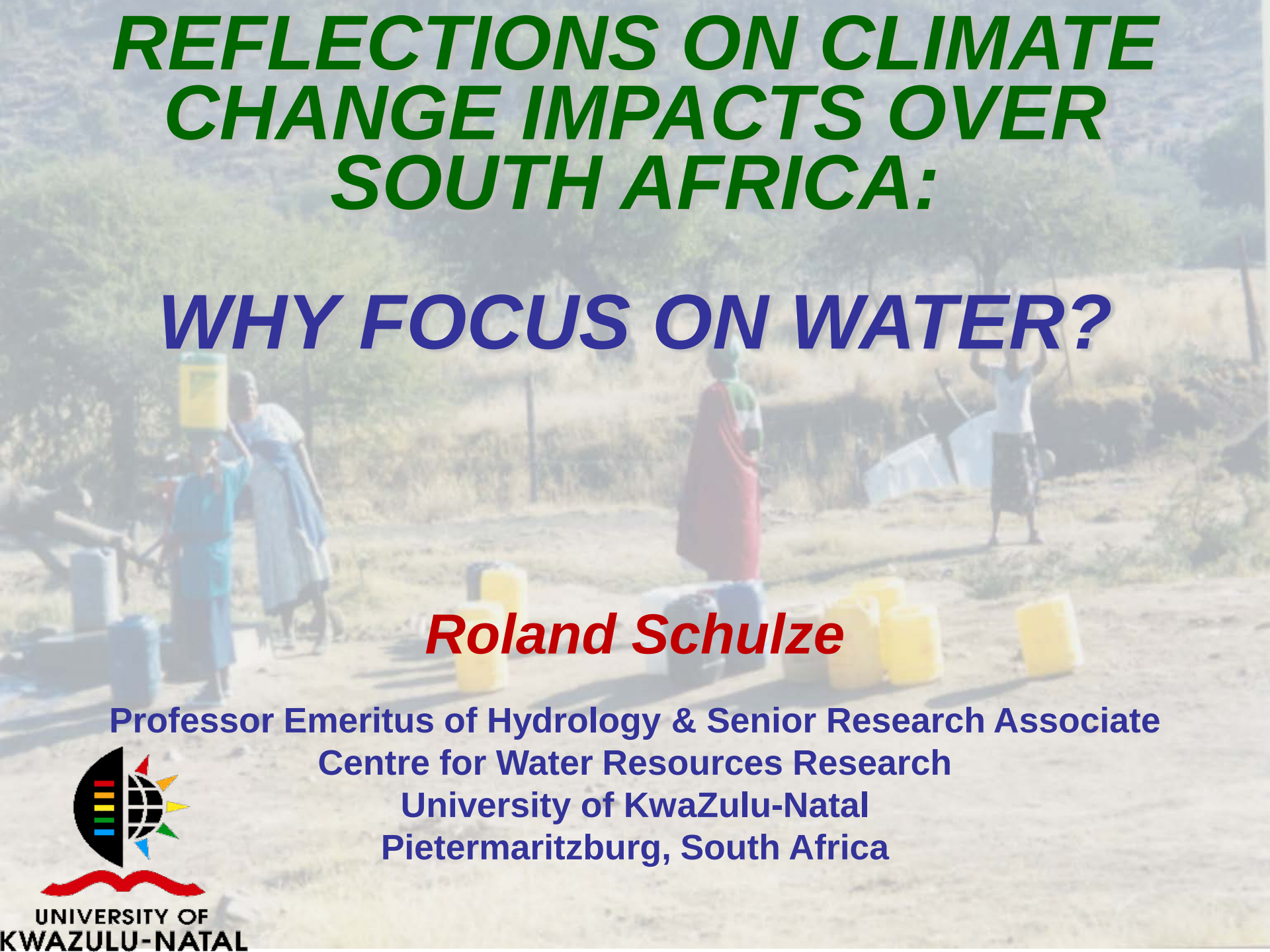
REFLECTIONS ON CLIMATE CHANGE IMPACTS OVER SOUTH AFRICA:

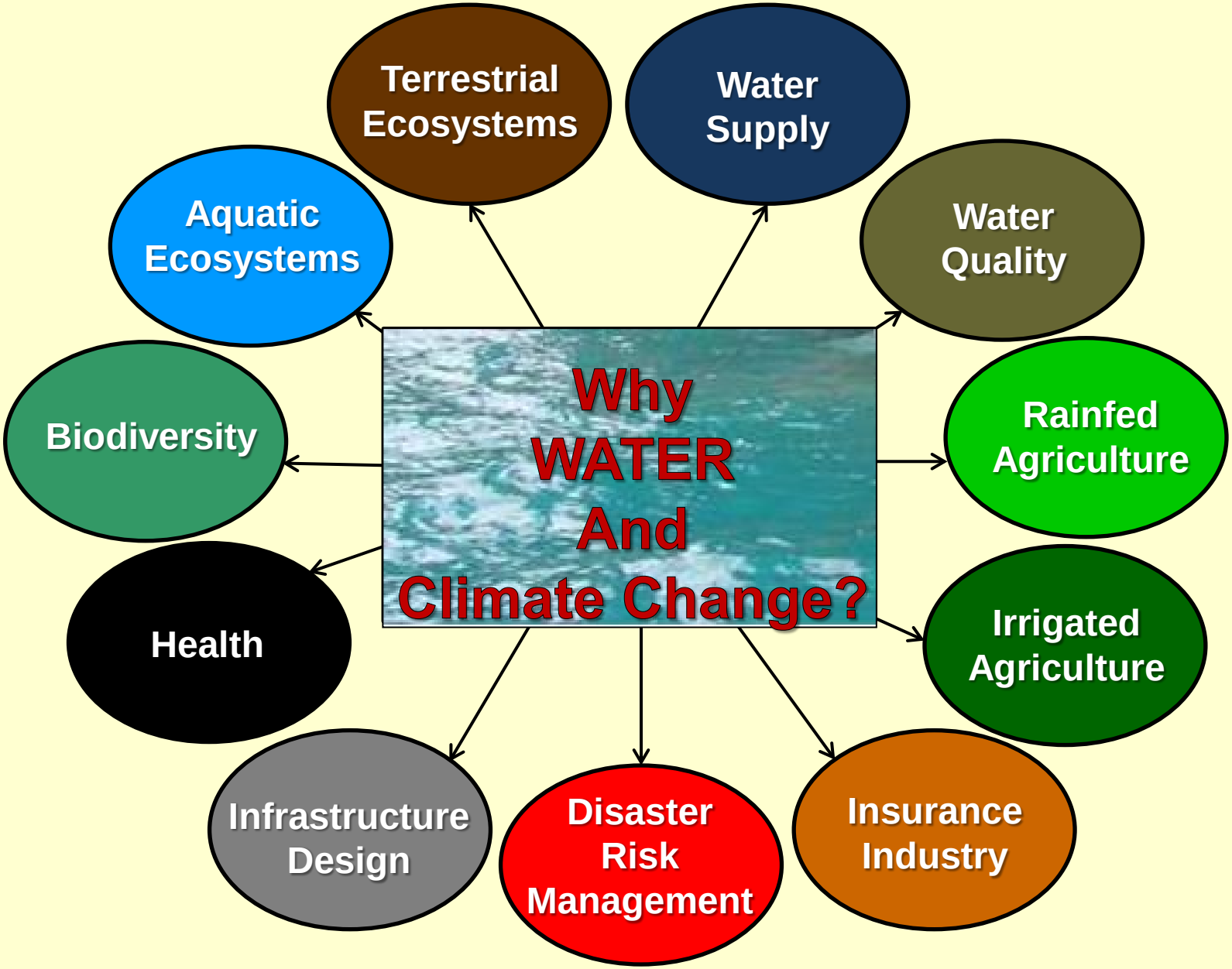
WHY FOCUS ON WATER?



Roland Schulze

Professor Emeritus of Hydrology & Senior Research Associate
Centre for Water Resources Research
University of KwaZulu-Natal
Pietermaritzburg, South Africa

UNIVERSITY OF KWAZULU-NATAL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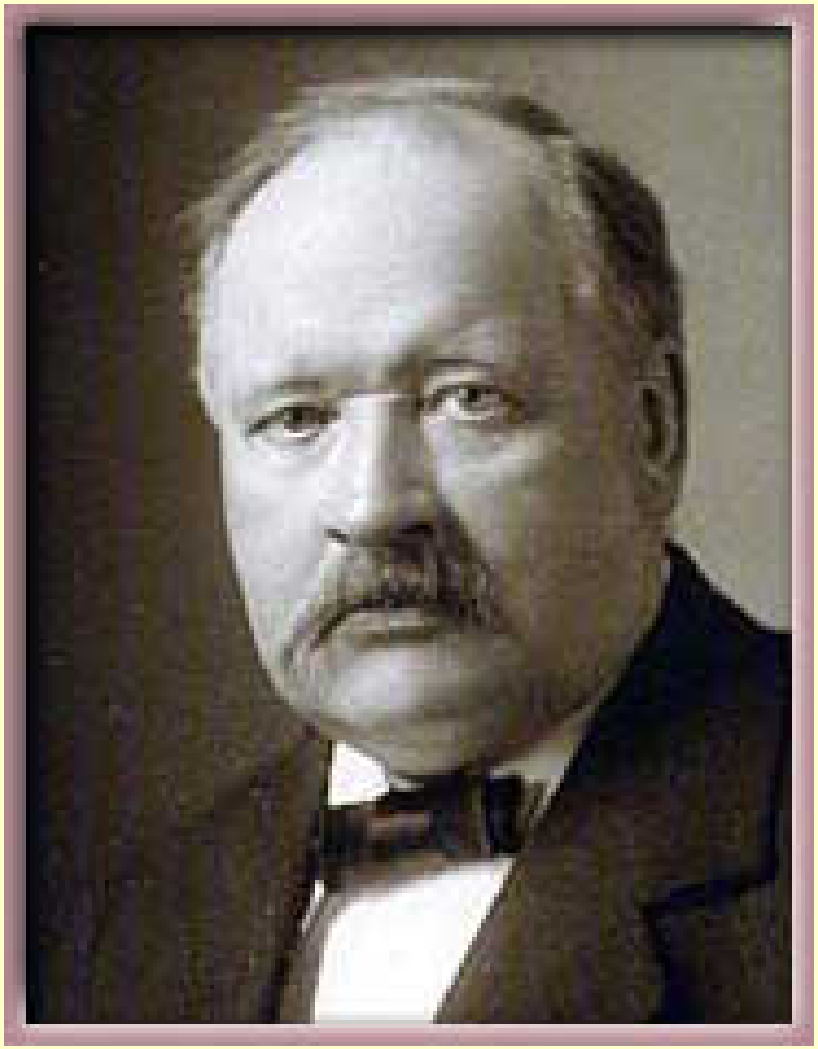
But, let's start with some History !



Svante ARRHENIUS

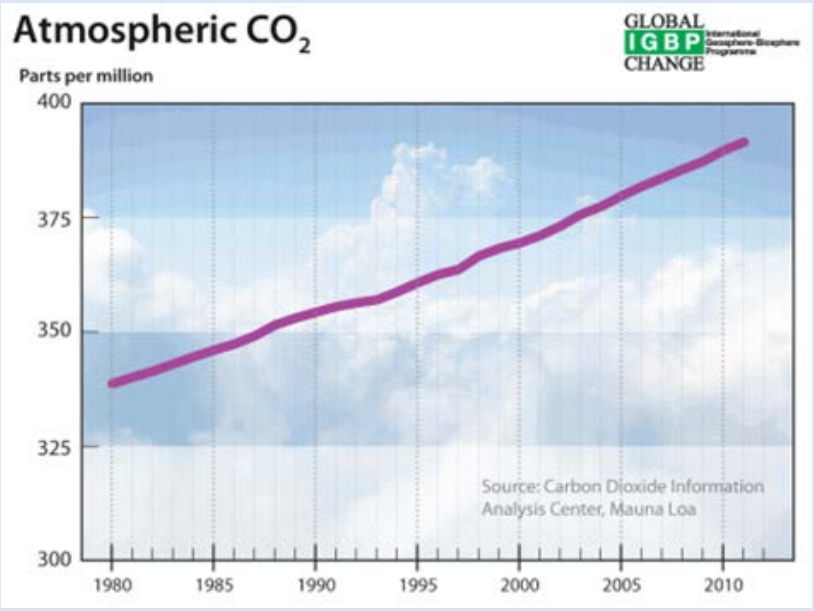
1859 born 15 February

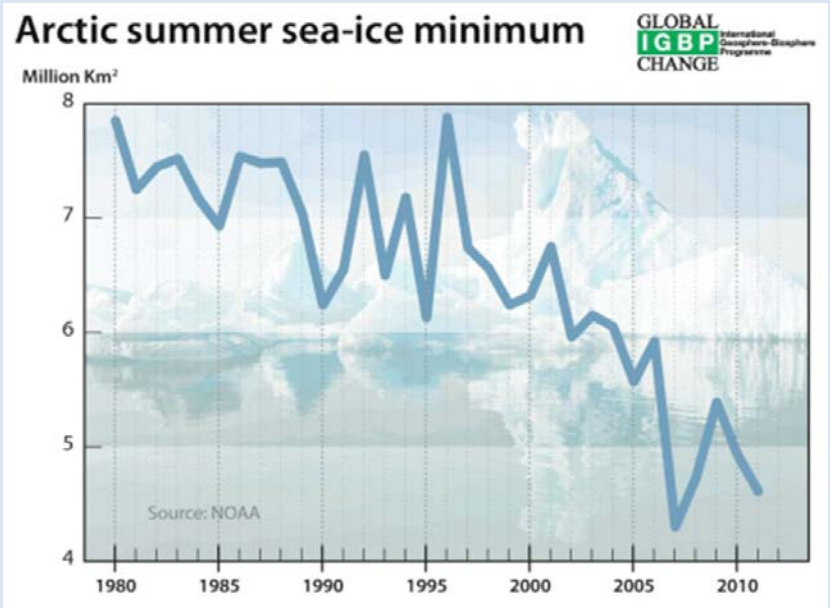
1884 PhD in Physics 4th Class

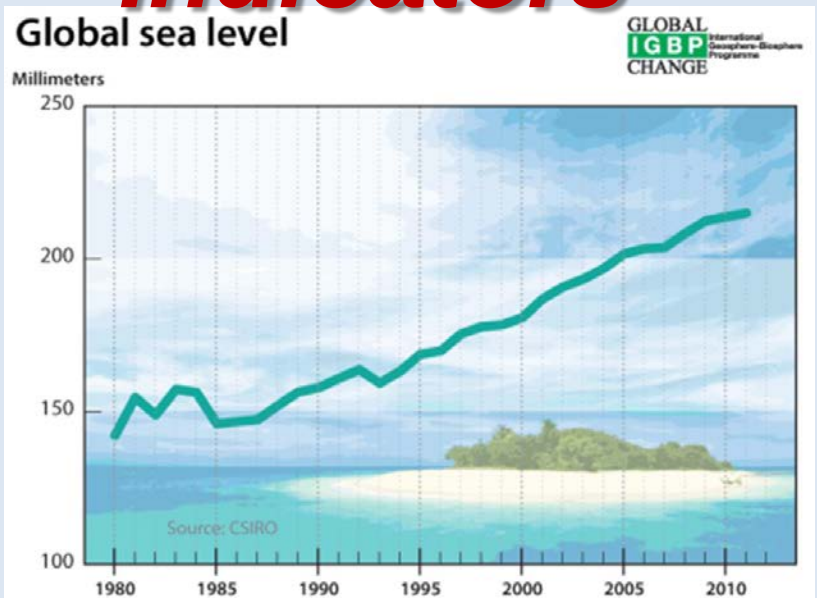
1896 First scientist to calculate how changes in CO_2 through burning fossil fuels could alter surface temperatures through the Greenhouse Effect

1903 Nobel Prize for Chemistry

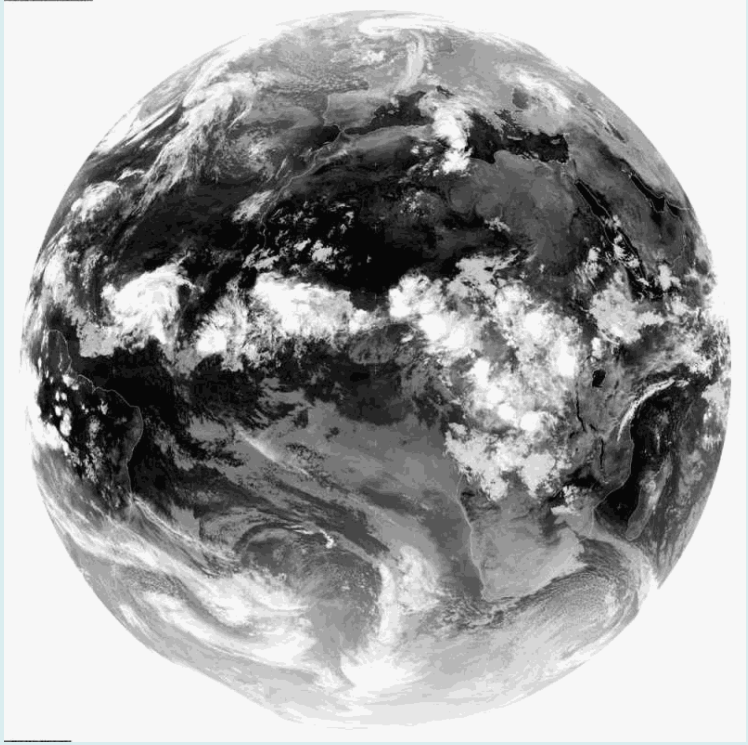
Science is now Monitoring CC with a Composite Index, like a Stock Exchange Index, Made up of Multiple Indicators

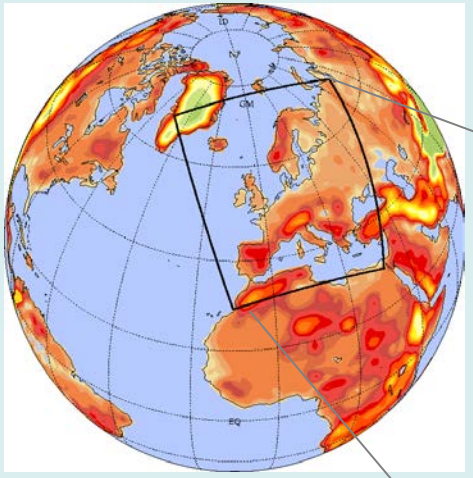


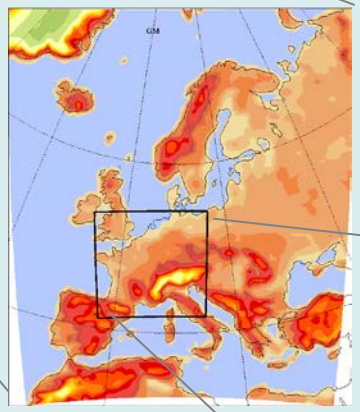


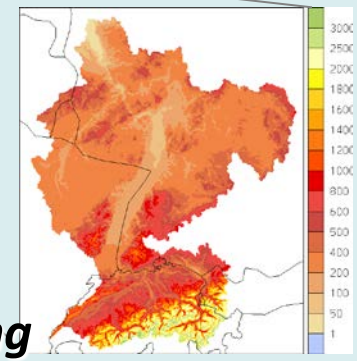


CC is a Global Issue, but Impacts/Adaptations are Local; hence Downscaling









Global Climate Models (GCMs) (e.g. HadCM3, ECHAM5, ~200 km)

Regional Climate Models (RCMs) or statistical downscaling (~25 km)

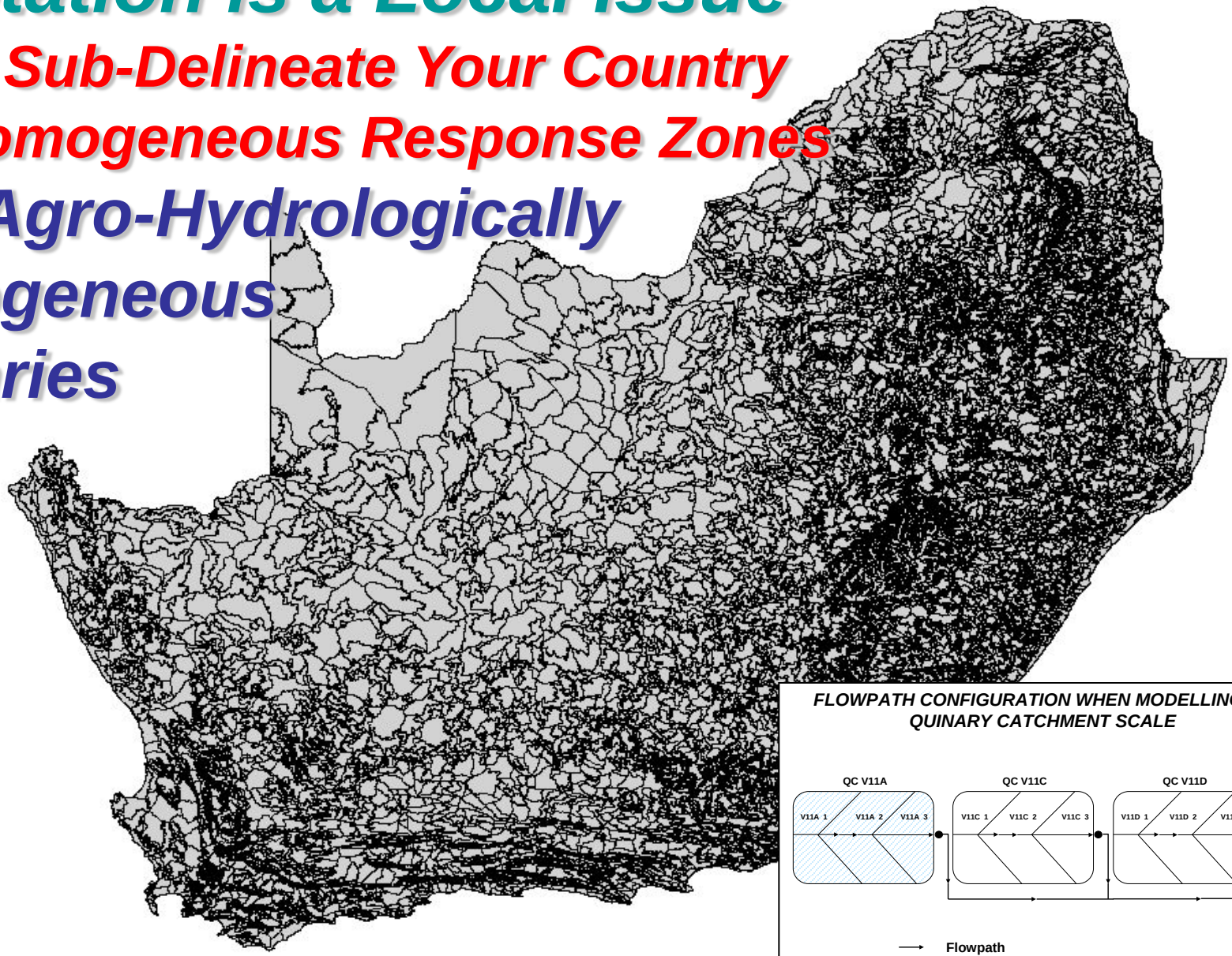
Impact Models (~5 km)

Hewitson, 2010

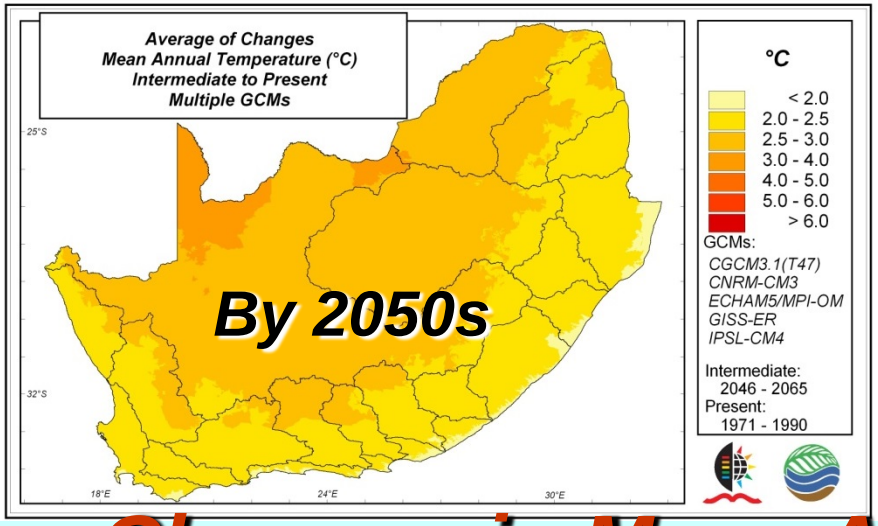
Adaptation is a Local Issue

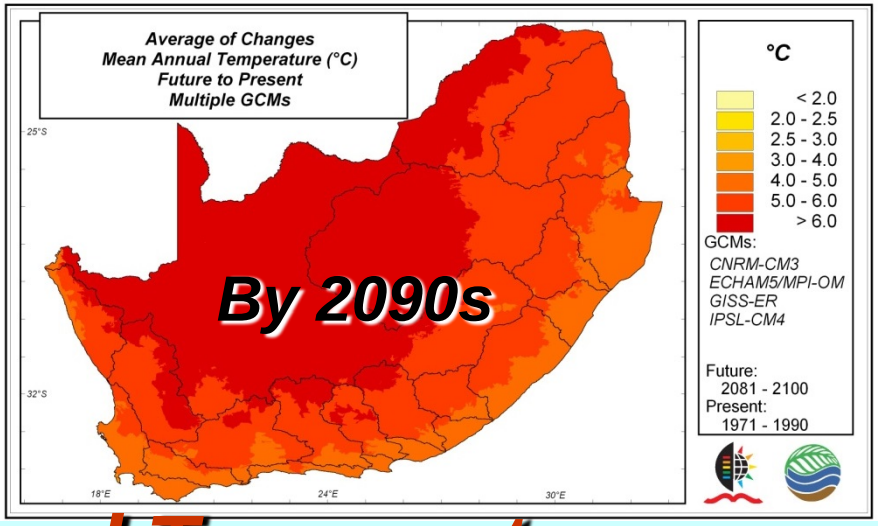
Hence Sub-Delineate Your Country into Homogeneous Response Zones

5838 Agro-Hydrologically Homogeneous Quinaries



FLOWPATH CONFIGURATION WHEN MODELLING AT QUINARY CATCHMENT SCALE

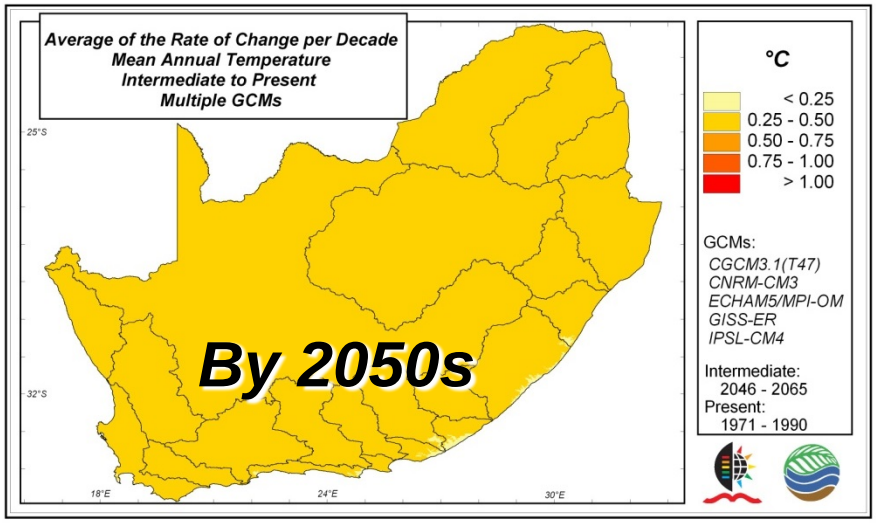


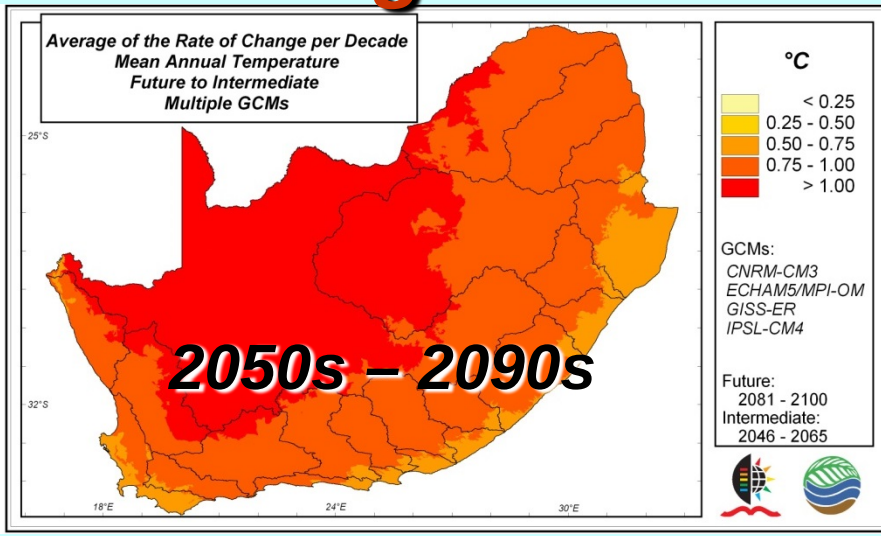


Changes in Mean Annual Temperature are Projected to be Significant

What are the consequences for SA's Water & Agric?

