ARC • LNR
Excellence in Research and Development

Appropriate Technologies for Soil and Water Management: South African Examples

Prof Sue Walker, Dr Kobus Anderson, Dr Kingstone Mashingaidze & Dr Mohamed M. Ahmed, & Erna Kruger

Agricultural Research Council

& Mahlathini Development Foundation

South Africa

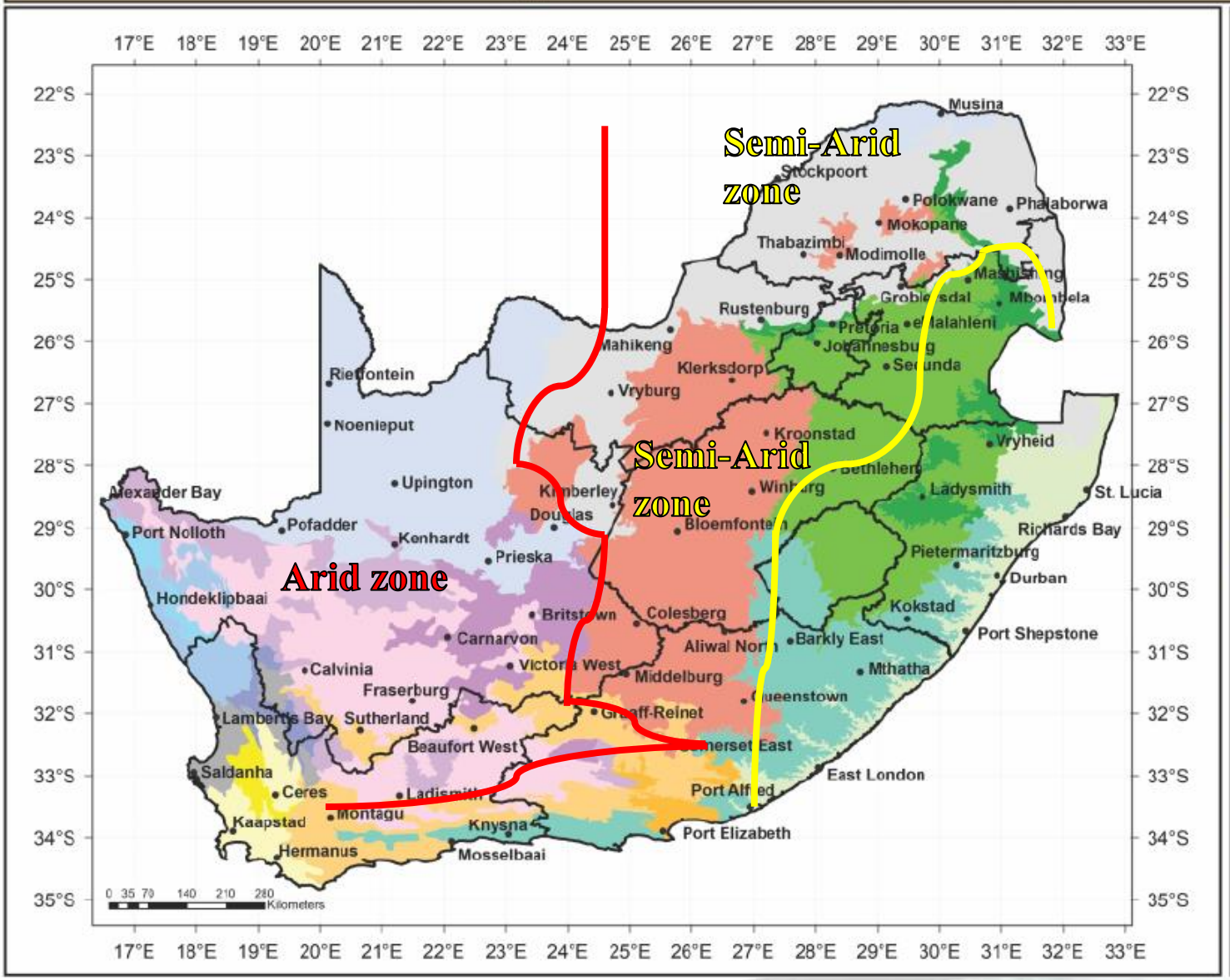
mahlathini development foundation

Overview of Situation in South Africa

- ✓ About ⅓ of arable land in SA only has **low potential**
- ✓ Crop production areas & rural communities located in **semi-arid** areas
  - ✓ Soils have some unsatisfactory characteristics.
  - ✓ Water shortage is due to a **low** and **erratic rainfall** pattern.
  - ✓ High intensity rainfall events, resulting in **high runoff losses.**
  - ✓ **High soil erosion** from arable lands by wind and water.
  - ✓ **High evaporation** rates from bare soil.
  - ✓ Results in poor retention of captured rainwater under conventional tillage.
- ✓ Crop yields and RWP are low
- ✓ High risk of crop failures using conventional production methods

Water and land conservation strategies are needed to address problems of low crop productivity across a large portions of arable area in South Africa.

