Drinking water supply options and management systems to meet the challenges of changing source water quality and quantity

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Main challenges of Water Supply Authorities

Two main challenges to provide

<u>sustainable</u>, <u>sufficient</u>, <u>high-quality</u> <u>drinking water</u>

Deteriorating quality of raw water sources

<u>plus</u>

Stricter standards for tap water quality

Highly variable availability of raw water

<u>as a result of</u>

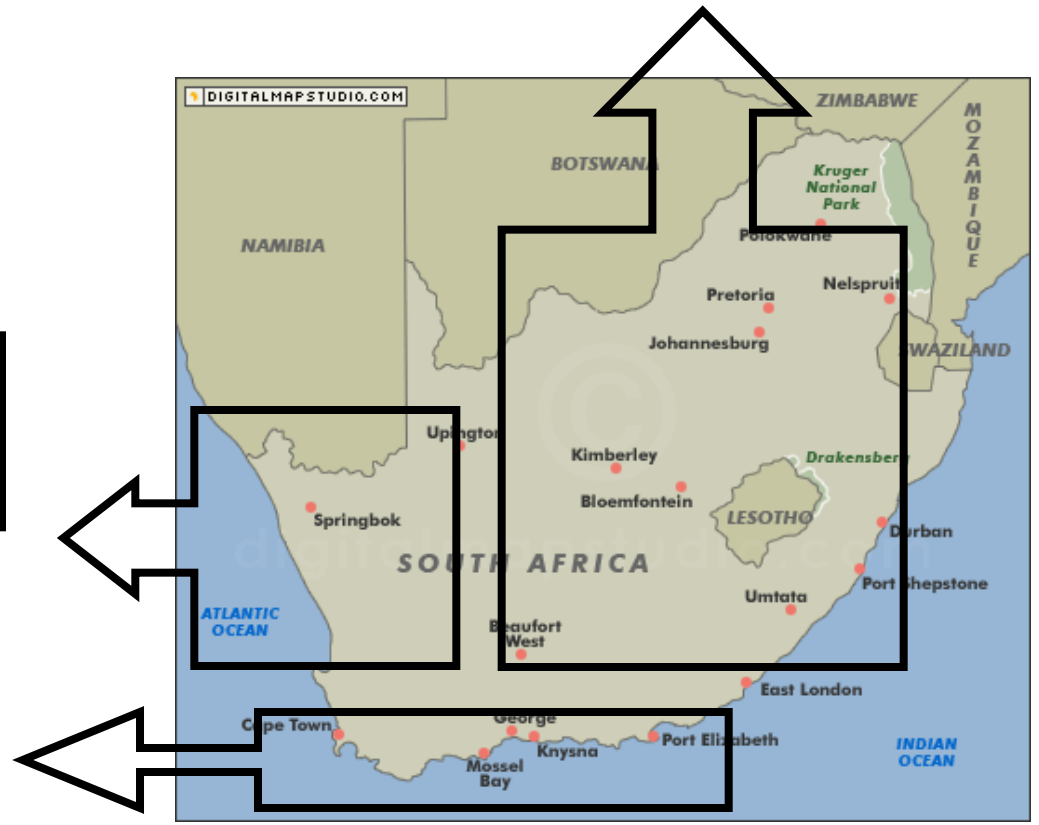
Changing weather patterns

Municipalities experience problems with water service delivery

Water Source Quality in South Africa

Inland waters: Variable turbidity *(high after rain)*
(surface waters) Low colour

Western area:
High TDS
groundwater



Coastal waters:
High colour (NOM)
Low turbidity

Degradation of source water quality

Extent of the problem:

- Increasing decline in water quality of raw water sources / will continue and will take time to eradicate

Driving forces:

- Increasing pollution / urbanisation / industrialisation / changes in lifestyle / higher waste-loads (esp. urban)

Implications:

- Improved treatment technologies required (conventional systems not able to treat new contaminants/high loads)
- Increase in water-borne diseases
- Advanced technologies required (membranes/UV)
- Use of POU systems to further treat water (urban areas)
- Improved O&M needed (privatisation?)
- Improved management tools needed

Water Availability in South Africa

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Past two years: Severe droughts!