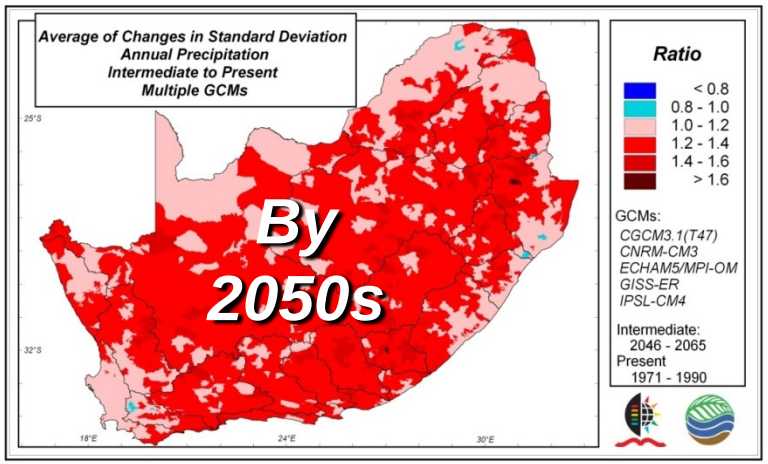
With the Rate of Change Increasing Over Time

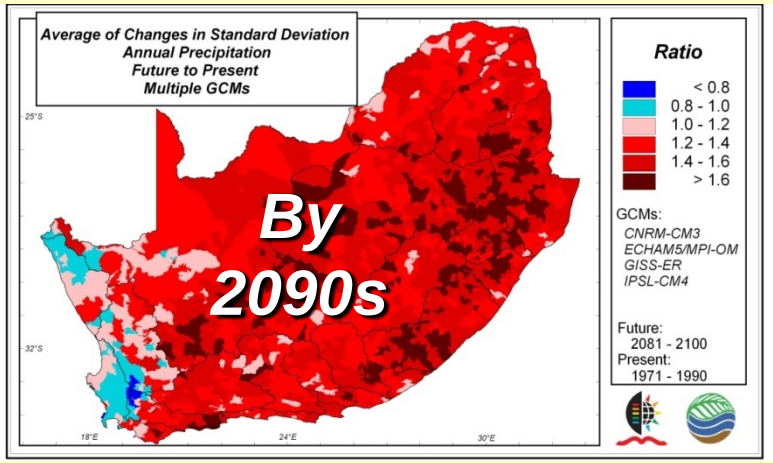




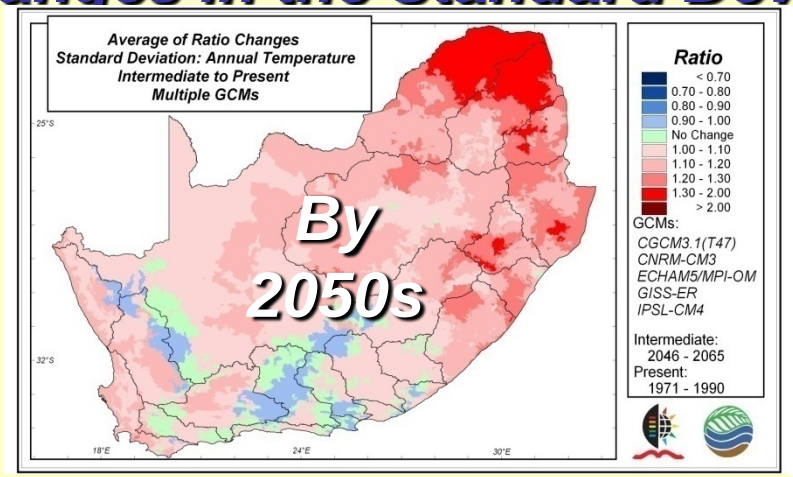
Future Year-to-Year Variability will Change…the Case of Projected Rainfall and Temperature over SA

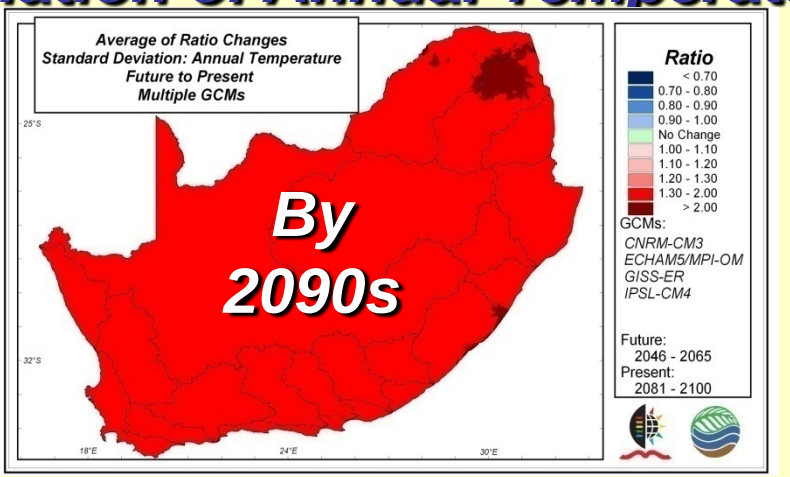
Changes in the Standard Deviation of Annual Rainfall





Changes in the Standard Deviation of Annual Temperature





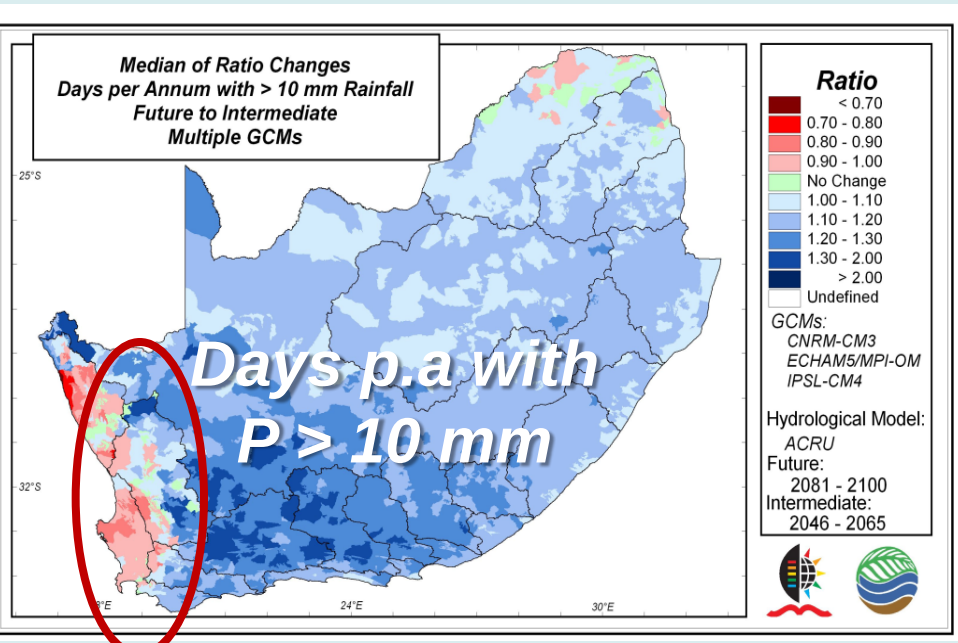
and what are the consequences for water/food security?

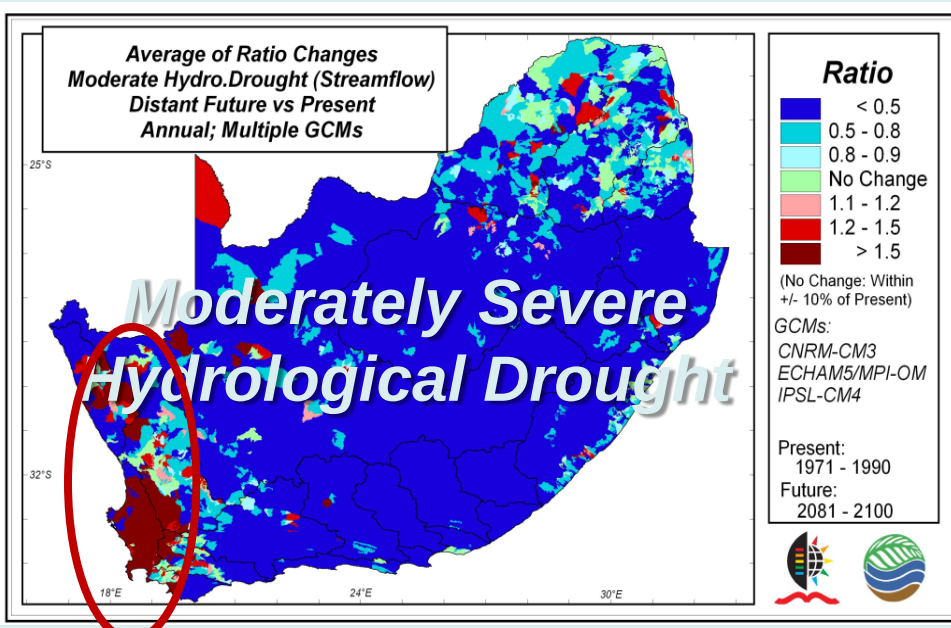
Some Areas will be 'Winners'

(with new opportunities)

Others will be 'Hot-Spots of Concern'

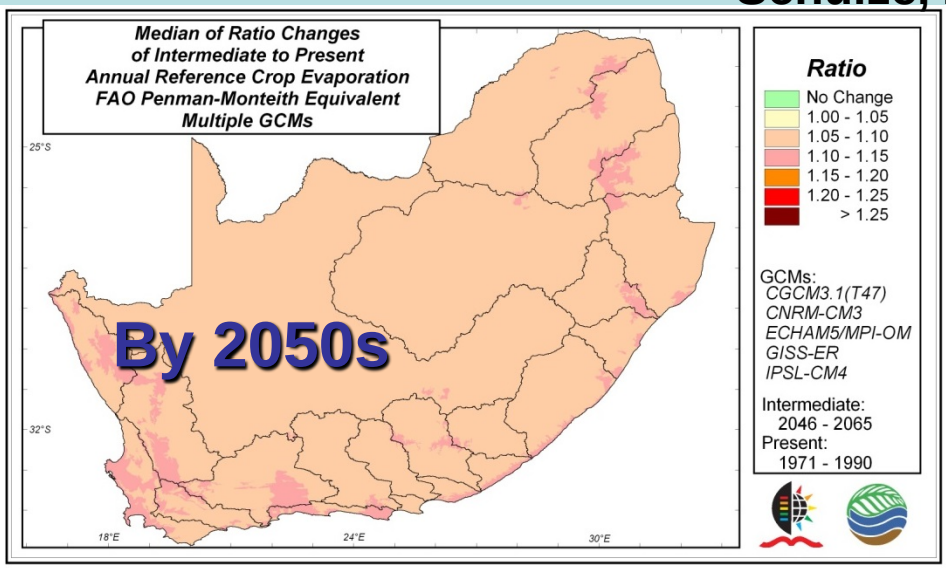
(especially in distant future, with added stresses)

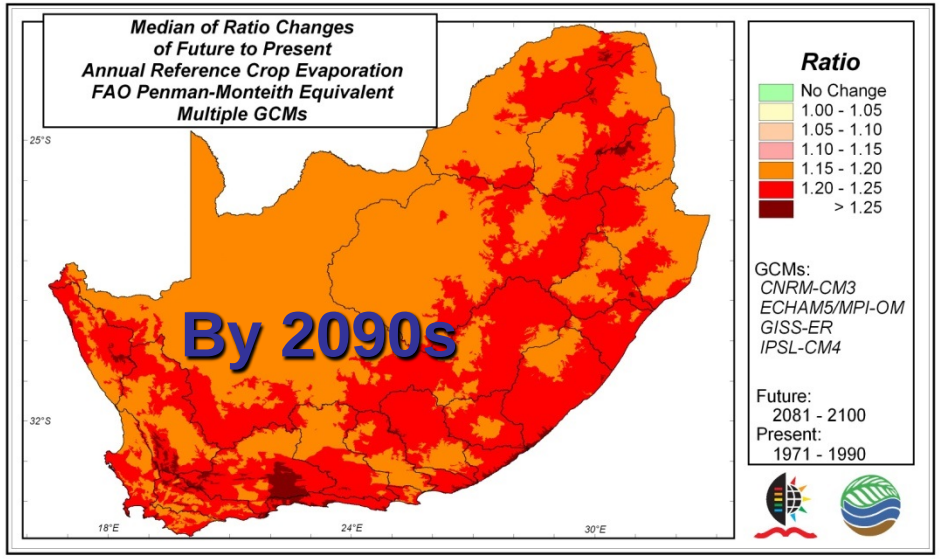




Evaporation from Dams and from the Soil is Projected to Increase

Schulze, 2011



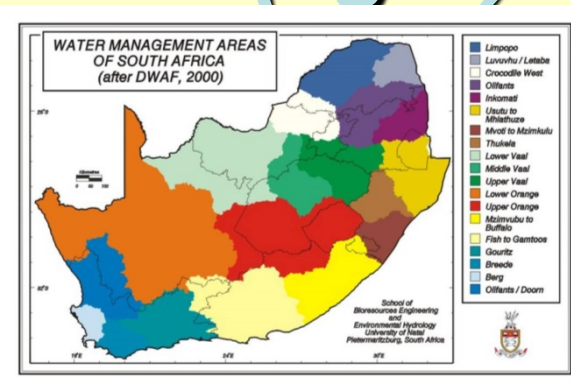


5 – 10 %

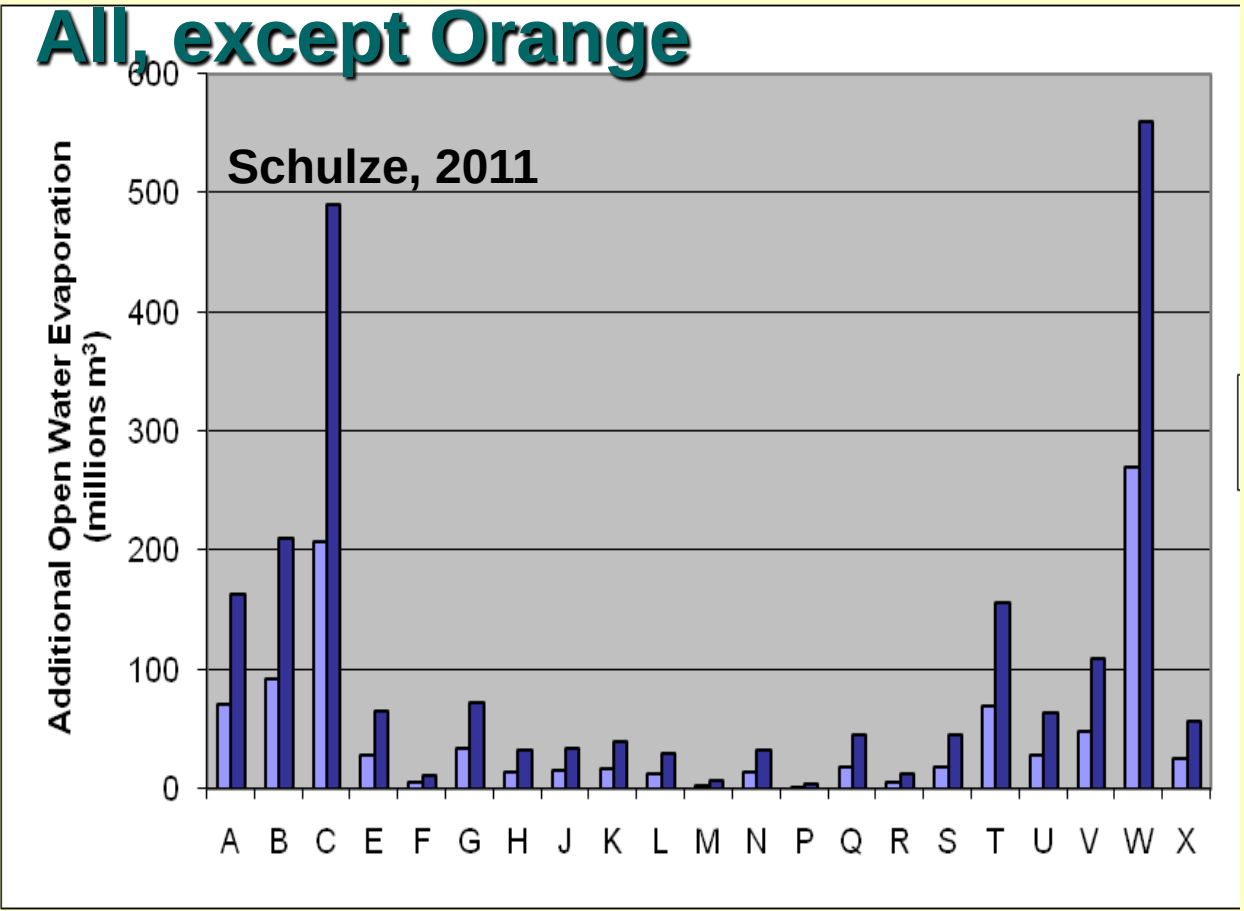
15 – 25 %

But, what will the consequences be?

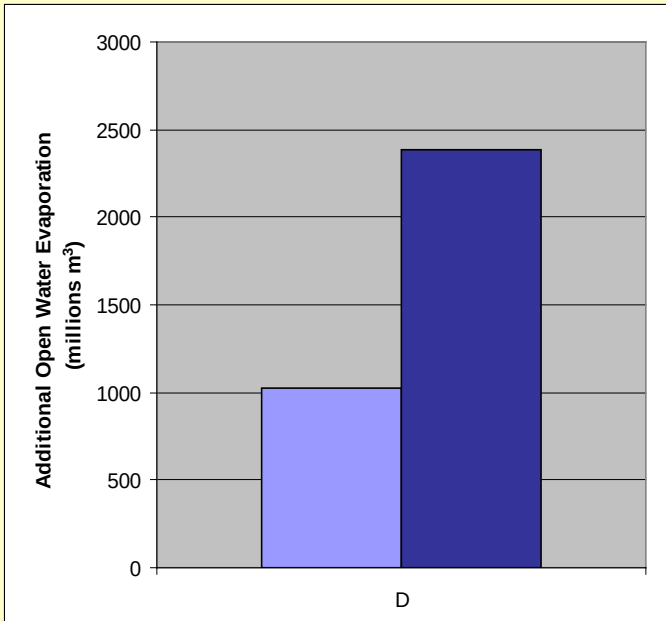
Additional Evaporation per Primary Catchment from Open Water Bodies (dams, rivers, wetlands) by 2050s (light) and 2090s (dark)



