THE LUCERNE-DAIRY WATER FOOTPRINT: SOME PRELIMINARY FINDINGS FOR SOUTH AFRICA

ME Scheepers
H Jordaan
J Barnard

T: +27(0)51 401 9111 | info@ufs.ac.za | www.ufs.ac.za

WATER RESEARCH COMMISSION

UNIVERSITY OF THE FREE STATE
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INTRODUCTION AND BACKGROUND

- Fresh water is a scarce resource internationally and in SA
  - Pressure on allocating scarce water between number of different uses (Ki-moon, B 2012:v)

- In SA water demand often exceeds water supply (Backeberg and Reinders, 2004).
  - Irrigated agriculture uses roughly 40% of exploitable runoff.
  - Increasing pressure from government and other sectors on agriculture to use less water and maintain crop yields.

- Irrigated agriculture's direct contribution to GDP is limited (Jordaan & Grové, 2012; Nieuwoudt, Backeberg & du Plessis 2004:162)
  - May be an inefficient allocation of scarce resource to allocate fresh water to irrigated agriculture in SA.
- Internationally the water footprint is becoming more important and attracting more attention from researchers.
  - The Water Footprint Network (WFN) is leading international research efforts on water footprints

WATER FOOTPRINT CONCEPT

- Hoekstra et al. (2011) define the water footprint of a product as the volume of fresh water (direct and indirect) that is used to produce a product, measured over the whole supply chain (or life cycle) of a product.

- Agricultural sector is crucial for food security in SA
  - Currently the agricultural sector is an inefficient user of fresh water (Nieuwoudt, Backeberg & du Plessis 2004:162)

    => Need to use water efficiently

- It is believed that water footprint information can guide policy towards sustainable use of fresh water (Hoekstra *et al.*, 2011).

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RATIONALE

- Dairy industry is important in South Africa from economic perspective (DAFF, 2014).
  - Contribute 7% of gross value of agricultural production.
  - Employ large number of workers along dairy value chain.

- Dairy industry's water usage is under increased scrutiny
  - Recent publicised farm visits in WC

- Dairy WF lies largely in feed production (95%+) (Hoekstra 2012, Mekonnen and Hoekstra 2010)
  - Thus, to minimise WF of dairy production focus on water use in production of feed for cows.

- Lucerne is a major feed crop for dairy cows in South Africa.
  - No information available to inform sustainable water use for production of lucerne in SA.

⇒ Objective to generate such info by exploring the WF of lucerne production on farm level
  - Follow the Global Water Footprint Standard developed by WFN to calculate the volumetric WF indicator for lucerne production in Vaalharts Irrigation Scheme.
    - as part of project assessing water footprints of field and forage crops, and food products derived from such crops.

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METHODS

- **Blue water footprint**: Surface and groundwater that is consumed along the value chain of a product. (Hoekstra et al., 2011:23).

- **Green water footprint:** All the rainwater that does not become run-off or the total volume of rainwater consumed during the production process (Hoekstra et al., 2011:30).

- **Grey water footprint:** The volume of freshwater needed to reduce the pollutants to ambient levels. (Hoekstra et al., 2011:30).

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METHODS (CONTINUED)

- Blue WF => Minimum of Irrigation Requirement and Effective Irrigation
- Green WF => Minimum of Effective Rainfall and Crop Water Requirement (ET)
- Grey WF => $WF_{proc,grey} = \frac{L}{c_{max} - c_{nat}}$ [volume/mass]
  - pollutant load that is discharged into the water body divided by the difference between the ambient water quality standard for that pollutant (the maximum acceptable concentration c_{max} and the natural concentration in the receiving water body, c_{nat} (Hoekstra et al. 2011:30)