1. **Water demand management (*water restrictions*)**
2. **Desalination**
3. **Water reclamation and wastewater re-use**

Reduced availability of raw water

Extent of the problem:

- Adverse weather conditions (droughts/flooding) / current effects will continue to at least 2050

Driving forces:

- Global warming / industrialisation / fossil fuel

Implications:

- Water stress due to less water available
- Unsustainable development in many regions

- Change of water quality in water sources
- Increased focus on alternative water supply options
- R&D for desalination / reuse / rainwater harvesting

- Implement improved water demand management

Addressing the challenges

Deteriorating quality of raw water sources

Highly variable availability of raw water

Addressing the challenges through guidance and intervention

- **Improved management systems**
- **Water quality monitoring tools**

- **Alternative raw water sources:**
  - **Water reclamation**
  - **Desalination**
  - **Upgrading existing systems**

Solutions through WRC projects to draw up Guidelines and Manuals





Water Treatment in South Africa - Treatment Processes

Inland waters:

Conventional treatment plants

- Deteriorating surface water quality (algae; T&O):
  - DAF; Ozone; Activated carbon
- Iron and manganese:
  - Advanced oxidation

Coastal waters:

- Conventional treatment plants
- DAF; ozonation; Fe and Mn removal; membranes; corrosion control

Western areas (brackish water):

Reverse osmosis; solar distillation (small-scale)

Operational Systems Used

Current systems:

- Manual control of chemical dosing systems
- Streaming current detector
- Coagulation dose calculated based on raw water UV
- Filter backwash based on routine basis (largely), head loss or turbidity measurement of filtrate
- Stabilisation using Stasoft programme

New developments:

- Manual and guidelines for small-systems operation and maintenance (incl. training aids) (WRC)
- Operation information tool (spreadsheet) (WRC)
- Guidelines for investigation of treatment plants (WRC)
- Process evaluation guidelines (tables)

Operation and Maintenance Issues at South African Water Treatment Plants

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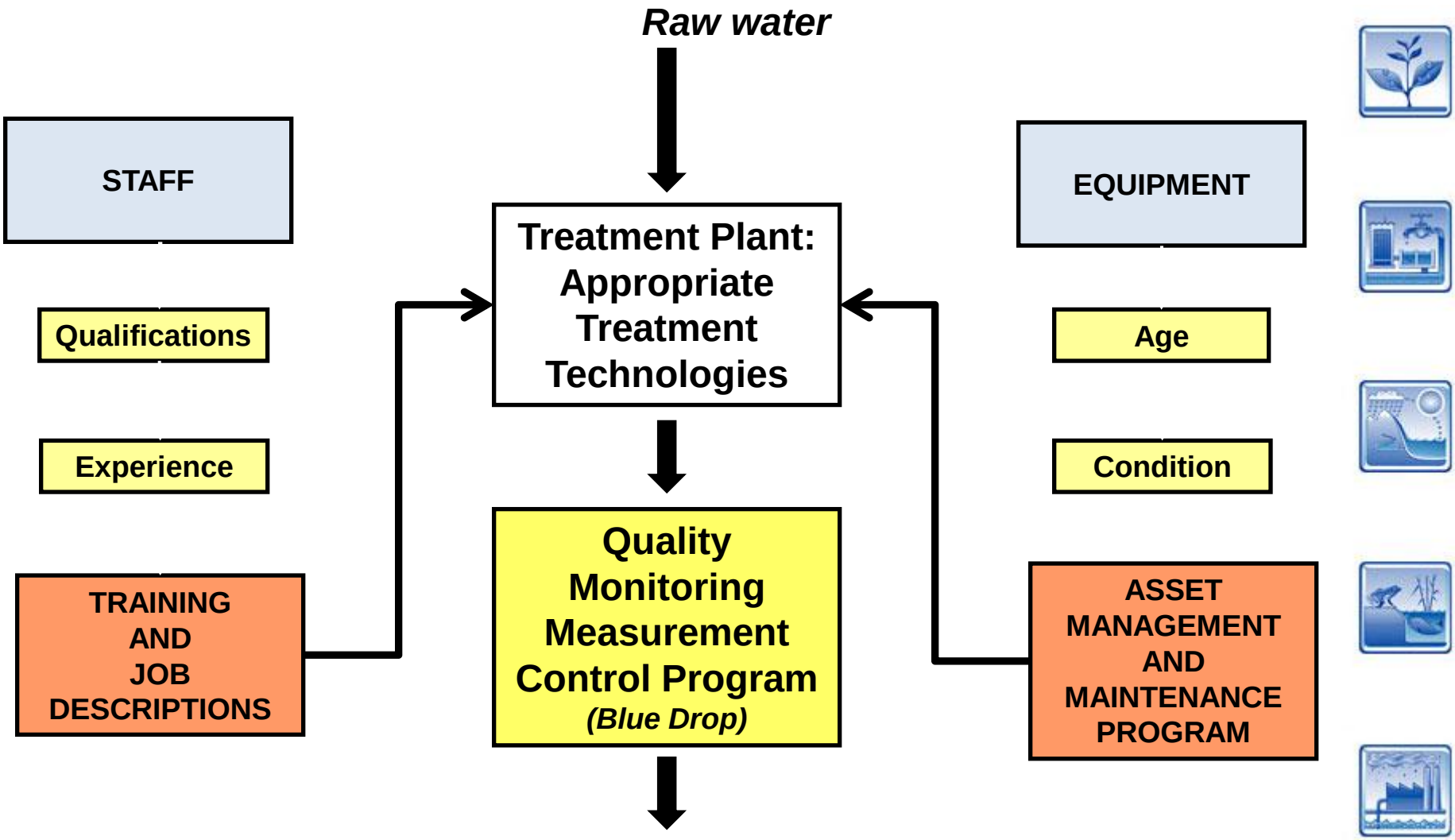
Water Treatment Plants

