Diversification of South Africa's water supplies under conditions of drought

Shafick Adams

WATER RESEARCH COMMISSION

The Water Research Commission

- Created by the Water Research Act, 1971.
- Water quantity and quality are critical to South Africa's long-term sustainability.
- Research and development have provided for the development of policies and strategies that allow for the sustainability of our water resources.
- Emphasises the important role of water-centred knowledge in the past, & its increasingly important role in providing knowledge which will allow us to deal with new challenges that are facing our limited water resources in future.
- Unique in that it is funded through a levy on sold water.

The WRC's mandate

Last amended Oct. 1996; Act highlights:

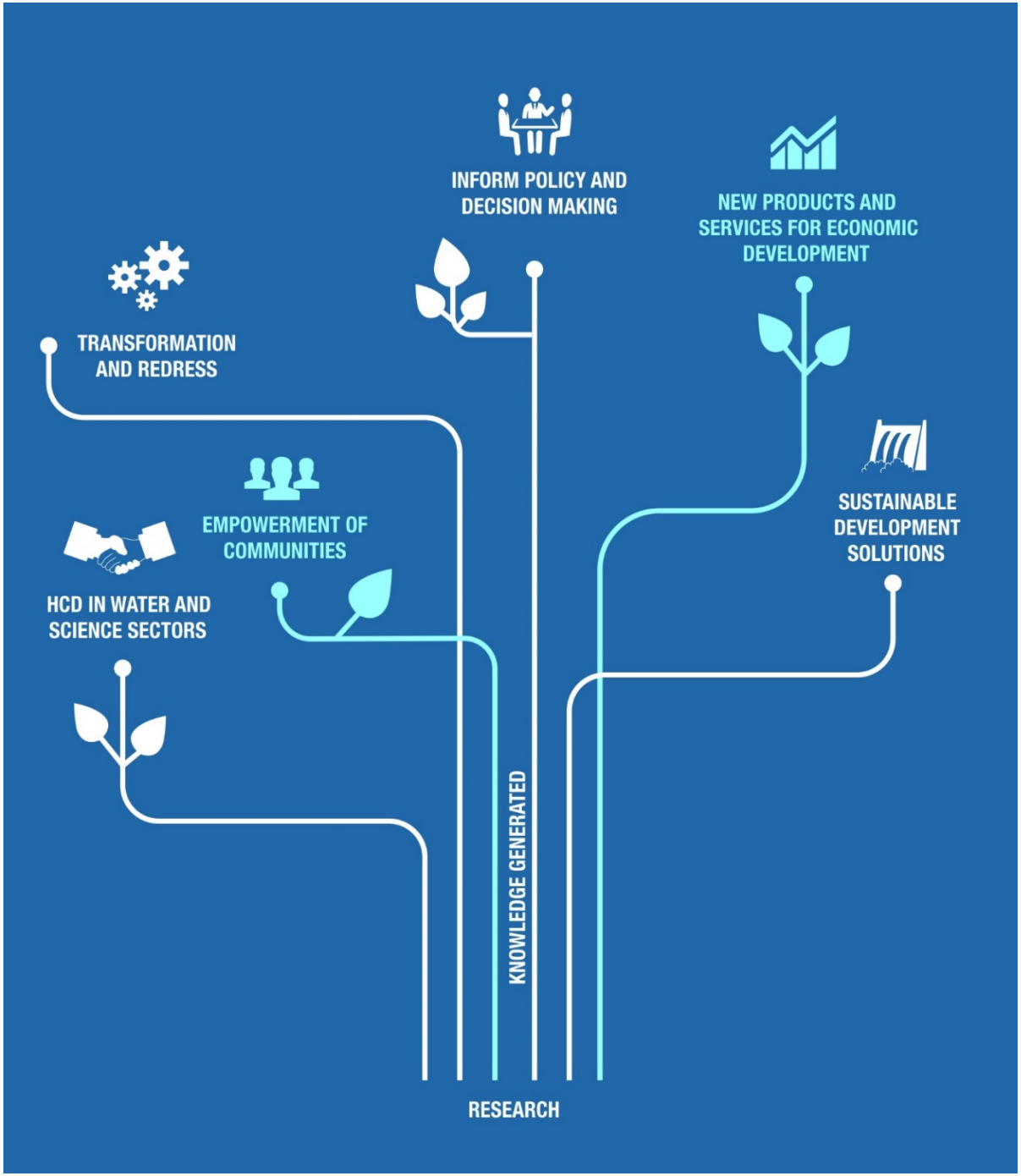
- **Promoting co-ordination, co-operation and communication in the area of water research and development.**
- **Establishing water research needs and priorities.**
- **Stimulating and funding water research according to priority.**
- **Promoting effective transfer of information and technology.**
- **Enhancing knowledge and capacity building within the water sector.**

The Water Research Commission

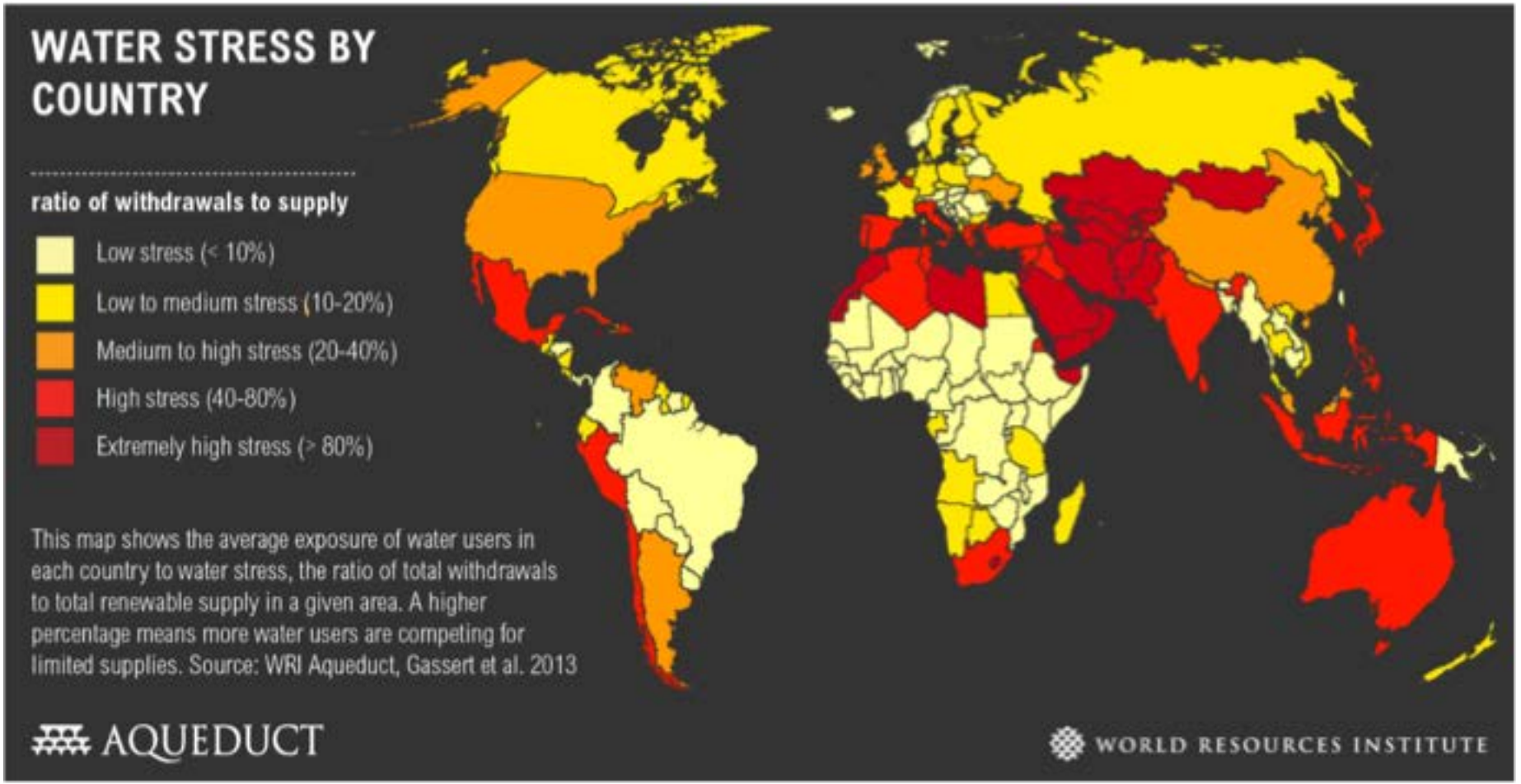
Strategic priorities

- To solve water and water-related problems which are critical to South Africa's sustainable development and economic growth, and are committed to promoting a better quality of life for all
- Fundamental research – that leads to a solution
- Applied research
- Innovations and novel solutions
- From Research Outputs to Application

Knowledge Tree

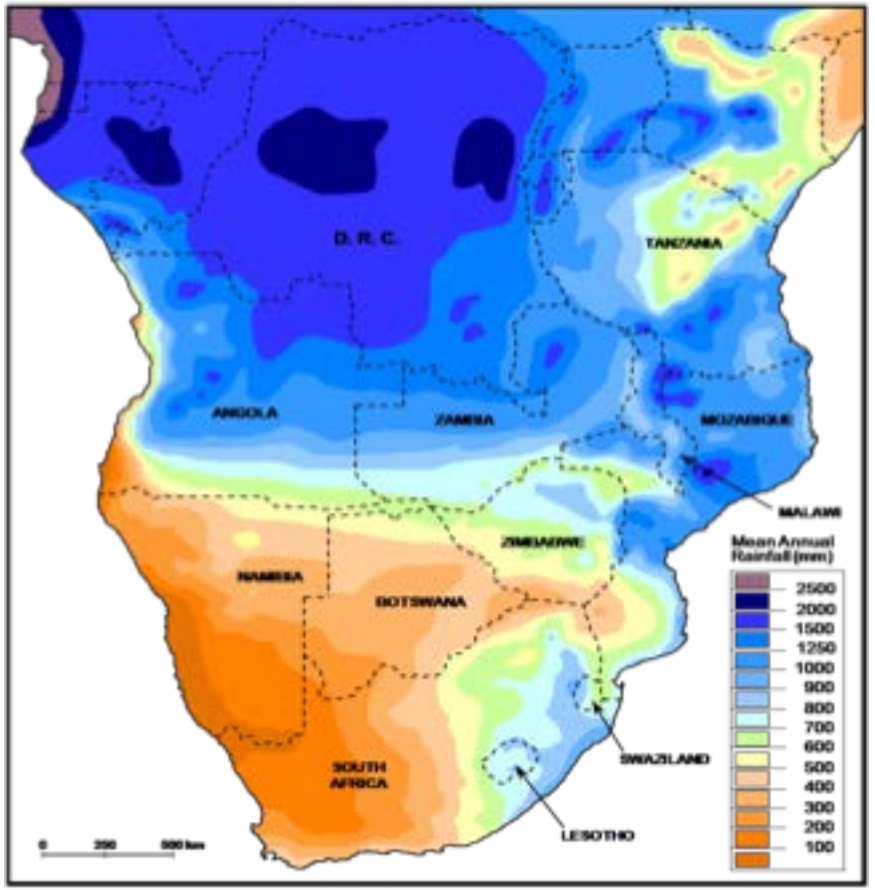


Linked by Stress



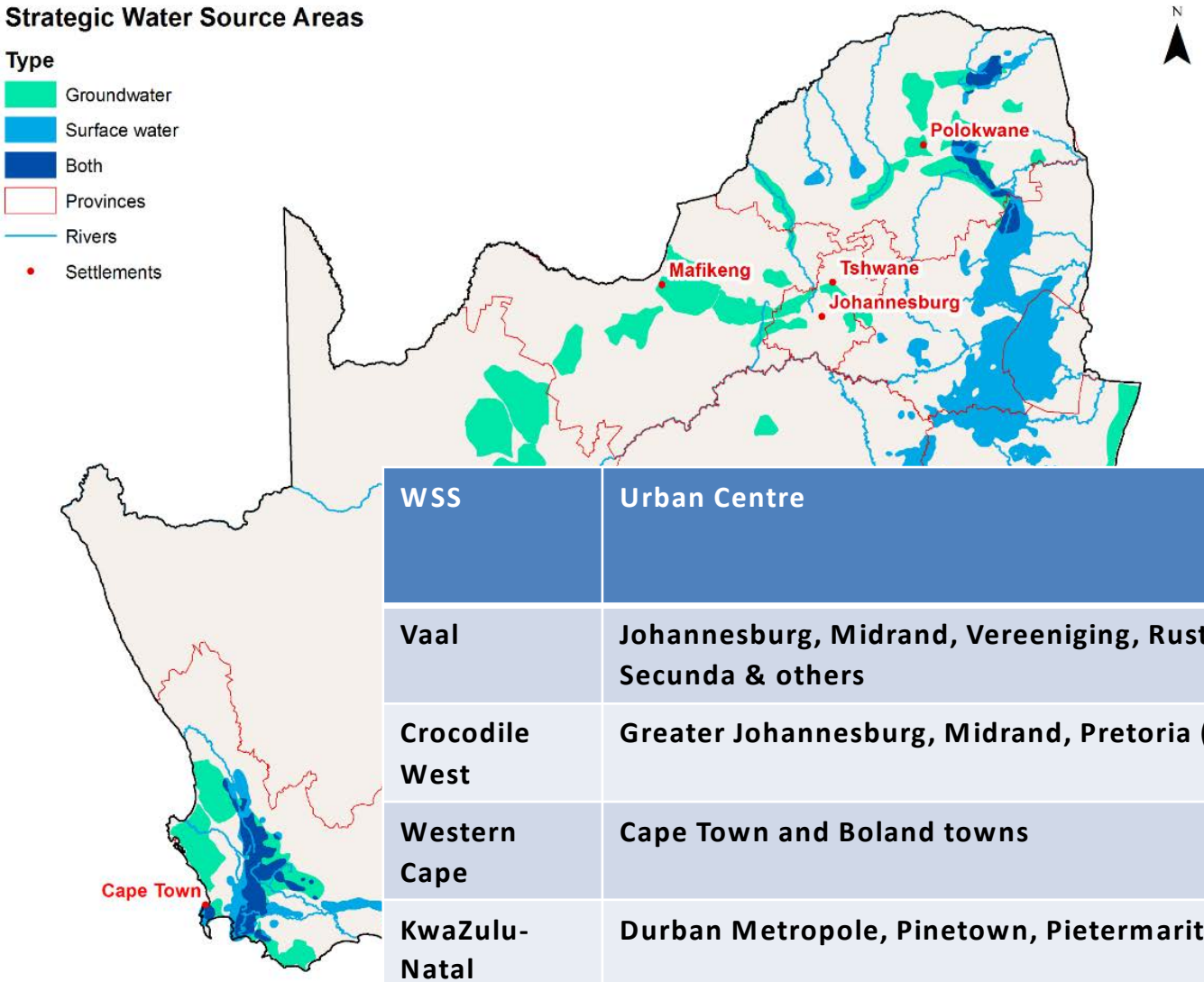
Average Annual Rainfall & Water Resource Situation

- South Africa is characterized by a skewed distribution of rainfall,
- High solar radiation and high evaporation rate
- Rainfall high: 1500mm N & E; reduces towards S & W: 100mm;
- Water availability is accordingly skewed in terms of distribution
- Evaporation rates far exceeds precipitation (relatively higher in areas where it rains less)
- Water is not always fit for use, even under natural conditions
- This translates into water scarcity (even before taking climate change or human induced impacts into account)
- Increased occurrence of extreme climate events.