The Köppen Climate Classification for South Africa



Legend

- Town

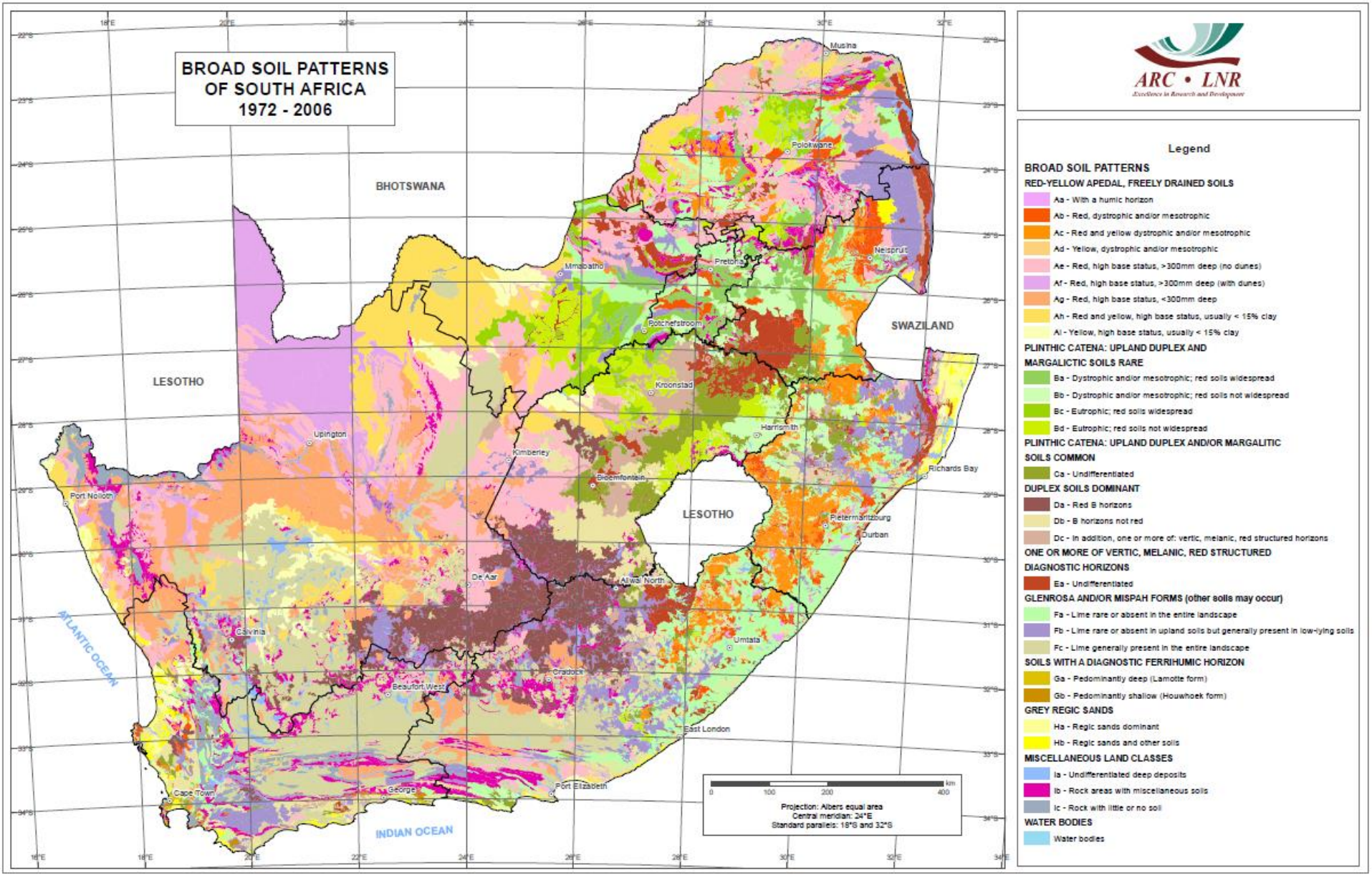
Köppen Description

- Arid with annual rainfall and cool
- Arid with annual rainfall and warm
- Arid with summer rainfall and cool
- Arid with summer rainfall and warm
- Arid with winter rainfall and cool
- Arid with winter rainfall and warm
- Temporate with annual rainfall and cool
- Temporate with annual rainfall and warm
- Temporate with summer rainfall and cool
- Temporate with summer rainfall and warm
- Temporate with winter rainfall and cool
- Temporate with winter rainfall and warm
- Semiarid with annual rainfall and cool
- Semiarid with annual rainfall and warm
- Semiarid with summer rainfall and cool
- Semiarid with summer rainfall and warm
- Semiarid with winter rainfall and cool
- Semiarid with winter rainfall and warm

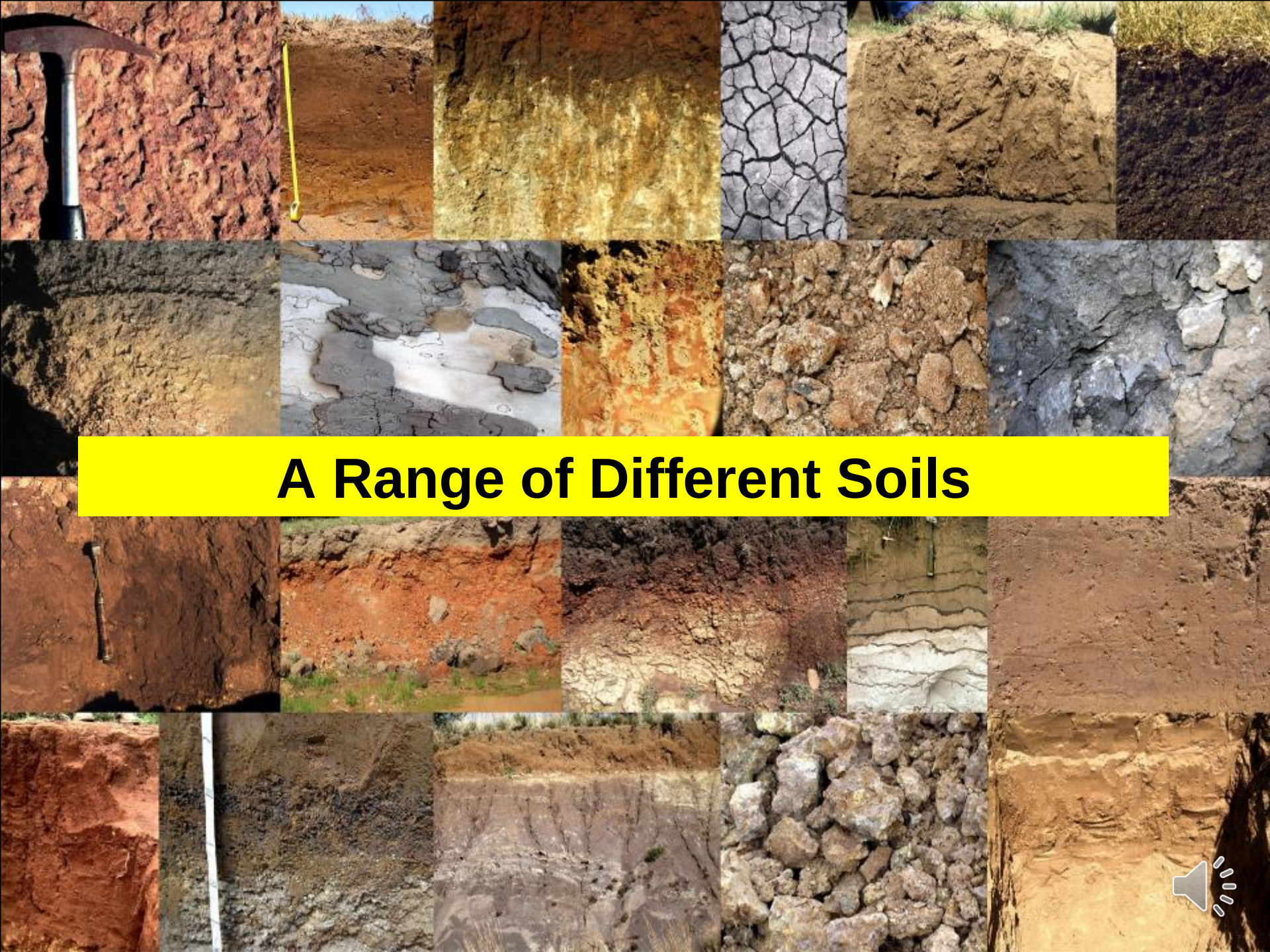
Agricultural Research Council
Soil, Climate and Water
Private Bag X79
Pretoria, 0001
Republic of South Africa
Tel: +27 (0)12 310 2500
Fax: +27 (0)12 323 1157