All, except Orange

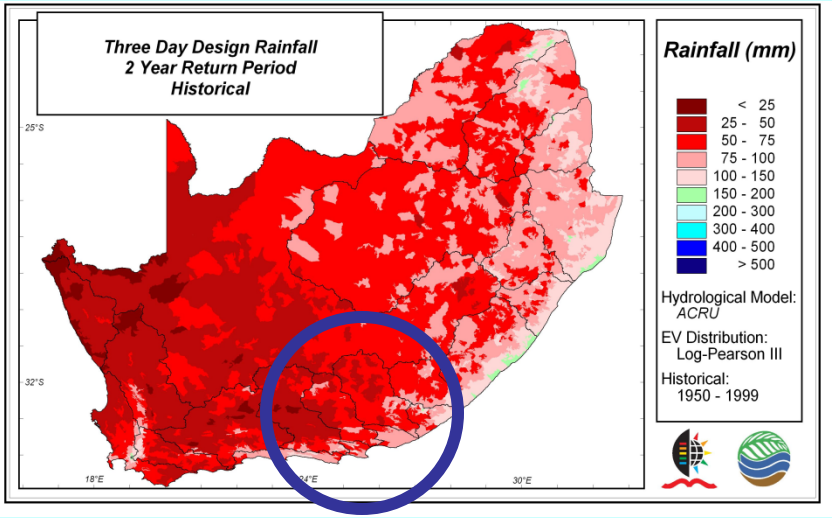


Orange

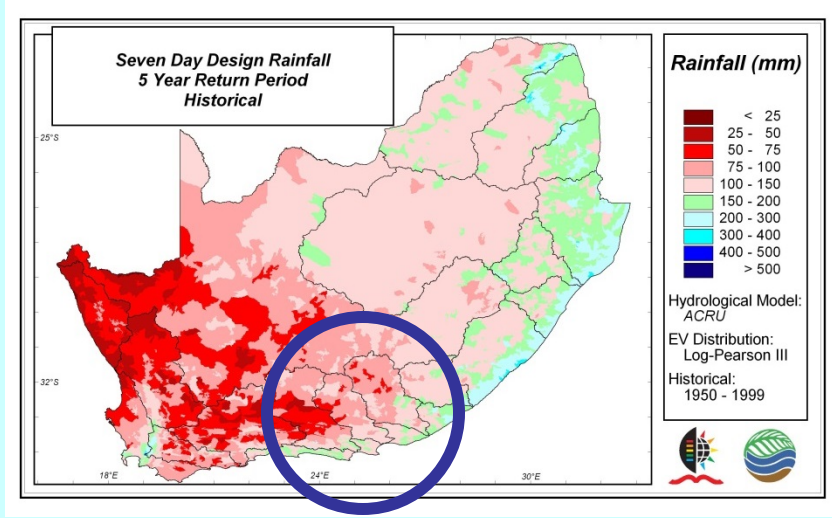


Long Duration Extreme Rainfalls are Projected to Change

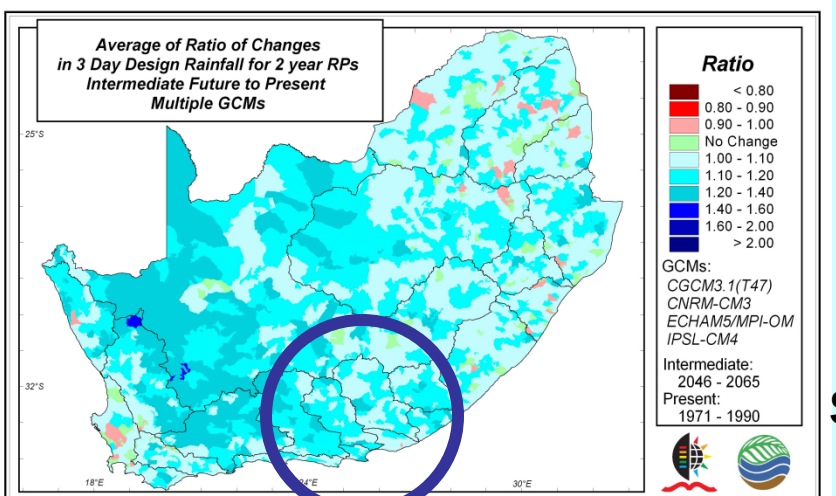
Present-Day 3 Day Rain, 2 Year RP



Present-Day 7 Day Rain, 5 Year RP

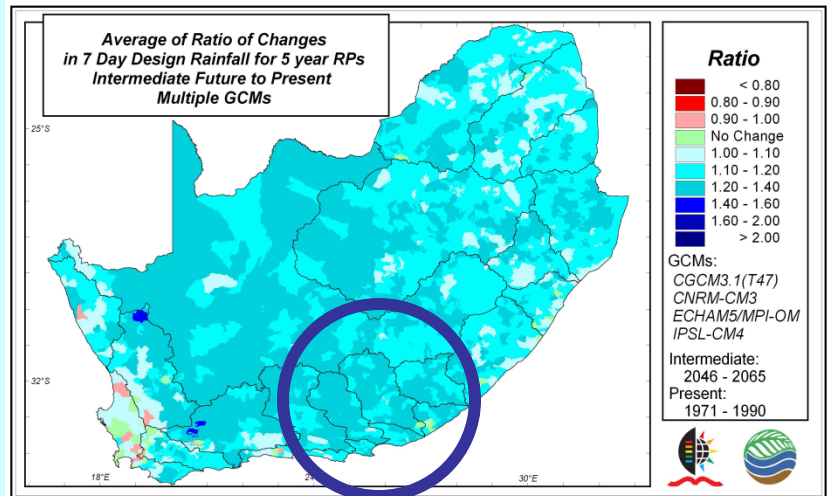


Δ in 3 Day, 2 Year RP Rain

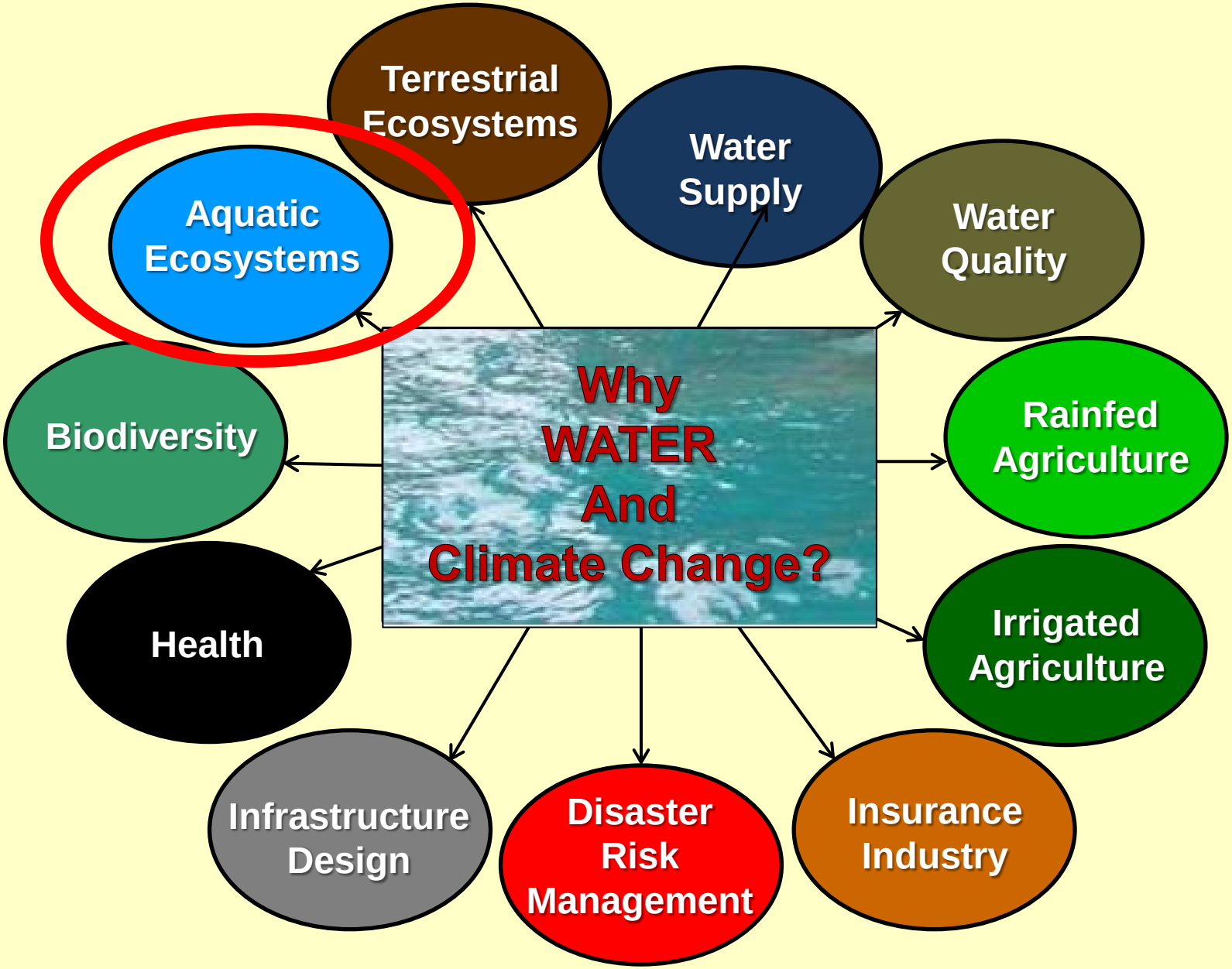


Schulze, 2012

Δ in 7 Day, 5 Year RP Rain



Remember: Developing Countries Contain Many Vulnerable Poor Urban and Rural Communities Whose CC Adaptive Capacity is Often Low and Whose Adaptation Needs are Highly Local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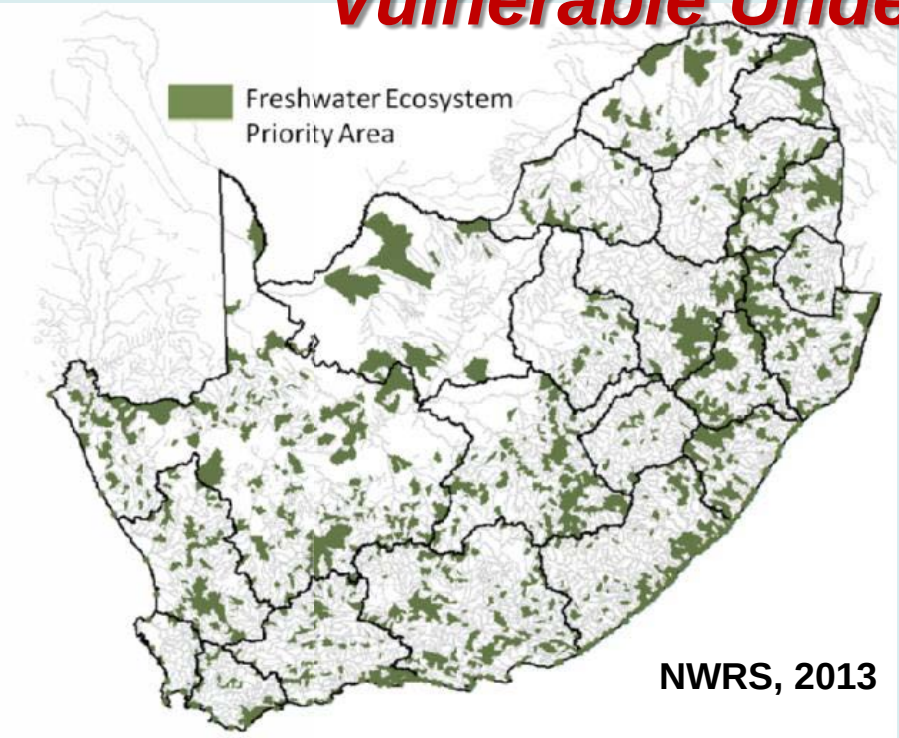
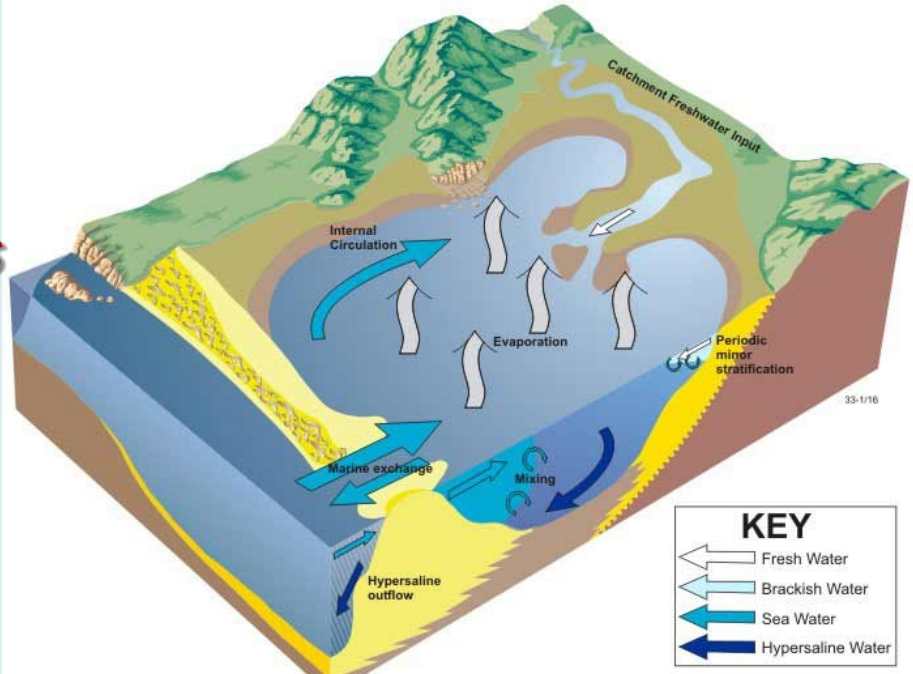
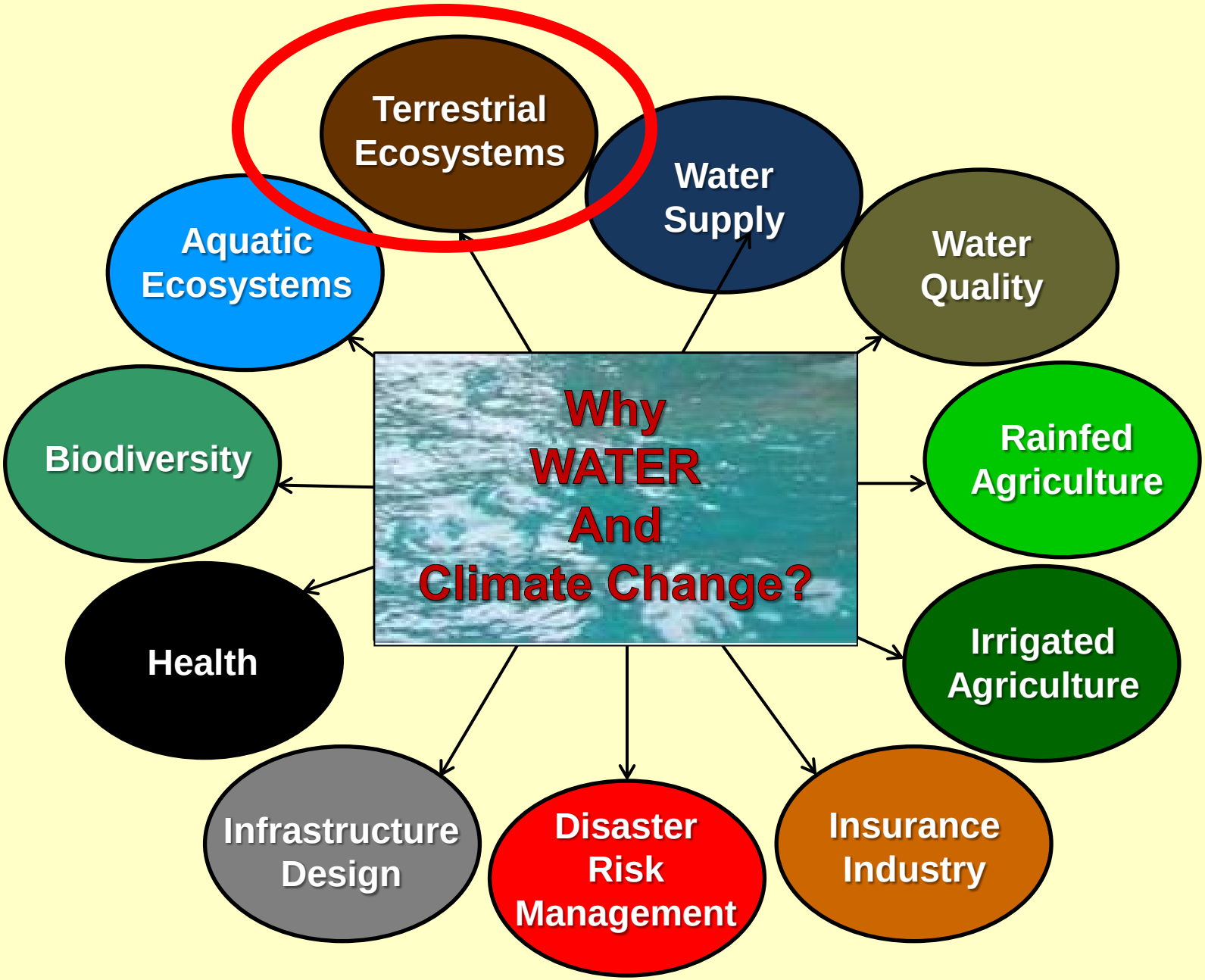
Many Already Fragile Aquatic Ecosystems (e.g. estuaries, wetlands) May Become Even More Vulnerable Under Future Climates



NWRS, 2013



Ecological & Economic Impacts on Estuaries, e.g. Increased hyper-salinity, Changes in habitat availability for certain species, Impacts upon juvenile fish species, and Impacts upon the livelihoods of people reliant on this system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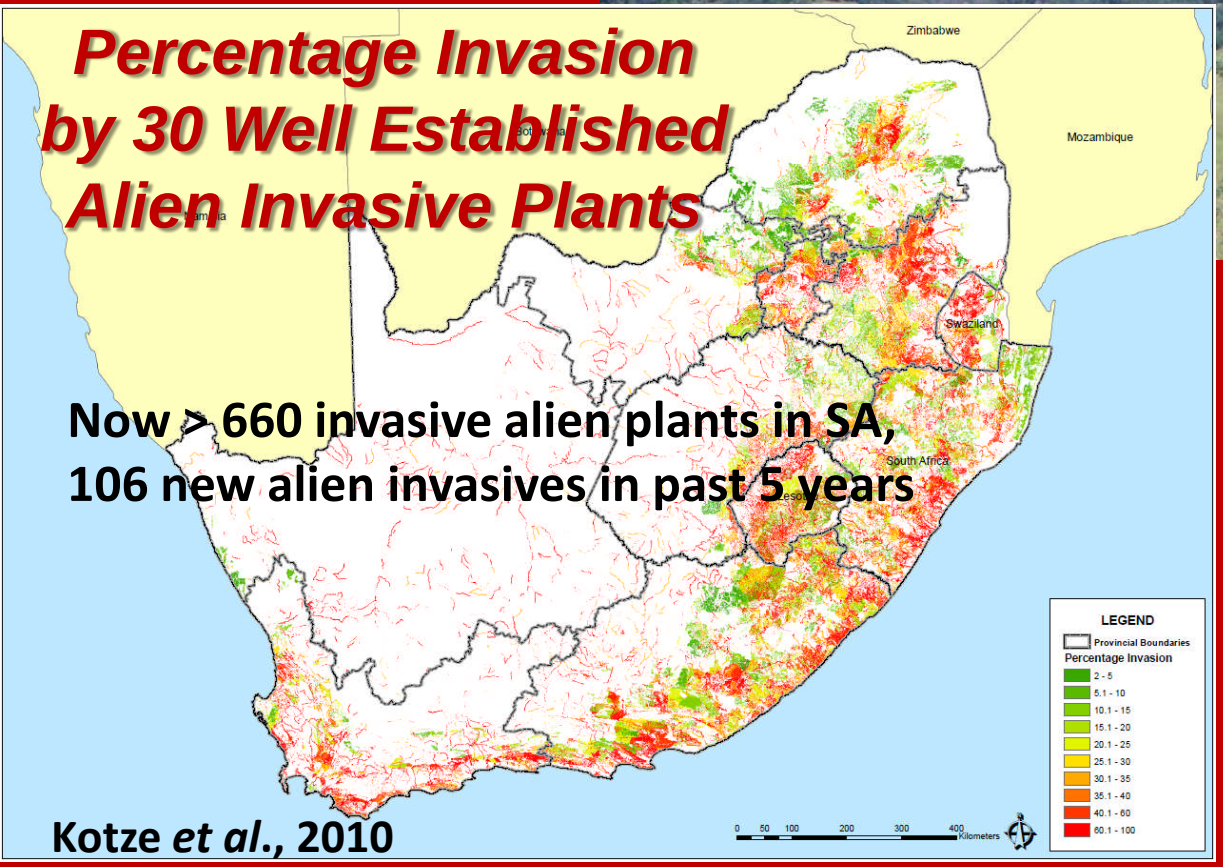
Hydrological Impacts of Farming Practices are Likely to be Exacerbated by Climate Change

E.g Extensive Annual Grassland Burning

…and Severe Overgrazing

FACT !! Our Natural Capital is Often Degraded by Alien Invasive Infestations

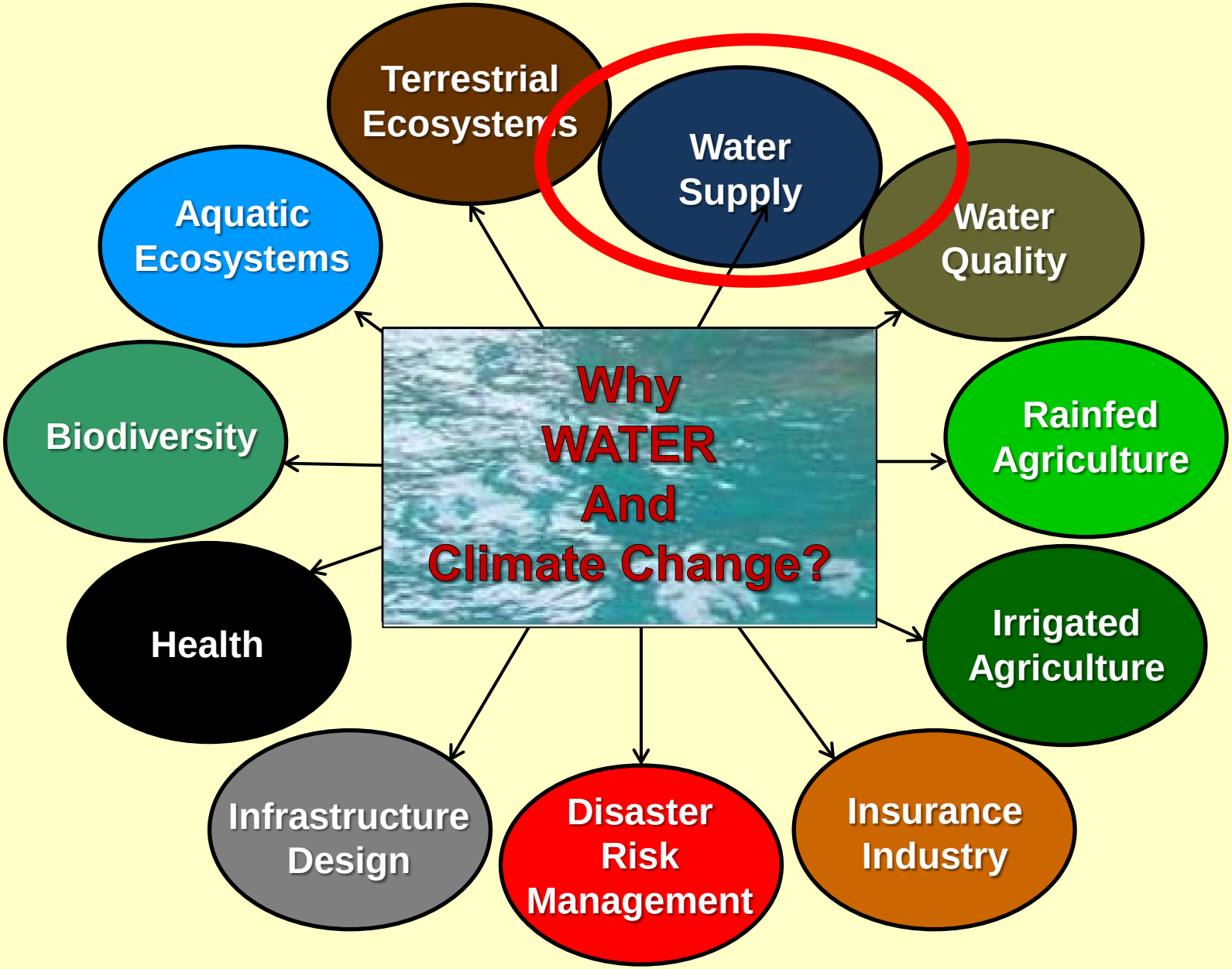
That Prime Land Could be Producing Water and Food



Now > 660 invasive alien plants in SA,
106 new alien invasives in past 5 years

Kotze *et al.*, 2010

With their High Water Demands Likely to be Exacerbated by Climate Change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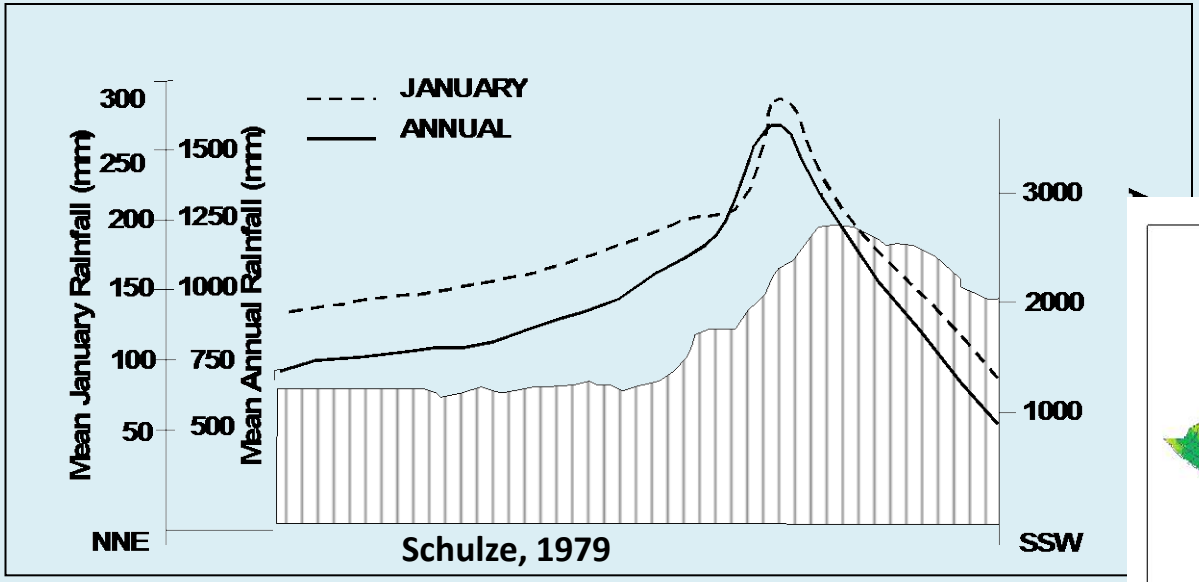
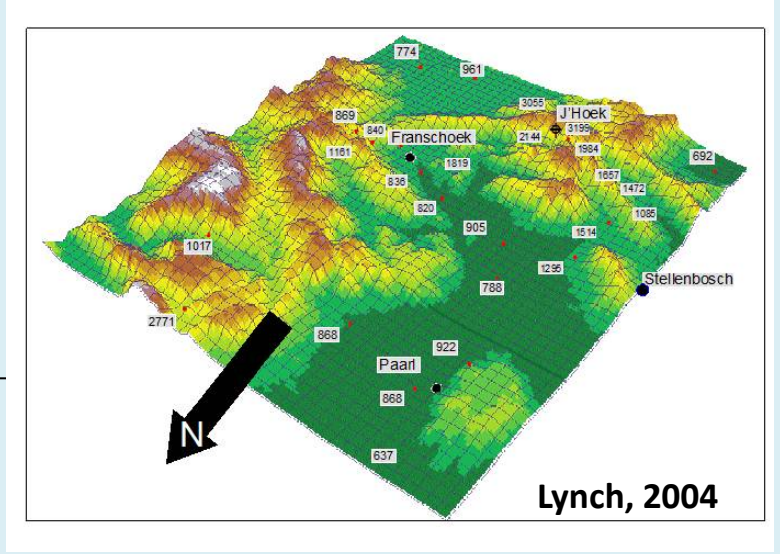
We Often Are Dependent on Mountain Regions for our Water Resources and We do Not Understand the Climate Change Dynamics in Mountain Terrain

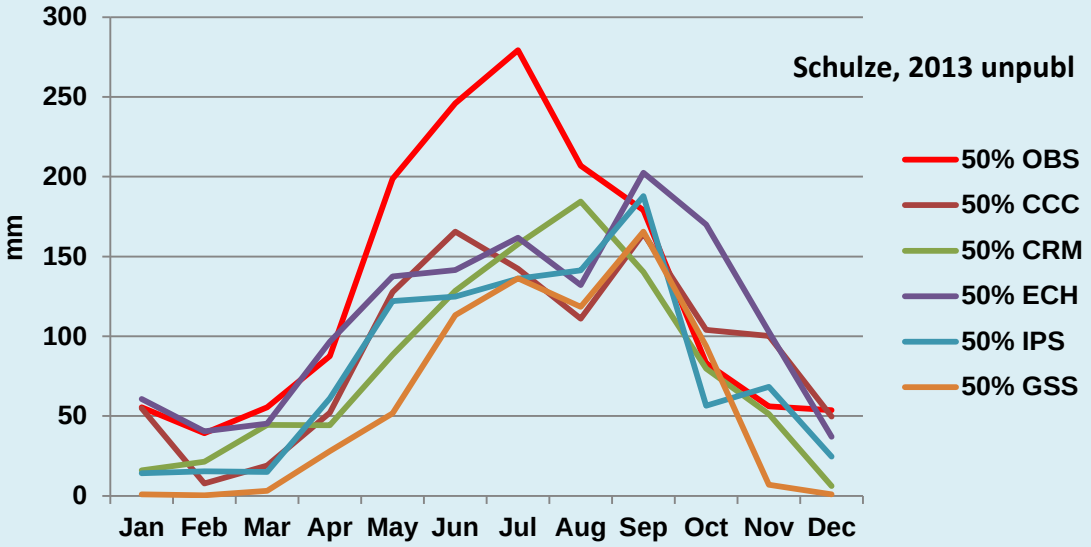
Source: Orange





But, Rainfall : Altitude Relationships are Complex in Mountain Regions

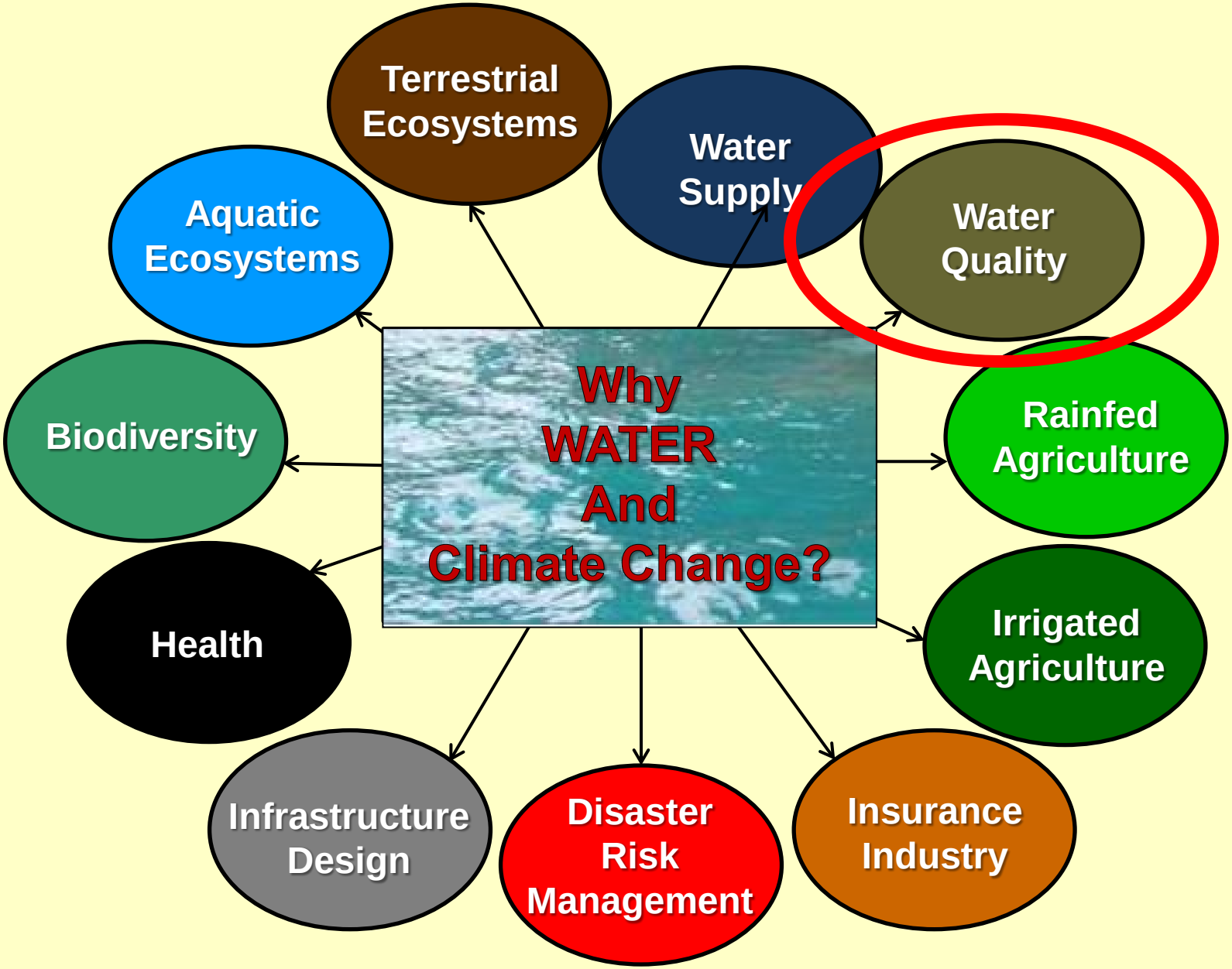
Headwaters G10A1
Median Monthly Rainfall