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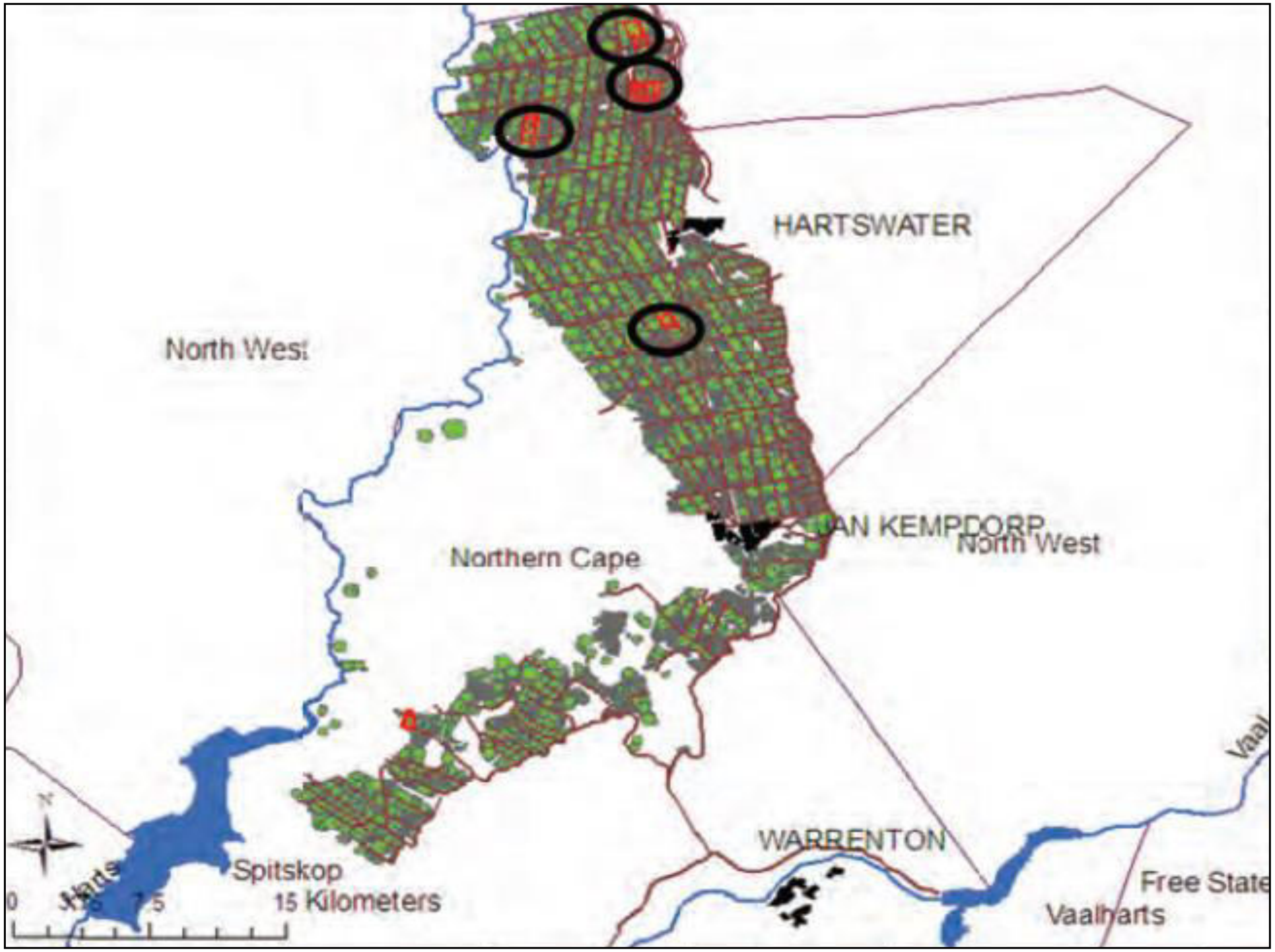
LUCERNE WATER DATA

- Vaalharts irrigation scheme - between the Vaal & Harts Rivers, Northern Cape
  - Falls within the Lower Vaal Water Management Area (WMA), Vaal River the main supplier of water to the irrigation scheme (Van Rensburg et al., 2012:30)
  - Inter-field and Intra-field differences => Need several measuring points to represent the bio-physical conditions in soils
  - 4m x 4m plots
  - Data measured over four seasons (two summers; two winters)

LOCATION MAP



LUCERNE BIOMASS PRODUCTION

- 4m x 4m ($16m^2$) manually cut when the whole field was cut
  - Weighed "wet", sample taken and dried in an 100^0C oven to obtain DM
  - Moisture content of the sample used to calculate DM of the $16m^2$ plot, yield then converted to DM/ha

- Process duplicated at every measuring point, every time the rest of the field was cut

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RESULTS: BLUE WATER FOOTPRINT