ARC • LNR

Excellence in Research and Development



ARC • LNR
Excellence in Research and Development



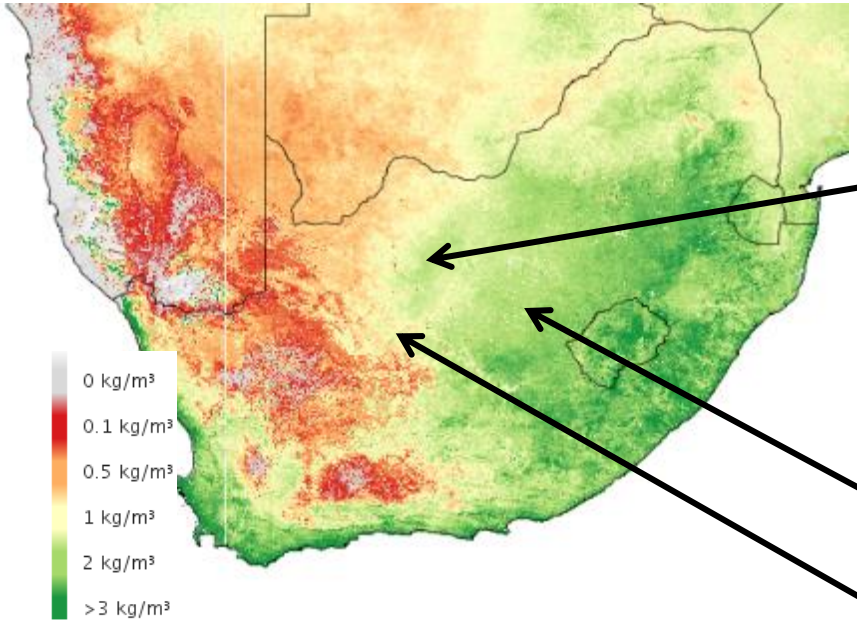
A Range of Different Soils

Water is Important in Farming

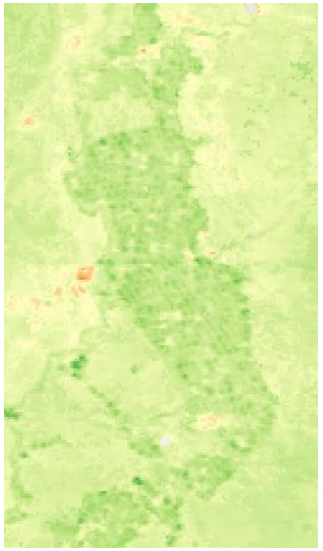
- ✓ Water is **most limiting natural resource &** under increasing stress.
- ✓ Plants need water to grow. The process of photosynthesis uses water to make the building blocks of life for plants.
- ✓ Agricultural water = used to grow fresh produce and sustain livestock. If decrease applied water cause production and yield to decrease.
- ✓ Management strategies are most important way to improve agricultural water use and maintain optimal production and yield.
- ✓ Many **semi-arid areas** are **marginal for crop production** due to low and erratic rainfall with large water losses through runoff and evaporation from soil surface = unproductive water losses that need to be minimized to improve crop production.



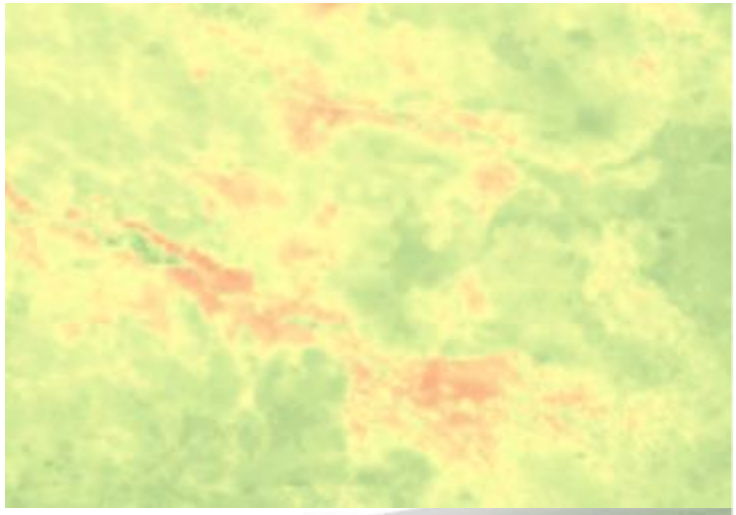
Water Productivity of Land (kg m^{-3})

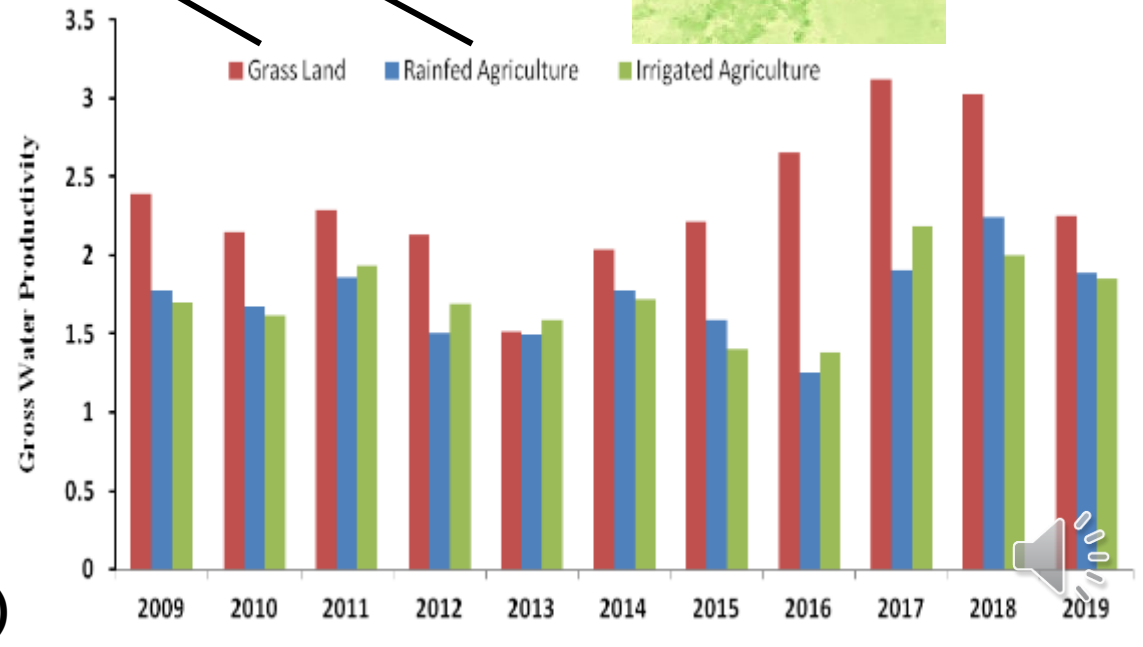


Irrigated area



Grassland area





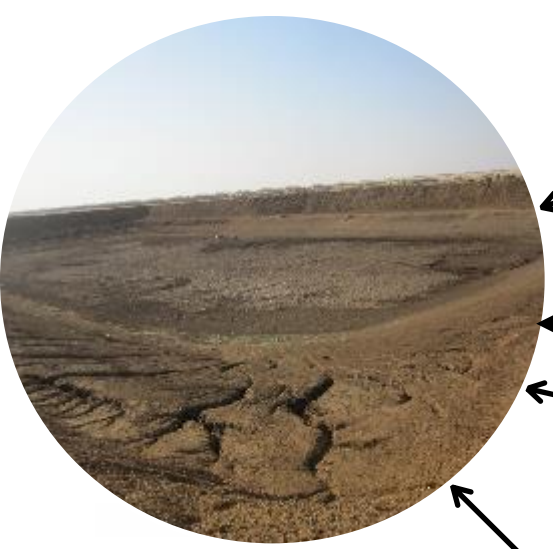
Gross Water Productivity (kg m^{-3})

Land Degradation

= reduction in soil capacity to produce crops/biomass for human & livestock

- ✓ Use **“degradation indicators”** or **“degradation cause indicators”** for quantification purposes
- ✓ **Use** water and wind erosion, soil salinity, soil acidity, aridity index and rainfall use efficiency, drought and land cover, loss of biodiversity