And GCMs do not Always Capture Headwater Rainfall Magnitudes, Peaks

Thus, setting up long term high altitude weather stations in developing countries is critical and timely, even if late in the day

A SAEON – Univ. of KwaZulu-Natal Initiative, Cathedral Peak, 2012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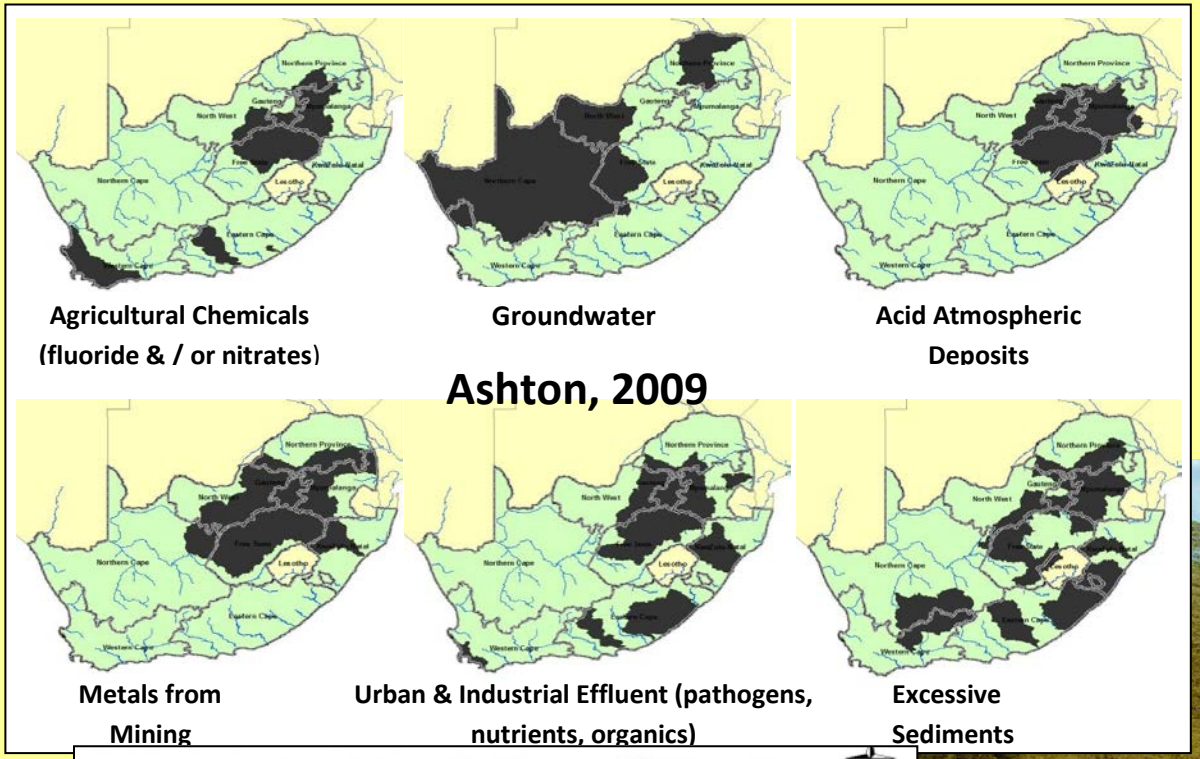
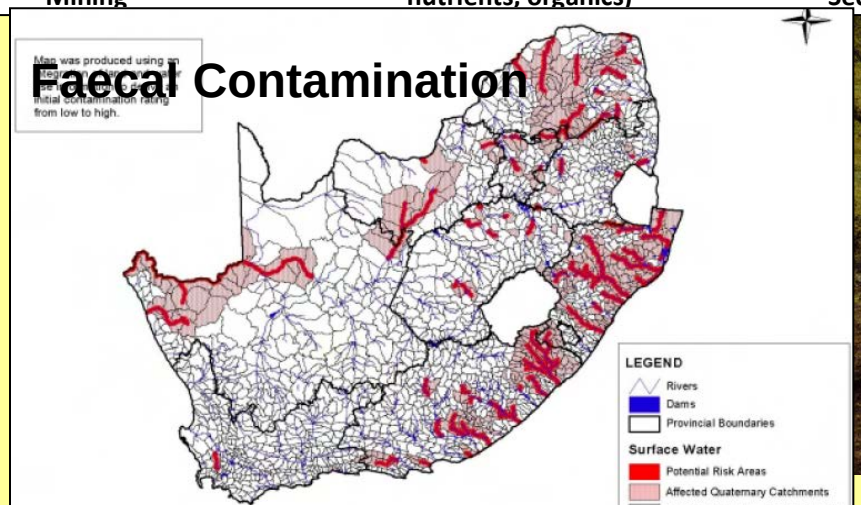
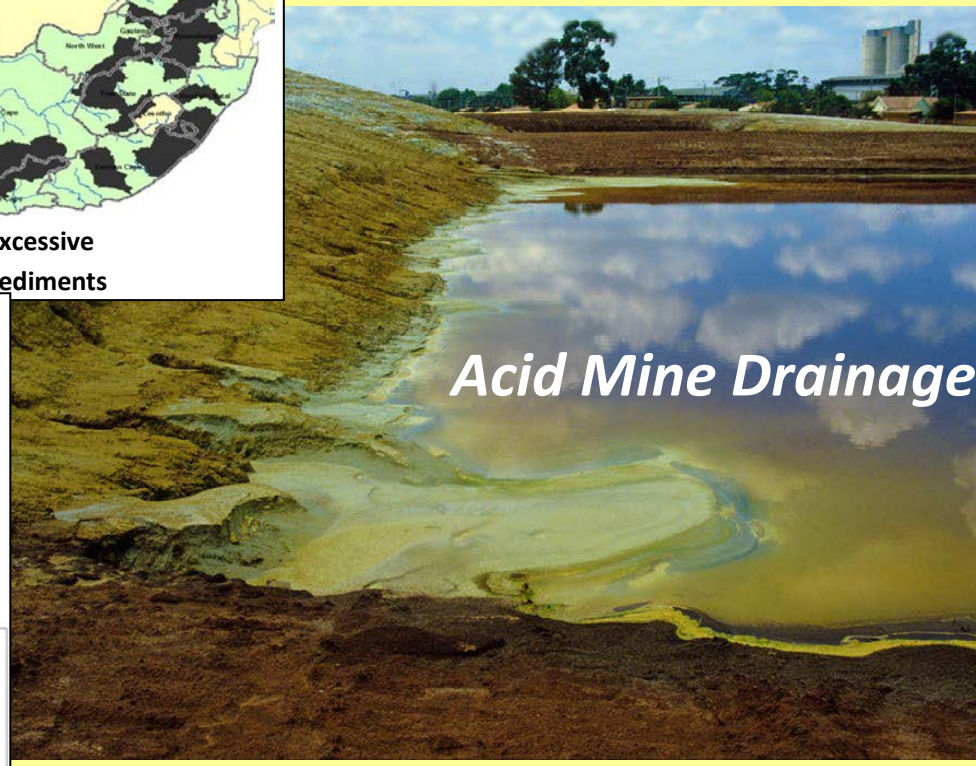
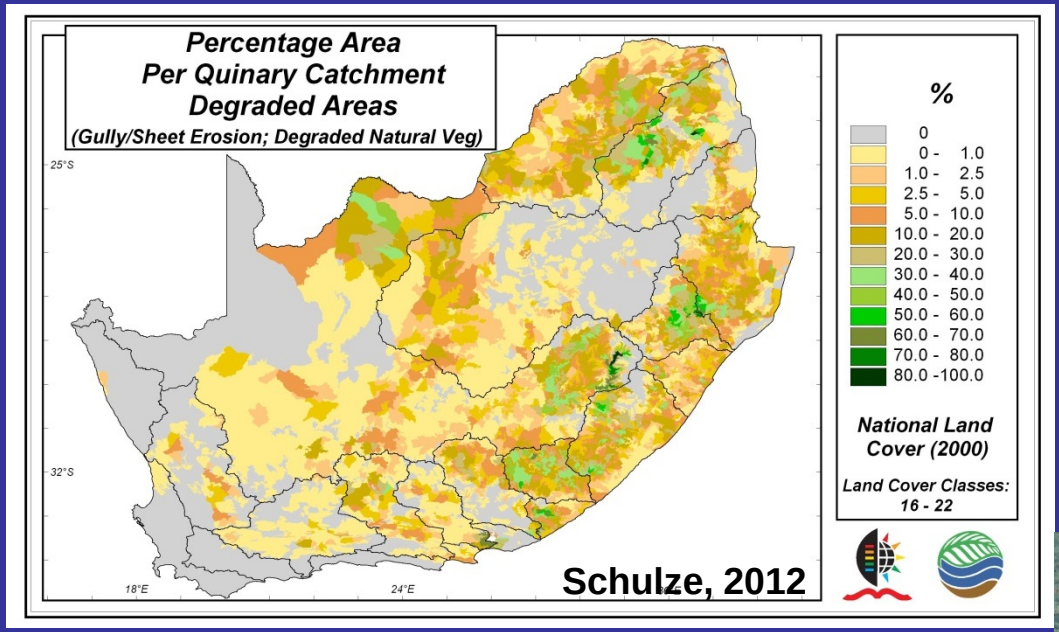
There are Many Causes of Poor Water Quality in SA; CC is Likely to Amplify Water Quality Impacts



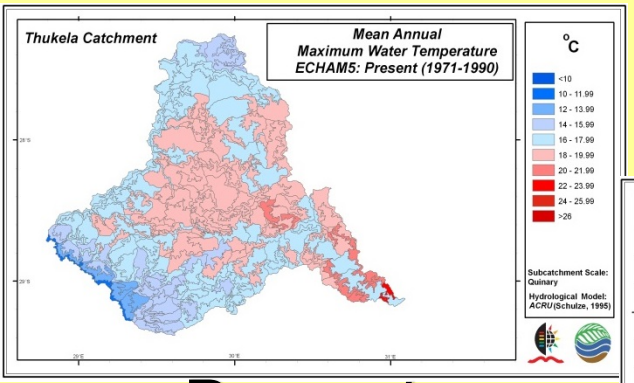




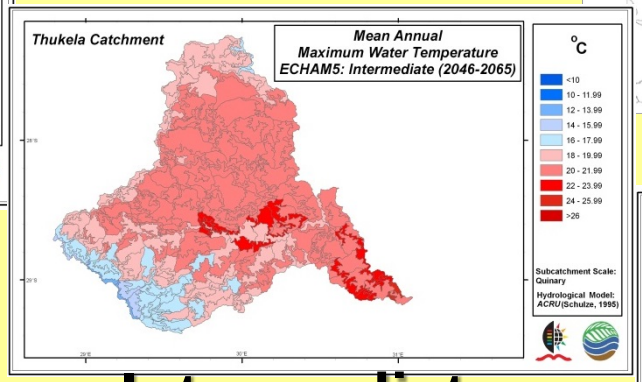
Large Tracts of Developing Countries are Degraded, with Effects of Degradation Likely to be Exacerbated by CC



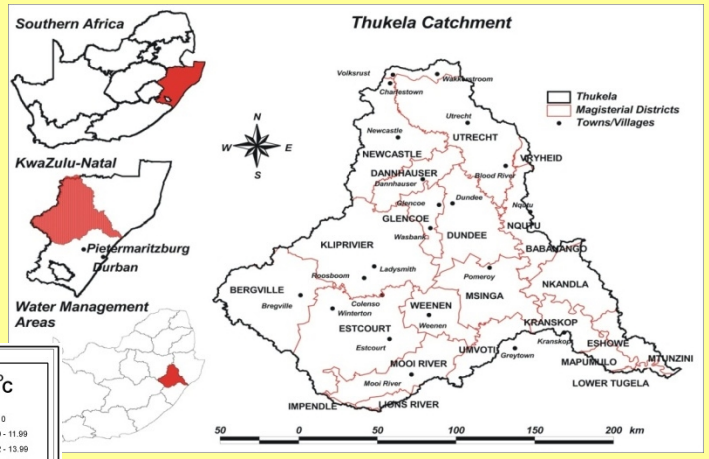
Water Temperatures are Projected to Increase Significantly with CC, with Health, Power Cooling & Aquatic Environmental Consequences

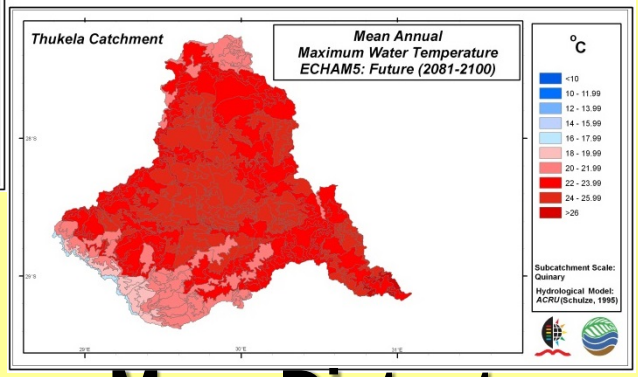


Present
1971 - 1990



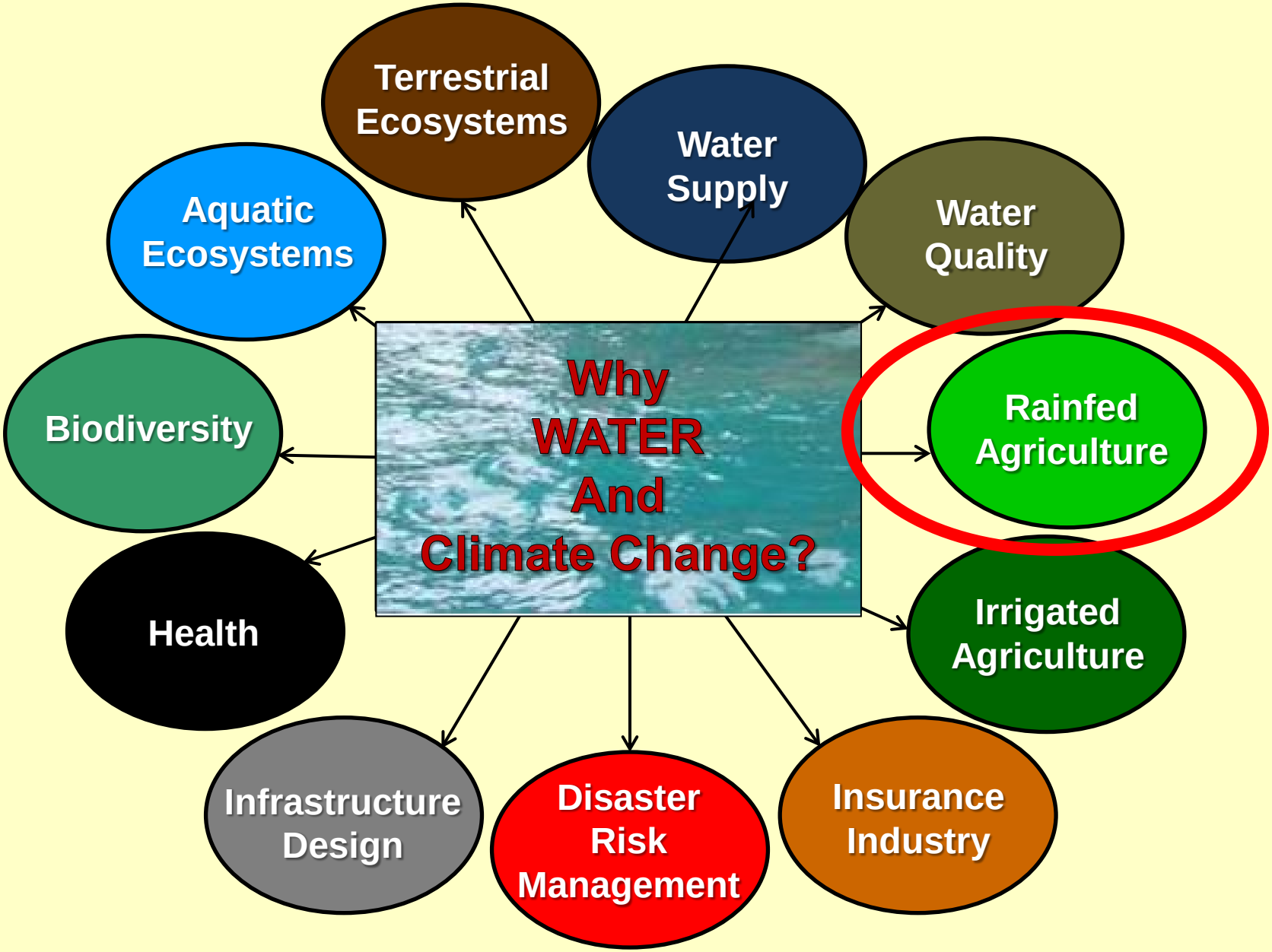
Intermediate
Future
2046 - 2065





More Distant
Future
2081 - 2100

Barichievy & Schulze, 2010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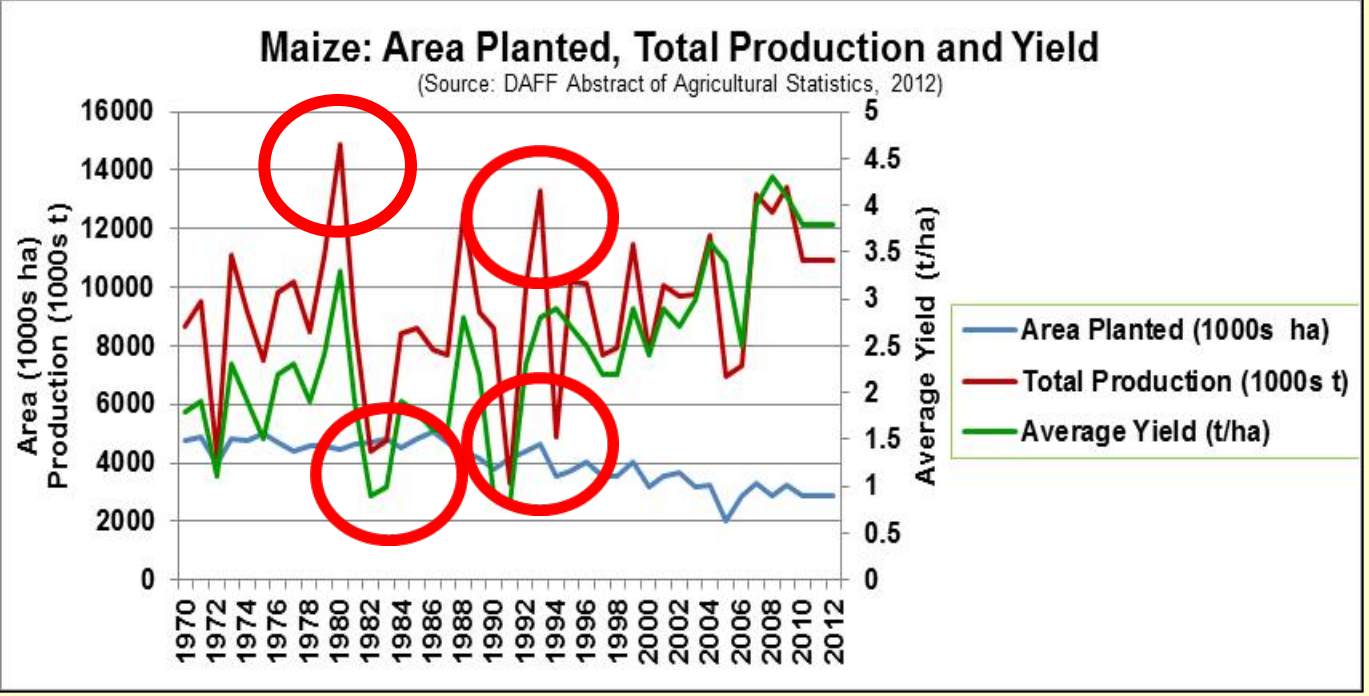
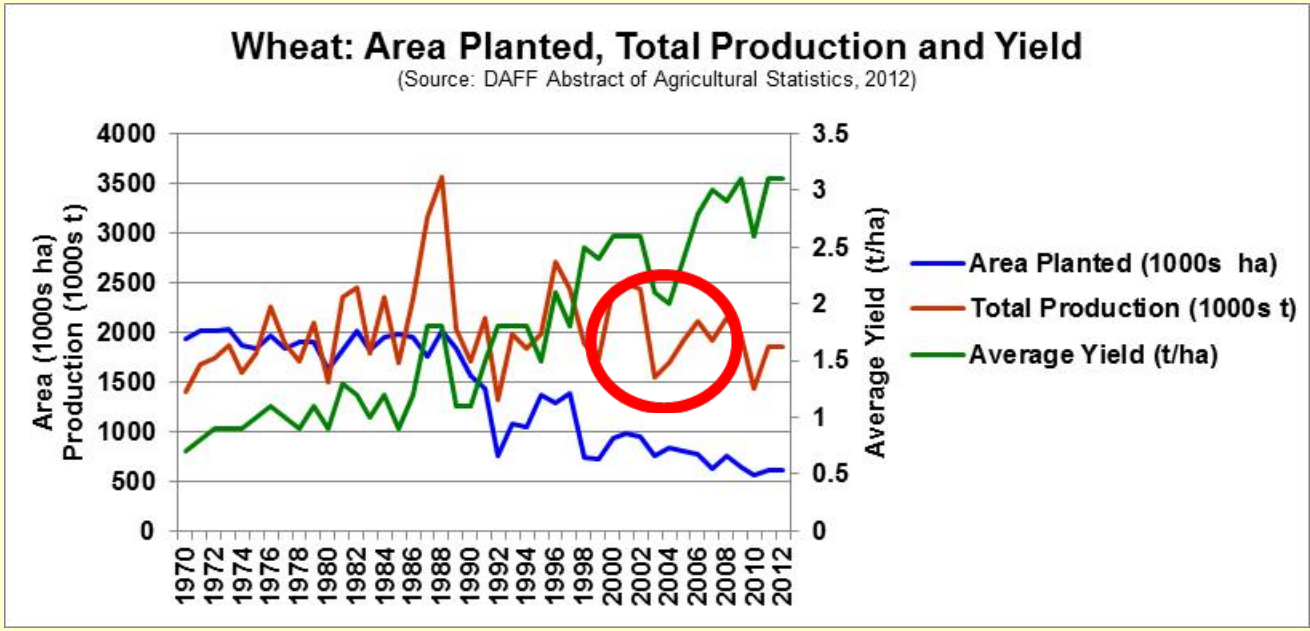
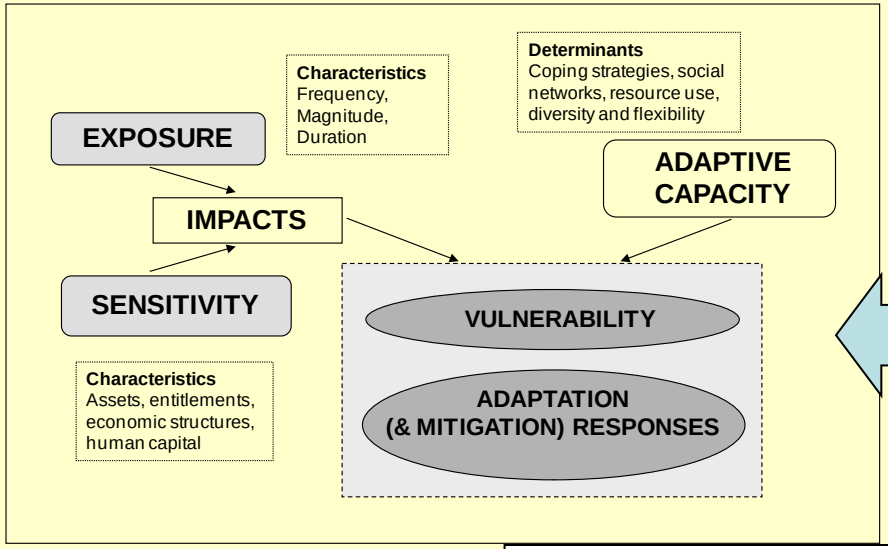


