

Challenges to farmers, optimising crop production while limiting water and energy usage Applied to potato production in South Africa

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Sustainability and resource use efficiencies

What is sustainable farming?

Based on empirical science but also a reflection of values in society

Moving target

Global initiatives to define sustainable farming

People, Planet, Profit

Ecological sustainability of agricultural production can be assessed through resource use efficiencies

‘Use’ refers to the amount of resources applied on an area basis, e.g. water use in mm irrigation water applied.

‘Use efficiency’ refers to the amount of produce produced for a certain amount of resources applied, e.g. water use efficiency in kg potato produced per mm water applied

Sustainability issues around potato cultivation

Potato has a high yield potential, but also a high demand for water and nutrients

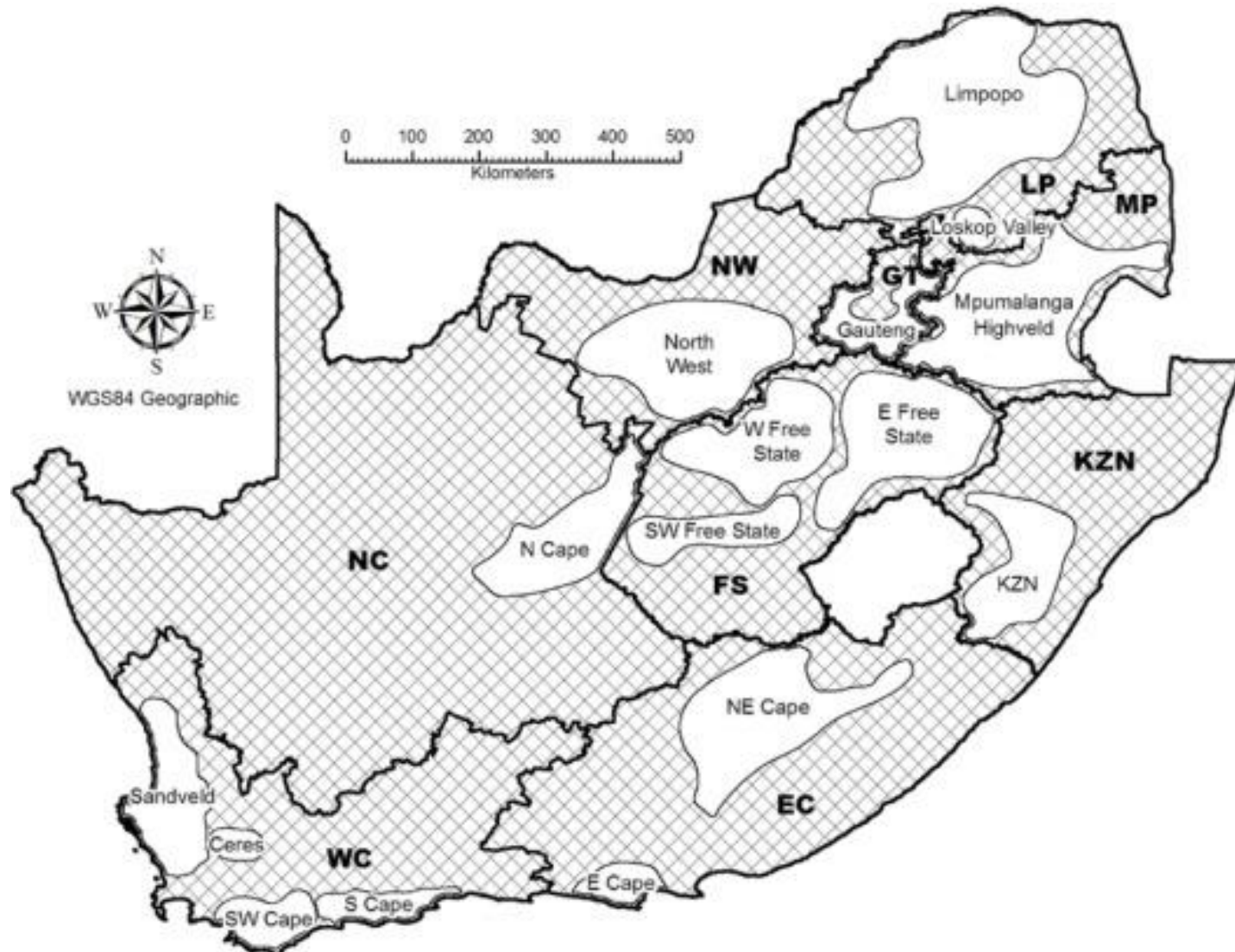
Due to a shallow rooting system, the risk of water drainage and nutrient leaching is high

Potato is sensitive to a range of pests and diseases, requiring intensive pest control

Potato is grown in areas with a high biodiversity value in South Africa (especially the Fynbos region), and wide rotations lead to high land use



Potato production regions in SA



On the ground



From the air





Approaches used to assess and understand the resource use efficiency potato production

Commercial potato growers interviewed in all 16 production regions;
smallholder potato farmers interviewed in two regions (KZN and Mp)

Resource use and use efficiencies of land, water, energy, fertiliser and seed input, and yield of each farmer was assessed