Land degradation causes are likely to occur concurrently



- Wind
- Water

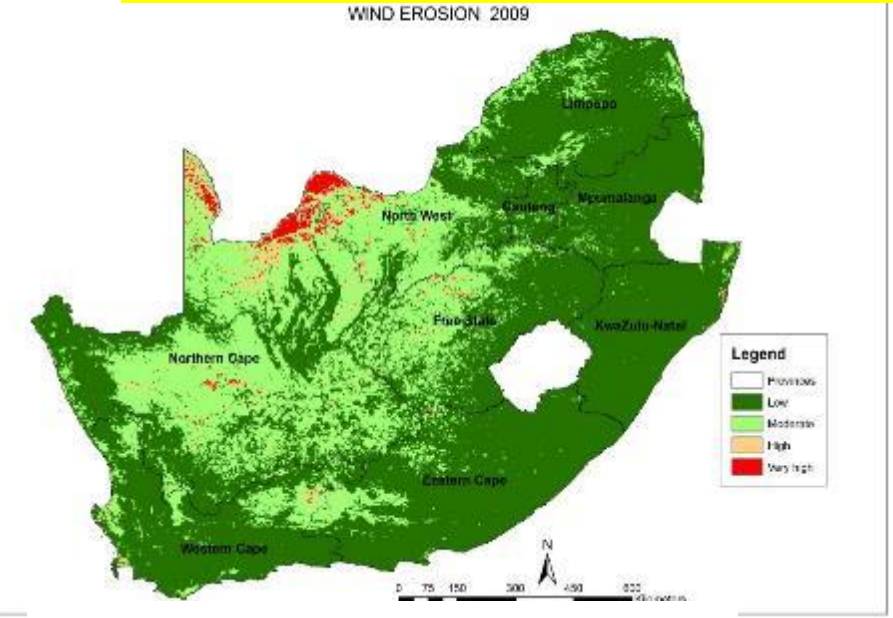
- pH
- EC

- Aridity
- Biomass

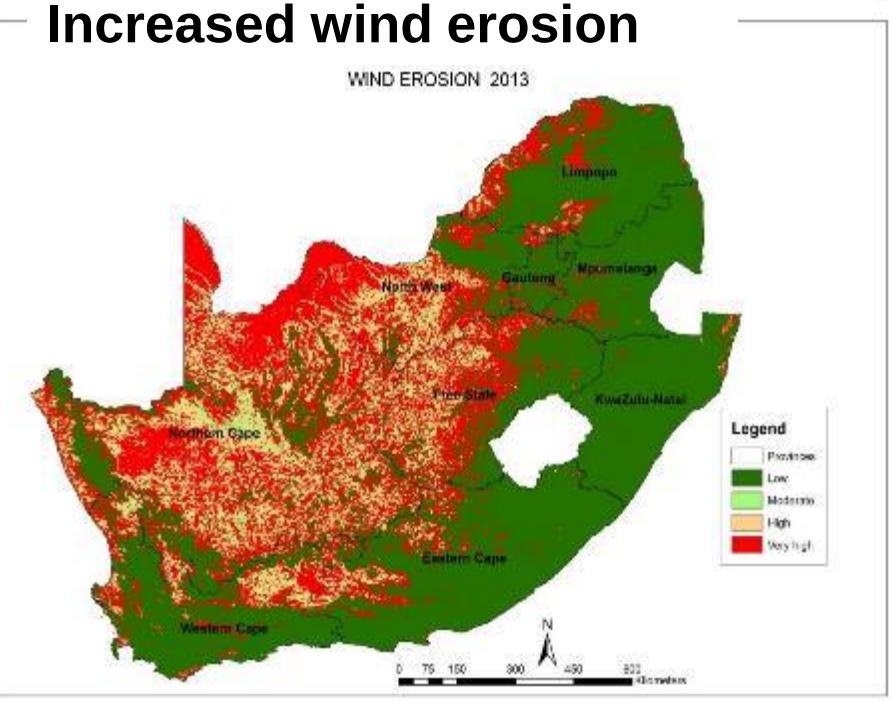
- Management
- Conservation practices
-

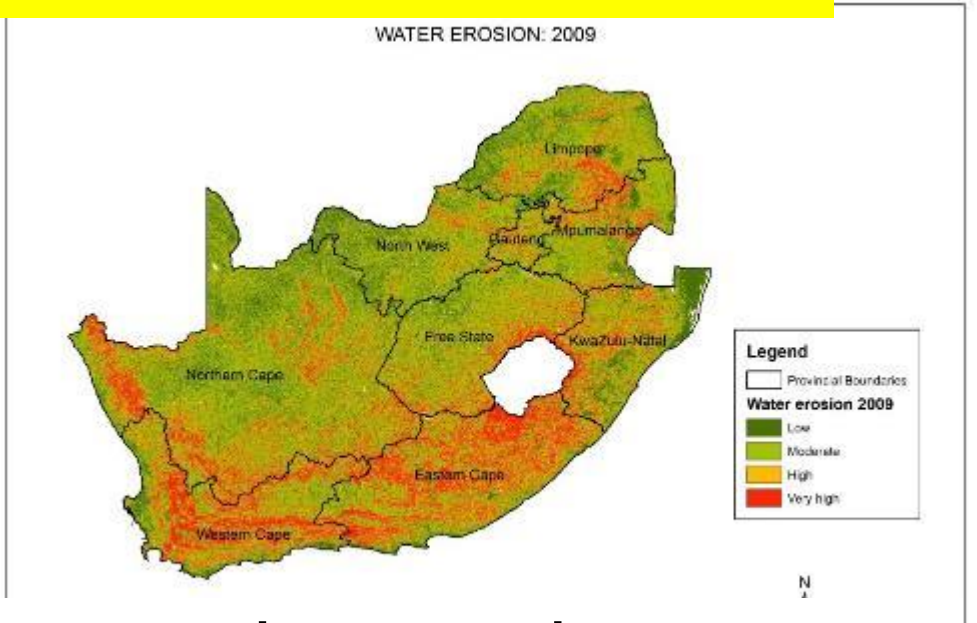
ARC • LNR
Excellence in Research and Development

