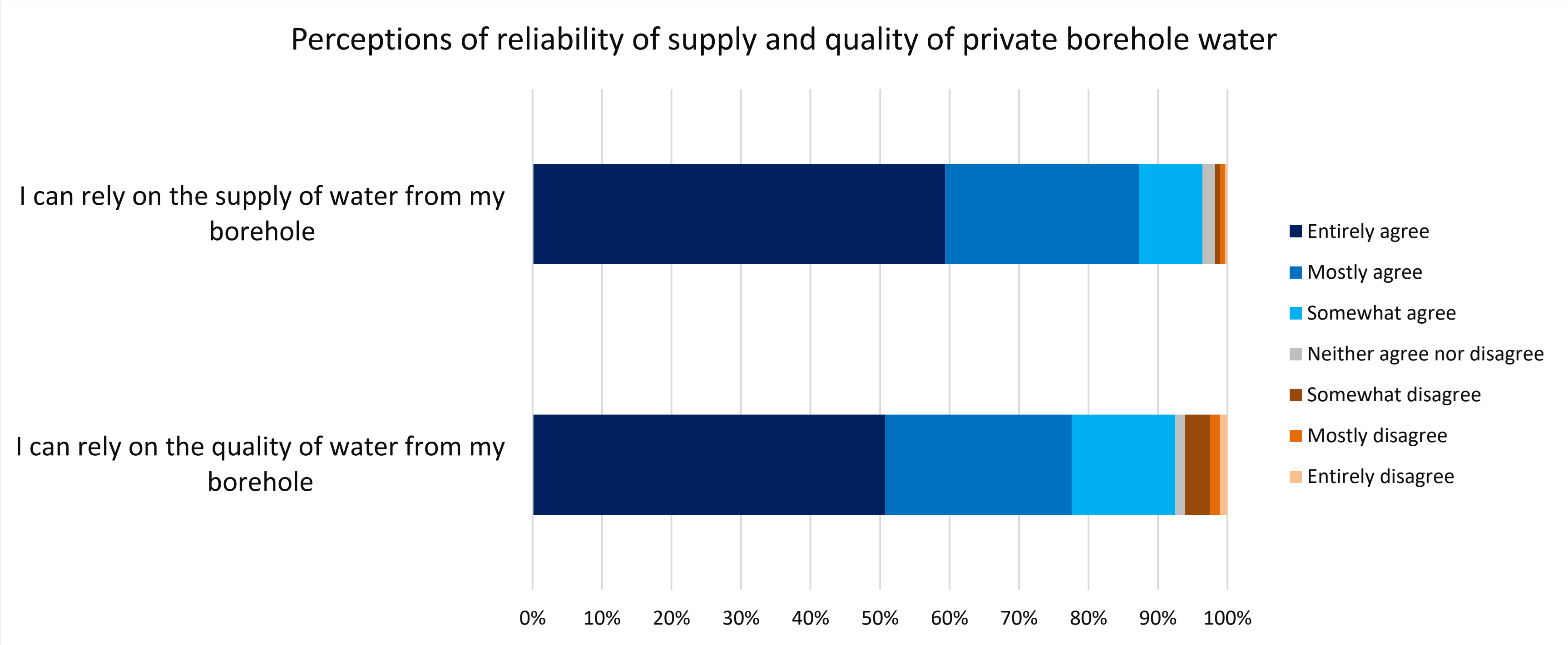
Proliferation of private boreholes



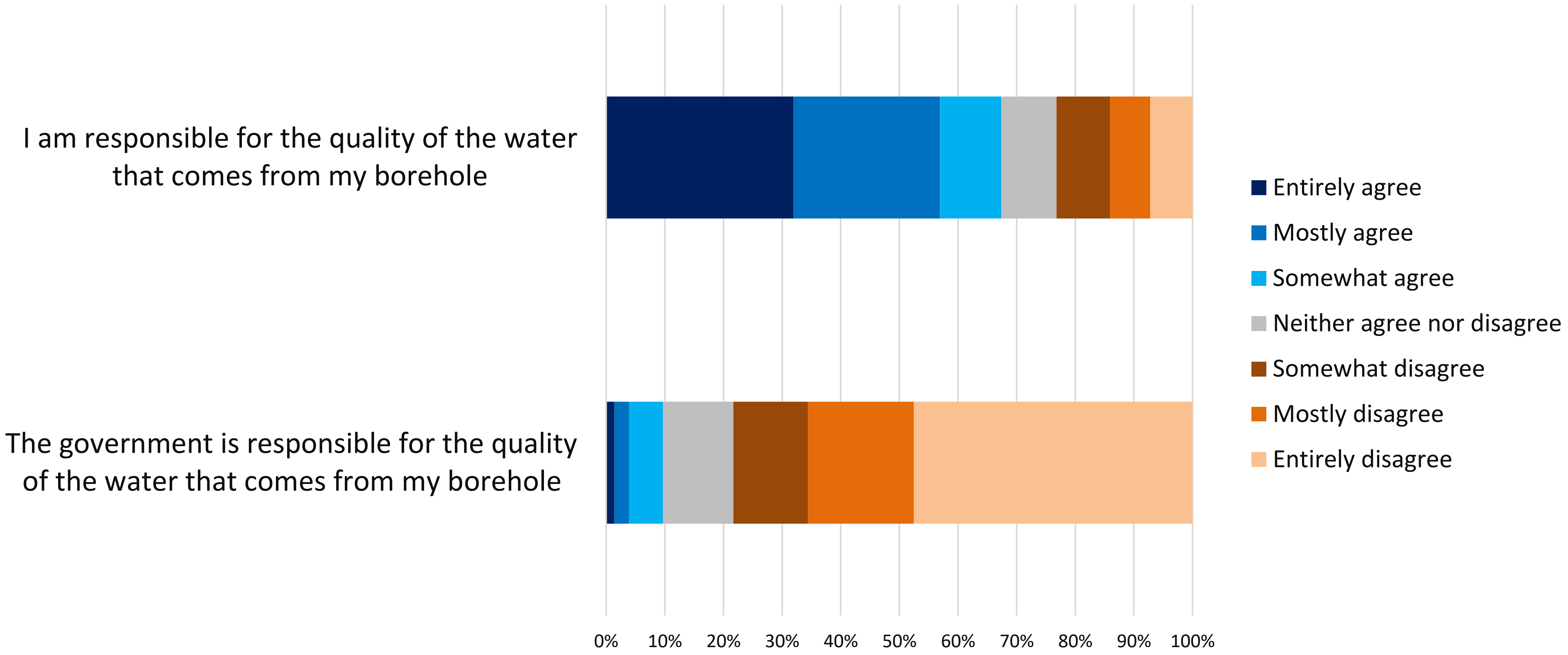
Government failures:

