STATE OF WATER IN SOUTH AFRICA
A Researcher’s Perspective

Roland Schulze
Professor Emeritus of Hydrology & Senior Research Associate

School of Bioresources Engineering & Environmental Hydrology
University of KwaZulu-Natal
Pietermaritzburg, South Africa
1,219,090 km²; 50 mil; 11 Languages
9 Provinces; 79% African, 9% White, 12% Col/Ind; 8% Tertiary Educ, 40% Primary/None
The South African Water Related Sector ... WHERE FROM?
Water in a Country of Contrasts
...with Significant Irrigation Projects
Supplied by Huge Dams and Water Transfers

Bloemhof Dam

Gariep Dam
...where Biological Water Quality Becomes Cause for Concern
...with High Mountains and High Rainfall in a Few Places
...but, Largely Semi-Desert

Photo: futureWorks
There are “wanted” forests and their impacts

And “unwanted” forests and their impacts
where Overgrazing can be Moderate

...or Severe

...with Significant Hydrological Consequences
and... Many Estuaries Under Stress

e.g. Orange Estuary: 25% of Natural MAR
Basic Human Needs: Present, Future
Equitable Access to Water
Sustainable, Efficient, Beneficial Water Use
Socio-Economic Development / Future Demands
Promoting Dam Safety
Managing Floods, Droughts
Reducing Water Pollution, Degradation
Protection of Ecosystems, Biodiversity
Meeting International Obligations
Redressing Past Inequities
Demand Management
Crisis Management
Environment Management
Political Management
N.W.A. TAKES INTO ACCOUNT
Integrated Water Resources Management Approach in S.A.

Formalising IWRM

- Existing lawful use
- Water availability (Models)
- Reserve scenarios
- ISP

- Develop Catchment Management Strategy
- NWRS

- Public awareness
  - License applications
  - Future use scenarios
  - Water for equity & rural development
  - Socio-Economics
  - Allocation schedule
  - Process to finalise

- Public Participation
  - Installed Modeling System
  - Management class & Reserve, RQO
  - Process to finalise

Interactive developing of reconciliation options

Recommendations

Source: Orange overarching ISP, 2004
With Integration Planned to Transcend Various Levels of Government

Source: Orange BAR, 2004
Each of the Designated Water Management Areas has a Well-Documented Internal Strategic Perspective
What are the Issues Around the State of Water Security and Water Governance in South Africa?
ISSUES AROUND WATER SECURITY & GOVERNANCE IN SOUTH AFRICA

1. Physical Environment
2. Legal & Governance Context
3. State of Water Resources
4. Critical Water User Sectors
5. Water Quality
6. The Aquatic Environment
THE PHYSICAL ENVIRONMENT: Nature is Unfair

1. Semi-Aridity
   - Evaporation > Rainfall by 1 - 10X

2. Low Rainfall to Runoff Conversion
   - Only 9% of Rainfall Converted to Runoff

3. Hydrological Amplification of Rainfall
   - Variability of Runoff 2 - 6X that of Rainfall

4. Outlier Events and Years
   - Means Become Meaningless
LEGAL, ADMINISTRATIVE, GOVERNANCE ISSUES IN SOUTH AFRICA

1. Multilevel Consciousness of Water Issues
2. Merger DWA and DEA
3. Launch of WfGD
4. Updates of NWRS
5. NWAC; Nat Planning Commission
6. Slow CMA Evolution
7. Integrated Monitoring & Info Systems
8. Lack of Regulatory Compliance
9. Technical Admin Skills Shortages
STATE OF WATER RESOURCES IN SOUTH AFRICA

1. Stressed State of Water Resources
2. Complex Engineered Systems
3. Trans-Boundary Waters
4. Aging & Dysfunctional Infrastructure

STATE OF WATER RESOURCES IN SOUTH AFRICA
Location of Large Dams

a. 569 Large Dams (>1 mil m³)
b. Total Capacity 32400 mil m³
c. Capture ~70% MAR
d. 54 with Surface Area > 1000ha; 5 > 10000ha
Natural Background Water Quality
(Reflecting climate, geology, soils, vegetation characteristics)

1. Clear to turbid surface waters; low salt concentrations
2. Mostly turbid rivers; variable salt concs
3. Clear, transparent waters; low salt concs
4. Turbid rivers; high silt / clay contents; variable salts
5. Clear, acidic surface waters
6. Acidic surface waters; high humic / fulvic components
Alien Invasives

