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Excellence in Research and Development

Sustainable use of water resources and water management options in arid and semi arid regions to mitigate the impact of drought and enhance livelihoods.

Felix Reinders

ARC-Institute for Agricultural Engineering

7TH BIENNIAL NATIONAL LANDCARE CONFERENCE

4 October 2016

Sustainable use of water resources and water management options in arid and semi arid regions to mitigate the impact of drought and enhance livelihoods.

Introduction

Food security

International

National

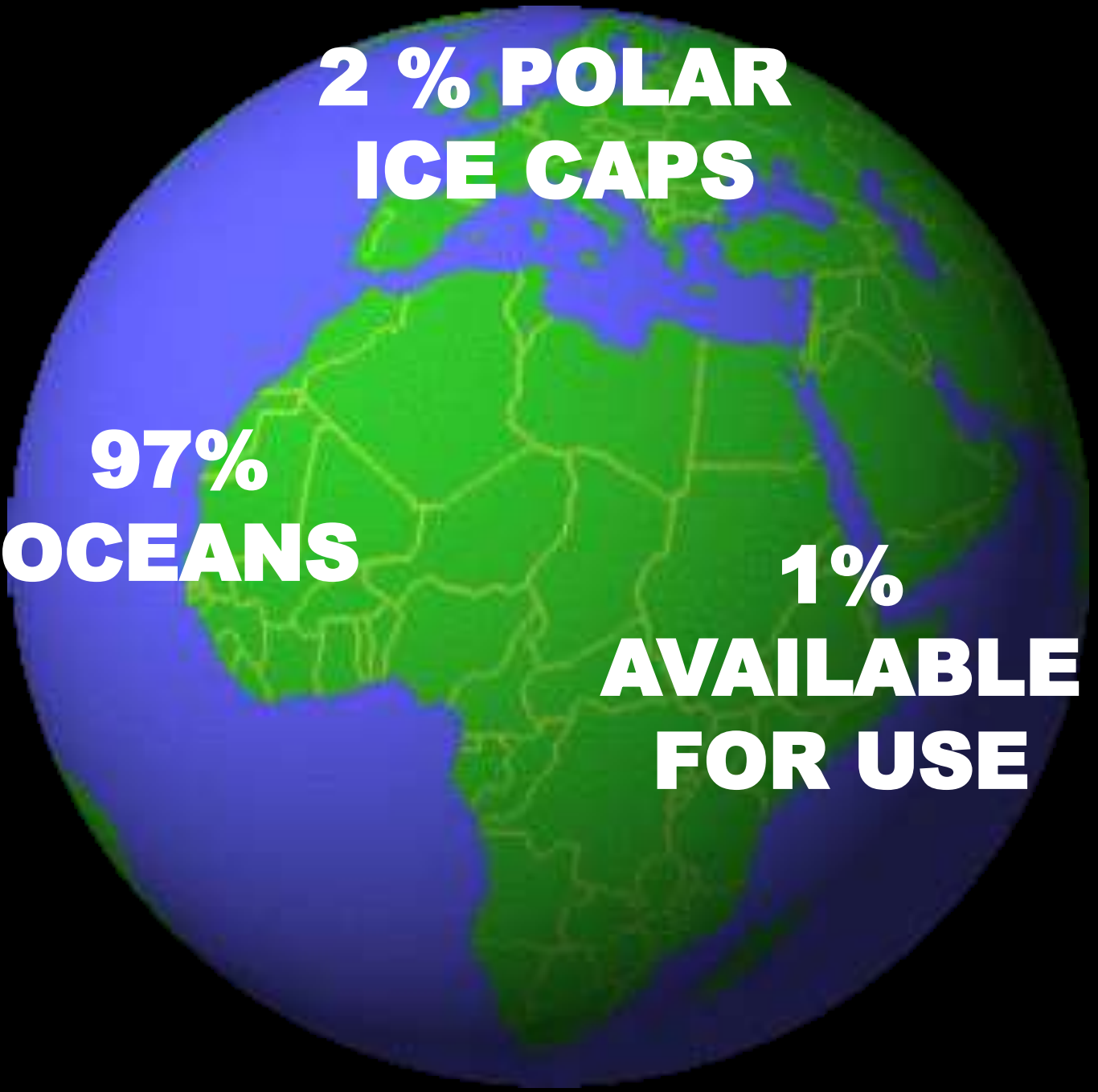
Irrigation

Conclusion

Introduction

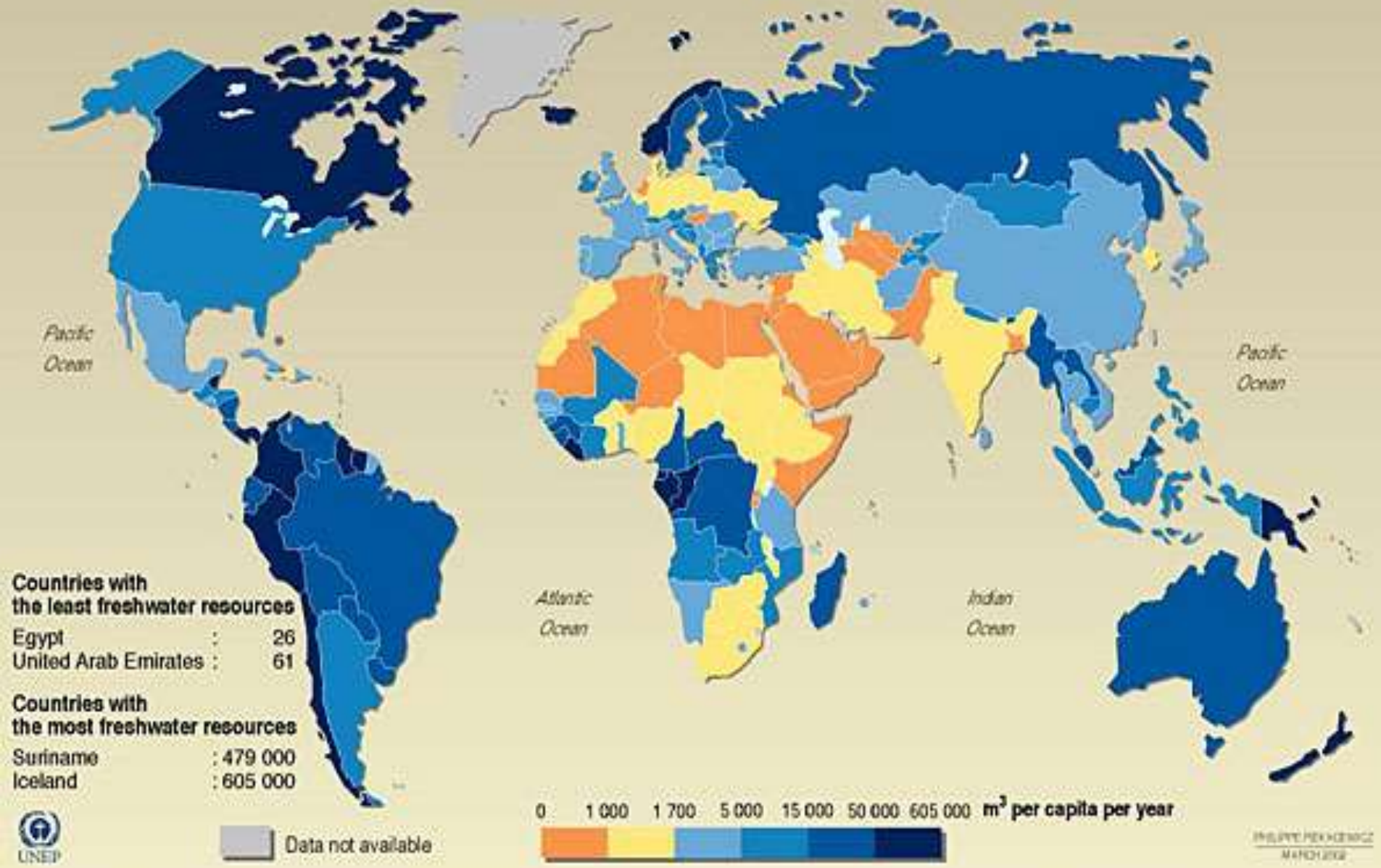

Research
Companies
Producers

WATER



Availability of Freshwater in 2000

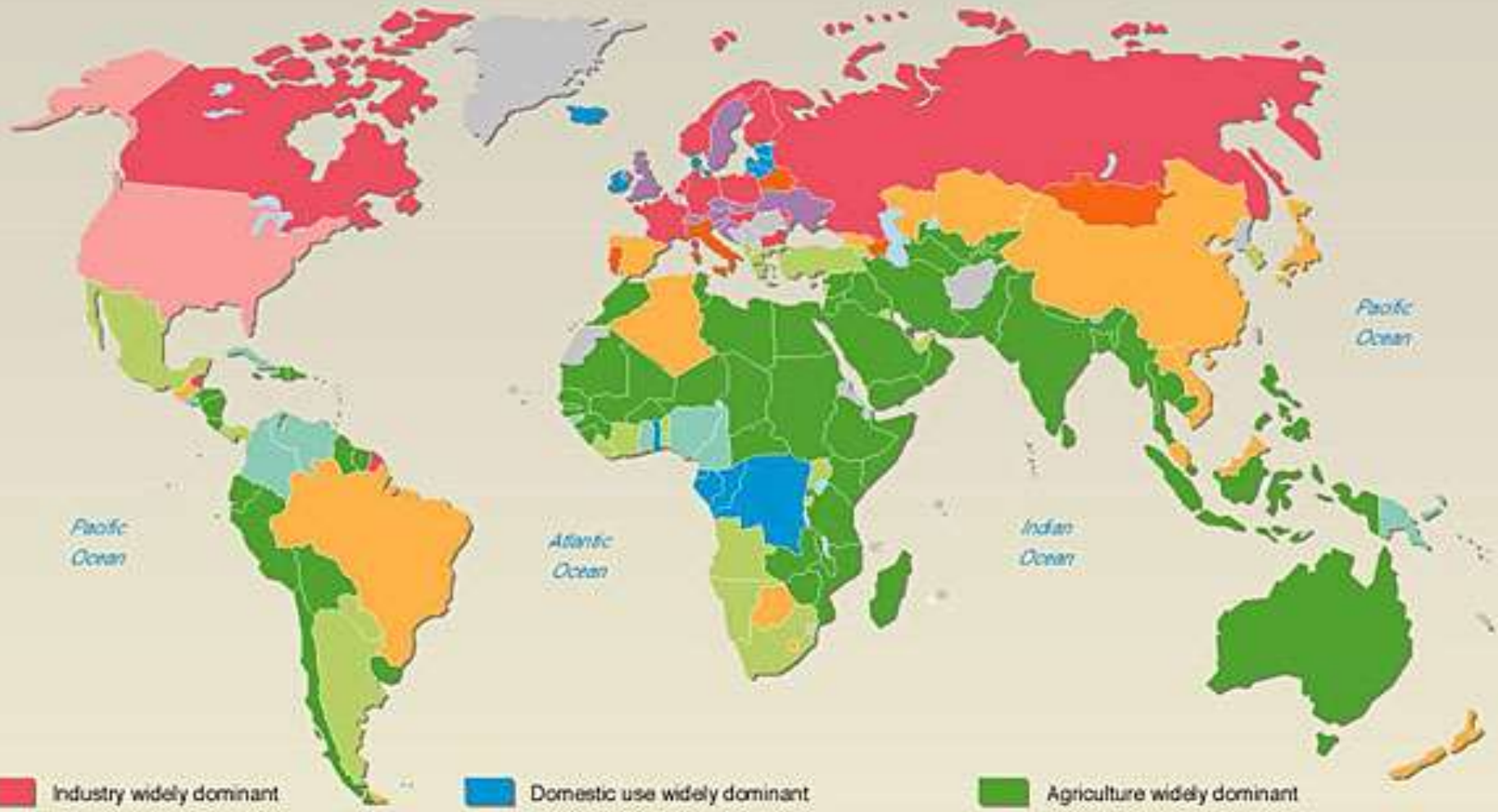
Average River Flows and Groundwater Recharge



Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000

Global Freshwater Withdrawal

Country Profiles Based on Agricultural, Industrial and Domestic Use

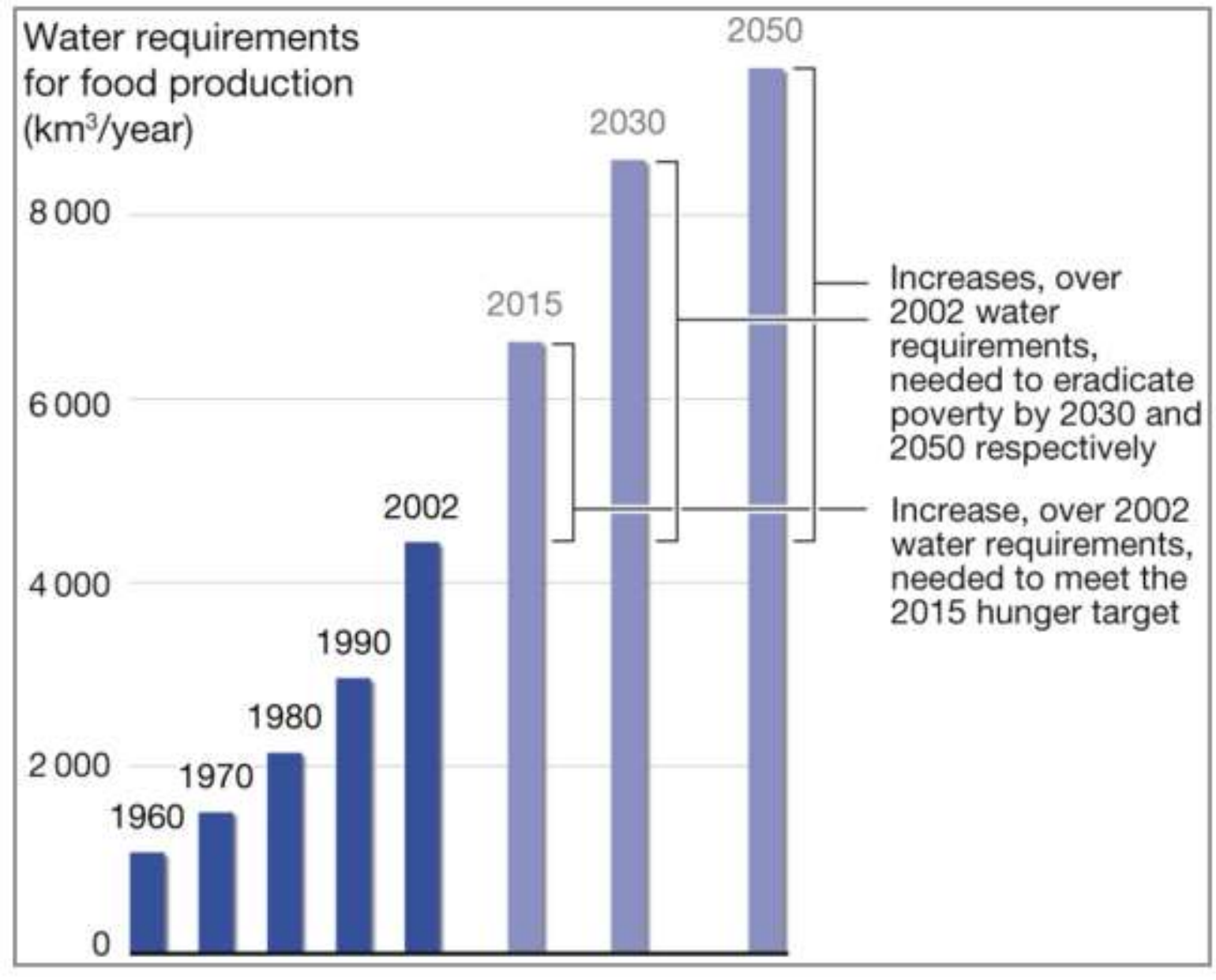


Source: Based on data fromTable FW1 in *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000

The agricultural sector is by far the biggest user of water:

- Agriculture accounted for 70% of the world's total water withdrawal,
- In Africa and Asia, 85-90% of all the freshwater used is for agriculture
- To satisfy global demand for food, by 2025, agriculture expected to increase water requirements by 1.2 times, (industry,1.5 and domestic consumption 1.8)
- 15% of the world's cultivated lands are irrigated, accounting for almost half of the value of global crop production

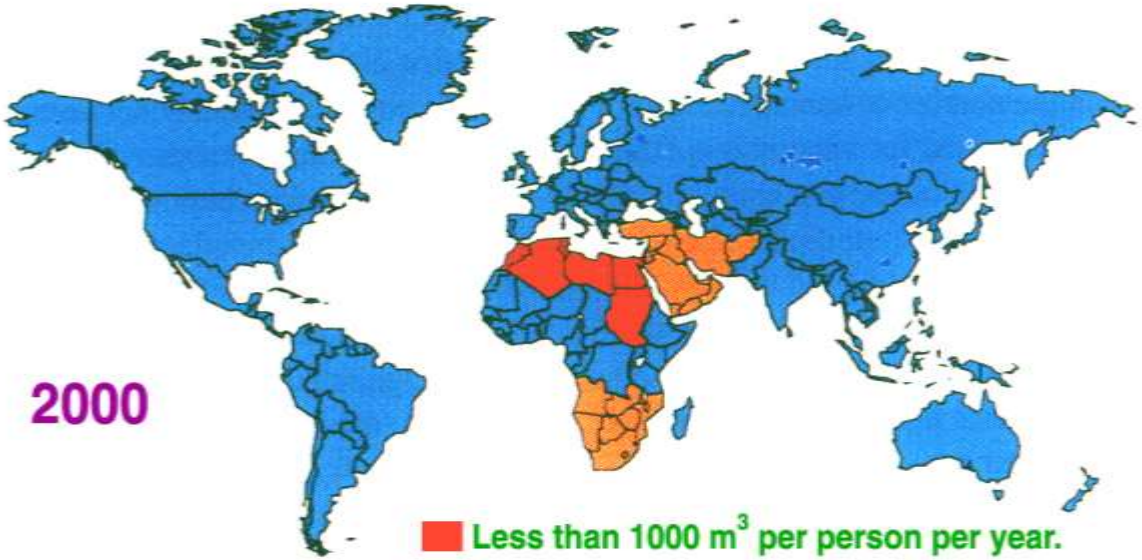
Water requirements for food production 1960-2050



Two thirds of the world's population

WILL BE AFFECTED BY WATER SHORTAGES BY THE YEAR 2030

Global Water Scarcity

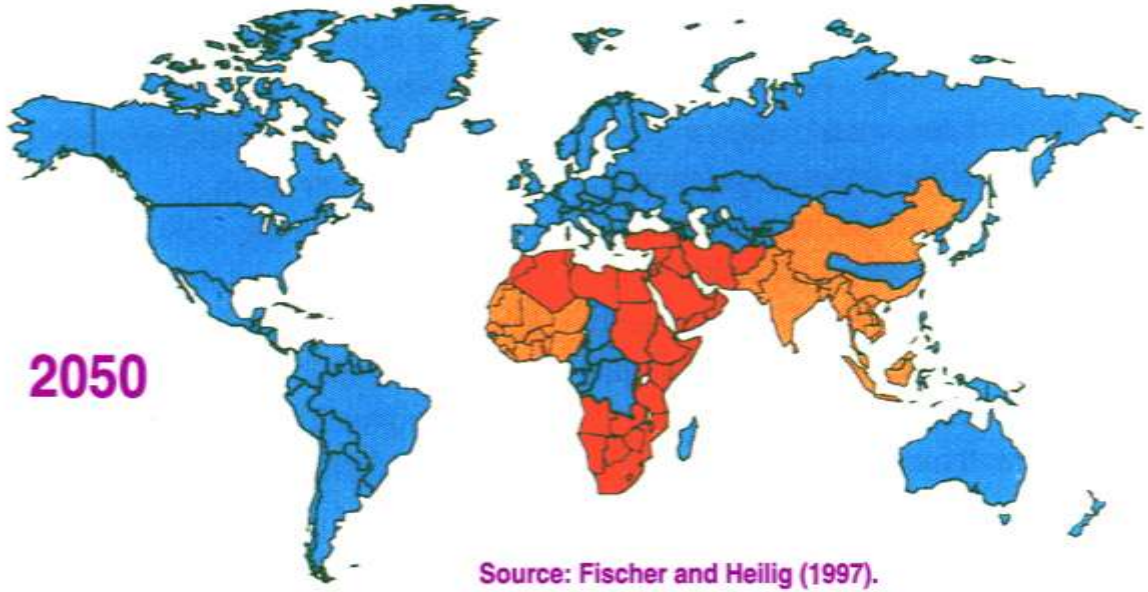


2000

Less than 1000 m^3 per person per year.

Between 1000 and 2000 m^3 per person per year.

Greater than 2000 m^3 per person per year.



2050

Source: Fischer and Heilig (1997).

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Food security

What is food security?

There are many different definitions of food security. The definition frequently used as defined at the World Food Summit of 1996:

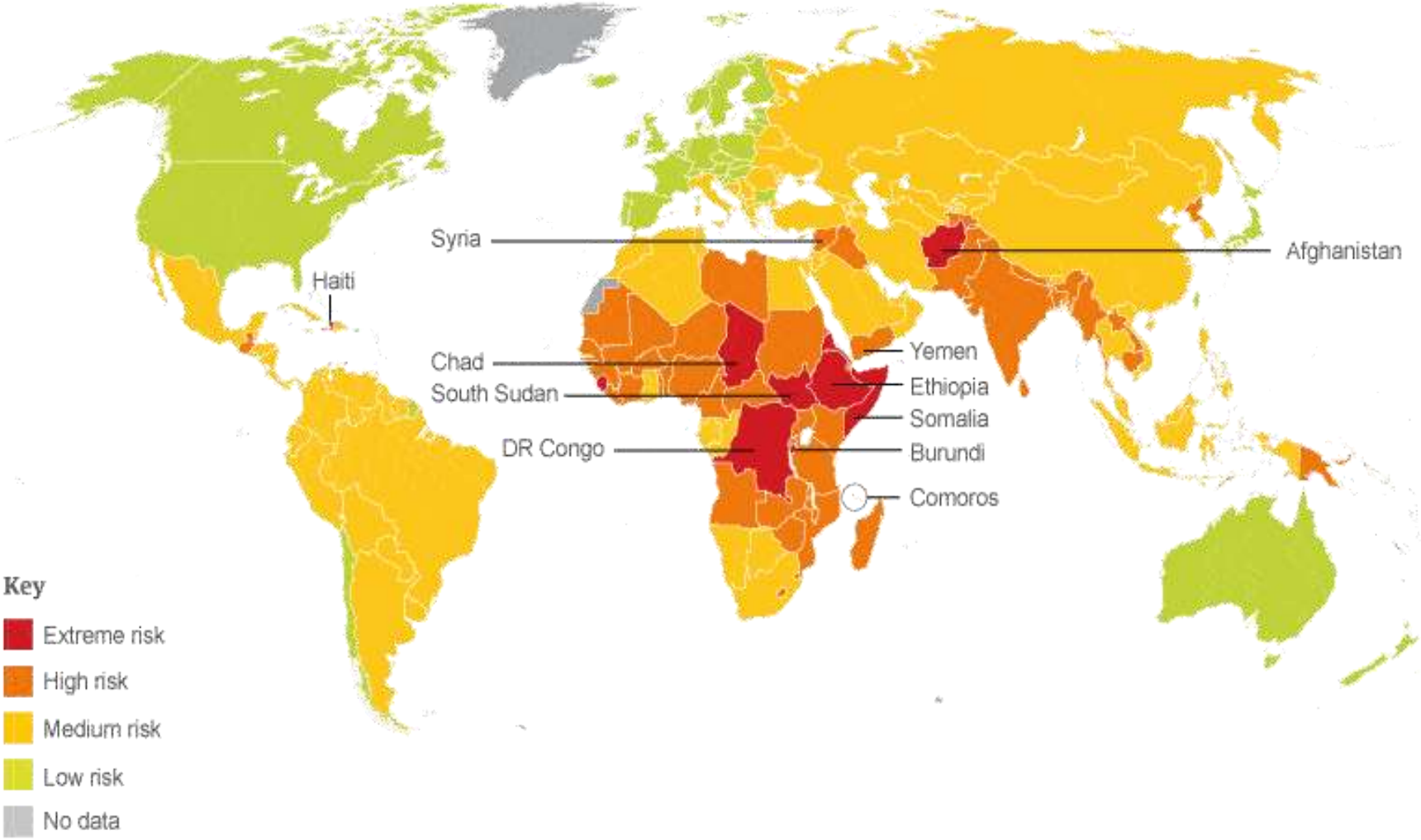
Food security is existing
“when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life”.

What is food security?

