

# ***STATE OF WATER IN SOUTH AFRICA A Researcher's Perspective***

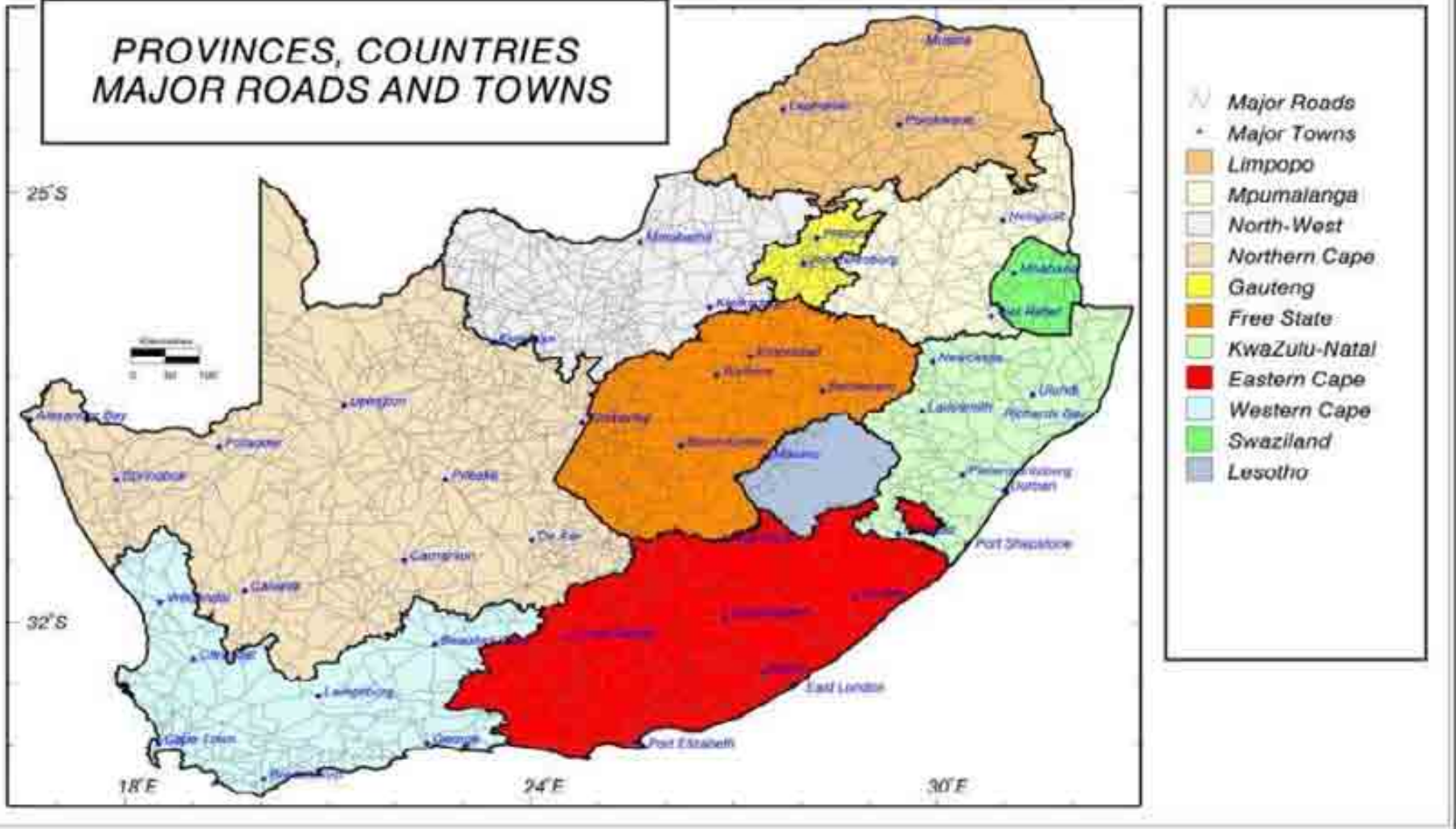
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**School of Bioresources Engineering & Environmental Hydrology  
University of KwaZulu-Natal  
Pietermaritzburg, South Africa**



**PROVINCES, COUNTRIES  
MAJOR ROADS AND TOWNS**



**1,219,090 km<sup>2</sup>; 50 mil; 11 Languages**  
**9 Provinces; 79% African, 9% White, 12%**  
**Col/Ind; 8% Tertiary Educ, 40% Primary/None**

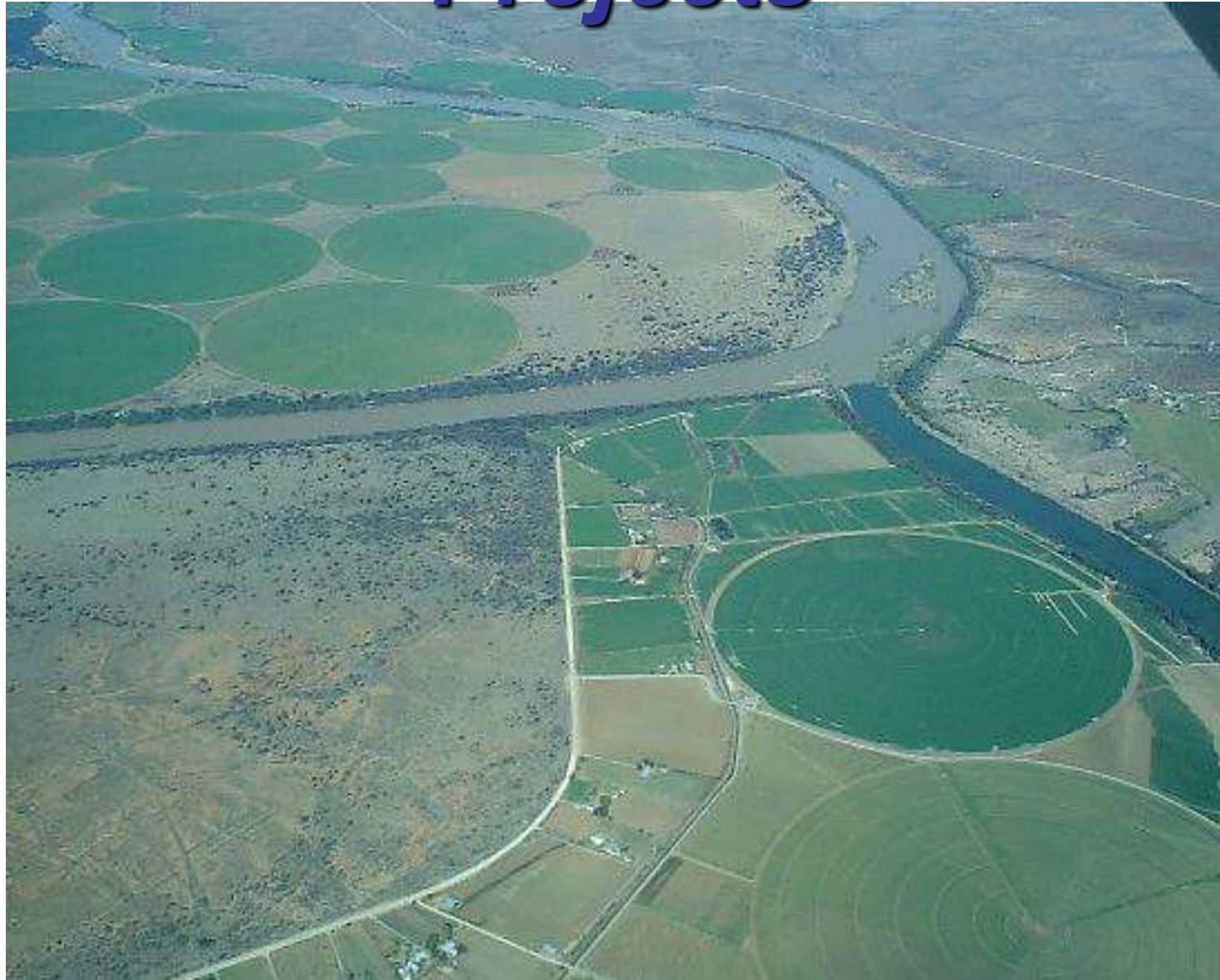
*The South African  
Water Related  
Sector ...*