WRC-UNEP, 2006

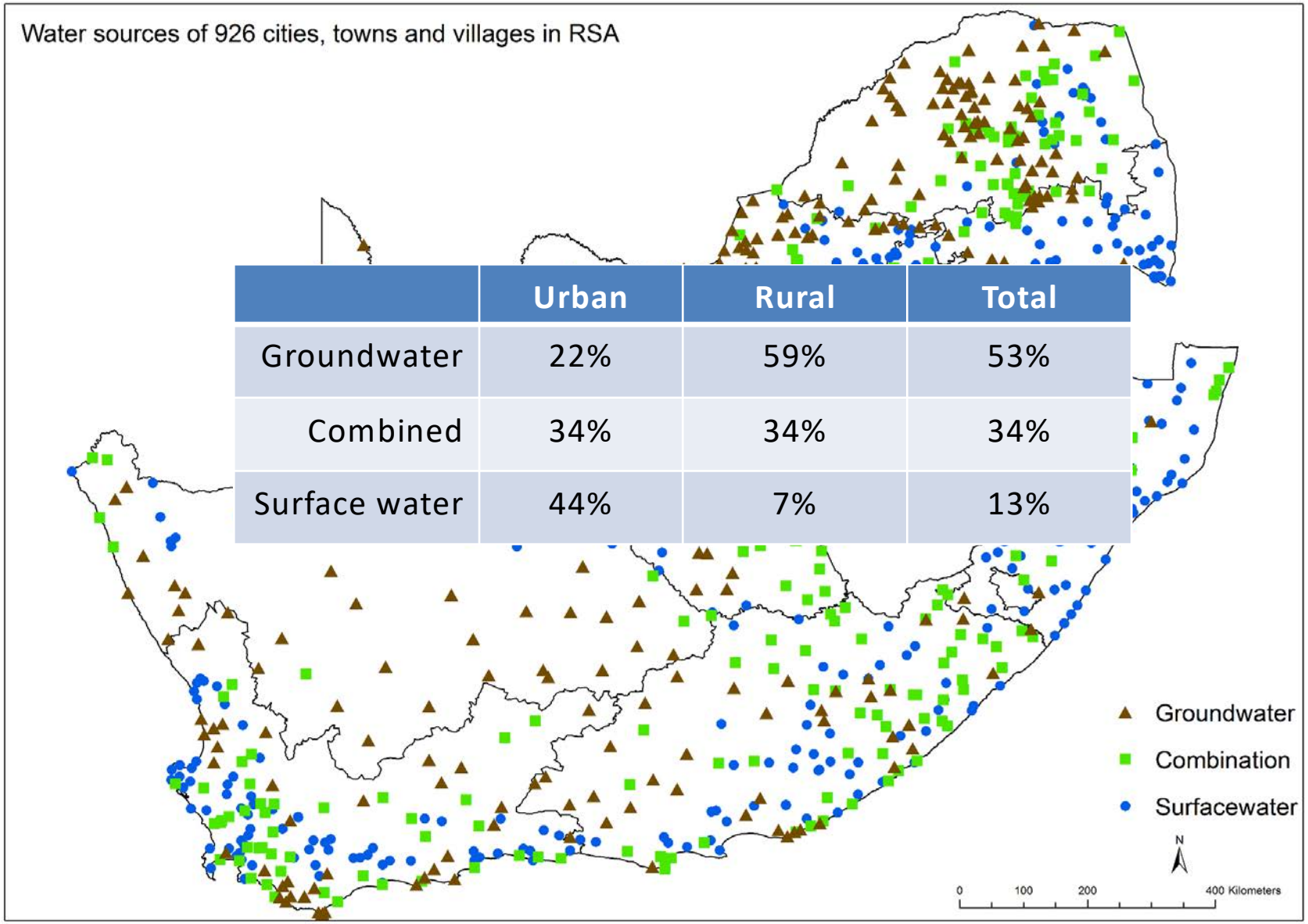
Water Source Areas



- Need to maintain ecological infrastructure
- Reduce streamflow reduction activities
- Regulate land use planning

WSS	Urban Centre	% linked to SWSA-sw
Vaal	Johannesburg, Midrand, Vereeniging, Rustenburg, Secunda & others	71
Crocodile West	Greater Johannesburg, Midrand, Pretoria (Tshwane)	>50
Western Cape	Cape Town and Boland towns	100
KwaZulu-Natal	Durban Metropole, Pinetown, Pietermaritzburg & others	98
Algoa	Nelson Mandela Metropol	91

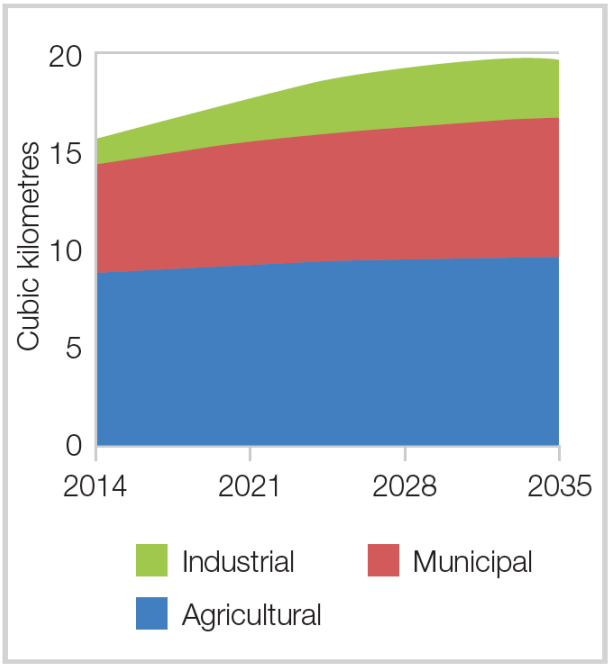
Source Water – Cities, Towns & Villages



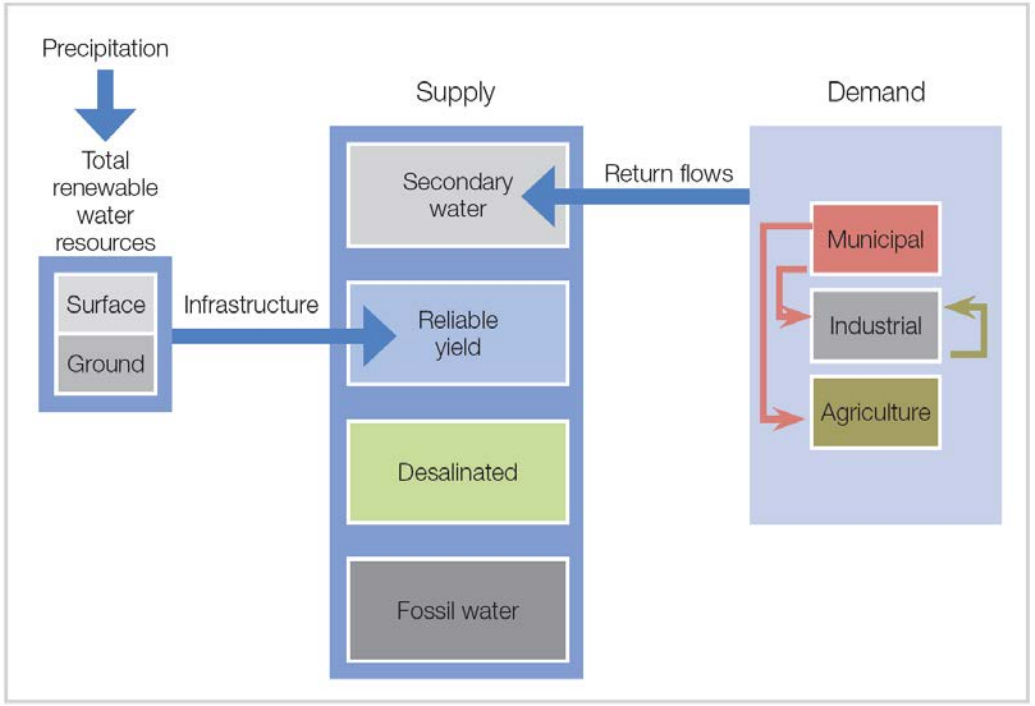
	Urban	Rural	Total
Groundwater	22%	59%	53%
Combined	34%	34%	34%
Surface water	44%	7%	13%

Supply and Demand Forecast

All forecasts indicate an increase in demand – like the International Futures Forecasting System. Data from NWRS2



Source: International Futures (IFs) version 7.0.



Institute for Security Studies

The Need for Water Supply Expansion

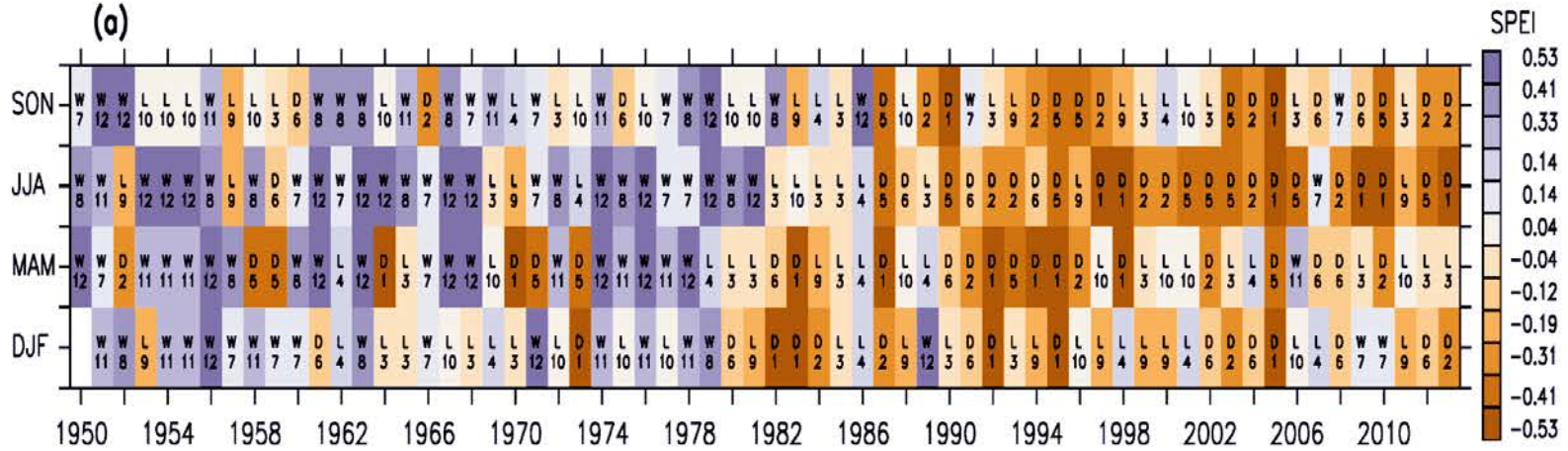
Drivers

- Semi-arid climate with low MAP of approximately 500
- Climate change and variability (frequency and intensity of droughts and floods)
- Limited water budget – 49 000 million cubic metres (WR2012 report)
- Limited storage
- Ever-growing demand for a limited water resource (agriculture, industry, domestic, …)
- Population growth
- Inefficient use
- Urbanisation [65% of SA population live in urban areas
- Wastewater generation
- Water quality issues
- Siltation of dams
- Optimal sites for dams all developed
- Donor catchment for inter-basin transfer (IBT) experience own demand
- Food and energy security

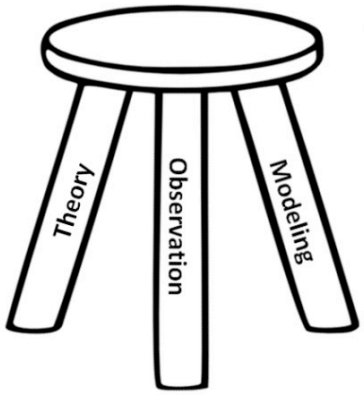
20th Century response

1. Government Water Policy driven by the construction of large dams, inter-basin transfer (IBT) schemes to store water.
2. Augmentation of dam storage (raising the height of existing dam)
3. Unsustainable exploitation of groundwater in some areas

Transition and Persistence of the Drought



- **Seasonal transition of the drought patterns from year to year.**
- **The colours indicate the average SPEI over Southern Africa. The number in each colour shows drought tag number.**
- **The figure shows that while some drought patterns easily transit to other drought patterns, others can persist and linger for more than two seasons.**

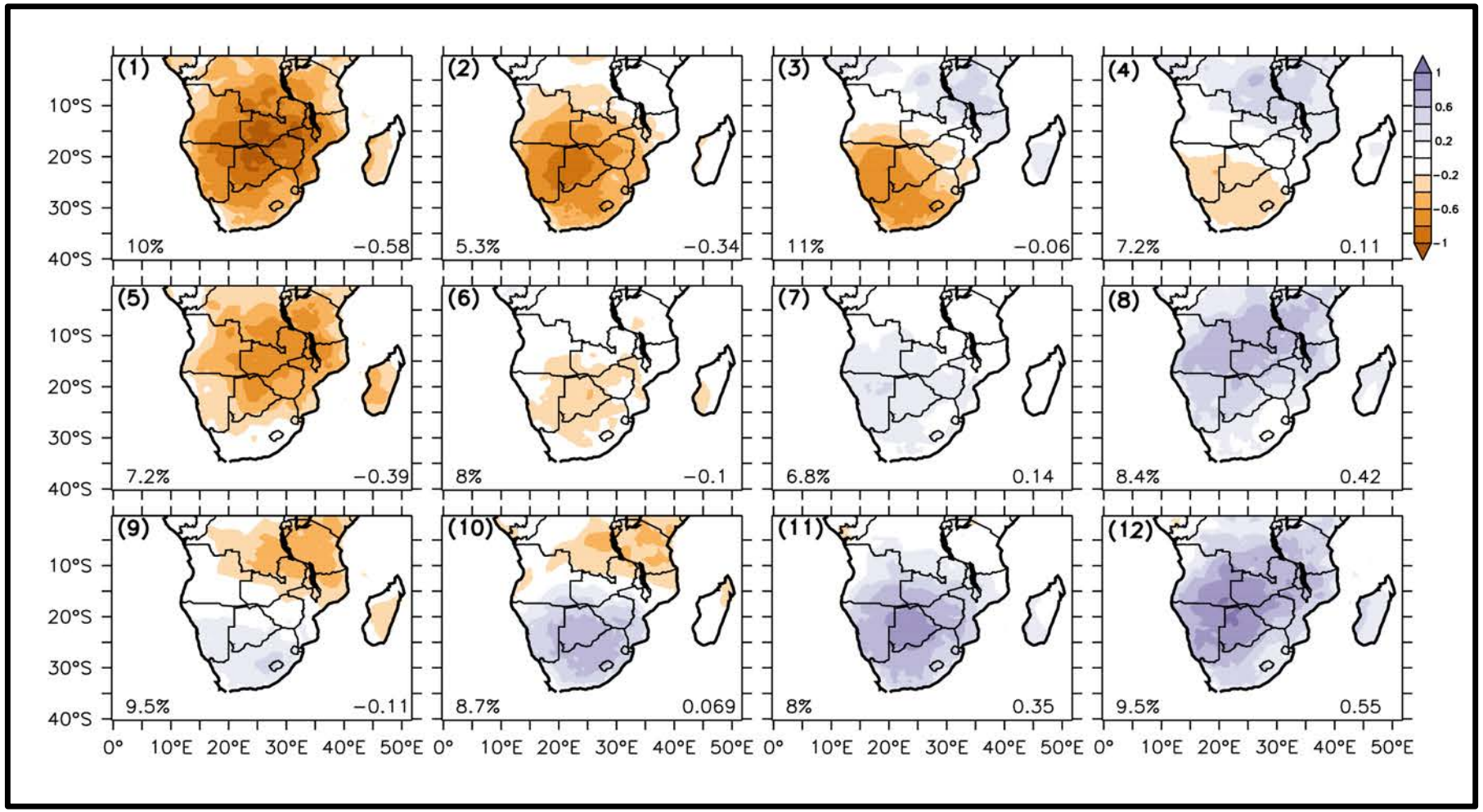


= Indicate that climate and weather is changing AND HAS CHANGED

Theory provide a reason to expect a change. Observations confirm that a change is taking place and computational modelling determine whether the observations reconcile with the theory and, if so, to project future changes.