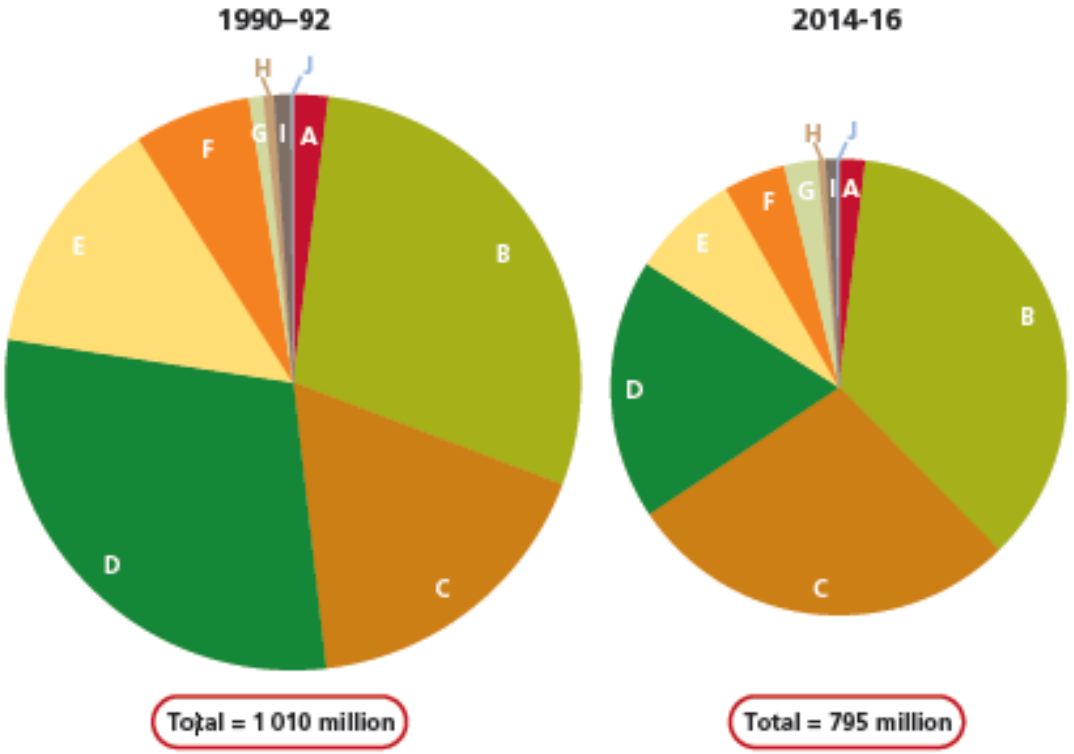
Food security includes the following aspects:

- Availability
- Access
- Affordability
- Quality
- Nutrition
- Safety

Food Security Risk Index 2013



The changing distribution of hunger in the world

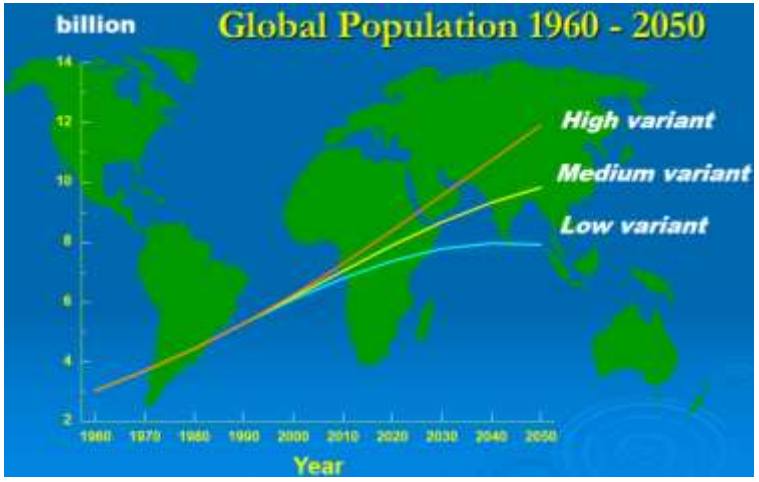


	Number (millions)		Regional share (%)	
	1990–92	2014–16	1990–92	2014–16
A Developed regions	20	15	2.0	1.8
B Southern Asia	291	281	28.8	35.4
C Sub-Saharan Africa	176	220	17.4	27.7
D Eastern Asia	295	145	29.2	18.3
E South-Eastern Asia	138	61	13.6	7.6
F Latin America and the Caribbean	66	34	6.5	4.3
G Western Asia	8	19	0.8	2.4
H Northern Africa	6	4	0.6	0.5
I Caucasus and Central Asia	10	6	0.9	0.7
J Oceania	1	1	0.1	0.2
Total	1 011	795	100	100

What are some of the issues affecting world food security?

Food security is one of the biggest challenges facing humankind. There are many factors which have combined to make food security such a large issue. This includes:

- **Increasing population -** In 2012, the world population was 7 billion. By 2050, it is predicted to reach 9 billion. Our current output of food is not enough to feed a population of 9 billion.



What are some of the issues affecting world food security?

- **Changing diets -** As countries develop and people become richer they tend to eat a more varied diet, including more meat, which requires more energy to produce. This also means there is more competition for the same types of food.

- **Reduced arable land -** The drive to produce more biofuels for transport uses edible crops and has reduced arable land.

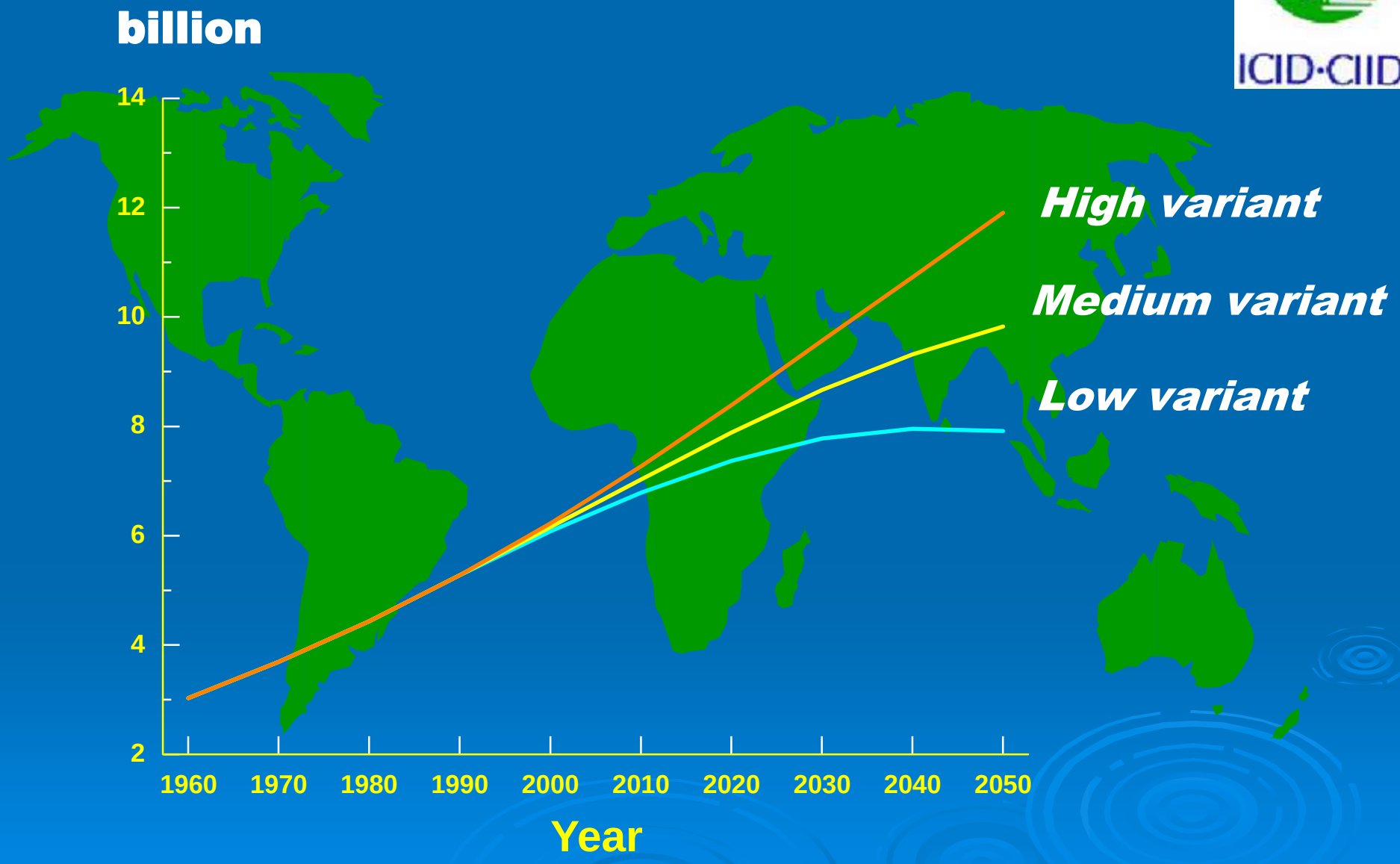
Transport costs - The relatively high price of oil in recent years has increased the price of food storage and distribution.

Climate change - Climate change is leading to a warmer world which will affect what crops can be grown where. Climate change can also lead to more frequent extreme weather events (e.g. floods) which can damage crops.

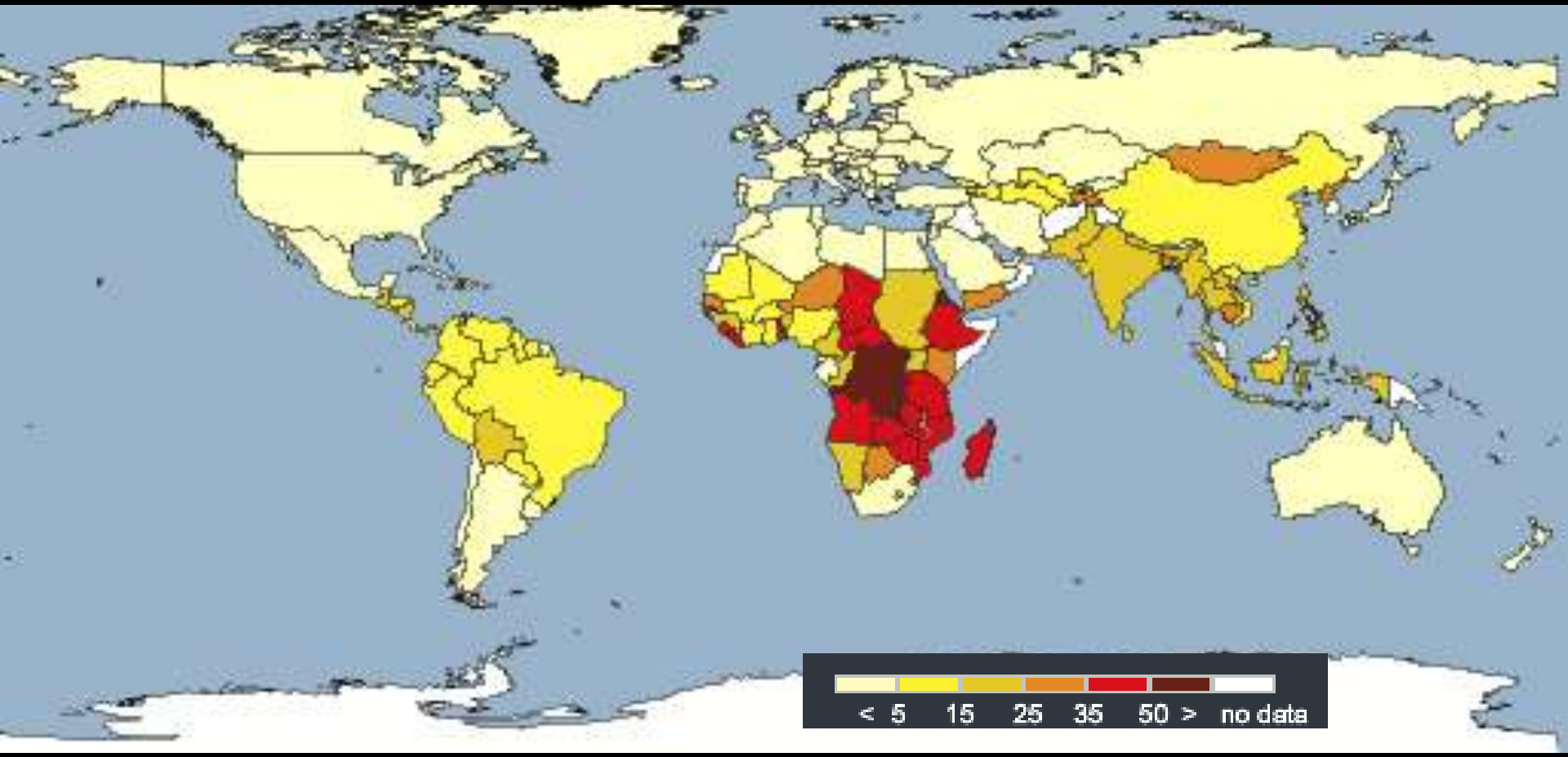
Pests and diseases - Pests and diseases are becoming more resistant to pesticides and sprays. The changing climate is also bringing pest and diseases into new areas where they could not previously survive.

International

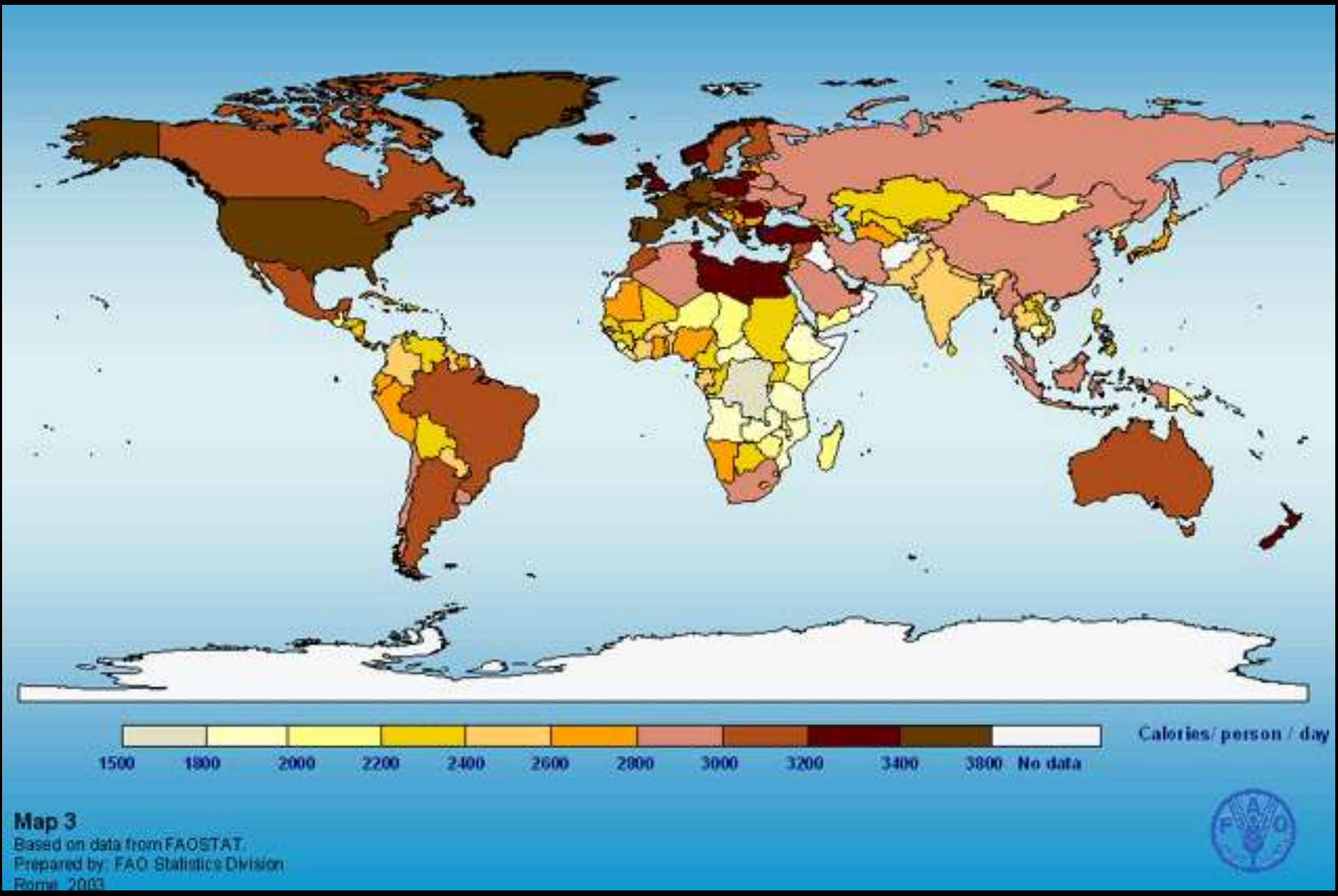
Global Population 1960 - 2050



Undernourishment in Total Population (%)

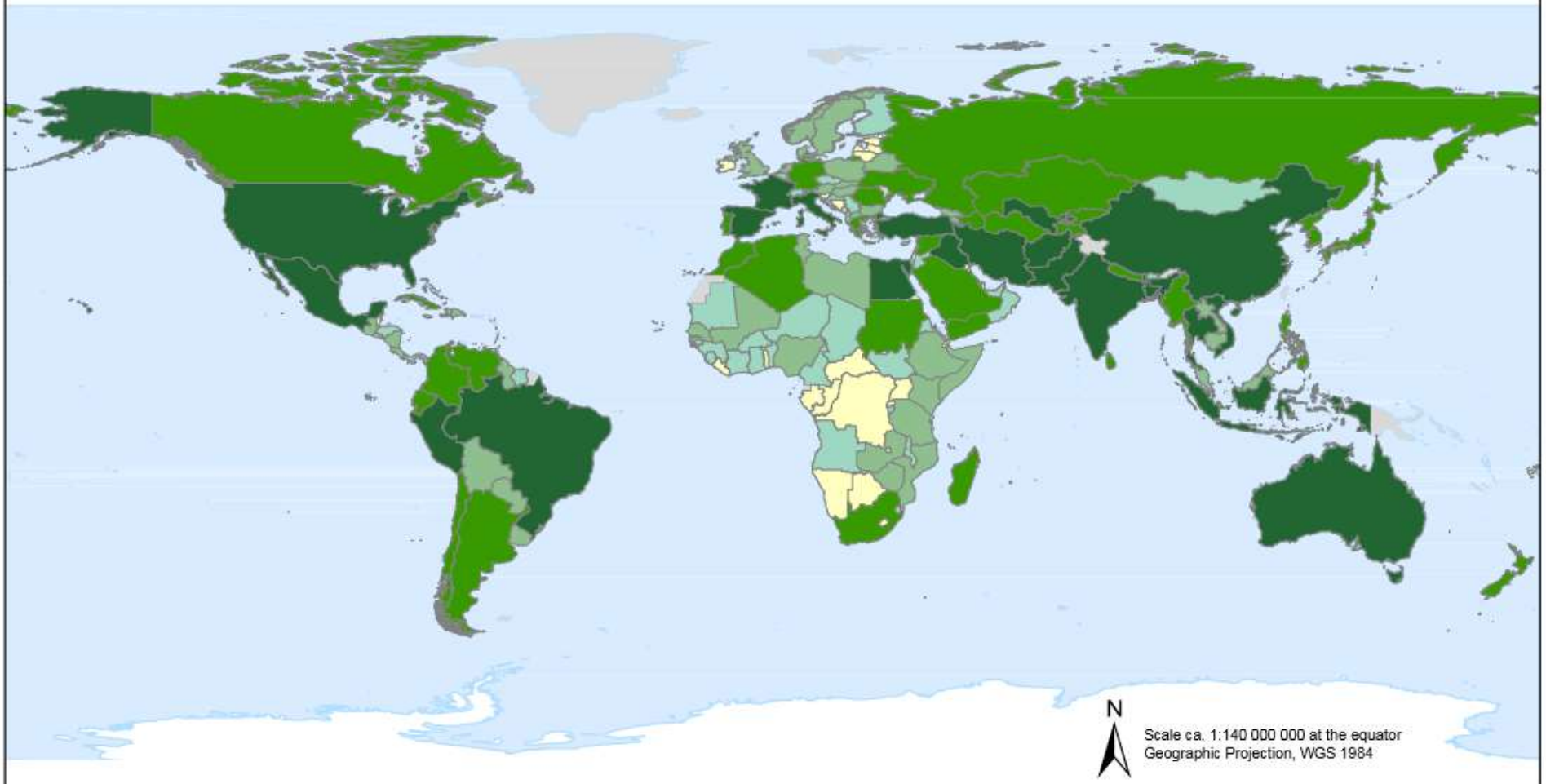


Food consumption



Food and Agriculture Organization of the United Nations

Area equipped for irrigation (1000 hectares)



Legend

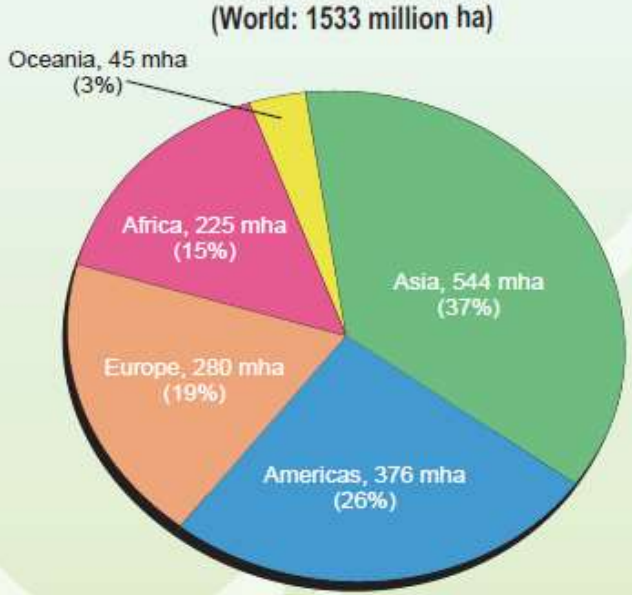
No data | < 20 | 20 - 100 | 100 - 500 | 500 - 2 500 | > 2 500 (1 000 ha)

FAO - AQUASTAT, 2015

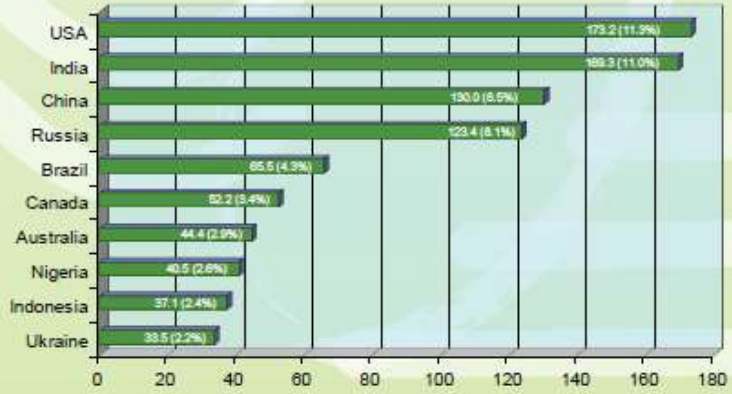
Source: AQUASTAT
Geographic Projection

ICID•CIID

Regionwise Arable and Permanent Cropped Areas of the World



Arable and permanent cropped area (million ha) and its share in the total area (%) Top 10 Countries



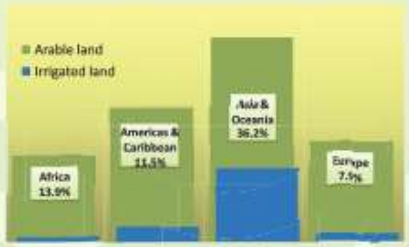
Source : ICID NCs (2010), FAO Stat-FAO Statistics Division (2011

ICID•CIID

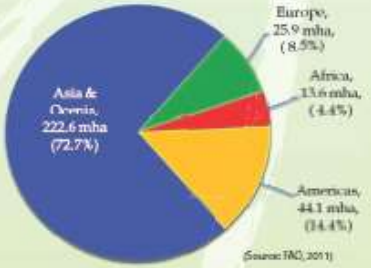
World Irrigation Scenario

World irrigated area (million ha)

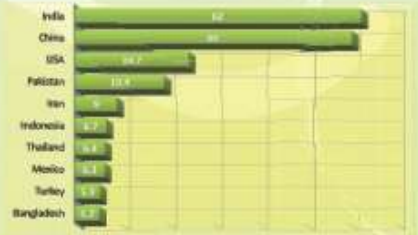
Irrigated area as percentage of arable land



Regional spread of irrigated area

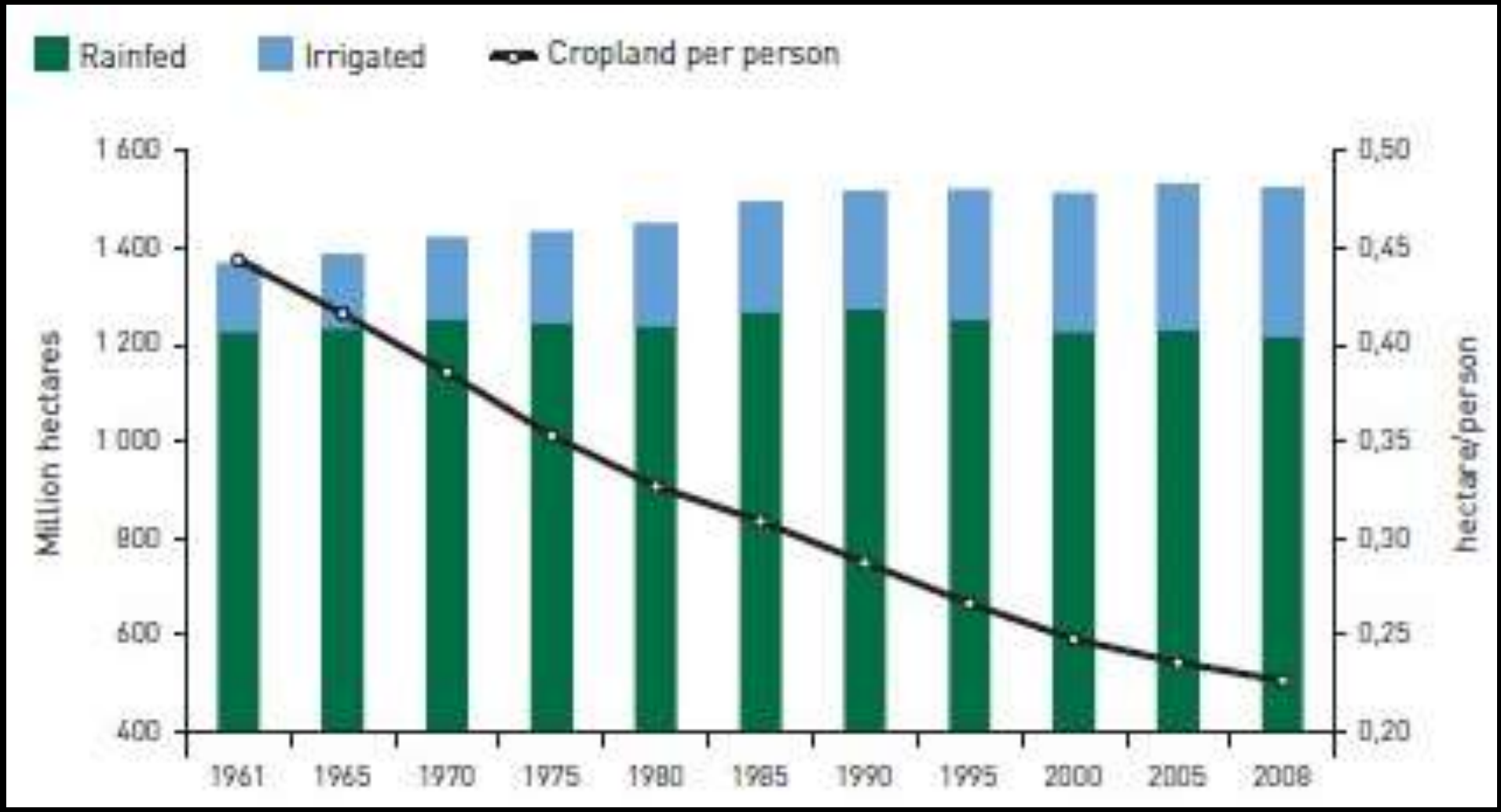


Irrigated area (million ha) - Top ten countries

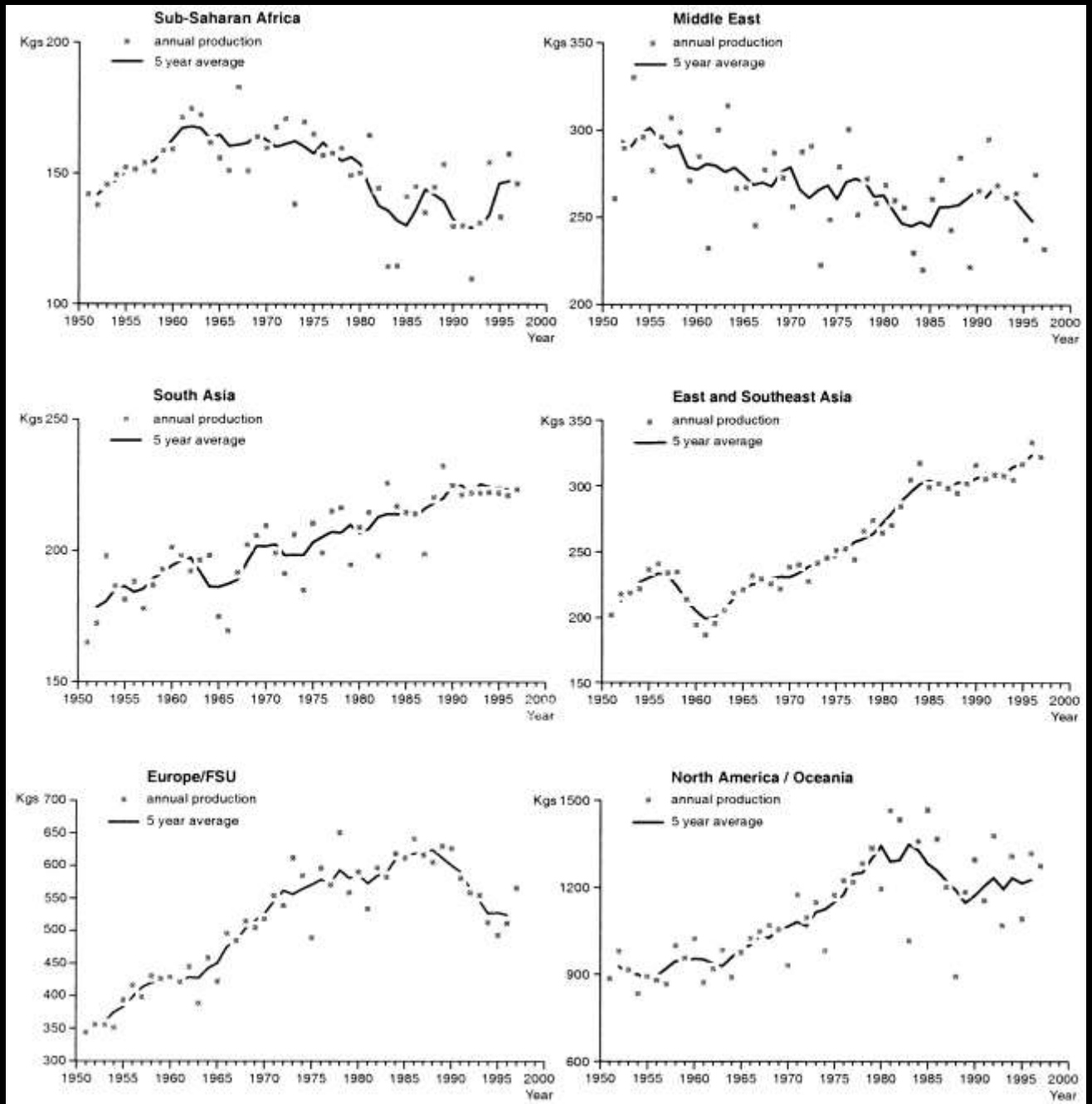


World irrigated area (Hectares/ 1000 people)

