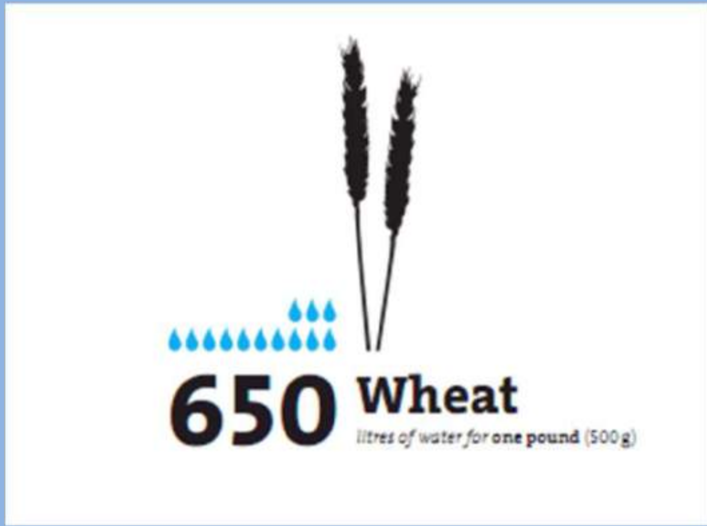
The water footprint of producing and distributing vegetable crops grown on the Steenkoppies Aquifer in Gauteng, South Africa

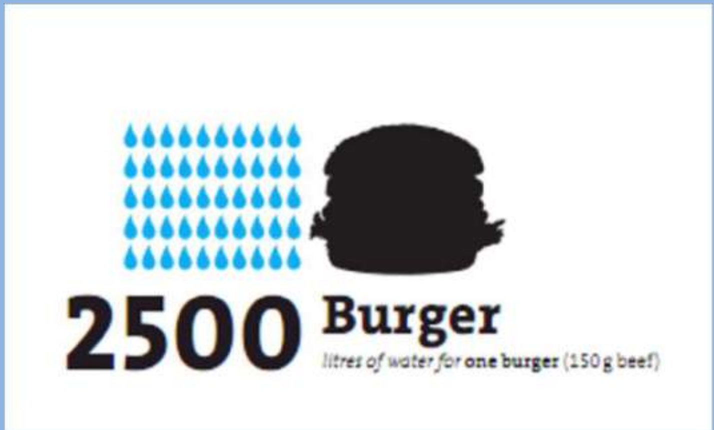
Michael van der Laan and Betsie le Roux

Water efficiency in the agri-processing sector in South Africa: practices, challenges and opportunities

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA


650 Wheat
litres of water for one pound (500 g)


840 Coffee
litres of water for one pot (750 ml)


2500 Burger
litres of water for one burger (150 g beef)

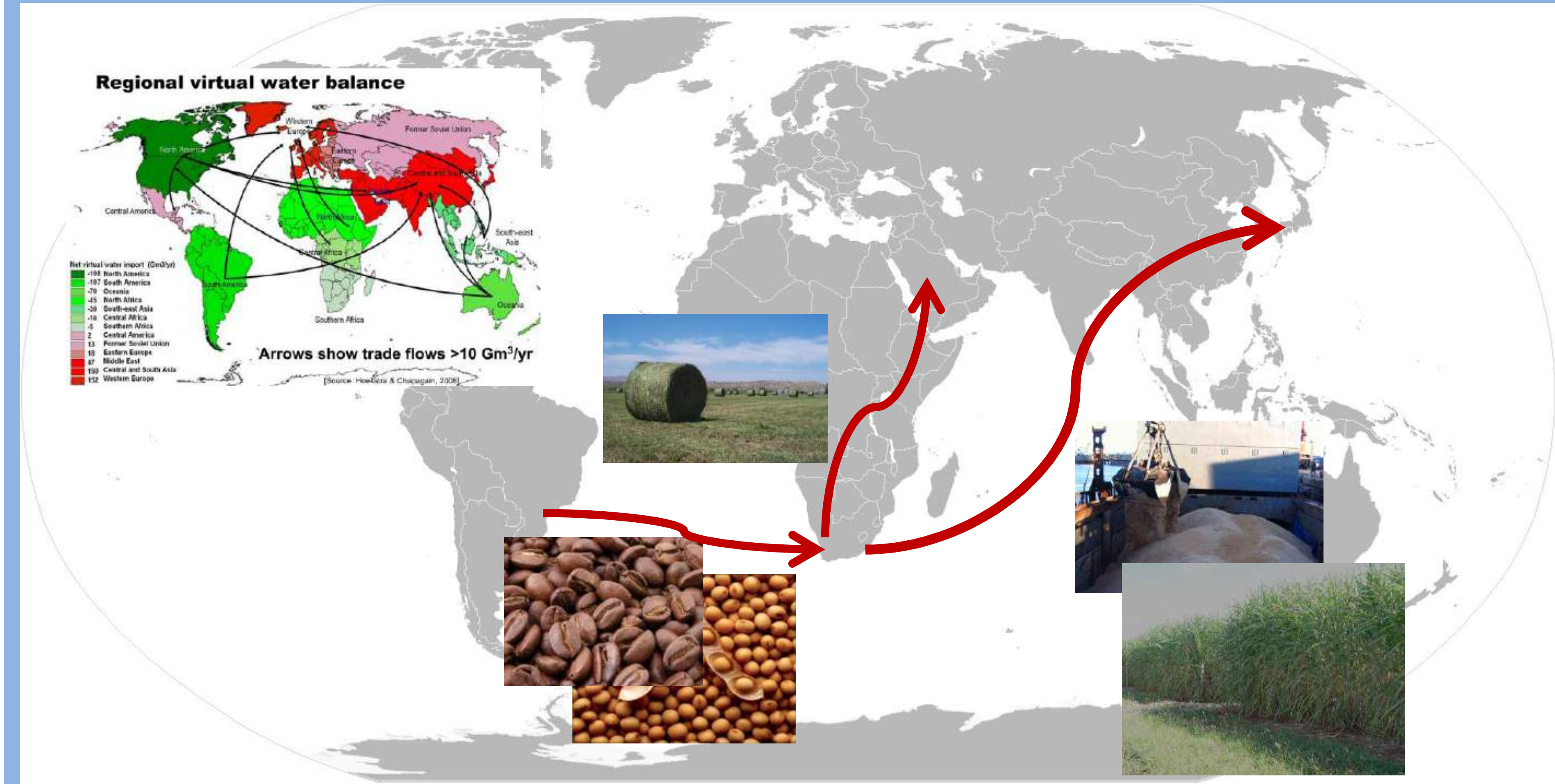

2500 Cheese
litres of water for one big piece (500 g)

Virtual water

- **Virtual water** accounts for all the water used to produce a product
- Useful to monitor the virtual flow of water between regions
- When reported as a water footprint it includes information on what, when and where

Photos: Google images

Virtual water flows



Water Footprint NETWORK · World Bank Institute · UNIVERSITY OF TWENTE.