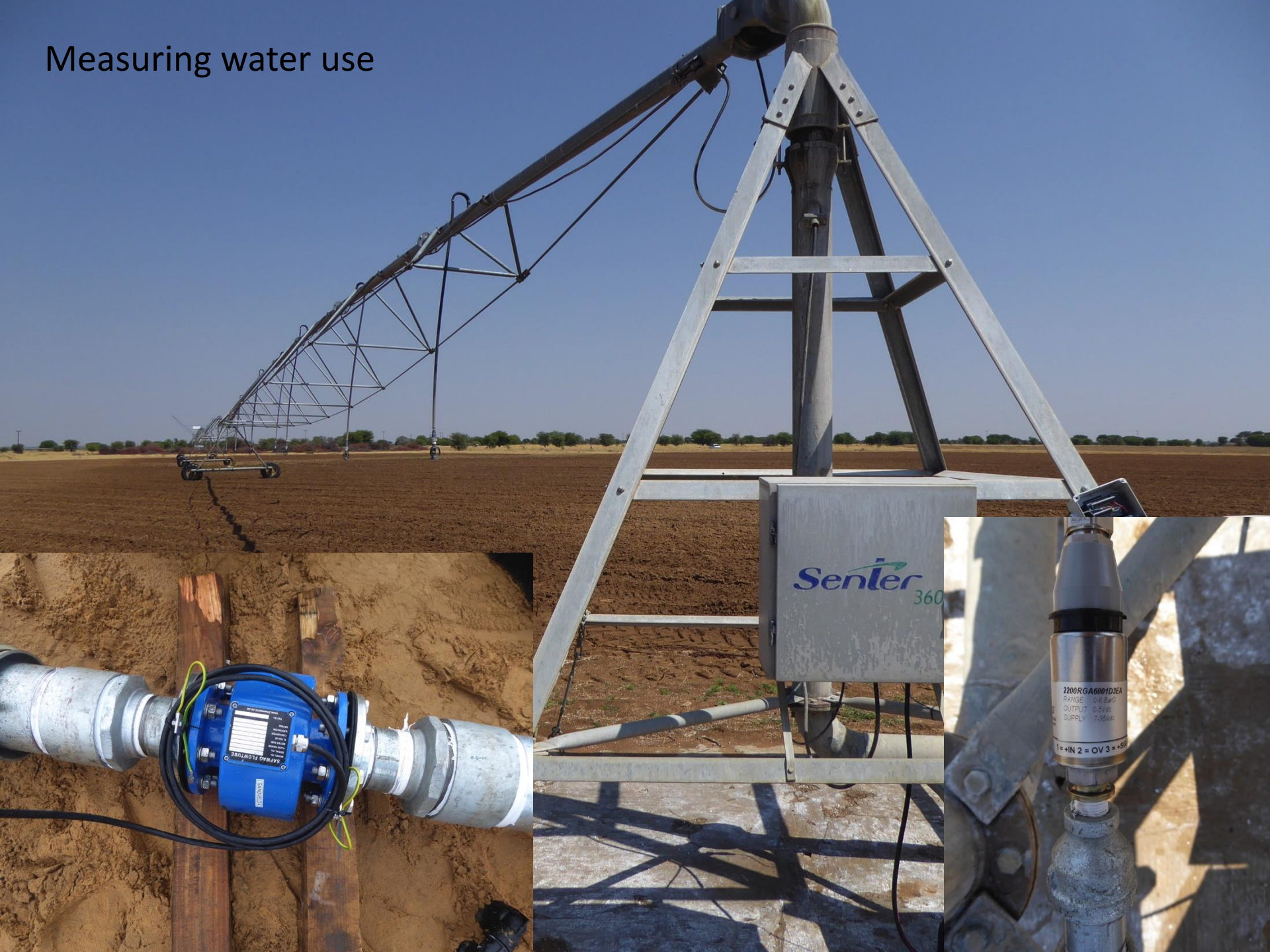
Energy use was estimated through the Cool Farm Tool-potato calculating the C – footprint in CO₂ equivalents (incl. methane and N₂O emissions) based on input use, farm operations, transport from and to markets, and yield. C footprint was used as a proxy for energy use.

Detailed field measurements of resource use efficiencies and losses of water and nutrient to the environment in potato fields in:

- the western Free State (Christiana)
- North West (Vryburg)
- Western Cape (Sandveld)



Measuring water use



Lysimeters





Deep drainage and nutrient losses from potato fields

In North-West (summer cultivation) farmers typically apply to a potato crop:

- 800-1000 mm water
- 250-325 kg N/ha
- 150-260 kg P/ha
- 300-370 kg K/ha

Drainage up to 491 mm was observed on a site with coarse sandy soil

Over the cropping season, nutrients were leached:

- 136 kg N / ha (mostly as NO_3)
- 0 kg P / ha
- 41 kg K / ha
- 507 kg Ca / ha
- 198 kg Mg / ha

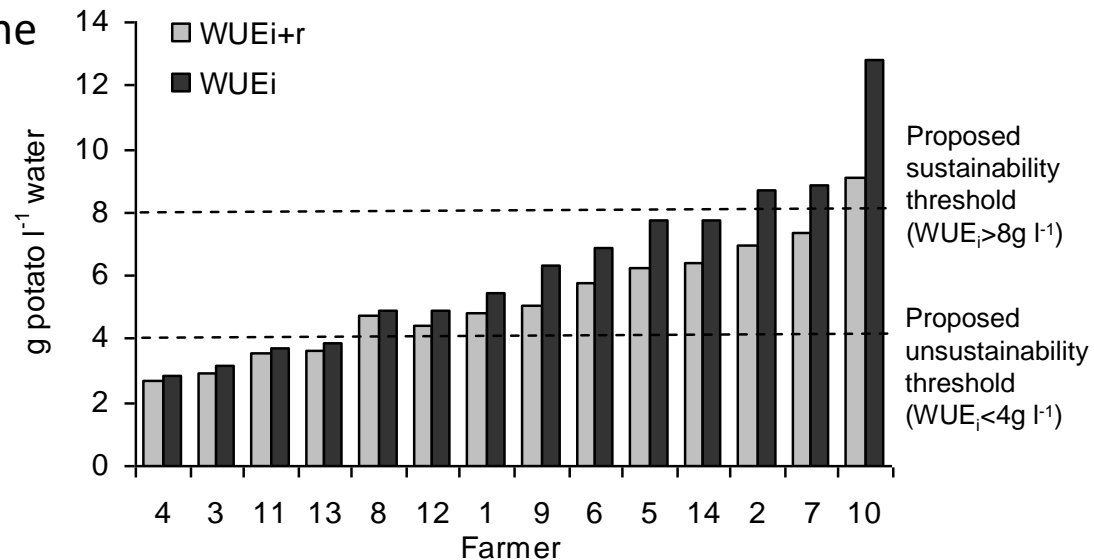
Results from interviews

Input use and use efficiencies greatly differ between regions, but also between growers within regions that are homogeneous in agro-ecology