Changes across South Africa

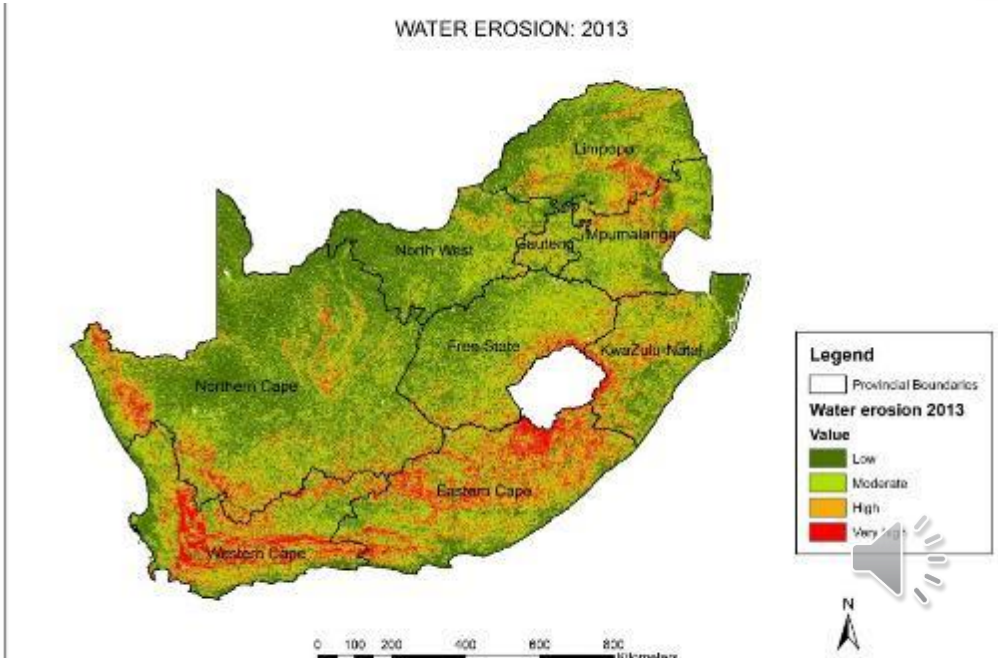


Increased wind erosion

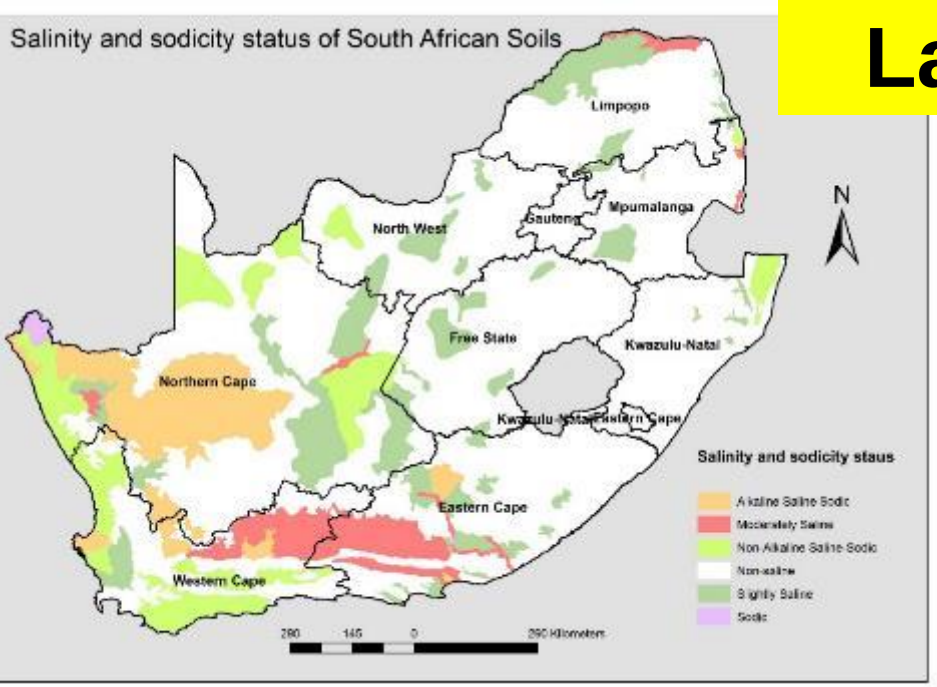


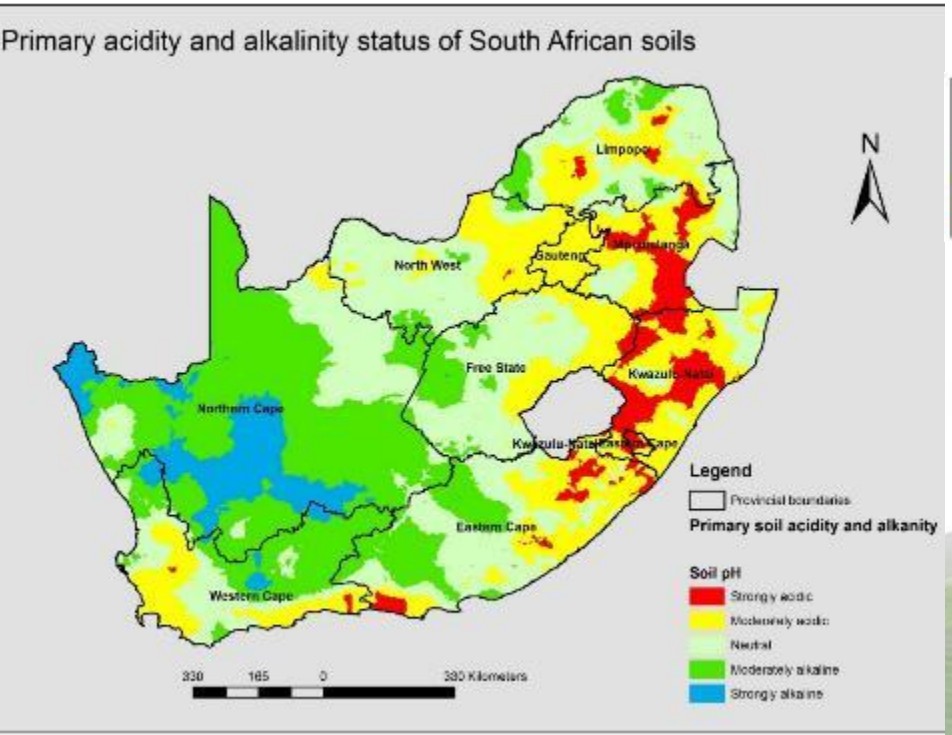


Decreased water erosion

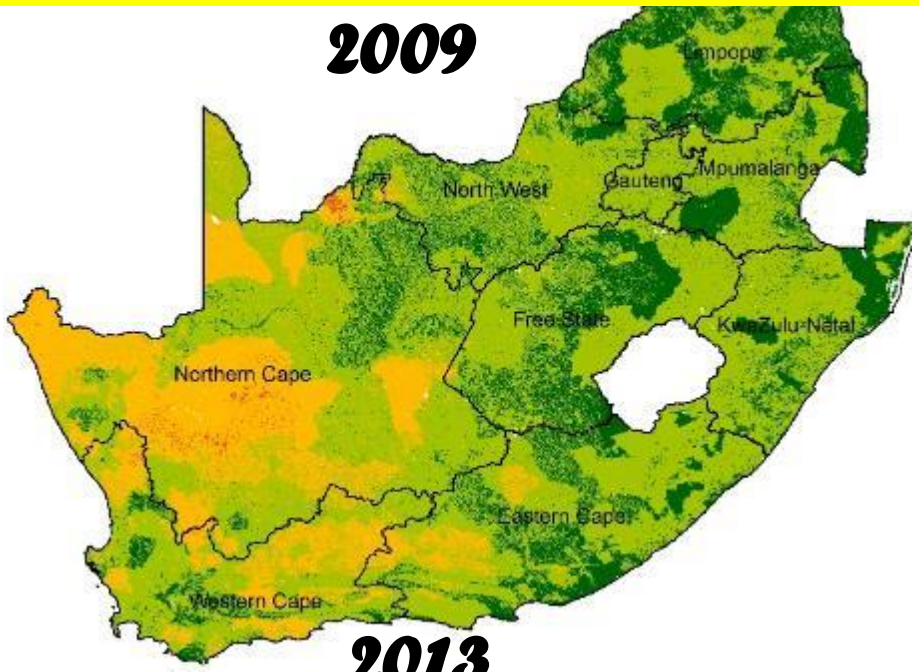


Land Degradation Index

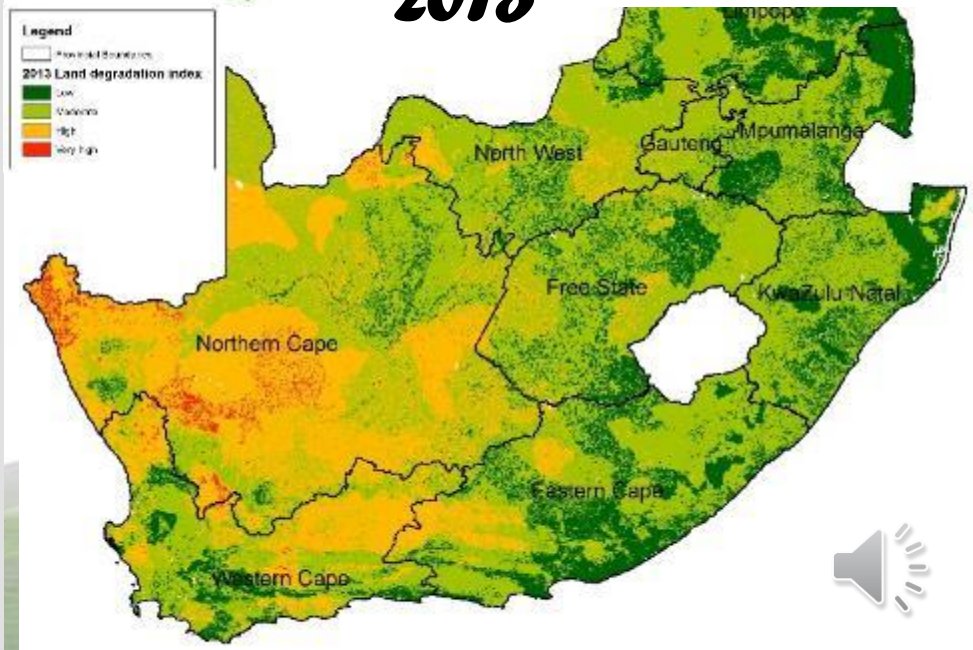




2009



2013



Basket of Climate-Smart Agricultural Interventions

Crop diversification – different crops and varieties;

- ✓ Cover crops and/or intercropping and/or agroforestry;
- ✓ Change cropping patterns and rotations;
- ✓ Integrated pest & weed management.

Conservation agriculture;

- ✓ Integrated nutrient and soil management;
- ✓ Organic agriculture;
- ✓ Soil compaction management;

Water management:

- ✓ Rainwater harvesting;
- ✓ Mulching;

Select intervention for a specific site as a response to soil type and changing climate conditions

ARC • LNR
Excellence in Research and Development

Crop Diversification

- Use crop species &/or varieties adapted to mean rainfall & available water.
- Diversify cropping system by introducing alternative crops or varieties, or intercropping or agroforestry.