Definitions of water footprint terms

Blue water refers to surface water (rivers, lakes, dams) and groundwater available to multiple users

Green water is water originating from rainfall that is stored in the soil

Grey water (footprint) refers to the volume of water required to dilute emitted pollutants to ambient levels

Calculations

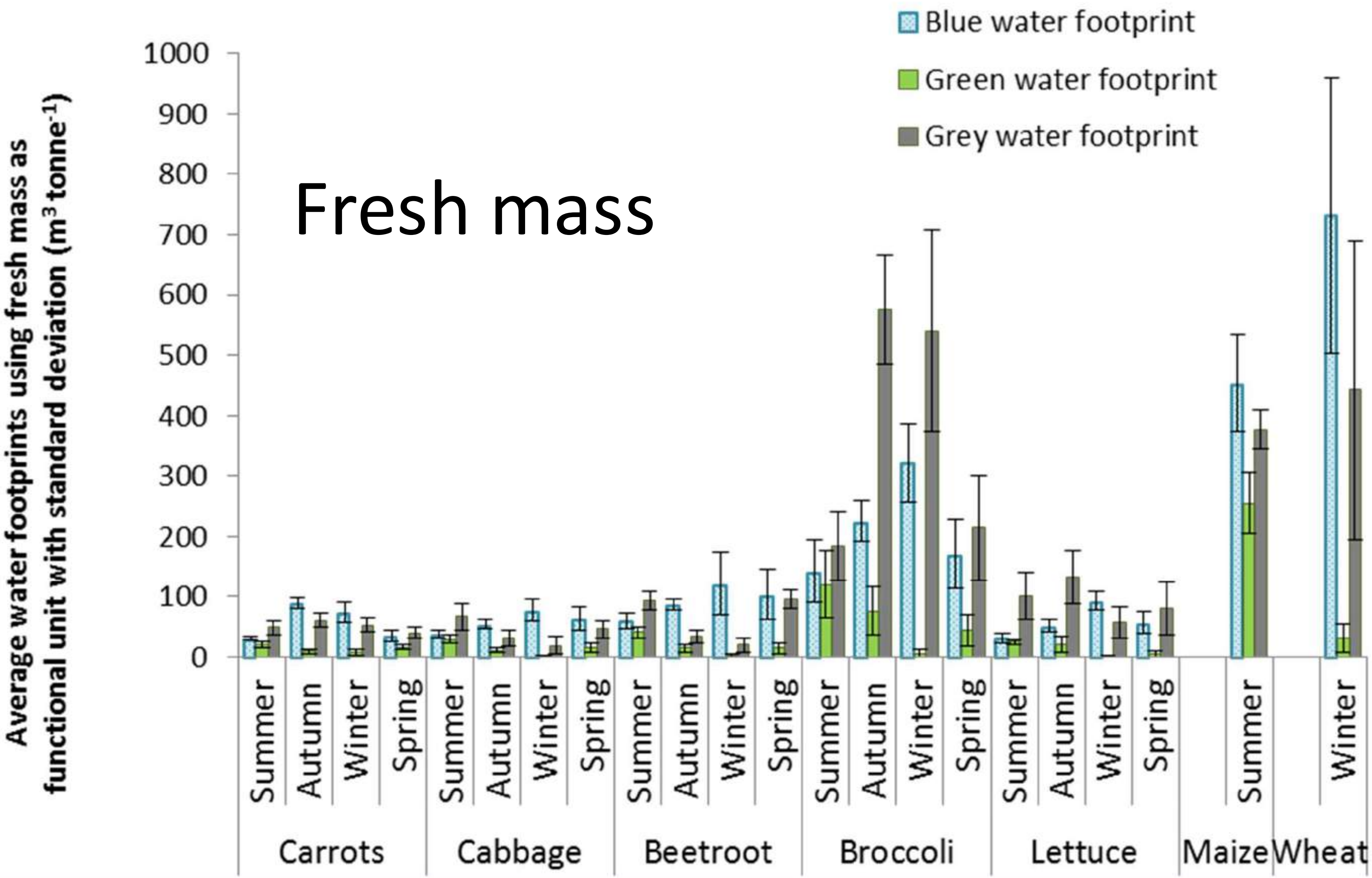
$$Blue\ water footprint = \frac{\min(irrig\ required, irrig\ applied)}{Crop\ yield}$$

$$Green\ water footprint = \frac{Crop\ ET\ -\ blue\ water\ use}{Crop\ yield}$$

$$Grey\ water\ footprint = \frac{Pollutant\ load/(Cmax - C_{min})}{Crop\ yield}$$

Maloney's Eye
Deodar Weather Station
A21F
Lazar Ave
R563
R540
R114
M5
R512
Muldersdrift
14
R28
M47
RUIMSIG
R24
Krugersdorp Municipal Nature Reserve
Krugersdorp
Roodepoort
CONSTANTIA KLOOF
KAGISO
WITPOORTJIE
R41
R558
M77
Randfontein
R28
DOBSONVILLE
Holfontein
14
R500
R41