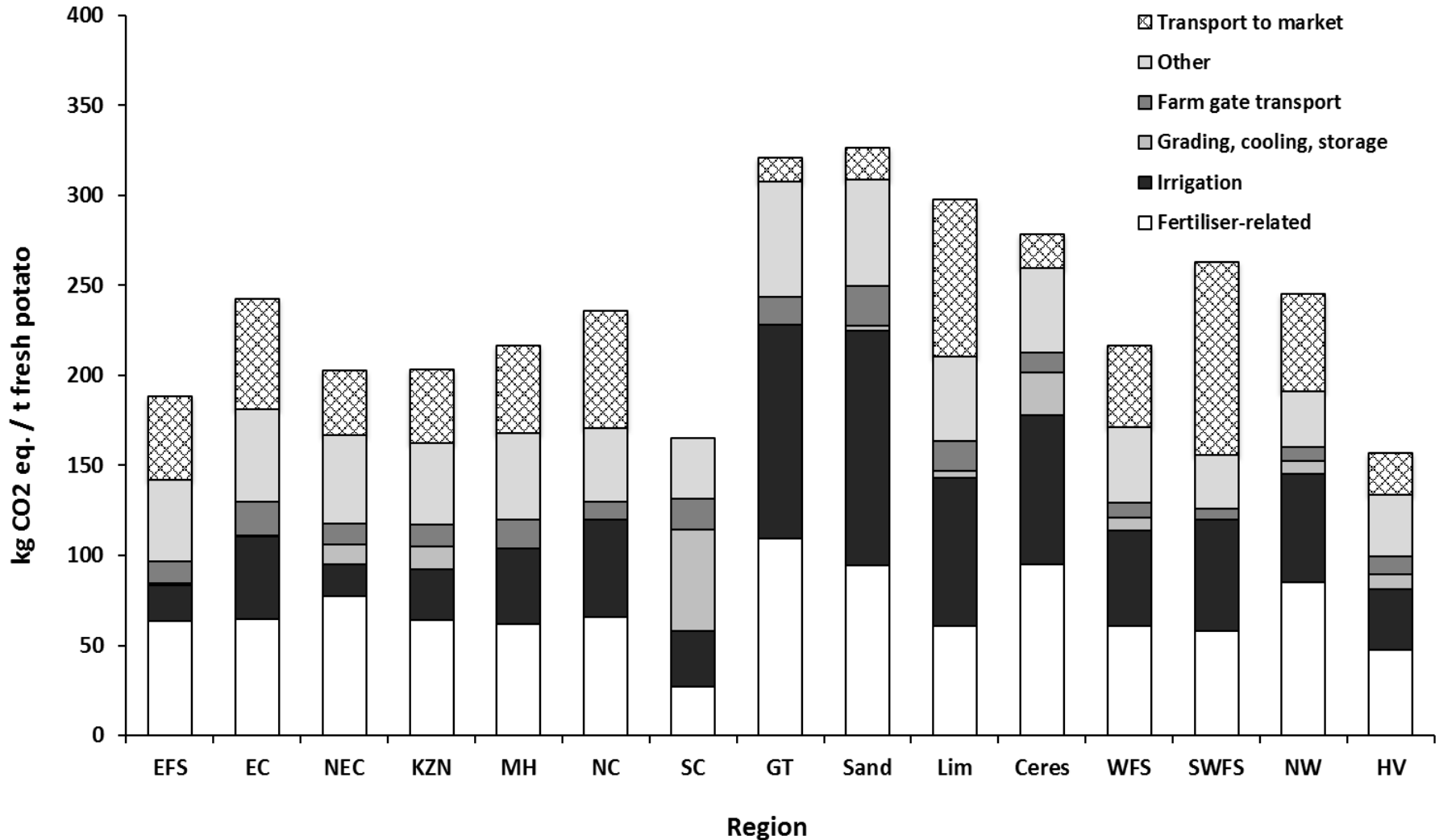
Input use (water, NPK fertilizer and energy) and the amount of radiation received during the growing season all significantly affect yield

Use efficiencies of resources generally do not correlate with yield.

Water use efficiency of farmers in the Sandveld region (western Cape):