- Variable quality of drinking water produced at many of the treatment plants
- Deteriorating infrastructure
- Operation of treatment plants not done cost-effectively

Investigations regionally and nationally to identify specific problems with sustainability/compliance

Main factors affecting treatment plant performance



Interventions

Capacity Building *(Training; Mentoring)*

O&M Manual and Training Aids

Operational Tool

Guidelines for Inspections

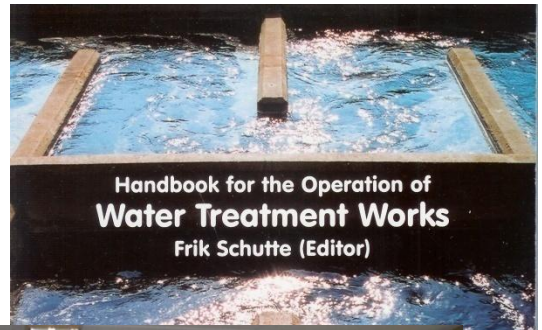
eWISA Municipal Assistant

New technologies

Capacity Building

Training

- Career path development
- Skills development (NQF)
- Short courses
- Telematic training



Mentorship

- DBSA mentorship scheme
- In-house mentorship initiatives

Problem: skills gap for transfer of responsibilities to senior process controllers/supervisors

WRC Project:
Smalsys O&M Manual and Training Aids

WATER RESEARCH COMMISSION

SECTION 1

SCOPE OF THE MANUAL

SECTION 2

MANAGEMENT GUIDELINES

SECTION 3

TECHNICAL GUIDELINES

SECTION 4

RESOURCES

WRC Project:
Operational Information Tool

Contents of OIT:

Water qualities

Flows

Dosages (coagulant/oxidant/chlorine)

Residuals (chlorine/chemicals)

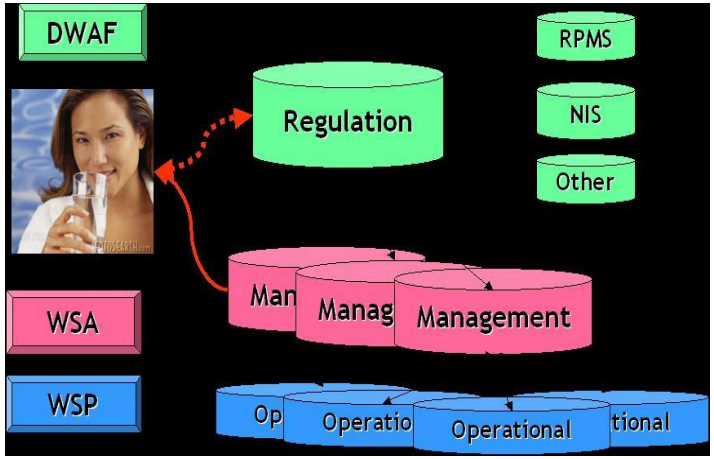
Visual observations (floc formation, etc)

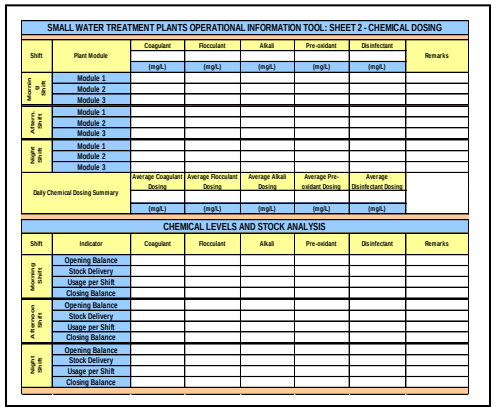
Operational tasks (desludge/backwash)

Routine operational tasks

Unit process performance targets

Monitoring schedule (samples/frequency)





SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 2 - CHEMICAL DOSING

Shift	Plant Module	Coagulant	Flocculant	Alkali	Pre-oxidant	Disinfectant	Remarks
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
Morning Shift	Module 1						
	Module 2						
	Module 3						
Afternoon Shift	Module 1						
	Module 2						
	Module 3						
Night Shift	Module 1						
	Module 2						
	Module 3						
Daily Chemical Dosing Summary		Average Coagulant Dosing	Average Flocculant Dosing	Average Alkali Dosing	Average Pre-oxidant Dosing	Average Disinfectant Dosing	
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	

CHEMICAL LEVELS AND STOCK ANALYSIS

Shift	Indicator	Coagulant	Flocculant	Alkali	Pre-oxidant	Disinfectant	Remarks
Morning Shift	Opening Balance						
	Stock Delivery						
	Usage per Shift						
	Closing Balance						
Afternoon Shift	Opening Balance						
	Stock Delivery						
	Usage per Shift						
	Closing Balance						
Night Shift	Opening Balance						
	Stock Delivery						
	Usage per Shift						
	Closing Balance						

eWISA and eWISA Municipal Assistant: Informing the management tools

- General: Contacts, staff, documention, photos, manufacturers and suppliers, classification of works, etc.