- Blue water footprint of a growing crop => minimum of the irrigation requirement and the effective irrigation
  - Irrigation requirement (IR) is the difference between the crop water requirement and the effective rainfall (Chapagain 2014)
  - IR of 524mm is smaller than the effective irrigation the blue water footprint of producing lucerne in Vaalharts is 524mm per year

Average	ET crop (mm)	Rain Eff. (mm)	Irrigation (mm)	Irrigation Req. (mm)	Rain + Irrigation (mm)
	1157	633	605	524	1238

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BLUE WATER FOOTPRINT (CONTINUED)

- ET_{blue} => 524.19mm/year
  - Convert to spatiotemporal dimension
    - » 5 241.93m^3/ha
  - Express WF in terms of volume per unit of output
    - » 171.34m^3/ton

ET Crop	ET Blue	CWU Blue	Yield	WF Blue
mm/period		m^3/ha	ton/ha	m^3/ton
1157.19	524.19	5 241.93	30.59	171.34

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RESULTS: GREEN WATER FOOTPRINT

- Green water footprint => minimum between effective rainfall and crop water requirement (Chapagain 2014)
  - Effective rainfall of 633mm is far smaller crop water requirement of 1 157mm.
  - Green WF of producing lucerne is therefore 633mm per year

Average	ET crop (mm)	Rain Eff. (mm)	Irrigation (mm)	Irrigation Req. (mm)	Rain + Irrigation (mm)
	1157	633	605	524	1238

GREEN WATER FOOTPRINT (CONTINUED)

- ET_{Green} => convert to water footprint of an hectare,
  - 6 330m^3ha^{-1}
  - Express WF in terms of volume per unit of output
    - 206.9$m^3.ton^{-1}$

ET Crop	ET Green	CWU Green	Yield	WF Green
mm/period		m^3/ha	ton/ha	m^3/ton
1157.19	633.00	6 330.00	30.59	206.9

RESULTS: GREY WATER FOOTPRINT

- Total salts drained per hectare taken as the load (L).
  - Drained total dissolvable salts already accounts fertilizer leaching and deterioration in irrigation water quality
- The load => 3 486 $kg.ha^{-1}$
- C_{max} taken as the EC_e of the soil at the end of the production season => True Grey WF
  - C_{max} => 252.25mS m^{-1} convert to $kg.l^{-1}$

EC_e (mS m^{-1})	ΔS_{Soil} (kg ha^{-1})	S_R (kg ha^{-1})	S_I (kg ha^{-1})	$\pm S_D$ (kg ha^{-1})	S_{Pre} (kg ha^{-1})
252.25	-1278	95	2662	-3486	-549

GREY WATER FOOTPRINT (CONTINUED)

- C_{nat} natural concentration in the receiving water body (Hoekstra et al. 2011:30)
  - – EC_i of irrigation water taken as c_{nat}
  - – C_{nat} => 58.4mS m^{-1} convert to $kg.l^{-1}$

$$WF_{grey,Lucerne} = \frac{3486kg.ha^{-1}}{193.8 \times (7.5 \times 10^{-6})kg.l^{-1}}$$

$$WF_{grey,Lucerne} = 2397557.20\ l.ha^{-1}$$

$$= 2397.56\ m^3.ha^{-1}$$

$$= \mathbf{78.37\ m^3.ton^{-1}}$$

LUCERNE WATER FOOTPRINT

- Total WF => Add Blue WF, Green WF and Grey WF

ET_{Crop}	ET_{Green}	ET_{Blue}	CWU	CWU_{Green}	CWU_{Blue}	WF_{Grey}	Yield
mm/period			m^3/ha				ton/ha
1157.193	633.000	524.193	11571.933	6330.000	5241.933	3282.329	30.594

$WF_{Lucerne}$	WF_{Green}	WF_{Blue}	WF_{Grey}
m^3/ton			
456.609	206.903	171.339	78.367

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CONCLUSIONS

- 456.6m^3 of water is used to produce 1ton of lucerne
- Green water footprint is largest of the three different types of water footprints of lucerne production.
- ➢ Special attention is needed on irrigation water use for lucerne production in Vaalharts to minimise water footprint.

- These results are only but part of the final result of WFA.
  - Only volumetric WF-indicator has been calculated.
    - Indicating volume of freshwater used in production of lucerne
    - Doesn’t provide any info on sustainability of water use
- Comprehensive sustainability assessment (Water footprint vs. available water) is needed, followed by response formulations.

Thank You
Dankie

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