- Failure to connect
- Failure to supply
- Failure to enforce

Confidence in water availability

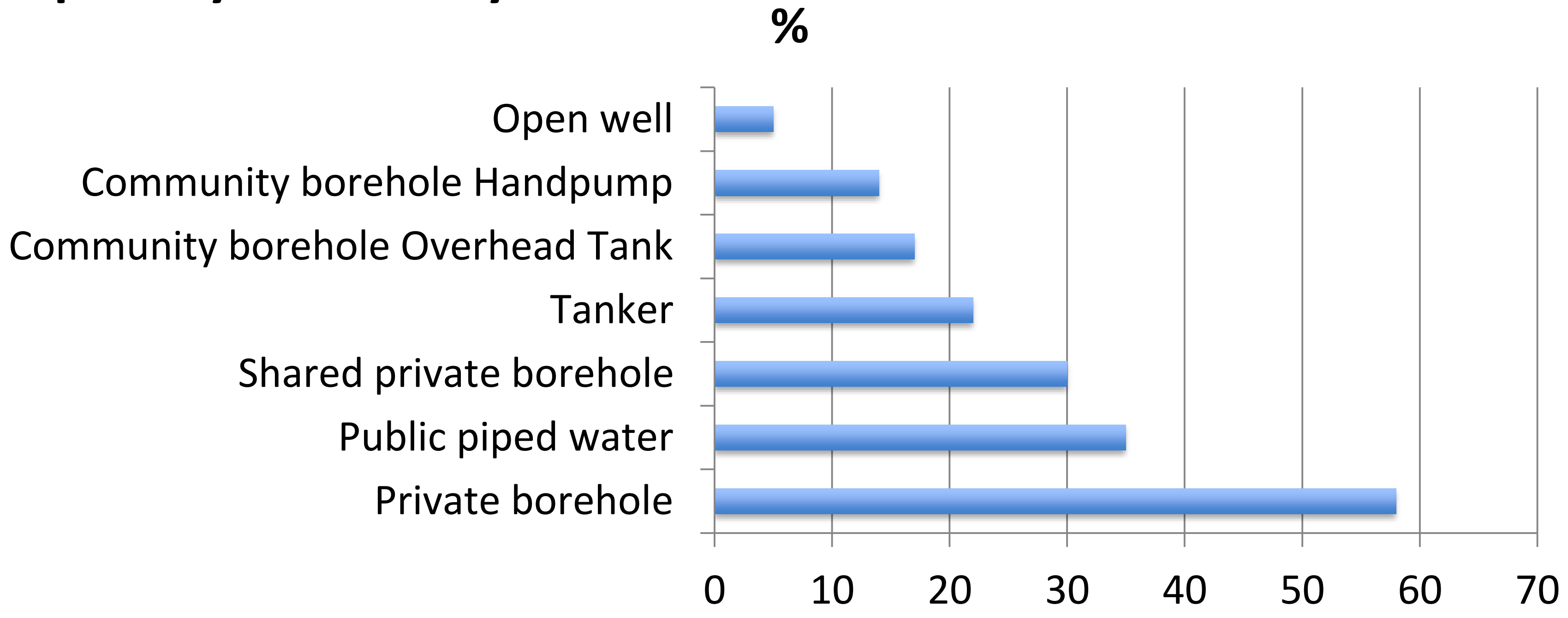


Responsibility for water quality

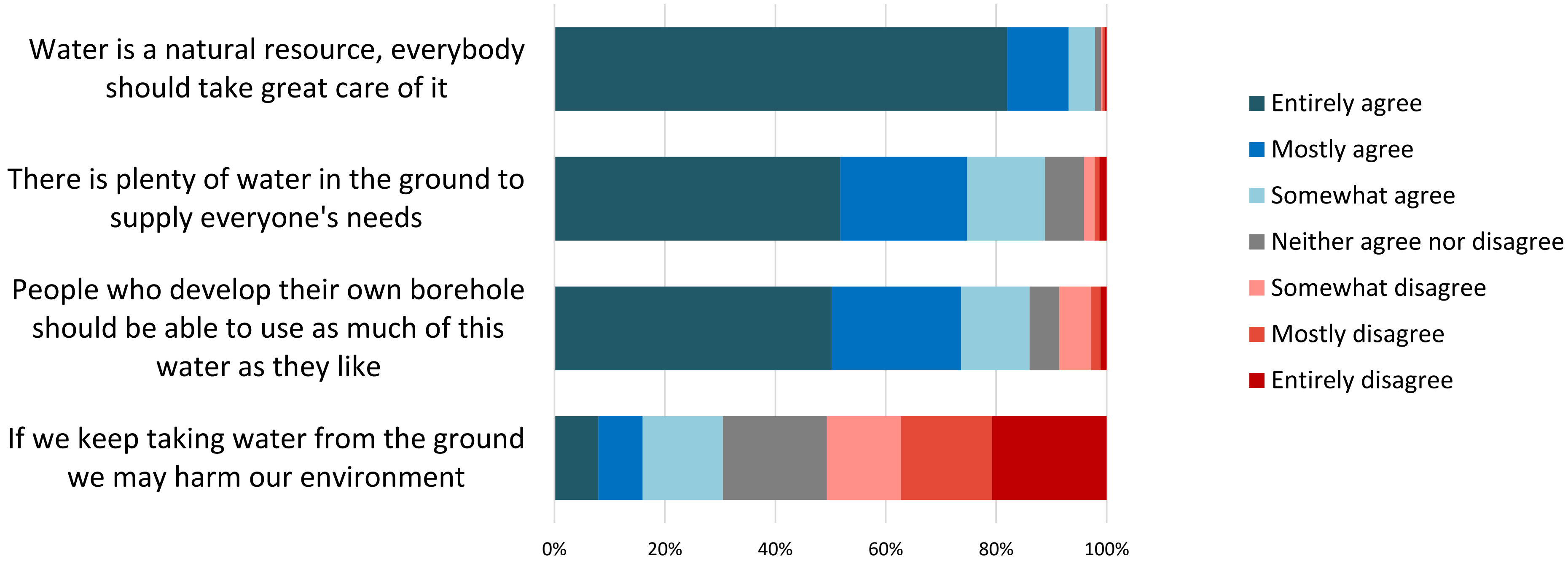


Trust and control

Propensity to drink by source



Quantity of water available

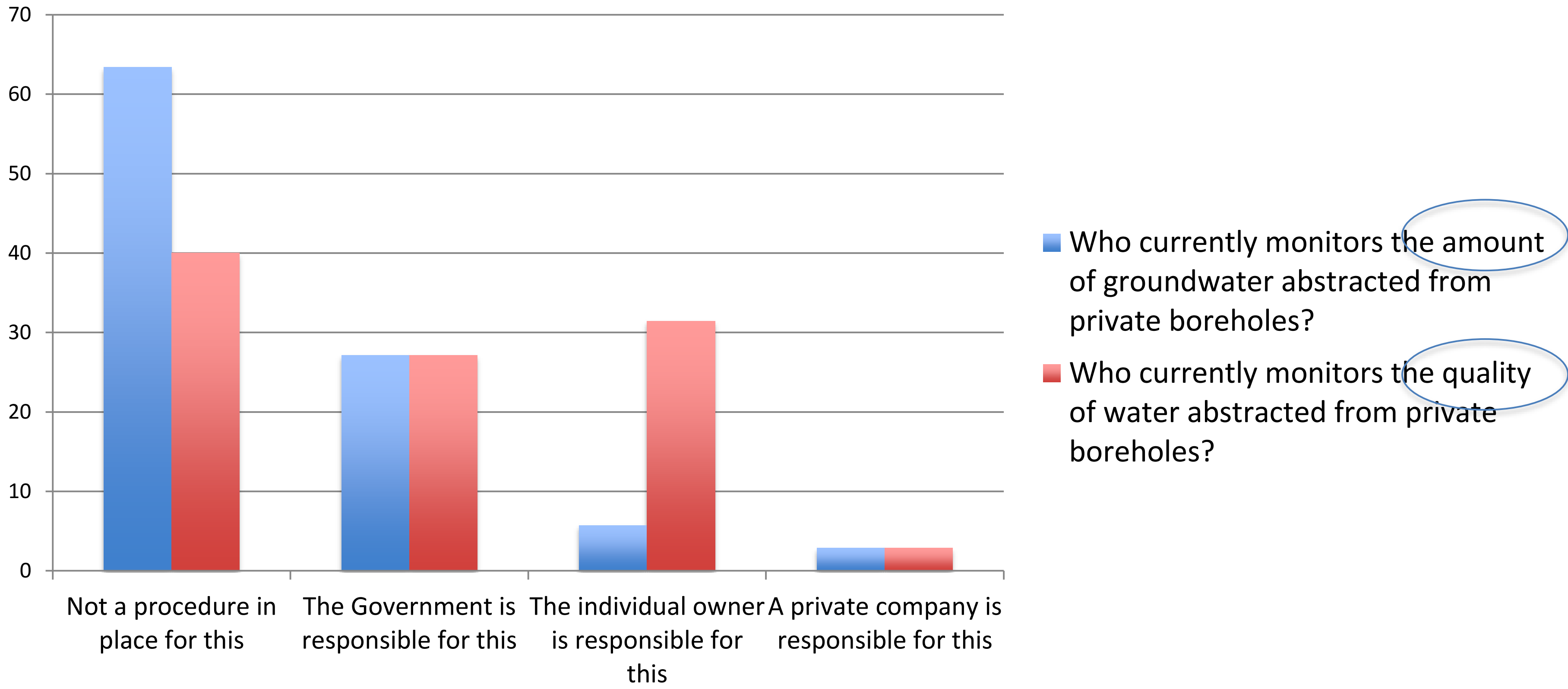


Management and monitoring (Lagos/Nigeria)

- No procedures (or capacity) in place
- No implementation of existing regulations
- Newly introduced legislation will not apply to domestic boreholes

- No heed of informal monitoring through practice:
  - Falling water tables
  - Increasing pollution
  - Salt water intrusion at deeper depths

Global Survey



Resilience

- Demonstrates resilience of society to long-term water crisis – augmented supply
- Dispersed system with redundancy
  - resilience against **specific** shocks
- Risk of creating a tipping point, with an enhanced vulnerability (see Boelsmand et al, 2016)
- Transference of vulnerability into the future and to the urban poor
  - Highlights significance of management and monitoring gap

Groundwater management

- Inherently complex (invisible)
- A common pool resource
- Governed by access rather than rights
- Anarchic practices
- About influencing the behaviour of individual users (importance of social capital and institutions)
- Need to recognise the significance of individual and collective perceptions (and who has capacity to act)

Conclusions

- Governance not solely a technical-political construct: Choices and perceptions count
- Risk of injustices and inequality rising as poor are stranded (unequal exercise of equal rights)
- Challenge of regaining control should not be underestimated
- Monitoring a first step towards resource management?

Thank you

Healya2@cardiff.ac.uk

This work is supported by the Natural Environment Research Council
Grant number: NE/P01545X/1.

Key Groundwater challenges for urban areas

Helen Bonsor helnso@bgs.ac.uk
Deputy Chief Geologist Scotland,
IAH Urban Groundwater Network Director
British Geological Survey, The Lyell Centre, Scotland

https://urbangw.iah.org/

Urban Groundwater Network

International Association of Hydrogeologists

HOME ACTIVITIES COMMITTEE RESOURCES JOIN US

Home