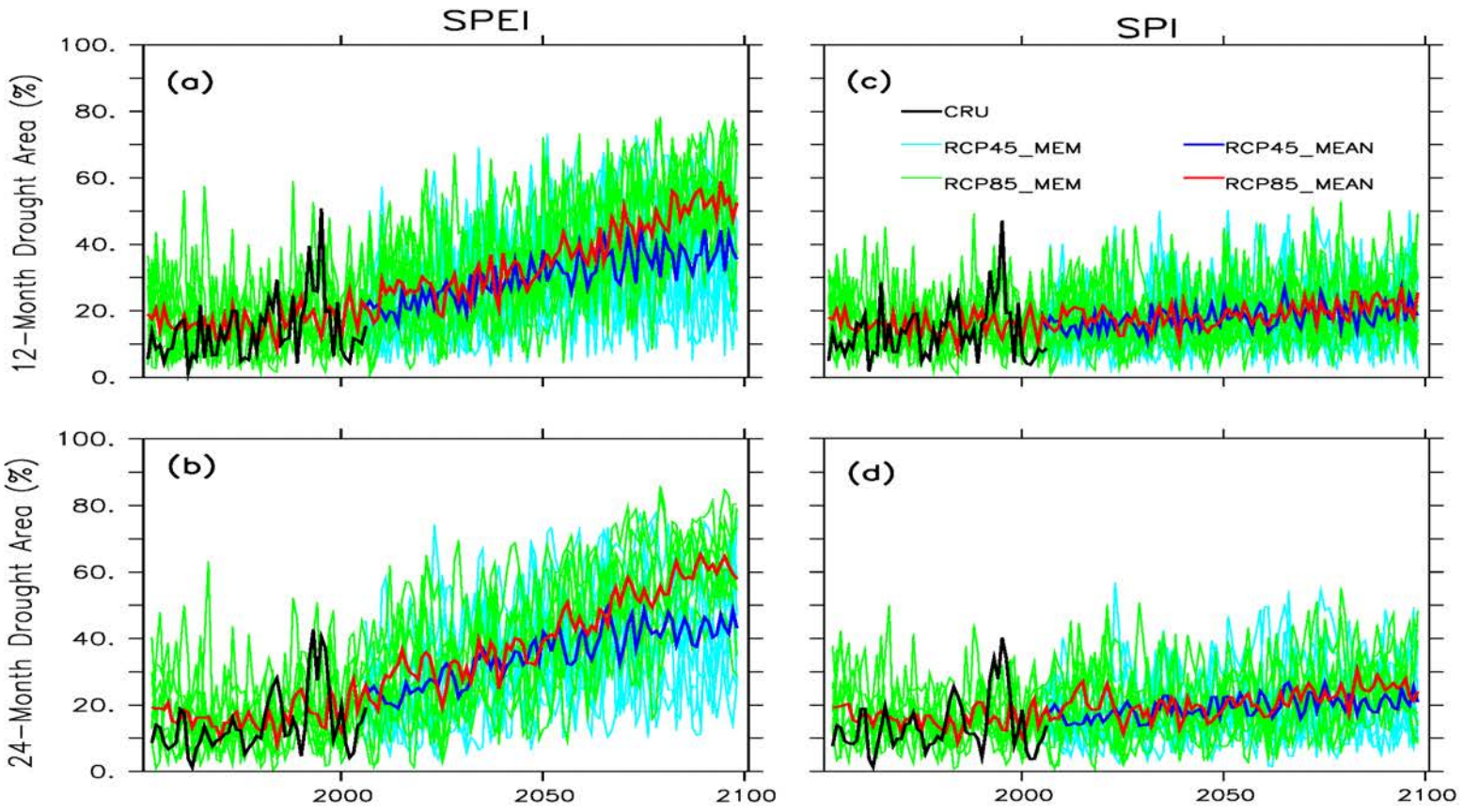
Source: Huber & Gulledge (2011)

Major Drought Patterns over Southern Africa

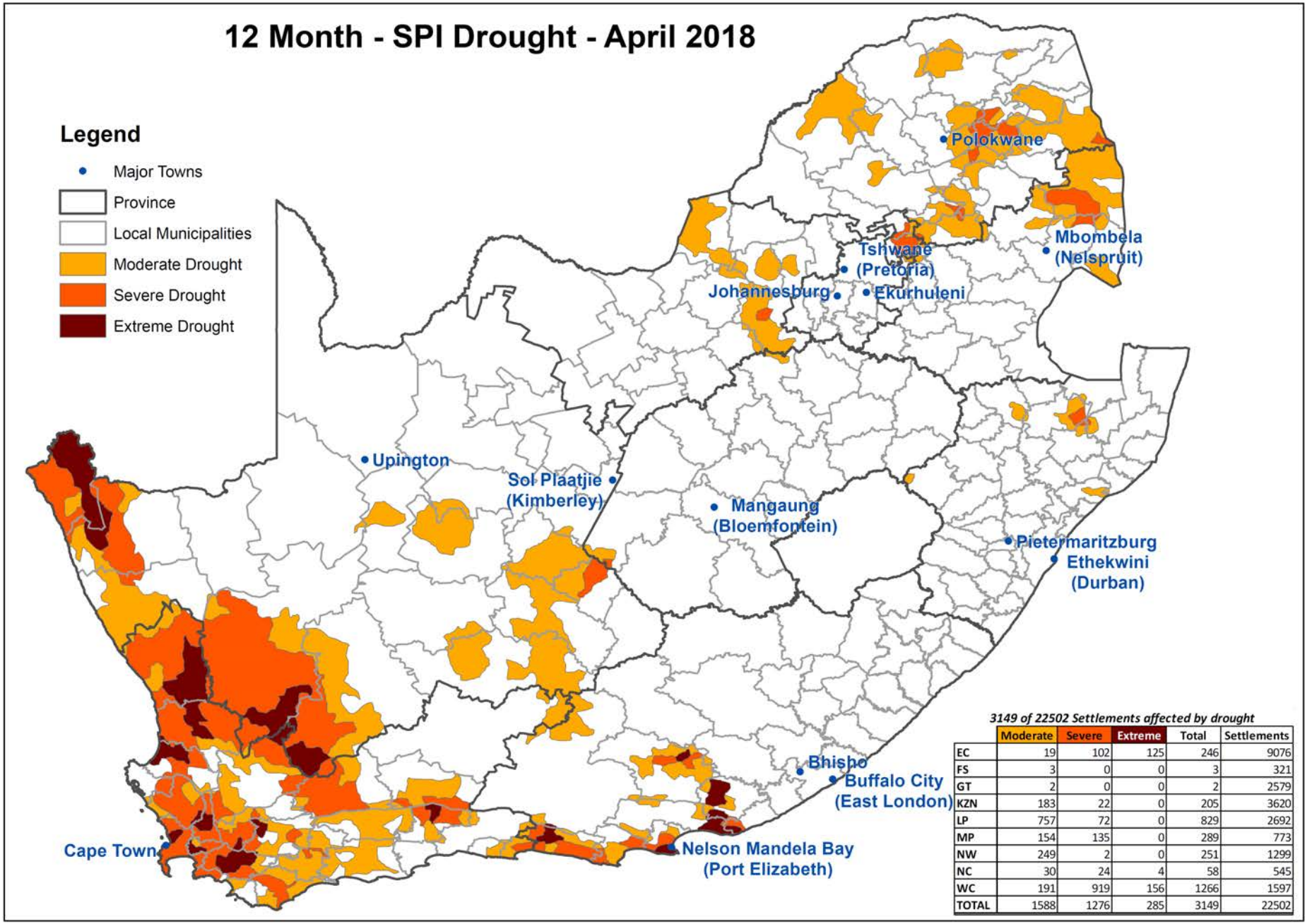


WRC Project: K5/2317, B Abiodun UCT

Future projections of percentage of Southern African area covered with drought



12 Month - SPI Drought - April 2018



3149 of 22502 Settlements affected by drought

	Moderate	Severe	Extreme	Total	Settlements
EC	19	102	125	246	9076
FS	3	0	0	3	321
GT	2	0	0	2	2579
KZN	183	22	0	205	3620
LP	757	72	0	829	2692
MP	154	135	0	289	773
NW	249	2	0	251	1299
NC	30	24	4	58	545
WC	191	919	156	1266	1597
TOTAL	1588	1276	285	3149	22502

DWS, NIWIS

Areas affected by the drought … not all about Cape Town

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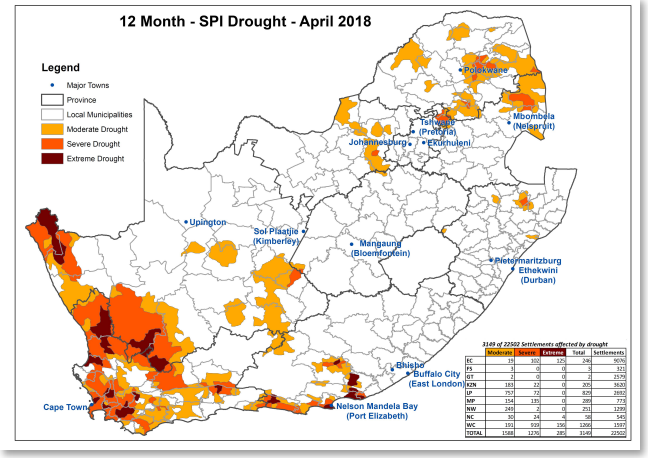
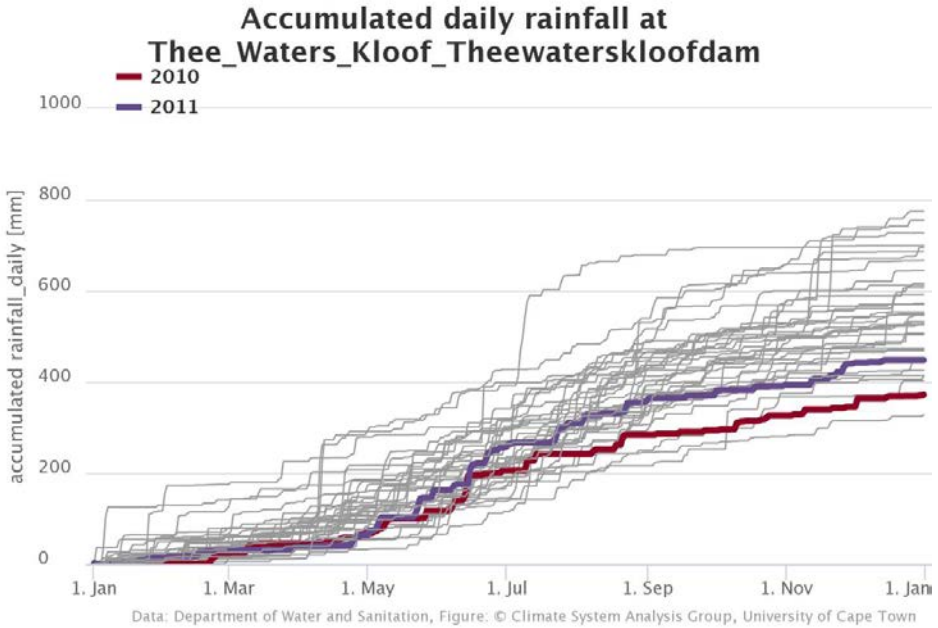
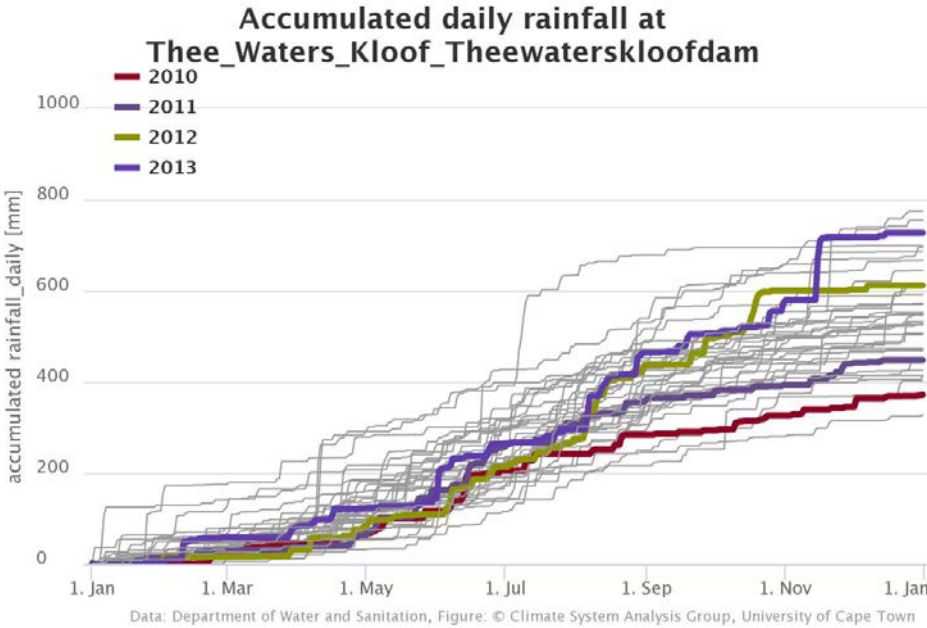
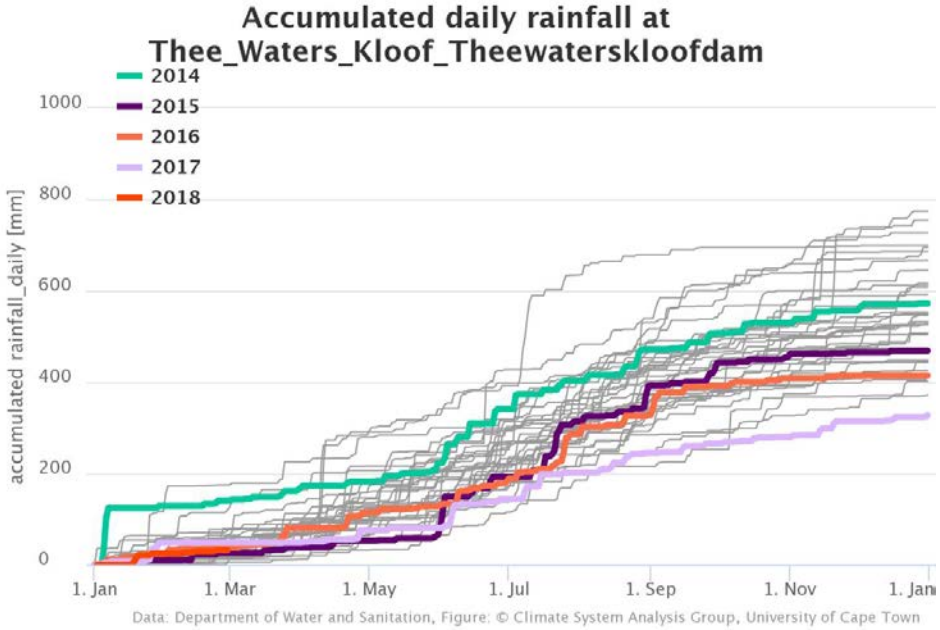