*WHERE FROM?*

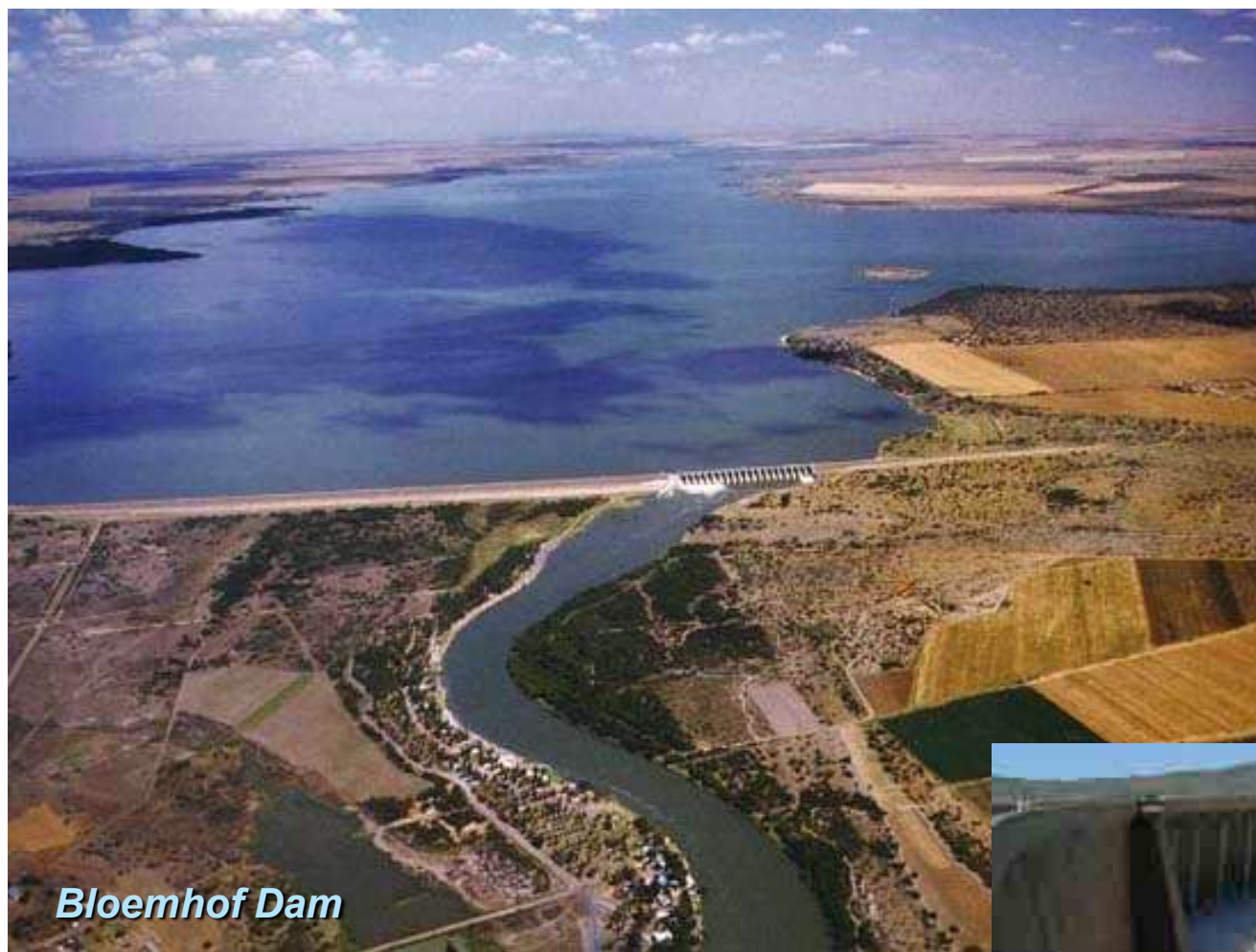
# *Water in a Country of Contrasts*



# ***...with Significant Irrigation Projects***



***Supplied  
by Huge  
Dams and  
Water  
Transfers***



***Bloemhof Dam***



***Gariiep 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*

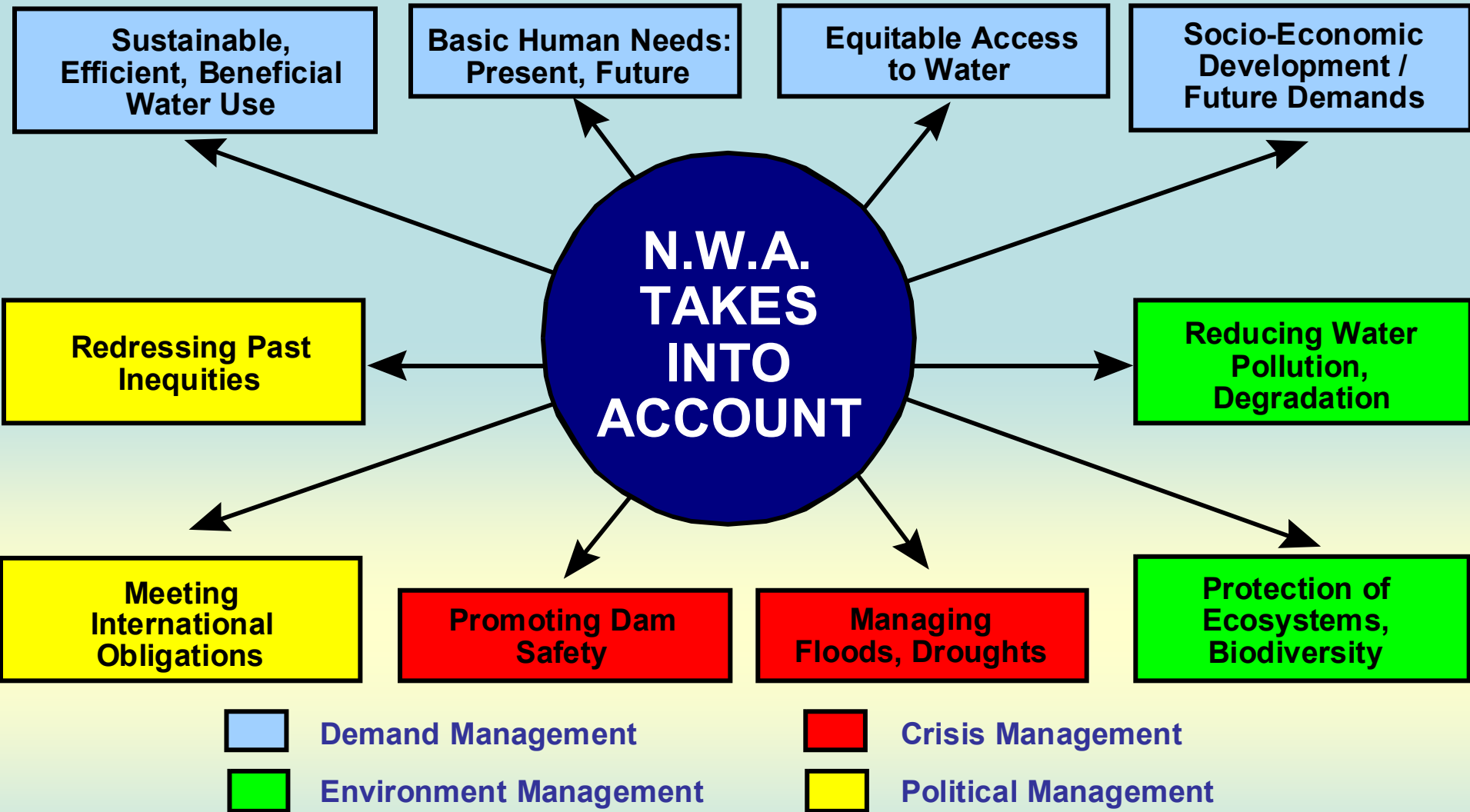


*...or Severe*

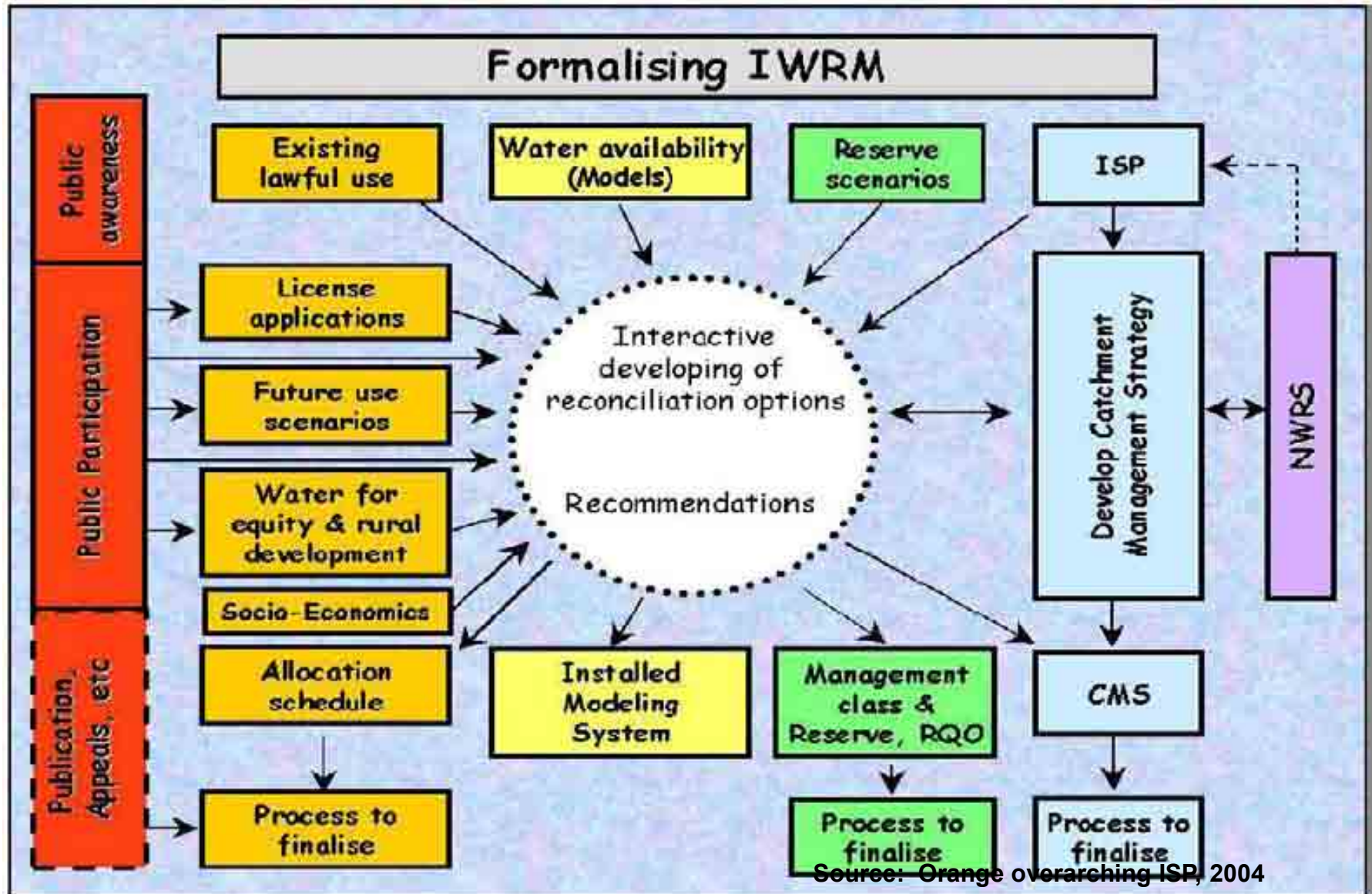
*...with  
Significant  
Hydrological  
Consequences*

*and... Many Estuaries Under Stress*  
*e.g. Orange Estuary: 25% of Natural MAR*

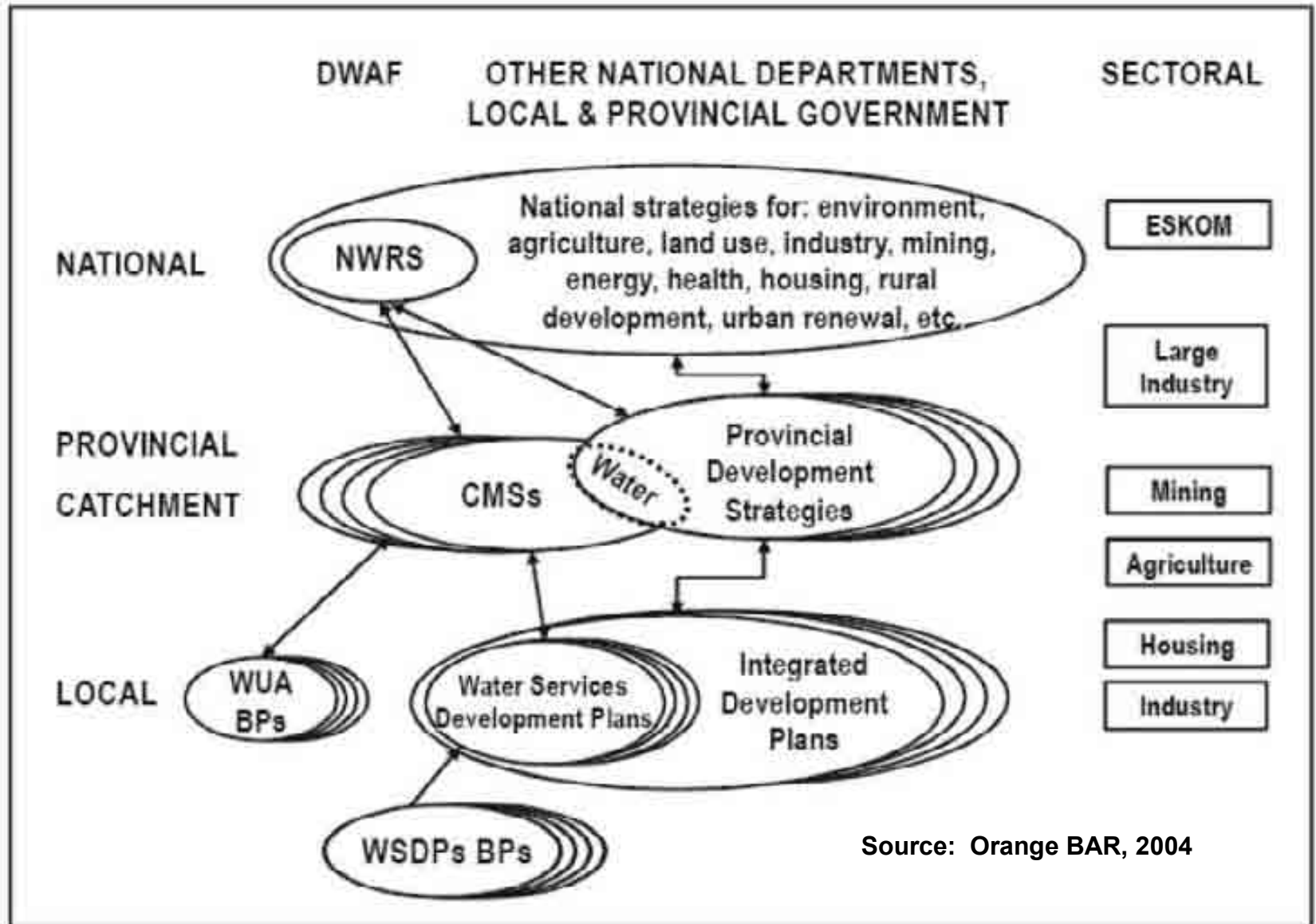




# Integrated Water Resources Management Approach in S.A.

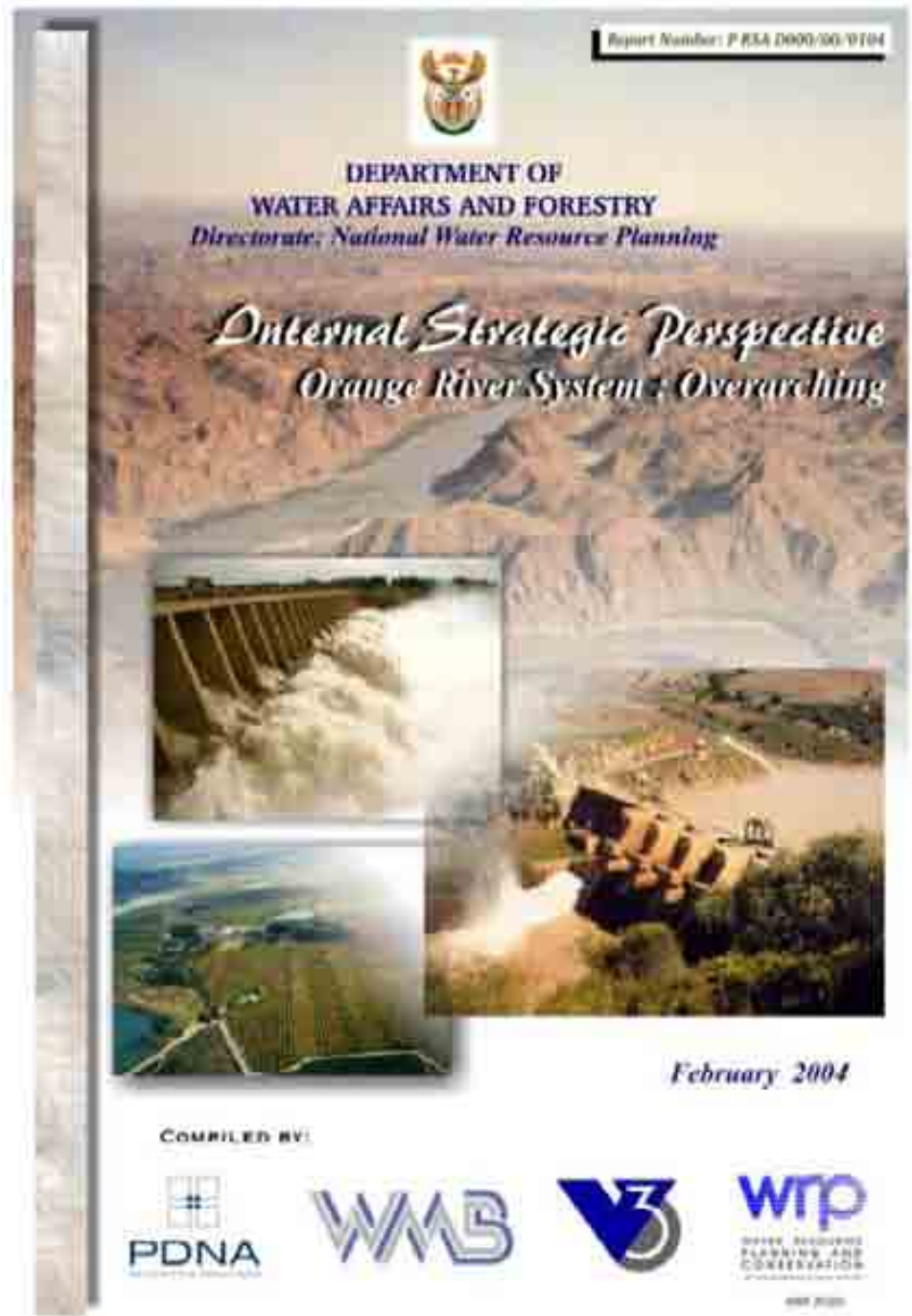


# *With Integration Planned to Transcend Various Levels of Government*



Source: Orange BAR, 2004

*Each of the  
Designated Water  
Management  
Areas has a Well-  
Documented  
Internal Strategic  
Perspective*





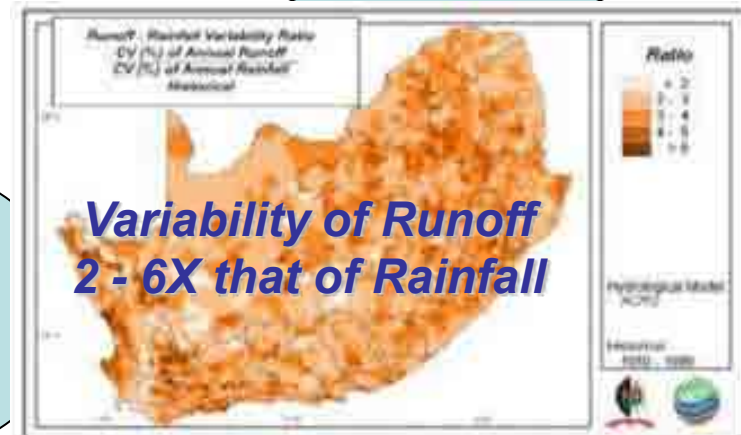
*What are the Issues  
Around the State of  
Water Security and  
Water Governance  
in South Africa?*