Fresh mass



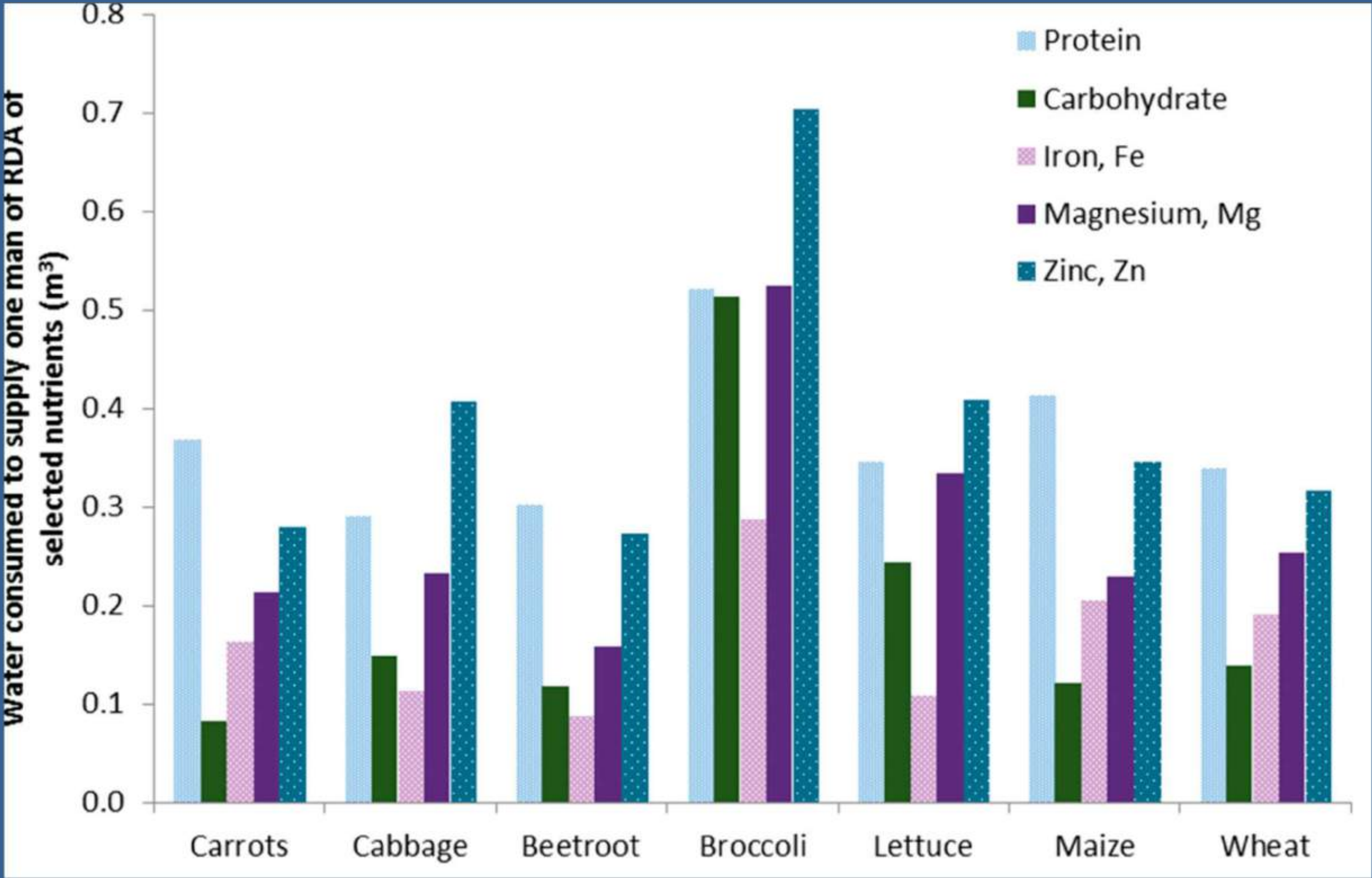
Blue water footprint
Green water footprint
Grey water footprint
Average water footprints using fresh mass as functional unit with standard deviation (m3 tonne-1)
1000
900
800
700
600
500
400
300
200
100
0
Summer
Autumn
Winter
Spring
Carrots
Cabbage
Beetroot
Broccoli
Lettuce
Maize
Wheat

Crop water footprints

Crop	Month	Average seasonal WFs of crops (m³ tonnes⁻¹)			
		Blue	Green	Blue + Green	Grey
Carrots	Summer	36	25	61	48
	Autumn	104	12	116	60
	Winter	88	7	95	52
	Spring	45	17	62	39
Cabbage	Summer	38	29	66	66
	Autumn	53	11	64	31
	Winter	77	1	79	18
	Spring	63	16	79	46
Beetroot	Summer	60	40	100	92
	Autumn	87	14	101	33
	Winter	121	3	124	20
	Spring	104	15	118	96
Broccoli	Summer	142	120	262	183
	Autumn	225	76	301	575
	Winter	322	5	327	540
	Spring	170	44	214	214
Lettuce	Summer	31	24	56	100
	Autumn	51	20	71	131
	Winter	93	1	93	56
	Spring	56	6	62	80
Maize	Summer	452	253	707	377
Wheat	Winter	732	30	762	443

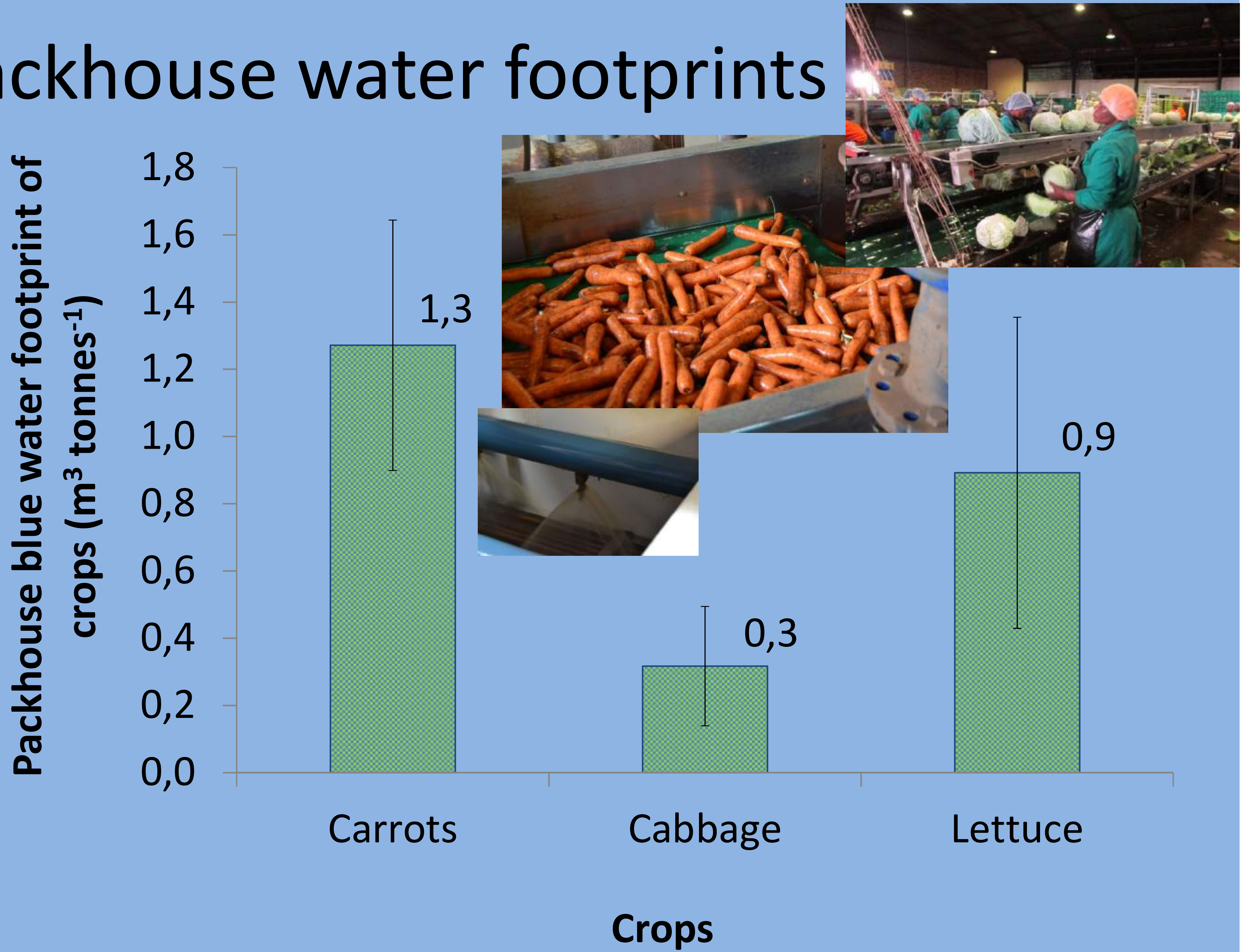
Crop	Season	Blue WF
		WFN (m^3 tonnes $^{-1}$)
Carrots	Summer	36
	Autumn	104
	Winter	88
	Spring	45