...in Water

(Source: O-SRB – PreTDA, 2008)
Industrial Pollution

(Source: O-SRB – PreTDA, 2008)
Mining Pollution

(Source: O-SRB – PreTDA, 2008)
CLIMATE CHANGE AND WATER QUALITY

1. Acid Mine Drainage
2. Salinisation
3. Eutrophication
4. Micro-Pollutants
5. Micro-Biological Pollutants
6. Sediment Production

(Ashton, 2009)
The aquatic environment is a LEGITIMATE water user and NOT a competing resource
Conservation Status of South Africa’s Freshwater Ecosystems

- Critically Endangered
- Endangered
- Vulnerable
- Currently Not Threatened

CSIR (2010)
Health Status of South African Estuaries

Van Niekerk and Turpie (2011)
PES (RWS) Damaged Ecosystems

Extensive annual grassland burning

...and severe overgrazing
WHERE ARE WE NOW?

Factoring in climate change
We Need to Model to the Local Scales that Matter

5,838 Agro-Hydrologically Relatively Homogeneous Interlinked Quinaries

FLOWPATH CONFIGURATION WHEN MODELLING AT QUINARY CATCHMENT SCALE

QC V11A
V11A 1 V11A 2 V11A 3
QC V11C
V11C 1 ... 2 V11D 3
...

Flowpath
Quaternary Catchment Outlet
External Quaternary Catchment
Internal Quaternary Catchment

Procedure: Jenks’ Optimisation using Natural Breaks in Altitude
Changes in Mean Annual Temperature are Projected to be Significant With Significant Amplification Over Time

By 2050s

By 2090s

By 2050s – 2090s
Future Variability will not be Stationary... the Case of Projected Temperature & Rainfall over SA

Changes in the Standard Deviation of Annual Rainfall

![Map showing changes in standard deviation of annual rainfall by 2050s and 2090s](image)

Changes in the Standard Deviation of Annual Temperature

![Map showing changes in standard deviation of annual temperature by 2050s and 2090s](image)
Potential Evaporation Will Increase

By 2050s

5 – 10 %

By 2090s

15 – 25 %
Additional Evaporation per Primary Catchment from Open Water Bodies (dams, rivers, wetlands) by 2050s (light) and 2090s (dark)

All, except Orange
Changes in Groundwater Recharge
Intermediate Future : Present

Median Year

Dry Year

Wet Year
Irrigation Water Demand

1. We Know Present Demand

2. What Median Changes in Future? Winners & Losers

3. At Different Levels of Confidence
Torrential Rains.. Massive Floods
Durban, 11 December 2009
Projected Changes in Short Duration (10 min – 24 h) Design Rainfall

Average of Ratio of Changes
Short Duration (10 min - 24h) Design Rainfall
All Return Periods
Intermediate to Present, Multiple GCMs.

Ratio
- < 0.80
- 0.80 - 0.90
- 0.90 - 1.00
- No Change
- 1.00 - 1.10
- 1.10 - 1.20
- 1.20 - 1.40
- 1.40 - 1.60
- 1.60 - 2.00
- > 2.00

GCMs:
- CGCM3.1/T47
- CNRM-CM3
- ECHAM5/MIROC-OM
- IPSL-CM4

Intermediate:
- 2046 - 2065
Present:
- 1971 - 1990

Average of Ratio of Changes
Short Duration (10 min - 24h) Design Rainfall
All Return Periods
Future to Present, Multiple GCMs.

Average of Ratio of Changes
Short Duration (10 min - 24h) Design Rainfall
All Return Periods
Future to Intermediate, Multiple GCMs.
More Tropical Cyclones & Cut-Off Lows... Signs of Climate Change...?

Durban, March 2007

March 2007
Median of Ratio Changes
Highest Annual Streamflow in 10 Years
Intermediate Future: Present
Multiple GCMs

<table>
<thead>
<tr>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.70</td>
</tr>
<tr>
<td>0.70 - 0.80</td>
</tr>
<tr>
<td>0.80 - 0.90</td>
</tr>
<tr>
<td>0.90 - 1.00</td>
</tr>
<tr>
<td>No Change</td>
</tr>
<tr>
<td>1.00 - 1.10</td>
</tr>
<tr>
<td>1.10 - 1.20</td>
</tr>
<tr>
<td>1.20 - 1.30</td>
</tr>
<tr>
<td>1.30 - 2.00</td>
</tr>
<tr>
<td>&gt; 2.00</td>
</tr>
</tbody>
</table>

GCMs:
CGCM3.1(T47)
CNRM-CM3
ECHAM5/MPI-OM
IPSL-CM4
Hydrological Model: ACRU
Present: 1971 - 1990
Intermediate: 2046 - 2065
Projected Changes in Transboundary Flow Characteristics: Sabie INTO Moçambique

**SABIE (QUINARY CATCHMENT 5826)**

**PROJECTED CHANGES IN**

MONTHLY ACCUMULATED STREAMFLOWS

**STANDARD DEVIATIONS OF MONTHLY STREAMFLOWS**

- **AVG PRE**
- **AVG INT**
- **AVG FUT**
Water Temperatures are Projected to Increase Significantly into the Future
What Consequences in S.Africa?
WHERE TO IN THE FUTURE?