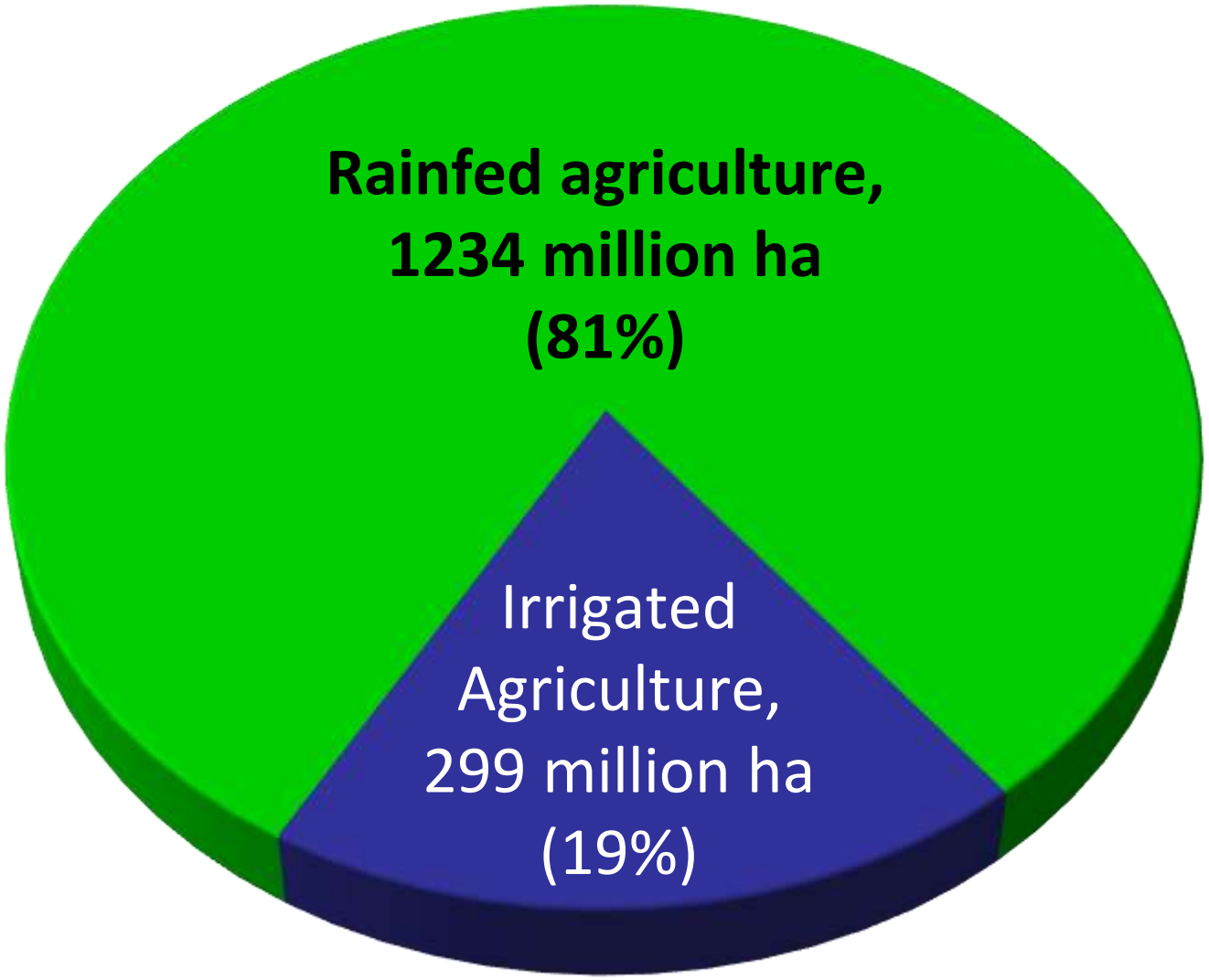
Land under irrigation and rainfed cropping (1961-2008)



Per-capita cereal production by world region

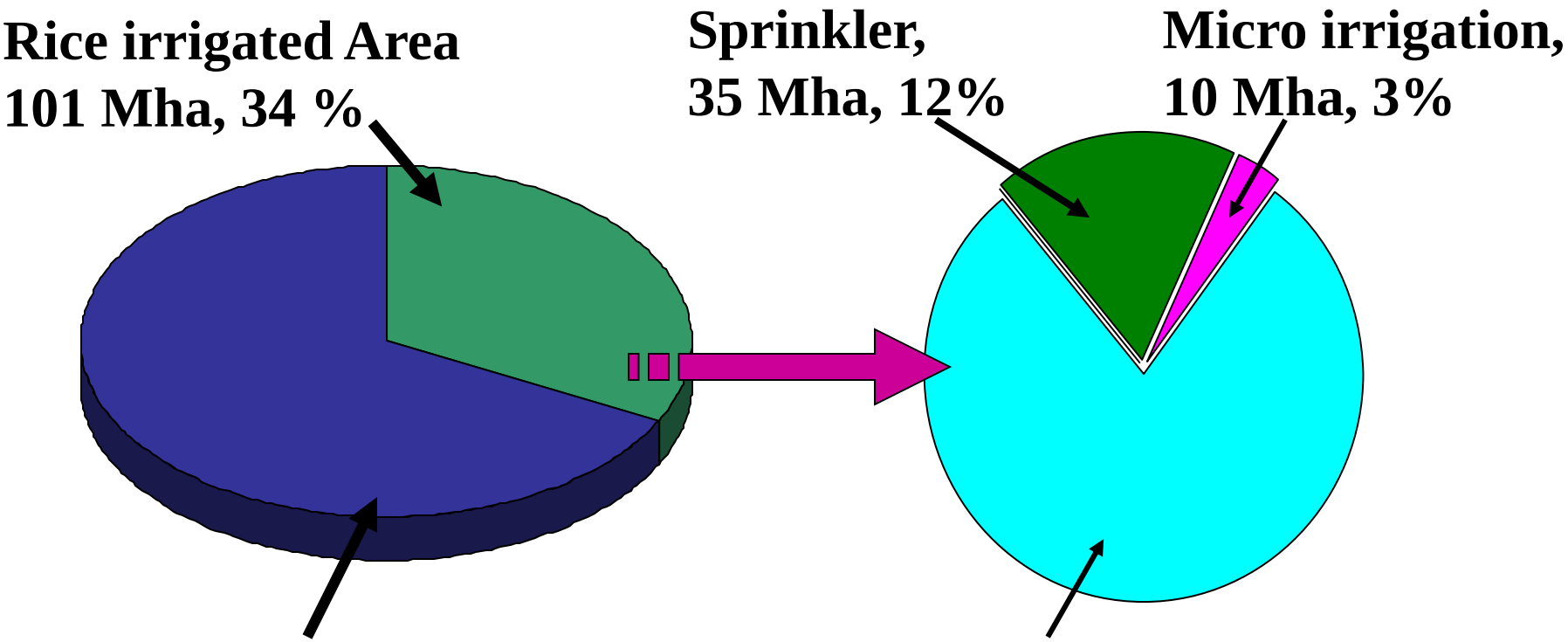


Global irrigated area



World-wide Coverage of Irrigation

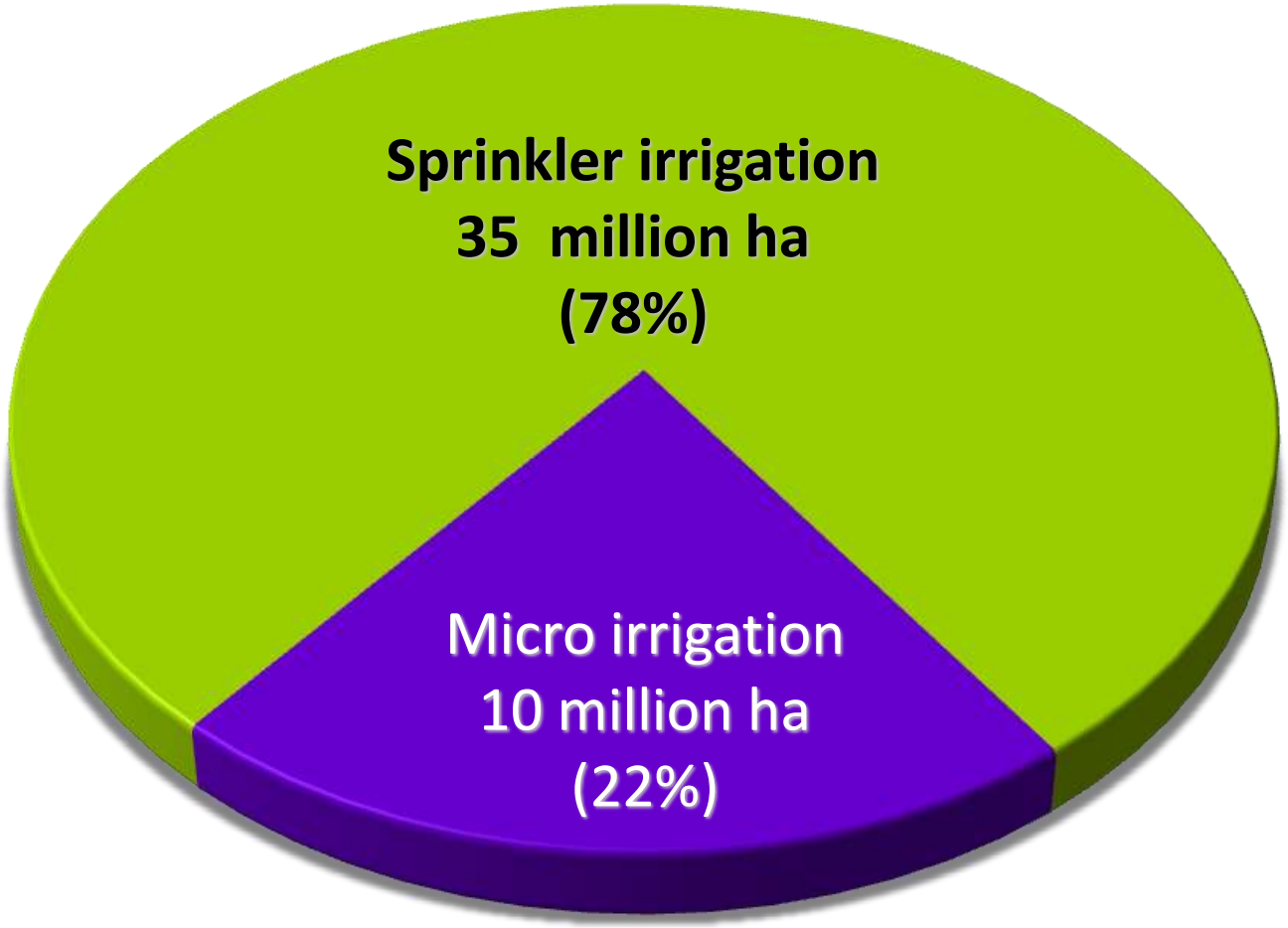
Total irrigated area = 299 Mha



ICID•CIID

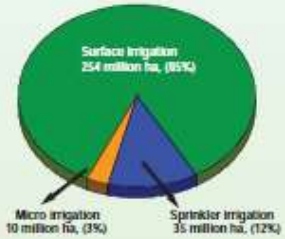
Sprinkler and Micro irrigated Area in the World

(45 MILLION HA - 15% OF THE WORLD IRRIGATED AREA)

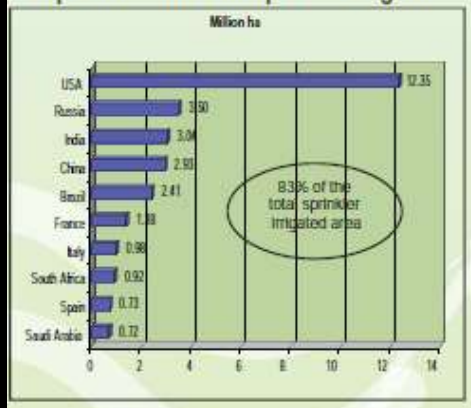


ICID•CIID

Sprinkler and Micro Irrigated Areas of the World

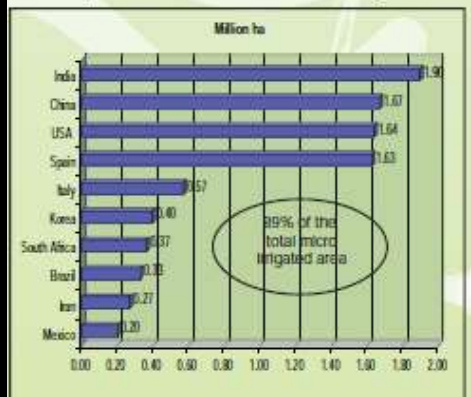


Top Ten Countries in Sprinkler irrigation



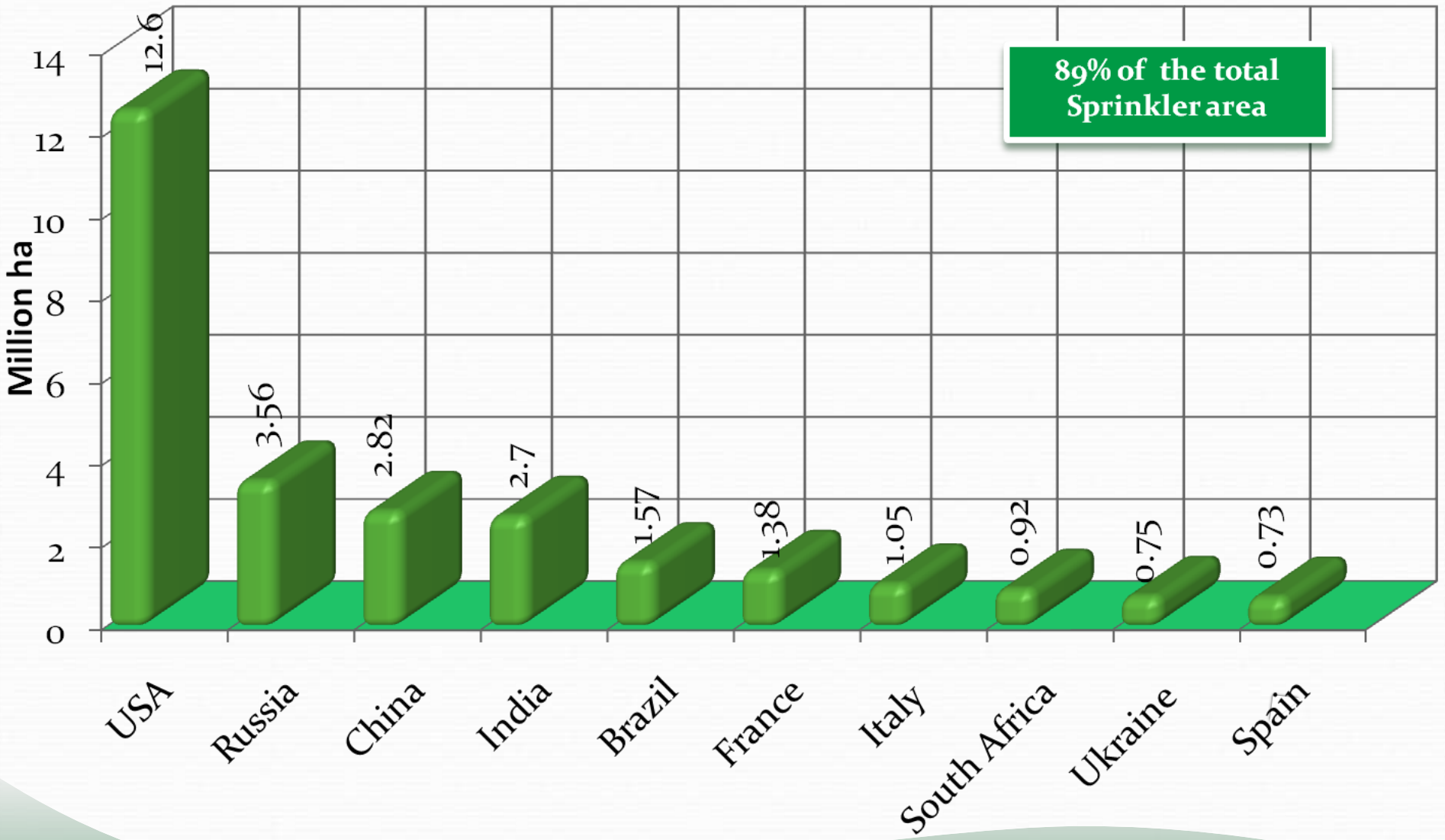
Sprinkler (centre pivot) irrigation, Iran

Top Ten Countries in Micro irrigation

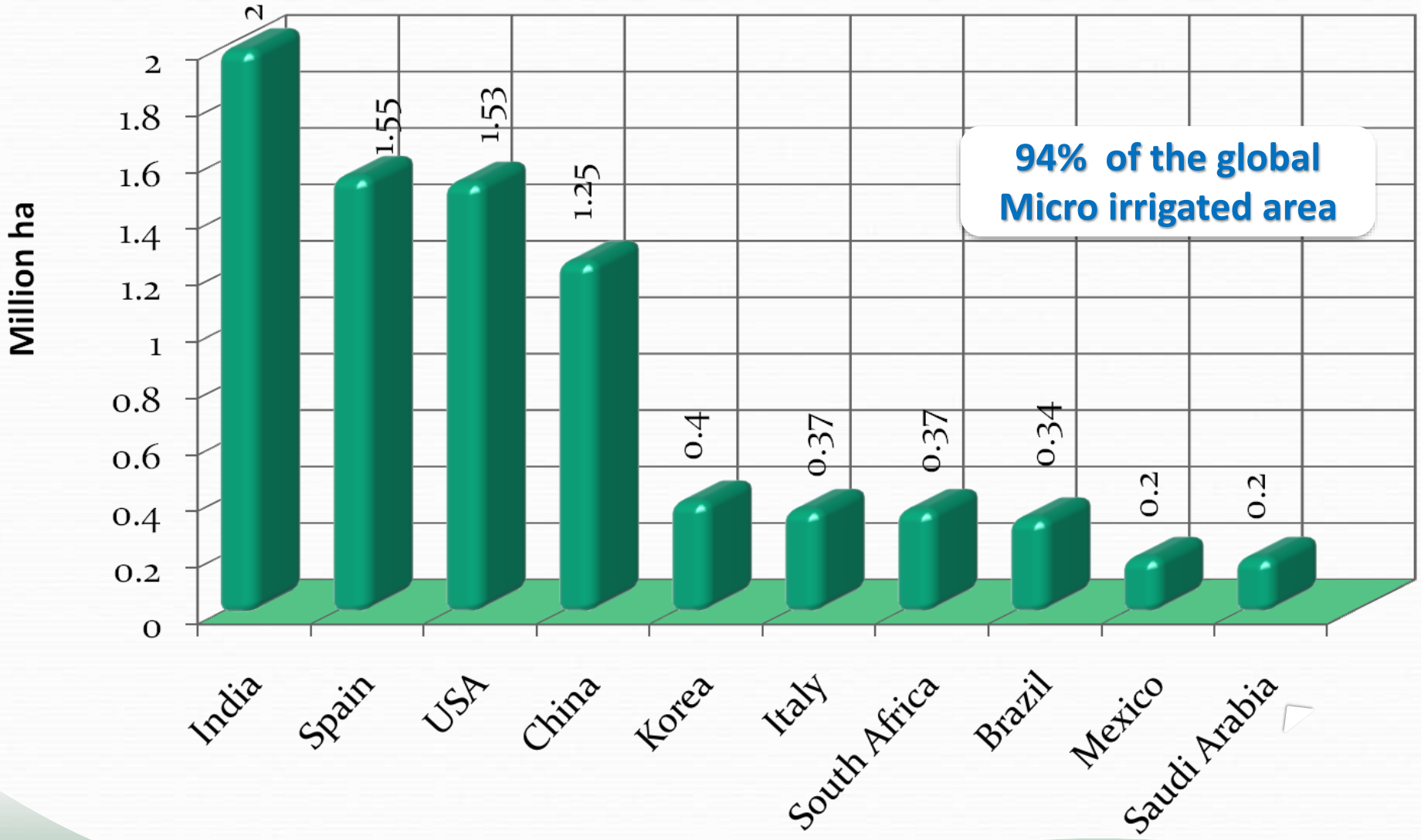


Drip irrigation, Spain

Top 10 sprinkler irrigation countries



Top 10 micro irrigation countries



Cultivated Land Worldwide

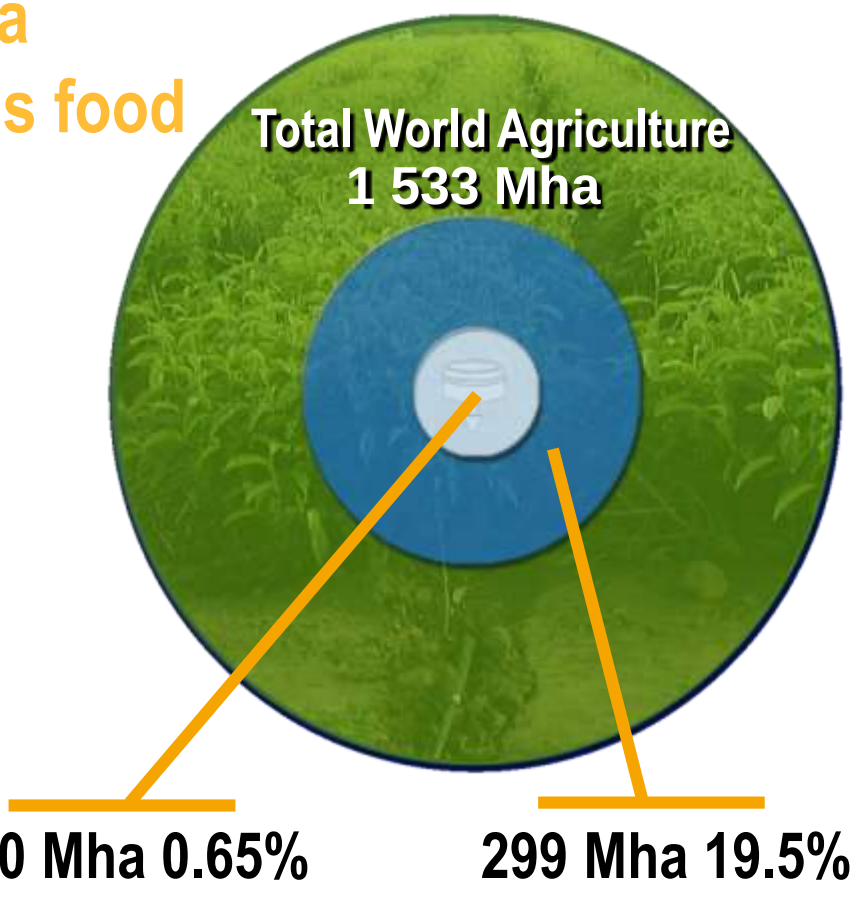
- 1 533 Mha – Total world Agriculture Area
- 299 Mha – Currently under Irrigation