Water insecurity largely persists across rural areas

Source: DWS, NIWIS





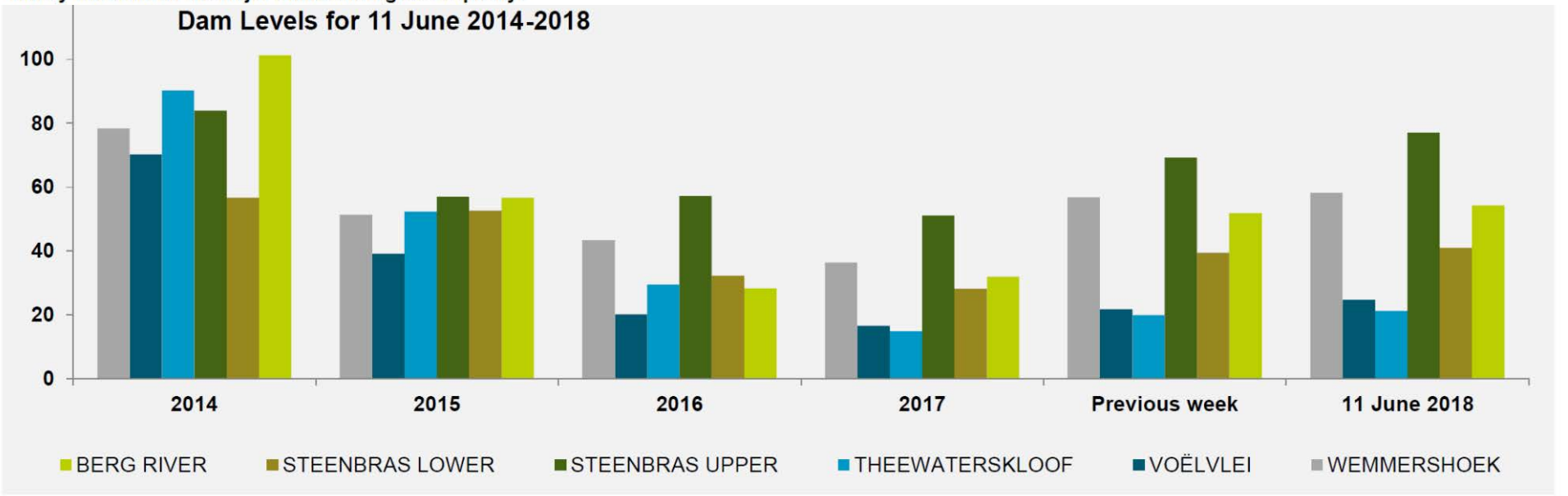


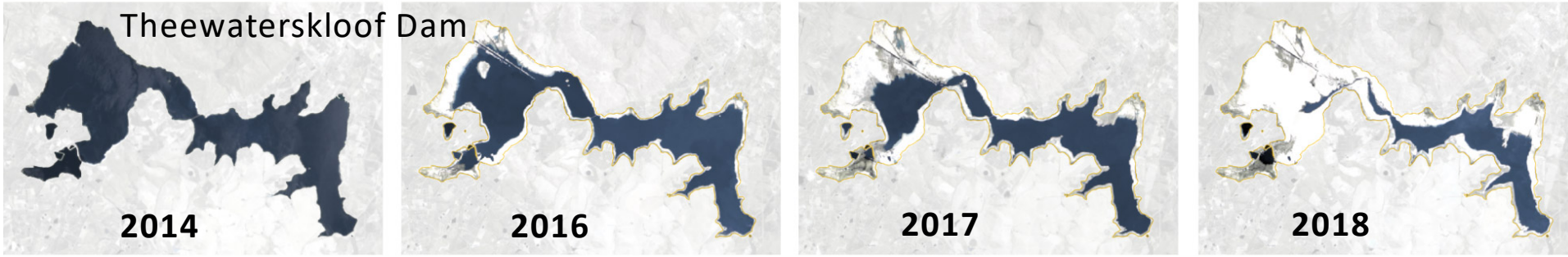
(www.csag.uct.ac.za/current-seasons-rainfall-in-cape-town/)

MAJOR DAMS	STORAGE						
	CAPACITY	%	%	%	%	%	%
	Ml	11 June 2018	Previous week	2017	2016	2015	2014
BERG RIVER	130 010	54.3	51.8	31.9	28.3	56.6	101.3
STEENBRAS LOWER	33 517	40.9	39.5	28.2	32.3	52.7	56.6
STEENBRAS UPPER	31 767	77.0	69.2	51.2	57.2	57.0	84.0
THEEWATERSKLOOF	480 188	21.3	20.0	14.9	29.5	52.3	90.2
VOËLVLEI	164 095	24.8	21.8	16.7	20.1	39.2	70.2
WEMMERSHOEK	58 644	58.2	56.8	36.4	43.3	51.4	78.4
TOTAL STORED	898 221	285 651	267 501	187 424	265 813	455 038	771 722
% STORAGE		31.8	29.8	20.9	29.6	50.7	85.9

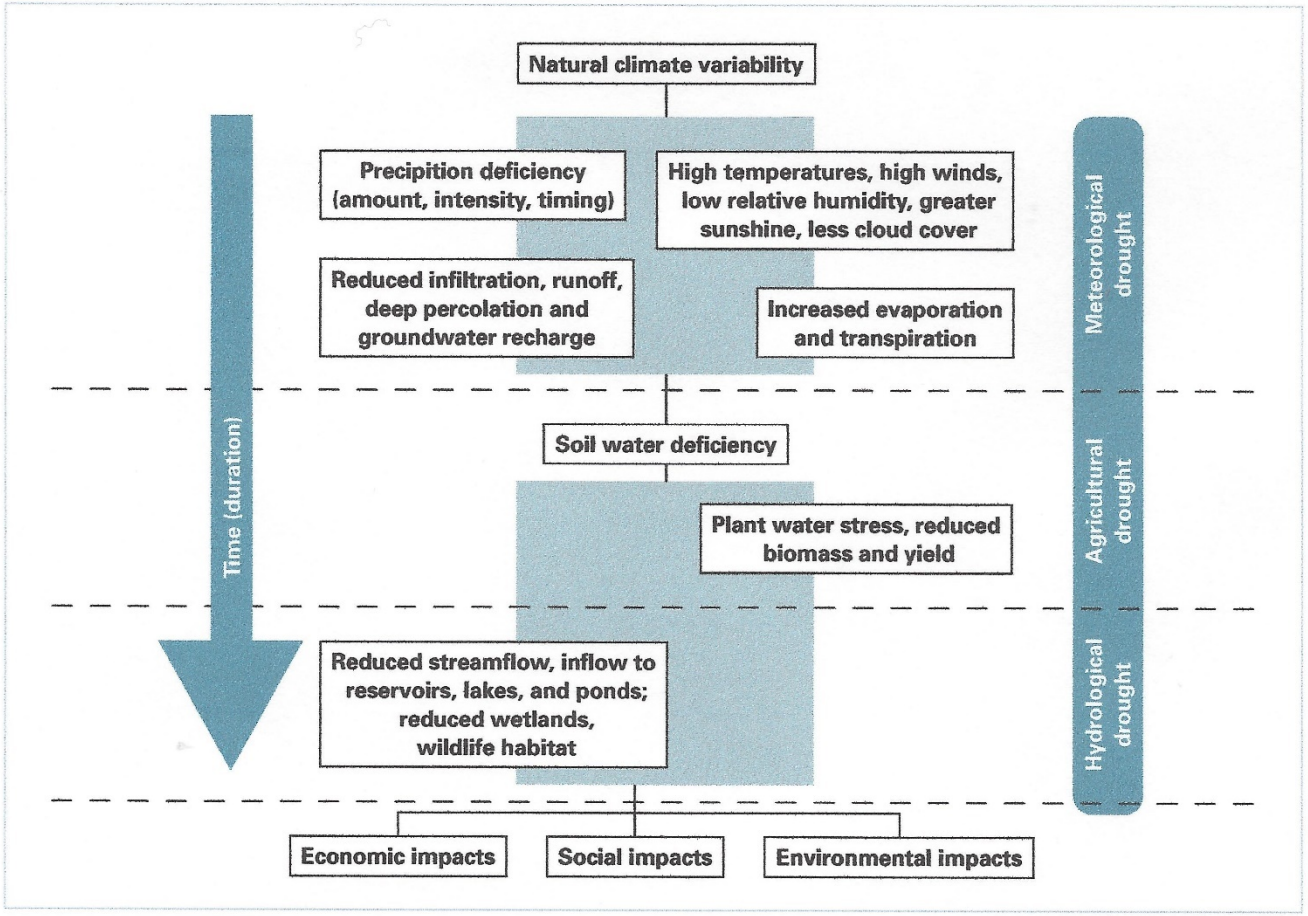
NOTES:

1) Capacity of the major dams of the Western Cape Water Supply System is 99.6% and that of the minor dams 0.4% of the combined capacity of the major and minor dams. Kindly note that all the Major Dams show gross capacity.





Understanding droughts



Source: National Drought Mitigation Center, University of Nebraska – Lincoln, USA, in WMO, 2006

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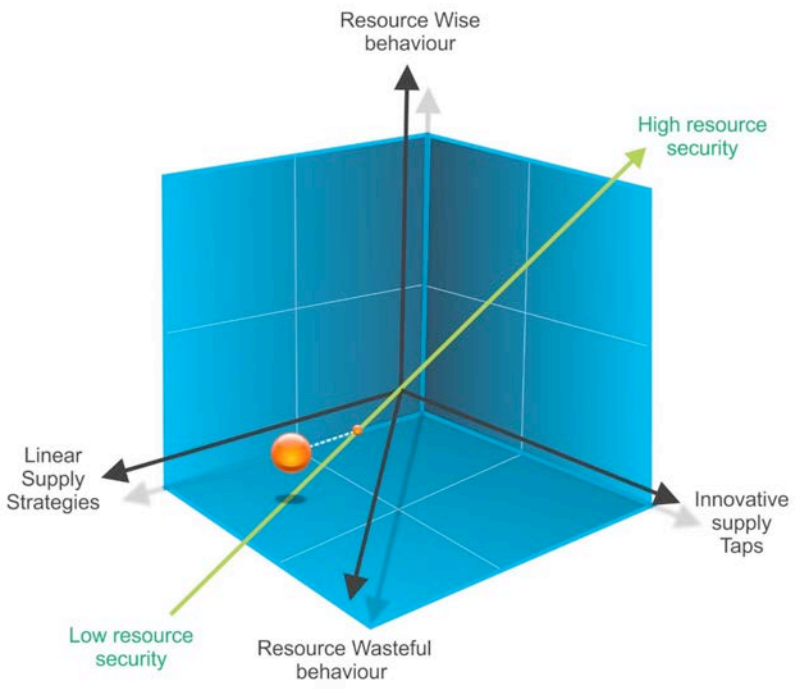
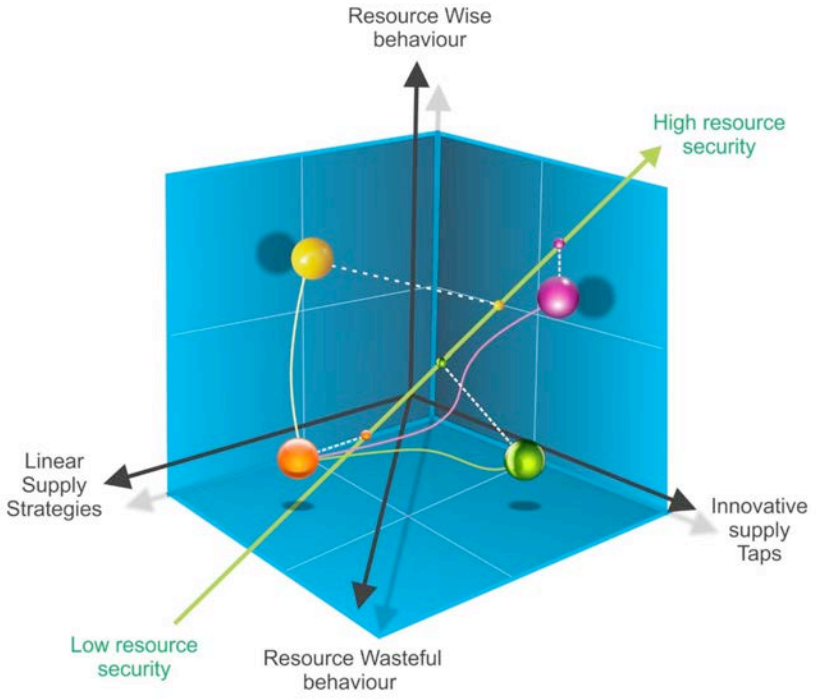
Access to water supply services "drought"