Facing some big issues in climate change
FACING THE BIG ISSUES IN CLIMATE CHANGE

We need to become practical in enhancing adaptive capacity to climate change in the water related sectors.
On Adaptation...

Categories to be Considered in Enhancing Adaptive Capacity to CC in the Water Sector

1. Knowledge and Skills Participation
2. Policy Instruments
3. Risk Sharing / Spreading
4. Enhancing Adaptive Capacity via Technological and Structural Change
5. Changes in Uses/Activities/Location
On Adaptation…2
Categories to be Considered…

1. Enhancing Adaptive Capacity via Technology / Structures
   a. Storage & Reticulation (e.g. Surface; Groundwater; System Maintenance; Rainwater Harvesting)
   b. Desalination
   c. Flood / Storm Surge Control
   d. Early Warning Systems
   e. Communication
   f. Operations / Systems Improvement
   g. Water Demand Management
   h. Indigenous Coping
   i. Precipitation Enhancement
On Adaptation... 

Categories to be Considered...

2. Knowledge, Skills and Participation

a. Research and Development
   i. Efficient technologies
   ii. Upgrade climate modelling
   iii. Upgrade downscaling / RCMs
   iv. Improve forecasting skills / dissemination

b. Develop Risk Maps / Floodlines

c. Communication / Training / Dissemination

d. Participatory Approach in Decision-Making
3. Risk Sharing / Spreading

a. Private Sector Strategies

i. Insurance

* Primary insurance
* Re-insurance
* Micro-insurance

ii. Banks

* Development Banks
* Private Banks
* Micro-lenders

b. Public Sector Strategies

* Flood and Drought Relief
On Adaptation...5

Role Players in the SA Water Sector for whom CC Adaptation is Important

1. National Water Planners (e.g. DWA)
2. Regional Water Planners (e.g. CMAs)
3. Bulk Water Suppliers (e.g. Umgeni Water)
4. Municipalities (e.g. eThekwini-Durban)
5. Disaster Risk Management (National, Provincial, Local)
6. Insurance Industry (e.g. Santam)
7. Irrigated Agriculture (e.g. Pongola Irrigation Board)
8. Rainfed Agriculture, incl. Forestry (e.g. Mondi, SAAU)
9. Poor Rural Communities
10. Informal Urban Settlements (e.g. Khayalitsha)
11. Individual Households
12. Thermal Electric Power Utilities (e.g. Eskom)
13. Hydro-Electric Power (e.g. Gariep Dam, LHDA)
14. Transport Sector (e.g. SANRAL, Provincial)
On Adaptation...6

What are we Adapting to in the SA Water Sector?

1. Flash Floods
2. Regional Floods
3. Agricultural Droughts
4. Hydrological Droughts
5. Surface Water Supply
6. Groundwater Supply
7. Water Quality Deterioration
8. Design Precipitation
9. Design Hydrology (peaks, hydrographs)
10. Sea Level Rise
11. Storm Surges
12. Environmental Issues
### ENHANCING ADAPTIVE CAPACITY

<table>
<thead>
<tr>
<th>TECHNOLOGICAL AND STRUCTURAL</th>
<th>COPING WITH / ADAPTING TO?</th>
<th>CROSS REFERENCES TO SCHULZE (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Storage and Reteculation</strong></td>
<td>- Flash Floods</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Surface water</td>
<td>- Regional Floods</td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- Large Reservoirs</td>
<td>- Hydrological Droughts</td>
<td>Ch 5.5, 6.1, 6.2, 8.1, 8.2</td>
</tr>
<tr>
<td>- <strong>Early Warning Systems</strong></td>
<td>- Agricultural Droughts</td>
<td>Ch 4.2, 6.1, 6.2, 8.2</td>
</tr>
<tr>
<td>- Short-Term (Days to Weeks)</td>
<td>- Surface Water Supply</td>
<td>Ch 5.5, 6.1, 6.2, 8.1, 8.2</td>
</tr>
<tr>
<td>- Medium-Term (Month to Season)</td>
<td>- Storm Surges</td>
<td>Ch 4.2, 6.1, 6.2, 8.2</td>
</tr>
<tr>
<td>- Long-Term (Years to Decades)</td>
<td>- Groundwater Supply</td>
<td>Ch 5.5, 6.1, 6.2, 8.1, 8.2</td>
</tr>
<tr>
<td>- <strong>Operations / System Improvements</strong></td>
<td>- Hydrological Droughts</td>
<td>Ch 5.5, 6.1, 6.2, 8.1, 8.2</td>
</tr>
<tr>
<td>- Reservoir Operations Rules</td>
<td>- Agricultural Droughts</td>
<td>Ch 5.5, 6.1, 6.2, 8.1, 8.2</td>
</tr>
<tr>
<td>- <strong>Water Demand Management</strong></td>
<td>- Groundwater Supply</td>
<td>Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4</td>
</tr>
<tr>
<td></td>
<td>- Surface Water Supply</td>
<td>Ch 5.3</td>
</tr>
<tr>
<td></td>
<td>- Water Quality</td>
<td>Ch 5.7, 8.3</td>
</tr>
</tbody>
</table>