19% of total agricultural land area supplies about **40%** of the world's food

- 10 Mha are drip irrigated

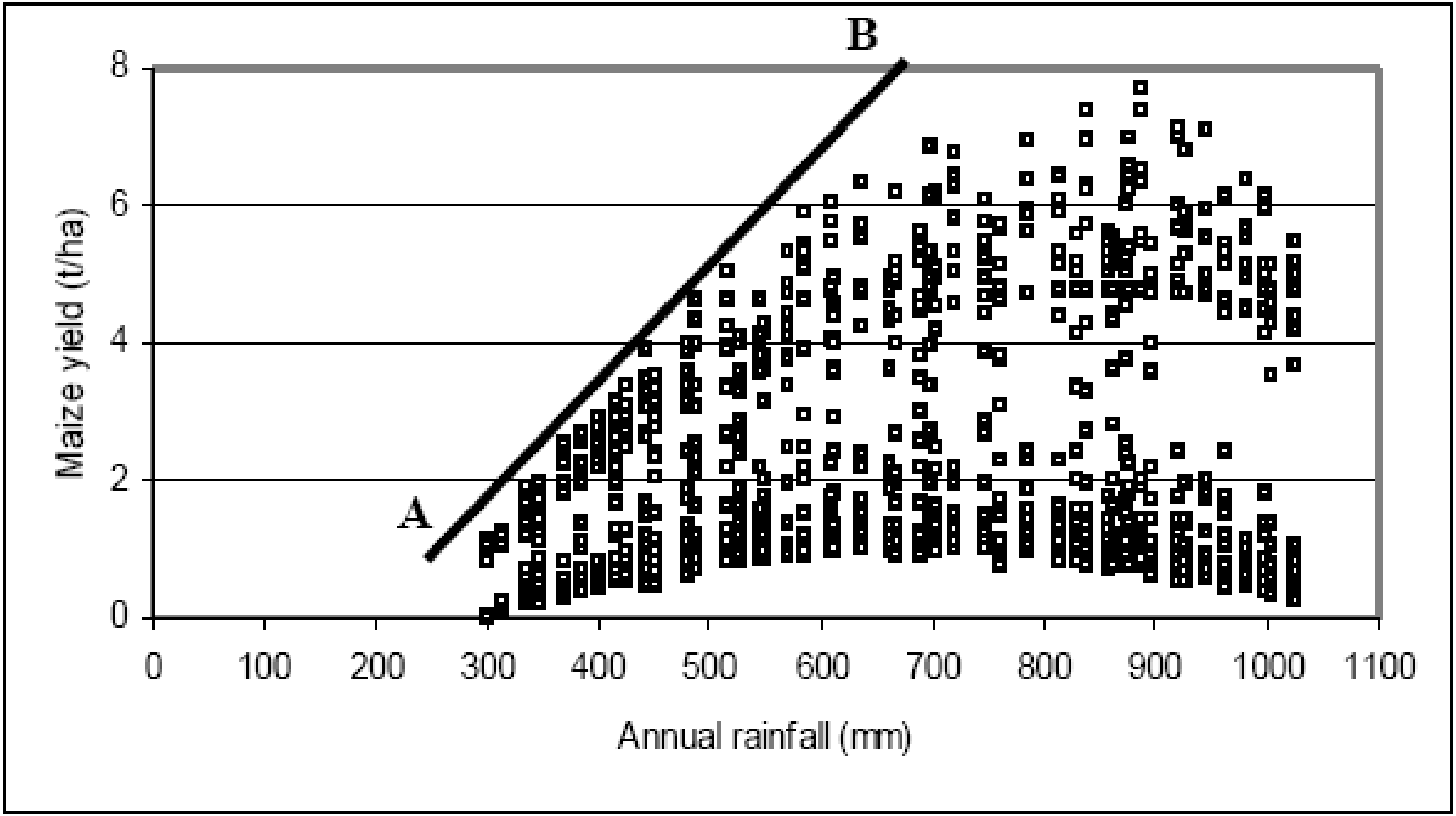
Crop productivity values:

- Rain fed 2.0-4.0 tons/ha
- Irrigated 8.0-10.0 tons/ha

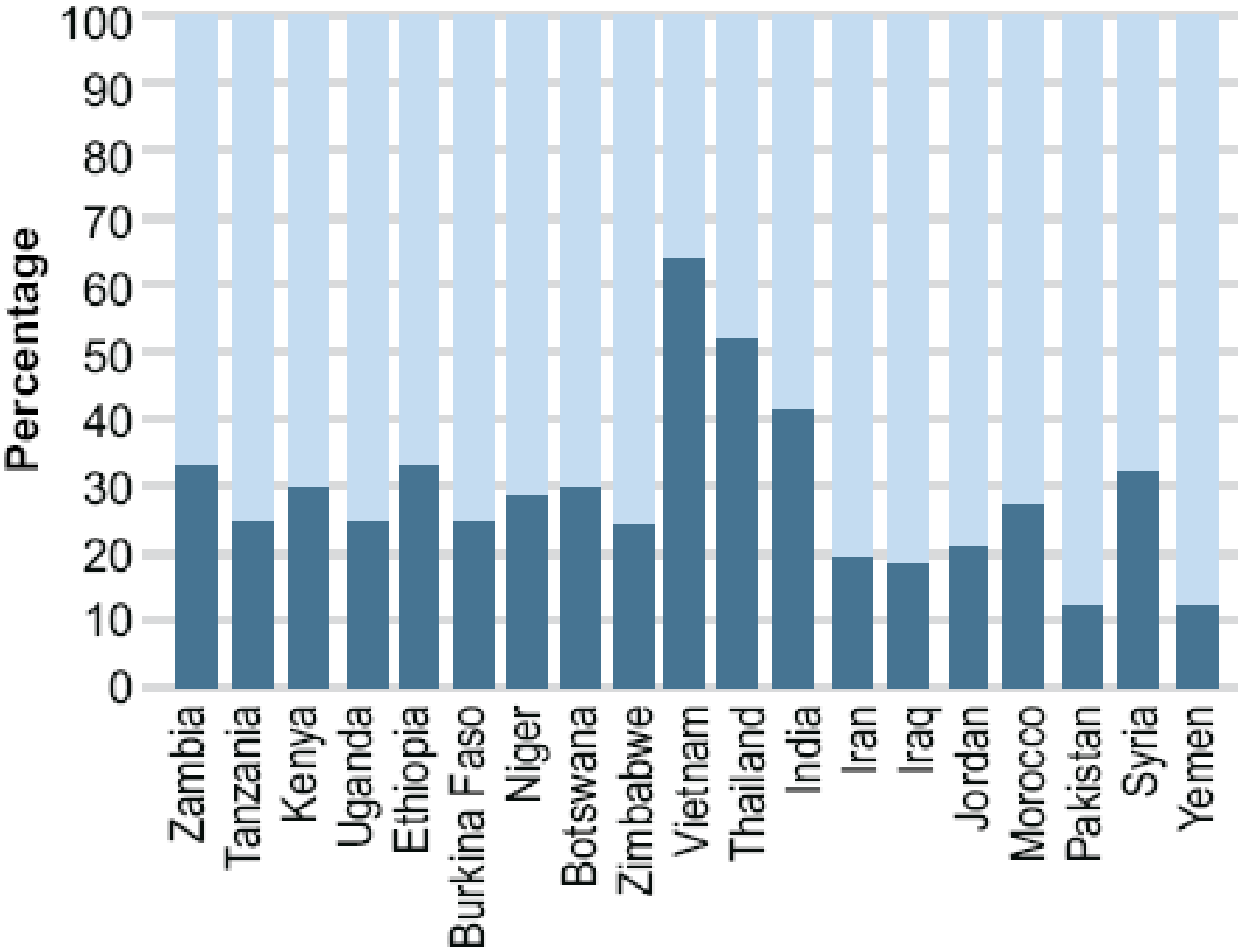


Source: ICID - CIID

Maize yield as a funtion of annual rainfield



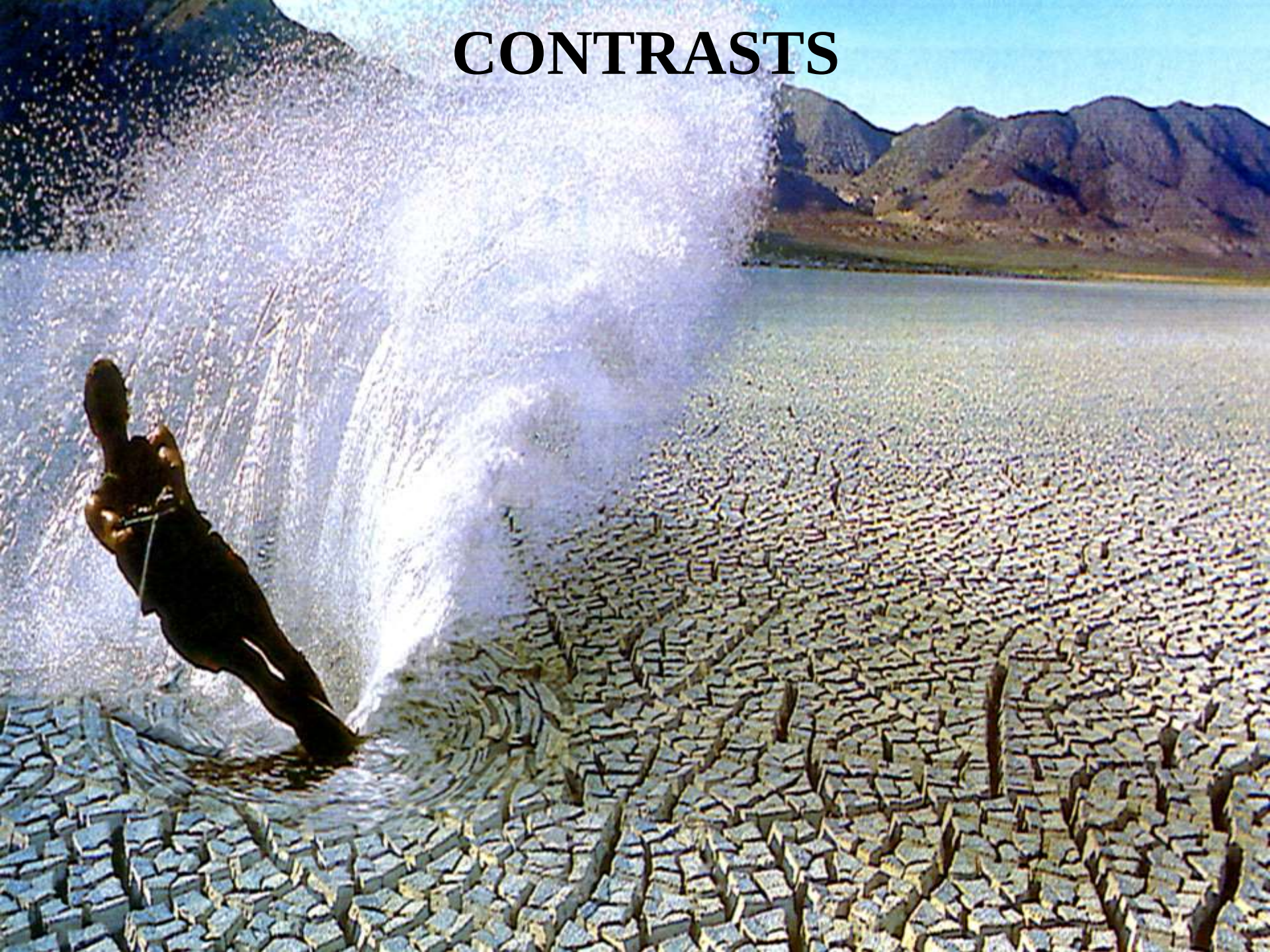
Gap between farmer's yields and achievable yields




Botswana
amibia
North West
Gauteng
Mpumalanga
Swazi-
land
South Africa
KwaZulu-
Natal
Free State
Northern Cape
Lesotho
Eastern Cape
Western Cape