Groundwater is a major source of urban water supply worldwide and aquifer storage represents a key resource for achieving water supply security under climate change and extended drought

IAH's Urban Groundwater Network (UGN) is an official network of International Association of Hydrogeologists (IAH), created to:

- Support the development of science, understanding and management of urban groundwater
- Foster knowledge-exchange between network members and other professionals

There are many ongoing activities happening in the network, including workshops, conference sessions and network meetings. Our activities are currently focused over three key regions: **North Atlantic-European region**; **SE Asia**; and **Africa**, but we are always looking to involve participation from all regions.

We hope our new website will highlight the network's activities and encourage others to get involved.

Find out more

- Activities
- Join us

IAH is an international charitable organisation that promotes sound development and management of groundwater – seen by many as the worldwide family of hydrogeologists.

2018 activities

Nordic Water Conference 2018

Bergen, NORWAY, 13–15 August

Hydrology and water resources management in a changing world

The 30th Nordic Hydrological Conference is focusing on: promoting discussion between the scientific communities to key challenges in our changing world; stimulating cooperation between research institutions; and developing understanding how hydrogeological and hydrological knowledge can improve decision-making.

IWA-IAH UGN workshop 2018

Tokyo, JAPAN, 16–21 September

The IAH UGN is holding a jointly organised IWA-IAH UGN special workshop at the World Water Congress event.

This will be focusing on developing discussion amongst researchers, government, regulators, water utilities, and wider professionals at to how sustainable groundwater management can be integrated into urban infrastructure development, including water utility facets; what are the key research understanding required; and what strategies are needed to resolve scarcity and quality constraints.

The workshop aims to provide the basis for concerted knowledge exchange and action on addressing urban groundwater issues — bringing together practitioners and experts to identify challenges and the solutions, as well as how to leverage this into action to move from coping to adaptive management.