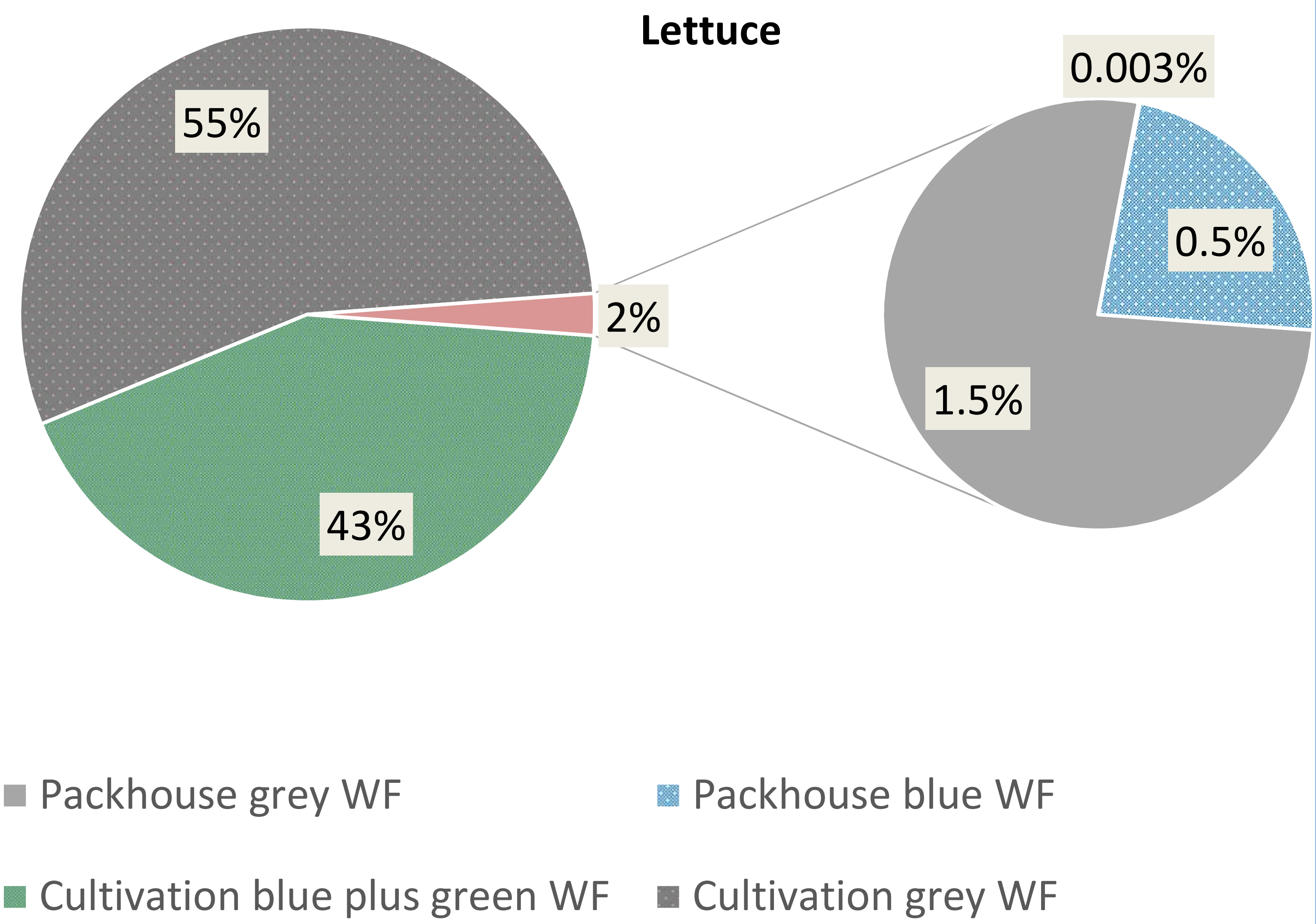


Blue plus green water footprint to supply a man (aged 31–50) with their Recommended Dietary Allowance (RDA) in terms of selected nutrients