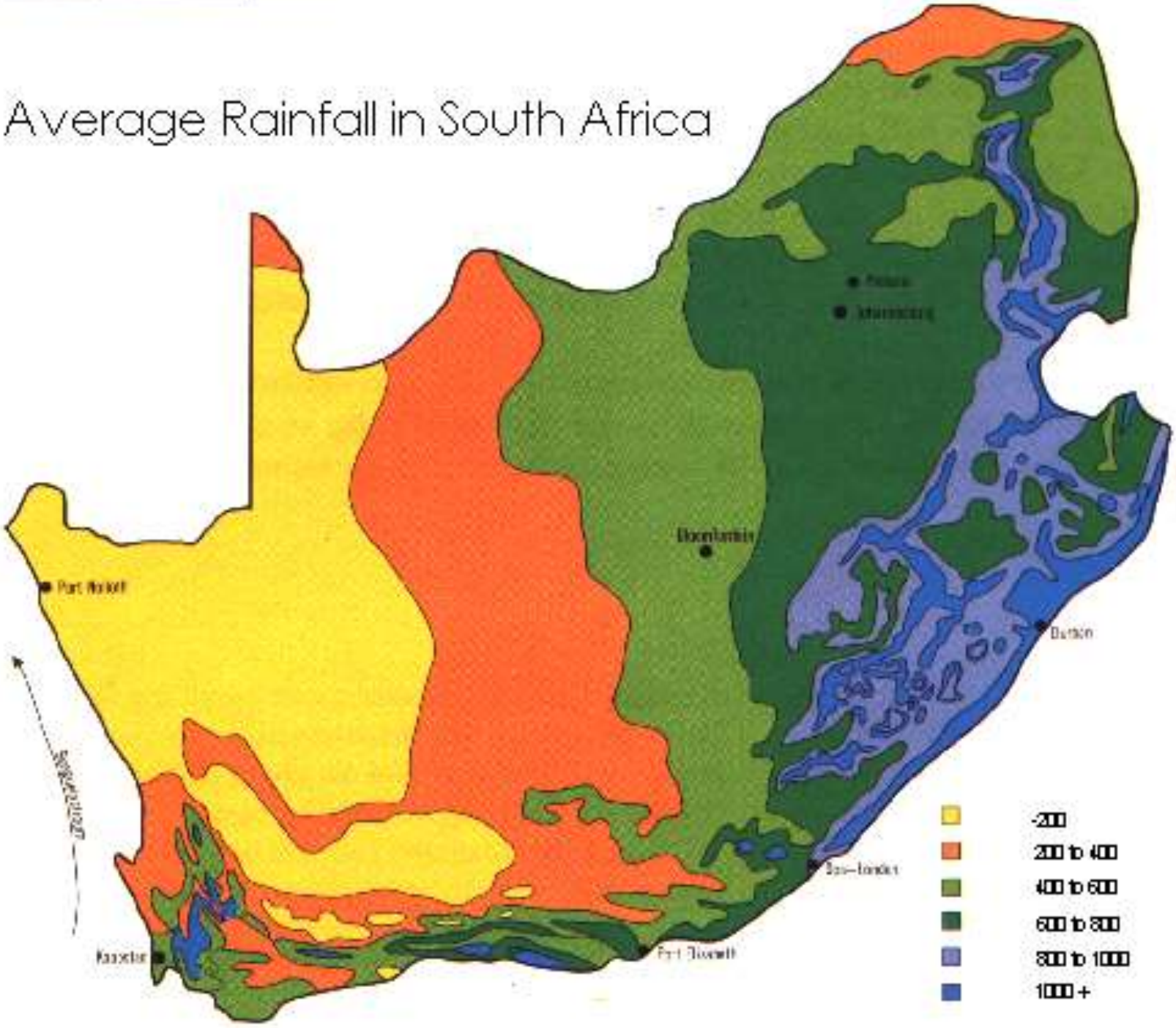
National

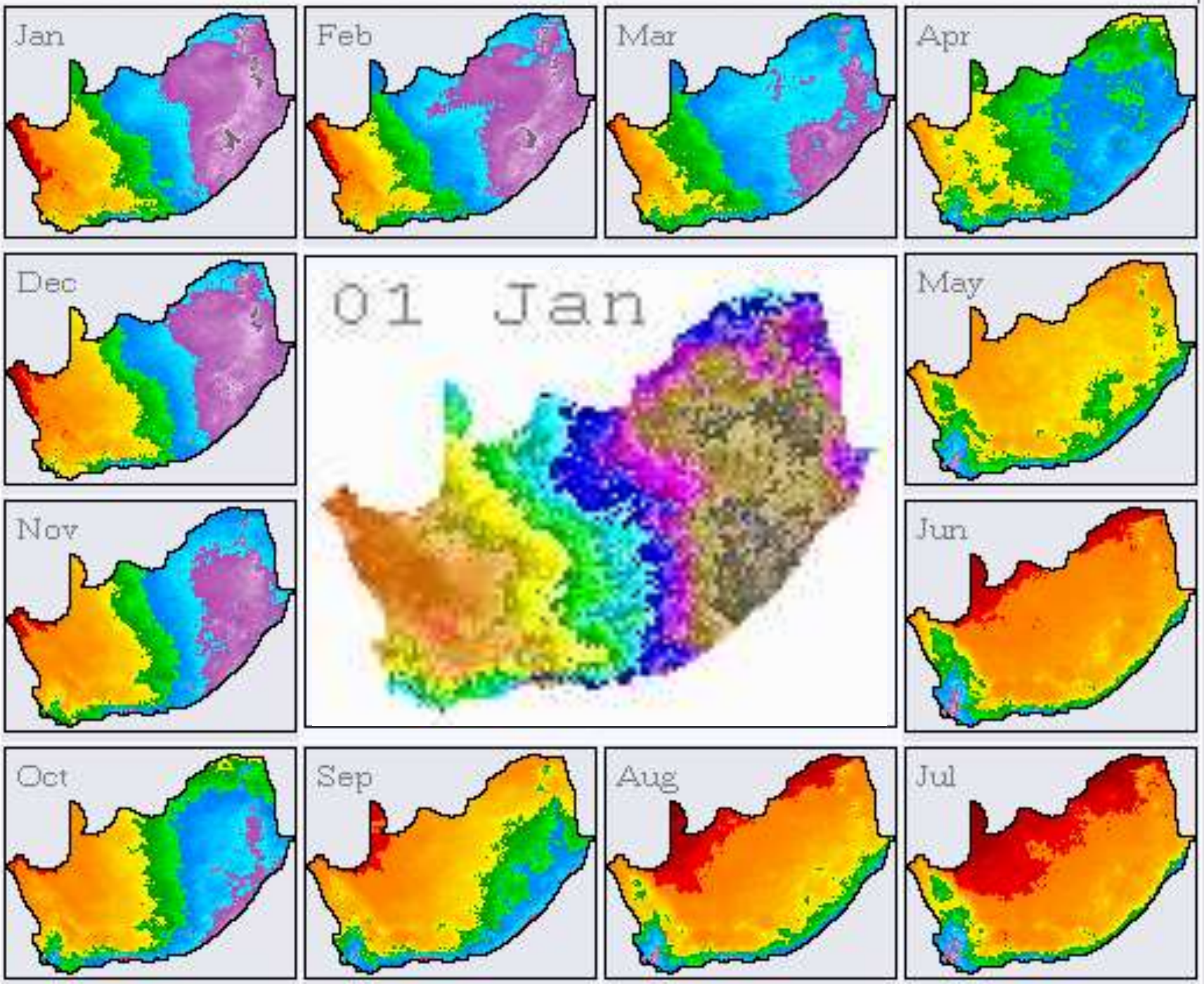
CONTRASTS



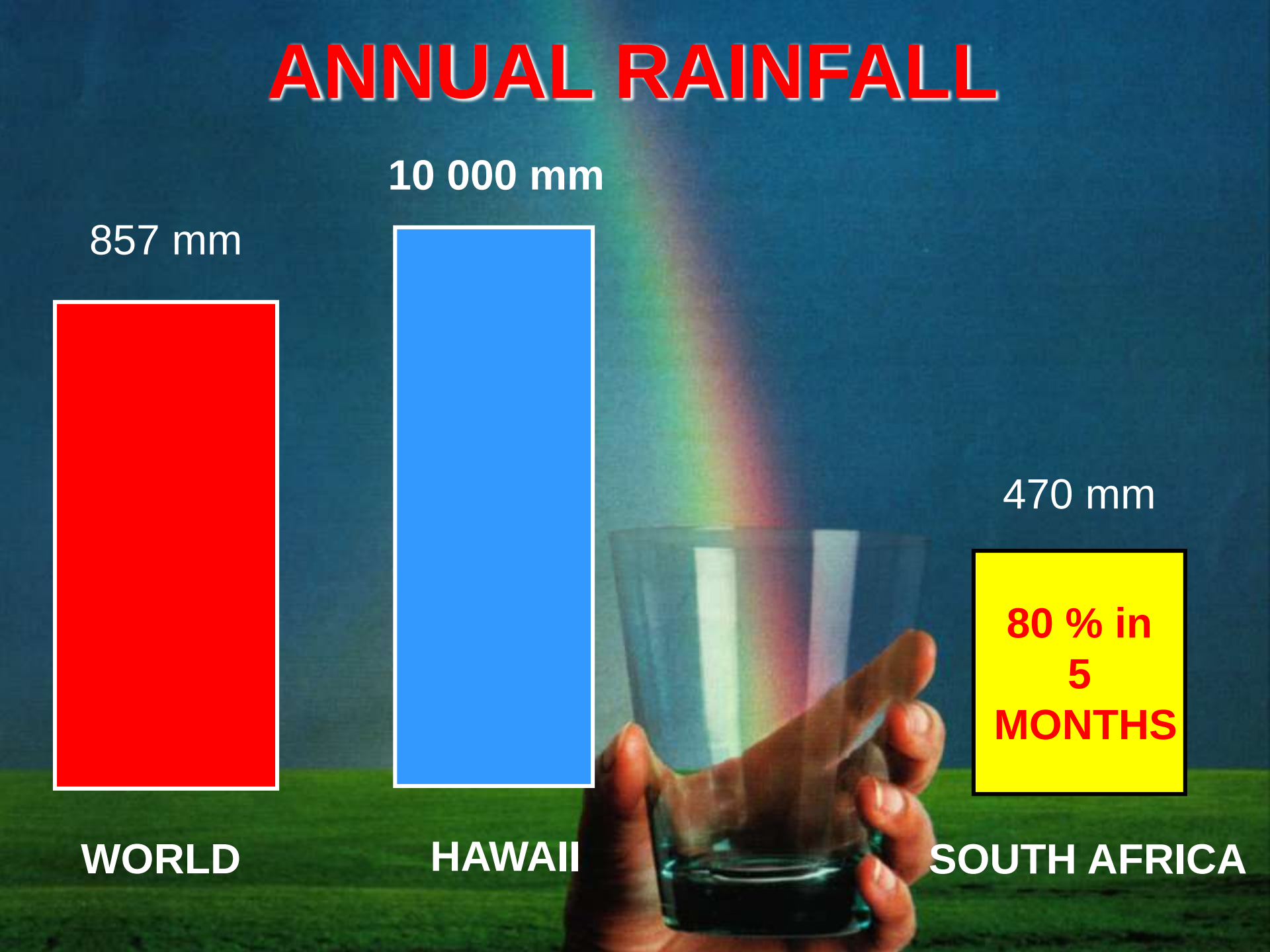

Rain

Average Rainfall in South Africa

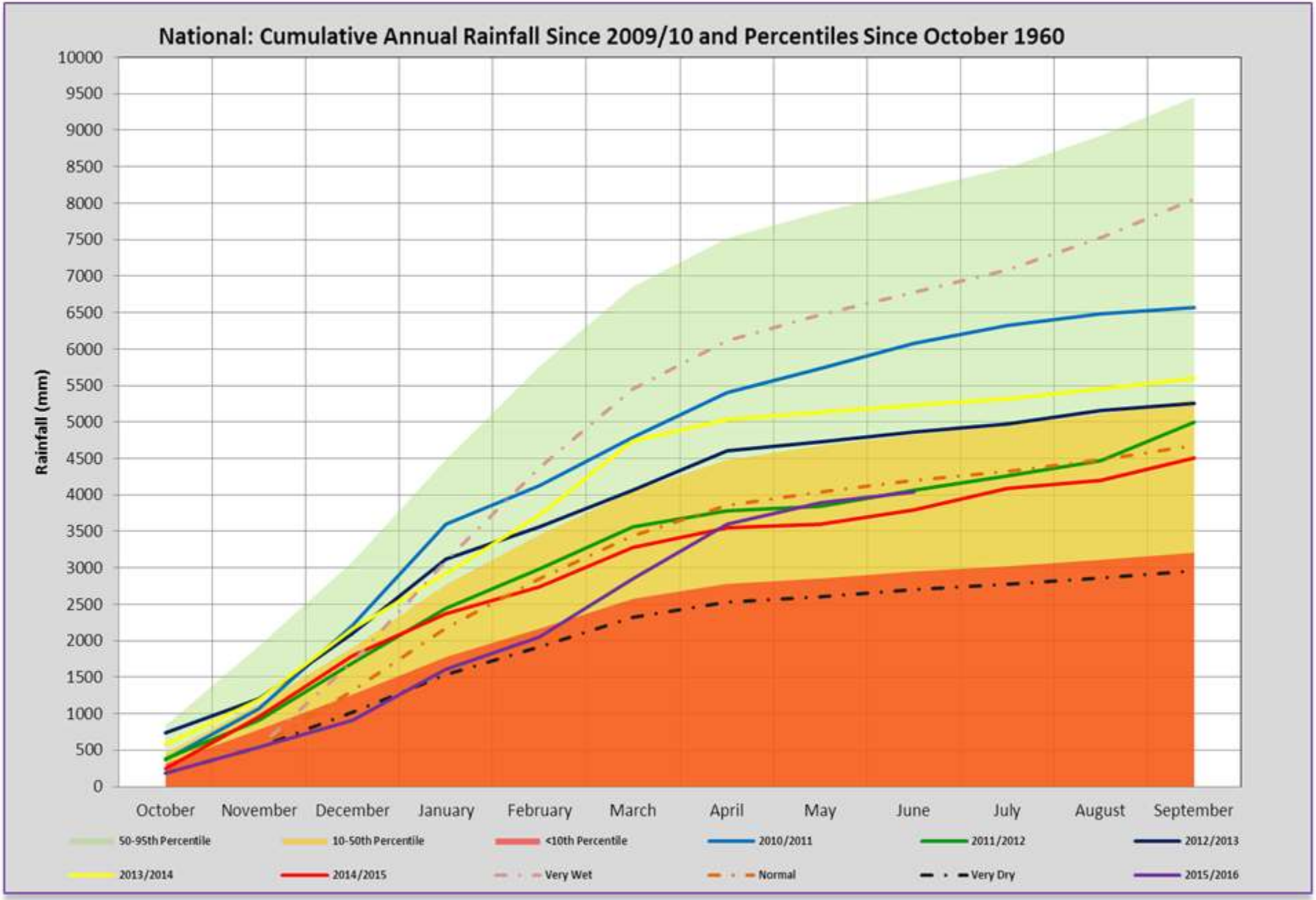


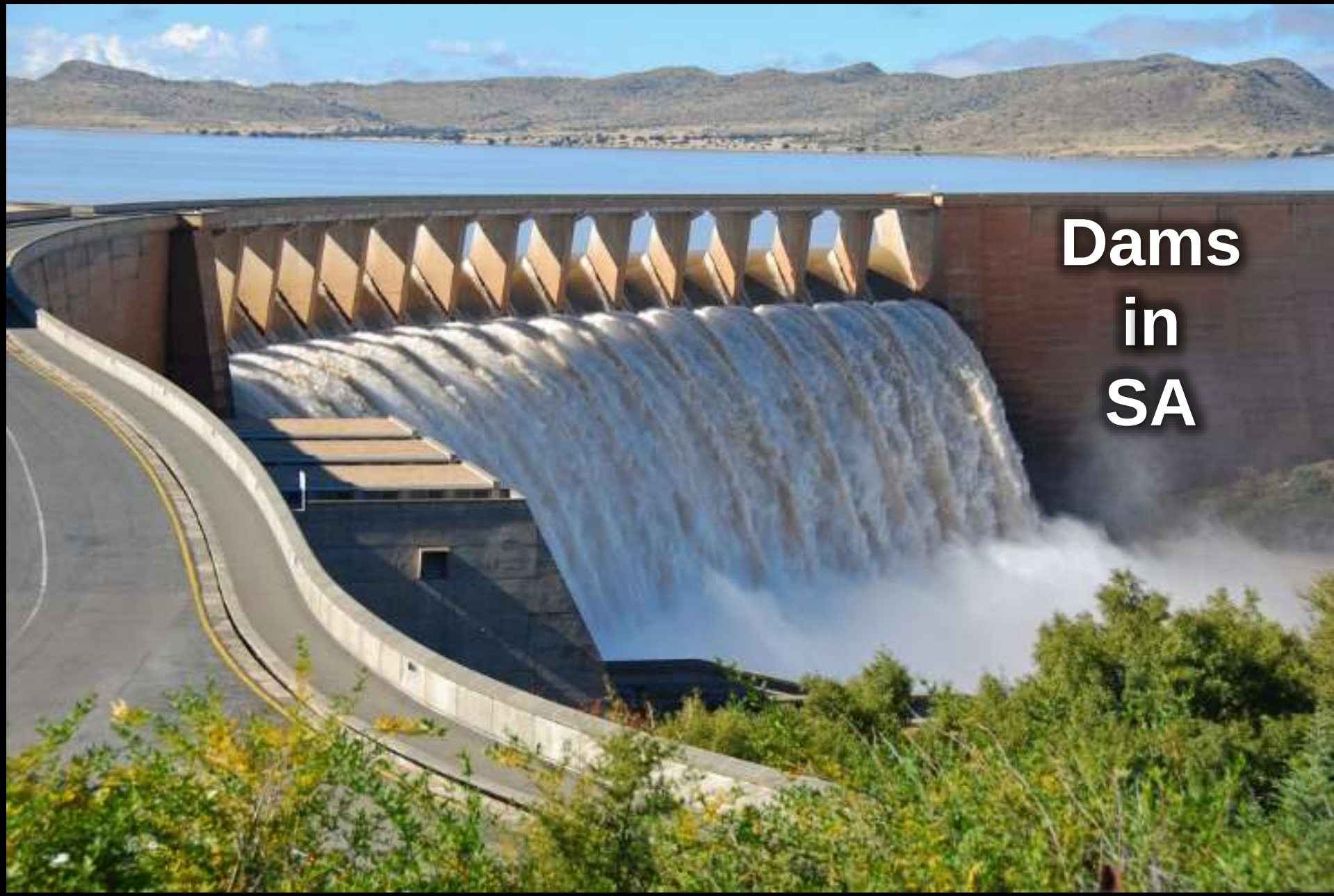

Jan
Feb
Mar
Apr
Dec
01 Jan
May
Nov
Jun
Oct
Sep
Aug
Jul

ANNUAL RAINFALL



National: Cumulative Annual Rainfall




Dams
in
SA

Extensive Water Resource Development

406 domestic water related dams

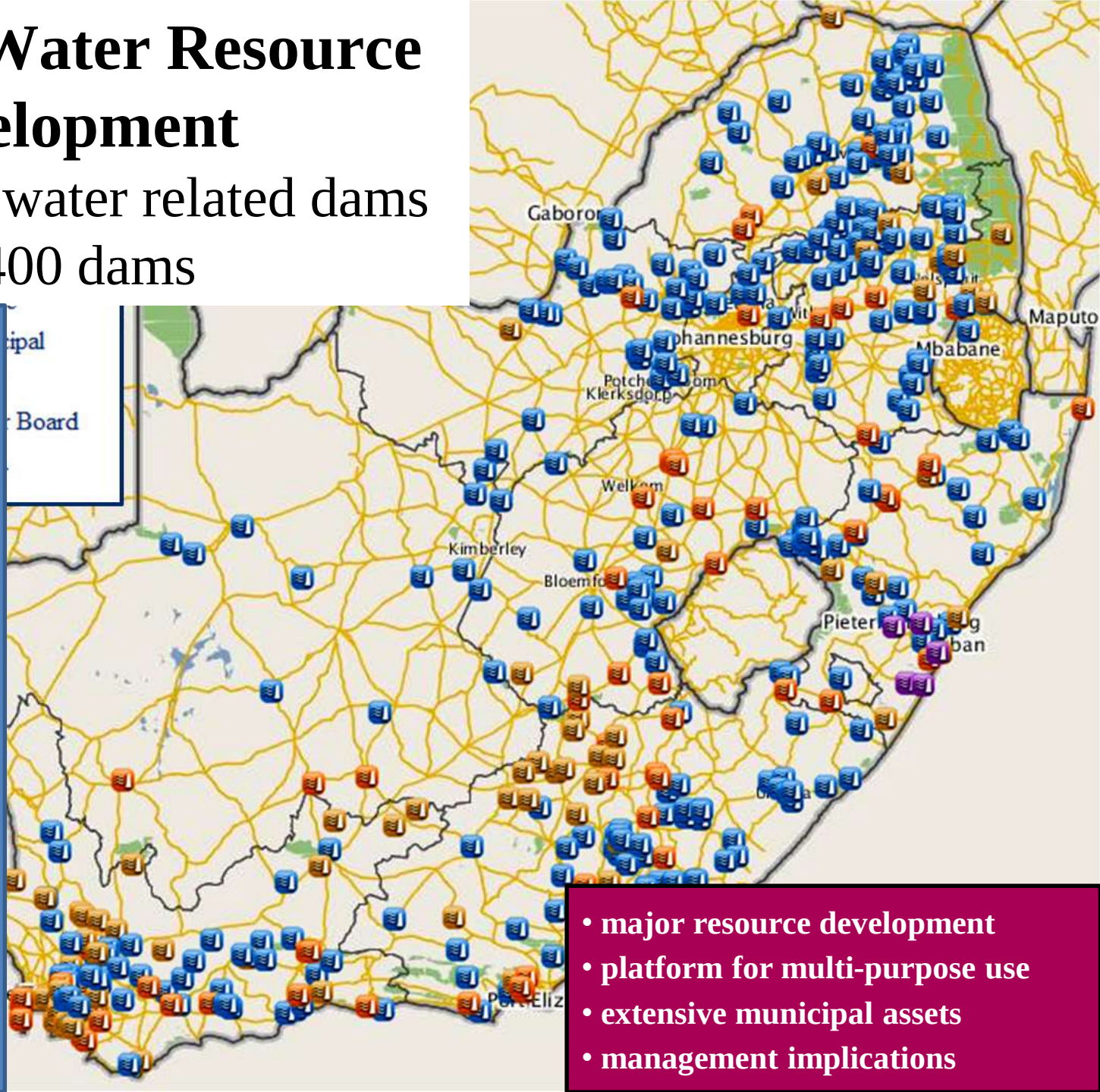
>4400 dams

4395 dams on Dam Safety Register
(4558 on WSAM)
(359 DWS owned)
(259 municipal owned)

2828 water supply related (includes irrigation & excludes mines, floods etc.)

406 for domestic supply

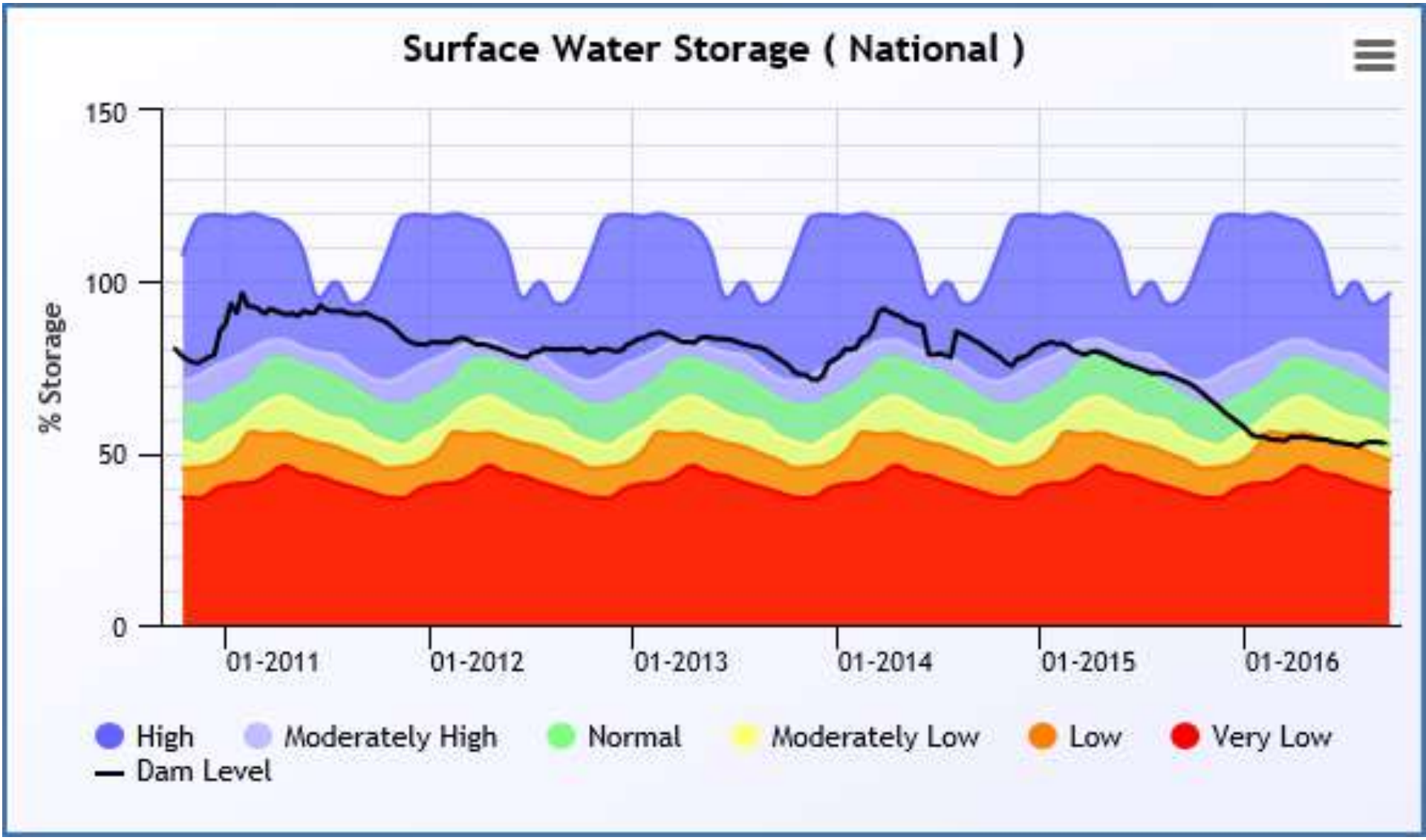
Others (irrigation, waste, flood, pollution control)

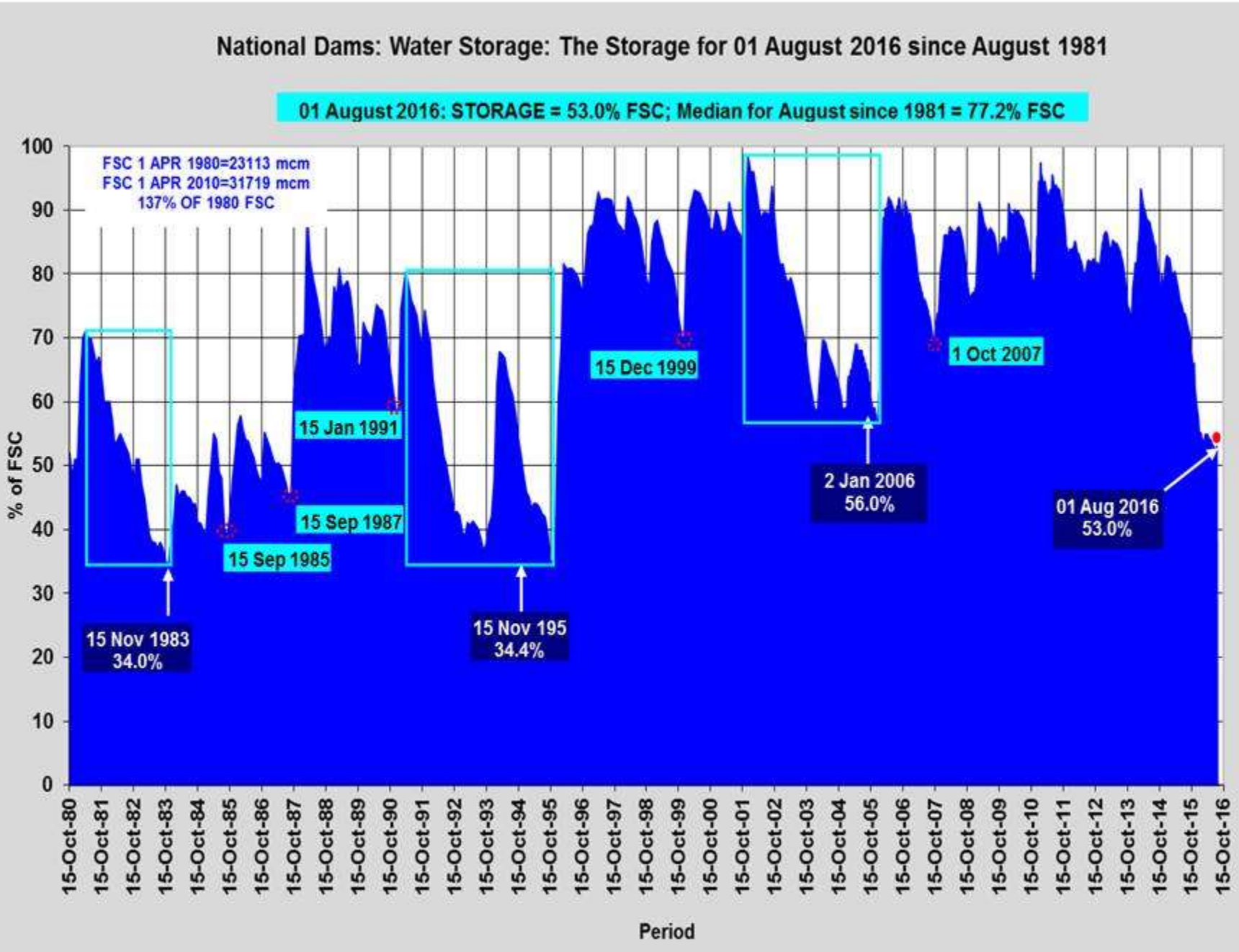


- major resource development
- platform for multi-purpose use
- extensive municipal assets
- management implications

Dam levels
30 September 2016
Provincial summary

Province	Nett FSC million m^3	This Week (%)	Last Week (%)	Last Year (%)
Eastern Cape	1833	65	65	80
Free State	15971	54	55	73
Gauteng	115	82	82	89
Kwazulu-Natal	4669	43	43	62
Lesotho*	2376	38	38	61
Limpopo	1508	48	49	75
Mpumalanga	2539	51	52	76
North West	887	62	63	63
Northern Cape	146	63	62	79
Western Cape	1870	62	62	72
Total	**31913**	**52**	**53**	**71**

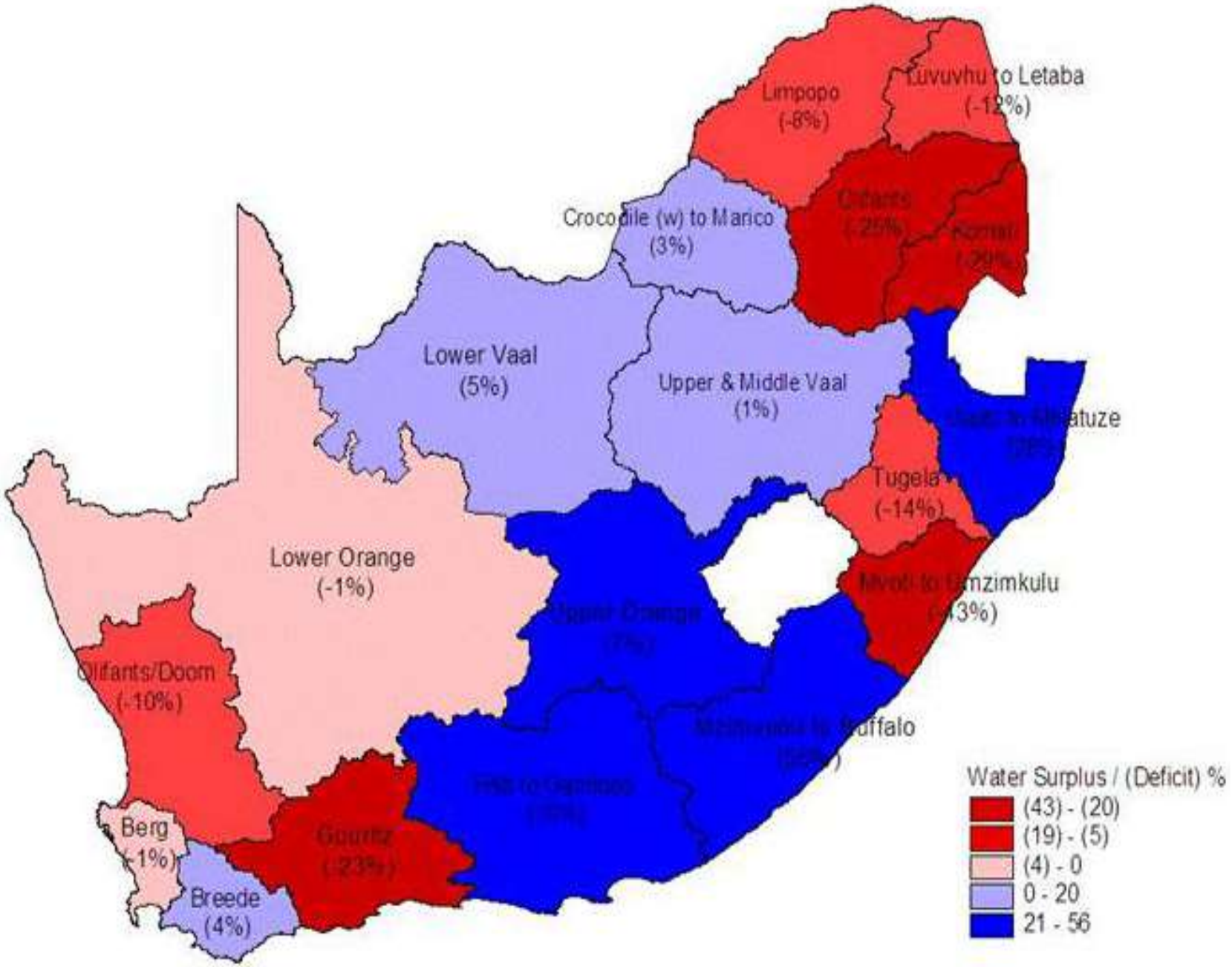

Surface Water Storage (National)
% Storage
150
100
50
0
01-2011
01-2012
01-2013
01-2014
01-2015
01-2016
High
Moderately High
Normal
Moderately Low
Low
Very Low
Dam Level


National Dams: Water Storage: The Storage for 01 August 2016 since August 1981
01 August 2016: STORAGE = 53.0% FSC; Median for August since 1981 = 77.2% FSC
FSC 1 APR 1980=23113 mcm
FSC 1 APR 2010=31719 mcm
137% OF 1980 FSC
% of FSC
Period
15 Nov 1983
34.0%
15 Sep 1985
15 Jan 1991
15 Sep 1987
15 Nov 195
34.4%
15 Dec 1999
2 Jan 2006
56.0%
1 Oct 2007
01 Aug 2016
53.0%

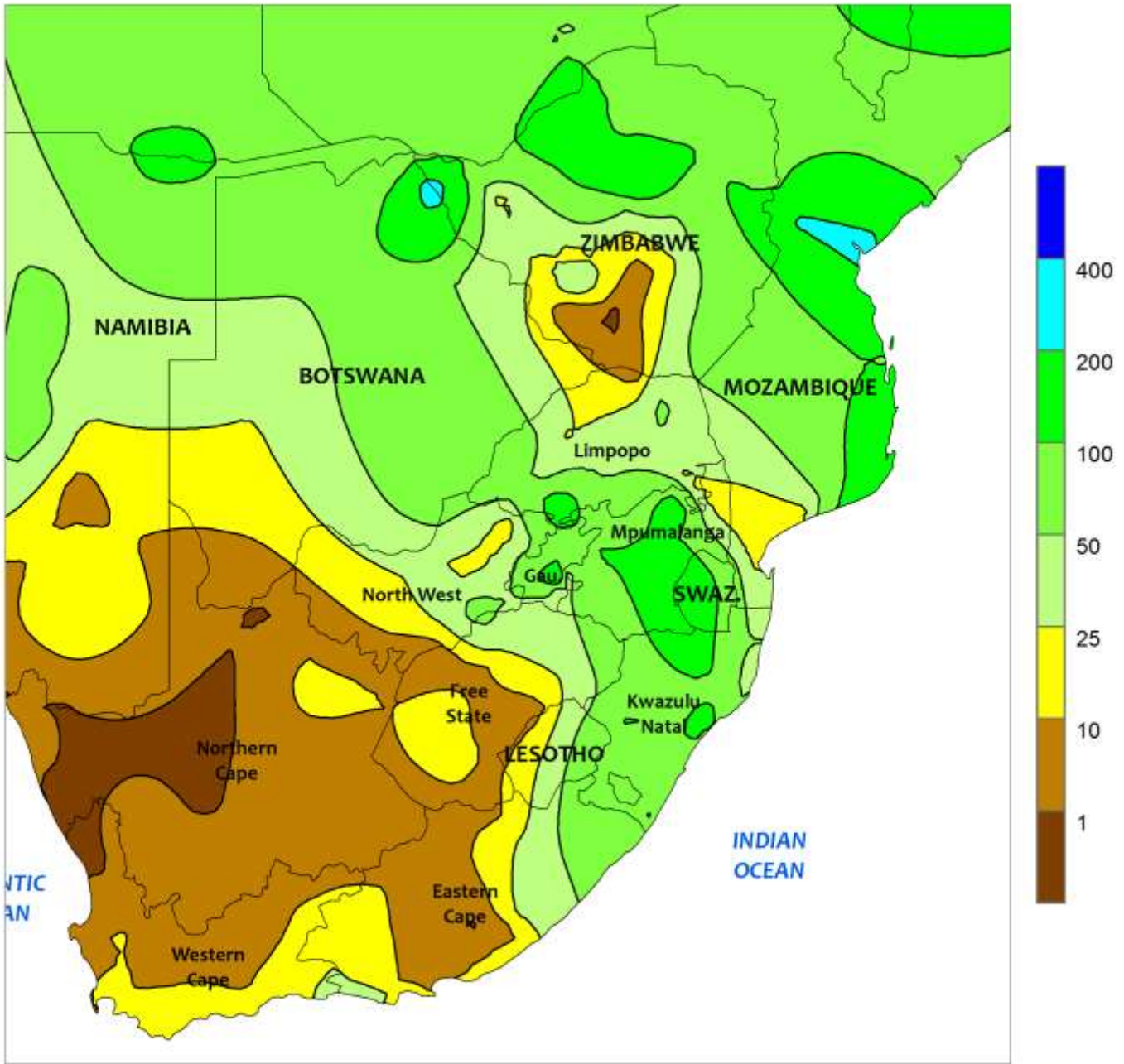
RSA Water Resources

- The Orange River carries about 10% of the flow of the Zambezi River and about 1% of the flow in the Congo.
- The total surface runoff of 49 000 million m^3 of all the RSA rivers added together is less than half of the MAR of the Zambezi River.
- We have to share many of our larger rivers with other countries.
- 12 of the 19 water management areas in the country faced a deficit.