- Water quality and plant performance: Monitoring points, water quality and flow data, graphical procedures and statistics to MANAGE the performance of the plant and the quality of water/effluent

- Asset management: Inventories, replacement costs, life span of equipment, maintenance schedules, reporting, etc.

- Financial management: Budgeting and management

- Inspections and incidents

Water supply situation

Issues identified during assessment of current rural water treatment situation in South Africa:

- **Water treatment systems mostly not sustainable (insufficient participation/training/not sufficient funds allowed/available for maintenance/ineffective financial control)**

- **Interruptions in water supply/availability due to extreme weather events**

- **Decentralisation vs centralisation**
- **Unpredictability of migration patterns (from/to rural areas)**

- **Availability of funds for capital development and maintenance of infrastructure**
- **Cost recovery**
- **Poor operation and maintenance of water treatment plants**

Water Reclamation

New Technologies

- **Membrane technologies**
  - *MF and UF (woven fibre submerged)*
  - *point-of-use (POU) systems*
- Ozonation
- Desalination

Automation

Maintenance requirements





New WRC Projects on Drinking Water treatment

- Energy Efficiency of Water Treatment Plants
- Membrane Technologies
- Nanotechnology
- Home Water Treatment Devices

Need for Guidelines on Water Reclamation for Municipal Engineers

Decentralised vs centralised Water supply in South Africa

Decentralisation

"Systems treating water for drinking purposes at household level, for a few households or for a small village."

Point-of-use (POU) systems:

Treatment of only the part used for drinking *(2 – 8 L/p.d)*

Point-of-entry (POE) systems:

Treatment of all water supplied to a household *(100 – 150 L/p.d)*

Small-scale systems (SSS):

Treat water for several families or for a small village

(Plant size: 1000 – 10000 L/d)

Household systems = POU; POE

Decentralised systems = POU; POE; SSS

Areas of application of POU, POE and SSS in SA

POU:

- in very remote areas
- water collected in dams or rivers or from boreholes
- used without treatment or boiling/hypochlorite
- emergency treatment

POE:

- not widely practiced
- pressure sand filtration
- membranes (emerging)

SSS:

- in many rural areas of South Africa
  (KZN; Eastern Cape; Limpopo)
- conventional small systems
- slow sand filters
- package plants
- membrane systems (emerging)