IAH-UGN congress session 2018

Daejeon, KOREA, 9–14 September

Understanding of Asian urban groundwater resources – key challenges and opportunities

Groundwater forms a pivotal resource for Asian cities, and worldwide, for water, energy, flood mitigation, integrated surface-ground water management, and low carbon sustainable cities. Developing new integrated planning approaches, where groundwater is accounted and managed requires improved understanding of urban groundwater resources and its resilience, alongside the socioeconomic, groundwater-use drivers and future environmental change. It is essential water utility facets of urban groundwater and investment are understood for future groundwater management in city planning approaches.

ABSTRACT SUBMISSION DEADLINE: 1 MARCH 2018.

All abstracts on urban groundwater management use, issues, information use, and presentation of new scientific understanding of key processes of urban groundwater resources and planning, are welcomed.

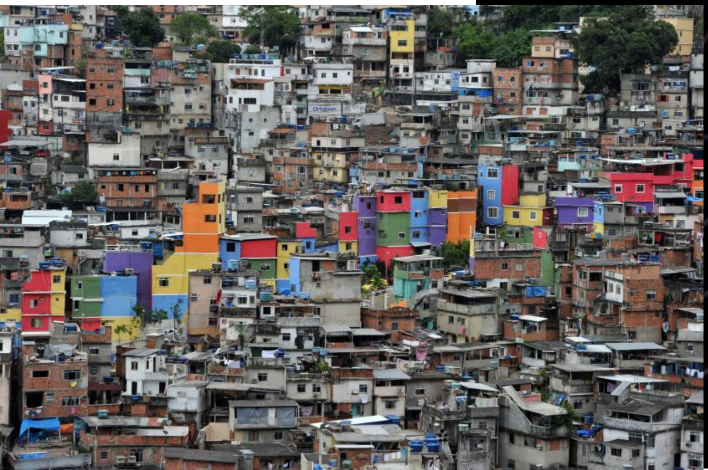
Increasingly urbanised world, yet little recognition of the subsurface environment, or its vital role

Cities cover

2% **Earths surface**

54% **population**

2050 urban population
= 2004 total population



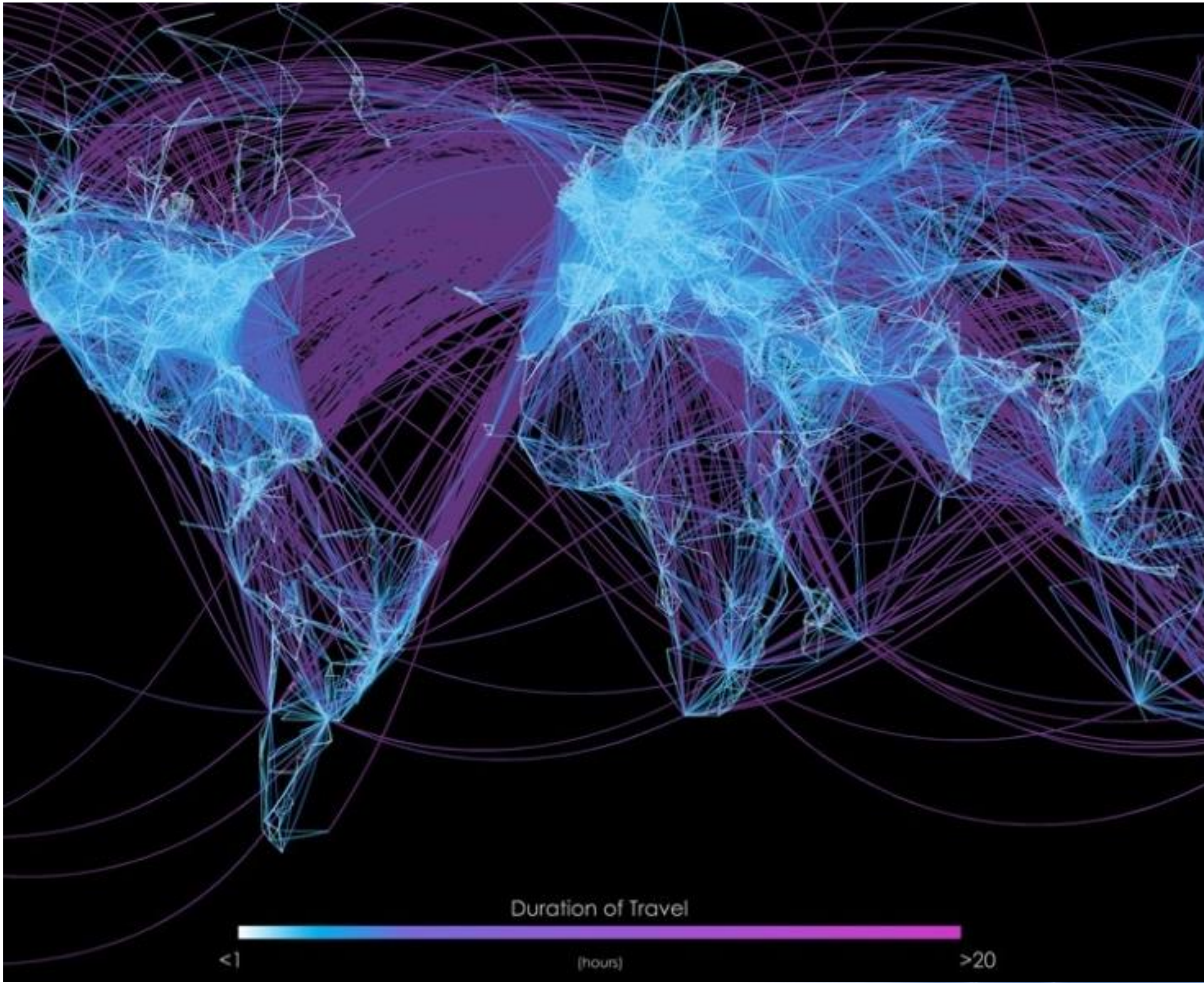
Cities are highly dense, complex, inter-connected places - *systems* – socially and physically

Complex Resource intense; Multiple layered land use at any one point

80% global economic activity generated in cities (World Bank 2013)

Engines of growth but also central to:

decarbonisation, global CC goals, and SDGs



'A perfect storm'