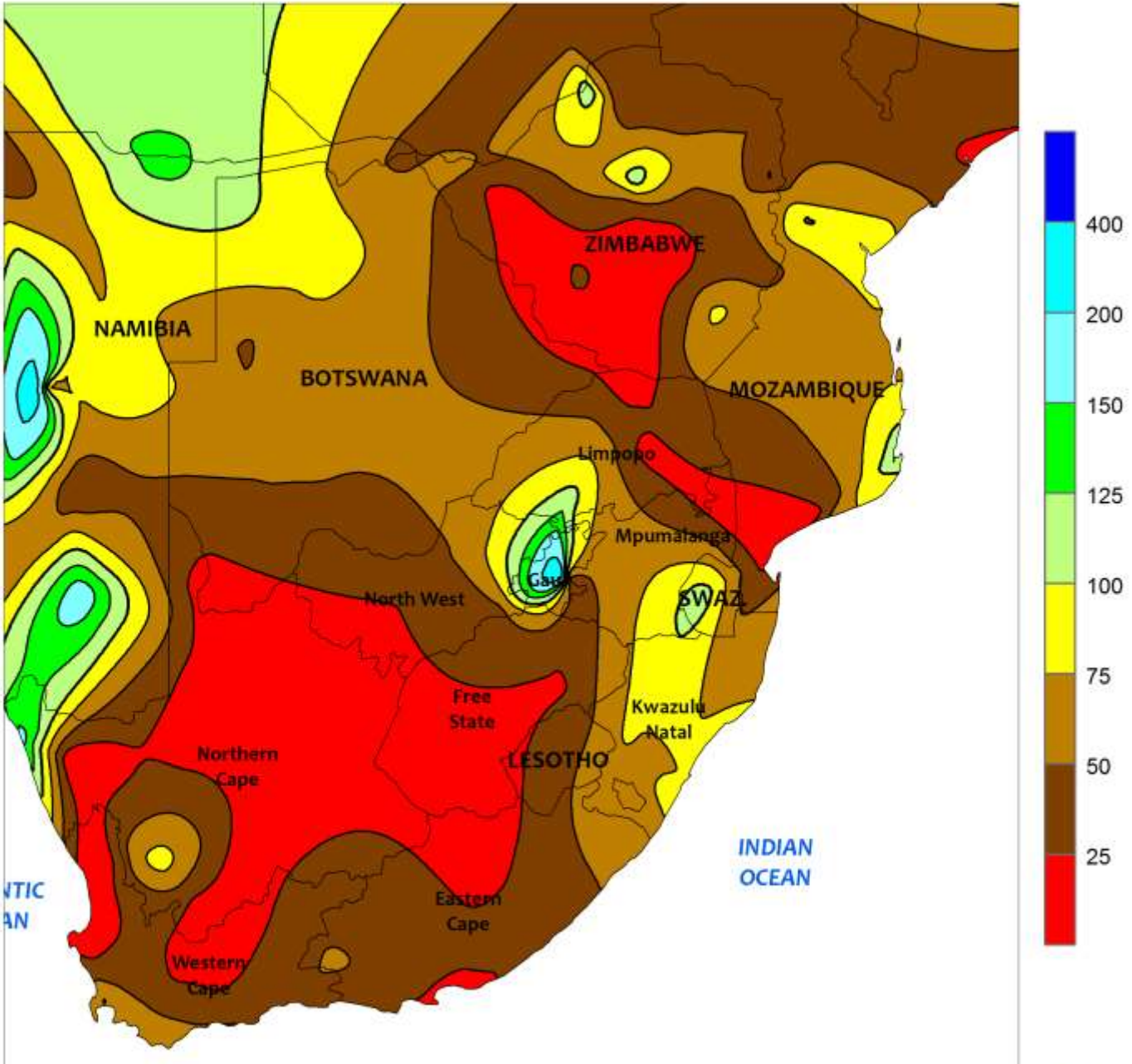
Water Management areas percentage surplus/deficit



SOUTH AFRICA
Total Precipitation (mm)
December 2015



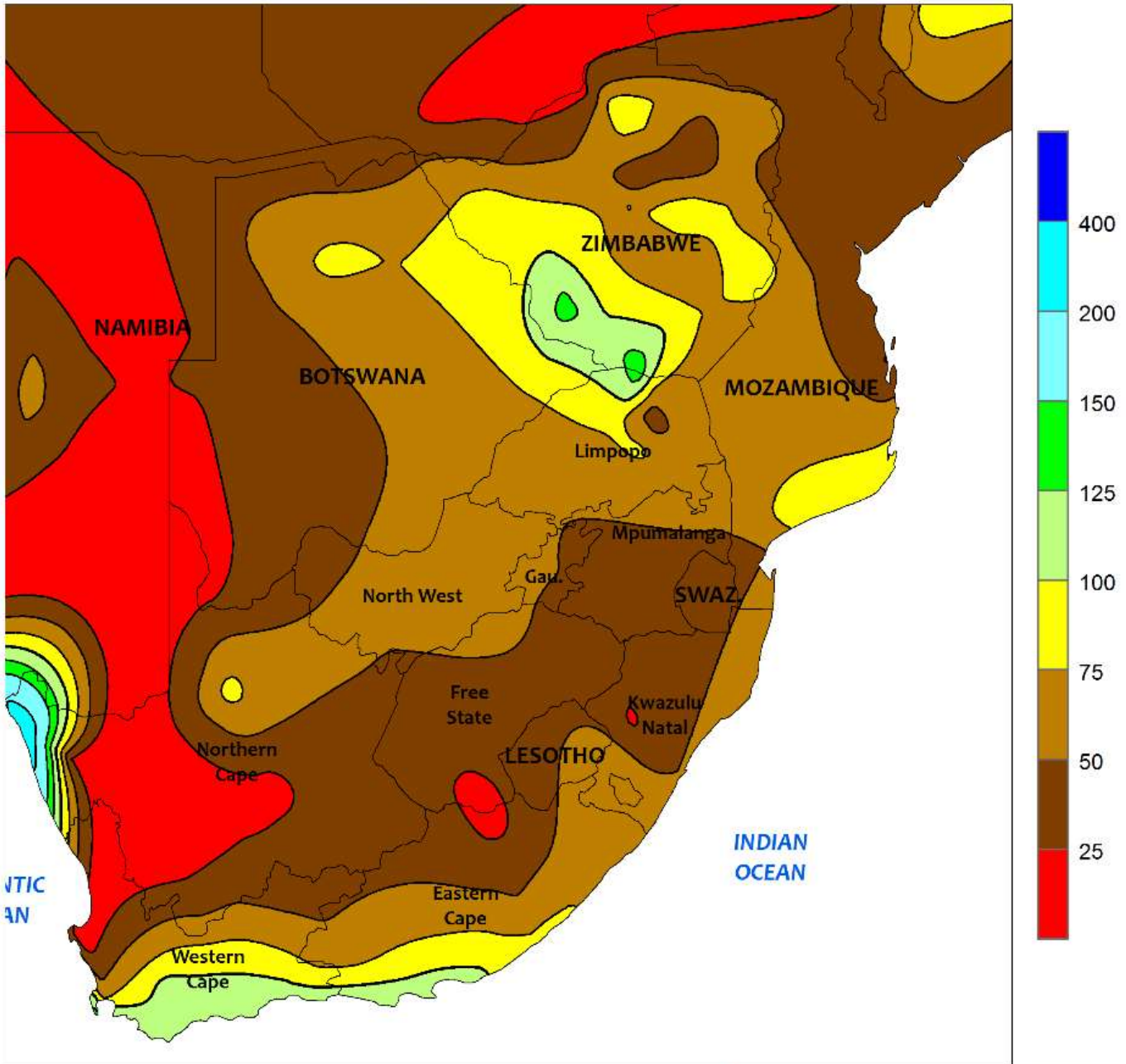
SOUTH AFRICA
Percent of Normal Precipitation
December 2015



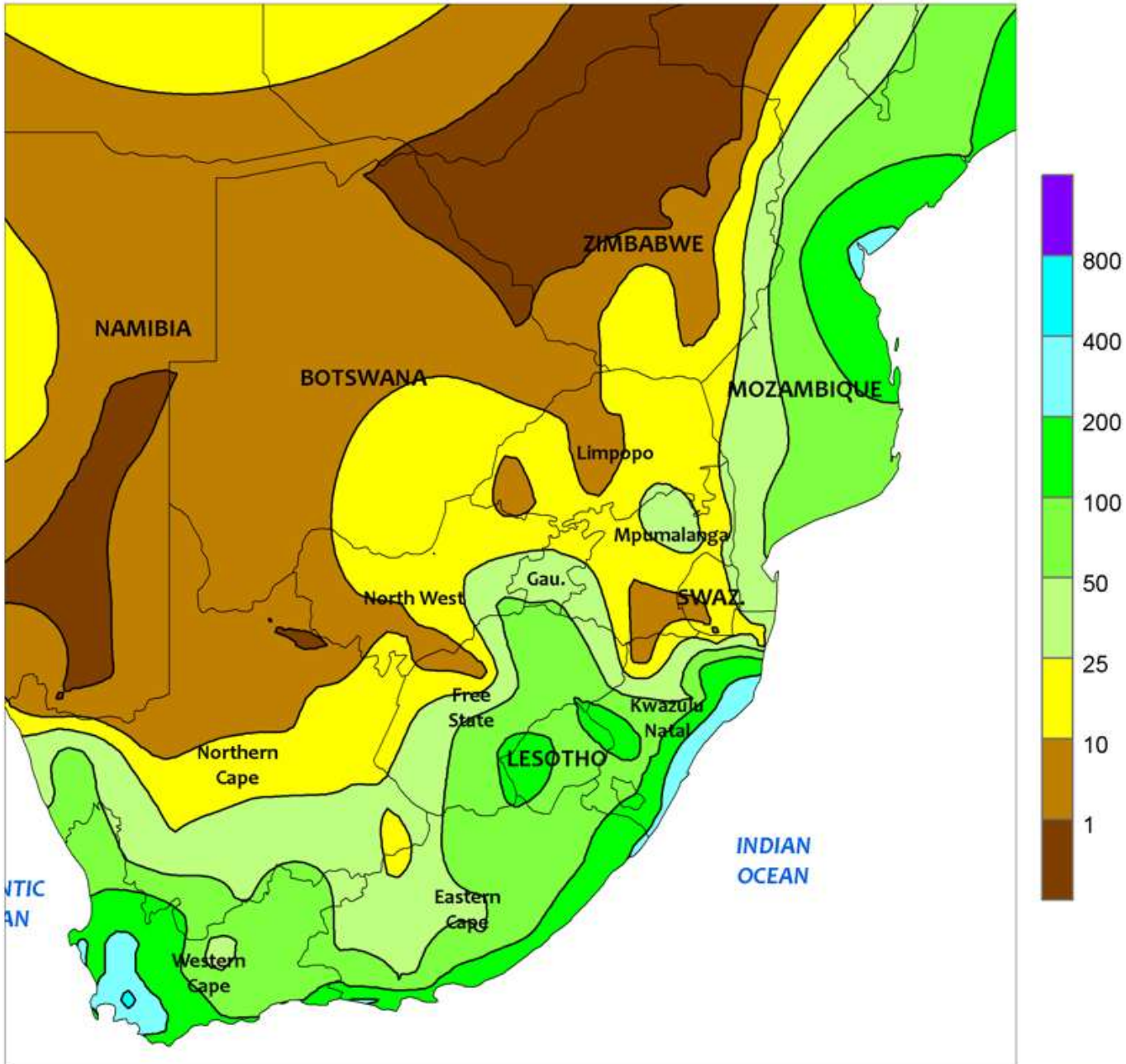
SOUTH AFRICA

Percent of Normal Precipitation

September 1, 2015 - November 30, 2015



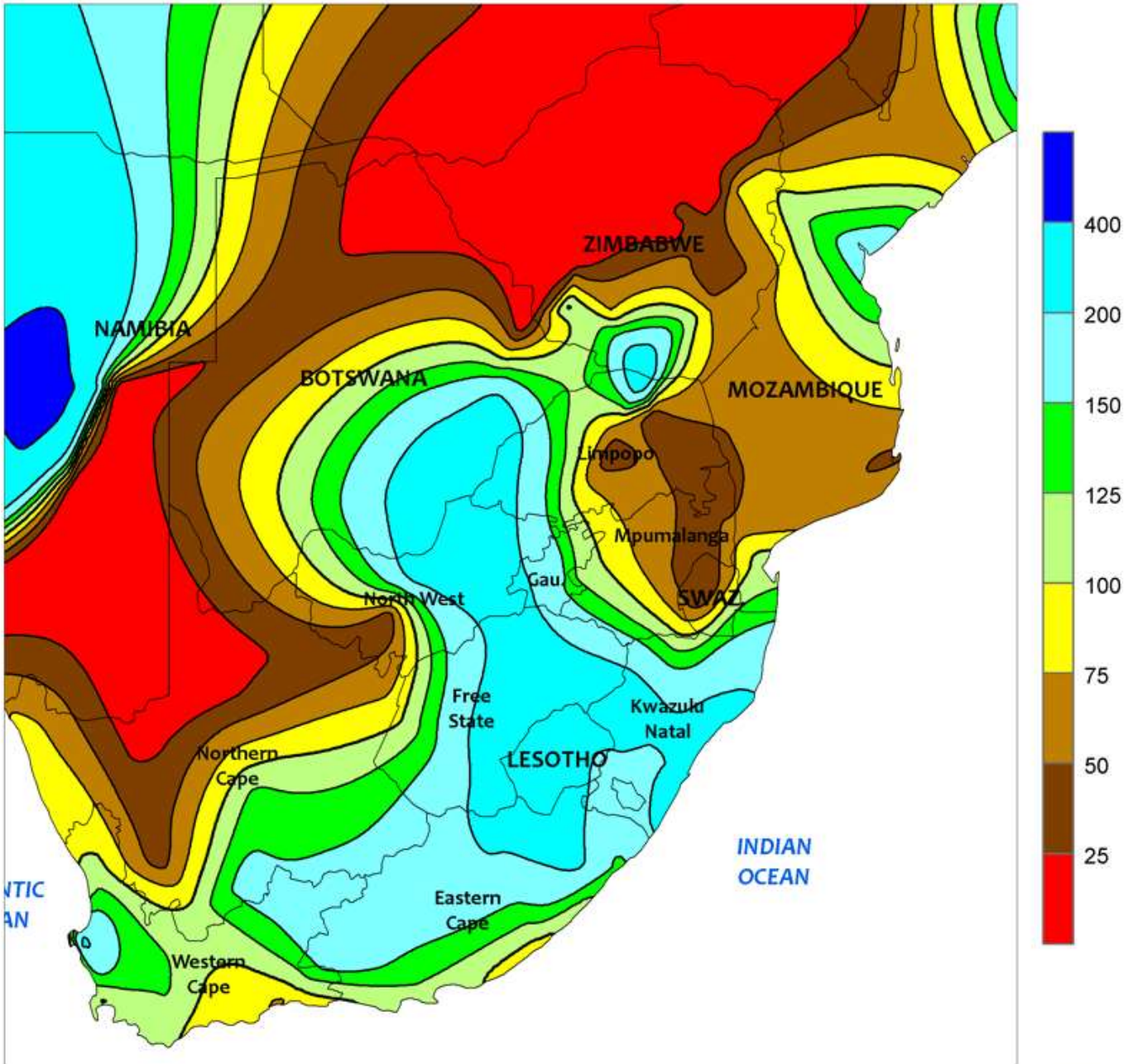
SOUTH AFRICA
Total Precipitation (mm)
June 1, 2016 - August 31, 2016



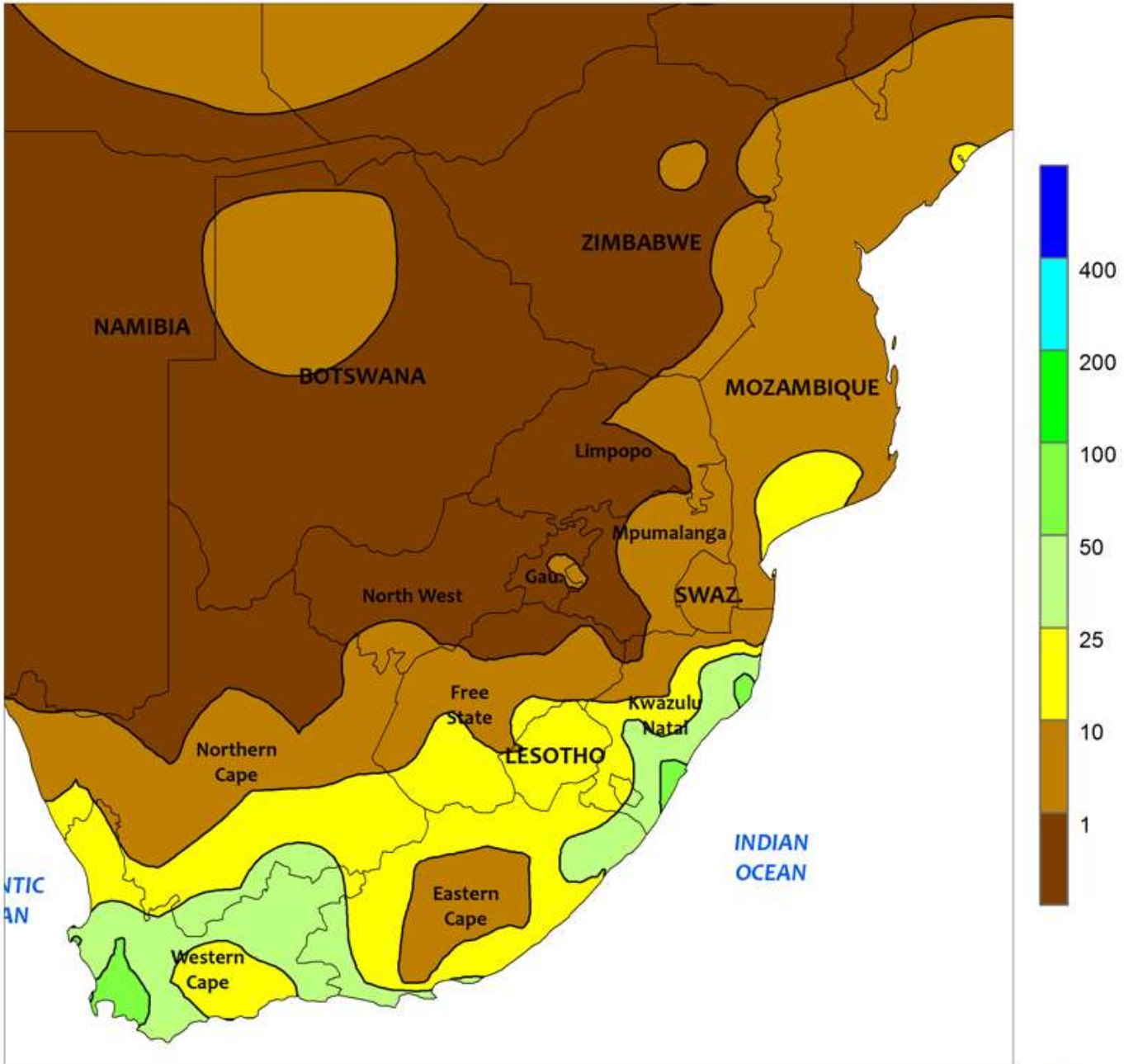
SOUTH AFRICA

Percent of Normal Precipitation

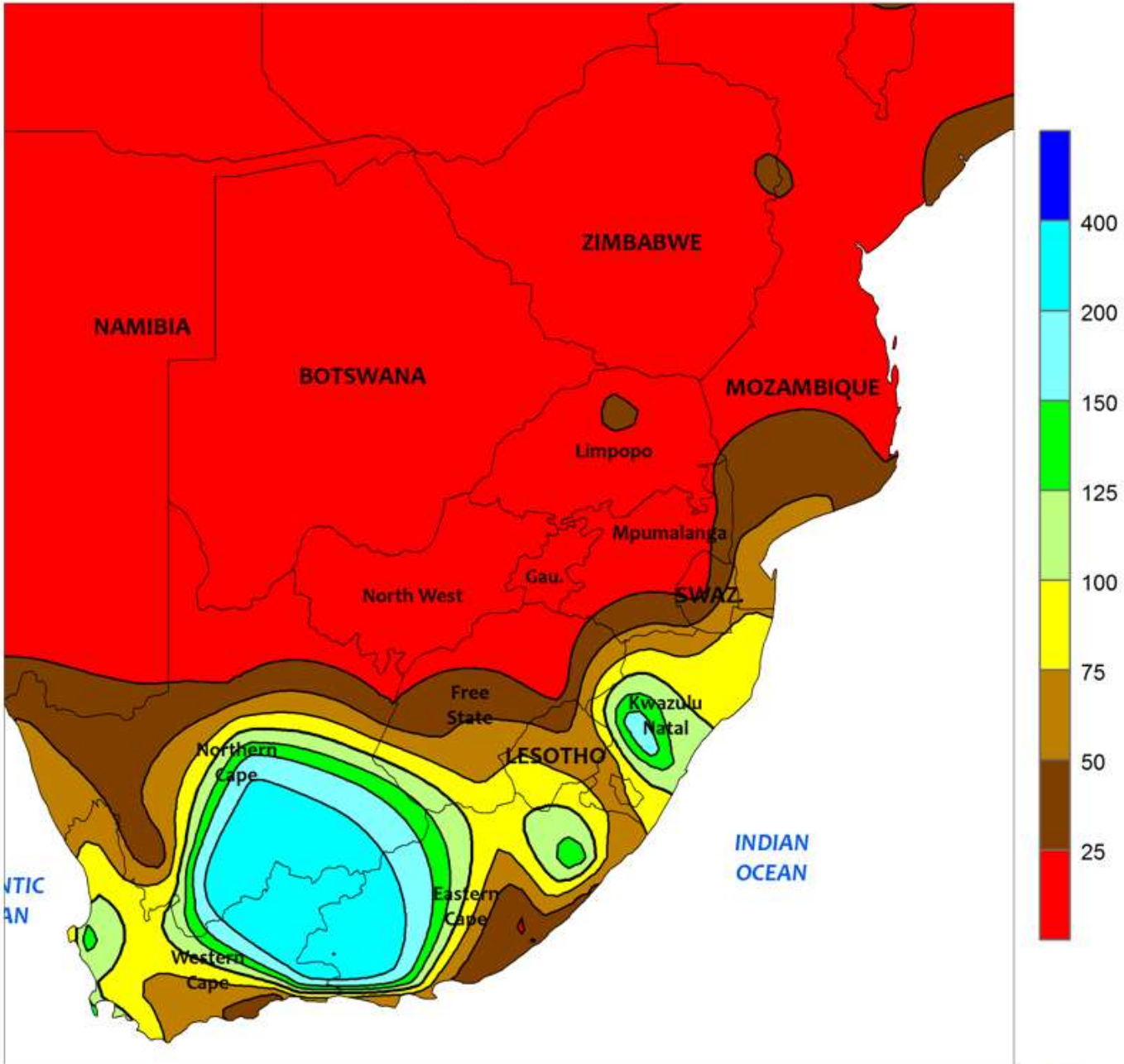
June 1, 2016 - August 31, 2016



SOUTH AFRICA
Total Precipitation (mm)
August 2016



SOUTH AFRICA
Percent of Normal Precipitation
August 2016



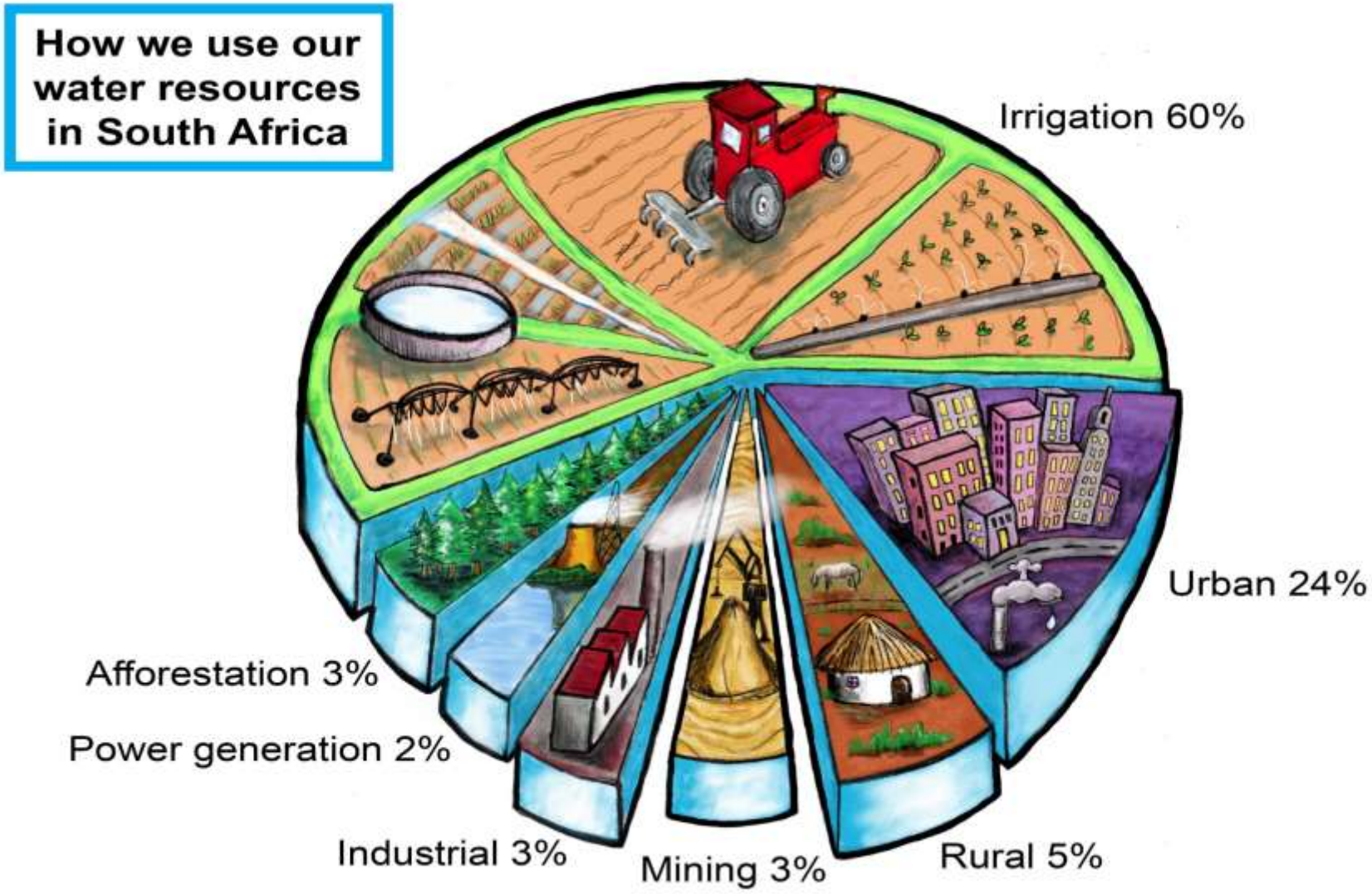
National water act (Act 36 of 1998)

Dictates water has to be

protected
used
developed
conserved
managed and
controlled

in a sustainable and equitable manner.