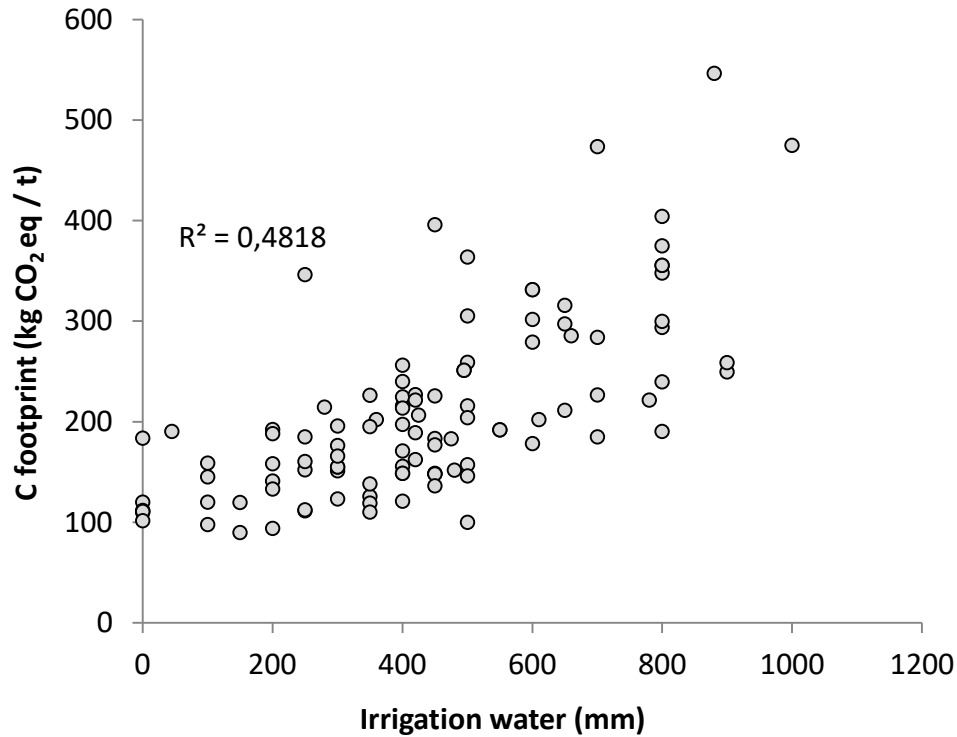


C-footprint of different regions

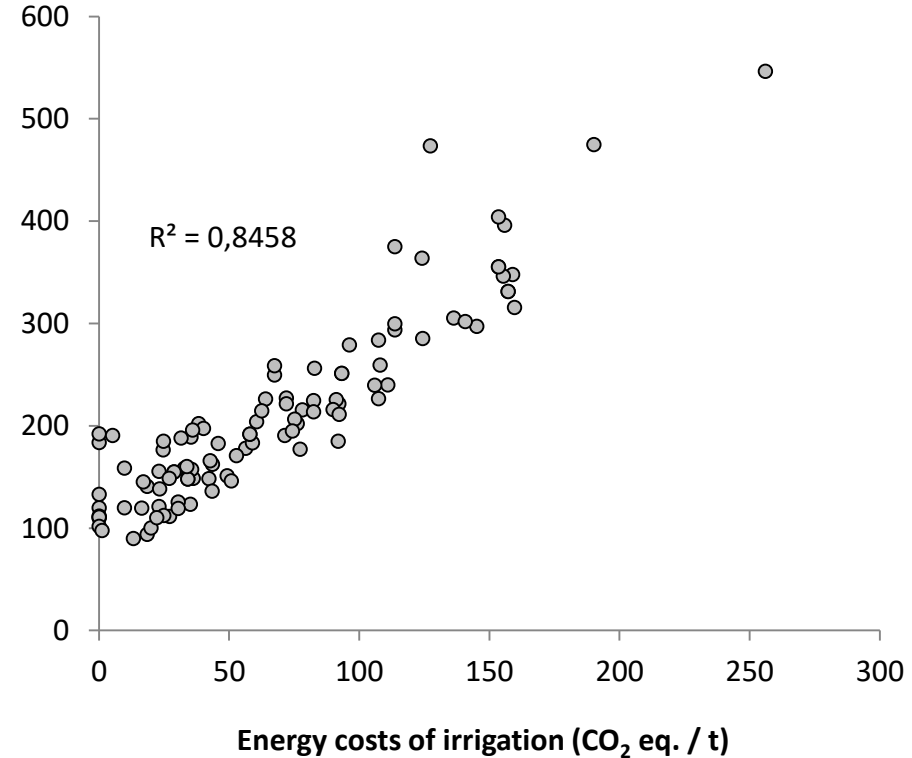


C footprint of individual growers as affected by the amount of irrigation water applied and the energy costs of irrigation