FACT !!
The climate dependence of yields in SA is undisputed

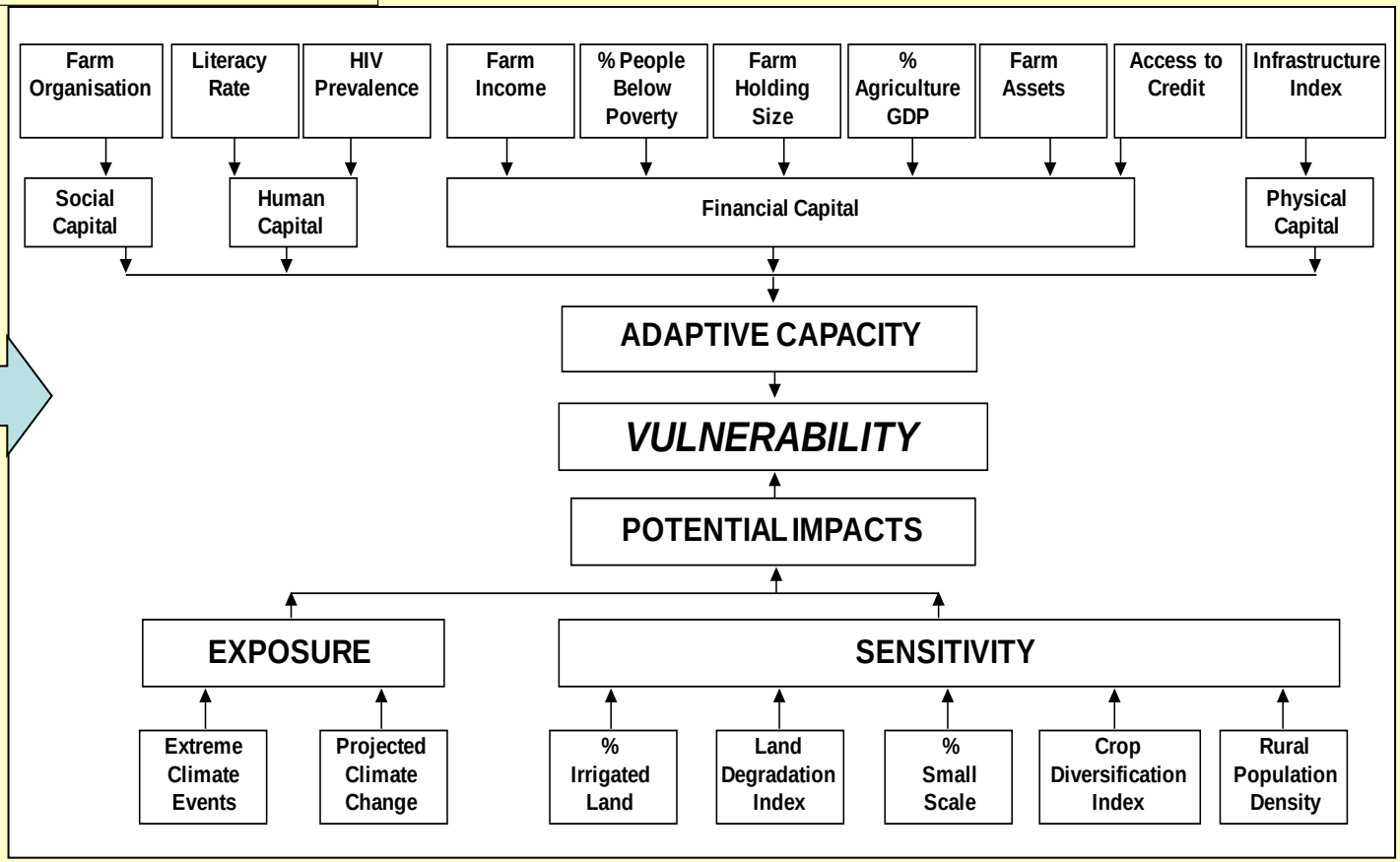
But, total production is up while area planted is down





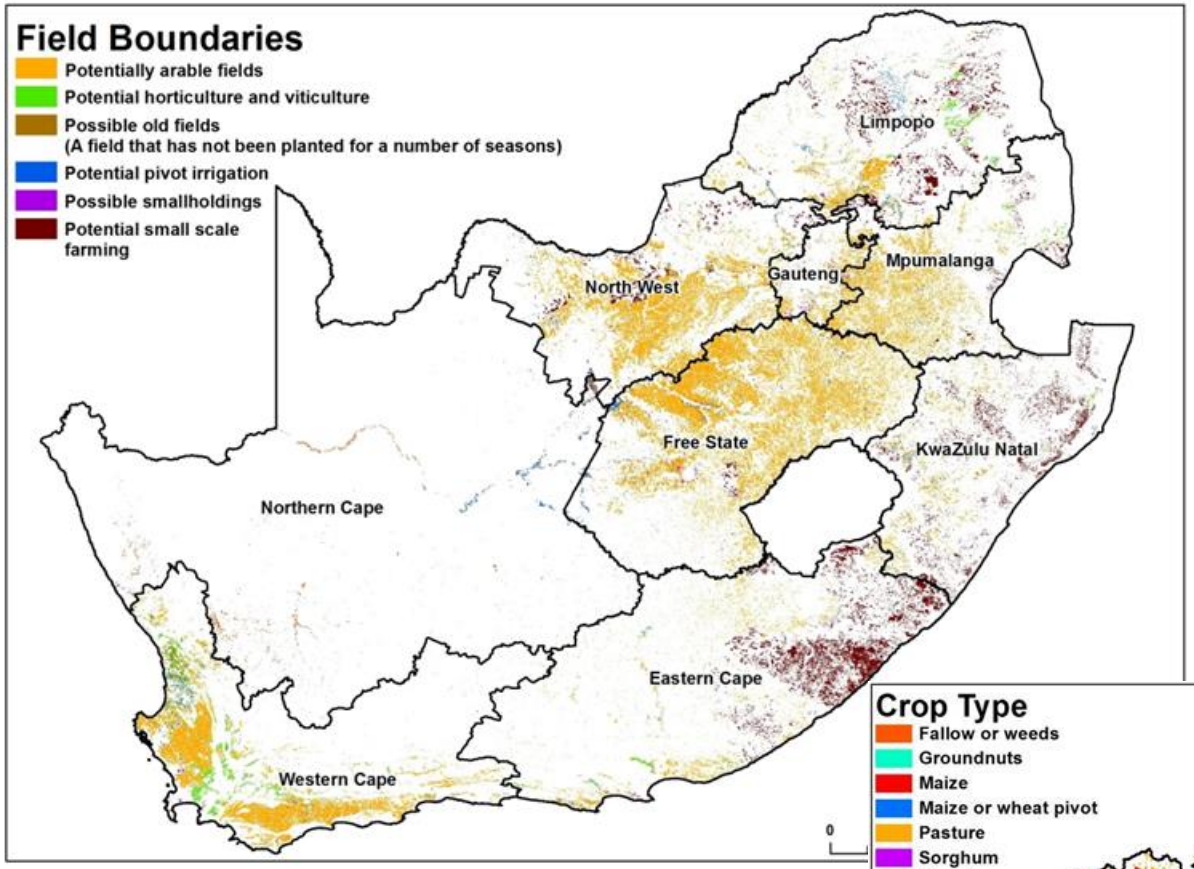
Food & Water Security are Linked to the Vulnerability - Impacts - Adaptation Framework

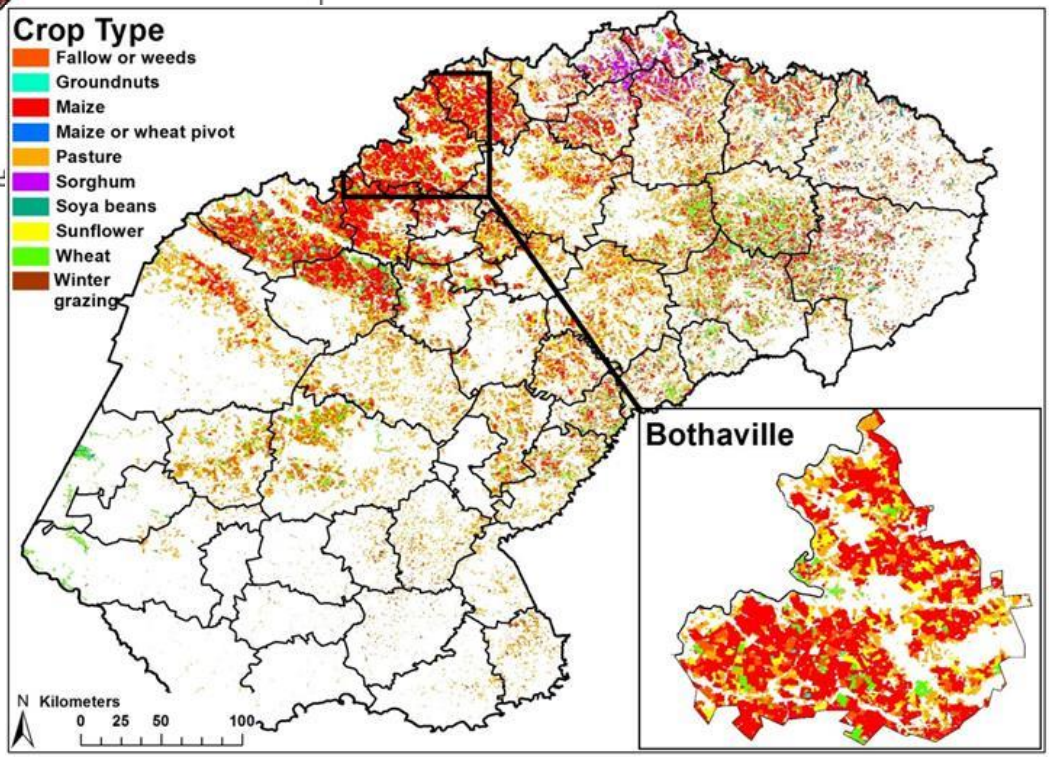
V-I-A Links and Indicators



Gbetibouo & Ringler, 2009

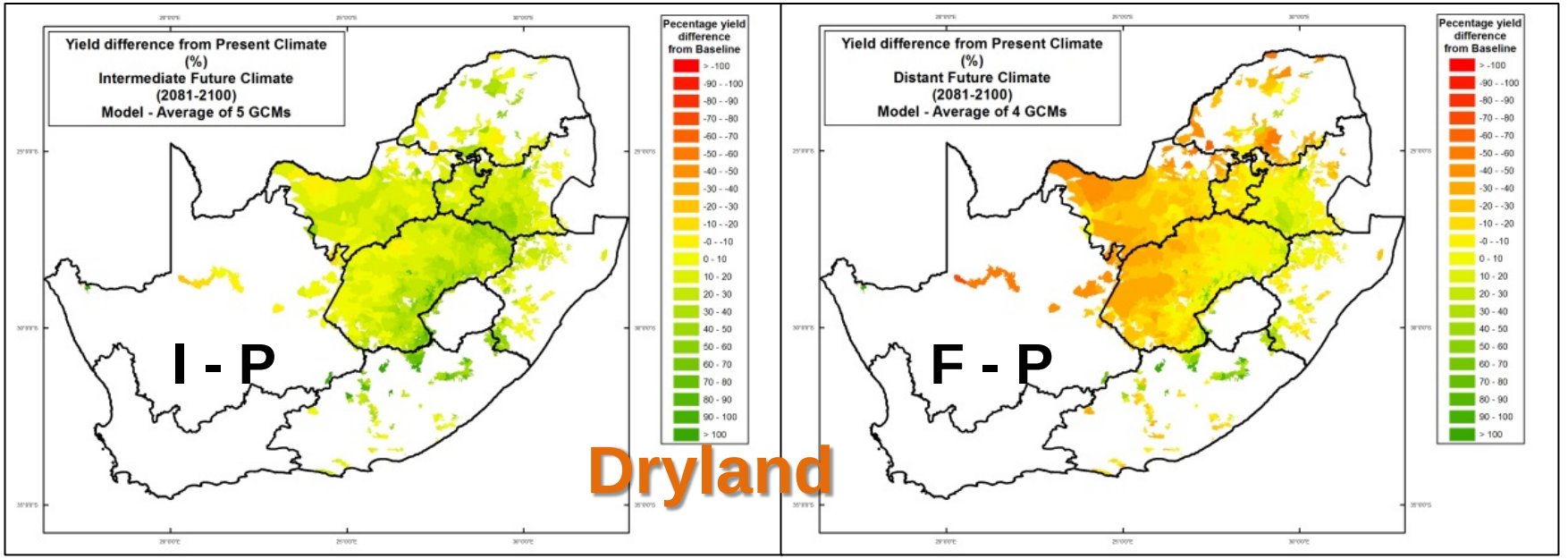
The Case of Maize in SA





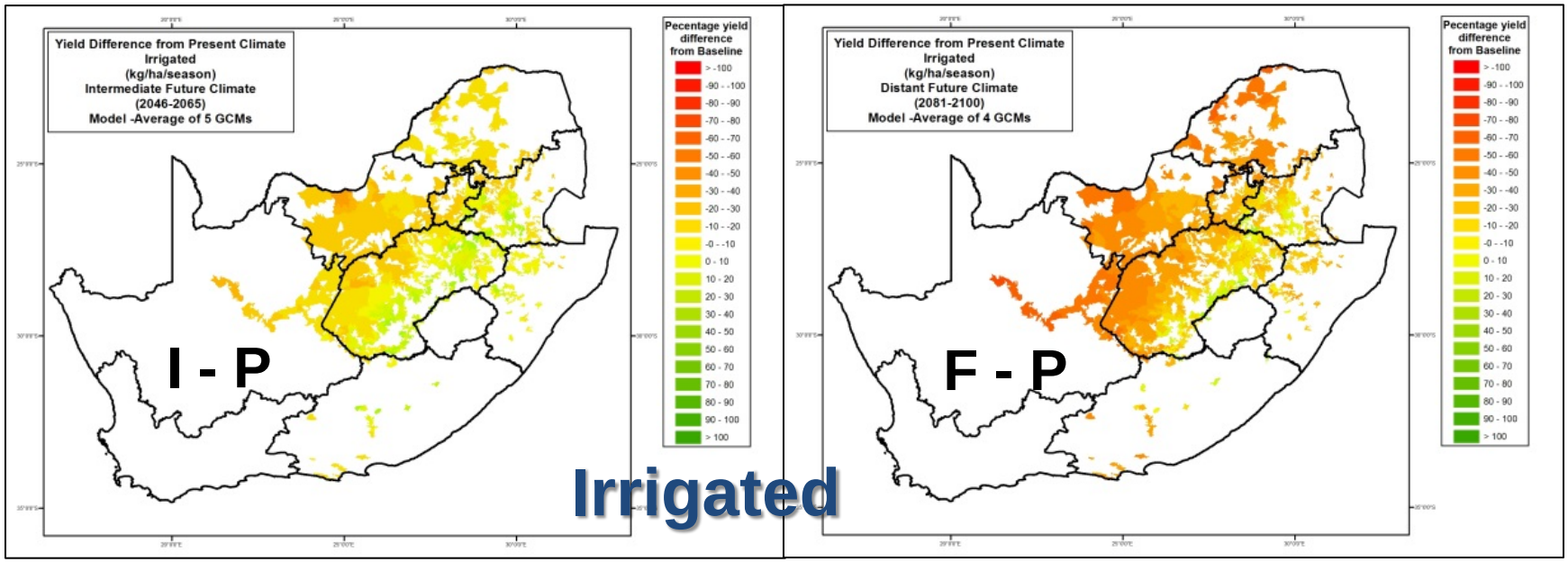
Study of 130 000 maize fields over SA, each with unique soils & climate

Durand & Schulze, 2014



Dryland

Yield Differences into the Future



Irrigated


Or, with the subsistence farmer ...

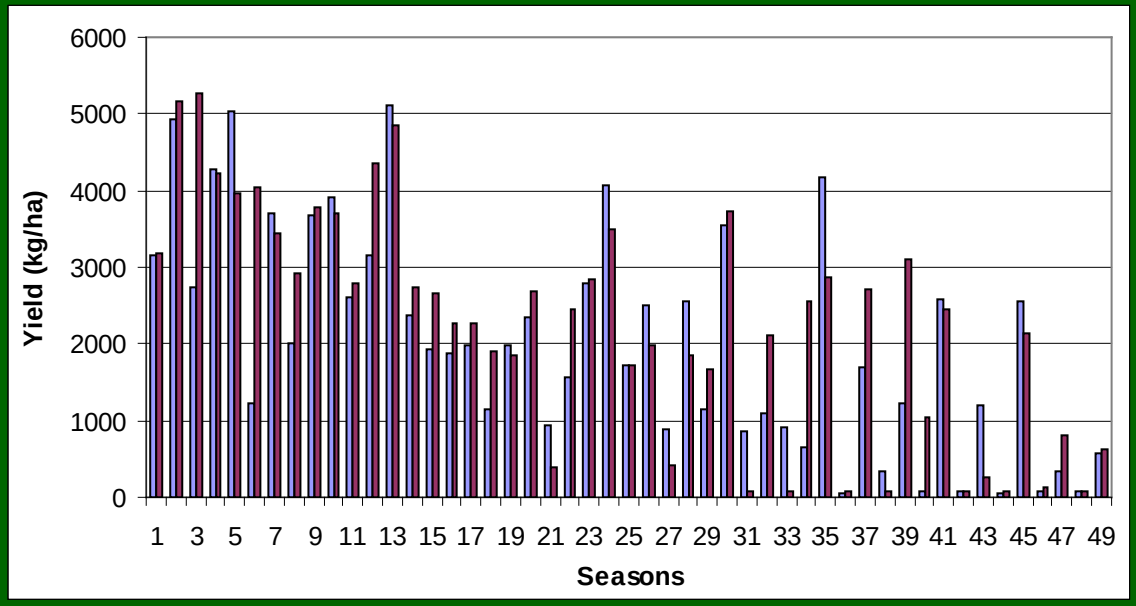
What About the Influence of Climate Change on Maize Yields When Fertilizing with Manure vs. Inorganic Fertilizer

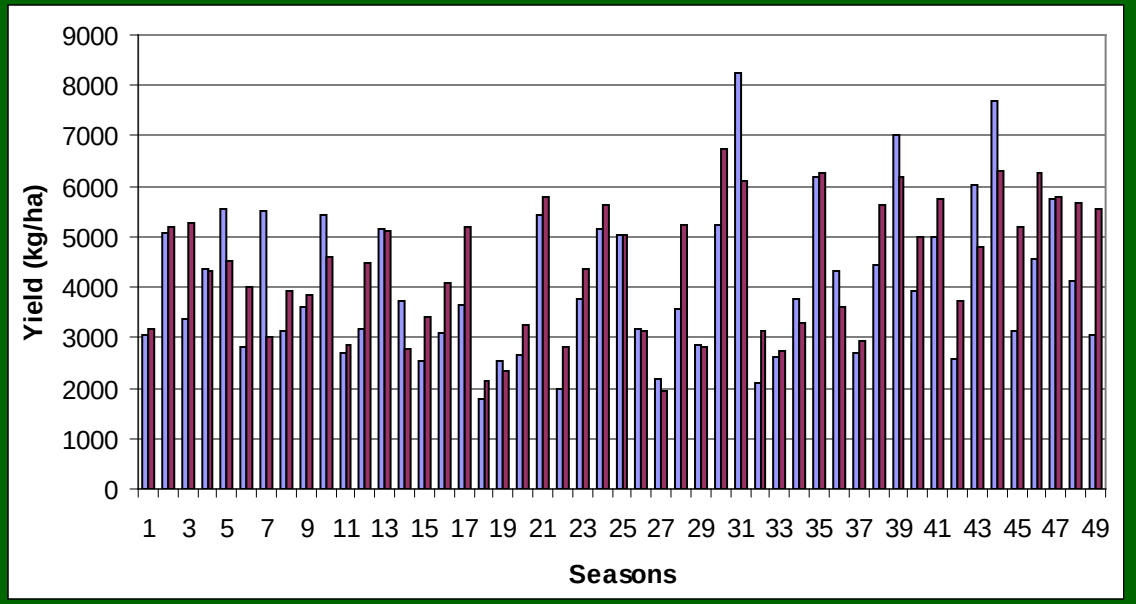
Manure
N ≡ 68 kg/ha

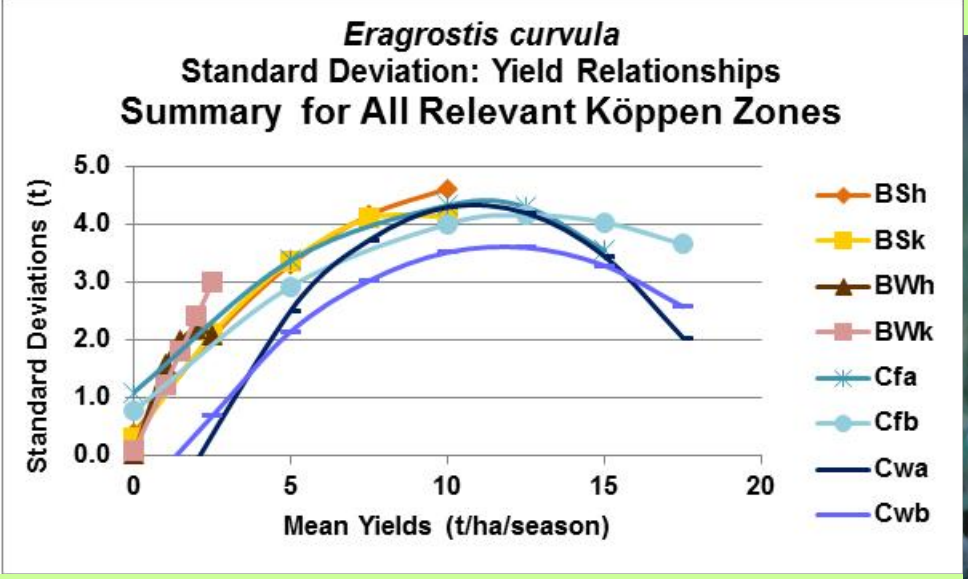
More Rapid Decomposition of Manure in Future

Inorganic
N ≡ 200 kg/ha

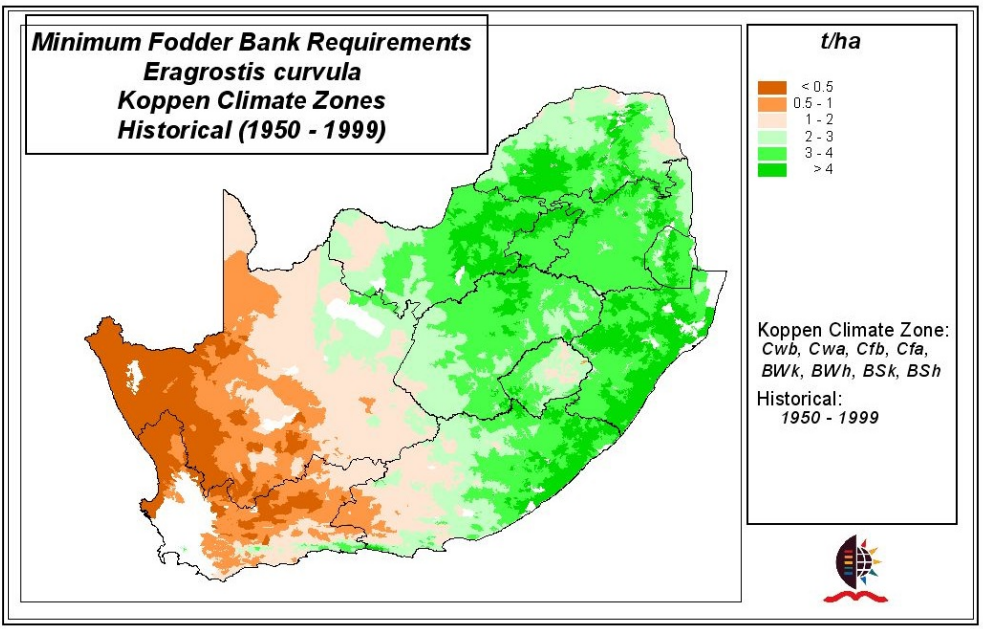
$2XCO_2$ + 2°C; Potshini KZN
Walker & Schulze, 2008