Path to water security





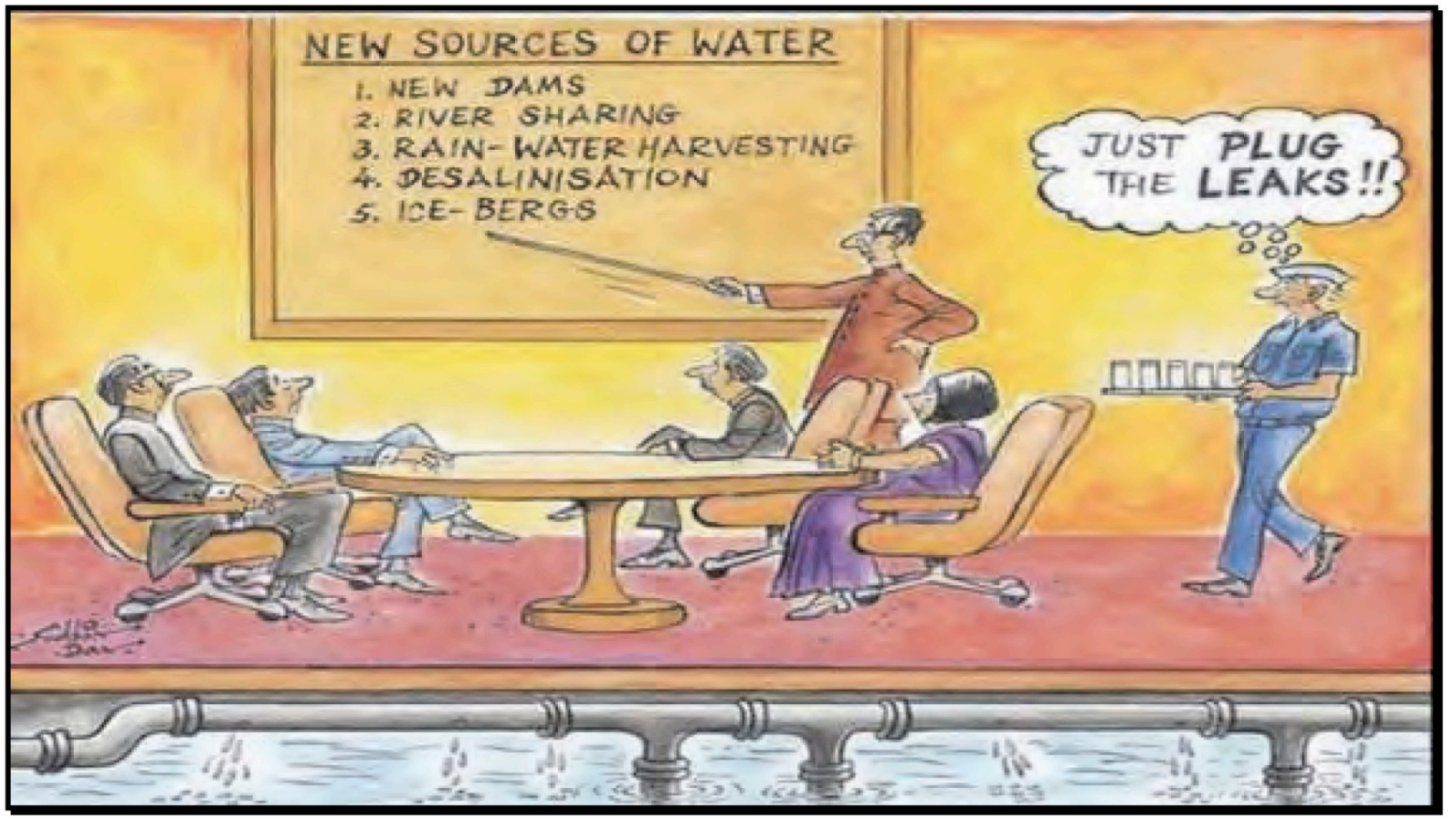


Figure 4: Fix the obvious! (Courtesy World Bank: Water and Sanitation Sector)

Diversifying Supply Mix

Several sources of alternative water resources:

1. **Desalination (seawater, brackish groundwater)**
2. **Rain water (harvested from roofs and in-field for agriculture)**
3. **Groundwater (enhanced recharge, deep groundwater)**
4. **Greywater (direct and indirect reuse)**
5. **Storm water (harvested and stored in detention reservoirs, recharged to aquifers)**
6. **Mine water (acid mine drainage, non-impacted, decant)**
7. **Waste water (direct and indirect reuse)**
8. **Fog (harvested using fog nets)**
9. **Cloud seeding to enhance rainfall**
10. **Icebergs**

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Improved prediction of climate and hydrological responses

+

A. **Water sensitive design**
B. **Water wise use & behaviours**
C. **Water Conservation and Demand Management (water saving devices, toilets, etc.)**
D. **Efficient agricultural practices**
E. **Enforcement of bylaws and regulations**
F. **Good land use planning**

= Water – Food – Energy – Environmental - Economic Security

Identifying “new” sources

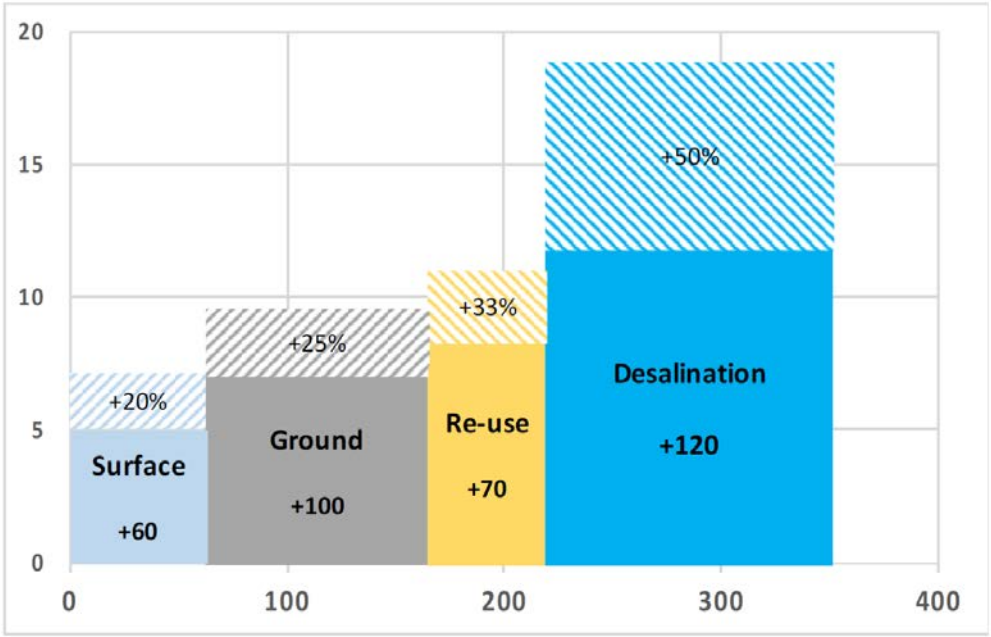
Direct potable reuse

Windhoek, Namibia

Unit Costs – Cape Town

Source	Target yield MLD	Notes
Ground	100	More could be abstracted from ground water sources in dry years.
Re-use	70	One large re-use reclamation plant (economies of scale)
Desalination	120	Optimal scale for desalination is 120-150 MLD
Surface water	60	Lower Berg River Voelvlei Augmentation scheme
Total (diverse sources)	**350**	

Target Unit Costs and uncertainty (Rand per thousand liters)



Additional supply - Million liters per day (MLD)

5 ZAR/1000 litres = USD 0.4/264.2 gallons

Source: City of Cape Town

Overview of Groundwater in South Africa

- 13-15 % of water supplied is from groundwater.
- 60% of communities supplied by groundwater and increases to 90% for some provinces.
- Total volume of available renewable groundwater is estimated to be between 10 343 million m^3/annum (7 500 million m^3/annum under drought conditions).
- Current use is estimated between 2 000 – 4 000 million m^3/annum.
- Prior to 1998 – Groundwater was considered 'Private' and did not feature prominently in any water resources planning.
- Current act – State is the custodian = 'Public' water and Prescribes the use of the principles of IWRM.
- Groundwater Strategy > National Water Resources Strategy

Groundwater Status Quo

Groundwater schemes fail because:

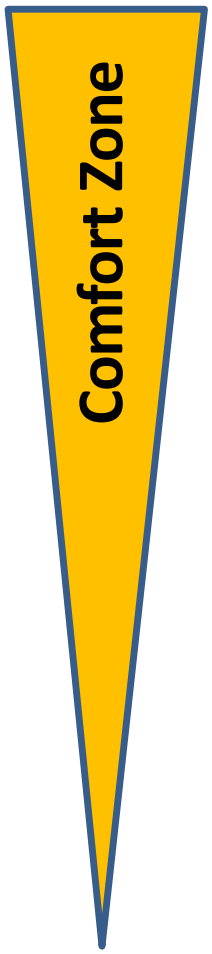
- **Lack of infrastructure maintenance, lack of monitoring**
- **Lack of buy-in, institutional support**
- **Funding models**

Related to institutional capacity

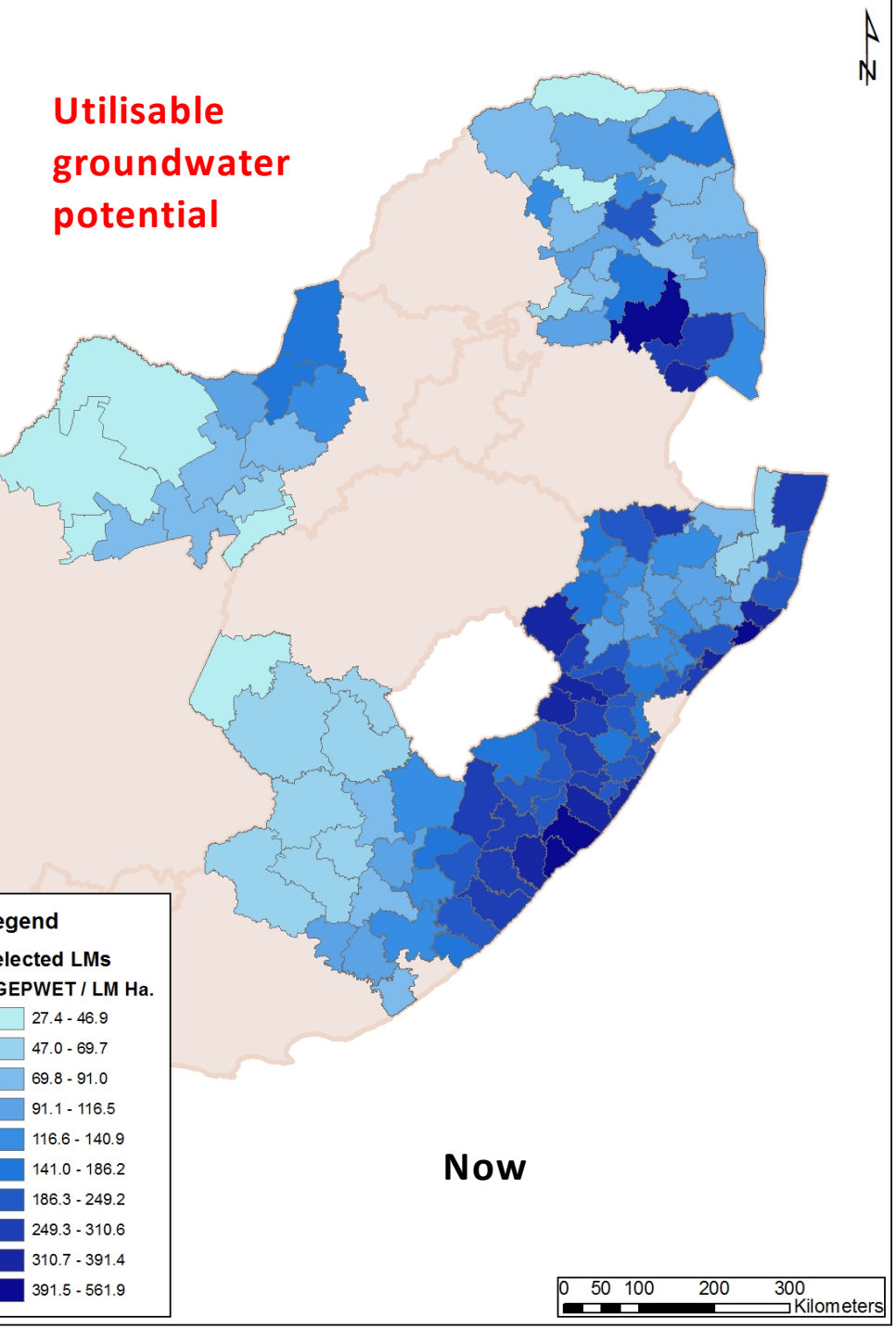
- **Borehole yields conflated with wellfield yields, in turn conflated with aquifer yields**
- **Poorly defined impacts of use**
- **Aquifer assessment lags (too far) behind infrastructure development**
- **Groundwater yields may be under-estimated because of application of the water balance method**