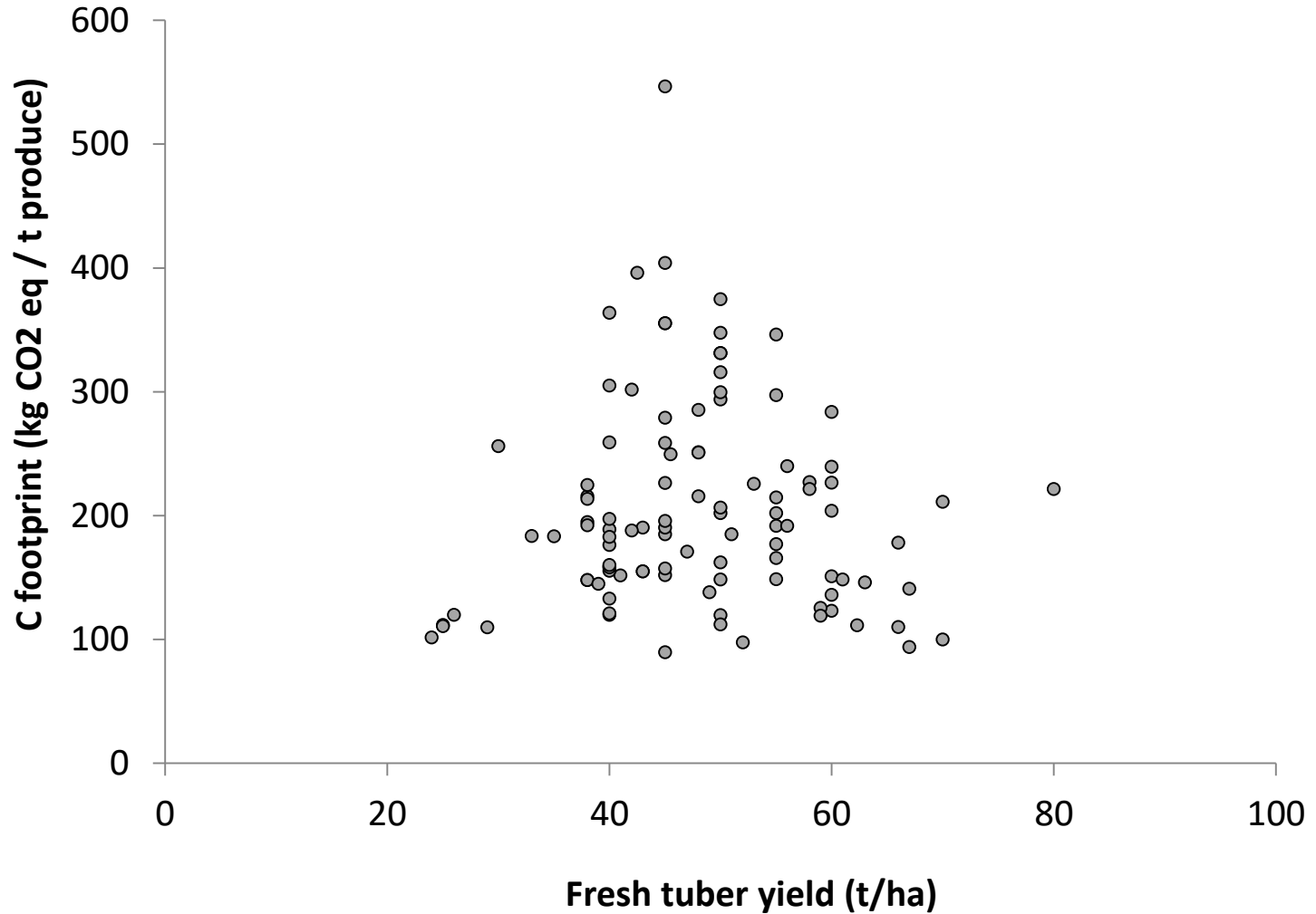
Amount of irrigation water



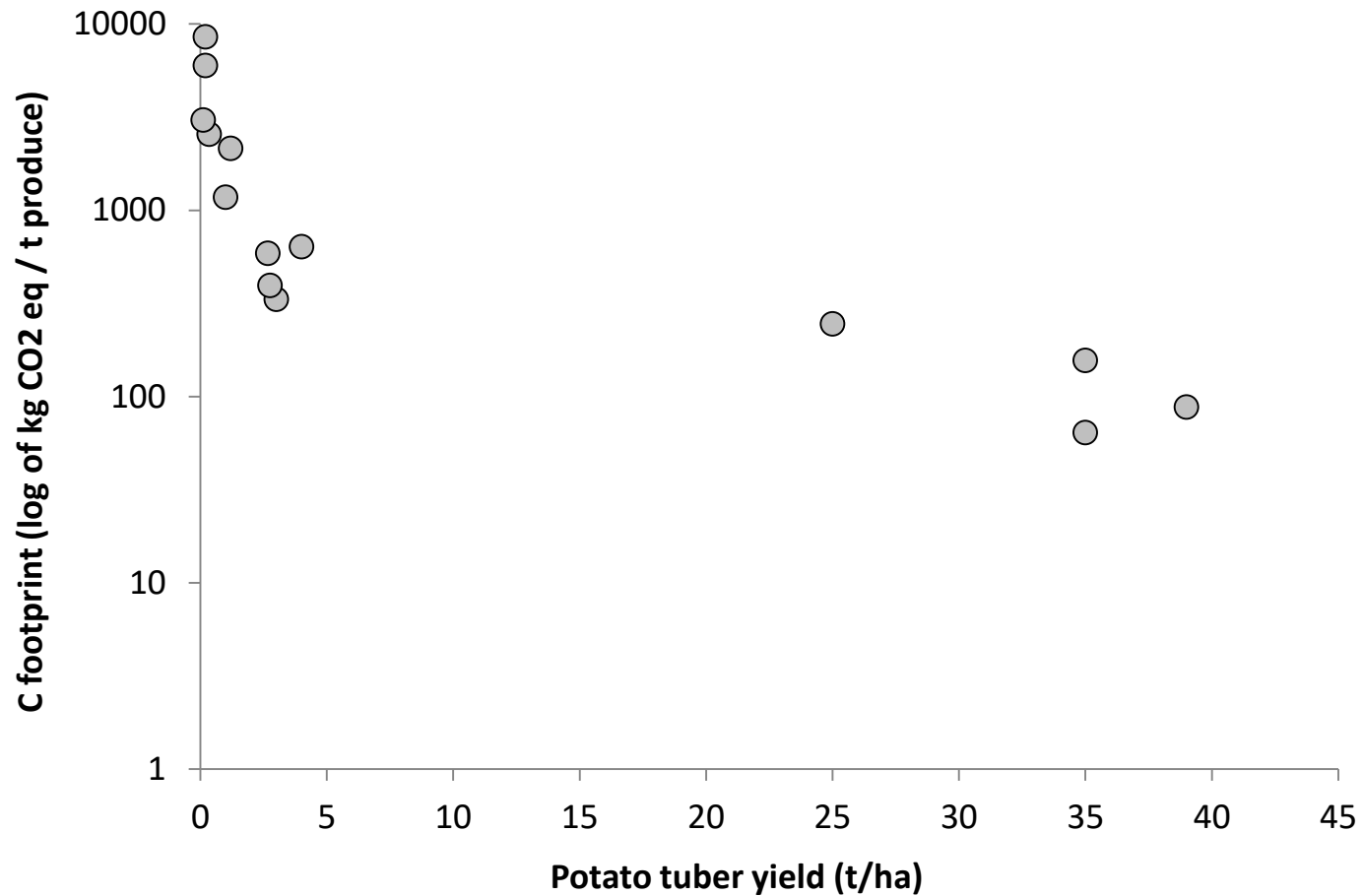
Energy costs of irrigation



C footprint of individual commercial farmers as affected by yield

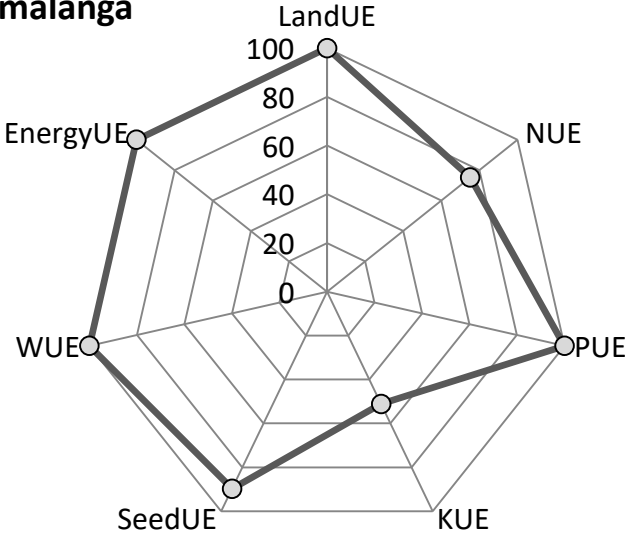


C footprint of individual smallholder farmers in KZN as affected by yield

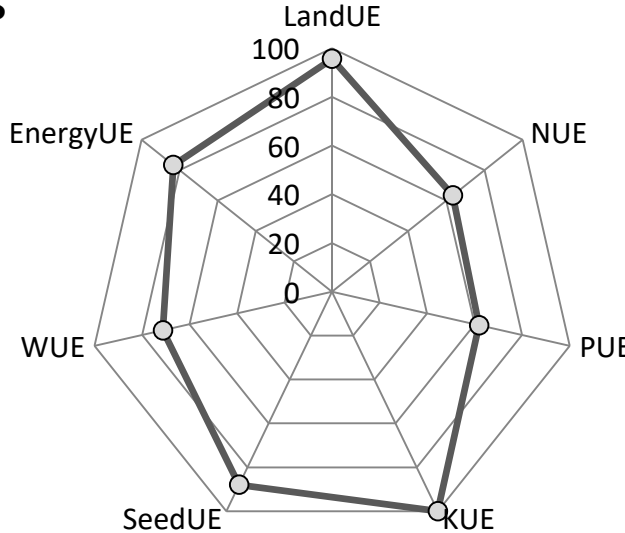