### KNOWLEDGE / SKILLS / PARTICIPATION

<table>
<thead>
<tr>
<th>COPING WITH / ADAPTING TO?</th>
<th>CROSS REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Research and Development</strong></td>
<td>- Efficient Technologies</td>
</tr>
<tr>
<td>- Upgrading of Climate Models</td>
<td>- Regional Floods</td>
</tr>
<tr>
<td>- Improvements to Downscaling / RCMs</td>
<td>- Hydrological Droughts</td>
</tr>
<tr>
<td>- Improvement of Forecast Skill / Dissemination</td>
<td>- Agricultural Droughts</td>
</tr>
<tr>
<td>- Development of Risk Maps / Floodlines</td>
<td>- Groundwater Supply</td>
</tr>
<tr>
<td>- <strong>Communication / Training / Dissemination</strong></td>
<td>- Surface Water Supply</td>
</tr>
<tr>
<td>- Participatory Approach in Decision Making</td>
<td>- Water Quality</td>
</tr>
<tr>
<td></td>
<td>- Regional Floods</td>
</tr>
</tbody>
</table>

### POLICY INSTRUMENTS

<table>
<thead>
<tr>
<th>COPING WITH / ADAPTING TO?</th>
<th>CROSS REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>International Conventions</strong></td>
<td>-</td>
</tr>
<tr>
<td>- International Water Agreements</td>
<td>-</td>
</tr>
<tr>
<td>- International Trade</td>
<td>-</td>
</tr>
<tr>
<td>- National Water Master Plans</td>
<td>-</td>
</tr>
<tr>
<td>- National Water Act of 1998</td>
<td>-</td>
</tr>
<tr>
<td>- NWRS</td>
<td>-</td>
</tr>
<tr>
<td>- Other National Master Plans</td>
<td>-</td>
</tr>
<tr>
<td>- National Environmental Management Act</td>
<td>-</td>
</tr>
<tr>
<td>- Conservation of Agric Resources Act (CARA)</td>
<td>-</td>
</tr>
<tr>
<td>- Disaster Management Policies/Plans</td>
<td>-</td>
</tr>
</tbody>
</table>

### RISK SHARING / SPREADING

<table>
<thead>
<tr>
<th>COPING WITH / ADAPTING TO?</th>
<th>CROSS REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Private Sector Strategies</strong></td>
<td>-</td>
</tr>
<tr>
<td>- Banks</td>
<td>-</td>
</tr>
<tr>
<td>- Development</td>
<td>-</td>
</tr>
</tbody>
</table>

### CHANGE OF USE / ACTIVITY / LOCATION

<table>
<thead>
<tr>
<th>COPING WITH / ADAPTING TO?</th>
<th>CROSS REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Land Use Measures</strong></td>
<td>-</td>
</tr>
<tr>
<td>- Adaptive Spatial Planning</td>
<td>-</td>
</tr>
</tbody>
</table>