2. Low  
infall to Runoff  
Conversion

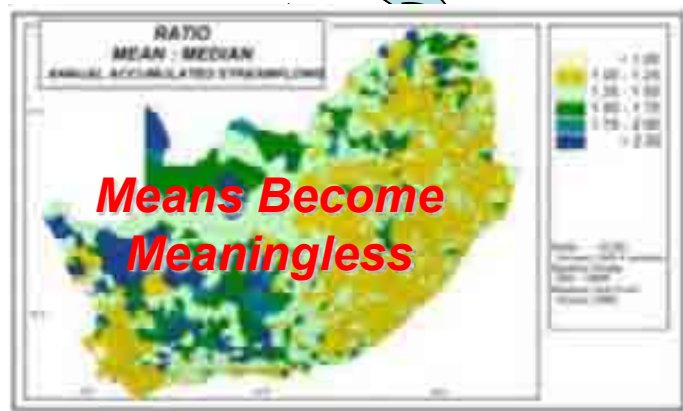


3. Hydrological  
Amplification  
of Rainfall

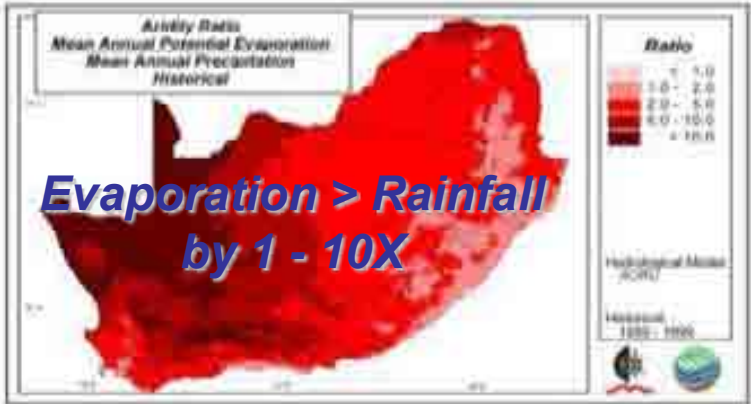


**THE PHYSICAL  
ENVIRONMENT  
Nature is Unfair**

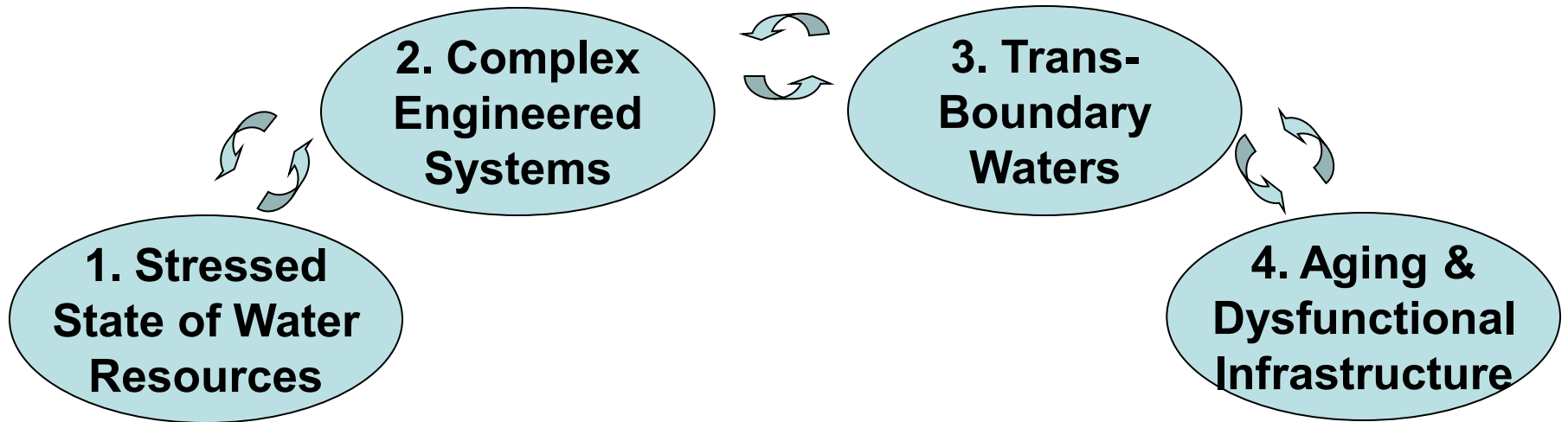
4. Outlier  
Events and  
Years



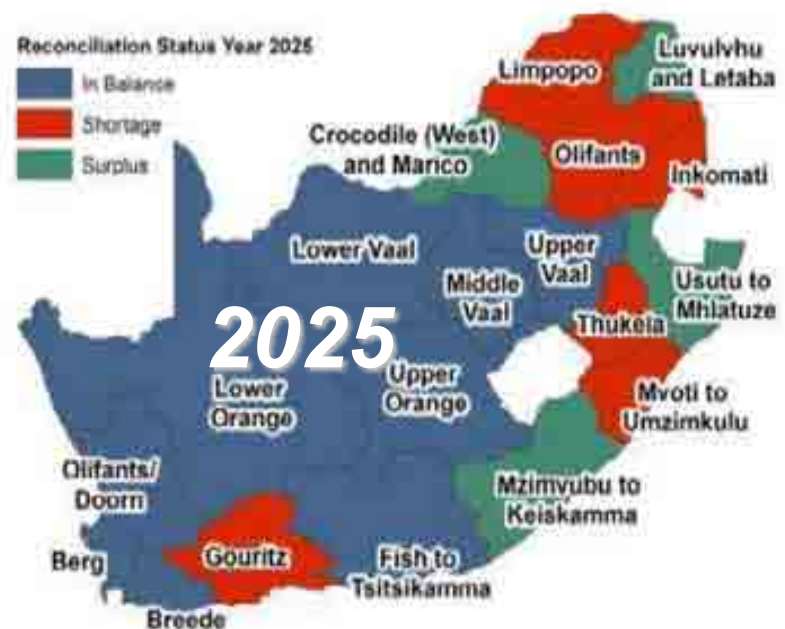
1. Semi-  
Aridity





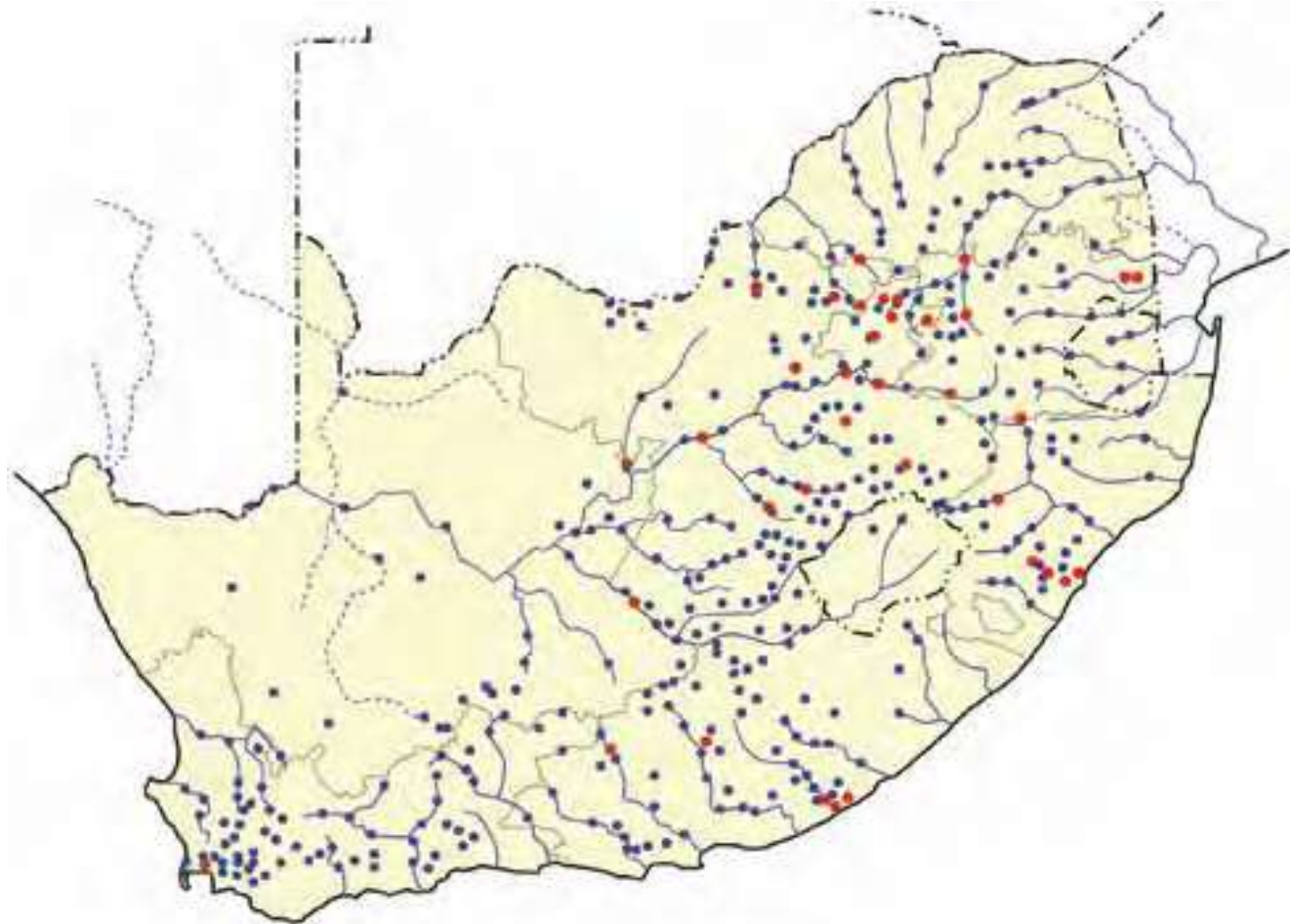


## **STATE OF WATER RESOURCES IN SOUTH AFRICA**



# Location of Large Dams

- a. 569 Large Dams**  
( $>1$  mil  $m^3$ )
- b. Total Capacity 32**  
400 mil  $m^3$
- c. Capture  $\sim 70\%$  MAR**
- d. 54 with Surface Area**  
 $> 1\ 000ha$ ; 5  $> 10\ 000ha$



# Natural Background Water Quality

(Reflecting climate, geology, soils, vegetation characteristics)

1. Clear to turbid surface waters; low salt concentrations

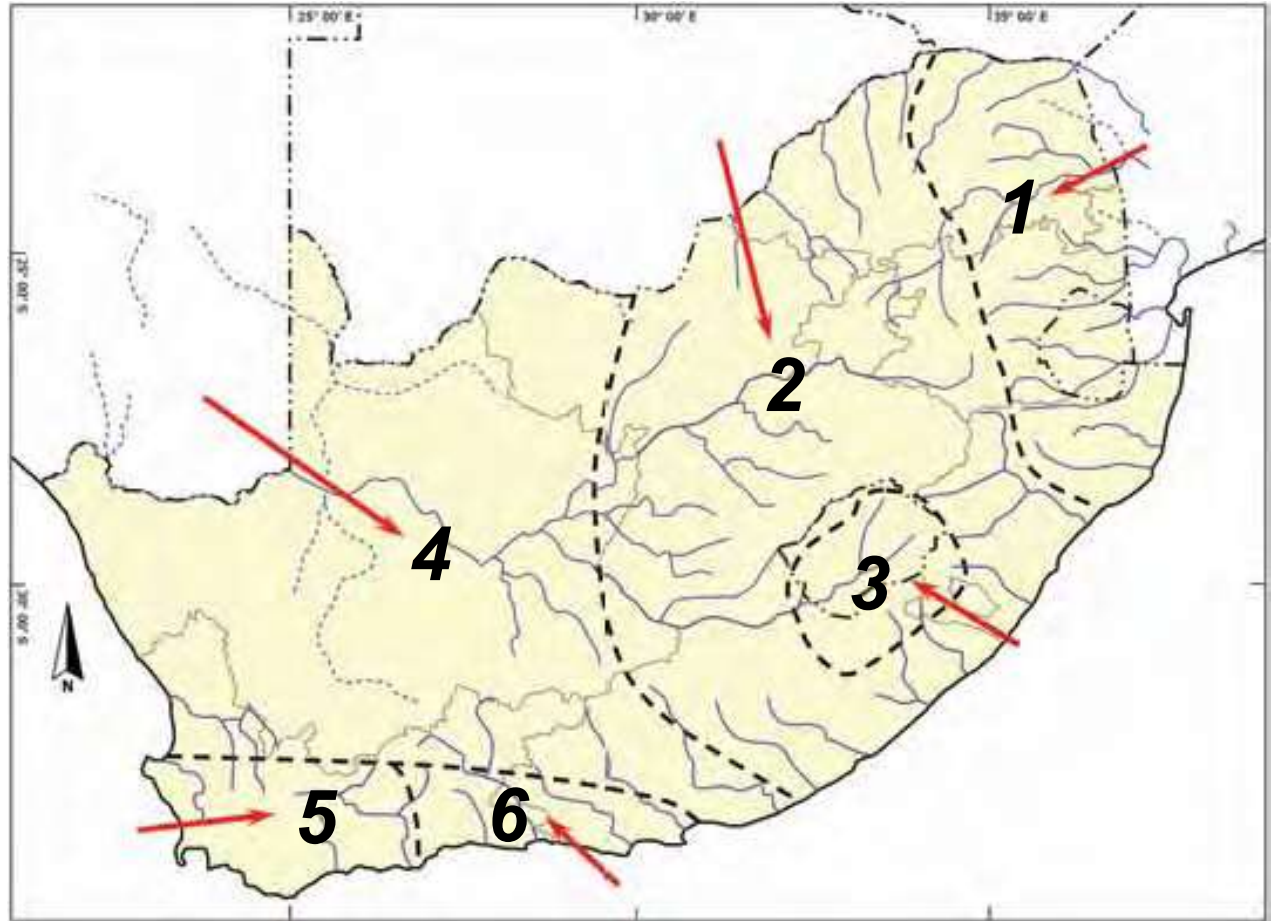
2. Mostly turbid rivers; variable salt concs

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





(Source: O-SRB – PreTDA, 2008)

# ***Alien Invasives ...in Water***



# ***Industrial Pollution***

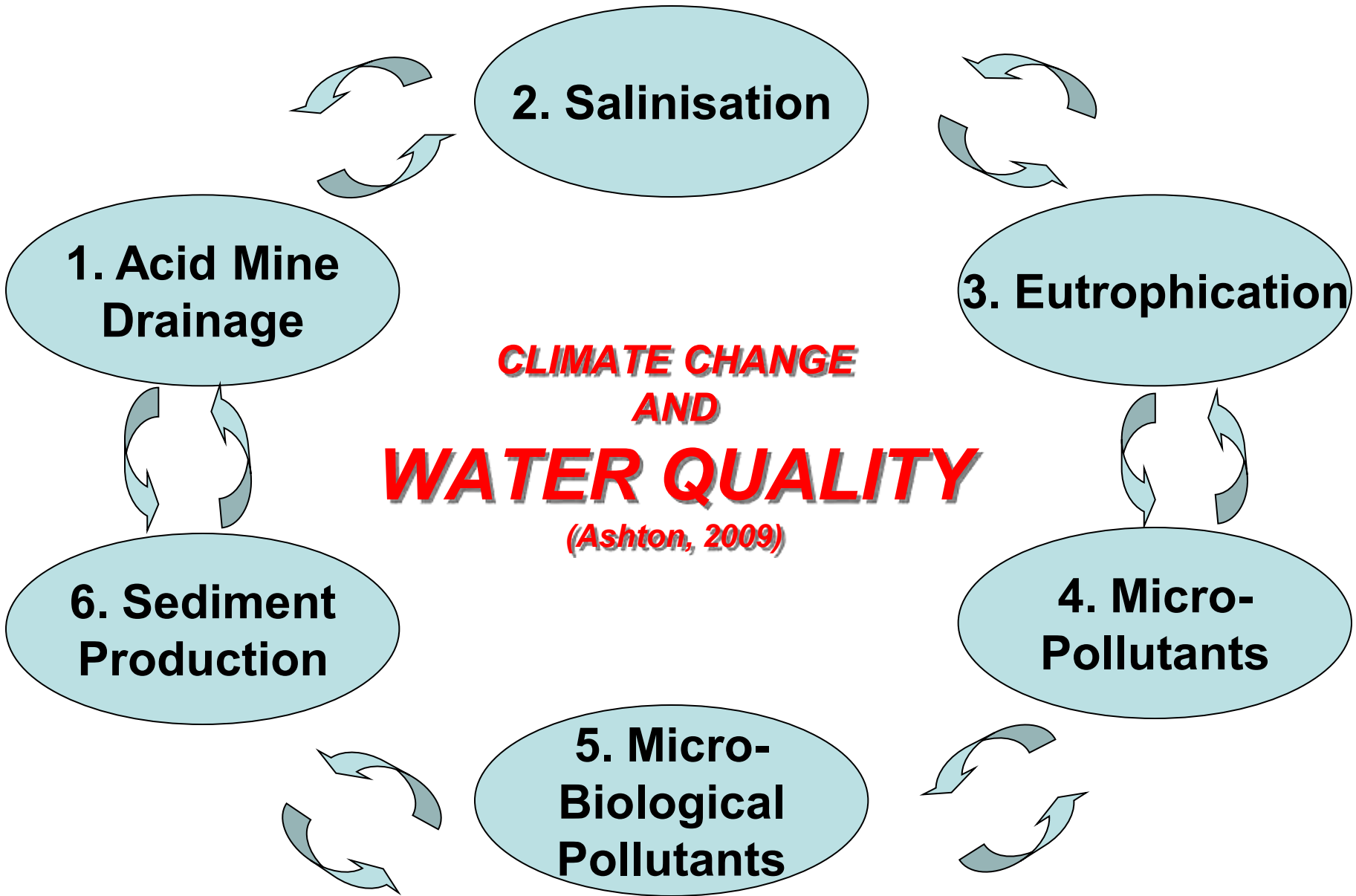


**(Source: O-SRB – PreTDA, 2008)**

# *Mining Pollution*



(Source: O-SRB – PreTDA, 2008)