Related to technical challenges

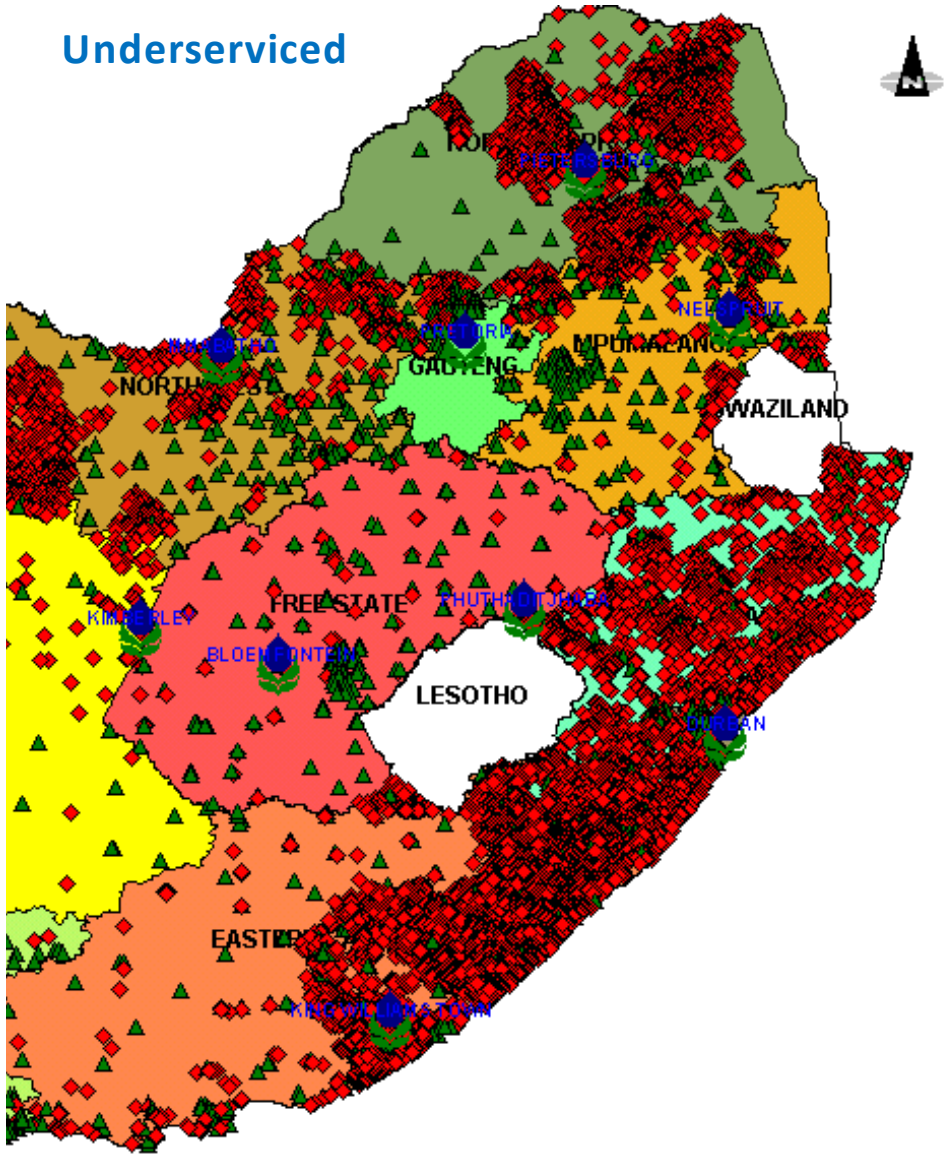
Issues – a Complex Problem



- **Technical / hydrogeological dimension** (distribution of K/T, aquifer types, groundwater quality, recharge variability, sustainability of the resource, etc)
- **Technical / engineering dimension** (existing O&M arrangements, engineering challenges, pump selections, protection zones, electricity vs diesel, etc)
- **Organisational, Economic, Social, Political dimensions** (available skills, systems for O&M, compliance monitoring, OPEX v CAPEX, reluctance to use alternative sources, cost recovery, political priorities, theft and vandalism, financial auditing, business models, organisational models, etc)
- **Emerging issues**


Utilisable groundwater potential
N
egend
elected LMs
GEPWET / LM Ha.
27.4 - 46.9
47.0 - 69.7
69.8 - 91.0
91.1 - 116.5
116.6 - 140.9
141.0 - 186.2
186.3 - 249.2
249.3 - 310.6
310.7 - 391.4
391.5 - 561.9
0 50 100 200 300
Kilometers

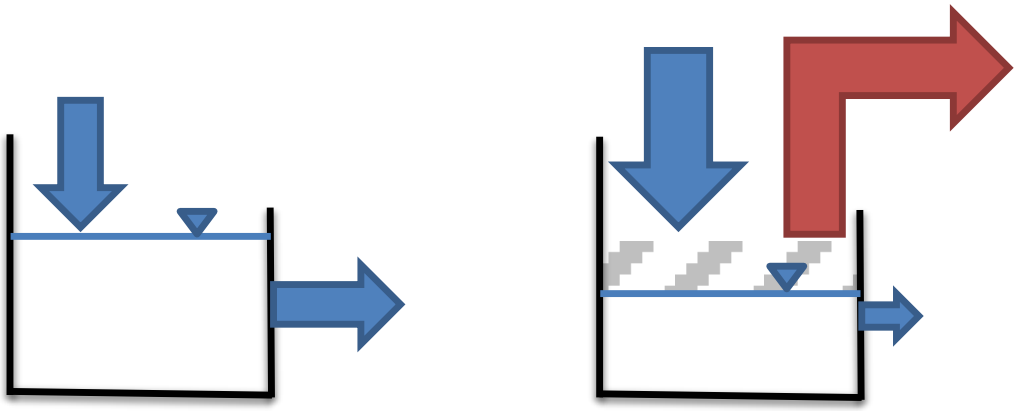
Now


Underserviced
GAUTENG
WAZILAND
FREE STATE
LESOTHO

1994

Stretching what we have

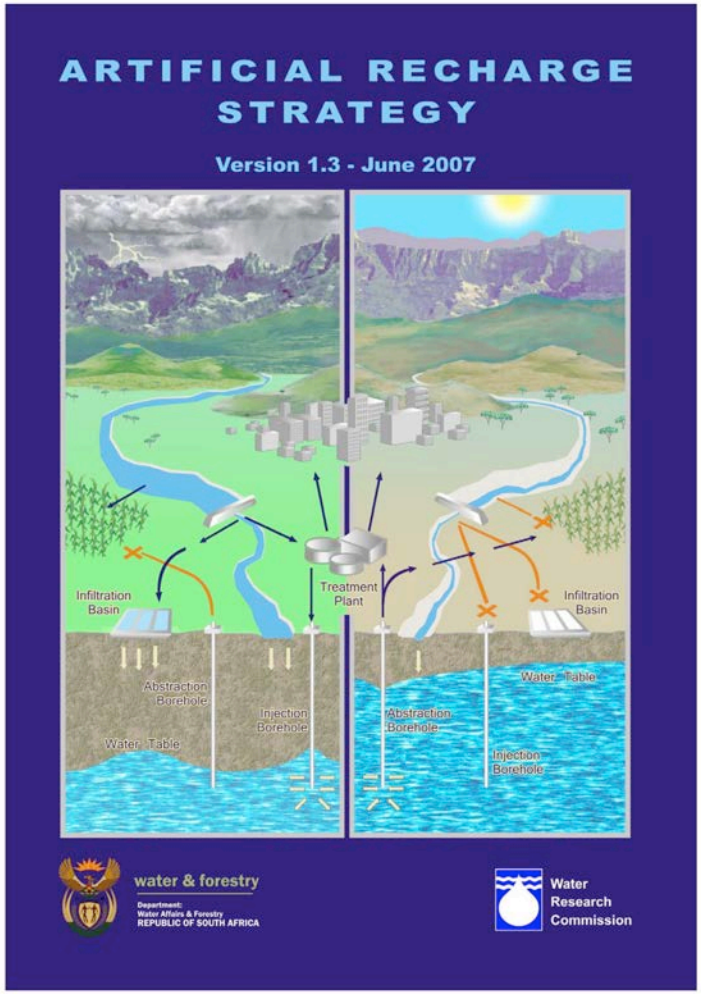
Capture Principle

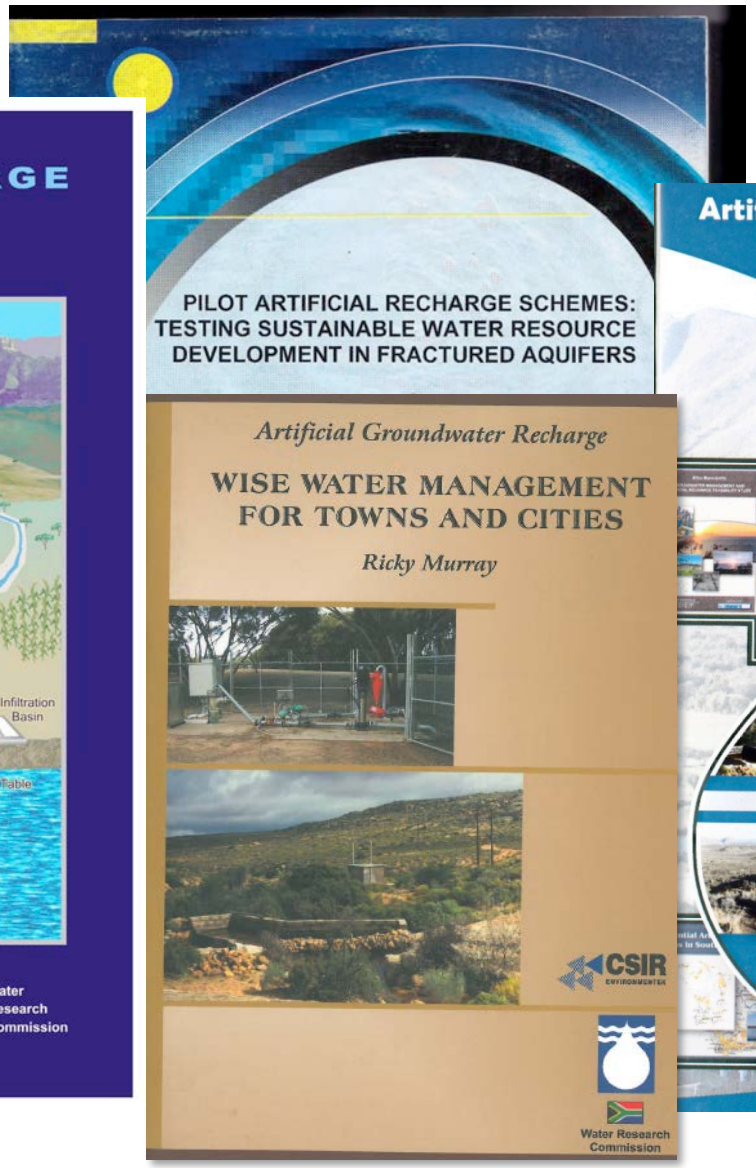


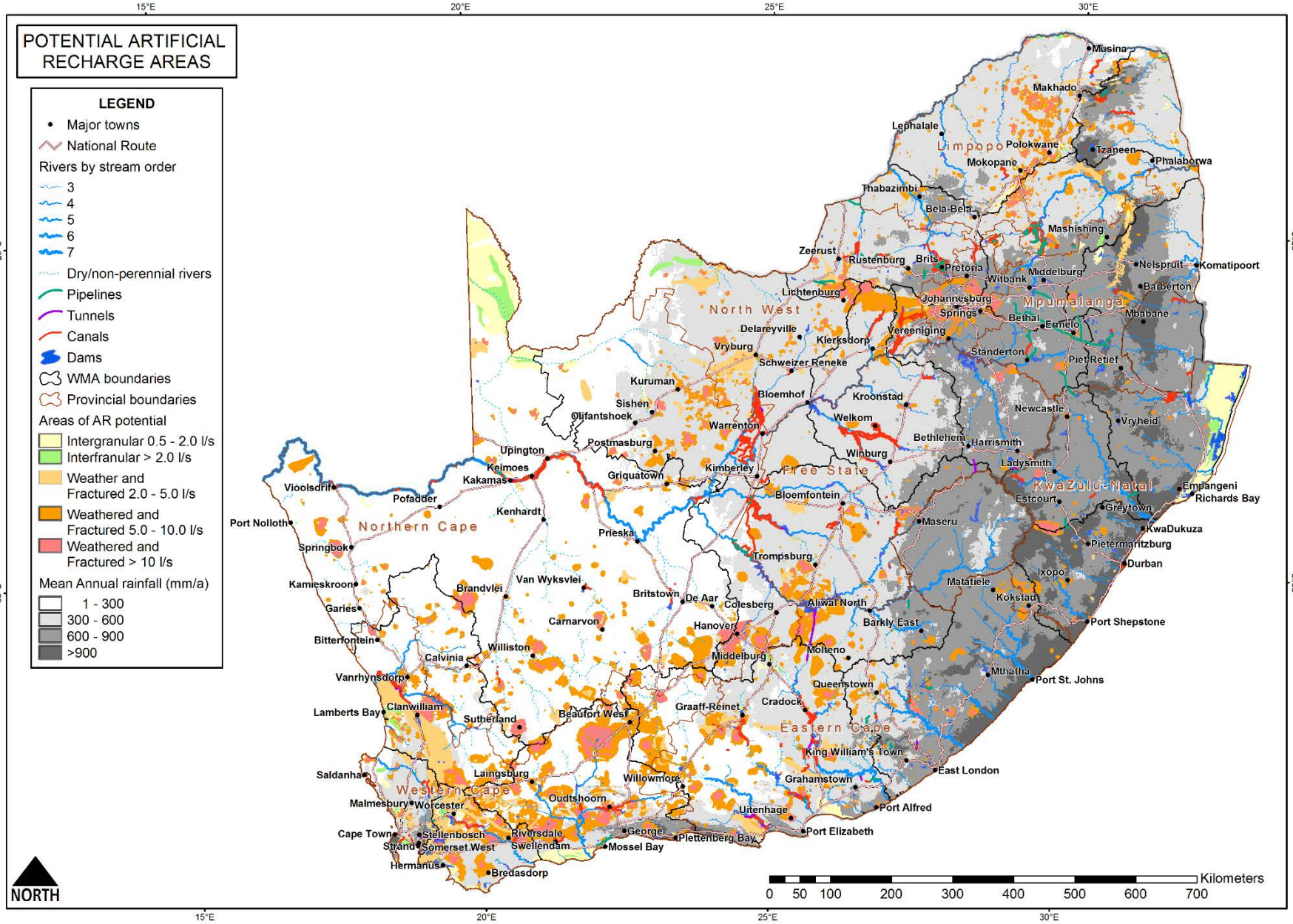
- Natural state: recharge & discharge dynamic equilibrium
- Pumping: abstracted water met by reduced discharge &/ enhanced recharge, & storage is reduced
- Maintainable aquifer yield: can be maintained indefinitely without continually depleting storage, met by reduced discharge &/ enhanced recharge, in a new dynamic equilibrium.
- Response time: time to new dynamic equilibrium