Overall efficiency and sustainability of production in the regions the Highveld (Mpumalanga), the South-Western Free State (SWFS), Gauteng and the Sandveld

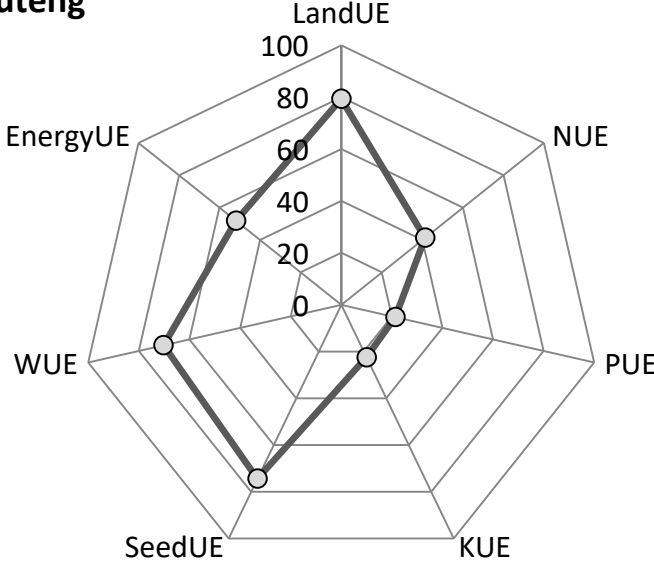
Mpumalanga



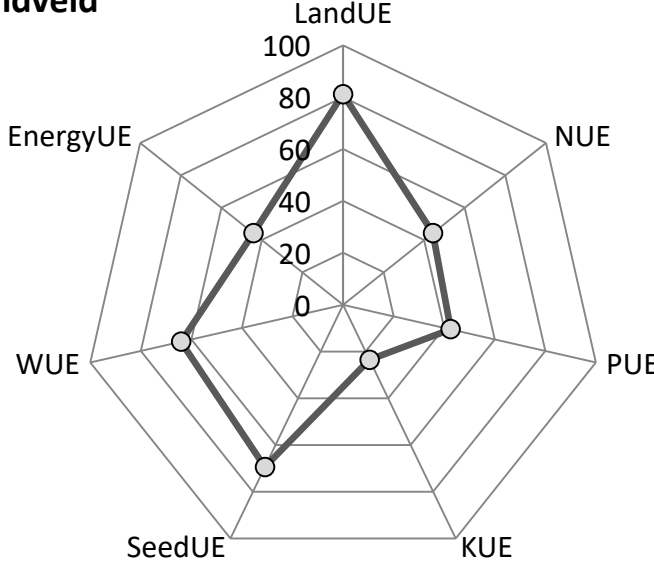
SWFS



Gauteng



Sandveld



Conclusions from interviews

Quantifying resource use efficiencies can assist farmers in identifying inefficient practices and yield limiting factors