**THE  
AQUATIC &  
TERRESTRIAL  
ENVIRONMENT**

**2. Challenges  
of Env Reserve**

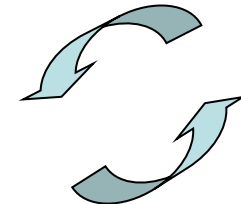
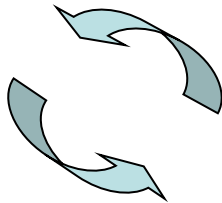
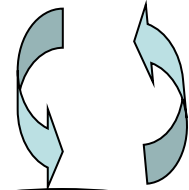
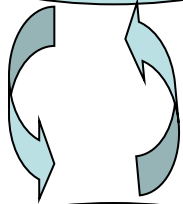
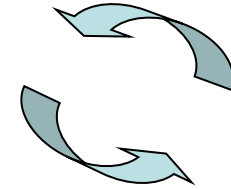
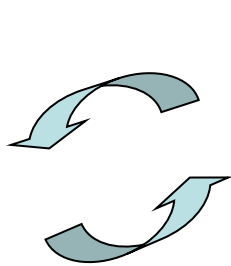
**1. Ecological  
Reserve**

**3. Pressure of  
Climate Change**

**6. On Questions  
of PES (RWS)**

**4. Alien Invasives**

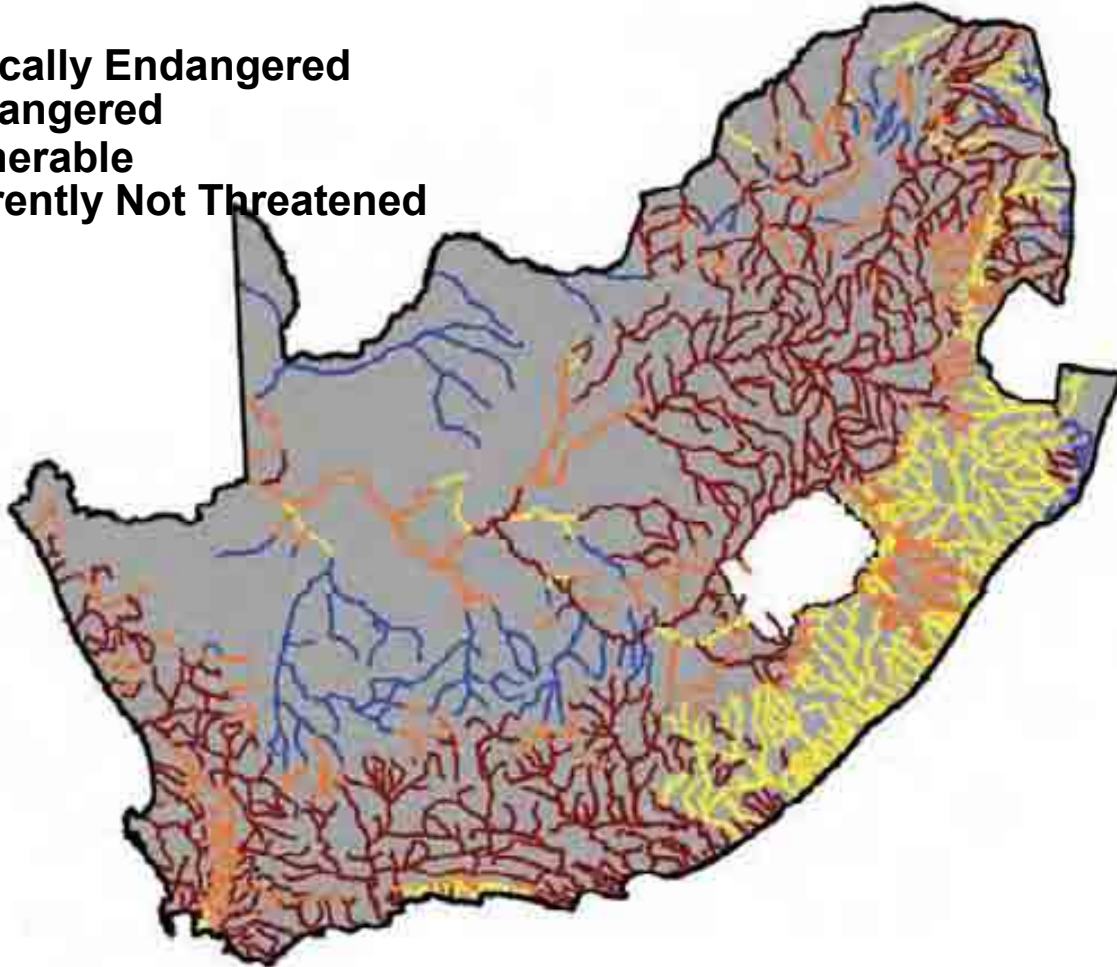
**5. Sediment  
Production**



***The aquatic environment is a  
LEGITIMATE water user and NOT a  
competing resource***

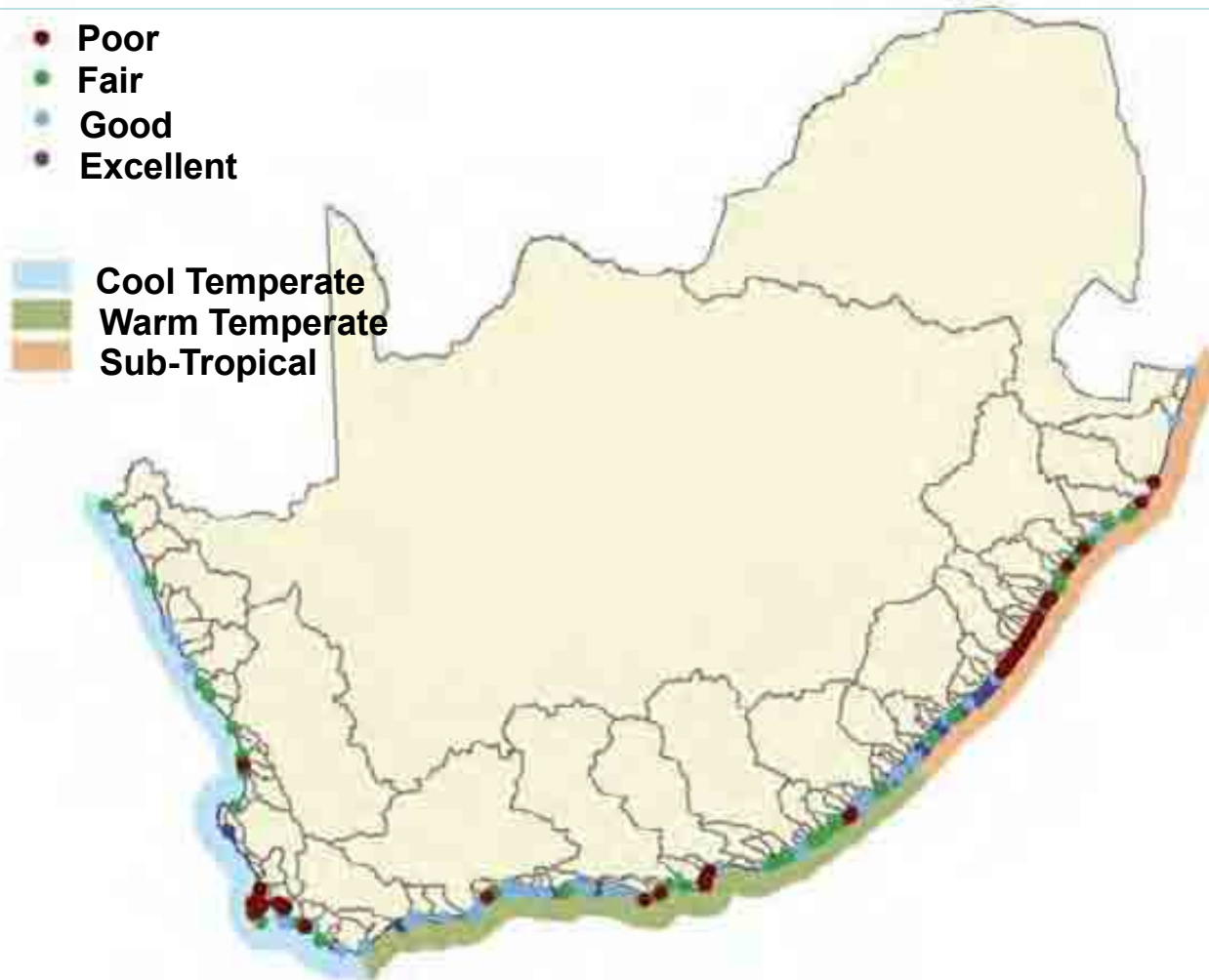
# Conservation Status of South Africa's Freshwater Ecosystems