EXISTING WATER USE

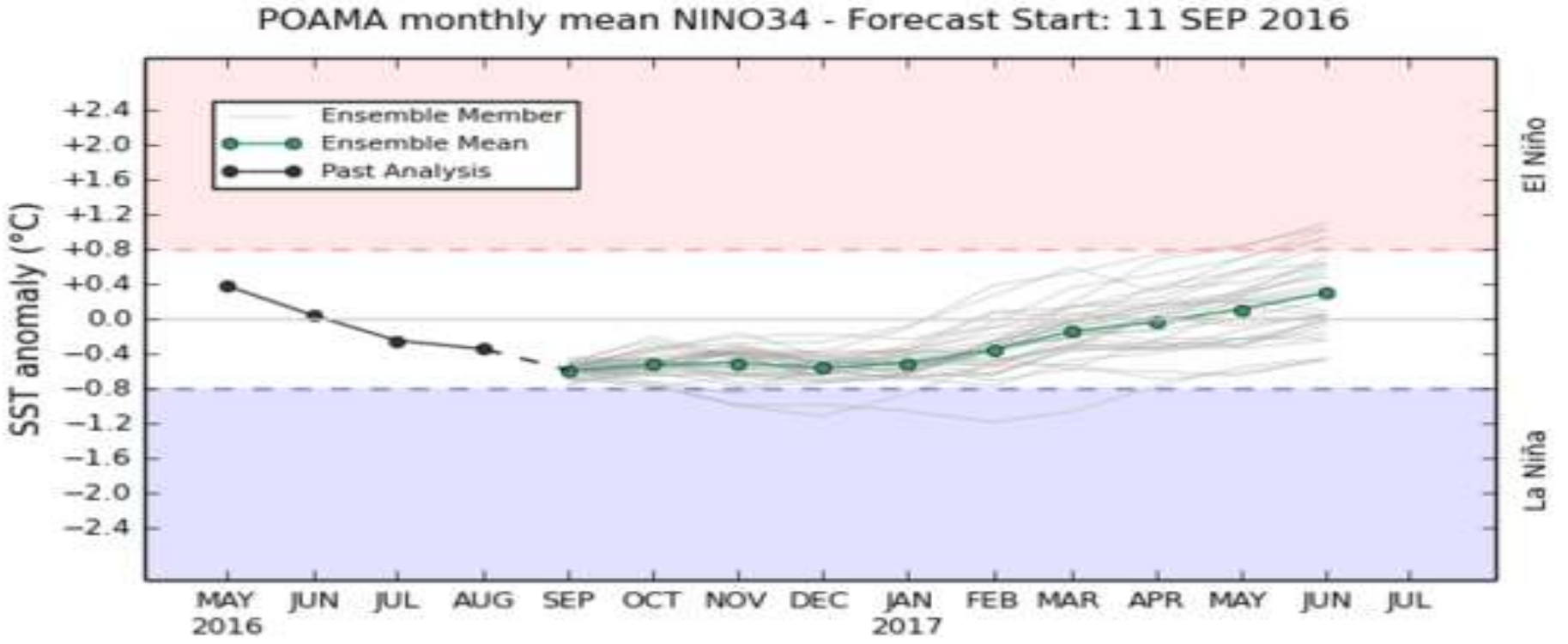


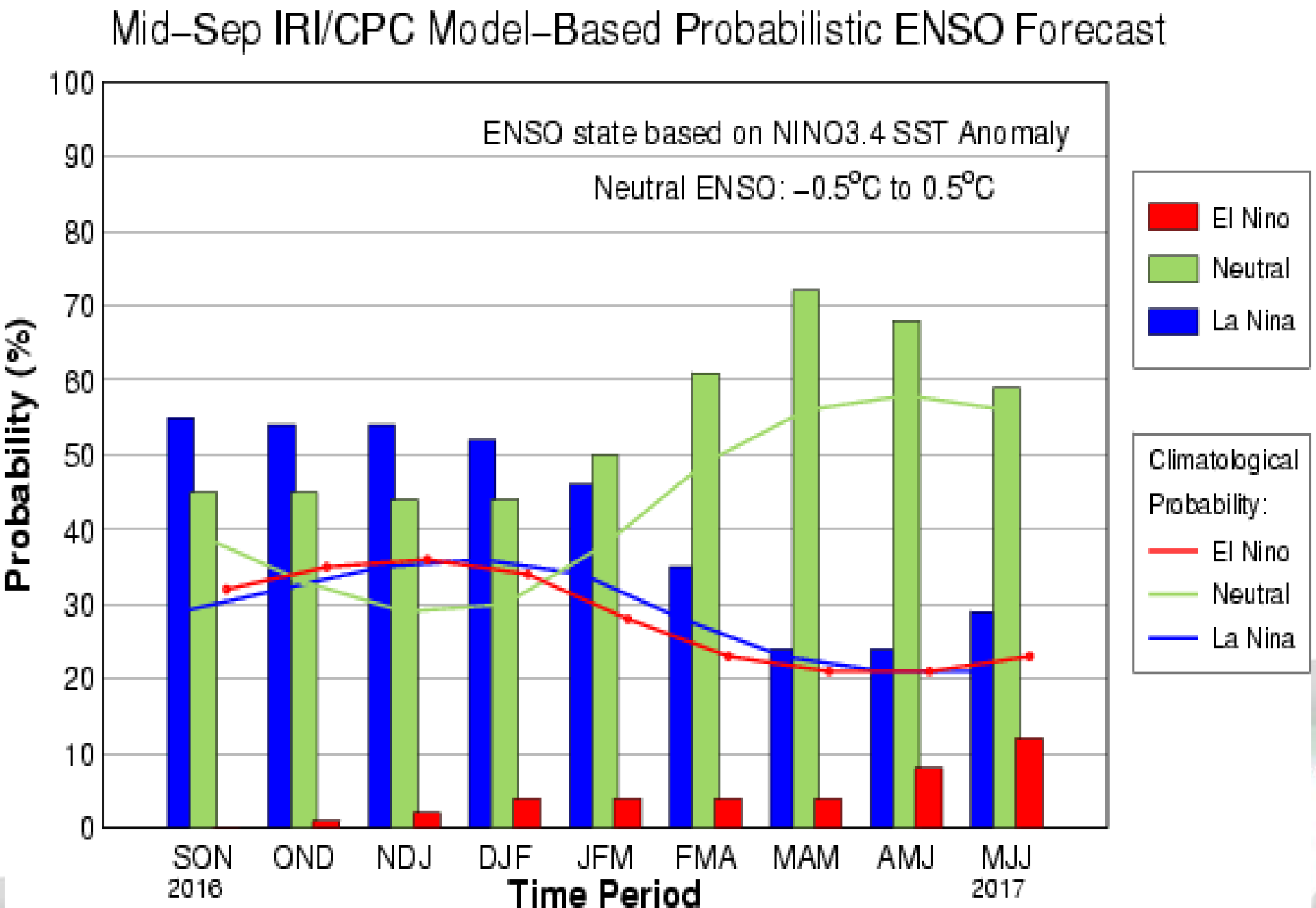

Climate
change

Coupled Global Forecast Models predict neutral (normal year) conditions or the development of a weak La Niña.

La Niña conditions are associated with wetter than normal conditions over the summer rainfall region during mid-summer.

A forecast for Equatorial Pacific Sea Surface Temperature (SST) anomalies, showing cooling towards borderline La Niña conditions, from the Australian Bureau of Meteorology.

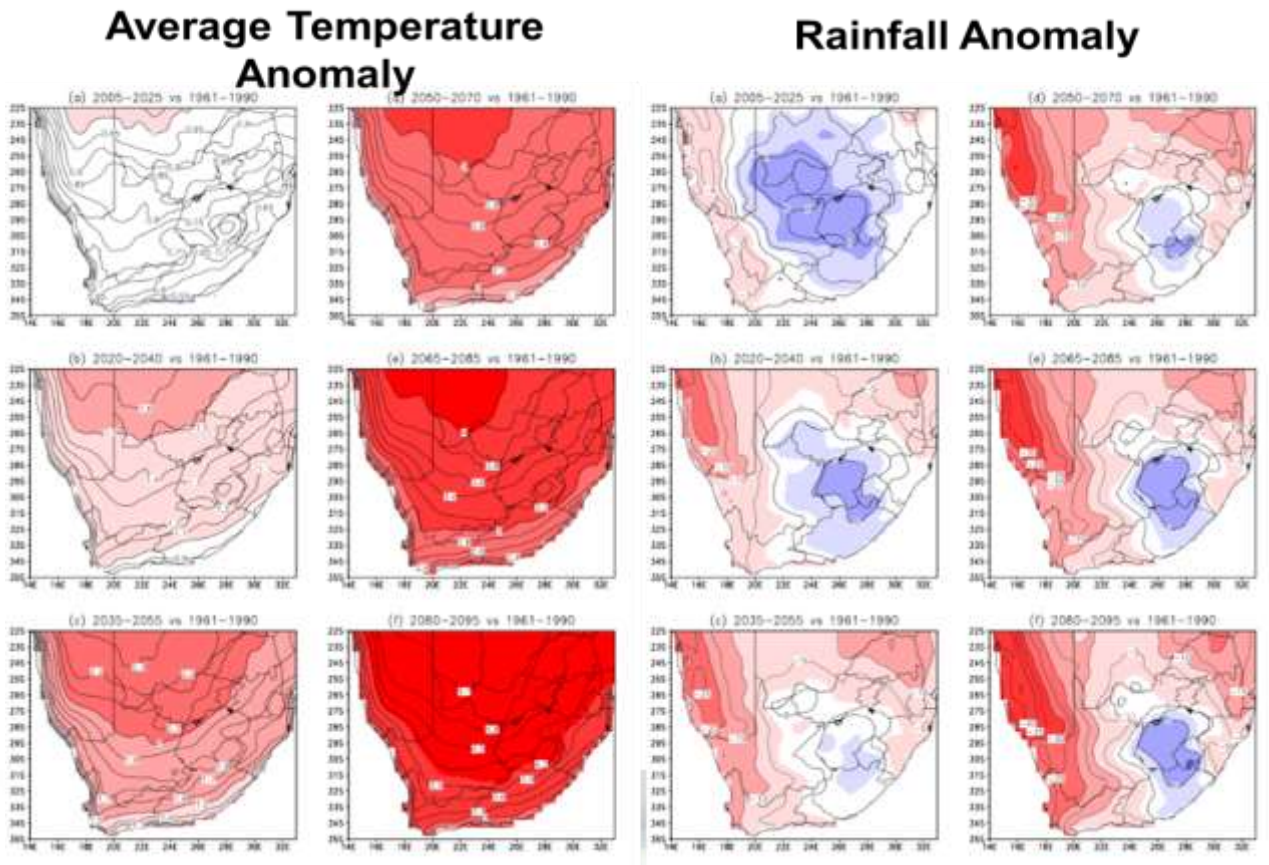



Mid–Sep IRI/CPC Model–Based Probabilistic ENSO Forecast
ENSO state based on NINO3.4 SST Anomaly
Neutral ENSO: –0.5°C to 0.5°C
Probability (%)
100
90
80
70
60
50
40
30
20
10
0
SON
OND
NDJ
DJF
JFM
FMA
MAM
AMJ
MJJ
2016
2017
Time Period
El Nino
Neutral
La Nina
Climatological Probability:
El Nino
Neutral
La Nina

Projected increase in average temperatures is the main driver of a potentially more arid environment in future

Projections based on climate simulations of the Conformal Cubic Atmospheric Model based on Sea Surface Temperatures and Sea Ice data as simulated by 6 coupled Global Climate Models, A2 ("business as usual") scenario.

The increase in **red** colour indicates the rise in average temperatures during the specific period. For rainfall maps, **red** denotes reduced rainfall, while **blue** denotes normal to above-normal rainfall.



GFDL-CM2.0 [The version 2.0 CGCM of the Geophysical Fluid Dynamics Laboratory (GFDL) of the National Oceanic and Atmospheric Administration (NOAA) in the US]
GFDL- CM2.1 [The version 2.1 CGCM of the Geophysical Fluid Dynamics Laboratory (GFDL) of NOAA]
ECHAM5/MPI-Ocean Model [The CGCM from MPI in Germany]
UKMO-HadCM3 (The Met Office Third Hadley Centre Coupled Ocean-Atmosphere GCM - United Kingdom)
MIROC3.2-medres (Model for Interdisciplinary Research on Climate 3.2, medium resolution version, of the Japanese Agency for Marine-Earth Science and Technology)
CSIRO Mark3.0 (The version 3.0 CGCM of the Commonwealth Scientific and Industrial Research Organisation in Australia)

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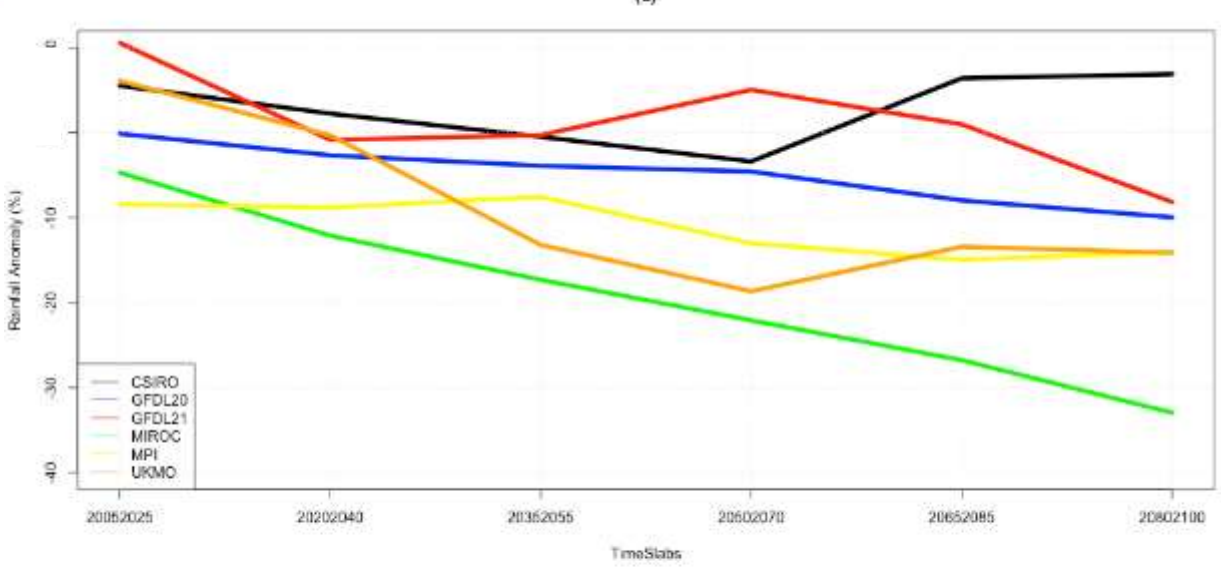
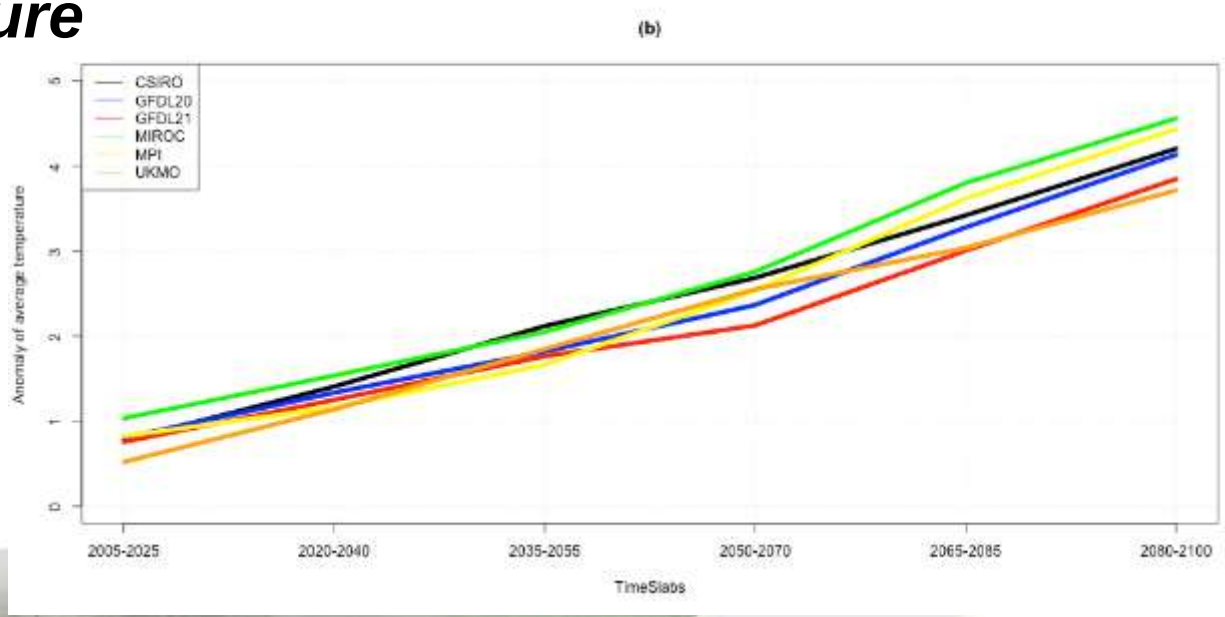
Range of possible outcomes
(6 different prediction models)

Rainfall



Temperature



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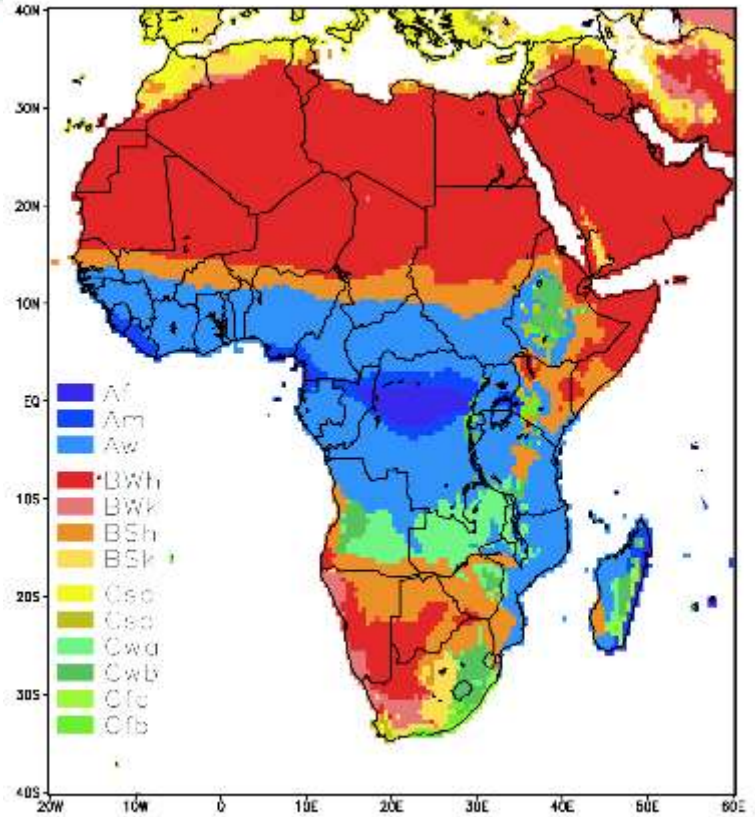
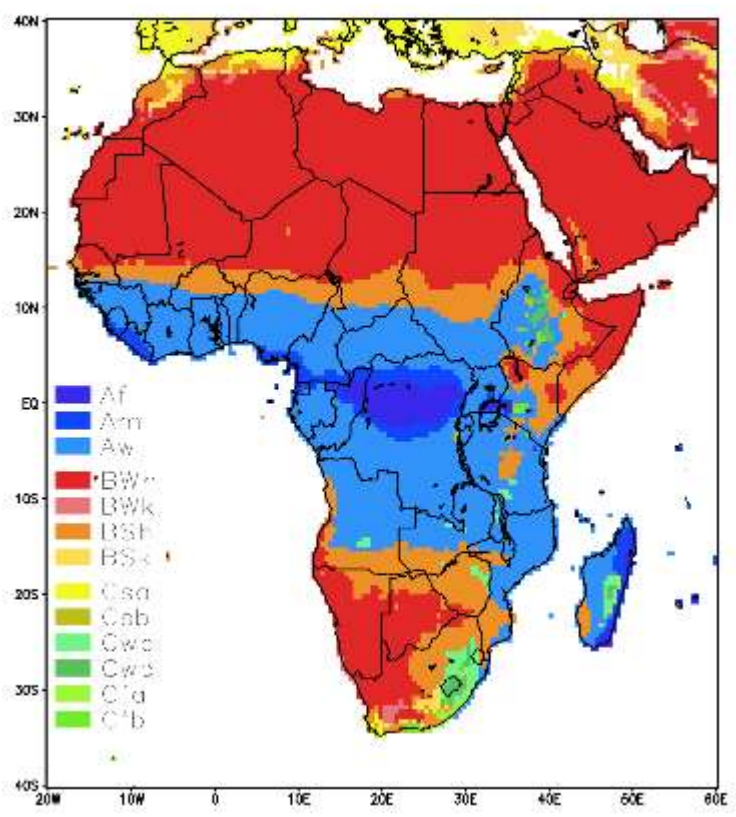
Projected expansion of *Arid, Desert, Hot* regions towards 2050

Köppen-Geiger climate cones: CSIRO Current



Köppen-Geiger climate cones: CSIRO 2050



Red areas illustrate the expansion of the *Arid, Desert, Hot* regions towards 2050

Köppen-Geiger Code	Description
Aw	Tropical, Savannah
BWh	Arid, Desert, Hot
BWk	Arid, Desert, Cold
BSh	Arid, Steppe, Hot
BSk	Arid, Steppe, Cold
Csa	Temperate, Dry Summer, Hot Summer
Csa	Temperate, Dry Summer, Hot Summer
Csb	Temperate, Dry Summer, Warm Summer
Cwa	Temperate, Dry Winter, Hot Summer
Cwb	Temperate, Dry Winter, Warm Summer
Cfa	Temperate, Without dry season, Hot Summer
Cfb	Temperate, Without dry season, Warm Summer

(Source: Engelbrecht, 2015)

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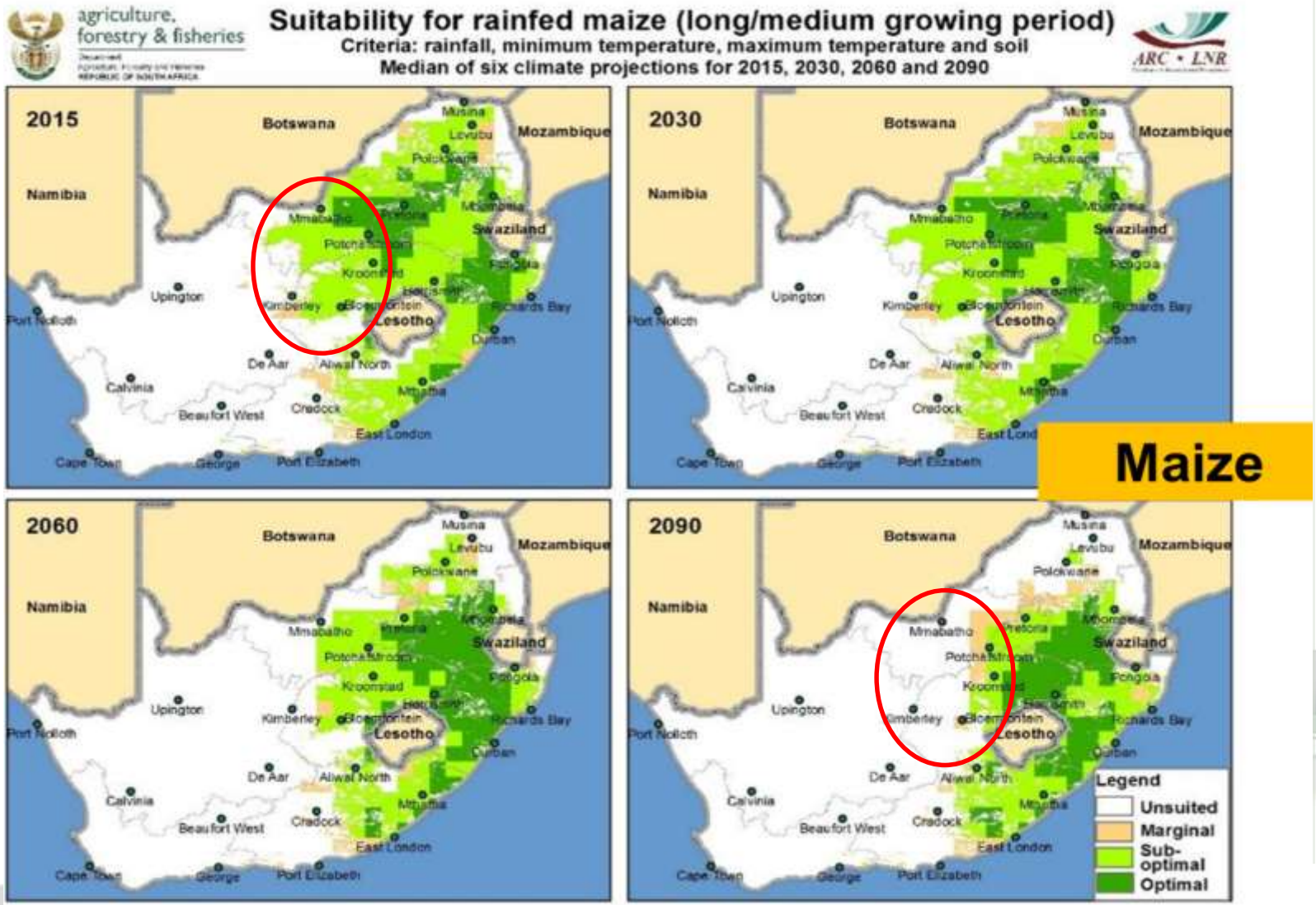
Potential impacts of projected climate change on occurrence of droughts and production potential

- **This is an example of one of the outcomes of a project for DAFF, where the suitability of climate for maize was considered. The maps below indicate a decrease in the maize production areas.**