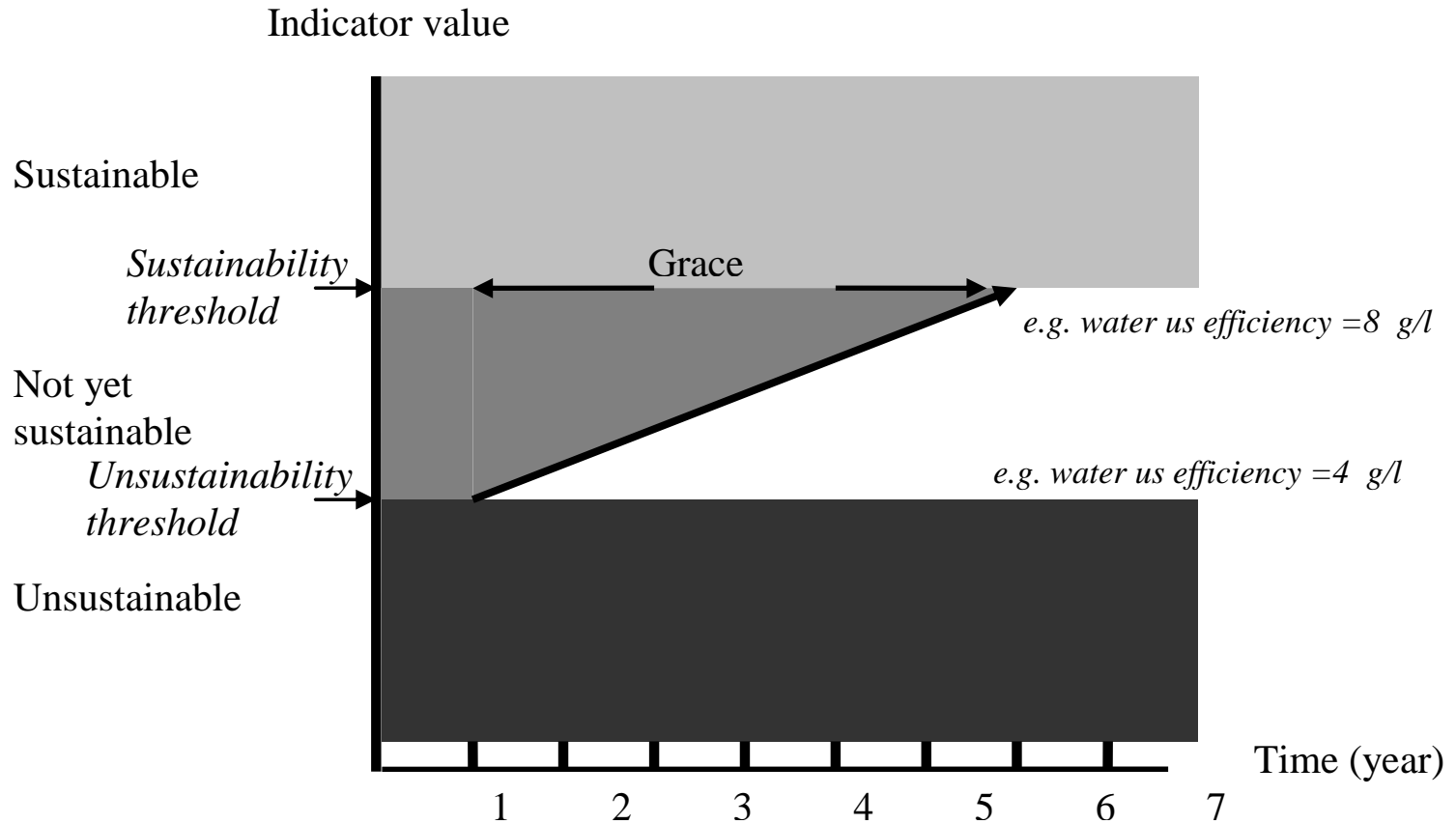
A large variability in resource use efficiencies among growers within regions having uniform agro-ecological conditions indicates a large potential for many farmers to improve resource use efficiencies

Water and energy use efficiency in crop production appear to be closely linked

Resource use efficiencies of SA potato farmers compares well with efficiencies reported in other parts of the world, despite challenging biophysical conditions in SA

Large differences in overall sustainability of production between regions were caused by differences in agro-ecological conditions, scarcity of resources, and in historical production orientation.

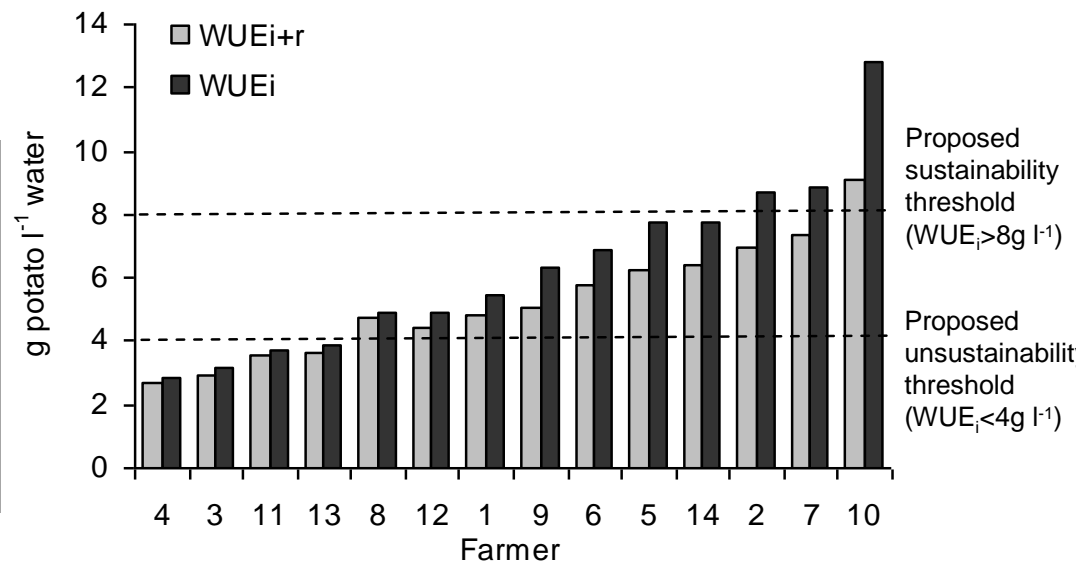
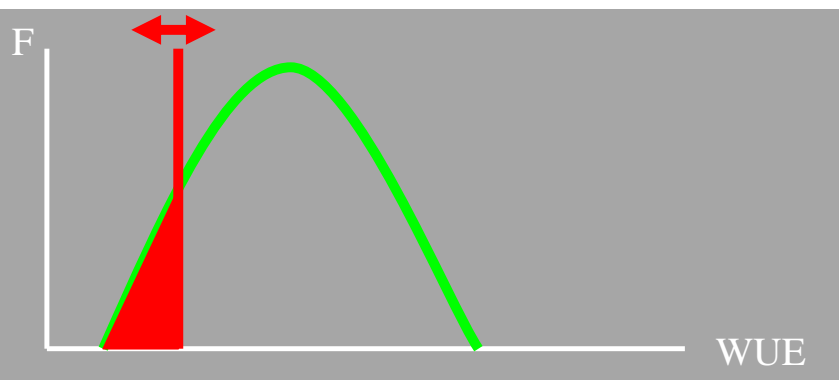
Actual and desired values of sustainability indicators



How to set norms for sustainable farming practices?