- 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**



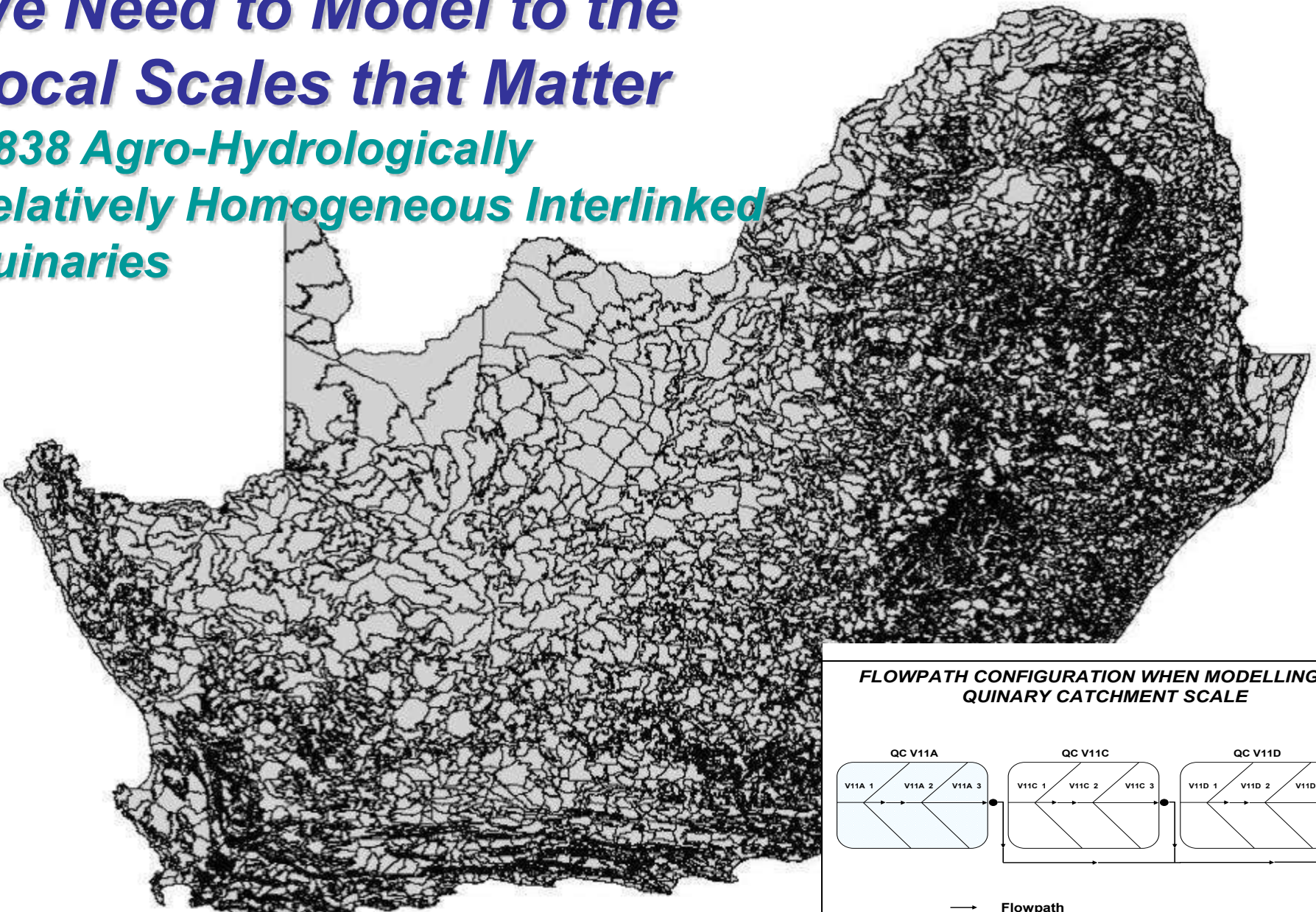


***WHERE ARE WE  
NOW?***

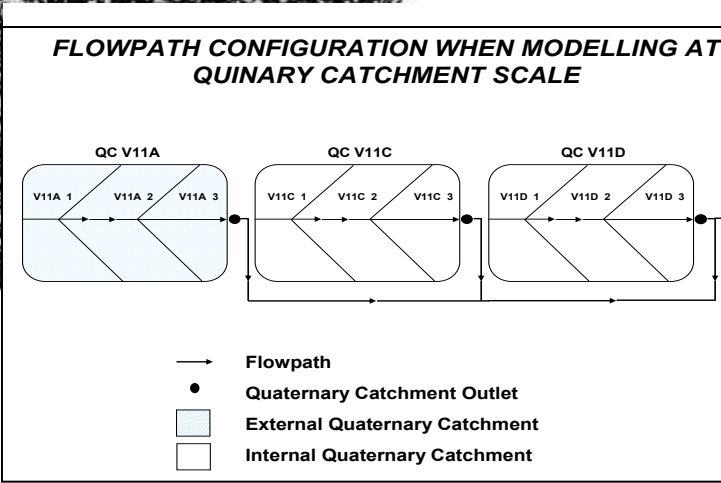
***Factoring in climate  
change***

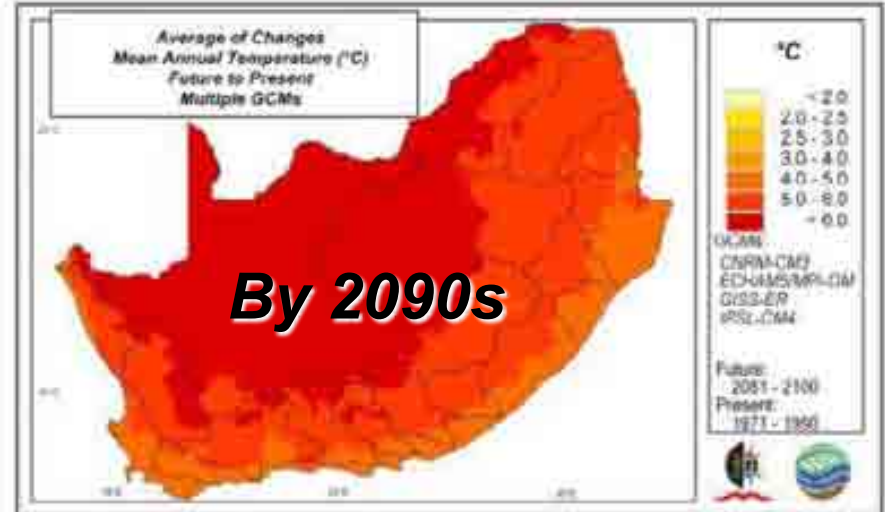
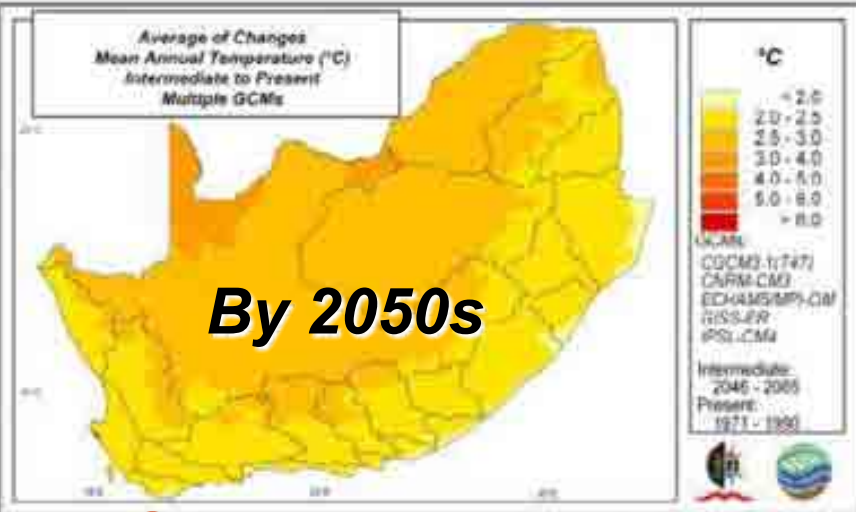
# We Need to Model to the Local Scales that Matter

5 838 Agro-Hydrologically Relatively Homogeneous Interlinked Quinaries



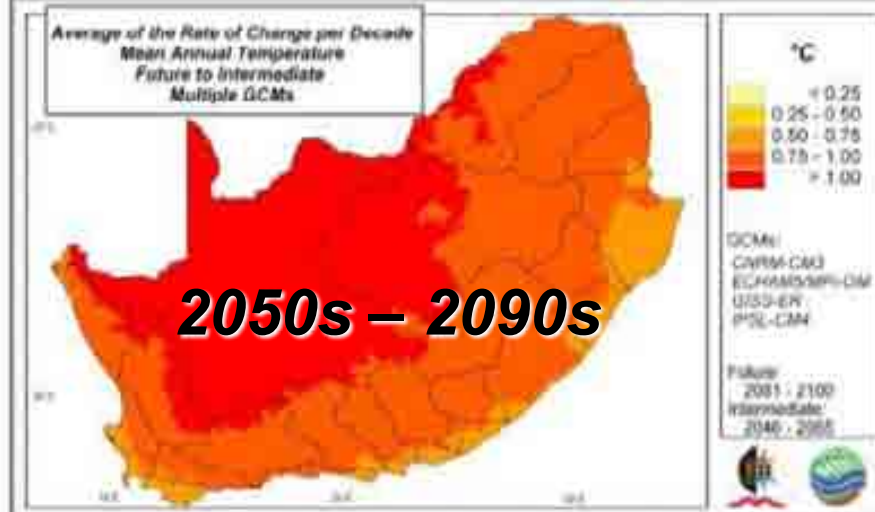
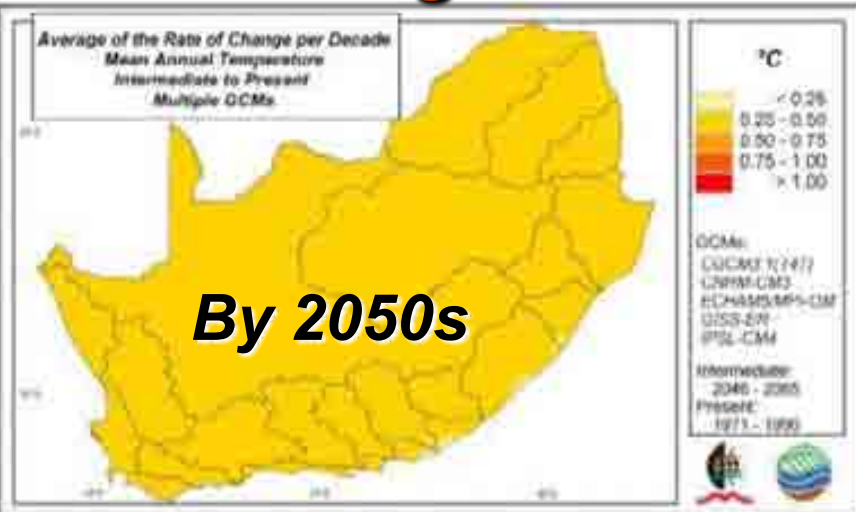
**Procedure: Jenks' Optimisation using Natural Breaks in Altitude**





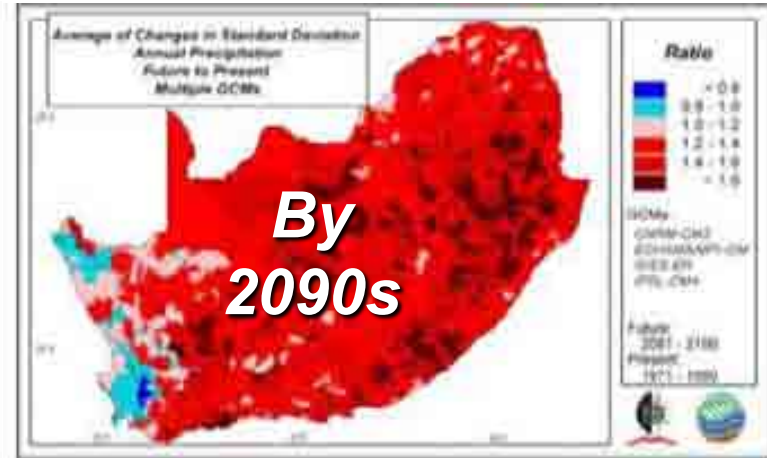
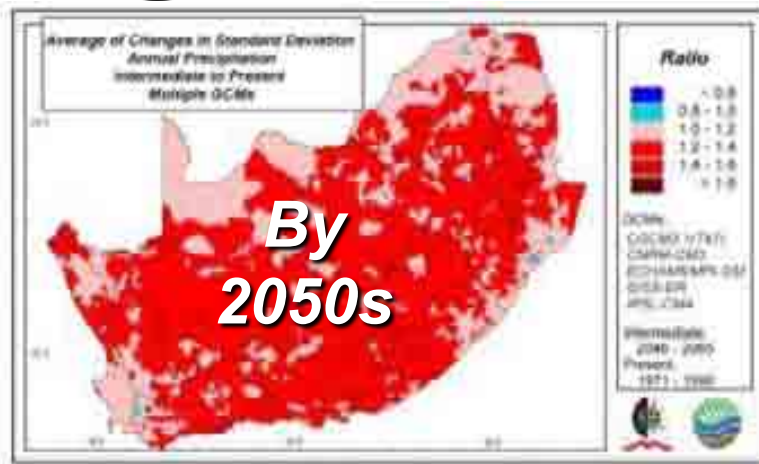
**Changes in Mean Annual Temperature are Projected to be Significant**

**With Significant Amplification Over Time**

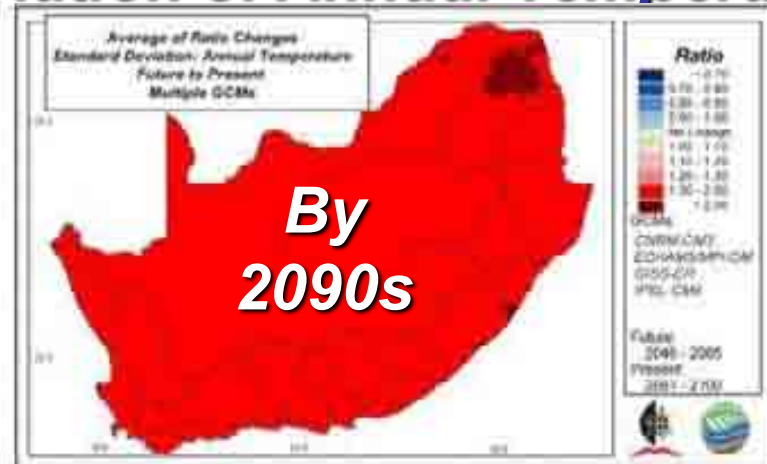
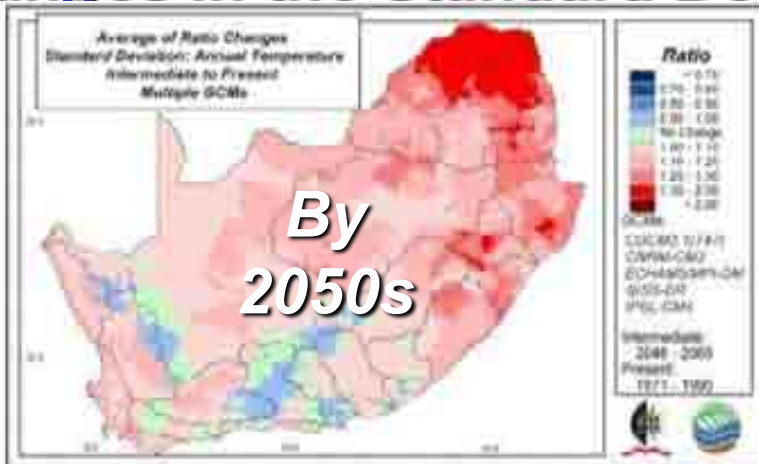


# **Future Variability will not be Stationary...the Case of Projected Temperature & Rainfall over SA**

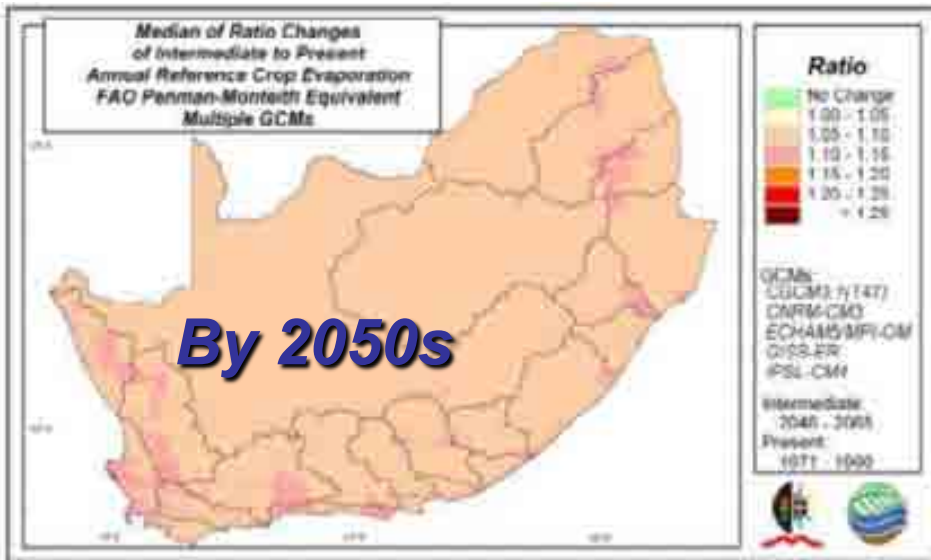
## **Changes in the Standard Deviation of Annual Rainfall**



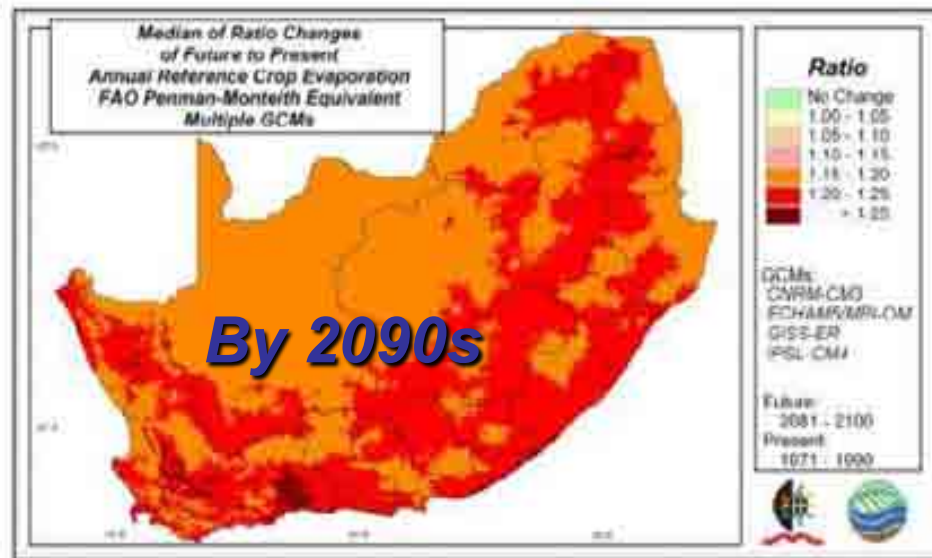
## **Changes in the Standard Deviation of Annual Temperature**