---

**Adaptation Options for National Water Planners**
## ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL

**COPING WITH / ADAPTING TO?**

<table>
<thead>
<tr>
<th>Technological and Structural</th>
<th>Cross References to Schulze (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Surface water</strong></td>
<td></td>
</tr>
<tr>
<td>- Large Reservoirs</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- <strong>Groundwater</strong></td>
<td></td>
</tr>
<tr>
<td>- Artificial Recharge</td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- Sand Dams</td>
<td>Ch 5.5, 6.1, 6.2, 8.1, 8.2</td>
</tr>
<tr>
<td>- <strong>System Maintenance</strong></td>
<td></td>
</tr>
<tr>
<td>- Supply Leakage Control</td>
<td>Ch 5.5, 6.1, 6.2, 8.1, 8.2</td>
</tr>
<tr>
<td>- <strong>Water Re-use / Recycling</strong></td>
<td></td>
</tr>
<tr>
<td>- <strong>Desalination</strong></td>
<td></td>
</tr>
<tr>
<td>- <strong>Flood / Storm Surge Control</strong></td>
<td></td>
</tr>
<tr>
<td>- Structures (i.e. Levees, Sand Bags, Wave Breaks, Planting)</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- <strong>Early Warning Systems</strong></td>
<td></td>
</tr>
<tr>
<td>- Near Real-Time (Hours to Days)</td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- Short-Term (Days to Weeks)</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Medium-Term (Month to Season)</td>
<td>Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4</td>
</tr>
<tr>
<td>- <strong>Communication of Forecasts to End Users</strong></td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- <strong>Water Quality and Quantity Monitoring Systems</strong></td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- <strong>Operations / System Improvements</strong></td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Reservoir Operations Rules</td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- <strong>Retrofitting Existing Structures</strong></td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- <strong>Water Demand Management</strong></td>
<td>Ch 5.6, 7.1</td>
</tr>
</tbody>
</table>

## KNOWLEDGE / SKILLS / PARTICIPATION

**COPING WITH / ADAPTING TO?**

<table>
<thead>
<tr>
<th>Knowledge / Skills / Participation</th>
<th>Cross References</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Research and Development</strong></td>
<td>All</td>
</tr>
<tr>
<td>- Efficient Technologies</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- <strong>Upgrading of Climate Models</strong></td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- Research and Development</td>
<td>All</td>
</tr>
<tr>
<td>- Improvement to Downscaling / RCMs</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Fine Scale Information Provision Relevant to Local Water Managers</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Communication / Training / Dissemination</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Awareness Creation at Operations Level (e.g. Senior Municipal Officials re. budget allocation and future special planning)</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Training at Local Level (e.g. Municipal WWT operators)</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Participatory Approach in Decision-Making</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Creations of Ongoing Learning and Communication Platforms between Main Water Users (e.g. WRC Reference Group meetings)</td>
<td>Ch 5.6, 7.1</td>
</tr>
</tbody>
</table>

## POLICY INSTRUMENTS

**COPING WITH / ADAPTING TO?**

<table>
<thead>
<tr>
<th>Policy Instruments</th>
<th>Cross References</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>National Water Strategies</strong></td>
<td>All</td>
</tr>
<tr>
<td>- Catchment Management Strategies</td>
<td>All</td>
</tr>
<tr>
<td>- River Management Plans</td>
<td>All</td>
</tr>
<tr>
<td>- Other National Strategies</td>
<td>All</td>
</tr>
<tr>
<td>- Integrated Development Plans (IDPs)</td>
<td>All</td>
</tr>
<tr>
<td>- Provincial Strategies</td>
<td>All</td>
</tr>
<tr>
<td>- Local Strategies</td>
<td>All</td>
</tr>
<tr>
<td>- Municipal Bye-Laws</td>
<td>All</td>
</tr>
<tr>
<td>- Disaster Management Policies / Plans</td>
<td>All</td>
</tr>
</tbody>
</table>

## RISK SHARING / SPREADING

**COPING WITH / ADAPTING TO?**

<table>
<thead>
<tr>
<th>Risk Sharing / Spreading</th>
<th>Cross References</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Private Sector Strategies</strong></td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- Re-Insurance</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- <strong>Land Use Measures</strong></td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- Conservation Structures</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Adaptive Spatial Planning</td>
<td>Ch 5.6, 7.1</td>
</tr>
<tr>
<td>- Alien Invasive Clearing Activities</td>
<td>Ch 7.2, 7.3</td>
</tr>
<tr>
<td>- Maintaining or Re-establishment of Natural Capital (e.g. wetlands, buffers etc)</td>
<td>Ch 7.2, 7.3</td>
</tr>
</tbody>
</table>
Vertical and Horizontal Integration in IWRM

Jewitt, 1998

GCM - General Circulation Model
CMA - Catchment Management Agency
CMC - Catchment Management Committee
TLC - Transitional Local Council
### RESPONSIBILITIES: GOVERNMENT, SCIENCE, INDUSTRY & COMMERCE

| a) **Invest:** in your country's scientific capacity, and grow centres of expertise |
| b) **Engage:** in communication between science and stakeholders |
| c) **Facilitate:** lower bureaucratic overheads, work trans-nationally, encourage multi-disciplinarity |
| d) **Enable:** policy, negotiation, partnerships to be effective (science informed policy) |