High dependency on food resources outside of cities

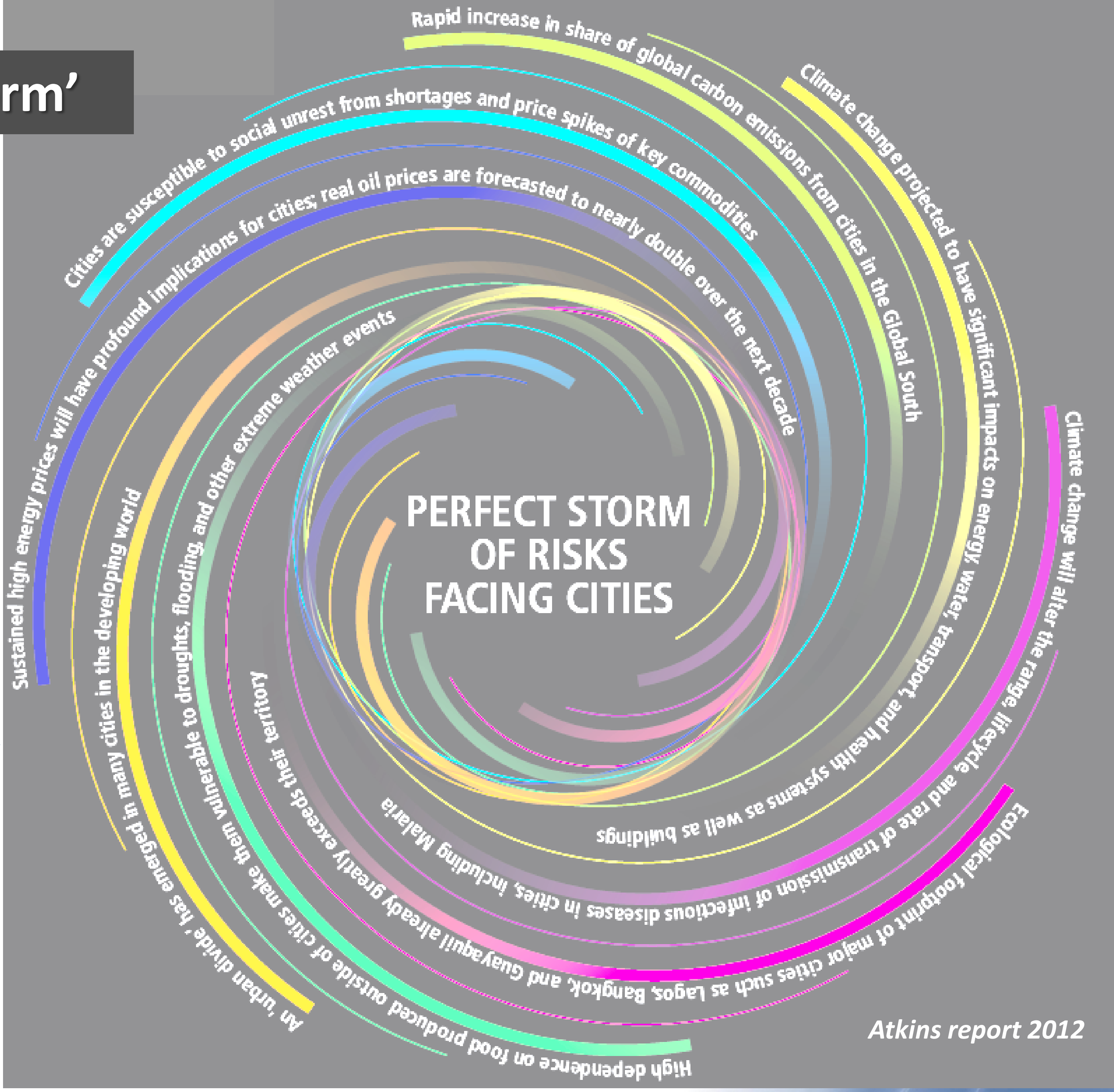
Rapid migration to urban areas

High env. footprint downstream – affecting water quality, national assets, pop health and growth

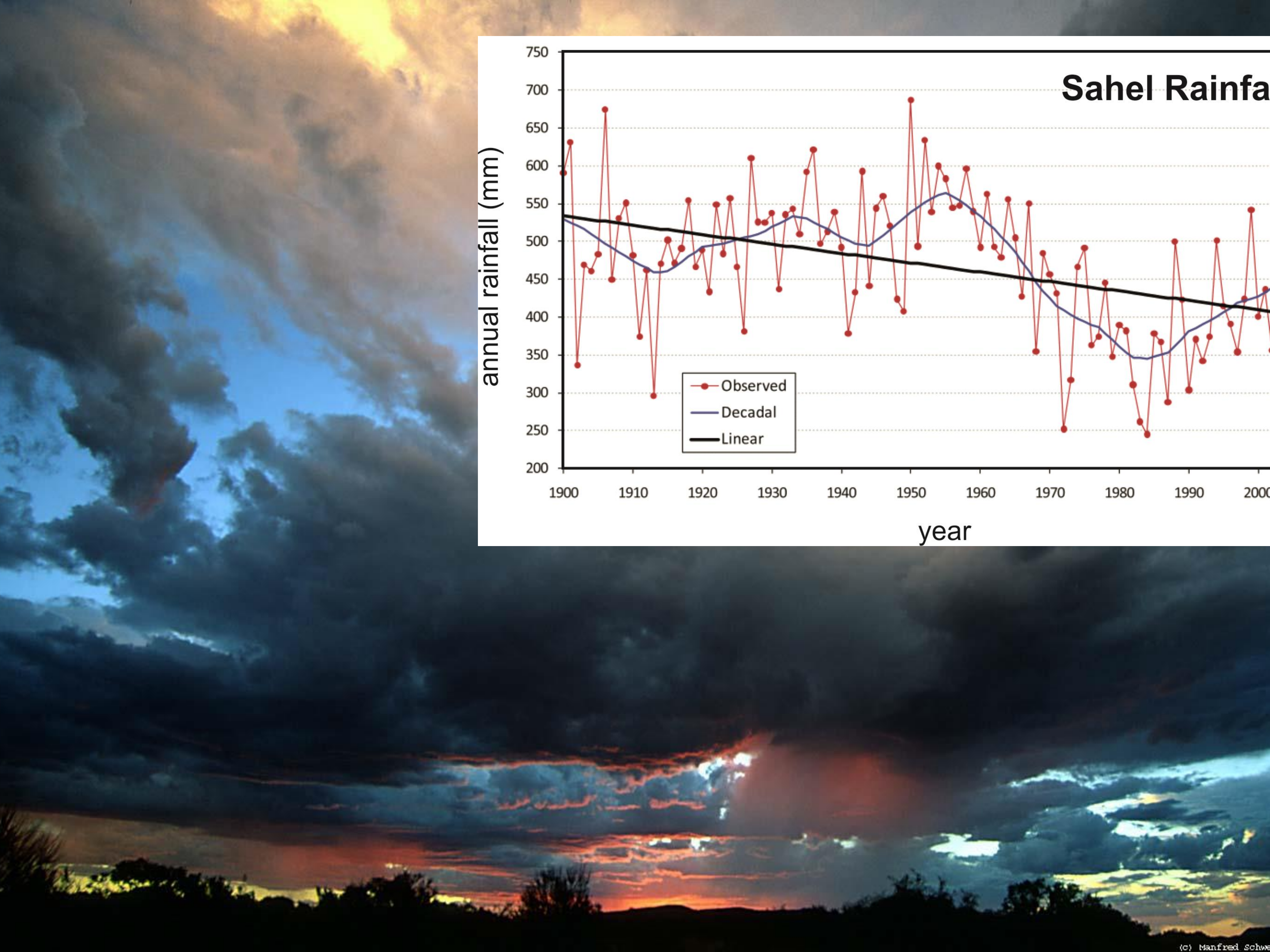
Pop density and Health risk – increasing urban yellow fever west Africa (WHO)