# Potential Evaporation Will Increase



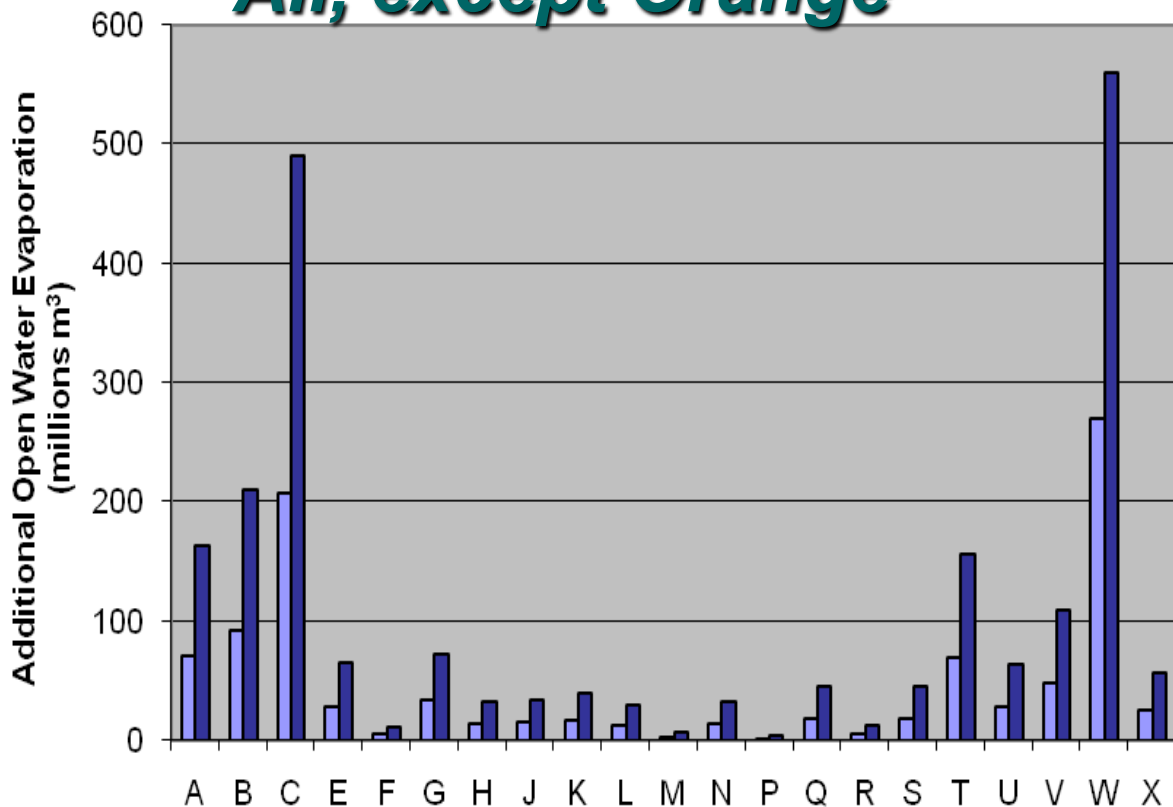
**5 - 10 %**



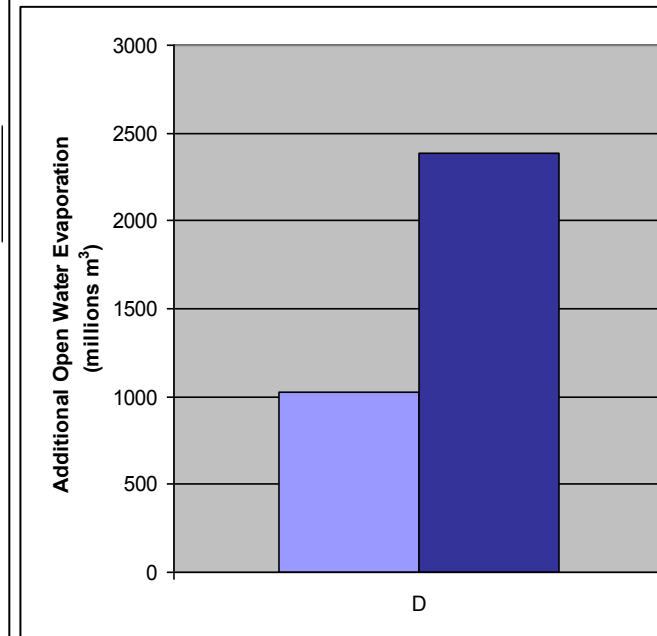
**15 - 25 %**

# ***Additional Evaporation per Primary Catchment from Open Water Bodies (dams, rivers, wetlands) by 2050s (light) and 2090s (dark)***

**All, except Orange**



**Orange**



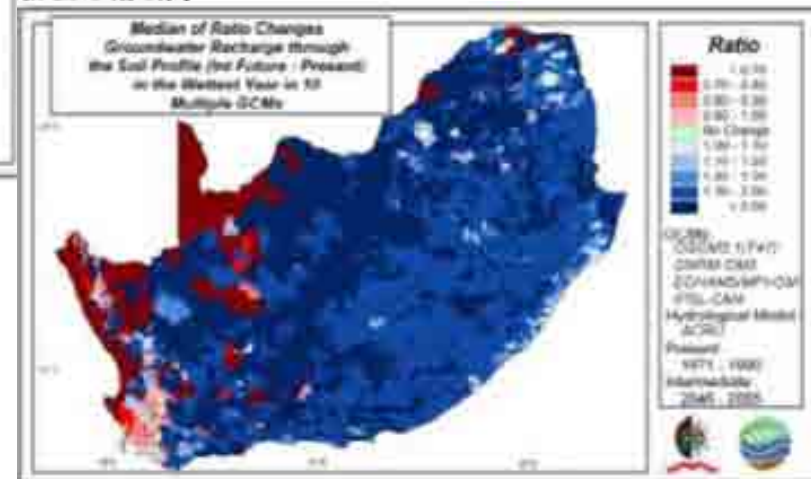
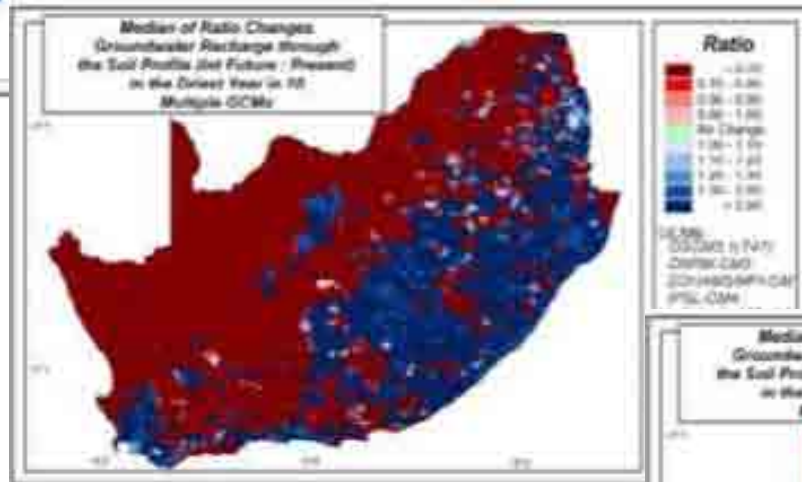
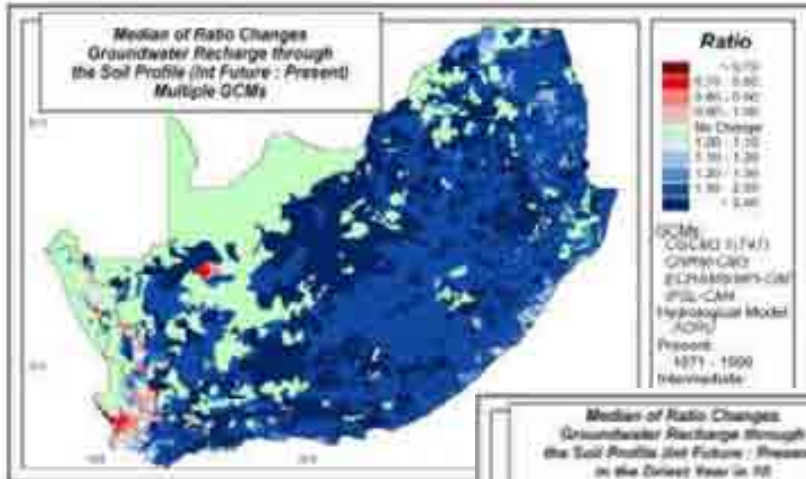
# Changes in Groundwater Recharge

## Intermediate Future : Present

Median Year

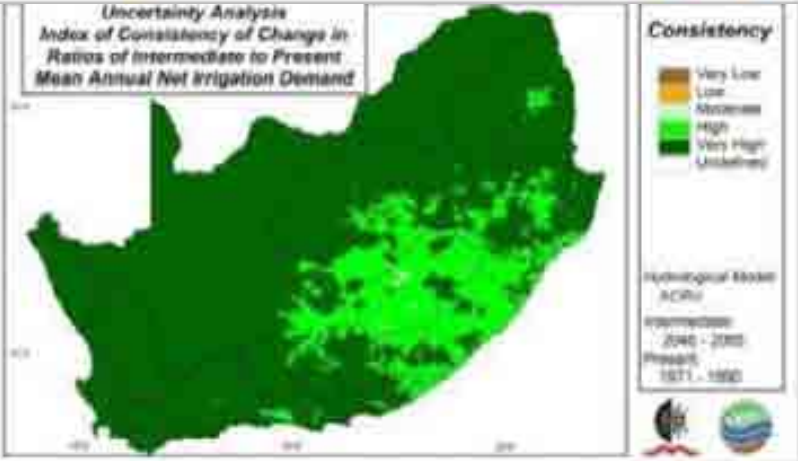
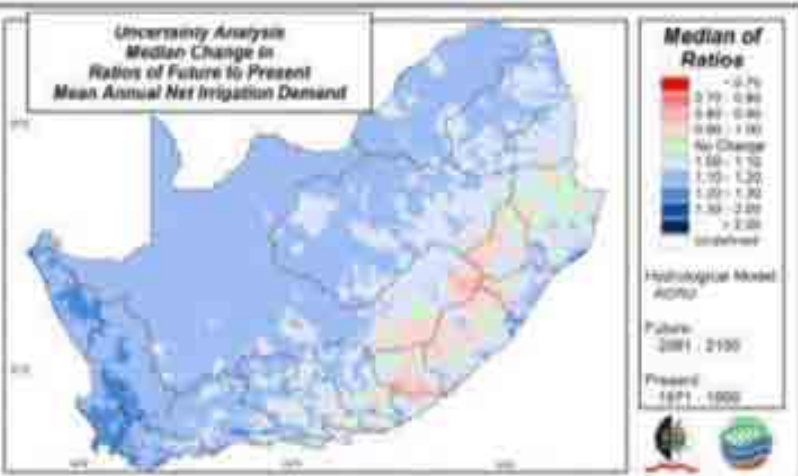
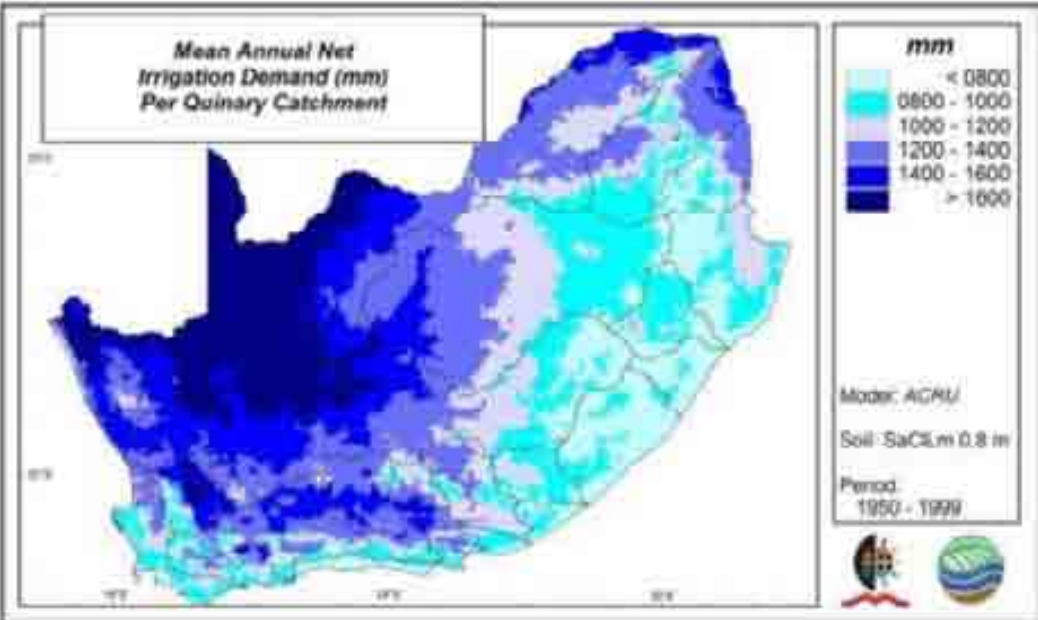
Dry Year

Wet Year



# Irrigation Water Demand

## 1. We Know Present Demand



## 2. What Median Changes in Future? Winners & Losers

## 3. At Different Levels of Confidence

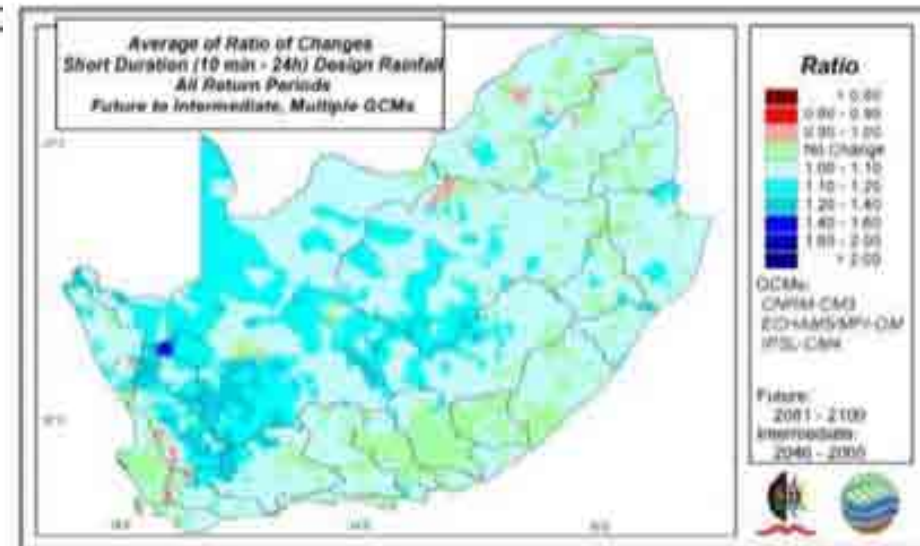
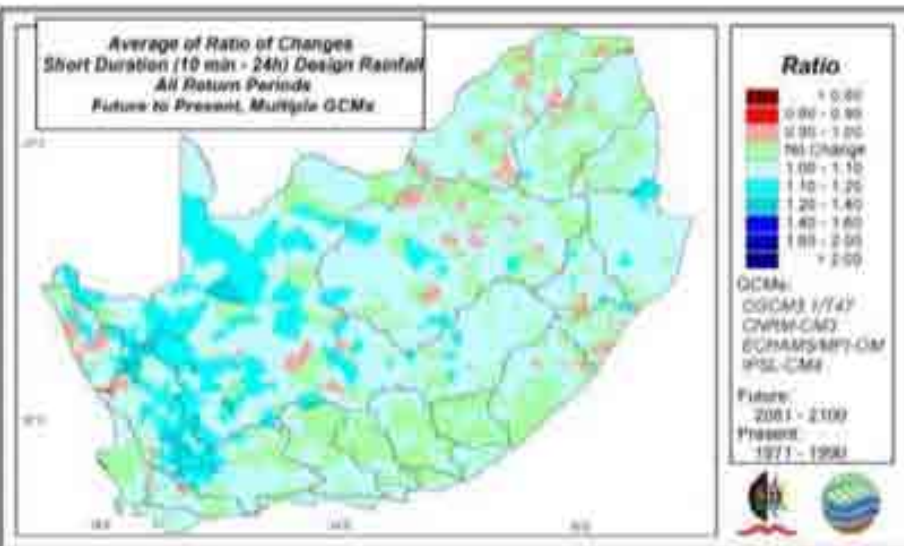
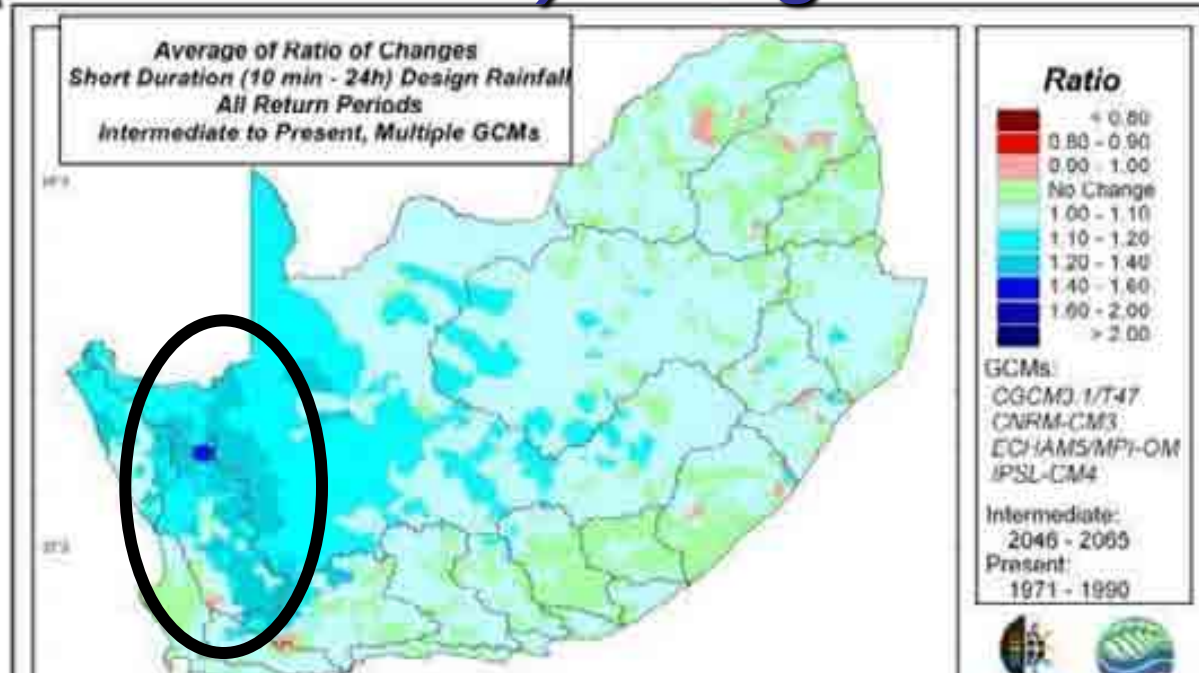