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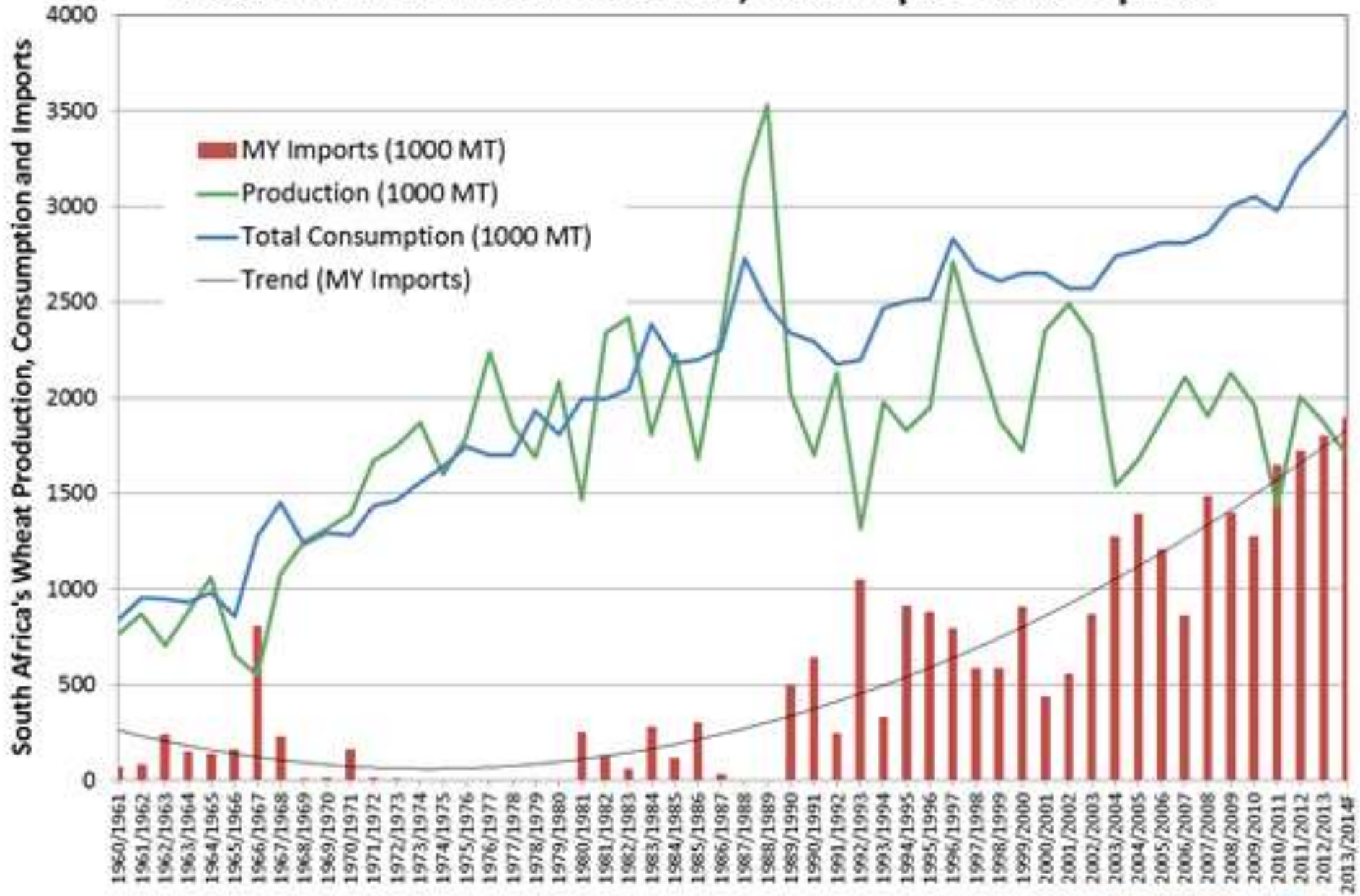
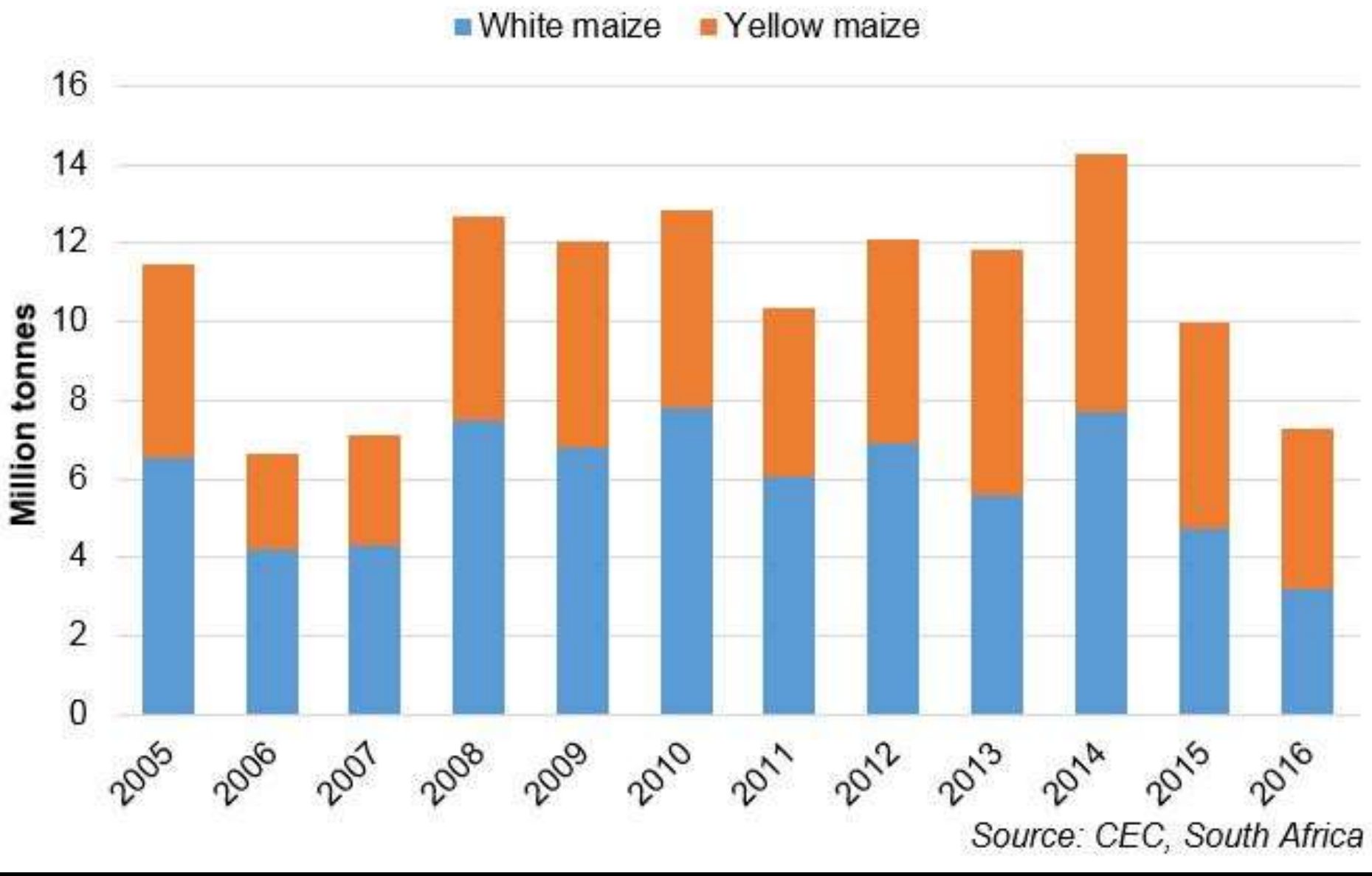
South Africa's Wheat Production, Consumption and Imports



Source: USDA's PSD Online
http://www.fas.usda.gov/psdonline/psdQuery.aspx

Linking U.S. Agriculture to the World
FAS

Figure 1 Maize production in South Africa



Source: CEC, South Africa

Challenge to South Africa to maintain food self sufficiency

Irrigation

Purpose of irrigation methods

- The purpose of an irrigation system is to apply the desired amount of water, at the correct application rate and uniformly to the whole field, at the right time, with the least amount of non-beneficial water consumption (losses), and as economically as possible.

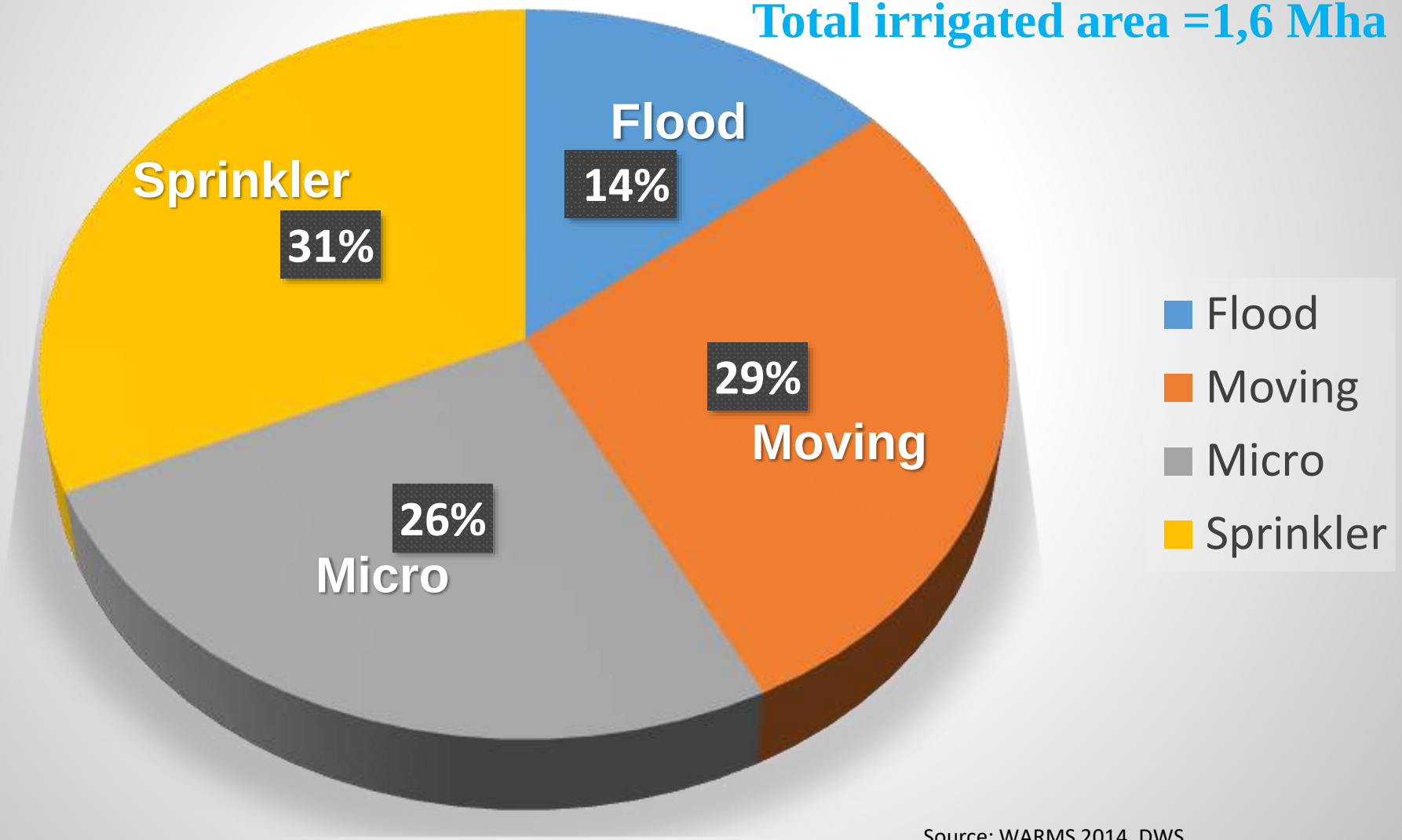
- Studies and research over 40 years on the techniques of flood-, sprinkler-, mechanized- and micro-irrigation contributed to the knowledge base of applying irrigation methods correctly.

Irrigation Systems

- Irrigation Systems
  - Flood
    - Basin
    - Border
    - Furrow
    - Short-furrow
  - Mobile
    - Centre pivot
    - Linear move
    - Travelling gun
  - Static
    - Sprinkler
      - Permanent
      - Portable
    - Micro
      - Drip
      - Micro sprayers
      - Mini Sprayers

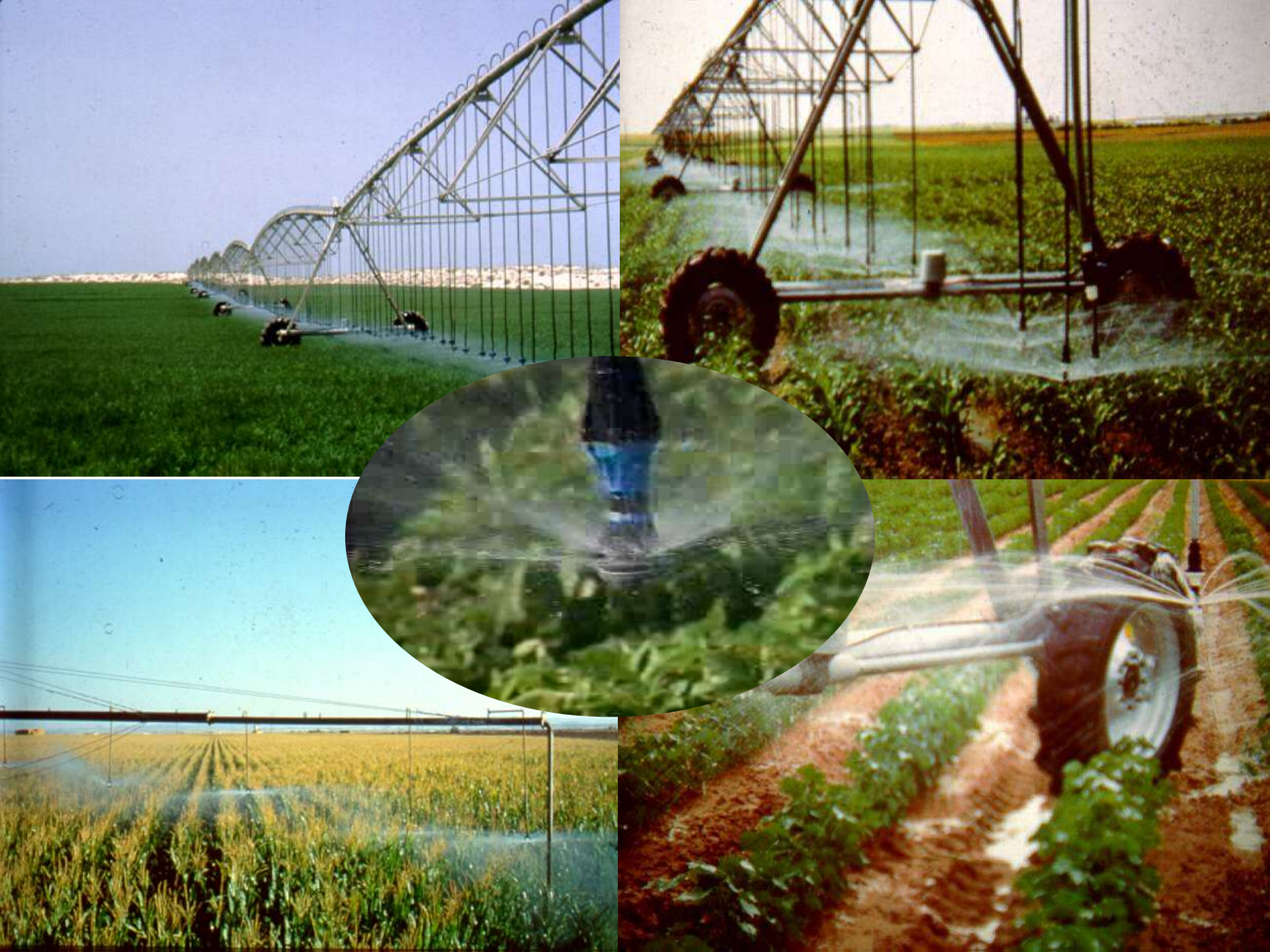
Irrigation Systems in South Africa

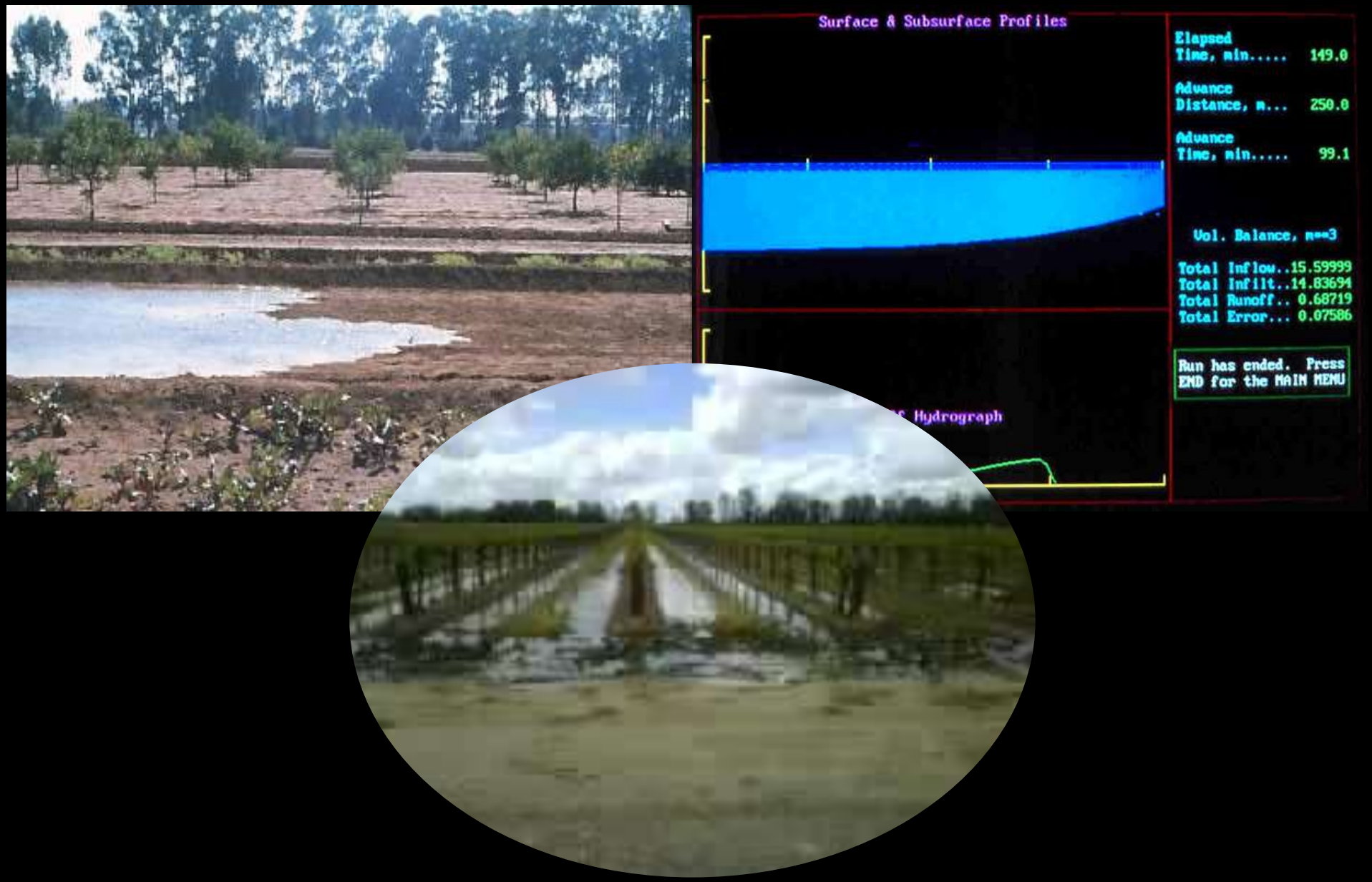
Total irrigated area =1,6 Mha

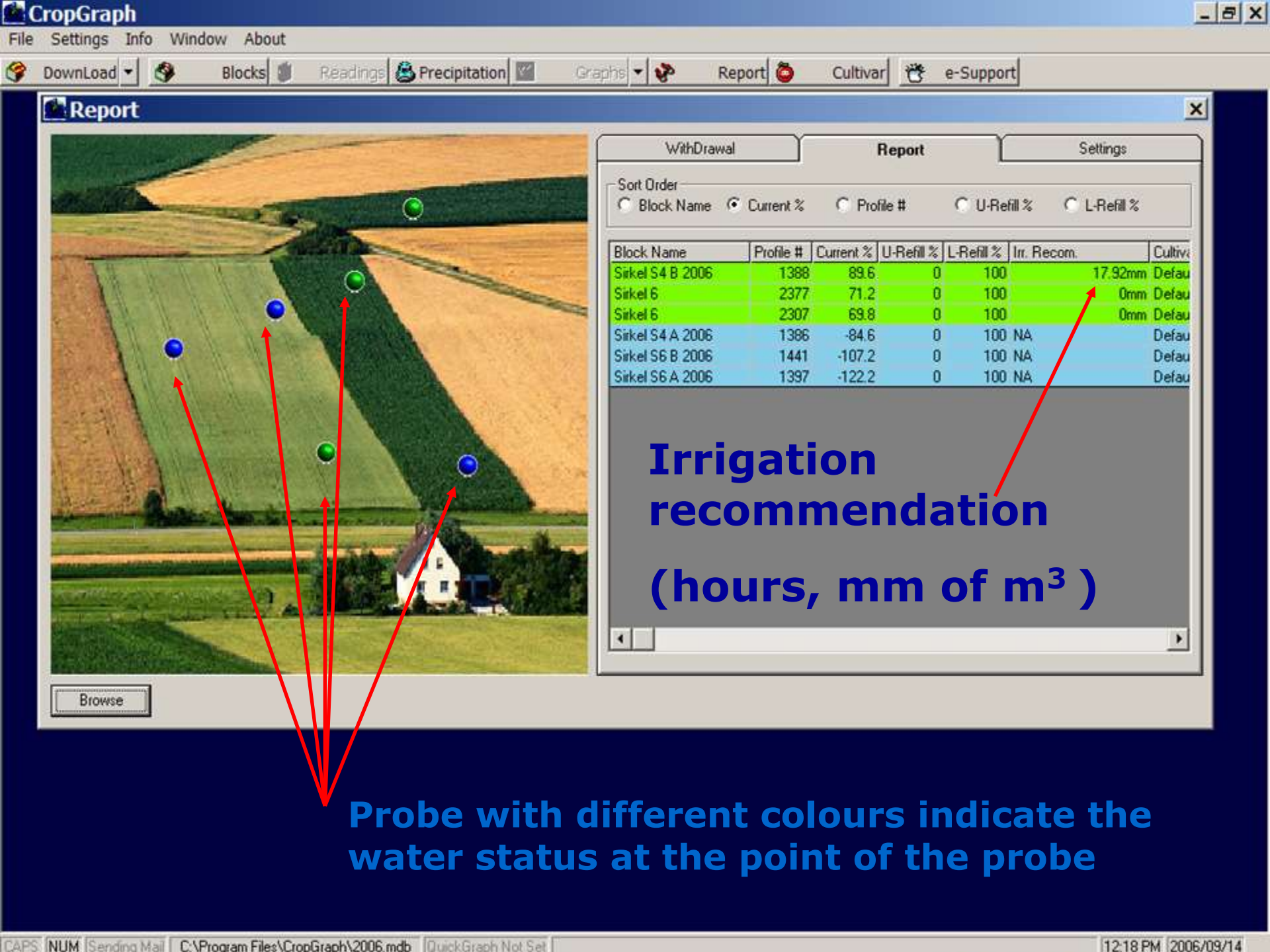


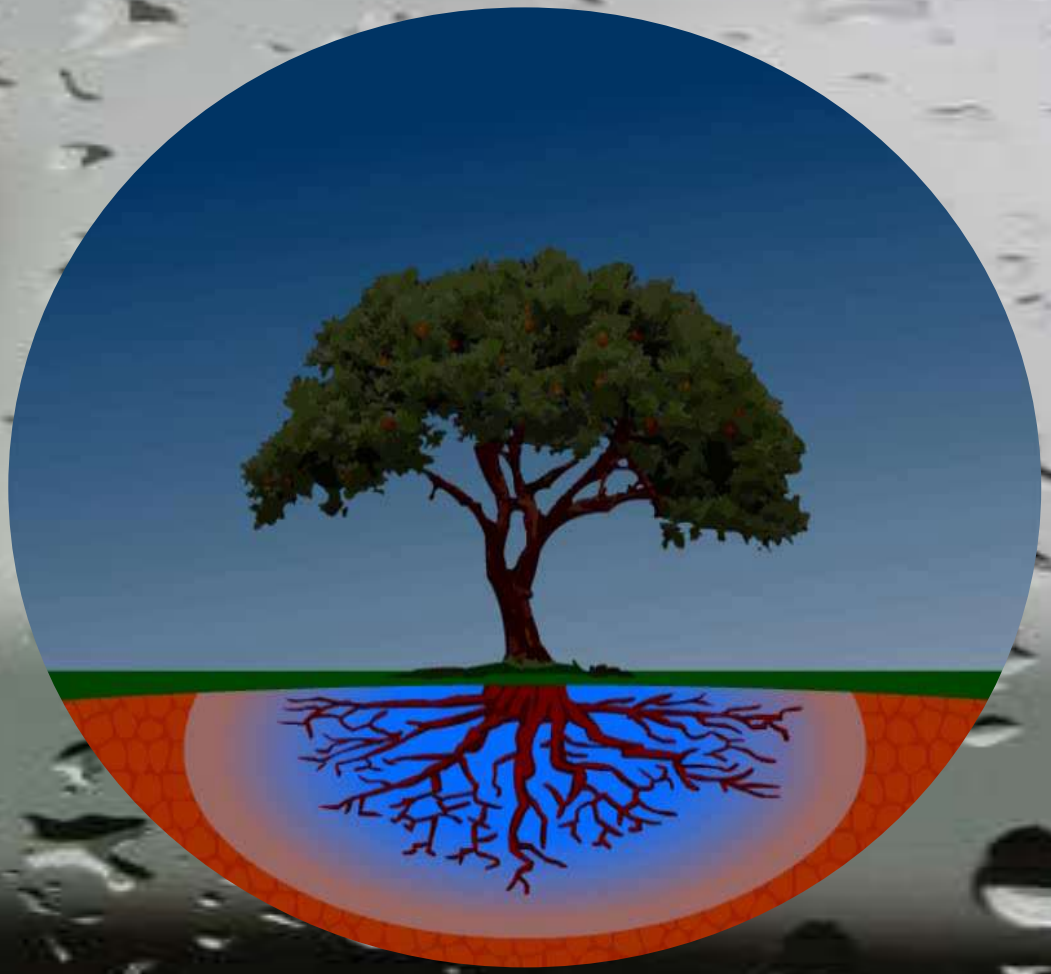
Source: WARMS 2014, DWS


e Regulation Range




Surface & Subsurface Profiles
Elapsed
Time, min..... 149.0
Advance
Distance, m... 250.0
Advance
Time, min..... 99.1
Vol. Balance, n=3
Total Inflow..15.59999
Total Infilt..14.83694
Total Runoff.. 0.68719
Total Error... 0.07586
Run has ended. Press
END for the MAIN MENU
Hydrograph


CropGraph
File Settings Info Window About
DownLoad Blocks Readings Precipitation Graphs Report Cultivar e-Support
Report
WithDrawal
Report
Settings
Sort Order
Block Name
Current %
Profile #
U-Refill %
L-Refill %
Block Name | Profile # | Current % | U-Refill % | L-Refill % | Irr. Recom. | Cultiv
Sirkel S4 B 2006 | 1388 | 89.6 | 0 | 100 | 17.92mm | Defau
Sirkel 6 | 2377 | 71.2 | 0 | 100 | 0mm | Defau
Sirkel 6 | 2307 | 69.8 | 0 | 100 | 0mm | Defau
Sirkel S4 A 2006 | 1386 | -84.6 | 0 | 100 | NA | Defau
Sirkel S6 B 2006 | 1441 | -107.2 | 0 | 100 | NA | Defau
Sirkel S6 A 2006 | 1397 | -122.2 | 0 | 100 | NA | Defau
Browse
Irrigation recommendation
(hours, mm of m3)
Probe with different colours indicate the water status at the point of the probe
CAPS NUM Sending Mail C:\Program Files\CropGraph\2006.mdb QuickGraph Not Set 12:18 PM 2006/09/14



Summary and Conclusion

- **Current conditions**
  - **Summer crop production areas (Limpopo, Mpumalanga, KwaZulu-Natal, North West, Free State) and the winter rainfall region are currently wetter this year than last year.**
  - **It is still clear that drought conditions are present at the longer time scale**

    (September 2015 - August 2016).

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- **Seasonal forecasts**
  - **Seasonal forecasts currently favour a normal start to the summer rainy season over the northeastern parts (southern Limpopo, Mpumalanga, KZN, eastern NW, eastern FS), while a slow/late onset is indicated over the central (western NW, western FS) to southern interior (Eastern Cape).**
  - **Some climate models predict a late and weak La Niña, expecting to some extent a wetter to normal season.**

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- **Impact of projected climate change**
  - **Rising temperature is the main cause of shifts in production areas.**
  - **These production areas could decrease for most crops (maize, soybean, sorghum, sunflower, potato, Smuts finger grass), increase for other crops (sugarcane, groundnut, cotton) or remain largely unchanged (wheat).**
  - **It is noted that rainfall predictions differ amongst models, indicating uncertainty of the predictions.**

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The importance of water:

- **Water is the key to food security**
  - **without water, crops simply cannot grow.**
- **Water is not just for primary production**
  - **it plays a vital role at all stages along the agricultural value chain**
- **Water for agriculture connects us all together**
  - **In times of scarcity we all have a responsibility to use water wisely, efficiently and productively.**

We need to be more ‘water smart’.

Be
‘WATER SMART’