a) Switch crops:

MAIZE TO SORGHUM TO MILLETS OR

BEANS TO COWPEA TO CHICKPEA TO

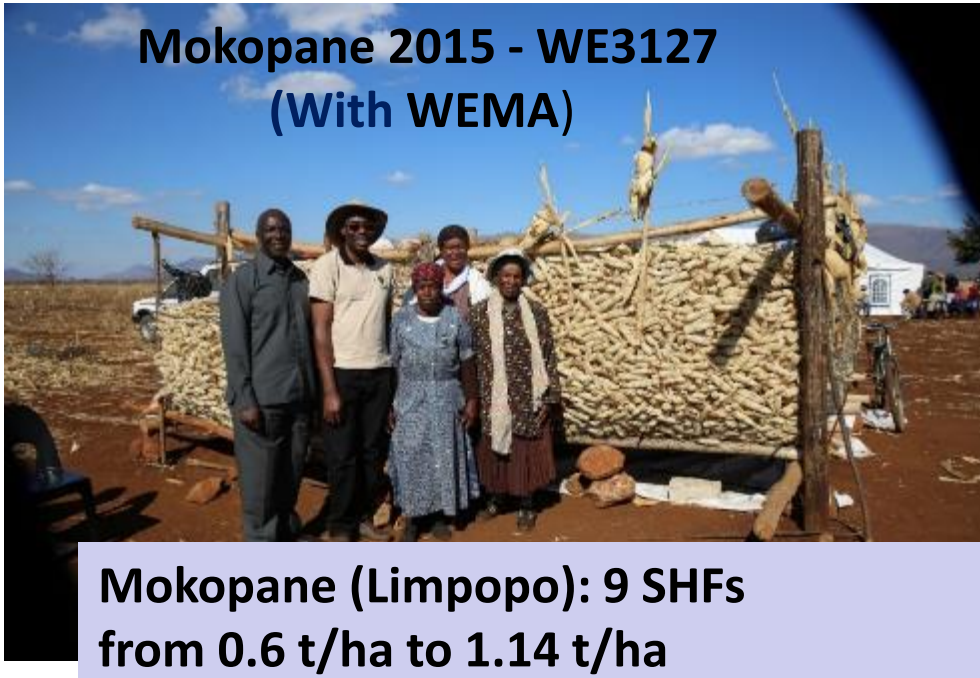
WEMA Maize Varieties

- ARC, with WEMA partnership, developed & registered 16 conventional drought tolerant maize hybrids - marketed under trade name Drought*TEGO*®.
- Farmers produced bumper yields even in drought years (e.g. WE3127 & WE3128)
- ARC released & registered 5 GM hybrids (WE6206B, WE6207B, WE6208B, WE6209B and WE6210B) with Bt (MON89034) transgene, marketed under trade name Drought *TELA*™ that is sold royalty-free to smallholder farmers.
- Hybrids have resistance to both stalk borer & fall armyworm as well as tolerance to drought & low soil nitrogen.
- Farmers growing Drought *TELA*™ hybrids not need to control fall armyworm & achieved good yields in Mpumalanga province despite a disaster 2019/20

Heavy fall armyworm infestation in smallholder farmer's crop in Xikukwani, Limpopo province, (3 March 2017)

No fall armyworm damage in Bt crop

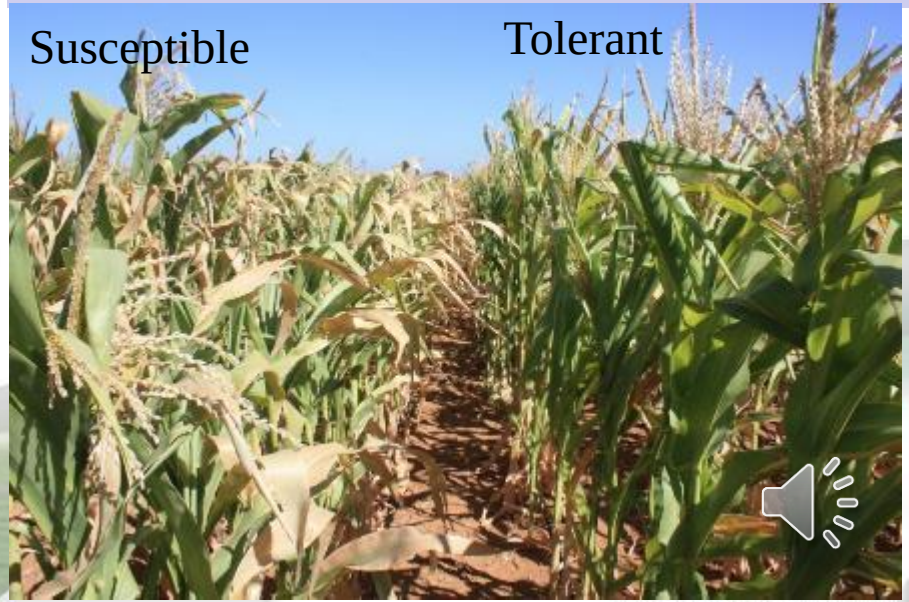
Feedback from WE3127 Maize Farmers 2014/15