# ***Torrential Rains.. Massive Floods***

**Durban, 11 December 2009**

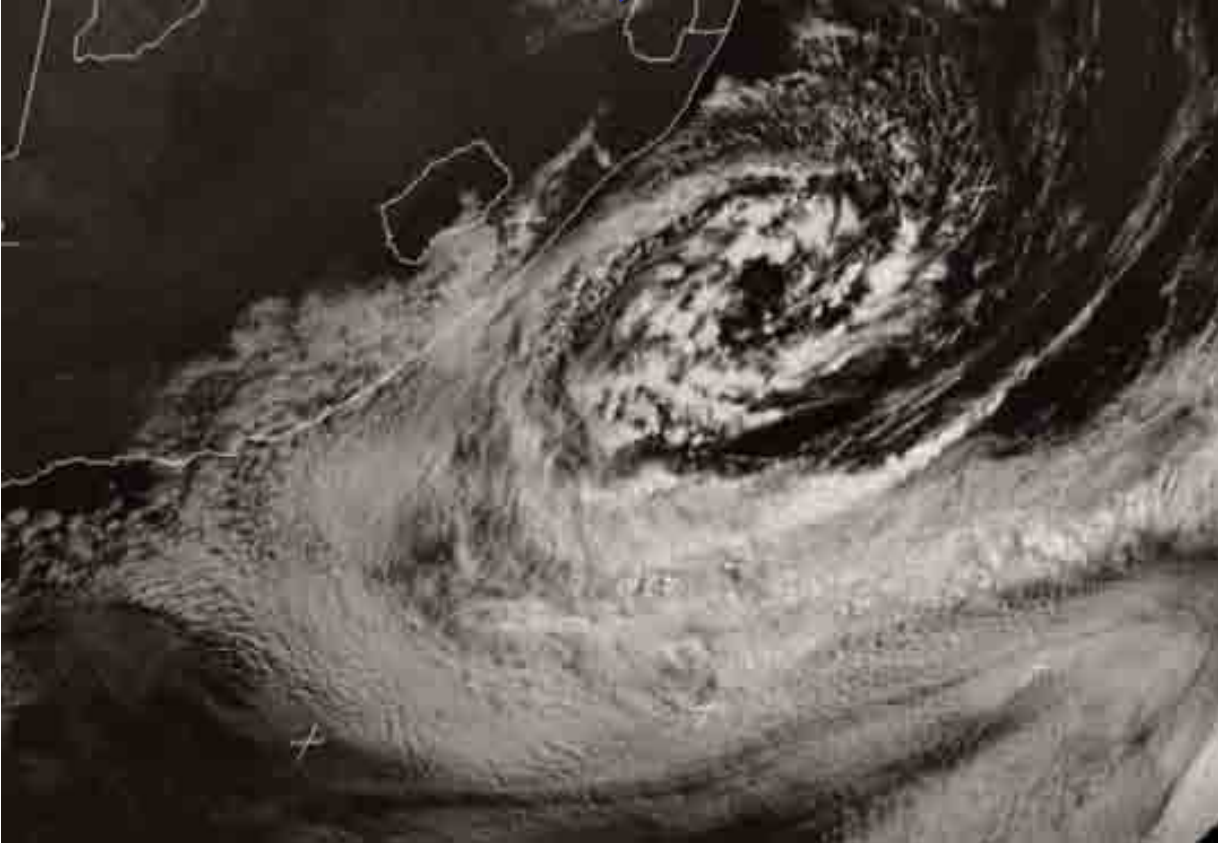


# Projected Changes in Short Duration (10 min – 24 h) Design Rainfall



# ***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**

25°S

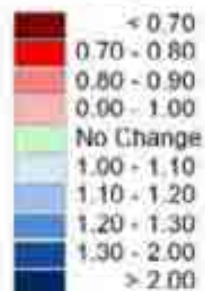
32°S

18°E

27°E

36°E

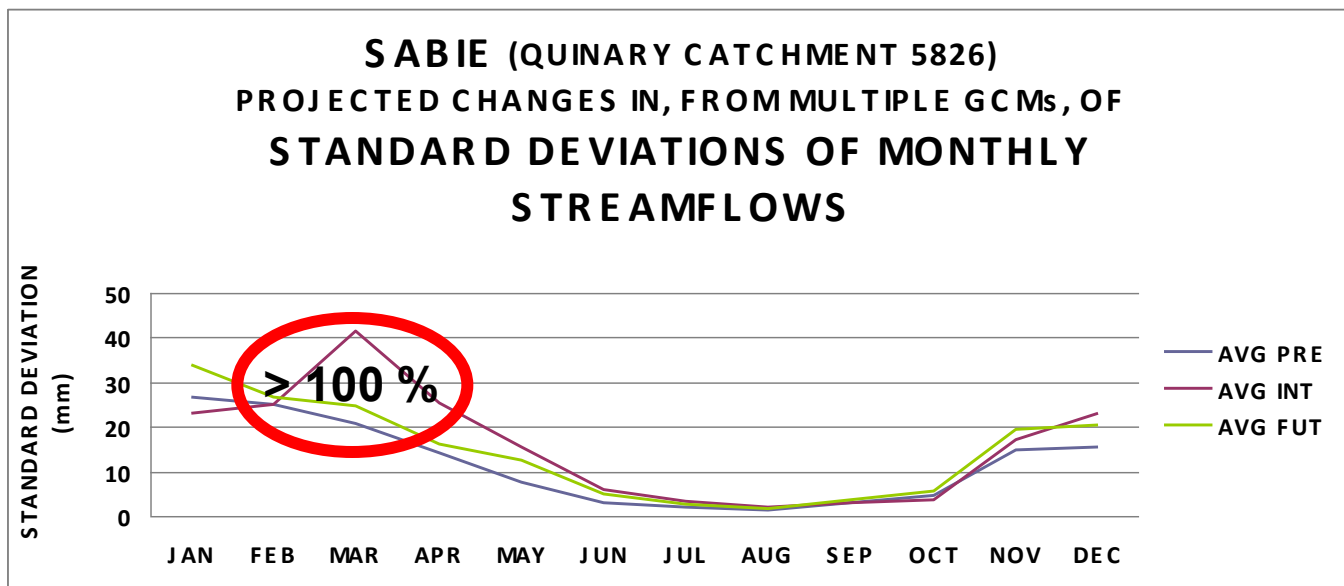
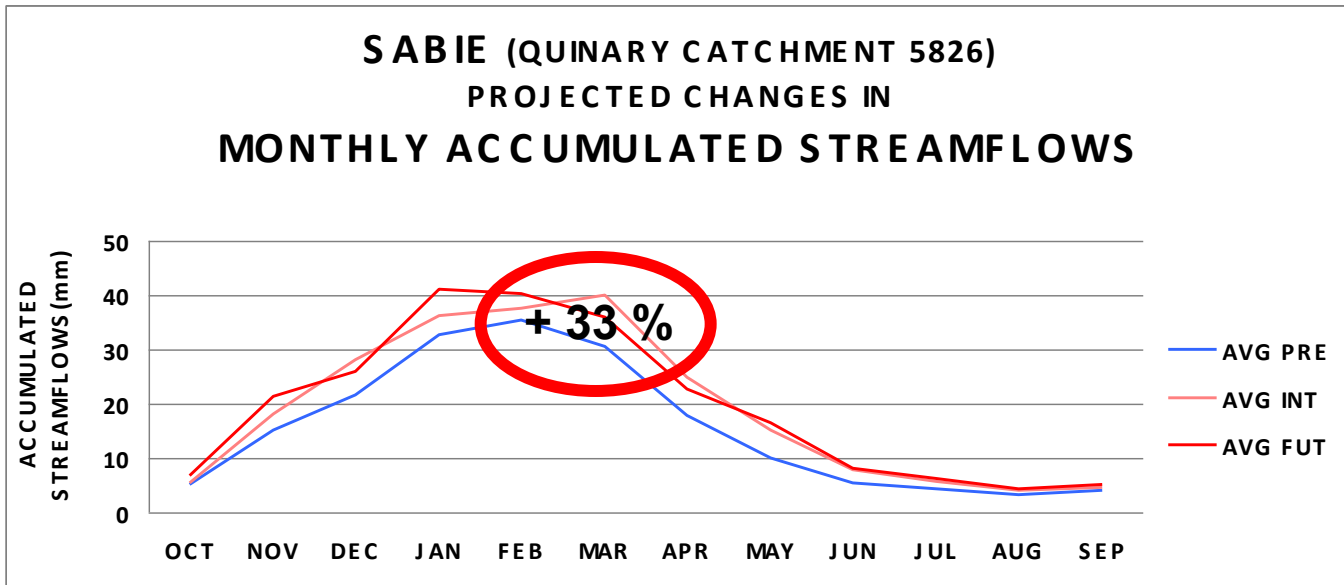
**Ratio**



GCMs:  
CGCM3.1(T47)  
CNRM-CM3  
ECHAM5/MPI-OM  
IPSL-CM4  
Hydrological Model:  
ACRU  
Present:  
1971 - 1990  
Intermediate:  
2046 - 2065

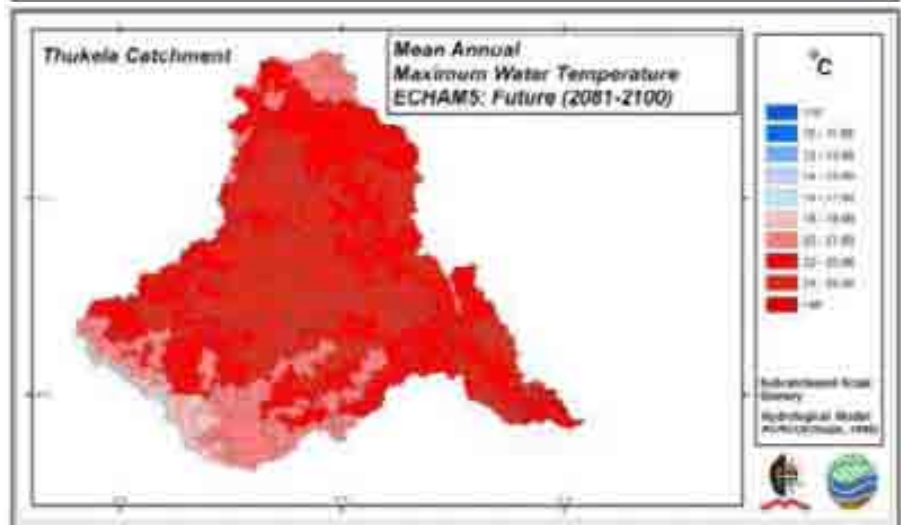
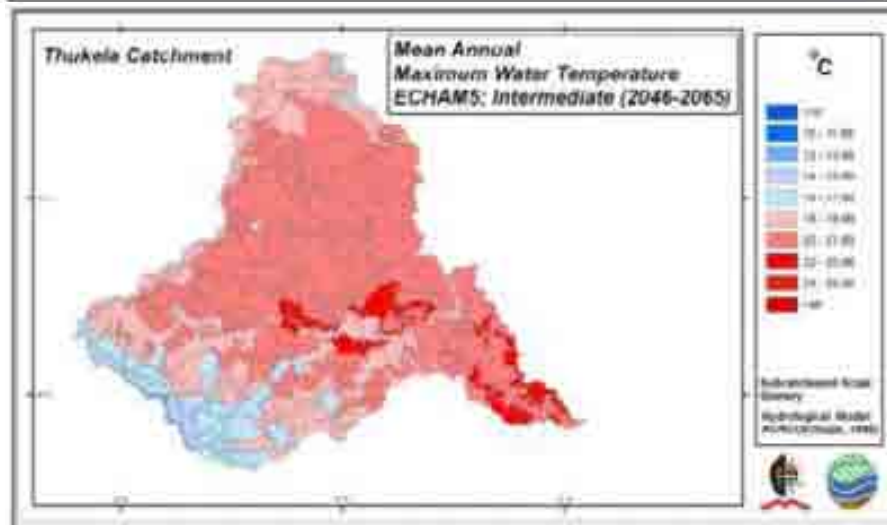
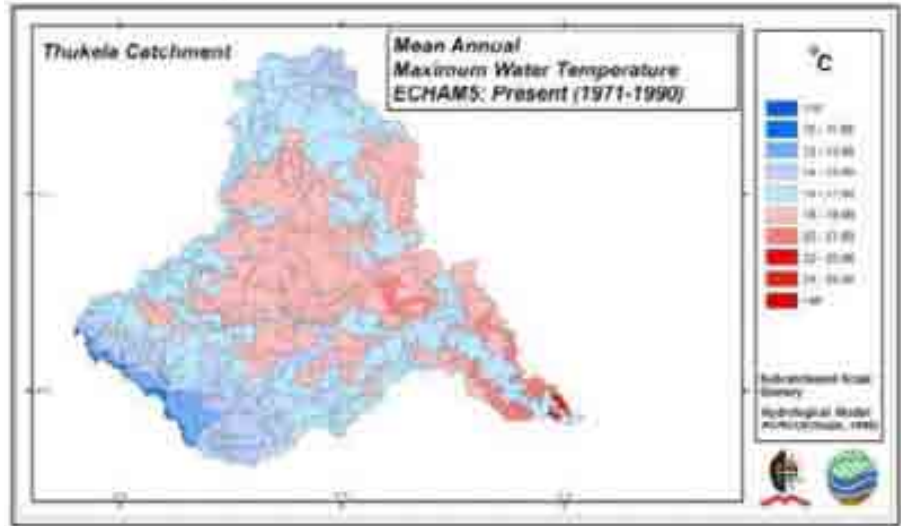
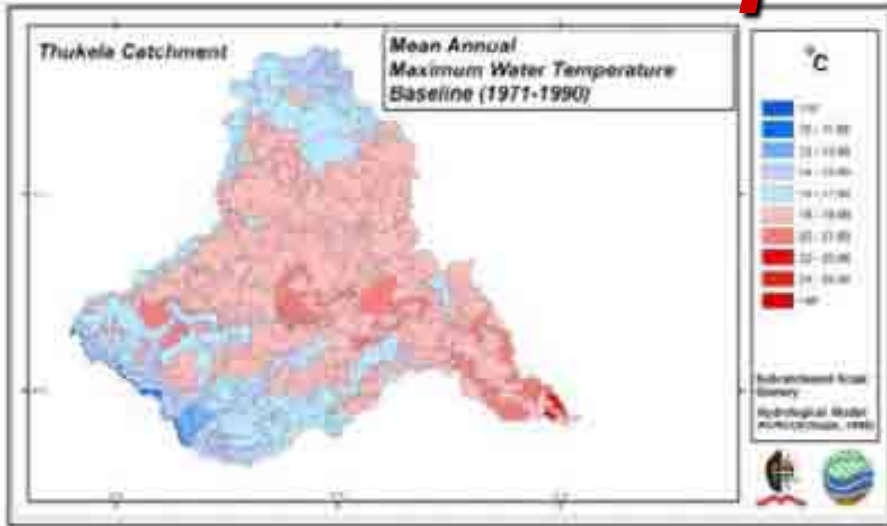