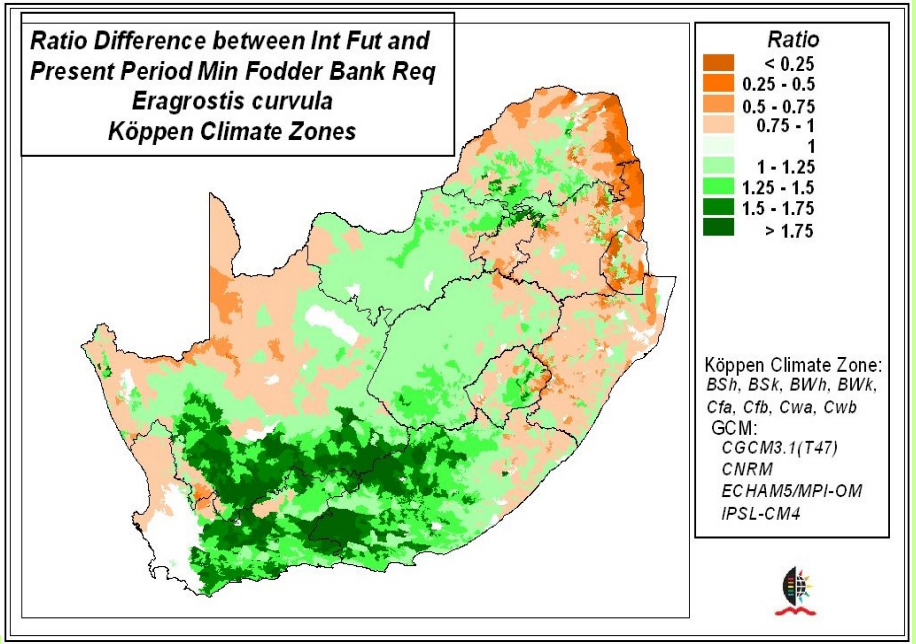






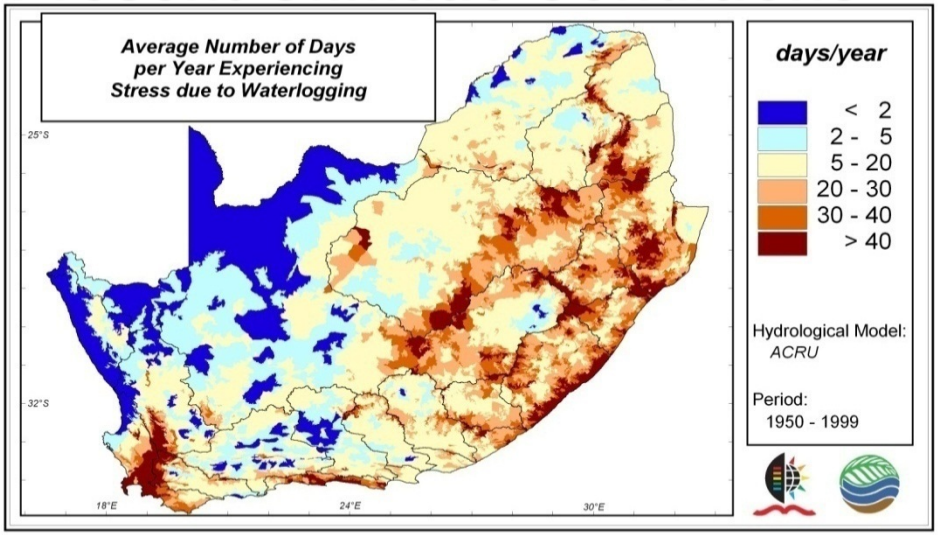
Fodder Banking with Eragrostis curvula



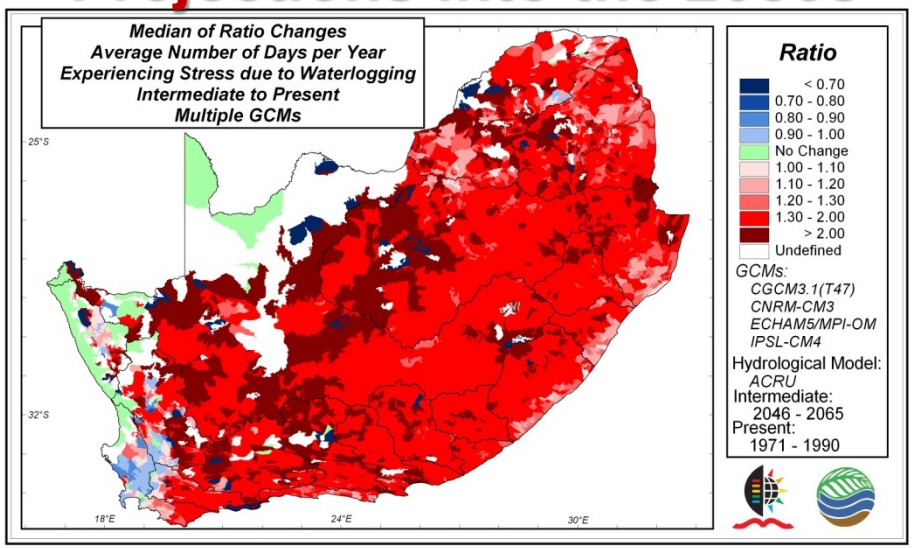


Projected Changes in Days with Waterlogged Soils … In-field Trafficability

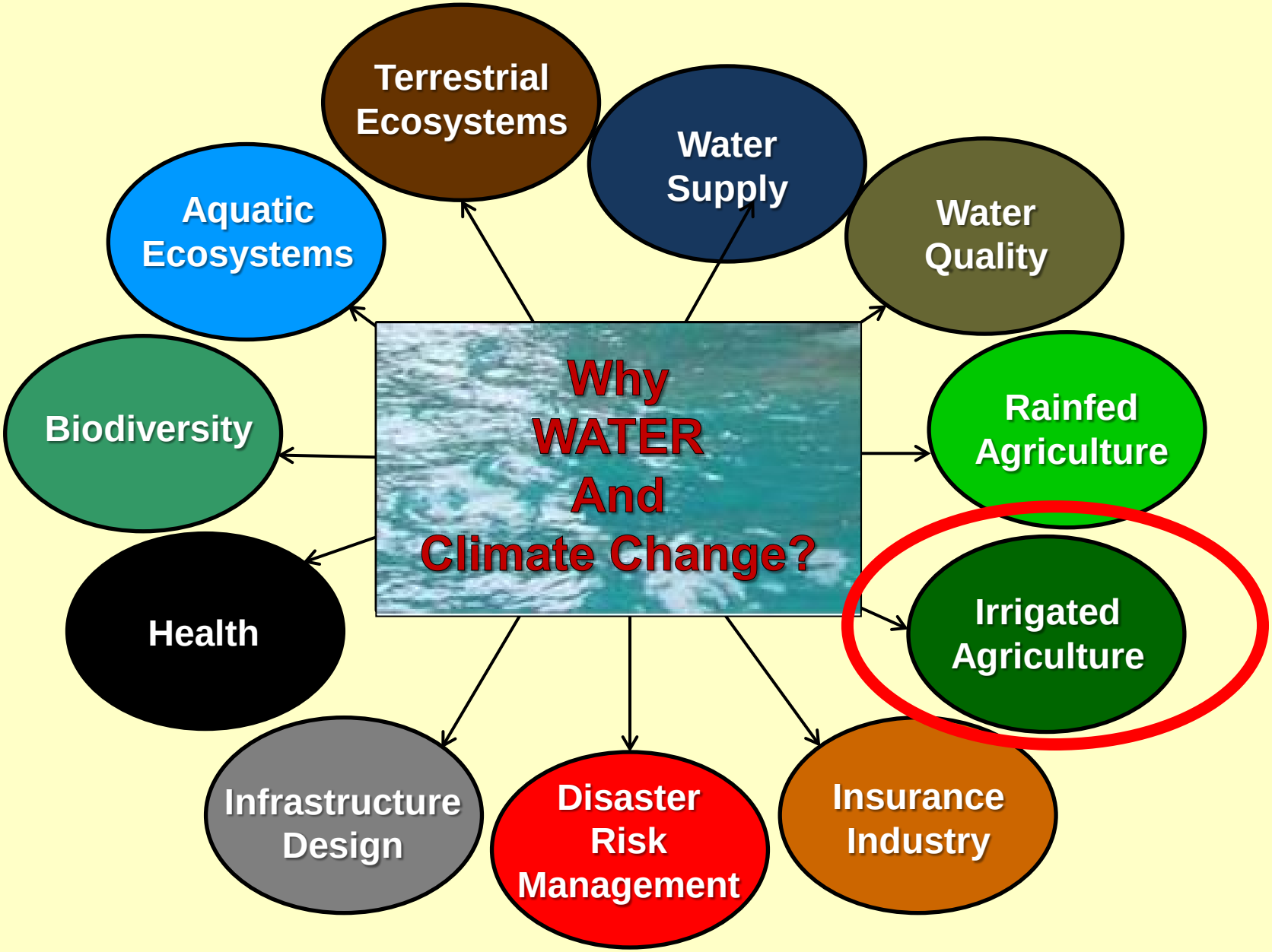
Present Climatic Conditions



Projections into the 2050s



Impacts?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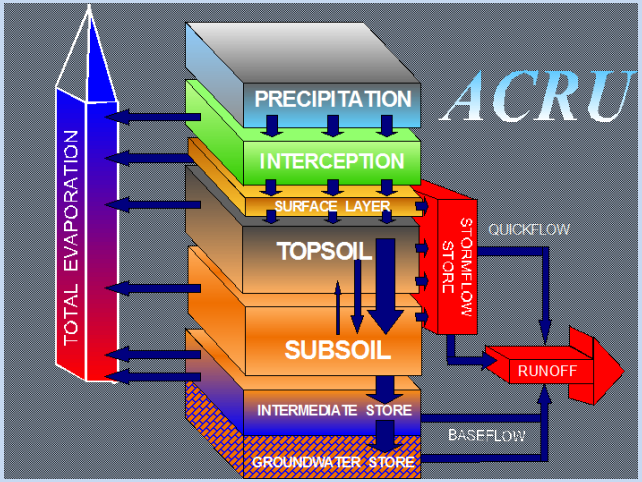
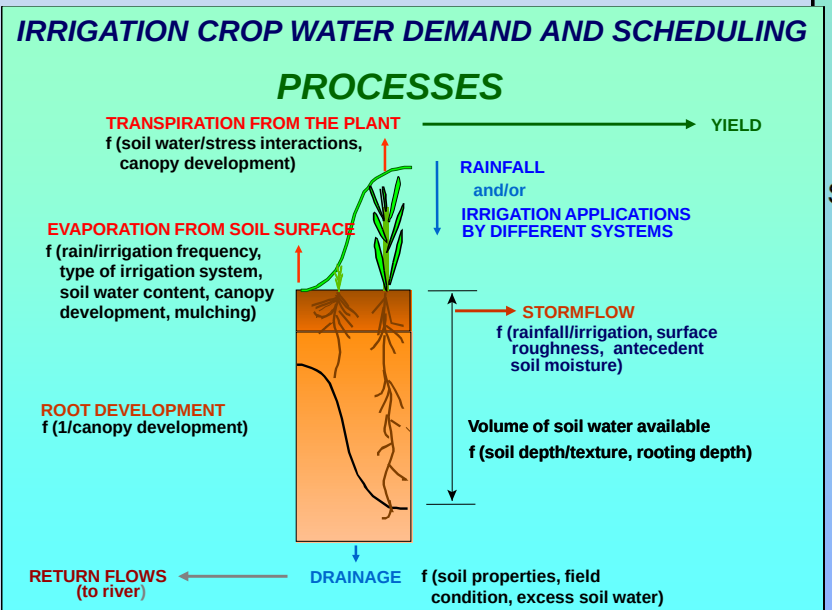
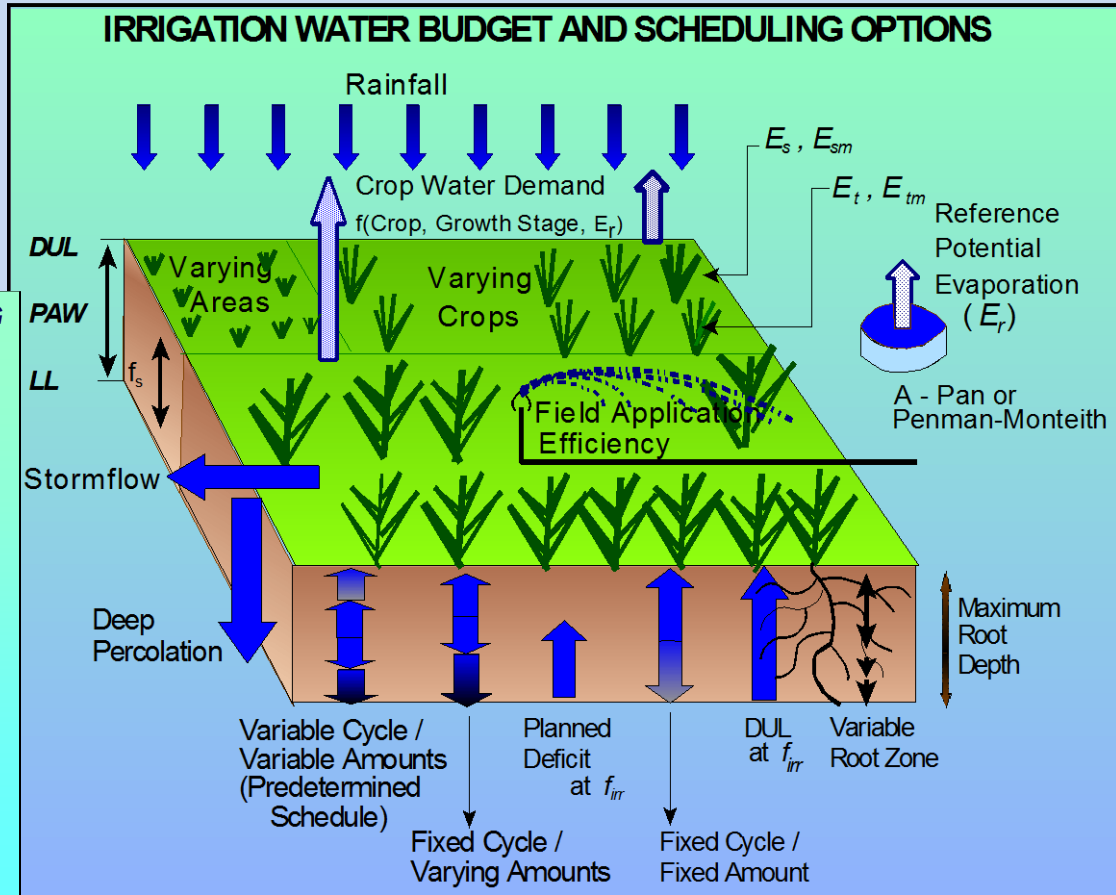
How do we Assess the Irrigation Water Demand by Crops ?





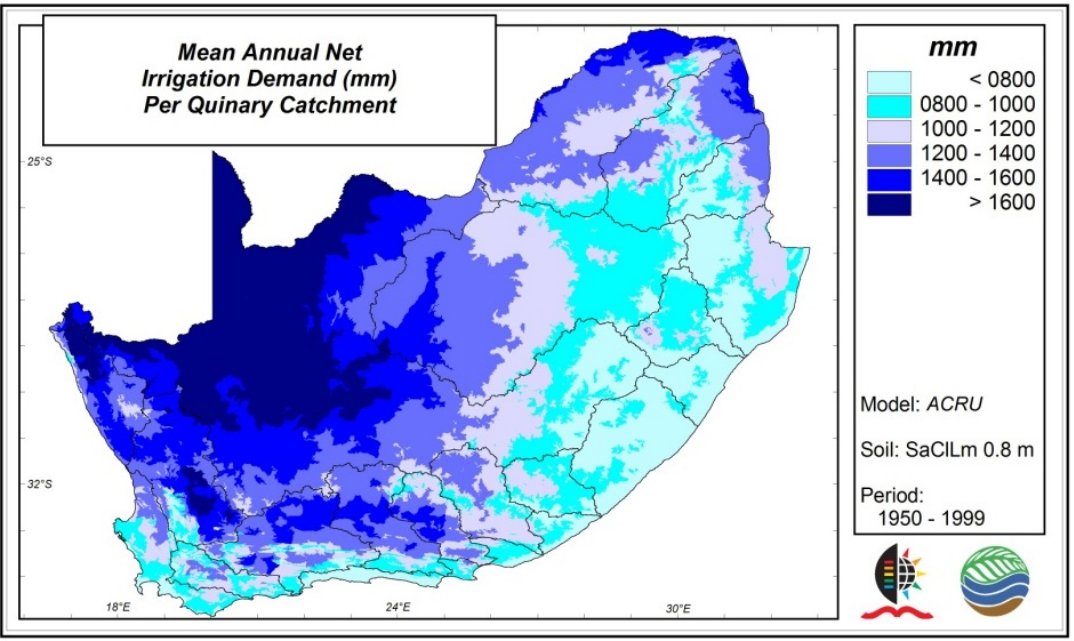


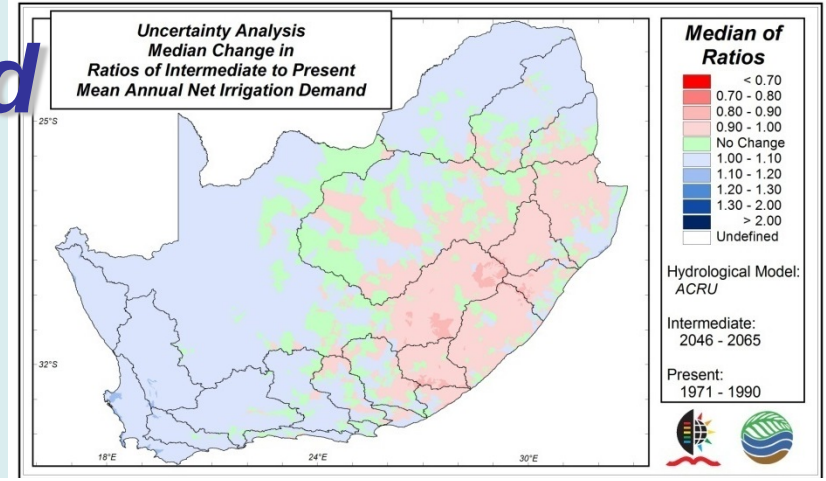
Irrigation Water Demand

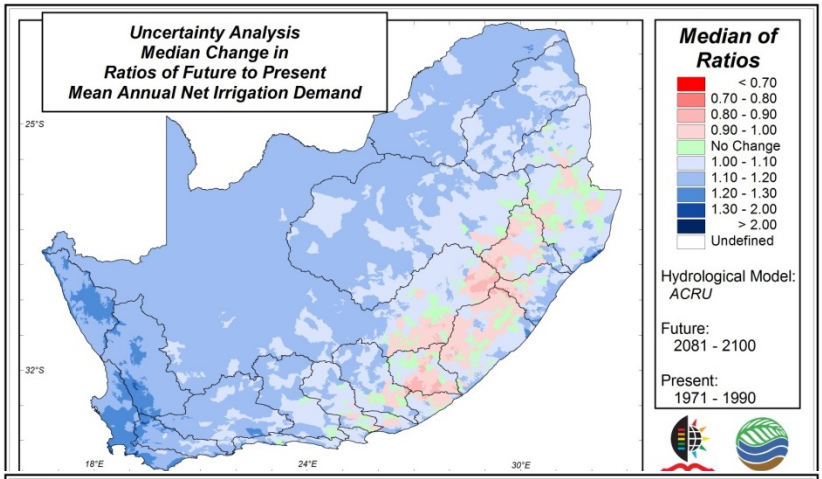
1. Present Demand

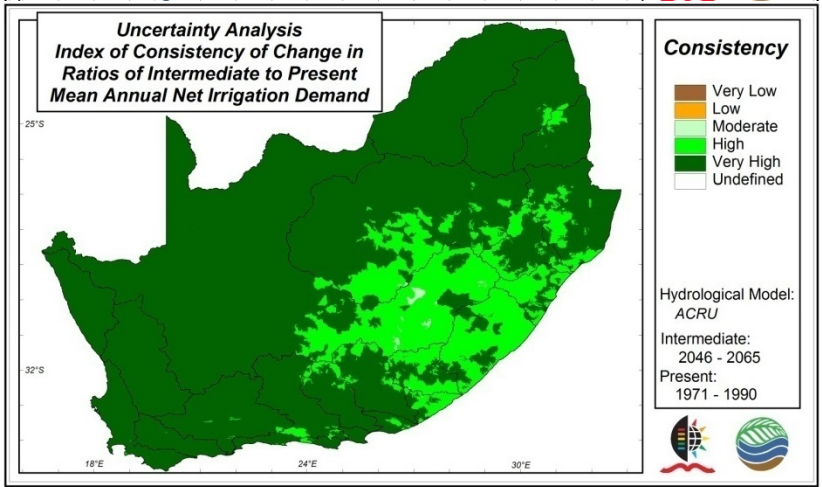
2. Future Projected Change

3. How Confident Are We?



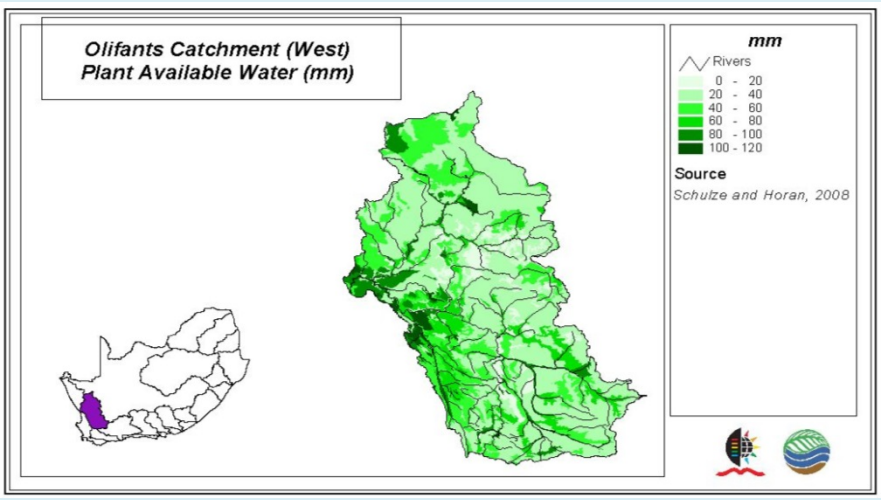




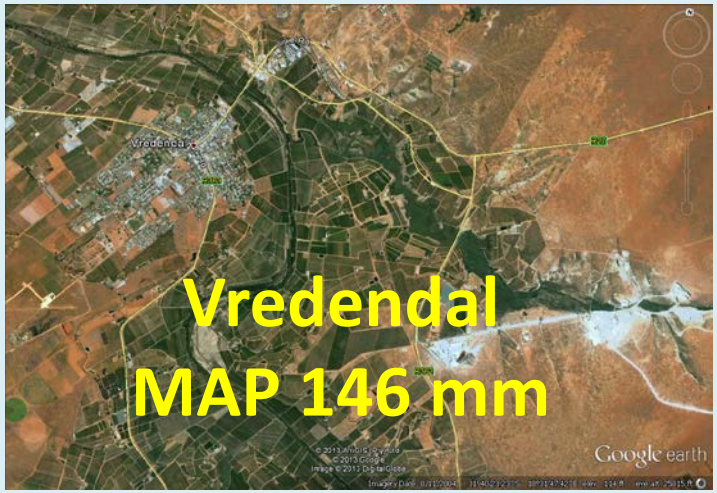


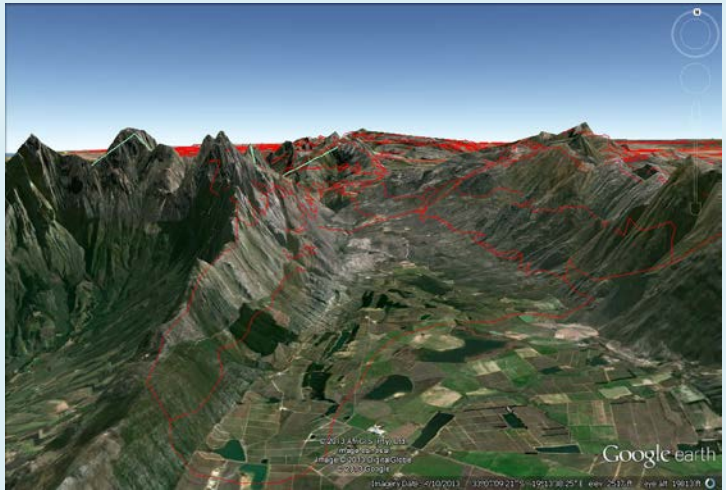
Winners and Losers (Schulze, 2011)

Assessing Real-World Problems: Irrigation in the Olifants-Doorn Catchment, W. Cape



Irrigation in the Valleys of the Cedarberg Mountains





This is what you see there

This is What the Challenge is: Irrigation Efficiency & Dam Re-Sizing Decisions

ESTUARY OF OLIFANTS | BULSHOEK DAM | ALGERIA TURNOFF | BEAVERLAC NATURE RESERVE | SOURCE OF OLIFANTS

LOWER OLIFANTS RIVER W.U.A. | CLANWILLIAM W.U.A. | CITRUSDAL W.U.A.

S-A1 → S-A4 → S-A3 →
S-A5 → S-A6
Clanwilliam
Citrusdal

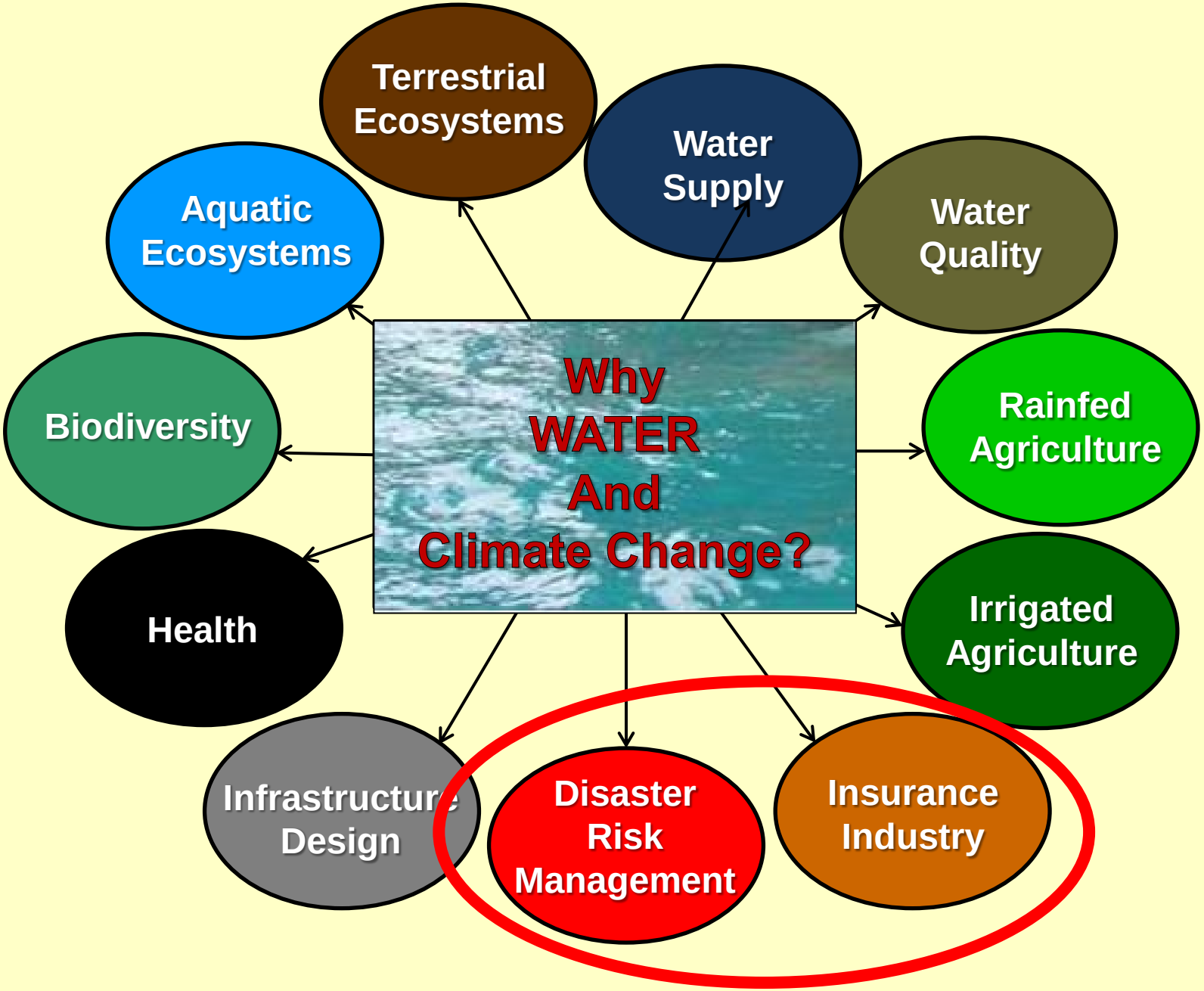
Quinary 2554 | Quinary 2551 | Quinary 2448 | Quinary 2445 | Quinary 2442

Ir = 1641 ha Citrus | Ir = 813 ha Citrus | Ir = 5579 ha Citrus | Ir = 1333 ha Citrus

Ir	= 16 675 ha
Grapes	= 13 152 ha
Tomatoes (a)	= 800 ha
Veg (w)	= 848 ha
Veg (s)	= 480 ha
Veg (a)	= 320 ha
Lucerne (a)	= 400 ha
Citrus	= 675 ha

Capacity	= 11902564 m^3	Capacity	= 4917907 m^3	Capacity	=
Area	=	Area	=	Area	=
Seepage	= 0%	Seepage	= 0%	Seepage	=52800/d
Env	= 0%	Env	= 0%	Env	=
Dead St	= 1%	Dead St	= 1%	Dead St	= 6%
Balancing	= 12%	Balancing	= 12%	Balancing	= 12%
Wind	= 5%	Wind	= 5%	Wind	= 5%