Mokopane (Limpopo): 9 SHFs from 0.6 t/ha to 1.14 t/ha

Mooifontein (NW) farmer:

- **250 mm rainfall**
- **2 t/ha WEMA hybrid vs 1.5 t/ha other commercial hybrids**



Intercropping and Agroforestry

Intercropping
= multiple crops together

Agroforestry - tree crops included
= multiple crops grown during any season

e.g. cereal & legumes in field together

e.g. fruit trees & vegetables

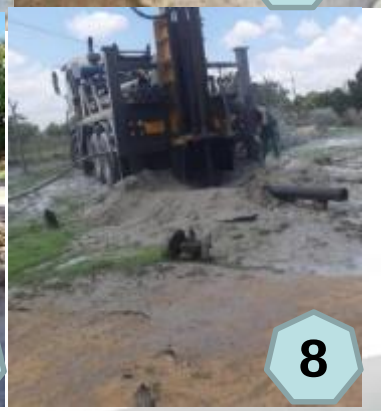
- pineapple & citrus
- pepper & tea

Produce similar or higher yields

ARC • LNR
Excellence in Research and Development

Climate-Smart Agric in Limpopo 2019-20

1. CA intercropping
2. Harvesting trad crops; sorghum, jugo beans
3. S&W conservation; stone lines
4. Check dams
5. Shallow trench beds

mahlathini development foundation

6. Small dams (lined with bentonite)
7. Mango production; pruning, fertilization
8. Water committees; drilling boreholes

ARC • LNR
Excellence in Research and Development

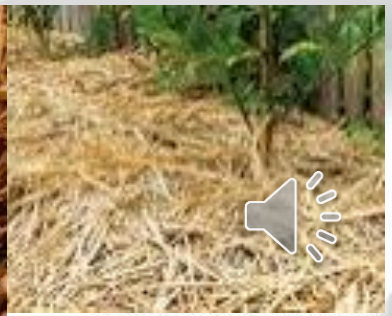
Cover crops

= any crop to cover soil - to manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases and biodiversity.

- ✓ Advantages:
  - Prevents soil erosion by wind & water especially on erodible soils on steep areas.
  - Add organic matter to soil; Improves soil texture and structure; Improves infiltration by reducing runoff.
  - Nitrogen fixation (if a legume); Can be cut & as mulch; Cut for fodder for livestock.
- ✓ Disadvantages:
  - If not cut regularly – competes for available water & nutrients & sunlight of cash crop;
  - Requires a high level of knowledge and skill.
- ✓ Cover crops are only recommended where sufficient rainfall to sustain two crops or with supplementary irrigation







Conservation Agriculture (CA)

= integrated crop and soil management strategy combining: *(FAO, 2008)*

- *(1) minimum soil disturbance, (2) permanent soil cover by crops, cover crops or crop residues and (3) diversification of crop rotations.*

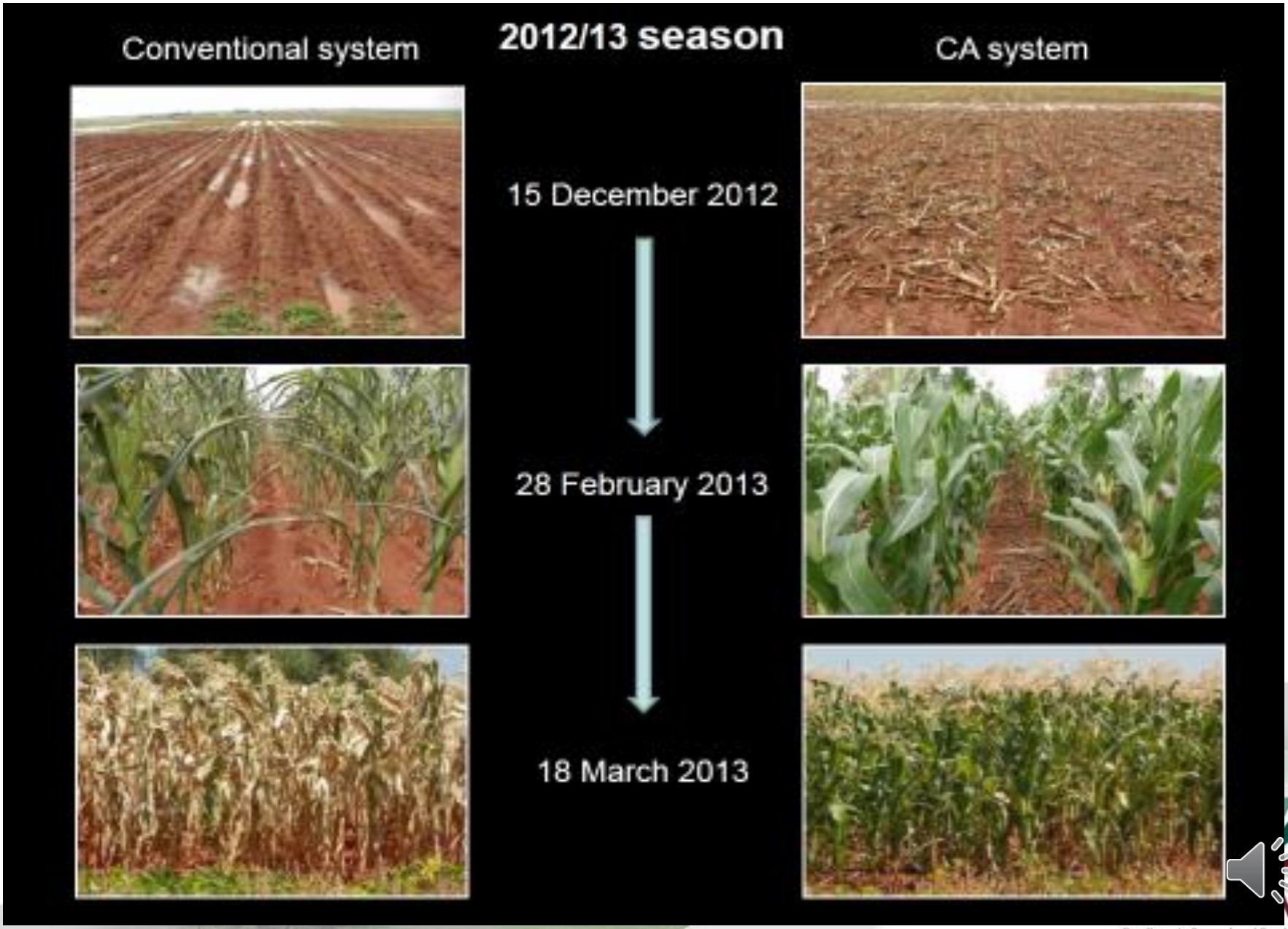
CA plays a major role in mitigating climate change effects through better soil water retention and improved soil health:

- CA trials conducted in Free State & North West Provinces for 10+ seasons to address - agronomy, pests and diseases, weed control, & soil microbiology.
- situated where rainfall is less than 600mm a year & 16% clay content soil.