# Projected Changes in Transboundary Flow Characteristics: Sabie INTO Moçambique



# 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...1***

## ***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...3***

## ***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***

# ***On Adaptation...4***

## ***Categories to be Considered...***

### ***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. eThekweni-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**

# Adaptation Options for National Water Planners

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	COPING WITH / ADAPTING TO?	CROSS REFERENCES TO SCHULZE (2011)
<ul style="list-style-type: none"> <li>• Storage and Reticulation               <ul style="list-style-type: none"> <li>- Surface water                   <ul style="list-style-type: none"> <li>▫ Large Reservoirs</li> </ul> </li> </ul> </li>   <li>• Early Warning Systems               <ul style="list-style-type: none"> <li>- Short-Term (Days to Weeks)</li> </ul> </li>   <li>- Medium-Term (Month to Season)</li>   <li>- Long-Term (Years to Decades)</li>   <li>• Operations / System Improvements</li> <li>- Reservoir Operations Rules</li>   <li>• Water Demand Management</li> </ul>	<ul style="list-style-type: none"> <li>• Flash Floods</li> <li>Regional Floods</li> <li>Hydrological Droughts</li> <li>Surface Water Supply</li> <li>Storm Surges</li>   <li>• Regional Floods</li> <li>Hydrological Droughts</li> <li>Agricultural Droughts</li> <li>Hydrological Droughts</li> <li>Agricultural Droughts</li> <li>Surface Water Supply</li> <li>Groundwater Supply</li> <li>Hydrological Droughts</li> <li>Surface Water Supply</li> <li>Groundwater Supply</li> <li>Water Quality</li>   <li>• Regional Floods</li> <li>Hydrological Droughts</li>   <li>• Agricultural Droughts</li> <li>Hydrological Droughts</li> <li>Sea Level Rise</li> <li>Surface Water Supply</li> <li>Groundwater Supply</li> <li>Water Quality</li> </ul>	<p>Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report</p> <p>Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.7, 8.3</p> <p>Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2</p> <p>Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.7, 8.3</p>
KNOWLEDGE / SKILLS / PARTICIPATION	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>• Research and Development               <ul style="list-style-type: none"> <li>- Efficient Technologies</li> <li>- Upgrading of Climate Models                   <ul style="list-style-type: none"> <li>▫ Improvements to Downscaling / RCMs</li> </ul> </li> <li>- Improvement of Forecast Skill / Dissemination</li> </ul> </li> <li>• Development of Risk Maps / Floodlines</li>   <li>• Communication / Training / Dissemination</li> <li>• Participatory Approach in Decision-Making</li> </ul>	<ul style="list-style-type: none"> <li>• All</li> <li>• All</li> <li>• All</li> <li>• All</li> <li>• Regional Floods</li> <li>Hydrological Droughts</li> <li>Sea Level Rise</li> <li>Storm Surges</li> <li>• All</li> <li>• All</li> </ul>	<p>Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Not in Report</p>
POLICY INSTRUMENTS	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>• International Conventions</li> <li>• International Water Agreements</li> <li>• International Trade</li> <li>• National Water Master Plans               <ul style="list-style-type: none"> <li>- National Water Act of 1998</li> <li>- NWRS</li> </ul> </li> <li>• Other National Master Plans               <ul style="list-style-type: none"> <li>- National Environmental Management Act</li> <li>- Conservation of Agric Resources Act (CARA)</li> </ul> </li> <li>• Disaster Management Policies/Plans</li> </ul>	<p>-</p>	
RISK SHARING / SPREADING	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>• Private Sector Strategies               <ul style="list-style-type: none"> <li>- Banks                   <ul style="list-style-type: none"> <li>▫ Development</li> </ul> </li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• All</li> </ul>	
CHANGE OF USE / ACTIVITY / LOCATION	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>• Land Use Measures               <ul style="list-style-type: none"> <li>- Adaptive Spatial Planning</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Flash Floods</li> <li>Regional Floods</li> <li>Sea Level Rise</li> <li>Storm Surges</li> </ul>	<p>Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report</p>

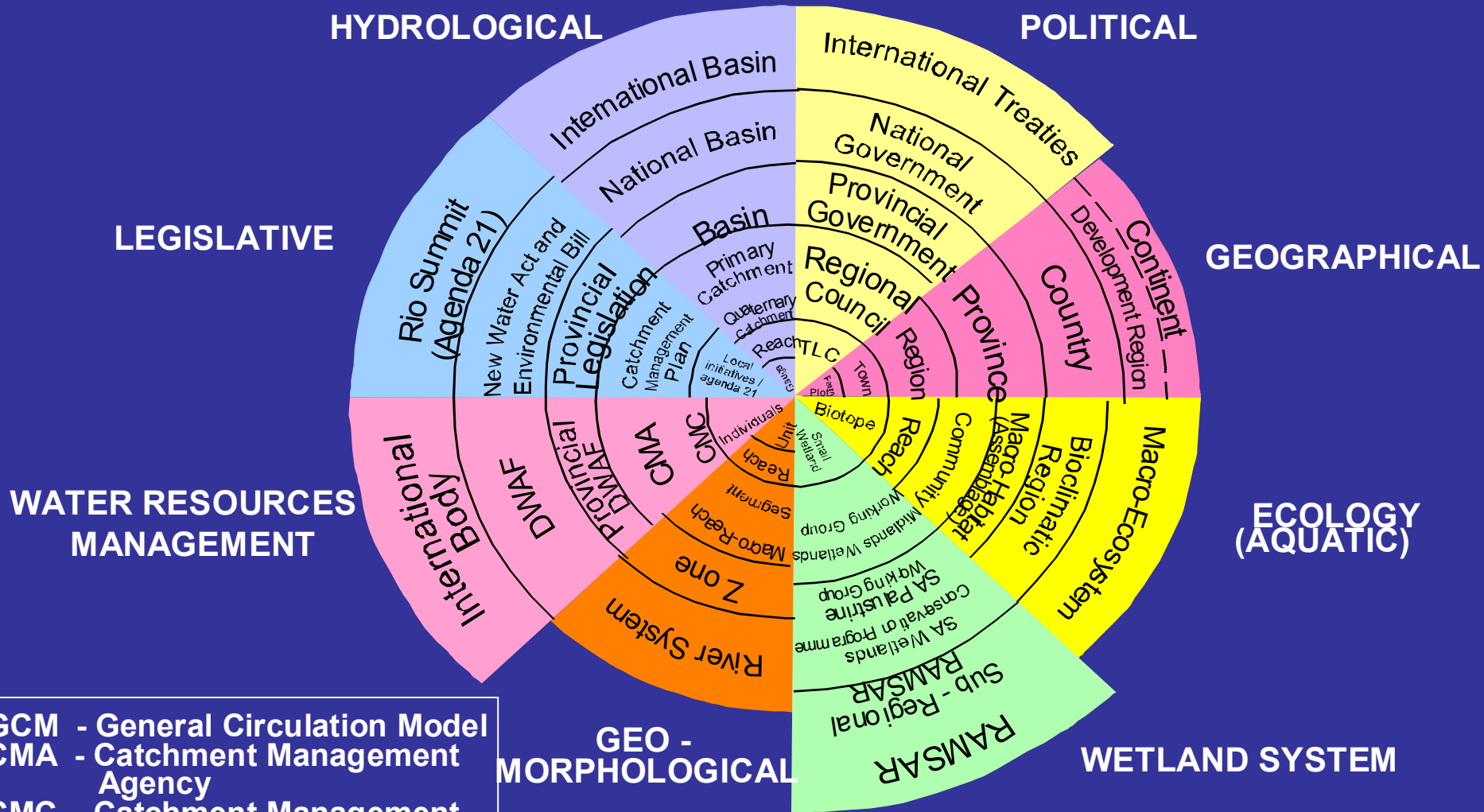
# Adaptation Options for SA Municipalities

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	COPING WITH / ADAPTING TO?	CROSS REFERENCES TO SCHULZE (2011)
<ul style="list-style-type: none"> <li>Storage and Reticulation               <ul style="list-style-type: none"> <li>Surface water                   <ul style="list-style-type: none"> <li>Large Reservoirs</li> </ul> </li> </ul> </li> <li>Groundwater               <ul style="list-style-type: none"> <li>Artificial Recharge</li> <li>Sand Dams</li> </ul> </li> <li>System Maintenance               <ul style="list-style-type: none"> <li>Supply Leakage Control</li> </ul> </li> <li>Water Re-use / Recycling</li> </ul>	<ul style="list-style-type: none"> <li>Flash Floods Regional Floods Hydrological Droughts Surface Water Supply Storm Surges</li> <li>Hydrological Droughts Groundwater Supply</li> <li>Flash Floods Hydrological Droughts Surface Water Supply Groundwater Supply</li> <li>Agricultural Droughts Hydrological Droughts Surface Water Supply Water Quality</li> <li>Hydrological Droughts Agricultural Droughts Surface Water Supply Groundwater Supply</li> <li>Hydrological Droughts Agricultural Droughts Surface Water Supply</li> <li>Flash Floods Regional Floods Sea Level Rise Storm Surges</li> <li>Flash Floods Regional Floods Hydrological Droughts Agricultural Droughts Surface Water Supply Groundwater Supply</li> <li>Hydrological Droughts Surface Water Supply Groundwater Supply</li> <li>Flash Floods Regional Floods Sea Level Rise Storm Surges</li> <li>?</li> <li>Flash Floods Regional Floods Hydrological Droughts</li> <li>Flash Floods Regional Floods Sea Level Rise Storm Surges Surface Water Supply Groundwater Supply</li> <li>Agricultural Droughts Hydrological Droughts Sea Level Rise Surface Water Supply Groundwater Supply Water Quality</li> </ul>	<p>Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.2</p> <p>Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.3</p> <p>Ch 5.6, 7.1 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3</p> <p>Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7, 8.3</p> <p>Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3</p> <p>Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4</p> <p>Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report</p> <p>Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3</p> <p>Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3</p> <p>Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Not in Report Not in Report</p> <p>Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3</p> <p>Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3</p> <p>Ch 5.7, 8.3</p>
KNOWLEDGE / SKILLS / PARTICIPATION	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>Research and Development               <ul style="list-style-type: none"> <li>Efficient Technologies</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>All</li> <li>All</li> <li>All</li> </ul>	

KNOWLEDGE / SKILLS / PARTICIPATION	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>Research and Development               <ul style="list-style-type: none"> <li>Efficient Technologies</li> <li>Upgrading of Climate Models                   <ul style="list-style-type: none"> <li>Improvements to Downscaling / RCMs</li> <li>Fine Scale Information Provision Relevant to Local Water Managers</li> </ul> </li> <li>Improvement of Forecast Skill / Dissemination</li> </ul> </li> <li>Communication / Training / Dissemination               <ul style="list-style-type: none"> <li>Awareness Creation at Operations Level (e.g. Senior Municipal Officials re. budget allocation and future special planning)</li> <li>Training at Local Level (e.g. Municipal WWT operators)</li> </ul> </li> <li>Participatory Approach in Decision-Making               <ul style="list-style-type: none"> <li>Creations of Ongoing Learning and Communication Platforms between Main Water Users (e.g. WRC Reference Group meetings)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>All</li> <li>All</li> <li>All</li> <li>All</li> <li>All</li> <li>All</li> </ul>	
POLICY INSTRUMENTS	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>National Water Strategies               <ul style="list-style-type: none"> <li>Catchment Management Strategies</li> <li>River Management Plans</li> </ul> </li> <li>Other National Strategies               <ul style="list-style-type: none"> <li>Integrated Development Plans (IDPs)</li> </ul> </li> <li>Provincial Strategies               <ul style="list-style-type: none"> <li>Provincial Growth and Development Strategies</li> </ul> </li> <li>Local Strategies               <ul style="list-style-type: none"> <li>Municipal Bye-Laws</li> </ul> </li> <li>Disaster Management Policies / Plans</li> </ul>		
RISK SHARING / SPREADING	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>Private Sector Strategies               <ul style="list-style-type: none"> <li>Insurance                   <ul style="list-style-type: none"> <li>Re-Insurance</li> </ul> </li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Regional Floods Flash Floods</li> </ul>	<p>Ch 7.2, 7.3 Ch 5.6, 7.1</p>
CHANGE OF USE / ACTIVITY / LOCATION	COPING WITH / ADAPTING TO?	CROSS REFERENCES
<ul style="list-style-type: none"> <li>Land Use Measures               <ul style="list-style-type: none"> <li>Conservation Structures</li> </ul> </li> <li>Adaptive Spatial Planning</li> <li>Alien Invasive Clearing Activities</li> <li>Maintaining or Re-establishment of Natural Capital (e.g. wetlands, buffers etc)</li> </ul>	<ul style="list-style-type: none"> <li>Flash Floods Regional Floods Sea Level Rise Storm Surges Agricultural Droughts</li> <li>Flash Floods Regional Floods Sea Level Rise Storm Surges</li> </ul>	<p>Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report Ch 4.2, 6.1, 6.2, 8.2 Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report</p>



# Vertical and Horizontal Integration in IWRM



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)