Stretching what we have

Managed Aquifer Recharge or Water Banking



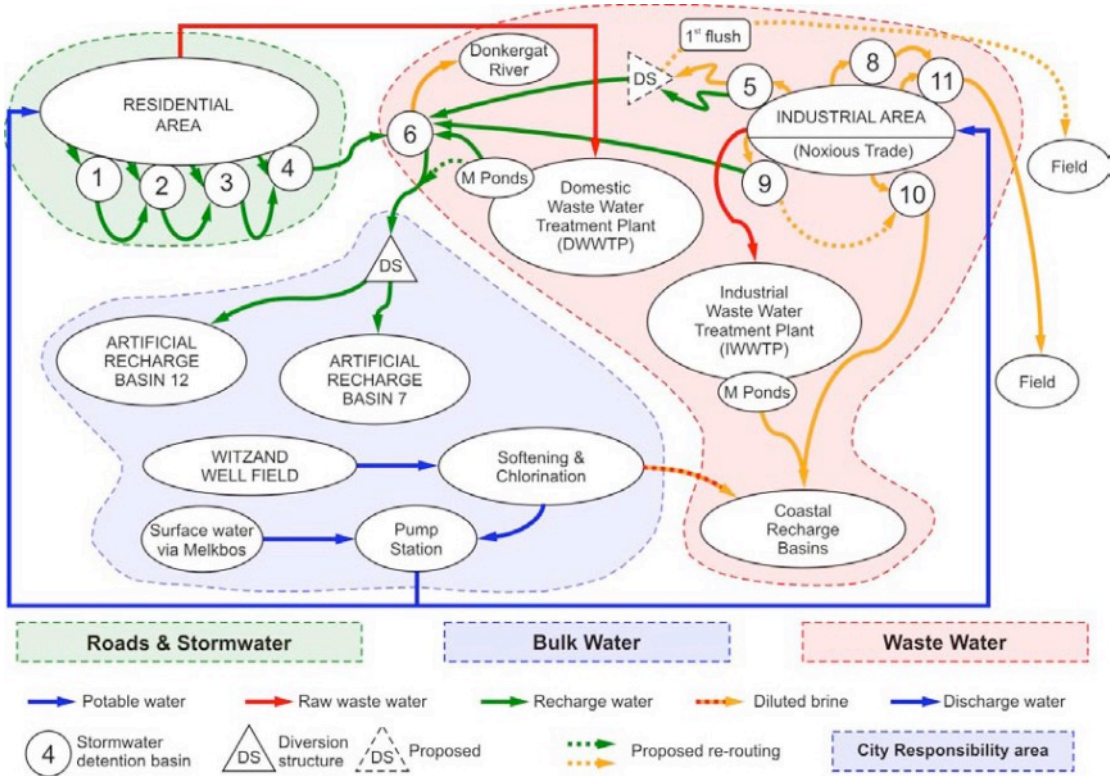



POTENTIAL ARTIFICIAL RECHARGE AREAS
LEGEND
Major towns
National Route
Rivers by stream order
3
4
5
6
7
Dry/non-perennial rivers
Pipelines
Tunnels
Canals
Dams
WMA boundaries
Provincial boundaries
Areas of AR potential
Intergranular 0.5 - 2.0 l/s
Interfranular > 2.0 l/s
Weather and Fractured 2.0 - 5.0 l/s
Weathered and Fractured 5.0 - 10.0 l/s
Weathered and Fractured > 10 l/s
Mean Annual rainfall (mm/a)
1 - 300
300 - 600
600 - 900
>900
15°E
20°E
25°E
30°E
25°S
30°S
NORTH
0 50 100 200 300 400 500 600 700 Kilometers
Limpopo
North West
Mpumalanga
Northern Cape
Free State
KwaZulu-Natal
Western Cape
Eastern Cape
Musina
Makhado
Lephalale
Polokwane
Tzaneen
Phalaborwa
Mokopane
Thabazimbi
Bela-Bela
Mashishing
Zeerust
Rustenburg
Brits
Pretoria
Witbank
Middelburg
Nelspruit
Komatipoort
Barberton
Lichtenburg
Johannesburg
Springs
Bethal
Ermelo
Mbabane
Delareyville
Klerksdorp
Vereeniging
Vryburg
Schweizer Reneke
Standerton
Piet Retief
Kuruman
Bloemhof
Kroonstad
Sishen
Olifantshoek
Warrenton
Welkom
Newcastle
Vryheid
Postmasburg
Bethlehem
Harrismith
Upington
Winburg
Keimoes
Kakamas
Griquatown
Kimberley
Ladysmith
Viooldrif
Pofadder
Bloemfontein
Estcourt
Empangeni
Richards Bay
Kenhardt
Greytown
Port Nolloth
Maseru
Prieska
KwaDukuza
Springbok
Pietermaritzburg
Trompsburg
Durban
Kamieskroon
Van Wyksvlei
Matatiele
Ixopo
Brandvlei
Britstown
De Aar
Colesberg
Aliwal North
Kokstad
Garies
Carnarvon
Barkly East
Port Shepstone
Hanover
Bitterfontein
Williston
Molteno
Calvinia
Middelburg
Mthatha
Vanrhynsdorp
Queenstown
Port St. Johns
Lamberts Bay
Clanwilliam
Graaff-Reinet
Cradock
Sutherland
Beaufort West
King William's Town
Saldanha
Laingsburg
Willowmore
East London
Grahamstown
Malmesbury
Worcester
Oudtshoorn
Uitenhage
Port Alfred
Cape Town
Stellenbosch
Riversdale
George
Plettenberg Bay
Port Elizabeth
Strand
Somerset West
Swellendam
Mossel Bay
Hermanus
Bredasdorp

39 Years of Water Banking in Atlantis

Initially prompted by the need to find an alternative to marine wastewater discharge, Atlantis began recharging its storm water and treated wastewater into its sandy soils in 1979. With the recognition that the natural groundwater yield of the aquifer was not sufficient to meet the long-term needs of the town, the focus shifted to *recharging* the aquifer and *recycling* water.

Infiltration basins with Cape Town's Table Mountain in the background.



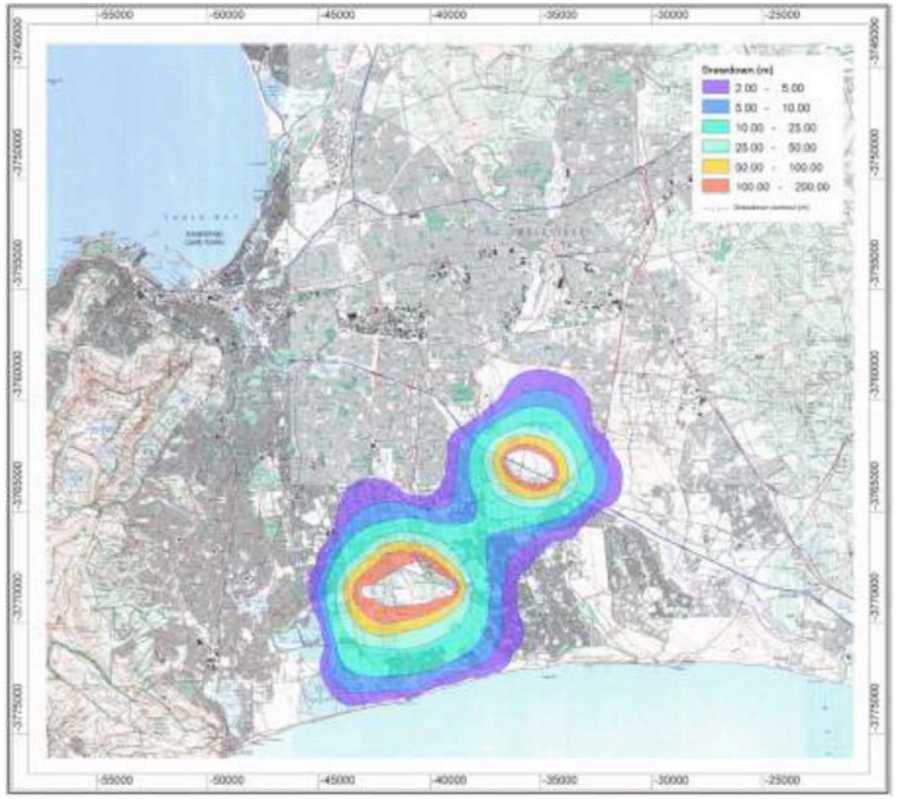
Tredoux (2010)

Groundwater Options: Cape Town

- **Current GW use in CoCT 2% of supply; plan is to increase to 20% (Source: CoCT)**
- **Potential Groundwater resources (short term):**
  - Table Mountain Group Aquifer (through springs [4 Mℓ/day] and abstraction points [60 Mℓ/day])
  - Sandy Coastal Aquifers – Cape Flats Aquifer (CFA) [20 Mℓ/day] & Atlantis & Silverstroom [15 Mℓ/day]
  - Deeper Malmesbury Group Aquifer under CFA [unknown]
- **Yields of the Cape Flats Aquifer can be significantly increased through direct and indirect managed aquifer recharge (MAR) as well as using the capture principle instead of sustainable yield where recharge = abstraction.**
  - 10 million m3/a without MAR to >17 million m3/a with MAR
  - MAR sources can be:
    - Treated wastewater effluent
    - Natural runoff
    - Rerouted groundwater from areas prone to groundwater flooding
    - Storm water runoff [done successfully in Atlantis]
- **WRC is investing in research to determine the viability of storing urban storm water in the 737 available storage ponds instead of letting it run off into the sea.**
  - Storage ponds are mainly dry for most of the time and are designed for flood attenuation.
  - 70% detention ponds, 23% retention ponds, and 7% constructed wetlands.

Cape Flats Aquifer: Cape Town

Figure 5-1 Hypothetical abstraction (blue circle) and injection (red square) sites with WWTW shown in white text, groundwater model boundary shown as red line.



Drawdown for scenario 1iv) Abstraction of 10 million m³/a per wellfield

- **Yields of the Cape Flats Aquifer can be significantly increased through direct and indirect managed aquifer recharge (MAR) as well as using the capture principle instead of sustainable yield where recharge = abstraction.**
  - 10 million m3/a without MAR to >17 million m3/a with MAR

Useful lessons for the current crisis: Cape Town

- Model results show aquifer can support >17 million m^3/a
- Further increase with MAR
- Drawdown implications?
- **Recommend combination of wellfields & decentralised abstraction**

Short Term million m^3/a	Long Term million m^3/a	Short Term Ml/d	Long Term Ml/d	Groundwater source
5.5	7.3	15	20	Atlantis & Silverstroom
7.3	**11.0**	**20**	**30**	**Cape Flats**
22	91	60	250	TMGA (Hottentots Holland Mountains, South Peninsula, Somerset West)
0.4	1.5	1	4	Somerset West
1.5	1.5	4	4	Oranjezicht & Albion Springs

Numbers from B. Wood, 18/10/17

Reuse

- Indirect potable reuse of wastewater: Mossel Bay
  - Indirect potable use of treated wastewater effluent to augment raw water supply
  - WWTW to provide 5 Ml/day of high quality treated effluent
  - Pre-treatment (in-line strainers), UF, RO
- Direct industrial reuse of wastewater: Durban
  - Commissioned in 2001; treats 47.5 Ml/day of domestic and industrial wastewater to a near potable standard
  - Sales to industrial consumers for direct use in their processes
  - Public Private Partnership: eThekwini Water Services and Durban Water Recycling (Pty) Ltd
- Direct potable reuse of wastewater: Windhoek, Namibia; Beaufort West, South Africa
- Direct potable reuse of mine water: eMalahleni

Beaufort West - DPR

- Treatment:
  - Phosphate removal
  - Settling
  - Sand filtration
  - Ultra filtration
  - Reverse osmosis
  - Advance oxidation (hydrogen peroxide/UV)
  - Final chlorination (residual)

Monitoring (= 17% of opex)

Managing Public Perception of DPR

- Twice project has been on front page of local news paper
- Test results are published in the local newspaper
- School tours through plant (very successful)
- Presentations a professional workshops
- Political buy in
- Naming (Beaufort West NEWater)
- Transparency with municipality
- Handed out water bottles to visitors

Reinventing the toilet

Off-the-grid sanitation

- Eliminates pathogens from human waste
- Has modular unit with hygienic interface
- Recovers energy, clean water, and nutrients
- Operates “off the grid”
- Costs less than 5 ZAR cents/user/day
- Systems undergoing Engineering Field Testing to understand performance under field conditions
- Partnership with Gates Foundation, Khanyisa, UKZN and eThekwini

WCDM in industries

No.	Title	Report no.
Natsurv 1	Water and wastewater management in the malt brewing industry	TT 676/16
Natsurv 2	Water and wastewater management in the metal finishing industry	TT 644/15
Natsurv 3	Water and wastewater management in the soft drink industry	TT 640/15
Natsurv 5	Water and wastewater management in the sorghum beer industry	TT 692/16
Natsurv 6	Water and wastewater management in the edible oil industry	TT 702/16
Natsurv 7	Water and wastewater management in the red meat abattoir industry	TT 701/16
Natsurv 8	Water and wastewater management in the laundry industry	TT 703/16
Natsurv 9	Water and wastewater management in the poultry abattoir industry	TT 730/17
Natsurv 10	Water and wastewater management in the tanning and leather finishing industry	TT 713/17
Natsurv 11	Water and wastewater management in the sugar industry	TT 721/17
Natsurv 12	Water and wastewater management in the paper and pulp industry	TT 704/16
Natsurv 13	Water and wastewater management in the textile industry	TT 724/17
Natsurv 17	Water and wastewater management in the iron and steel industry	TT 705/16

Planning and designing our spaces better

Water Sensitive Urban Design (WSUD) for South Africa:

FRAMEWORK AND GUIDELINES

Neil Armitage, Lloyd Fisher-Jeffes,
Kirsty Carden, Kevin Winter,
Vinothan Naidoo, Andrew Spiegel,
Ben Mauck & Daniel Coulson

Understanding unintended consequences

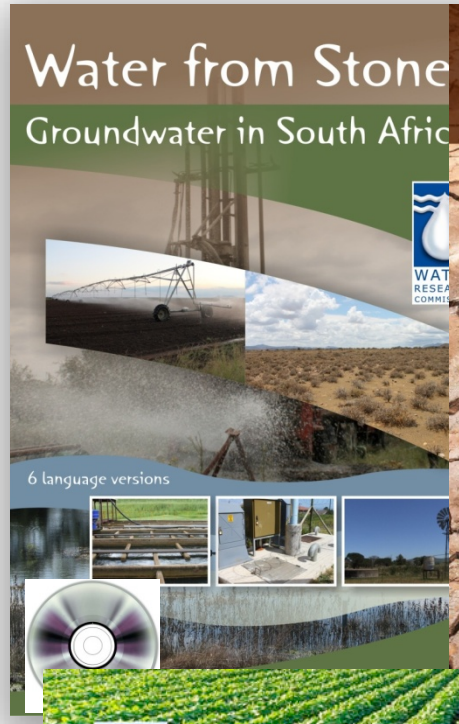
Minister, the drought being experienced in many parts of South Africa has had adverse impacts on society and the economy. An unintended consequence of the reduction in the availability of water has been the reduced flow of water in the systems that transmit and treat wastewater. A Water Research Commission (WRC) study set out to assess and quantify the extent of impacts on the proper functioning of wastewater collection, conveyance and treatment works that may emanate from reduced water volumes entering sewerage systems on the back of water demand management measures.