Packhouse water footprints



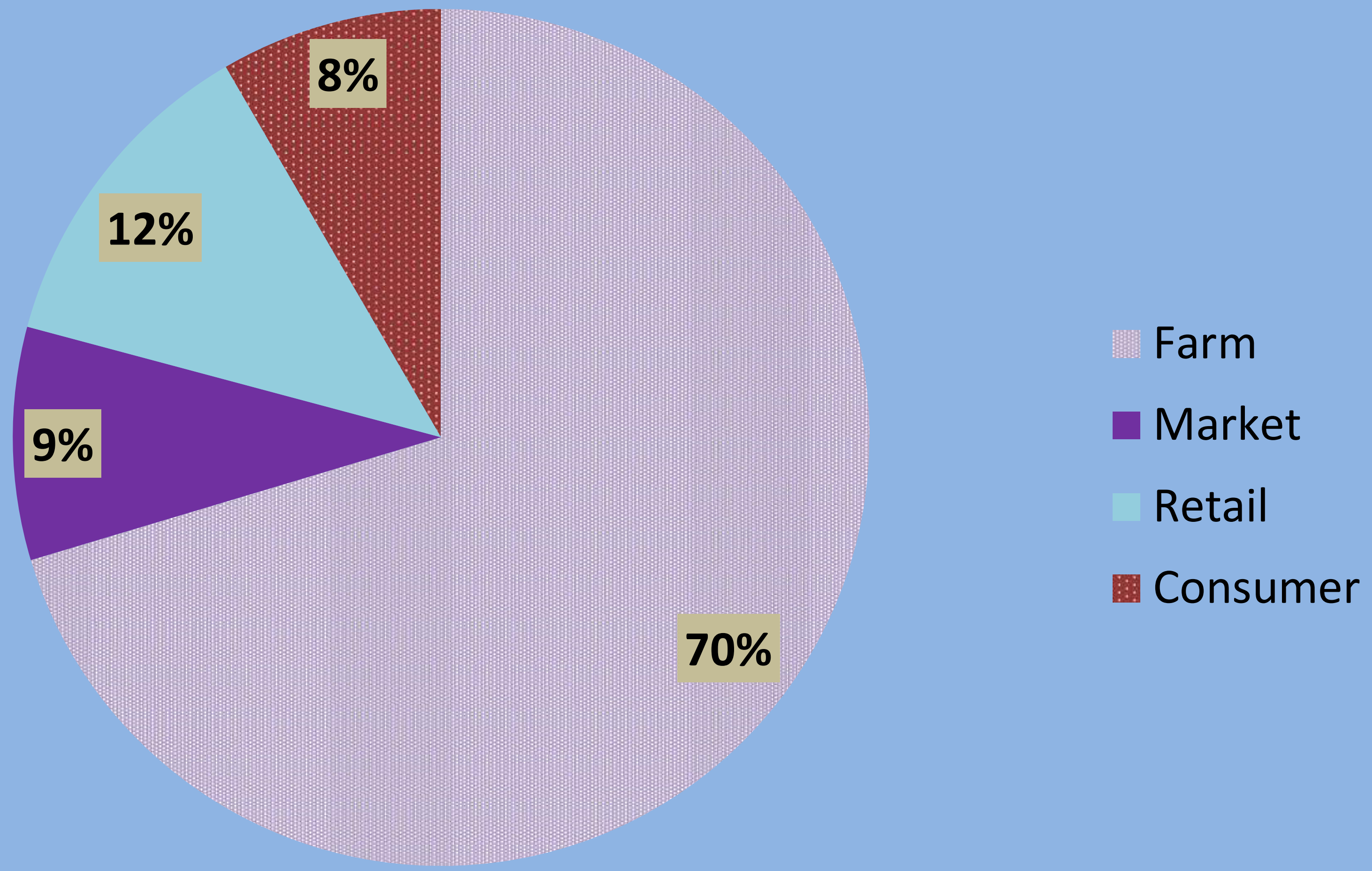
Relative water footprints



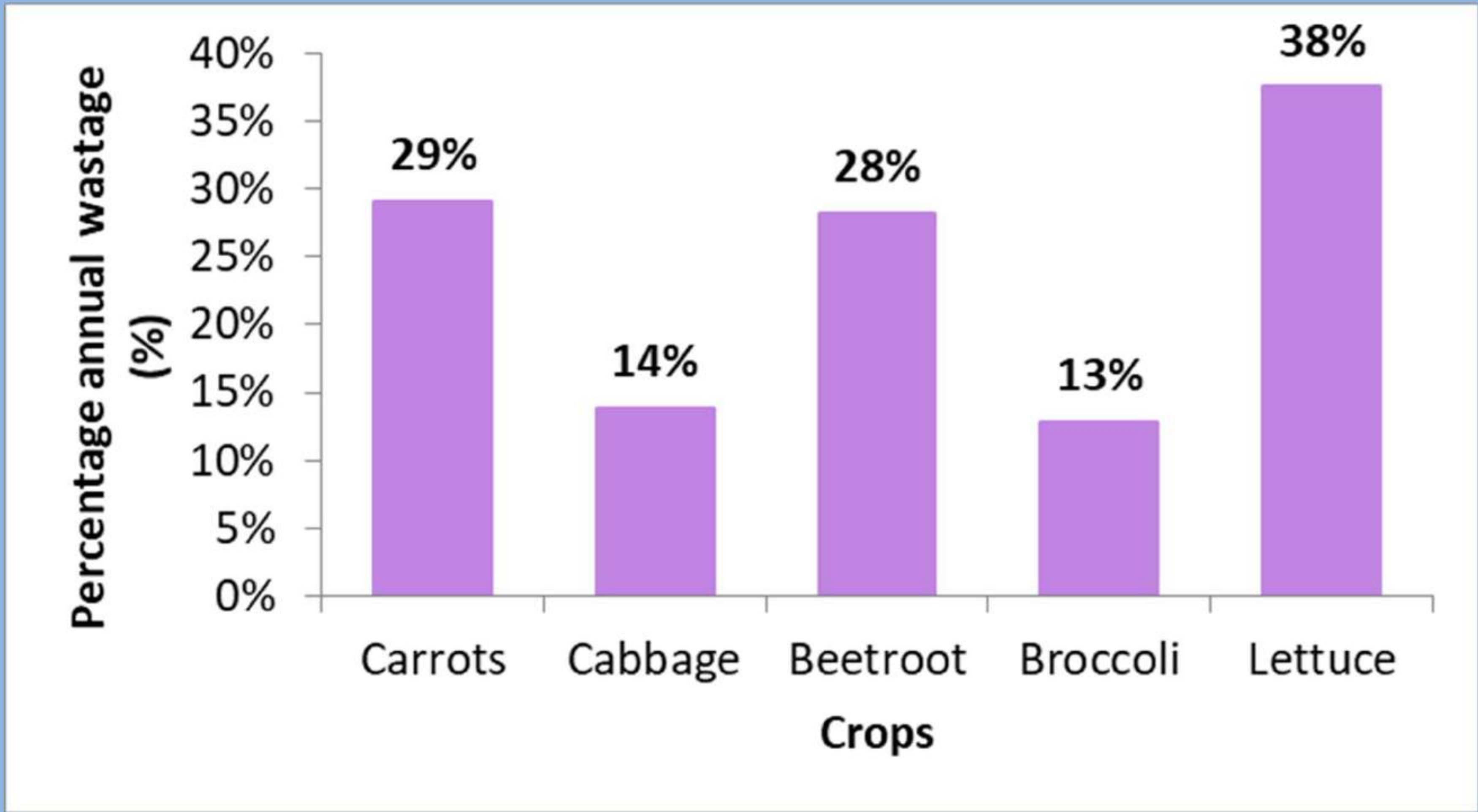
The in-field water footprint (evapotranspiration) is often >98% of the total water footprint