Multi-factor analysis of water supply options for rural areas

1. Used Parmenides EIDOS program (US)

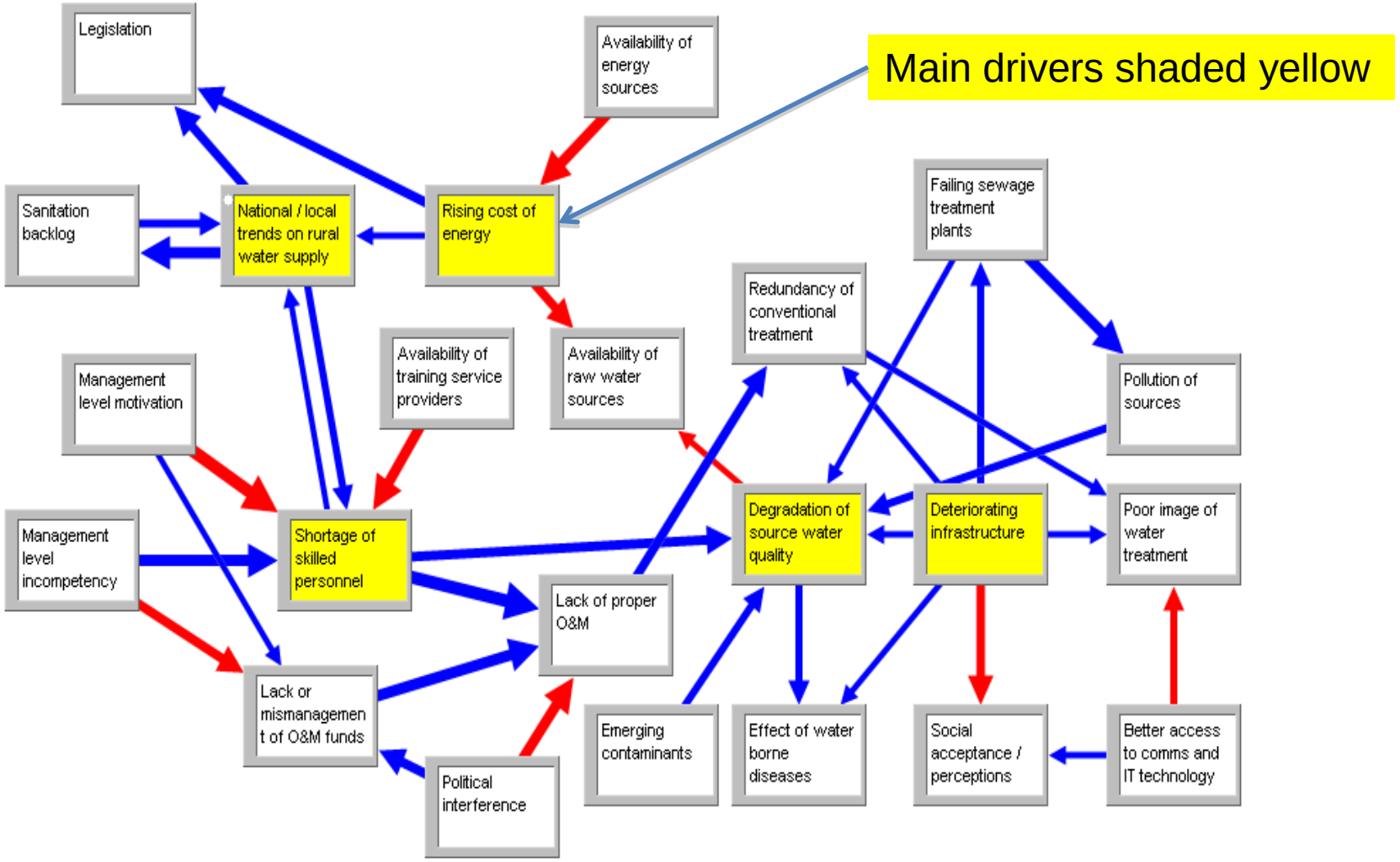
2. Define framework for analysis procedure

3. Identify internal and external driving factors impacting on water supply in South Africa, and determine five main drivers in each environment

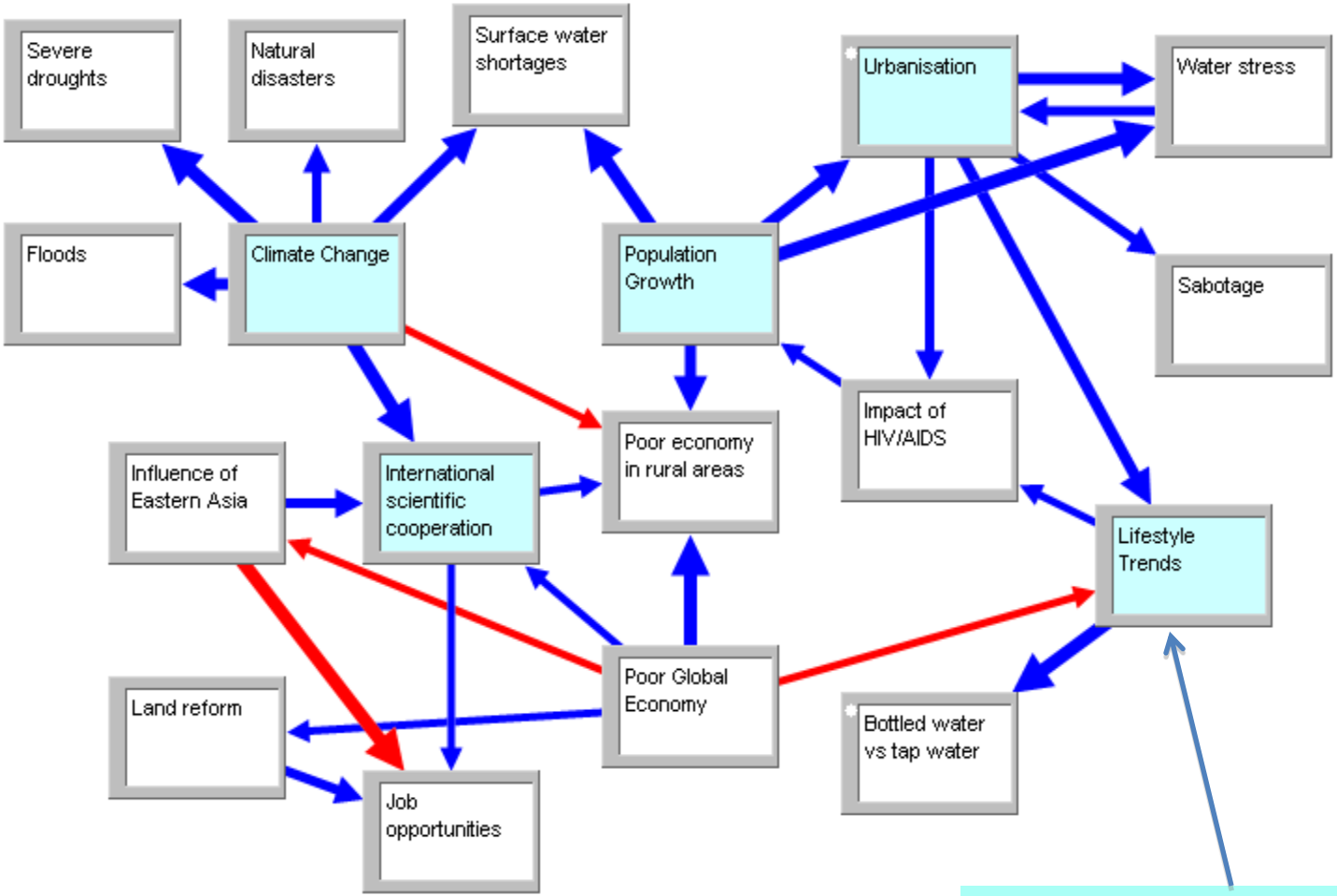
4. Consider three scenarios: centralised treatment; small decentralised treatment plants (typically package plants); POU systems (home water treatment devices)