Susceptible to unrest and social division

Global carbon emission



Atkins report 2012


Sahel Rainfa
annual rainfall (mm)
year
750
700
650
600
550
500
450
400
350
300
250
200
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Observed
Decadal
Linear
(c) Manfred Schwe

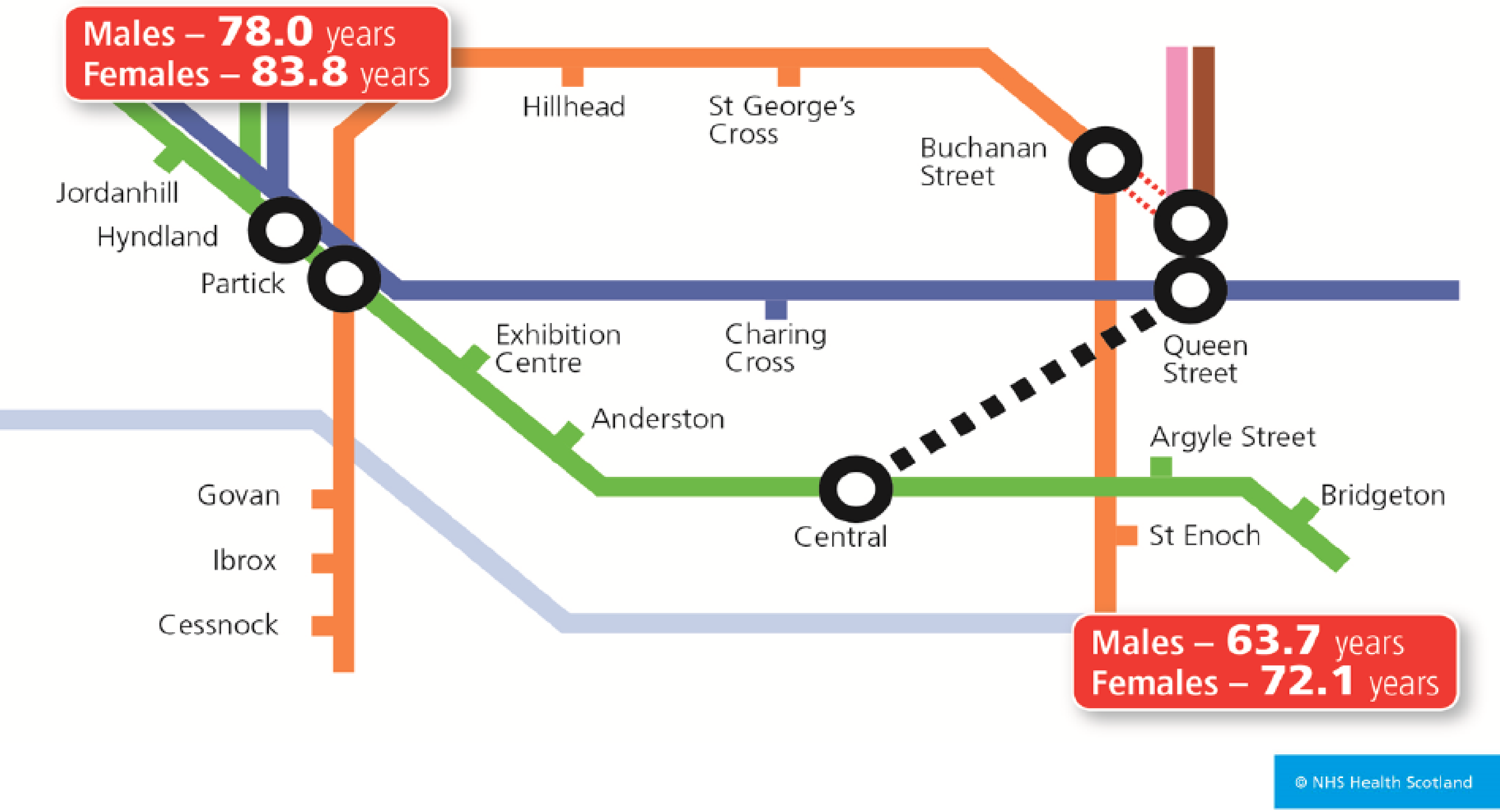
Urban Africa – only second to China

By **2050 56%** of Africans will live in cities (UN DESA 2014; Khan et al. 2015)

62% of these will live in informal settlements

Atkins report

How can cities work better for all?