Wastage

Wastage along supply chain

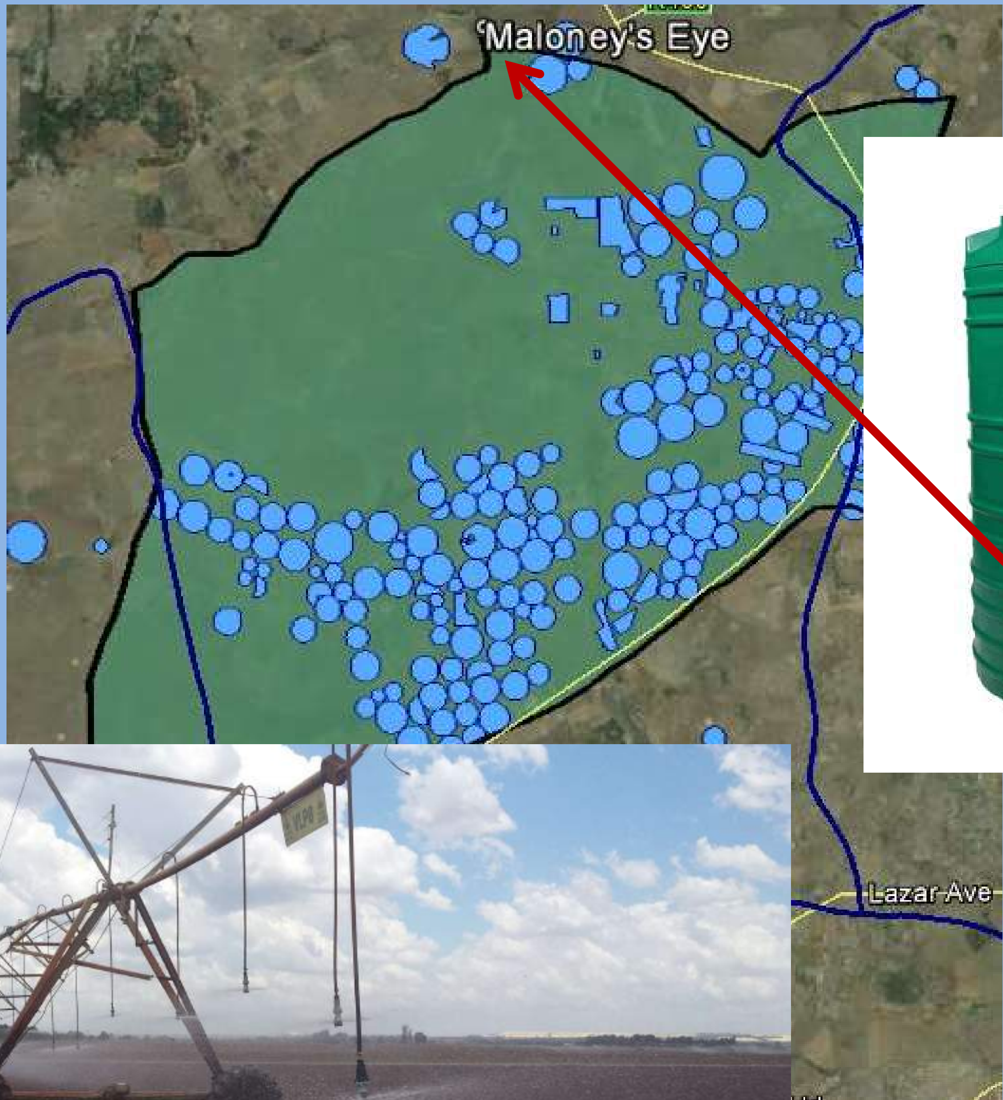


Average annual wastage