5. Compare options on weighted basis using EIDOS multi-factor software based on effect on main internal and external driving forces (factors)

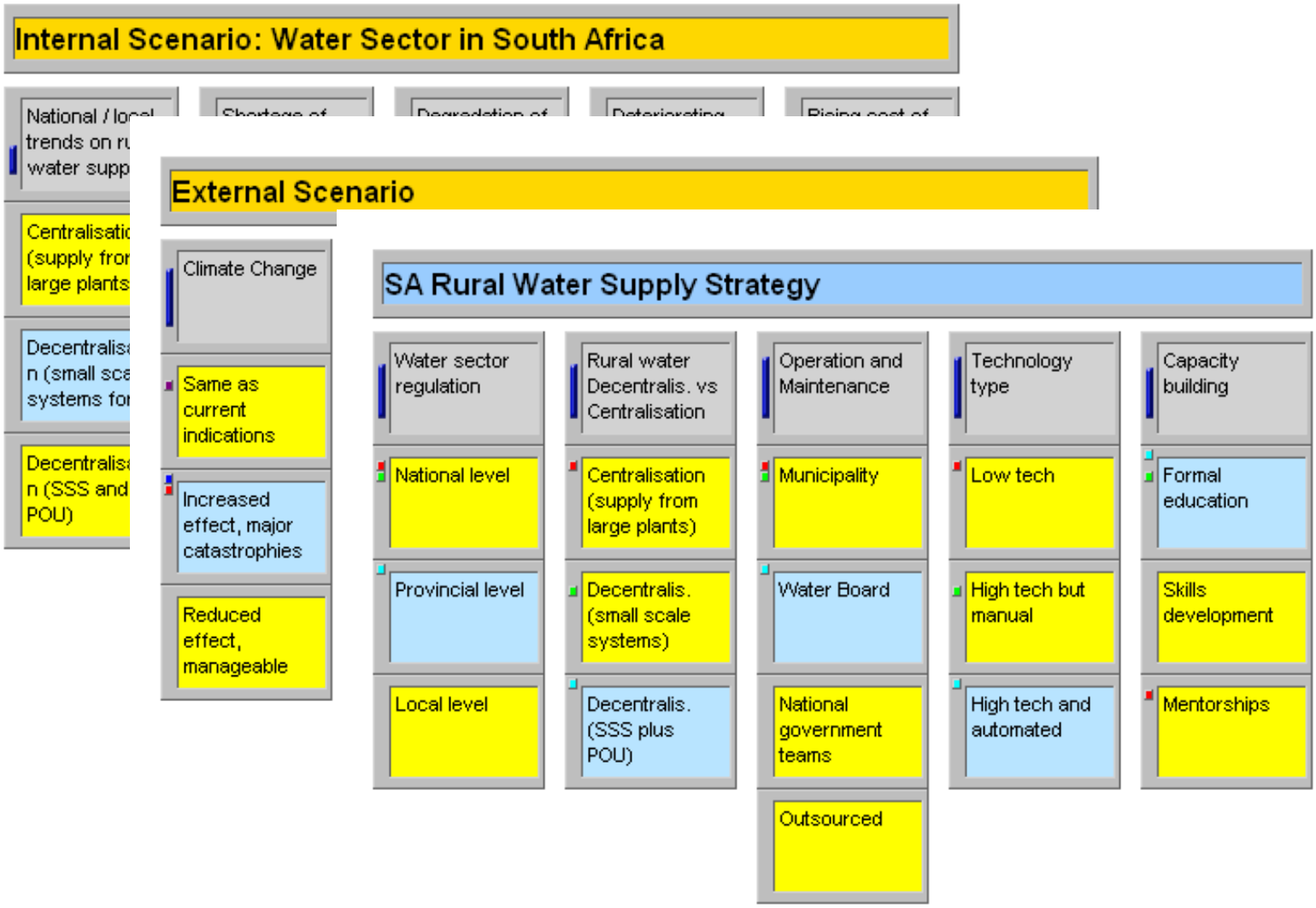
Internal factors affecting water supply



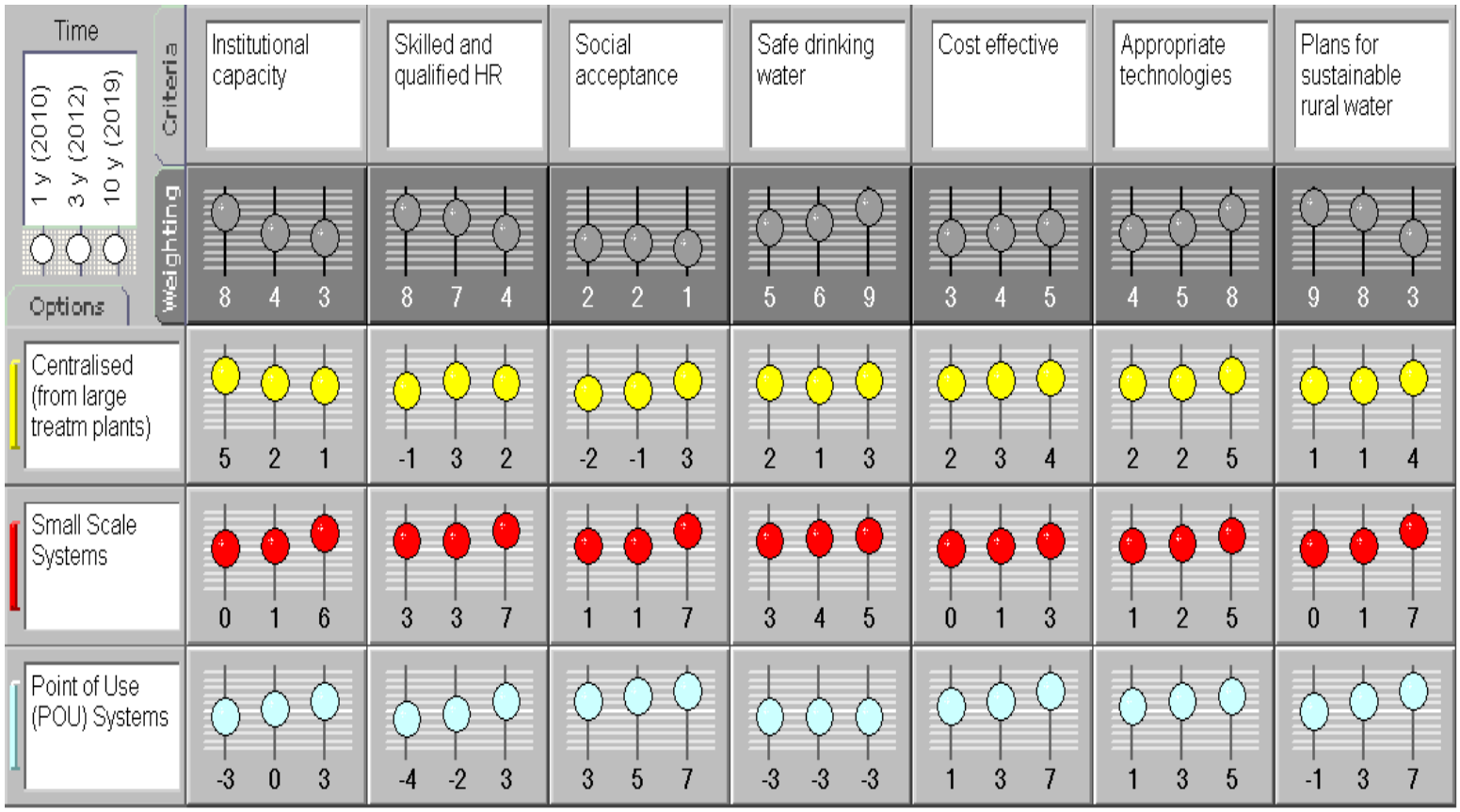
External factors affecting water supply



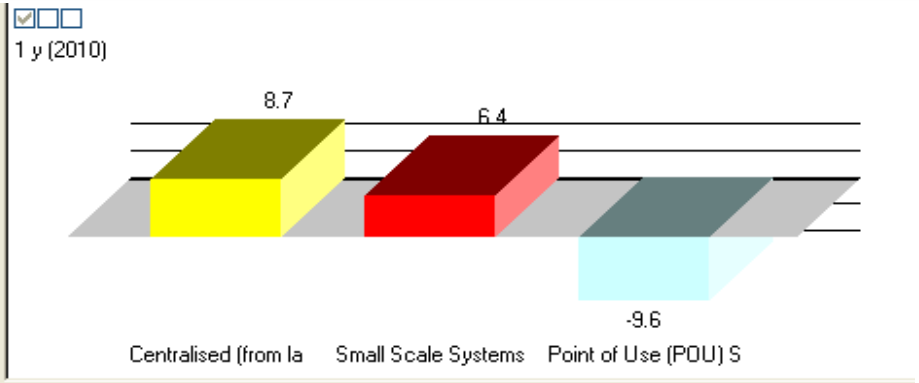
Main drivers and strategies for rural water supply

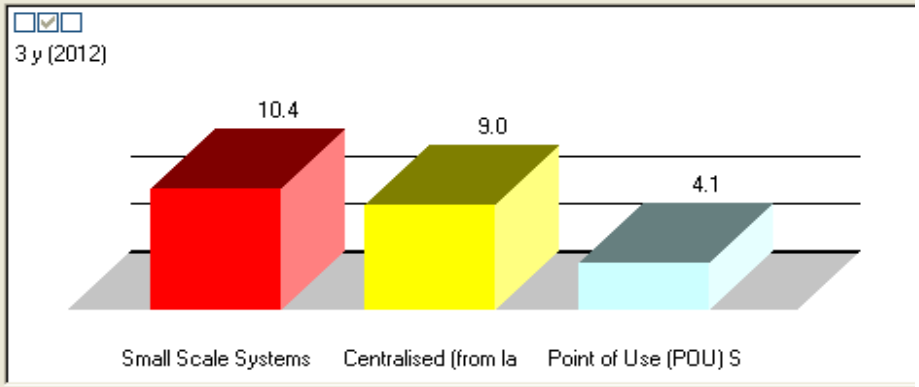


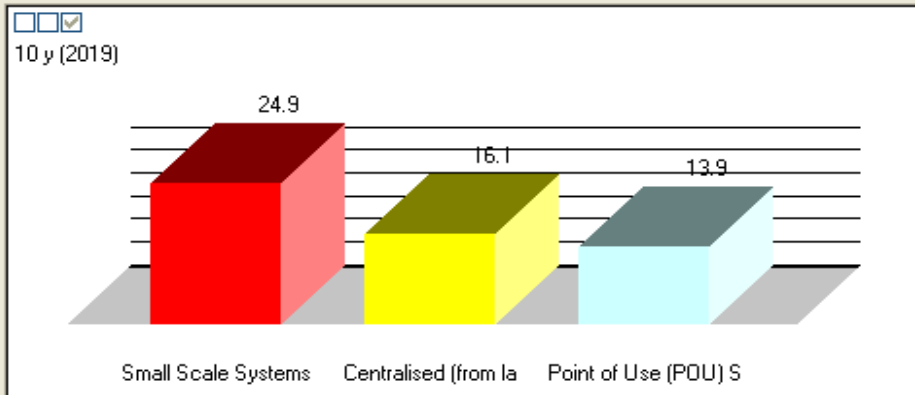
Rating of requirements for different water supply options



Ranking Analysis Results for the Three Scenarios







Conclusions on comparison of rural water supply options

1. Centralised systems currently still used the most and is the system of choice (mostly due to lack of capacity by communities to operate and manage decentralized systems by themselves). Also no clear guidelines exist for O&M of small treatment systems by communities.
2. With current focus on research and developing guidelines for small (decentralised) treatment systems, these systems will gain popularity in the next three years or so. Decentralised systems will then make up approximately the same portion of treatment as centralised systems.
3. 3. In around 10 years time small scale systems will have gained even more popularity, and POUs (home treatment devices) will also have increased its share in the rural water treatment market.





Conclusions on comparison of rural water supply options

1. Regulation and support functions can best be performed on a regional (provincial).
2. Decentralised systems will in medium to long term present better water supply options wrt sustainability, performance, operation and maintenance.
3. Water Boards have an important role to play in the operation and maintenance of the water supply function.
4. Automated high-tech treatment technologies for rural water treatment present an efficient and sustainable solution.





Further Research Needed …

- Integration of all the water supply and treatment management systems and monitoring tools

- Developing “smart”, “user-friendly” knowledge-based decision-support models for selection, costing and application of water supply options to meet the future water supply challenges

- Coordinate and fast-track all capacity building initiatives in the water sector, and make clear distinction between the needs of rural water treatment plants and larger plants (in the metropoles and large towns)

Thank you !

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