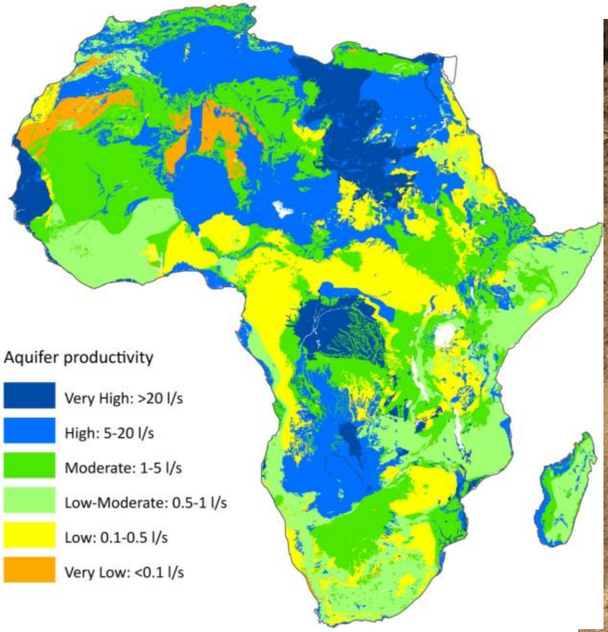


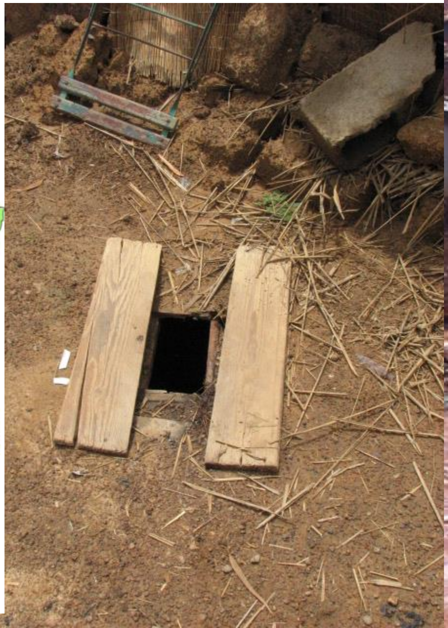
Key challenges

Lack of infrastructure – impacts supply and quality

Associated business and governance models

Equitable access



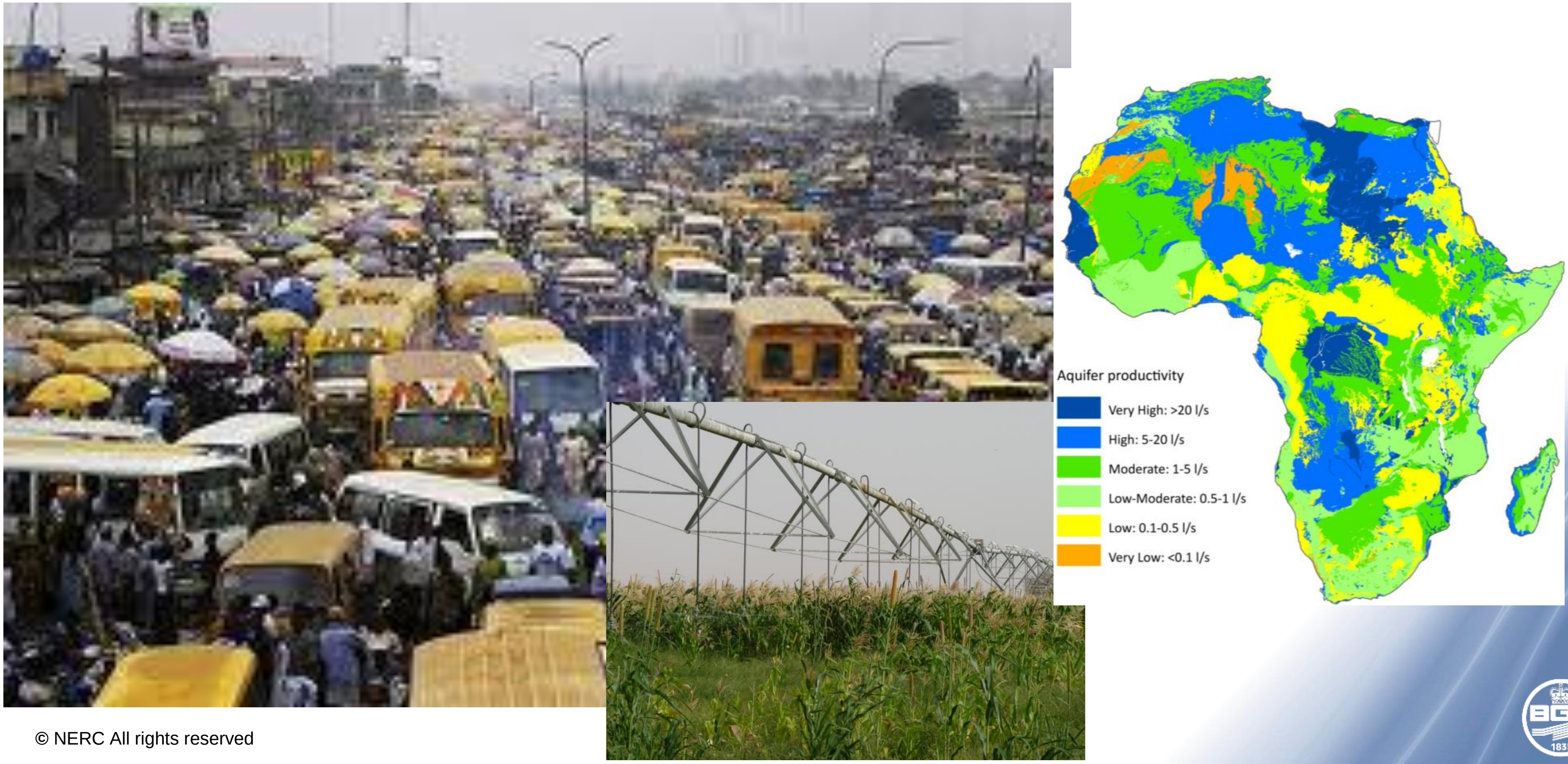


Urban-rural interface – intensity of demand for resources

Distribution of resources, intensity of demand – both for Water supply, food demands

Infrastructure needs

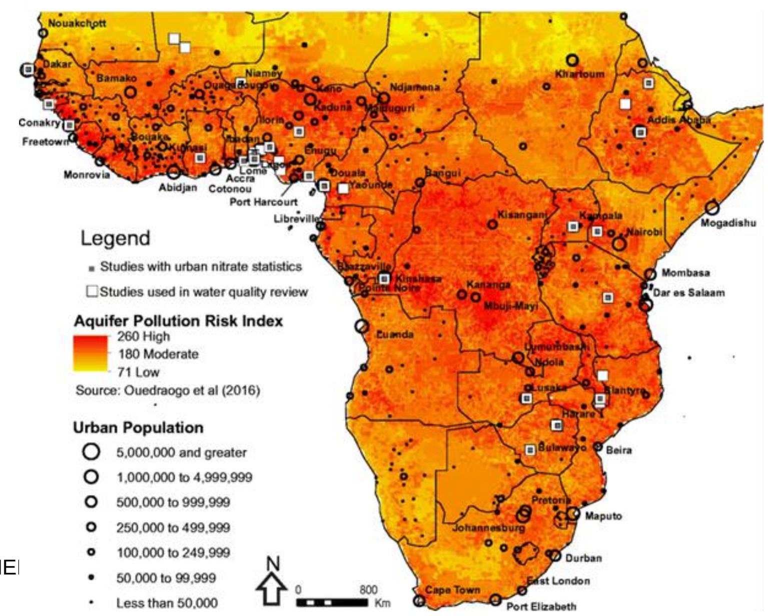
Intensity of demand which be sustained in different cities