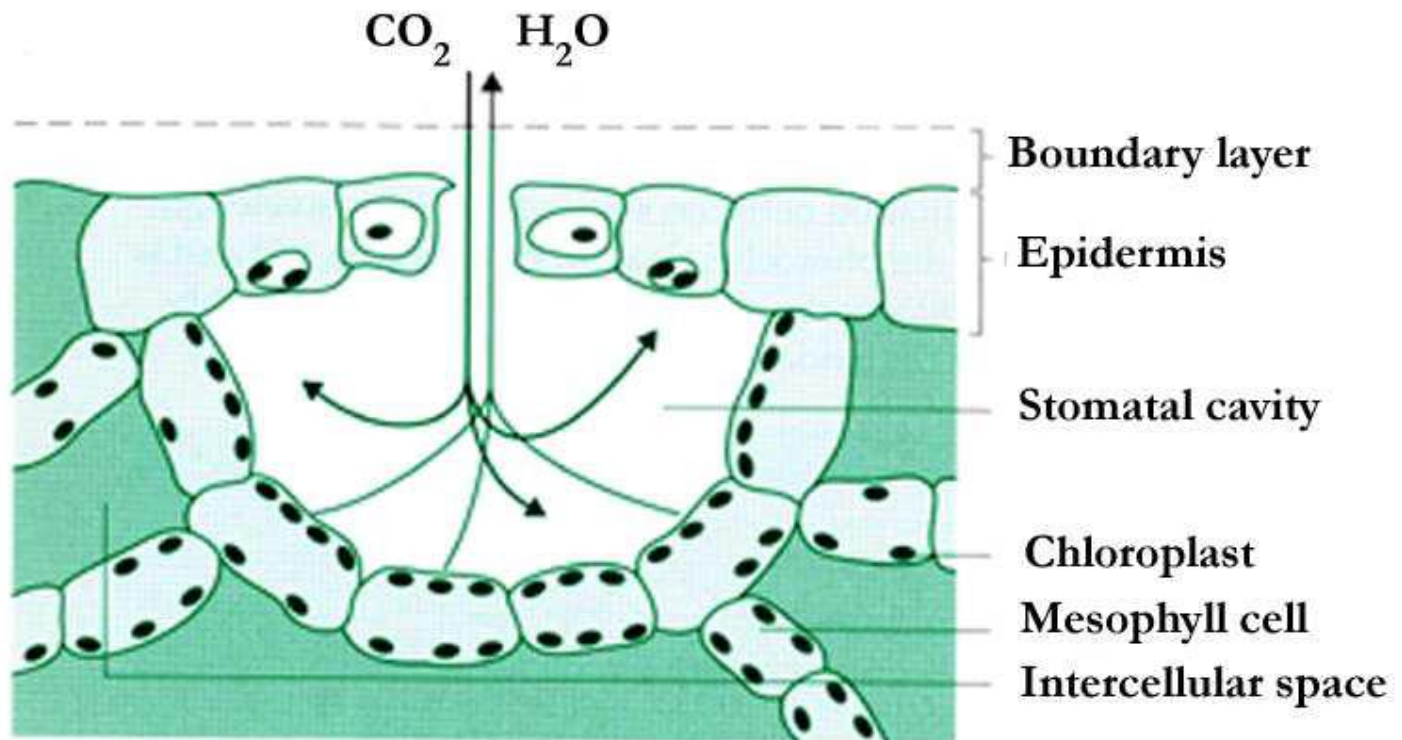
Ideally: based on in-depth knowledge of resource availability and agricultural practices

Alternatively: based on relative performance



What about the impact of future climate change on water use?

It is a common misunderstanding that climate change will automatically lead to higher evapotranspiration and a lower water use efficiency of crops



Free Air CO₂ Enrichment (FACE) experiments



Effects of a doubling of ambient CO₂ concentrations and an increase in ozone on growth rate of different crops

Wheat + 6 %

Rice + 6 %

Maize - 5 %

Sugar cane -7.5%

Potato + 29% (water use - 11%)

Cassava + 100%

Average from various FACE experiments

Large differences in CO₂ response between varieties within species

Impact of climate change on potato production in SA

Increased heat stress in potato in South Africa due to rising temperatures is, in most regions, compensated by the positive impacts of enhanced ambient CO₂ levels on crop growth and water use

The interior regions of South Africa grow potatoes under warmer conditions and face stronger temperatures increases, and as a result will face more negative impacts of heat stress than areas closer to the coast.

Risks of frost damage will reduce in winter plantings

While potato yields are generally expected to increase due to climate change, variability in yield (risks) will also increase, except for regions with cold stress / frost

Benefits of climate change are more evident if planting times can be advanced and if varieties are available that can better make use of the available growing season.

Final thoughts

Some smallholder farmers are highly efficient producers, the majority however is not

There is lots of room for improving the water and energy use efficiency of commercial crop production in South Africa

Decision support systems, such as irrigation scheduling tools, are essential to improve sustainability of production at field level

Appropriate pricing of inputs, especially of water, is also key

Integrated water management is important to improve sustainability of water use at regional level

- Complex problems that cannot be solved by one (group of) stakeholders

- Regulations that enable an efficient use of water

- Enforcement of regulations

Thank you

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