Capacity	= 12712565 m^3	Capacity	= 3037435 m^3
Area	=	Area	=
Seepage	= 0%	Seepage	= 0%
Env	= 0%	Env	= 0%
Dead St	= 1%	Dead St	= 1%
Balancing	= 12%	Balancing	= 12%
Wind	= 5%	Wind	= 5%
Draft	= Monthly Values	Draft	= Monthly Values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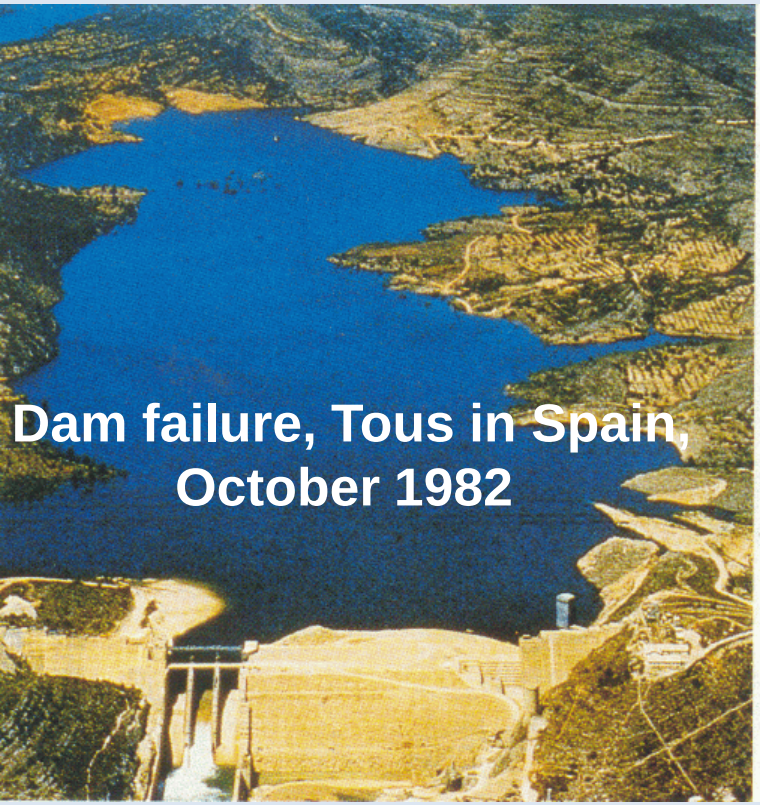
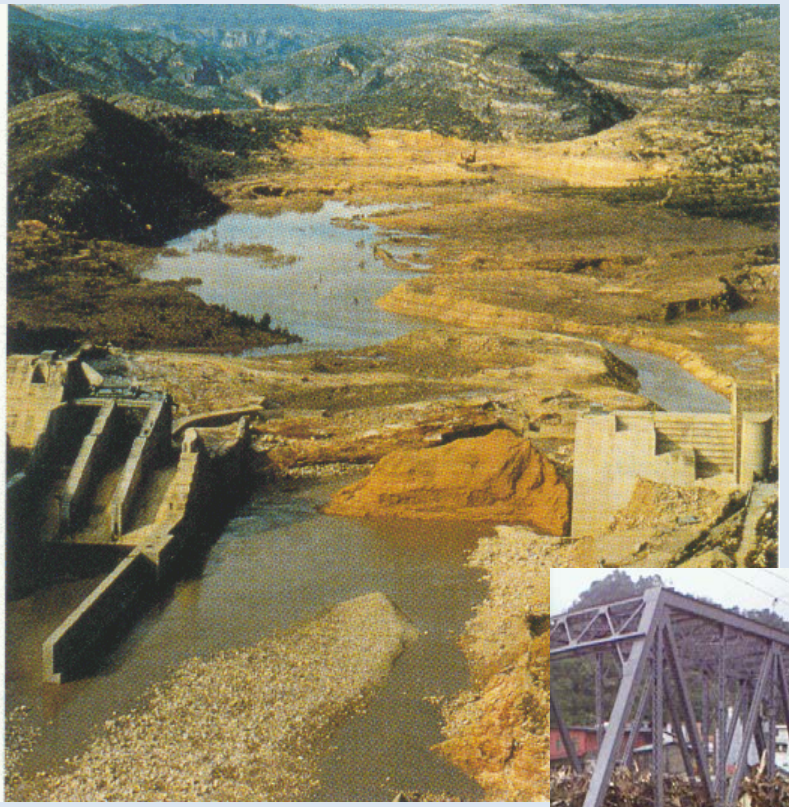
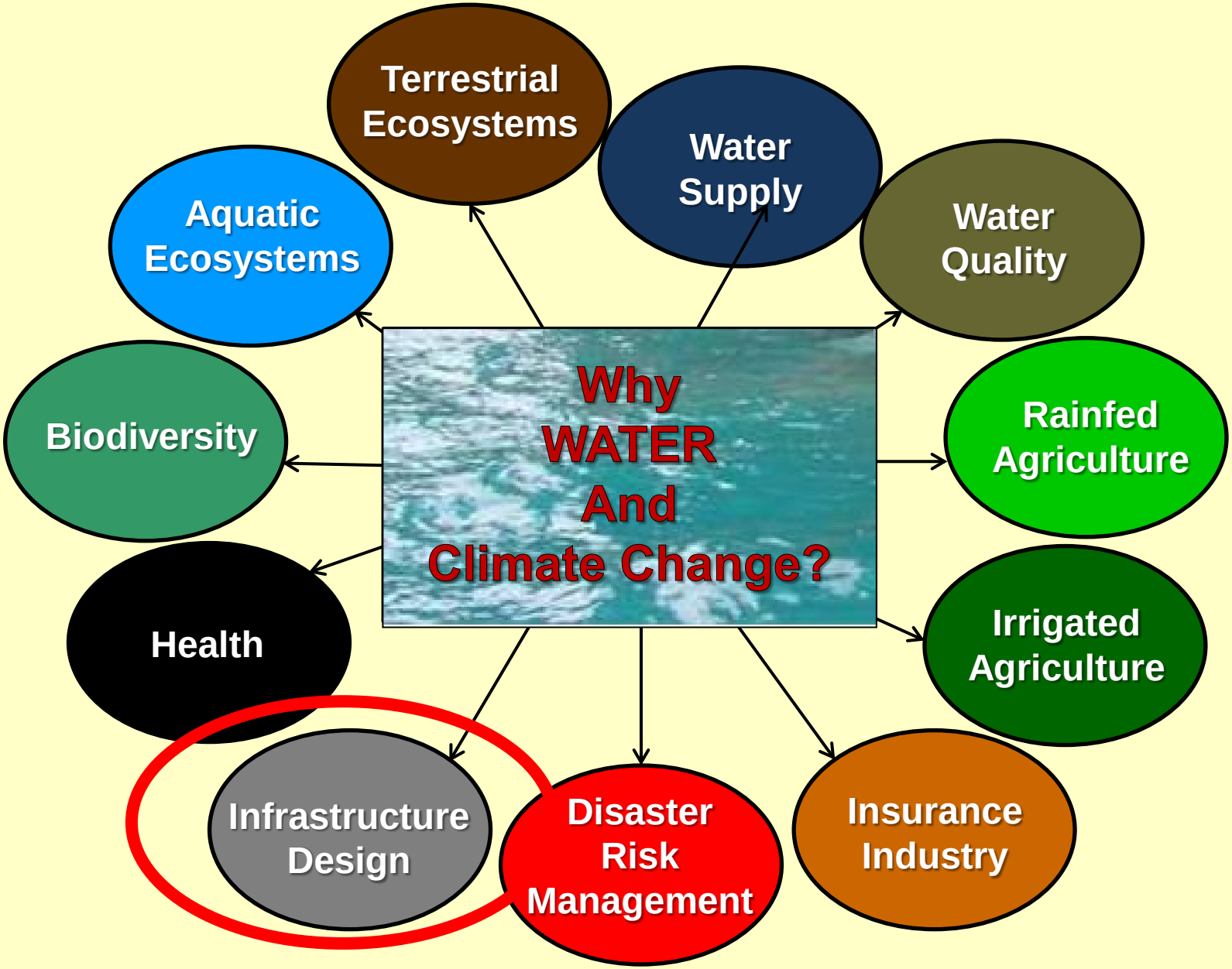




Examples of Water Related Disasters … What Does the Future Hold? Are we Prepared?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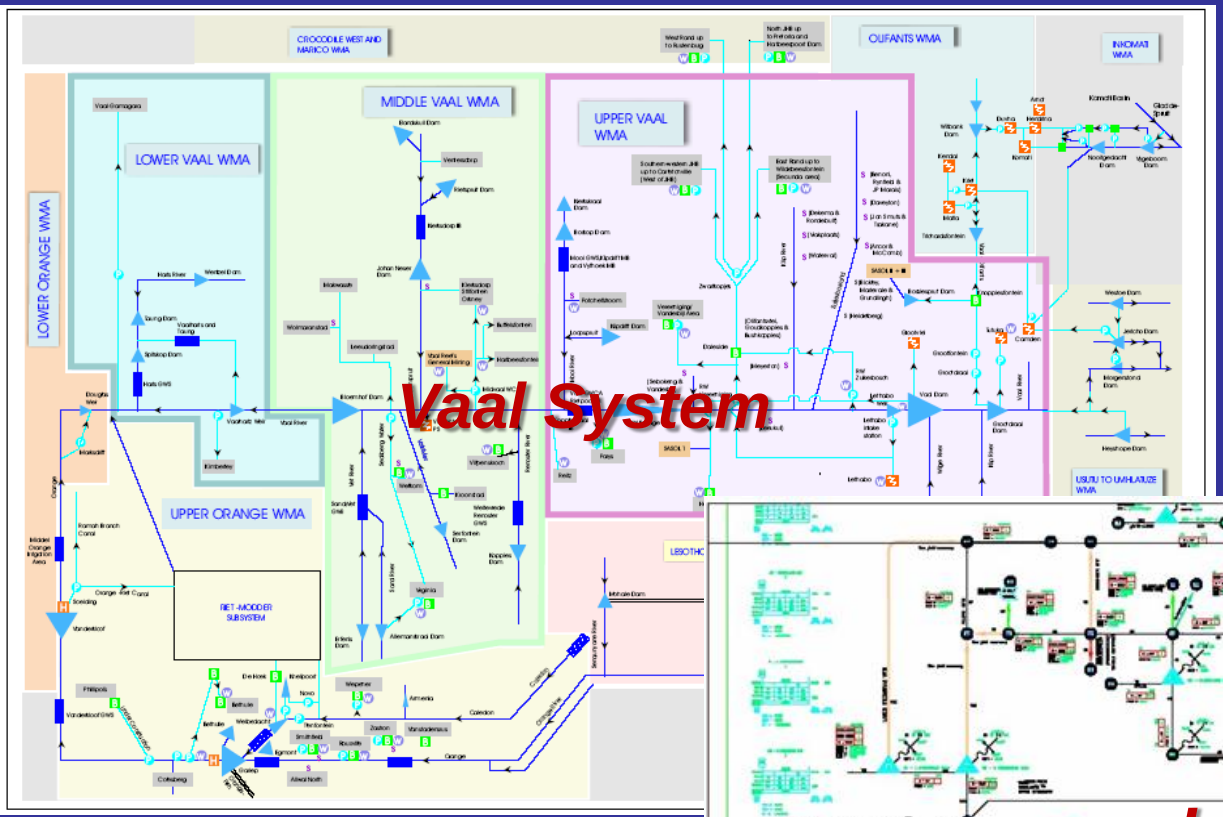
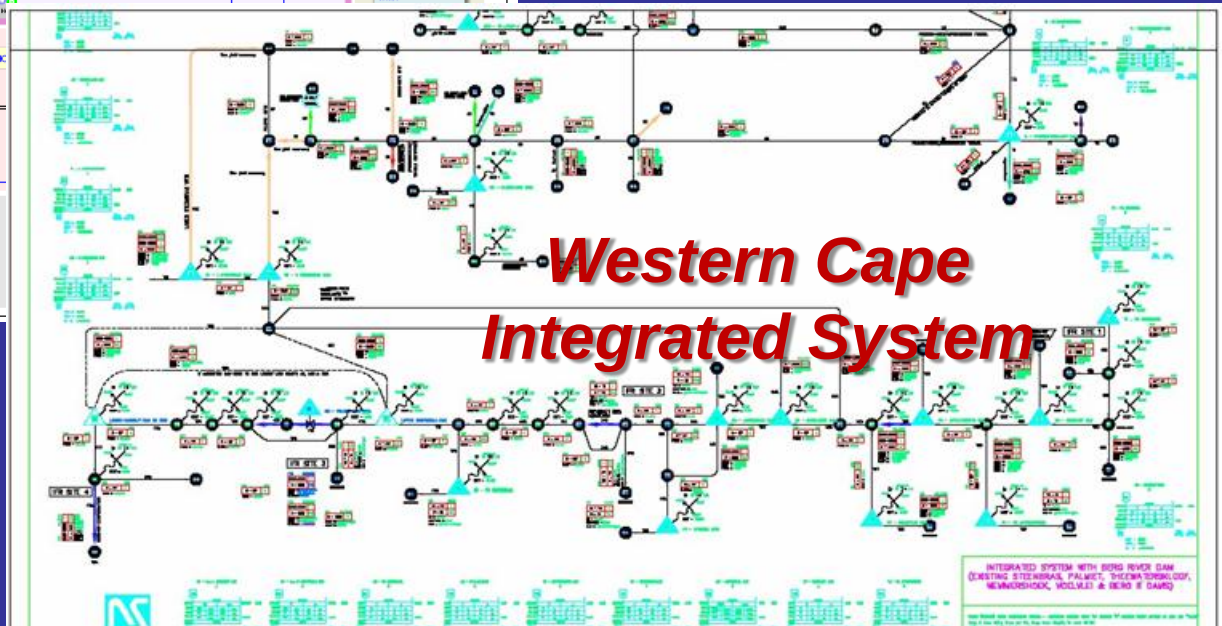
The Present: We Have "Re-Plumbed" Natural Flow Systems & We Need to Assess CC Impacts on these Re-Plumbed Systems

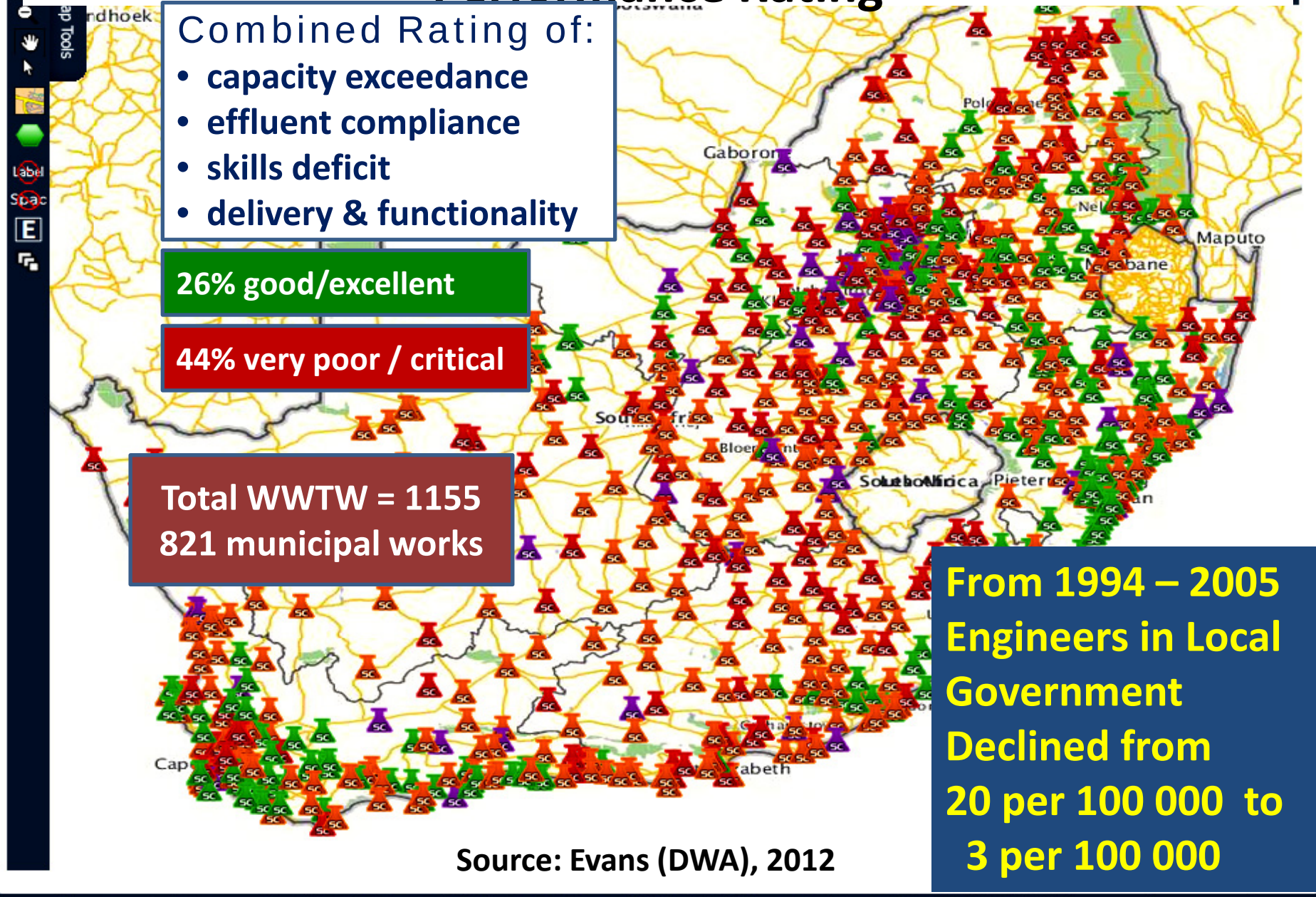




DWA, 2004

The Present: We are NOT Maintaining our Water Related Infrastructure – High Dysfunctunality

"High Risk Areas": Wastewater Treatment Works : Performance Rating



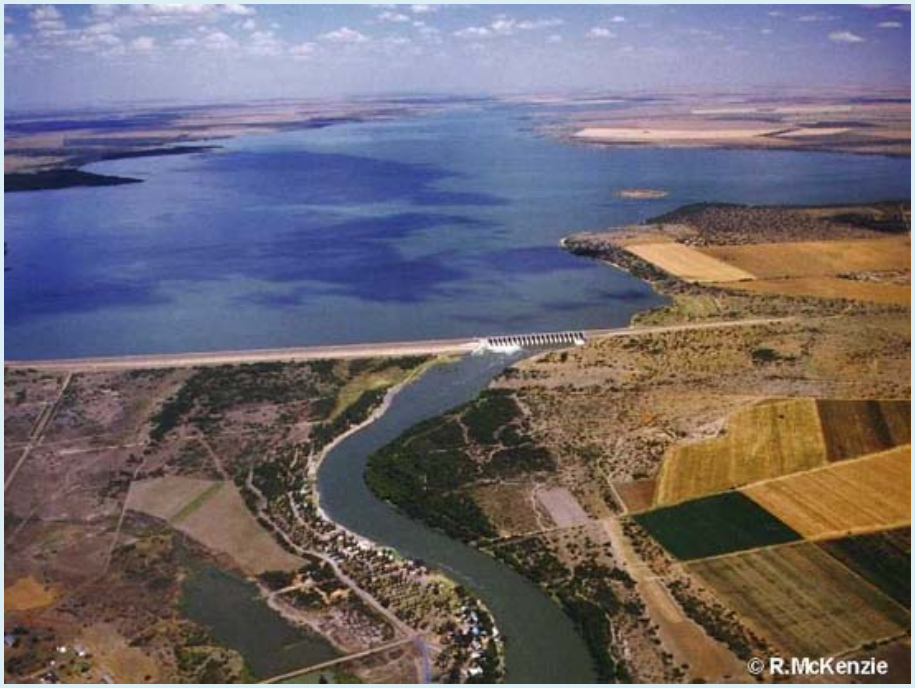
Source: Evans (DWA), 2012

But, We Have to Deal With Designs and Safety of Hydraulic Infrastructure

(dams, IBTs, WWTWs, stormwater systems etc)

- **Expensive,**
- **Essentially Irreversible and**
- **Usually have a Design Life 50 to 100 years…**

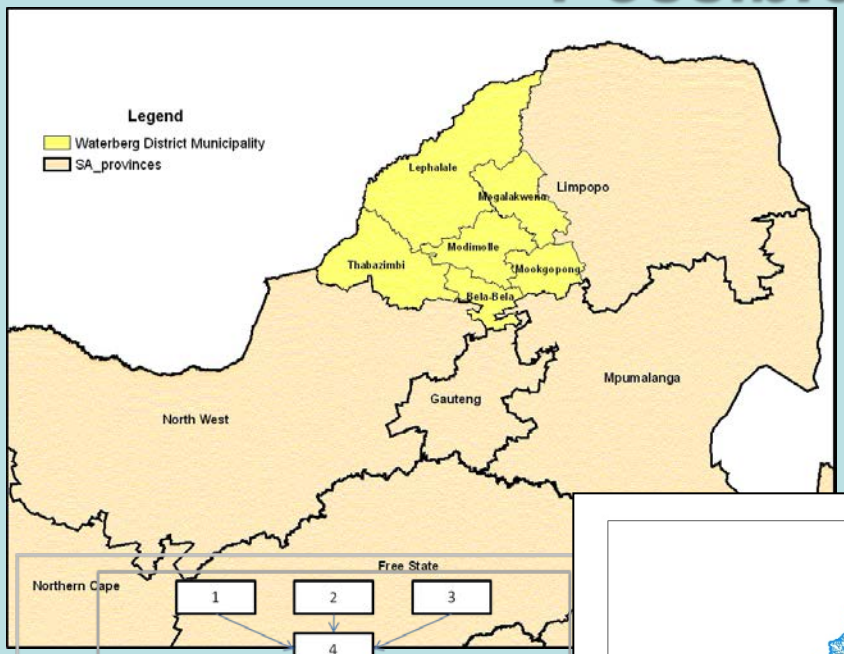
… to function well into the era of the extremes expected with CC. Are we factoring this into designs?

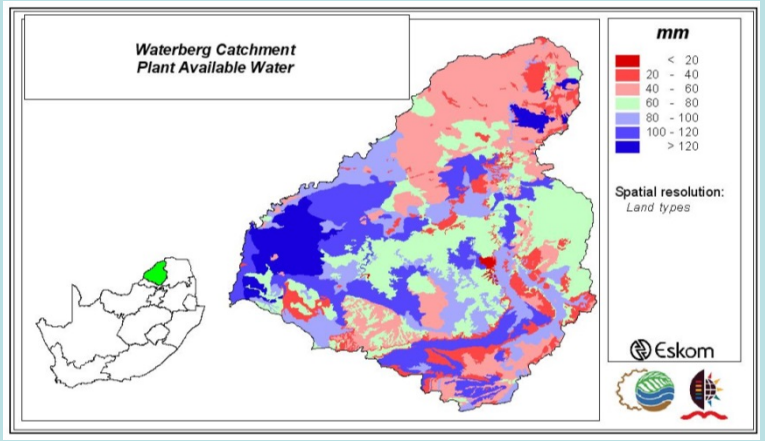


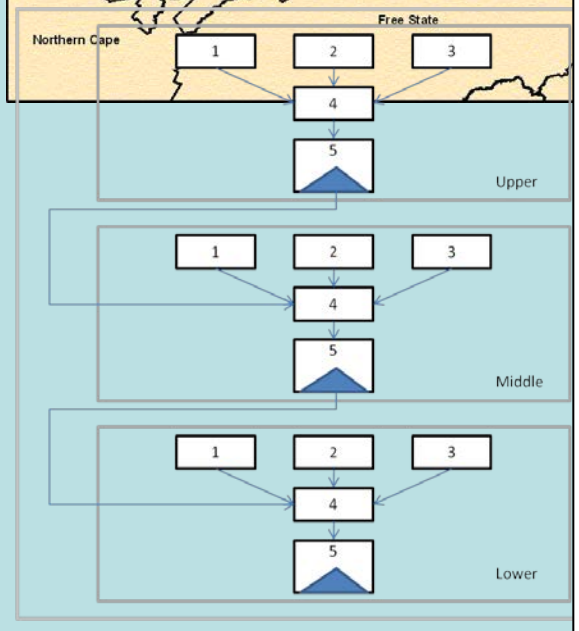
Remembering that the Conventional Engineering Concept of Stationarity (basing designs solely on [short? suspect?] historical data) is probably no longer valid !

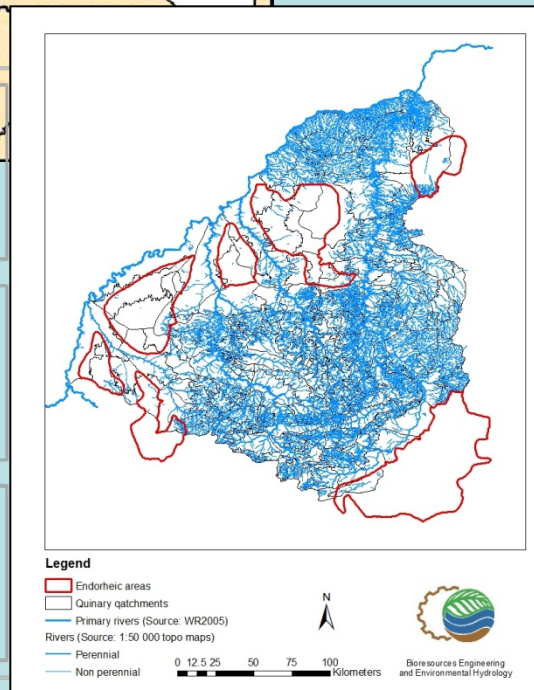
- We can no longer design water infrastructure on data which tells us only so much, but not the whole story
- Our CC research re. extremes needs refining
- Engineers designing hydraulic structures may need re-training

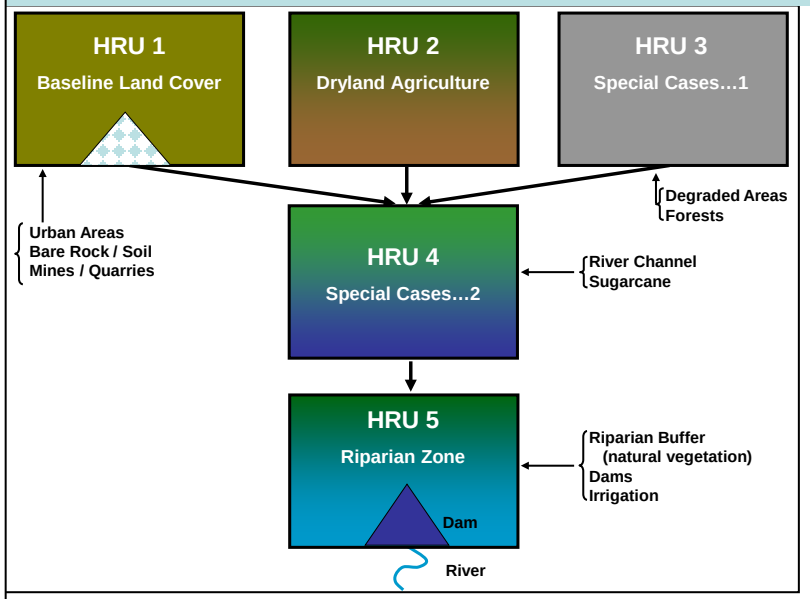
The Future: Major NEW DEVELOPMENTS are Still Being Initiated, Often with Little Consideration of Possible Impacts of CC