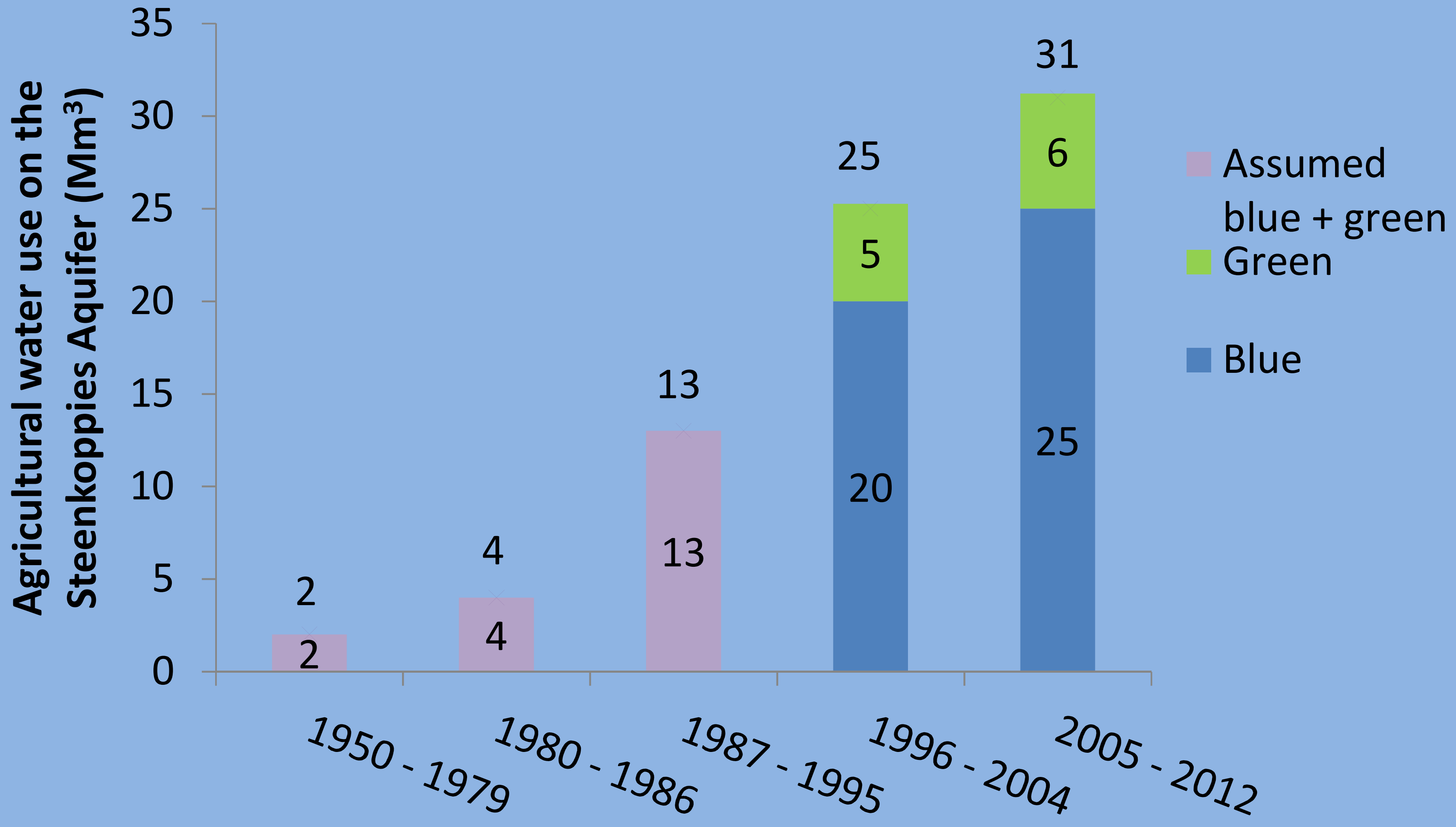


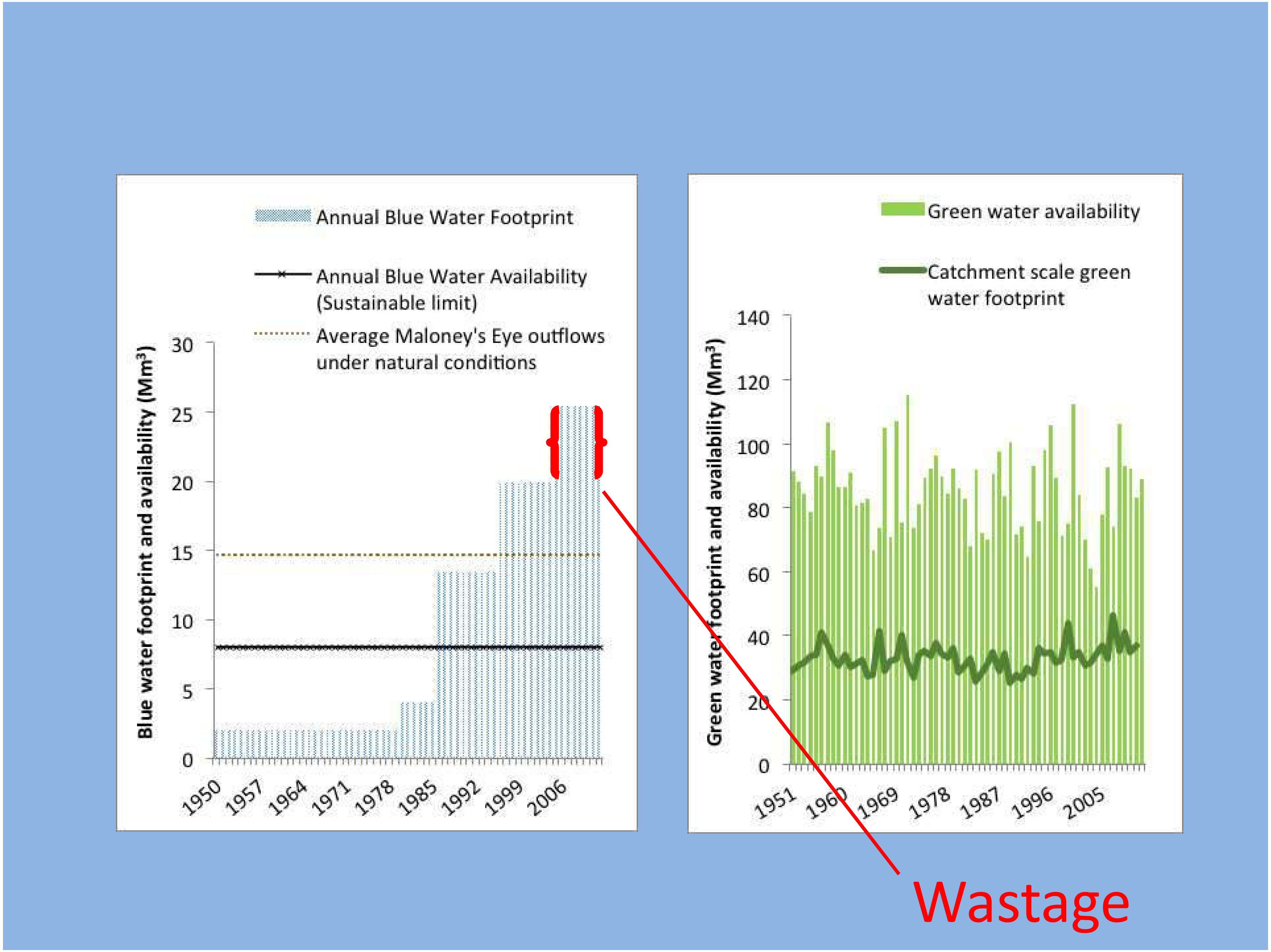
Wastage – correct term?