Impact:

- For example, during the 2012/13 growing season, the two provinces experienced severe drought causing damage to crops. Good yields were obtained in the CA field on the Hutton soil despite the drought.
- Maize yields showed an increase of between 113 to 167% from the CA fields compared to conventional ploughed-monoculture fields.

Benefits of Conservation Agriculture



Crop Production Implements

Full Tillage

Conventional tillage

Mouldboard plough

Conservation techniques

No-till or minimum tillage

Mouldboard plough

Rip on the row

"Hap ploeg"

Climate-Smart Agric in Eastern Cape 2020

1.CA; ripping of highly compacted soil prior to no–till planting
2. CA; basin and furrow planting demonstration for Fort Cox ATI learners
3. Natural pest and disease control ingredients for brews

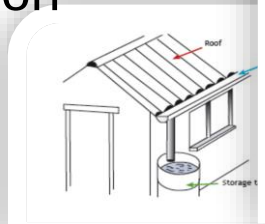
4. Building of a shade cloth tunnel in Xhukwane
5. Tower garden in Quzini

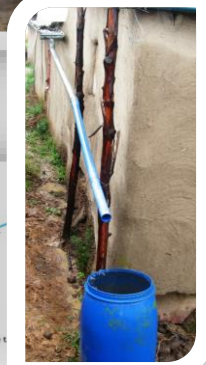
mahlathini development foundation

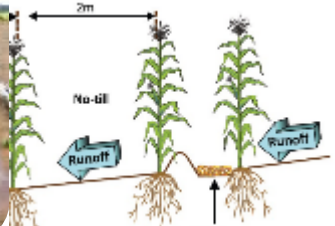
ARC • LNR
Excellence in Research and Development

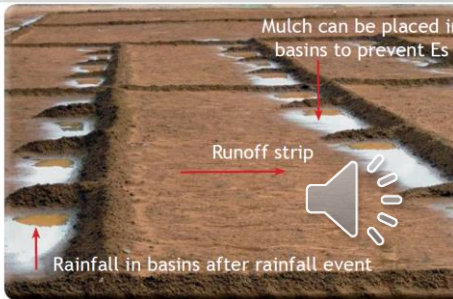
Rain Water Harvesting (RWH)

- Process to concentrate rainfall as runoff from one area for productive use on another area.
- Macro-catchment
  - Runoff collected from outside farm/field/land boundary
- Non field Micro-catchment
  - Runoff collected from man-made runoff area e.g. rooftops
- Micro-catchment = “in-field rainwater harvesting IRWH”
  - Runoff collected from within farm/field/land boundary
  - **Runoff area** = promotes runoff, acts as 2nd storage, minimizes soil evaporation with mulch & prevents erosion
  - **Basin area** = Stops runoff loss, maximizes infiltration, stores water in soil profile, minimizes evaporation
- **Requirements** = slope not > 8% on non-erodable soils, effective soil depth > 70 cm, annual rainfall 450 – 700 mm. clay >10% or duplex soils & avoid sandy soils.









In-field Rain Water Harvesting (IRWH)

Importance of IRWH

Conserves water

✓ Reduces rainwater loss reduce Es & ex-field runoff

Prevents soil erosion

Improves crop productivity

✓ plant crops in marginal areas

Food security, poverty alleviation & socio-economic status

✓ More household food & less poverty

✓ Improves socio-economic status

✓ Improves health status of community

✓ Profitable farm with lower risk

Benefits of IRWH

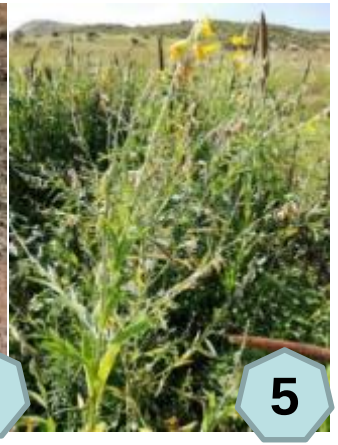
- Empowers people to **fight food insecurity and poverty** in rural areas
- **Increases yields** by 30-110 %
- **Decrease risk** of crop failure 43-63 %
- **Higher probability** 48-54% **to break even**
- **Socio-acceptable** (increases income, promotes education, improves social well-being of community, improves health, reduces crime, increases crop diversity)
- **Easy to implement** & low maintenance cost






Climate-Smart Agric in KZN 2019-20

1. Trench beds and tunnel in Gobizembe
2. Mixed cropping mulching and chameleons
3. Tower gardens in Ezibomvini



4. Fodder supplementation in Bergville
5. Green manure cover crops in Bergville

6. Seed saving in Bergville
7. Spring protection in Bergville and
8. Local water committee reticulation to 9 households

mahlathini development foundation

ARC • LNR
Excellence in Research and Development

Rainwater Harvesting Production Implements

In-field Rain Water Harvesting

Daling Plough

Furrow plough

Basin plough

Combined chisel & scraper plough

Mulching

= layer of material applied to the bare surface of soil.

Reasons to apply mulch: conservation of soil water, regulate soil temperature, improving soil fertility & health, reduce weed growth & enhancing visual appeal.

- ✓ Mulch is usually organic in nature - temporary (e.g. bark chips).
- ✓ May be permanent (e.g. plastic sheeting).
- ✓ Incorporated naturally into soil by activity of worms and other organisms.
- ✓ Used both in commercial crop production and gardening,
- ✓ When applied correctly, can dramatically improve soil productivity.
- ✓ Applied at various times of year
  - ✓ beginning of growing season - serve to warm soil by retaining heat.
  - ✓ allows early seeding and transplanting of certain crops,
  - ✓ encourages faster growth.
  - ✓ Mid-season - mulch stabilizes soil temperature and water,
  - ✓ prevents weeds growth from stored seeds.



ARC • LNR
Excellence in Research and Development

Farm in Response to Weather

- Farmers cannot change weather

But farmers can:

- Know what can be changed and act on it:
  - By changing crops & planting times
  - By increasing biodiversity in cropping & farming systems
  - By using weather forecasts and Apps
- Learn to cope with climate change and variability
  - Anticipate different conditions
  - Use local regular weather and seasonal forecasts

Conclusions

- **Climate-smart farming methods:**
  - Use limited rainfall for longer periods to buffer dry spells
  - Reduces soil evaporation
  - Avoids risk of crop failure
  - Stops runoff and therefore reduces erosion
  - Increase food production
- **Improved Sustainability of Farming System:**
  - Improved agronomic productivity
  - Reduced production risk
  - Conserves natural resource base
  - Economic more viable
  - Socially acceptable by communities

Farmers can make a difference by making the right choices from basket of technologies

ARC • LNR
Excellence in Research and Development

Requirements for successful application of these technologies

- Research to be Climate- smart, and sustainable
- Government must give commitment and support
- Small-scale infrastructure must be developed
- Education and training is vital for success
- On-farm trials & demonstration plots & farmers days

Support:

- From extension by provision of information
- For development of marketing and value chains

Commitment from all stakeholders:

- politicians; policymakers;
- researchers; agribusiness
- NGOs; extension & farmers

ARC • LNR
Excellence in Research and Development

WalkerS@arc.agric.za
AndersonK@arc.agric.za
MashingaidzeK@arc.agric.za
MohamedAhmedM@arc.agric.za
erna@mahlathiniorganics.co.za

ARC • LNR
Excellence in Research and Development