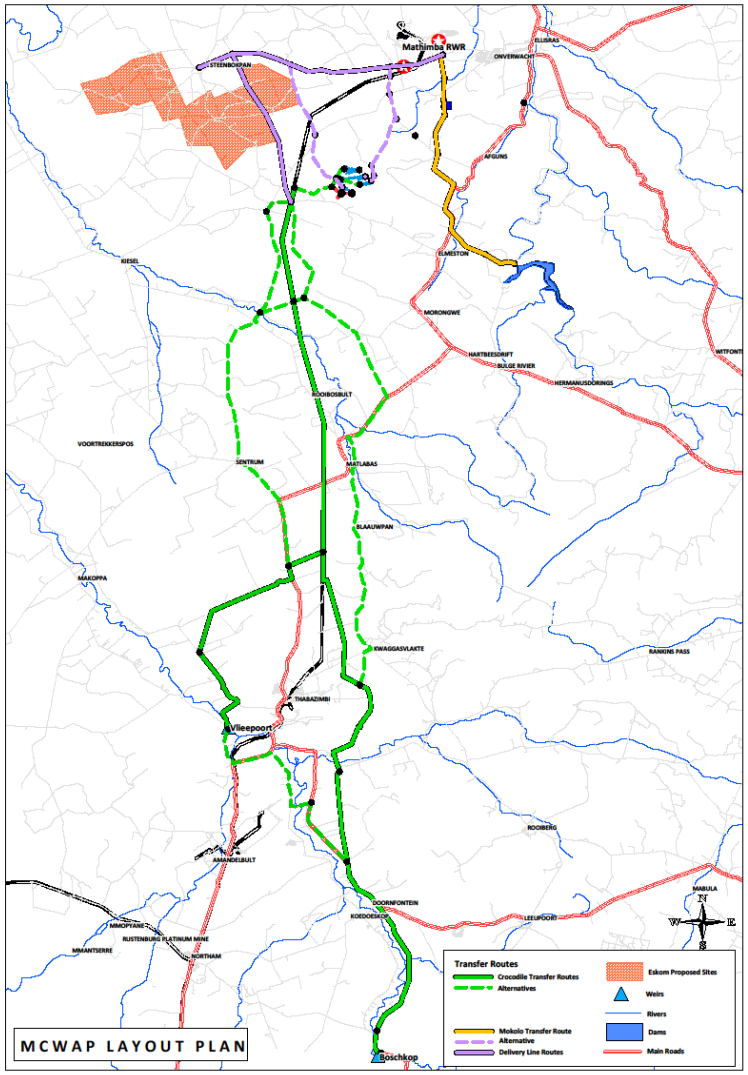


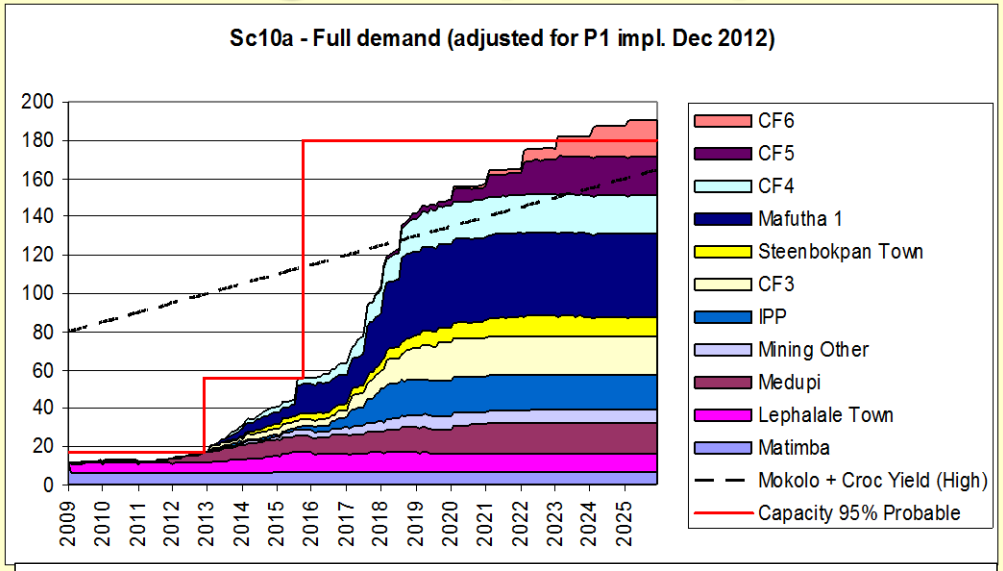


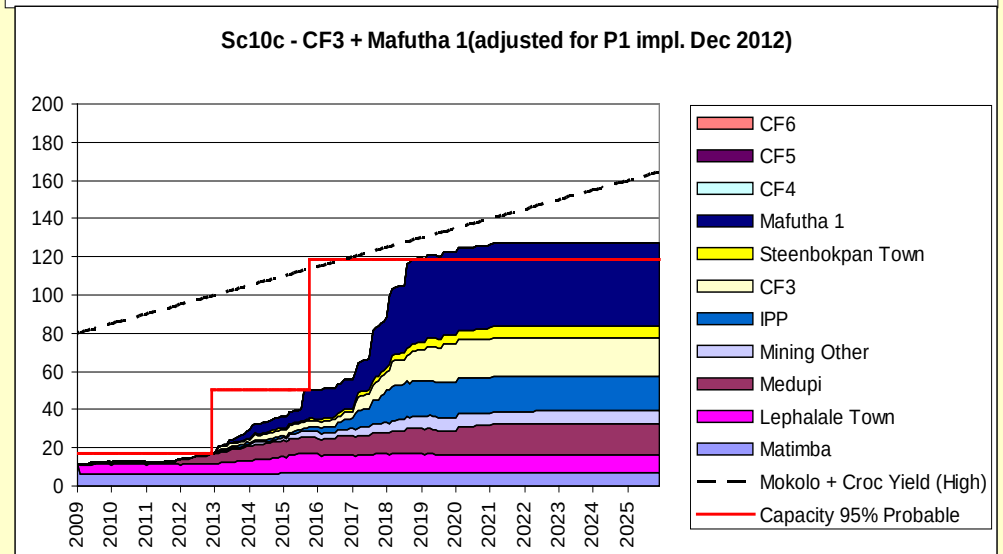

Steenbokpan
Medupi Power Station


MOKOLO AND CROCODILE WATER AUGMENTATION PROJECT PHASE 1
MCWAP-1: MOKOLO PIPELINE
IMPLEMENTING AUTHORITY:
TRANS-CALEDON TUNNEL AUTHORITY
CONSULTING ENGINEERS:
MOKOLO CROCODILE CONSULTANTS (MCC)
CONTRACTOR:
AVENG (AFRICA) LIMITED/UMBUTHO CIVIL & ELECTRICAL JV
CONTRACT No: TCTA 07 - 001

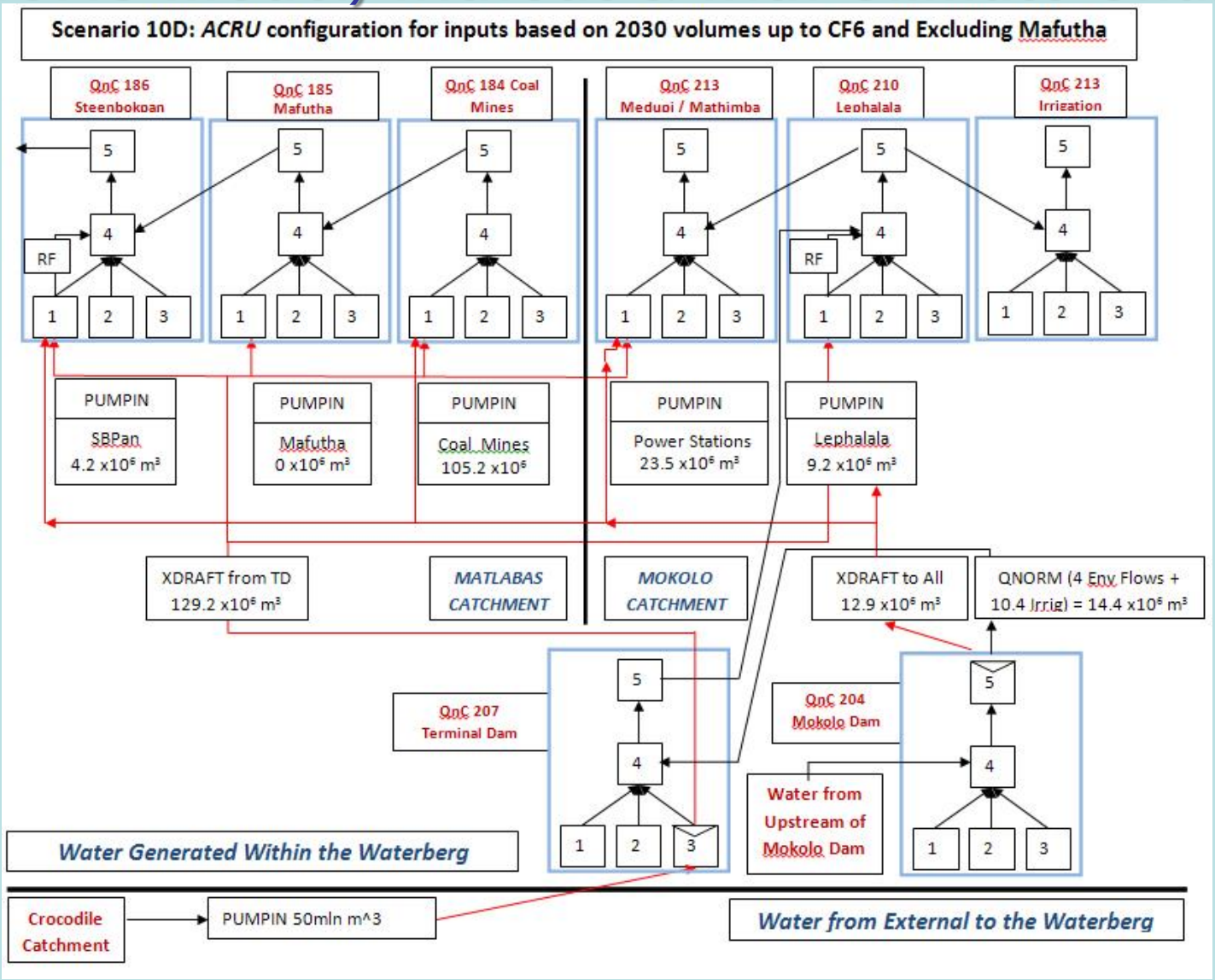
Waterberg: Different Development Scenarios and Their Water Security Ramifications .. What about Climate Change Superimposed?



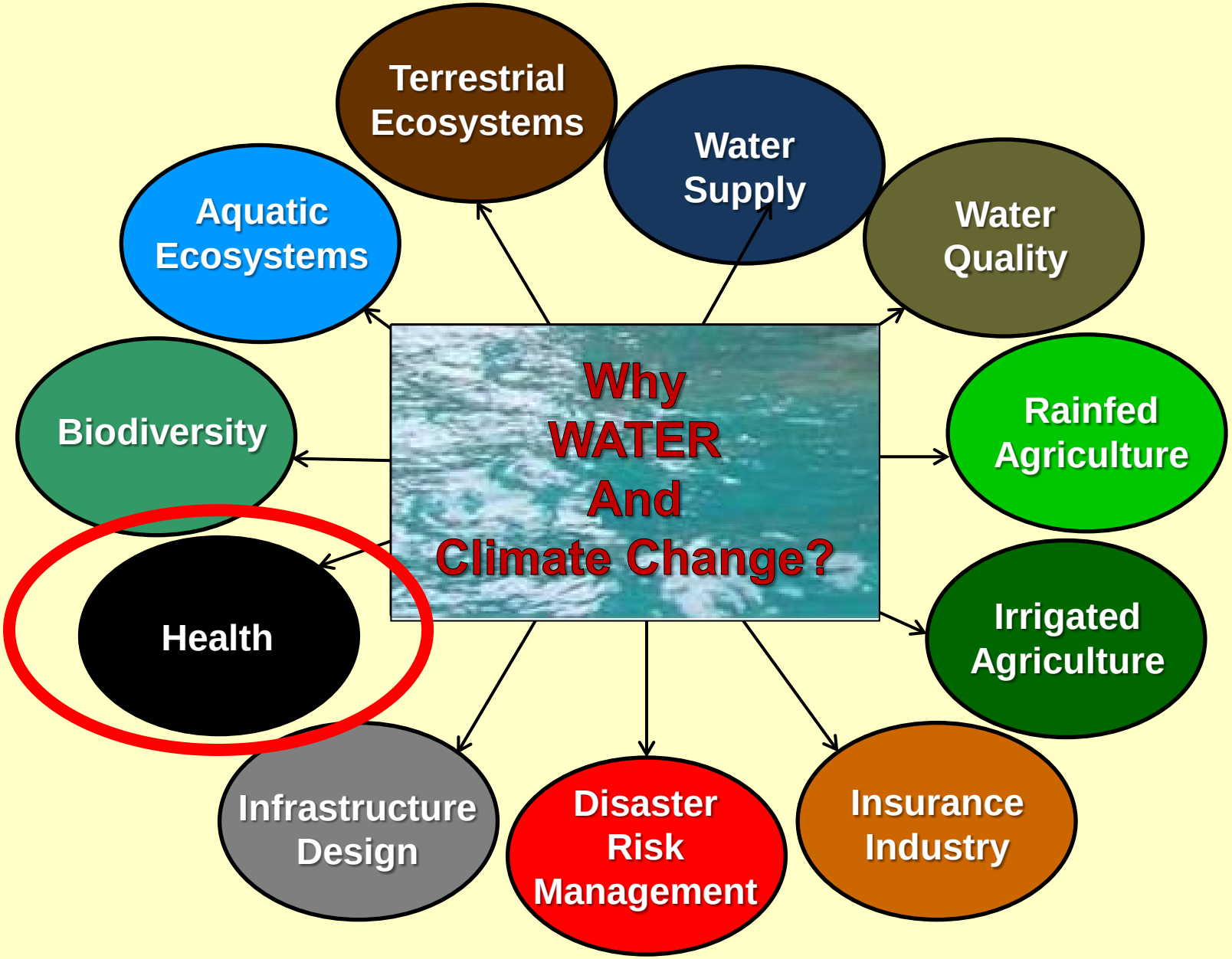




Modelling In-Stream & Downstream Impacts of Water Engineered Scenarios in the Waterberg with the ACRU model, without & with Climate Change



Schulze & Davis, 2013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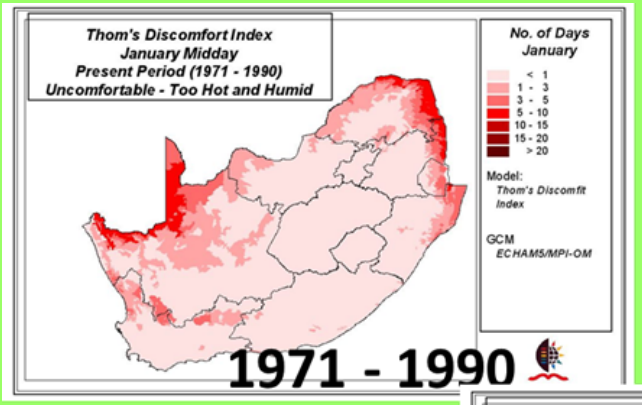
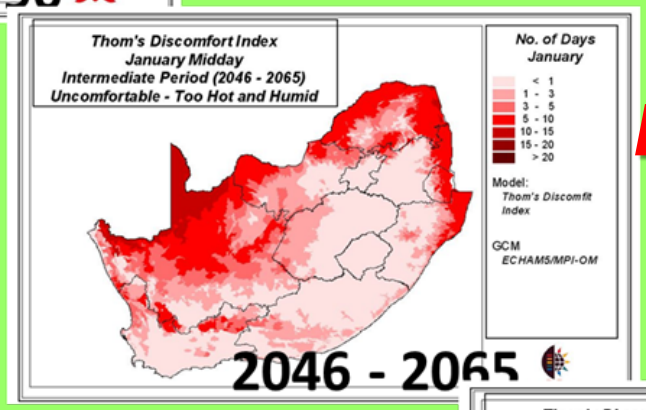
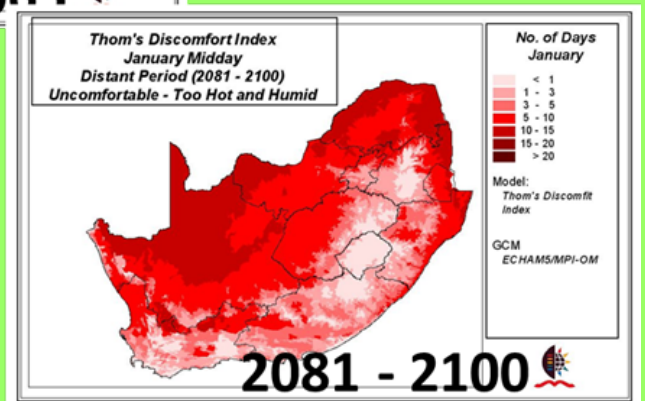
CLIMATE CHANGE AND HUMAN (AND ANIMAL) DISCOMFORT



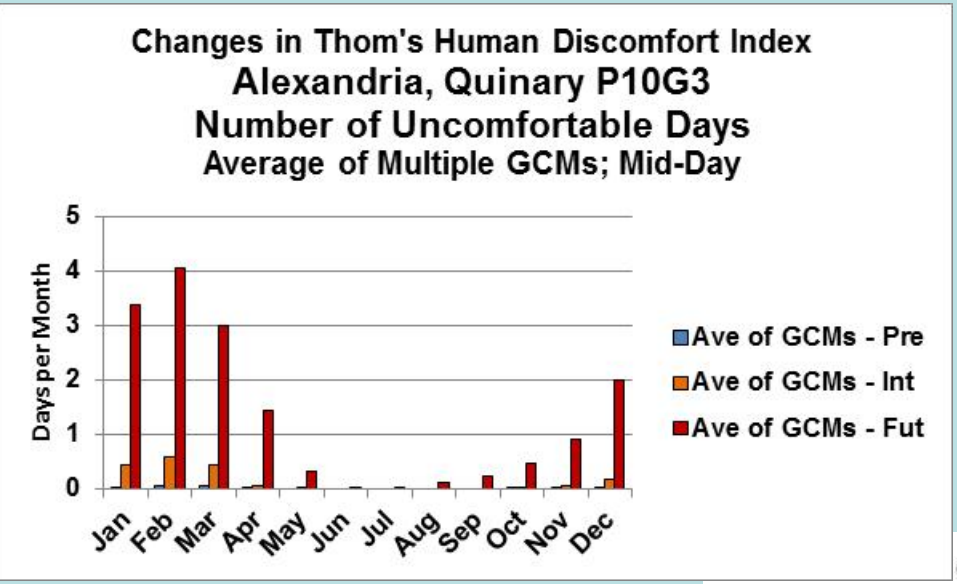


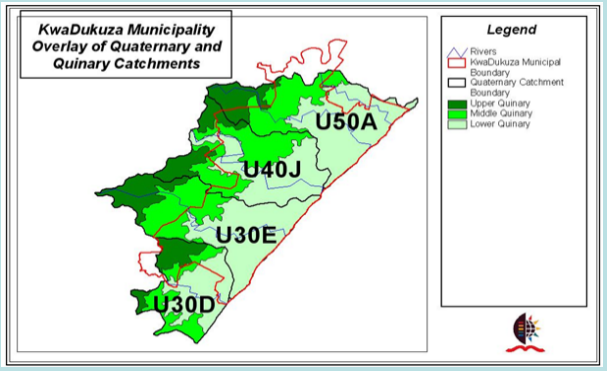


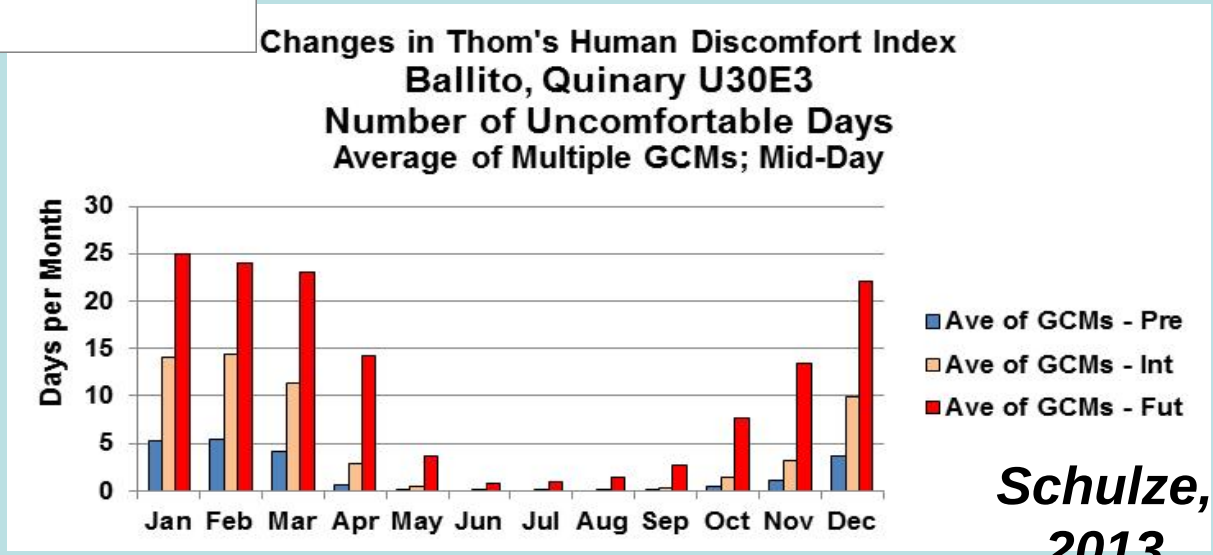
Projected Days in January when Humans (and Animals) Experience Discomfort / Heat Load Around Mid-day

Other Implications: Mortality; Water Usage; Energy Usage; Holiday Times

And, looking more closely…







Schulze, 2013

Repercussions: Evap; Milk production; Agricultural labourers

My Perspective Today:

Climate Change is a Risk Multiplier, Especially in Developing Countries

We need to ask country relevant climate smart questions

1. **beyond the AR5 Policy Makers' Document,**
2. **beyond the changes in 'DJF', 'MAM' syndrome,**
3. **beyond 'motherhood statements' on gloom & doom in Africa**
4. **beyond only assessing safe yields from big dams (essentially the DWA approach)**

to the realities of local water related vulnerabilities of ecosystems and humans in developing countries under CC (the 'drilling deeper')

Final Take Home Messages… 1

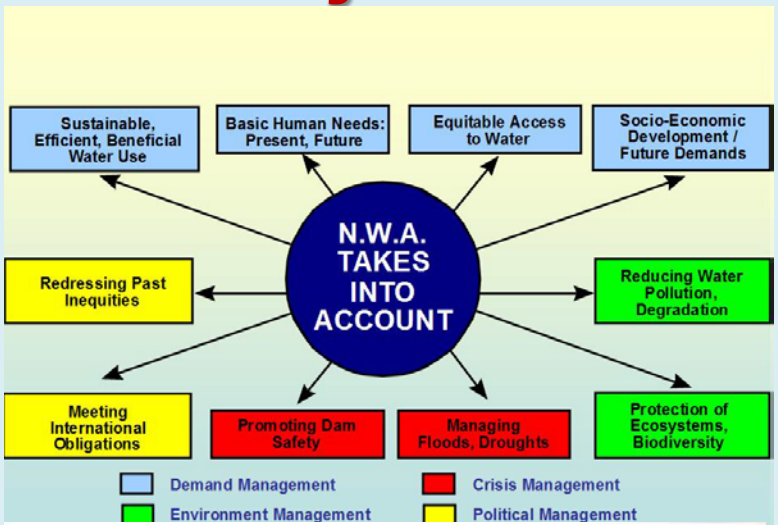
Water is the "Glue" to CC Adaptation, because of its Inter- and Cross Linkages to Health, Disaster Risk Management, Agriculture, Biodiversity

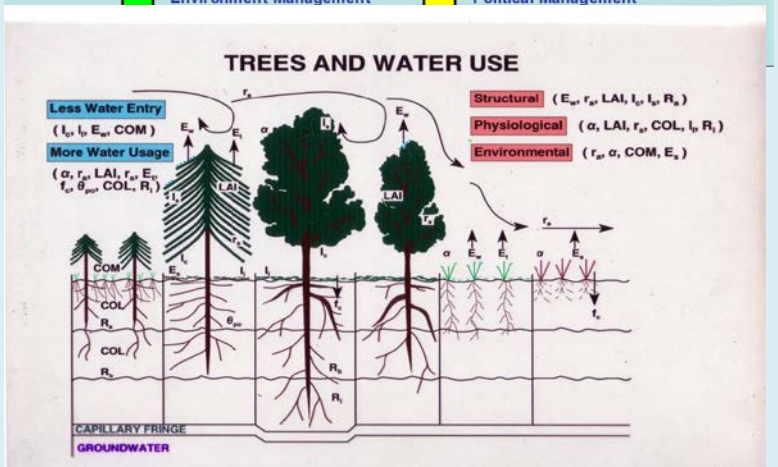
This places a huge responsibility on Hydrology and WR Management to get our CC act together re.

Disciplinary Research
Trans-disciplinary Research
Communication

Final Take Home Messages… 2

In developing countries CC could help promote institutional openness and jurisdictional cohesion





Final Take Home Messages… 3

Be Prepared!
Be Adaptive, not Reactive

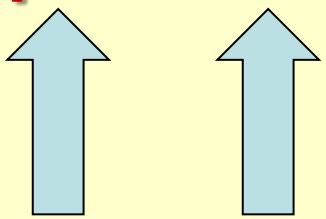
We need to Act NOW on Adaptation Strategies and Action Plans, rather than before Effects of CC become a Challenge an Order of Magnitude more Difficult to Adapting to

However, in developing countries we need to first tackle "deficit adaptation", i.e. doing now what we should be doing anyway!!

The Key Messages from the Take-Home Messages

1. CC poses new challenges to water managers
   a. Neither is CC all 'gloom and doom'
   b. Nor is it 'business as usual' , believing that 'everything under control'

2. There is a need to adapt, by way of
   a. A strategy for adaptation in the water sector
   b. Some practical approaches to adaptation



On Practical 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 Practical Adaptation…2
Categories to be Considered…

1. Enhancing Adaptive Capacity via Technology / Structures

a. Storage & Reticulation (e.g. Surface; Groundwater; System Maintenance; Rainwater Harvesting; Re-Use)

b. Desalination

c. Flood / Storm Surge Control (e.g. levees, wave breaks)

d. Early Warning Systems (near real-time; medium and long term)

e. Communication of Forecasts to End Users

f. Operations / Systems Improvements (e.g. ops rules; retrofitting; wastewater treatment works; sanitation)

g. Water Demand Management

h. Indigenous Coping

i. Precipitation Enhancement

j. Water Quality / Quantity Monitoring Systems

On Practical Adaptation…3

Categories to be Considered…

2. Knowledge, Skills and Participation

a. Research and Development

i. Efficient technologies
ii. Upgrading of climate modelling
iii. Improvements to downscaling / RCMs
iv. Fine scale info provision relevant to local managers
v. Improve forecasting skills / dissemination
vi. Development of drought resistant crops

b. Development of Risk Maps / Floodlines

c. Communication / Training / Dissemination

i. Awareness creation at higher decision making level
ii. Awareness creation at operational level
iii. Training at mid-management and local levels

d. Participatory Approach in Decision-Making

i. Establishment of interdepartmental learning platforms
ii. Establishment of an integrated communications system
iii. Creation of ongoing learning platforms btw water users

On Practical Adaptation…4 Categories to be Considered…

3. Policy Instruments

a. International Conventions

b. International Water Agreements

c. International Trade

d. National Water Master Plans

i. National Water Act of 1998
ii. Water Services Act of 1997
iii. National Water Resource Strategy of 2004, 2013
iv. Water for Growth and Development Framework of 2009
v. Catchment Management Strategies
vi. Estuary Management Plans

c. Other National Master Plans

i. National Environmental Management Act
ii. Conservation of Agricultural Resources Act

d. Provincial Strategies

i. Provincial Growth and Development Strategies
ii. Provincial Water Reconciliation Strategies

e. Local Strategies

i. Municipal Bye-Laws

On Practical Adaptation…5 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

Atlas of climate change and the South African Agricultural Sector: A 2010 perspective

www.daff.gov.za/Divisions/Other/Climate_Change_and_Disaster_Management/Documents

R.E. Schulze

(2011; 41 Chapters, pp 388)

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WATER RESEARCH COMMISSION

Available from WRC since February 2013; (pp 366) + Handbook on Adaptation