Irrigation water use on Steenkoppies

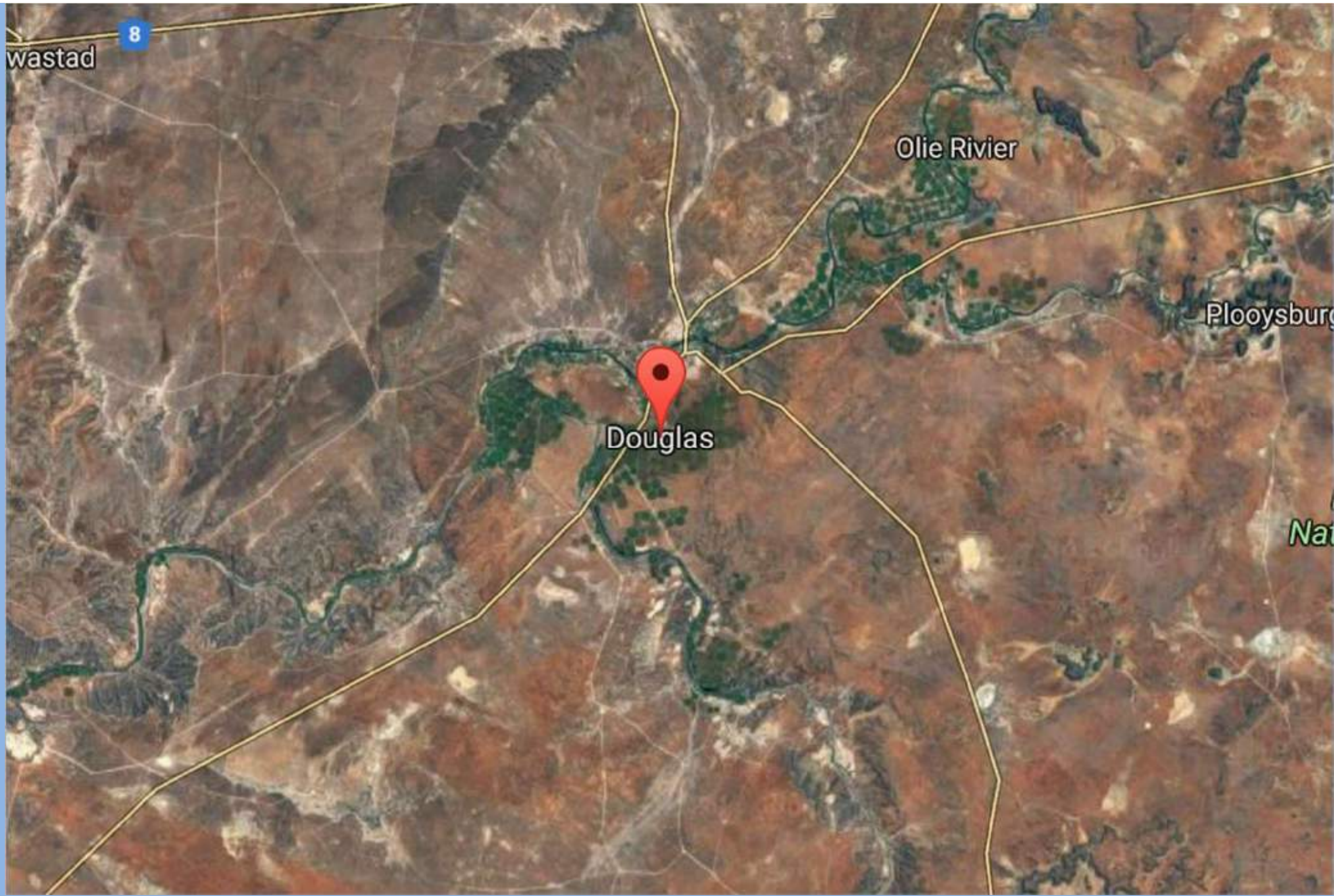


Catchment level irrigation WF

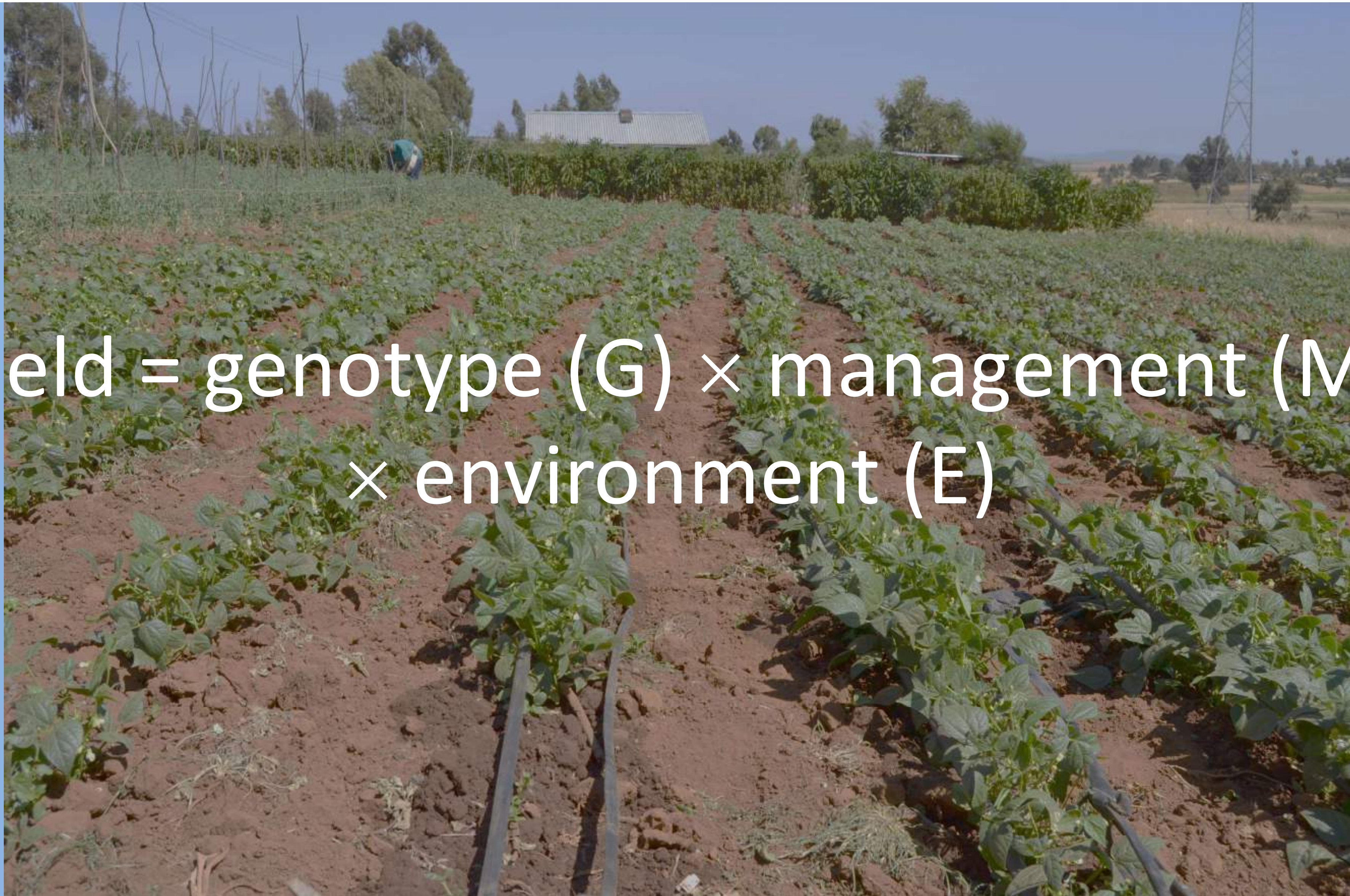




Annual Blue Water Footprint
Annual Blue Water Availability (Sustainable limit)
Average Maloney's Eye outflows under natural conditions
Blue water footprint and availability (Mm³)
0
5
10
15
20
25
30
1950
1957
1964
1971
1978
1985
1992
1999
2006
Green water availability
Catchment scale green water footprint
Green water footprint and availability (Mm³)
0
20
40
60
80
100
120
140
1951
1960
1969
1978
1987
1996
2005
Wastage



- If we use the maximum maize blue water footprint obtained in this study (676 m^3 $tonne^{-1}$), this equates to 8.4% of river flow (10 002 l s^{-1}), while if we use the minimum blue water footprint (338 m^3 $tonne^{-1}$), this equates to 4.4% of river flow (5 001 l s^{-1})



Yield = genotype (G) × management (M) × environment (E)

Yields <50% of realistically attainable yields in many parts of the world (e.g. SSA)

Conclusions - general

- Awareness raising among consumers through water footprinting has been great

- But product labelling of specific water footprints will not happen (MvdL)

- There are the socio-economic factors linked to water use that are not captured by a water footprint

Conclusions – eco-labelling

- Values can differ widely for same crop in different seasons and different areas

- "Interesting information, but not for decision making" (consumer or government)

- Water systems complex, no method can produce a single metric as with carbon footprint

Conclusions – methods

- Application depends on objectives, we now have more tools in the toolbox, plus they can be used synergistically
- Farmer benchmarking – will need to be for a specific area

Acknowledgements

- Water Research Commission Project K5/2273 'Estimating the water footprint of selected vegetable and fruit crops in South Africa'
- National Research Foundation
- Prof Keith Bristow, Teunis Vahrmeijer, Prof John Annandale

water

MDPI

Article

Estimating Water Footprints of Vegetable Crops: Influence of Growing Season, Solar Radiation Data and Functional Unit

Betsie le Roux [1], Michael van der Laan [1,*], Teunis Vahrmeijer [1,2], John G. Annandale [1] and Keith L. Bristow [1,3]

ELSEVIER

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Establishing and testing a catchment water footprint framework to inform sustainable irrigation water use for an aquifer under stress

CrossMark

Betsie le Roux [a,*], Michael van der Laan [a], Teunis Vahrmeijer [a,b], Keith L. Bristow [a,c], John G. Annandale [a]

water

MDPI

Article

Water Footprints of Vegetable Crop Wastage along the Supply Chain in Gauteng, South Africa

Betsie le Roux [1], Michael van der Laan [1,*], Teunis Vahrmeijer [1], John G. Annandale [1] and Keith L. Bristow [2]

IRRIGATION AND DRAINAGE

Irrig. and Drain. **(2018)**

Published online in Wiley Online Library (wileyonlinelibrary.com) **DOI:** 10.1002/ird.2285

COMPARING THE USEFULNESS AND APPLICABILITY OF DIFFERENT WATER FOOTPRINT METHODOLOGIES FOR SUSTAINABLE WATER MANAGEMENT IN AGRICULTURE[†]

BETSIE LE ROUX[1], MICHAEL VAN DER LAAN[1*], MARK B. GUSH[2] AND KEITH L. BRISTOW[1,3]