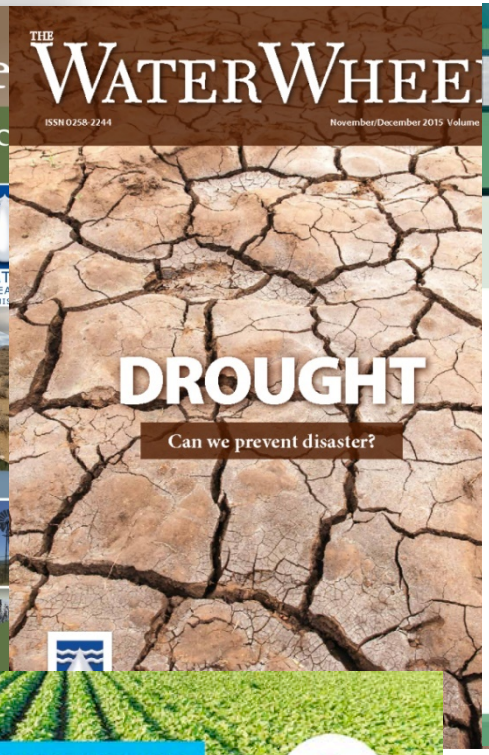
Better data for decision-making

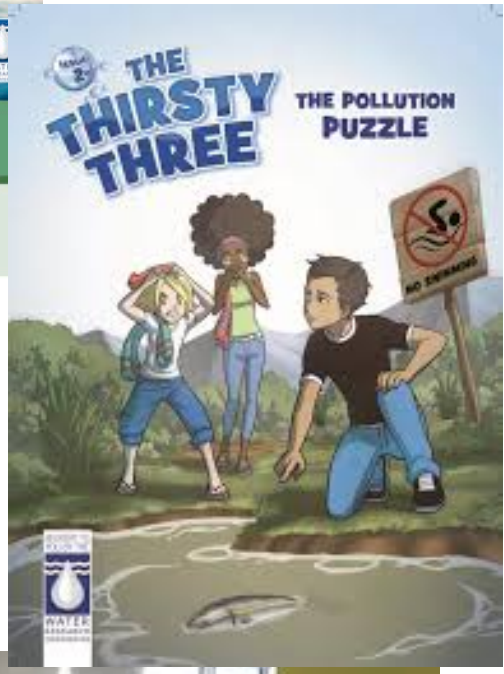
The State of Non-Revenue Water in South Africa (2012)

R Mckenzie, ZN Siqalaba & WA Wegelin

Public & Decision-makers perceptions and awareness creation – MOST IMPORTANT!



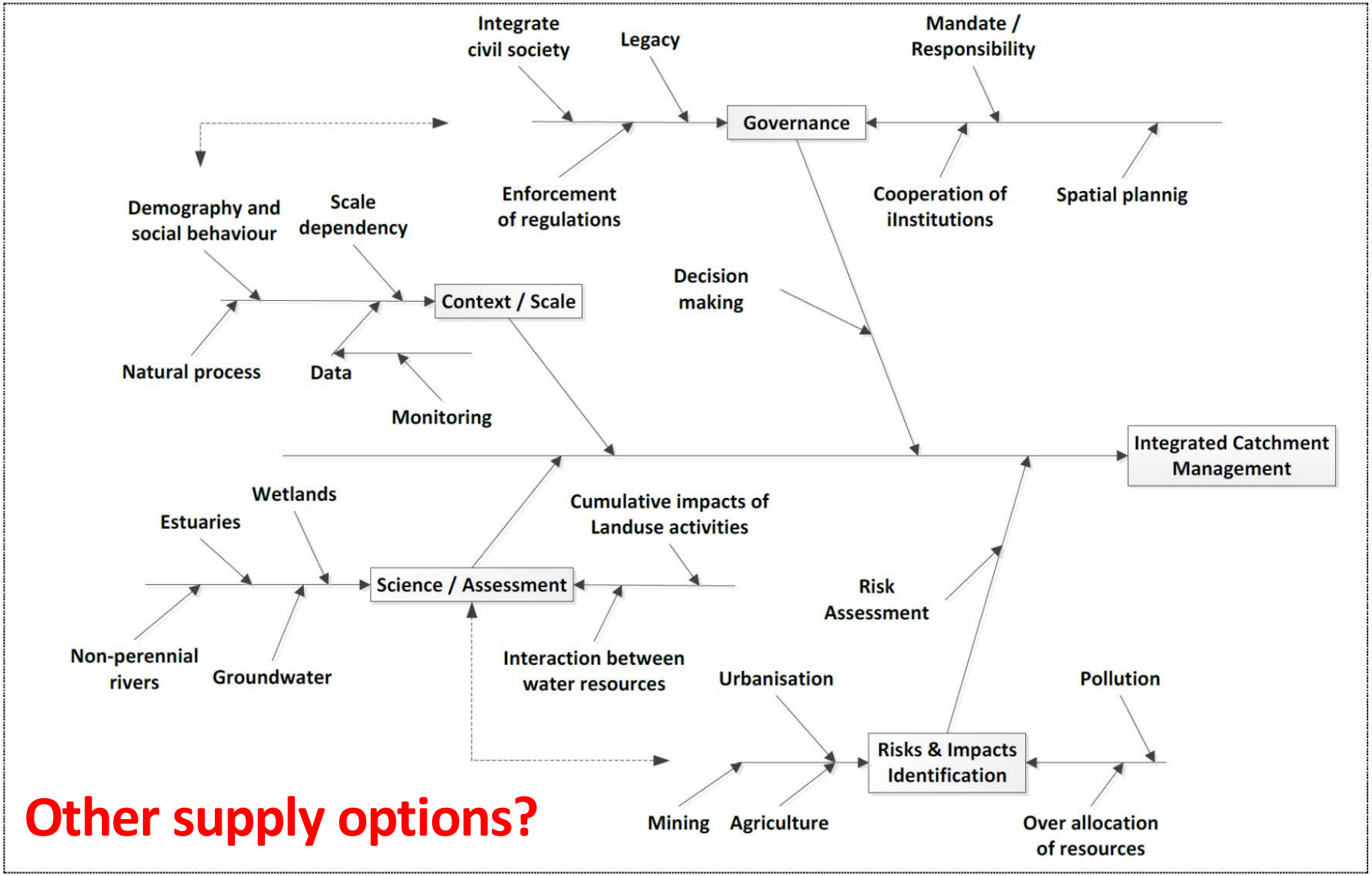




OCTOBER 2017

It has been said a number of times that South Africa is categorised as a middle-income country with gross inequities in income distribution. A high proportion of the population has low incomes. Despite their low incomes, most households rely mostly on purchased food for survival. Recent Water Research Commission studies have already confirmed that poor households spend as much as 70% of their total income on food, leaving very little for other household needs. Vegetable gardening at the backyard of our homes could help reduce the financial stress while ensuring household healthy diets.

As the world celebrates World Food Day on 16th October, we are reminded of how fast we need to change our mindset as


Integrate civil society
Legacy
Mandate / Responsibility
Governance
Enforcement of regulations
Cooperation of iInstitutions
Spatial plannig
Demography and social behaviour
Scale dependency
Context / Scale
Natural process
Data
Monitoring
Decision making
Integrated Catchment Management
Wetlands
Estuaries
Cumulative impacts of Landuse activities
Science / Assessment
Non-perennial rivers
Groundwater
Interaction between water resources
Risk Assessment
Urbanisation
Pollution
Risks & Impacts Identification
Mining
Agriculture
Over allocation of resources
Other supply options?

Concluding Remarks

- Climate will always play a significant role in development.
- Cape Town demonstrate an example of vulnerabilities potentially faced by other cities in the country.
- Proactive planning is a prerequisite for risk reduction and operational response.
- Lack of coordination; alignment and synergy across sectors are barriers for implementation
- Existing strategies and plans are still pursuing the sectoral or 'silo' approach.
- Weak appetite for implementation in favour of large and expensive schemes.
- Convert short-term (emergency) interventions into long-term solutions (e.g. groundwater resources)
- Diversification of finance models

Hierarchy of Science

Complexity

Development agenda

Economic Growth

Hydrogeology

Geology
Chemistry
Physics

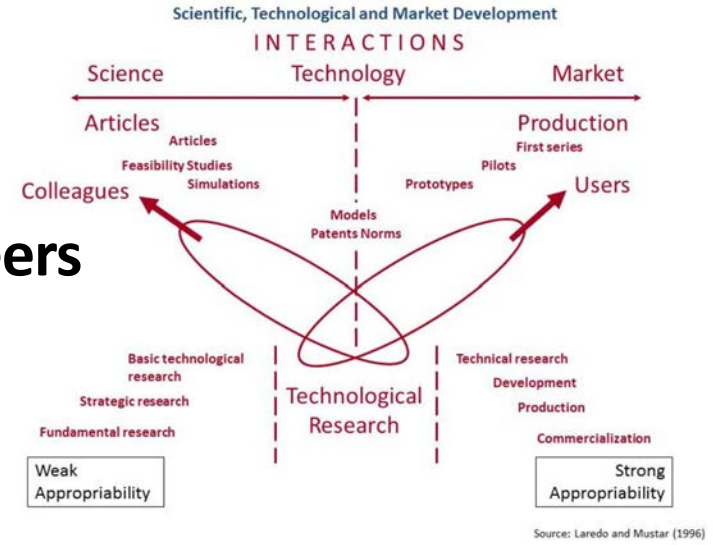
Decision-makers

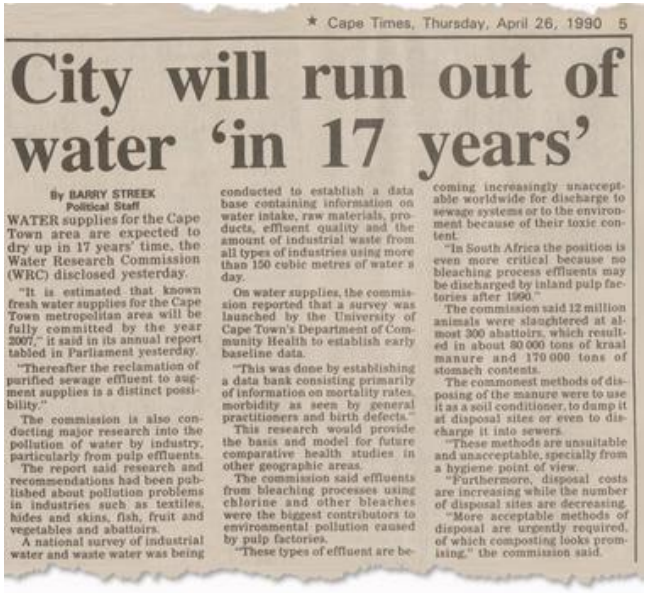
What do they lose sleep over?

?

Barriers

Scientists & Engineers





★ Cape Times, Thursday, April 26, 1990 5

City will run out of water 'in 17 years'

By BARRY STREEK
Political Staff

WATER supplies for the Cape Town area are expected to dry up in 17 years' time, the Water Research Commission (WRC) disclosed yesterday.

"It is estimated that known fresh water supplies for the Cape Town metropolitan area will be fully committed by the year 2007," it said in its annual report tabled in Parliament yesterday.

"Thereafter the reclamation of purified sewage effluent to augment supplies is a distinct possibility."

The commission is also conducting major research into the pollution of water by industry, particularly from pulp effluents.

The report said research and recommendations had been published about pollution problems in industries such as textiles, hides and skins, fish, fruit and vegetables and abattoirs.

A national survey of industrial water and waste water was being conducted to establish a data base containing information on water intake, raw materials, products, effluent quality and the amount of industrial waste from all types of industries using more than 150 cubic metres of water a day.

On water supplies, the commission reported that a survey was launched by the University of Cape Town's Department of Community Health to establish early baseline data.

"This was done by establishing a data bank consisting primarily of information on mortality rates, morbidity as seen by general practitioners and birth defects."

This research would provide the basis and model for future comparative health studies in other geographic areas.

The commission said effluents from bleaching processes using chlorine and other bleaches were the biggest contributors to environmental pollution caused by pulp factories.

"These types of effluent are becoming increasingly unacceptable worldwide for discharge to sewage systems or to the environment because of their toxic content.

"In South Africa the position is even more critical because no bleaching process effluents may be discharged by inland pulp factories after 1990."

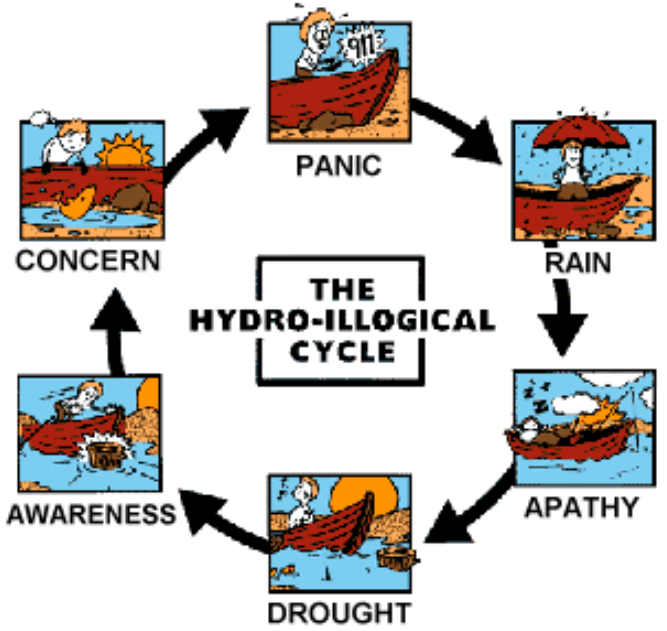
The commission said 12 million animals were slaughtered at almost 300 abattoirs, which resulted in about 80 000 tons of kraal manure and 170 000 tons of stomach contents.

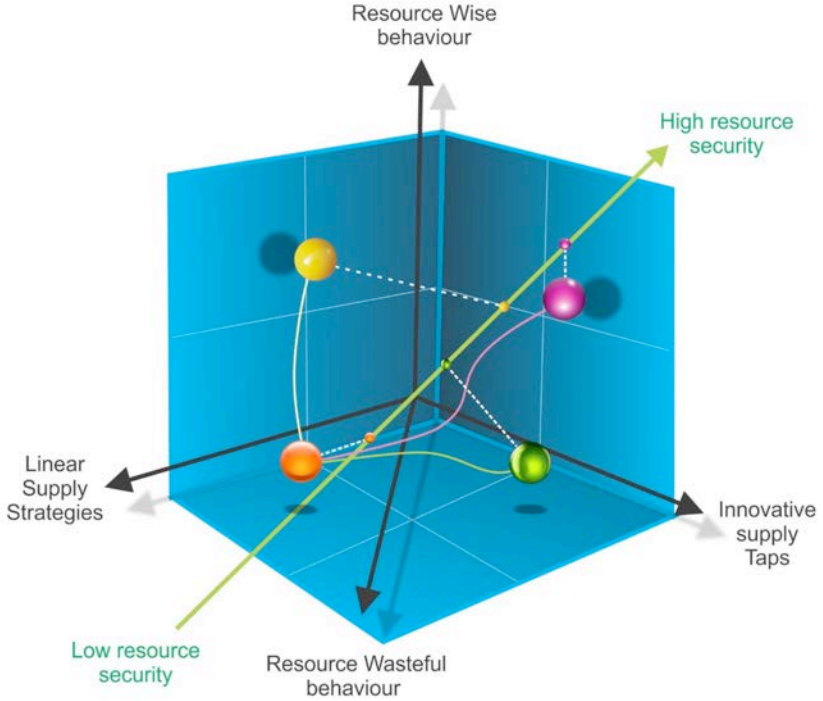
The commonest methods of disposing of the manure were to use it as a soil conditioner, to dump it at disposal sites or even to discharge it into sewers.

"These methods are unsuitable and unacceptable, specially from a hygiene point of view.

"Furthermore, disposal costs are increasing while the number of disposal sites are decreasing.

"More acceptable methods of disposal are urgently required, of which composting looks promising," the commission said.





Thank You

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