Upstream-downstream connections

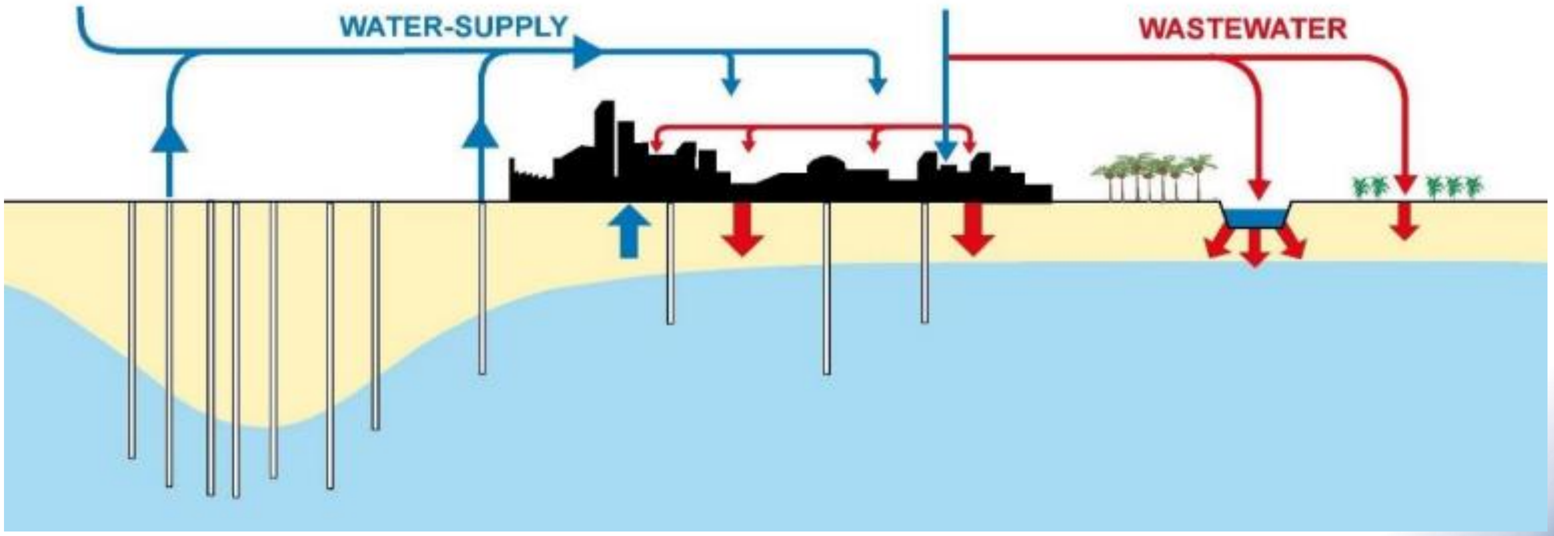
Water quality – within urban areas, and downstream – wider economic impact, health, supply

UP Gro Unlocking the Potential of Groundwater for the Poor



Upstream-downstream connections

Waste management



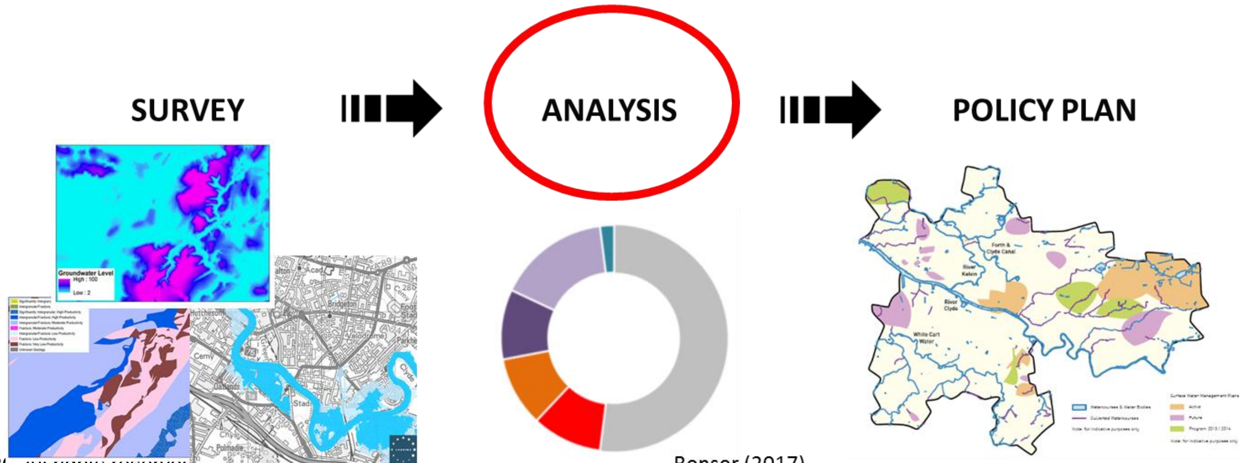
Lack of urban planning policy

Need for connected approaches across sectors

(health, water, transport, energy, economy) –

change constrained to sectors limited; transformational urban approaches

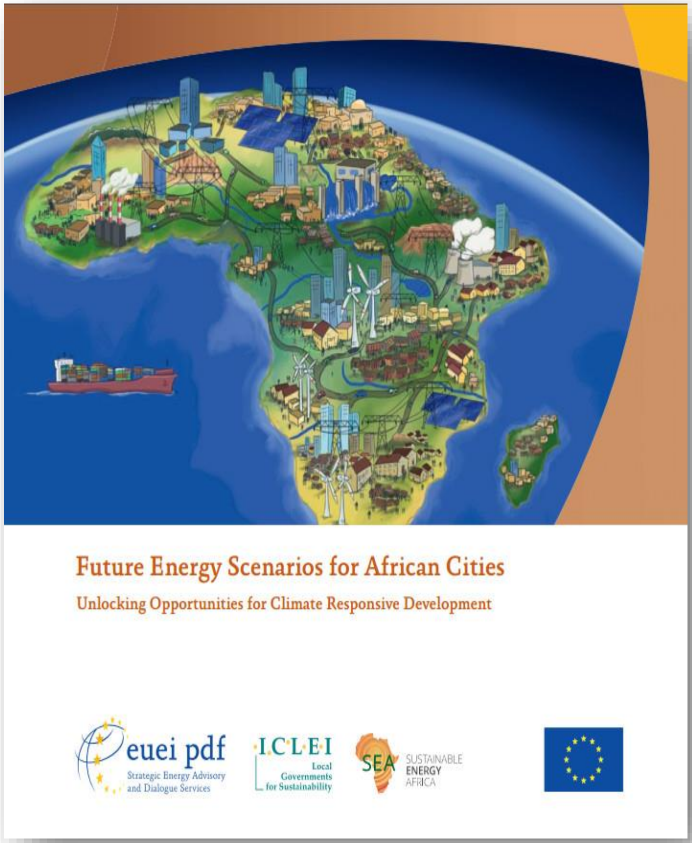
Value of inter-connected approach to increasing awareness of role GW has to play



Bonsor (2017)

Example of the significant downstream cost-benefits of inter-connected approaches & role GW has to play - Oslo

Need for connected approaches (gender, wealth, resource demands, health) **circular economies**



Role groundwater has to play

SDGs

Key role urban areas have to play in SDGs – which needs to be integrated more

Summary

Inter-connected, complex systems – which our approach needs to reflect

Key challenges –

- Lack of infrastructure
- Intensity of demand for resources vs distribution of resources – *rural urban interface*
- Water quality and waste management
- Upstream downstream connections -
- Lack of urban planning policy and cross-sectoral approaches, incentives, models

Groundwater and urban areas have key role to SDGs