MASSEY UNIVERSITY
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FARMED LANDSCAPES RESEARCH CENTRE

Water footprinting of pastoral dairy farming: effects of methods, data sources and spatial scale

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Courtesy: https://waterfootprint.org/

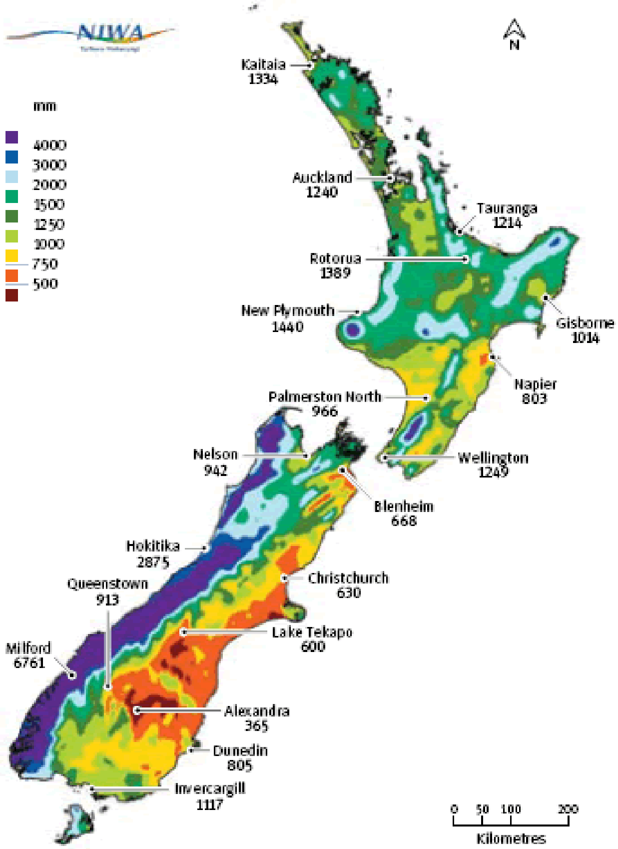

NZ land area is 27.1 million ha, out of which ~ 13.5 million ha under pastoral grazing mainly sheep and beef over 10 million ha

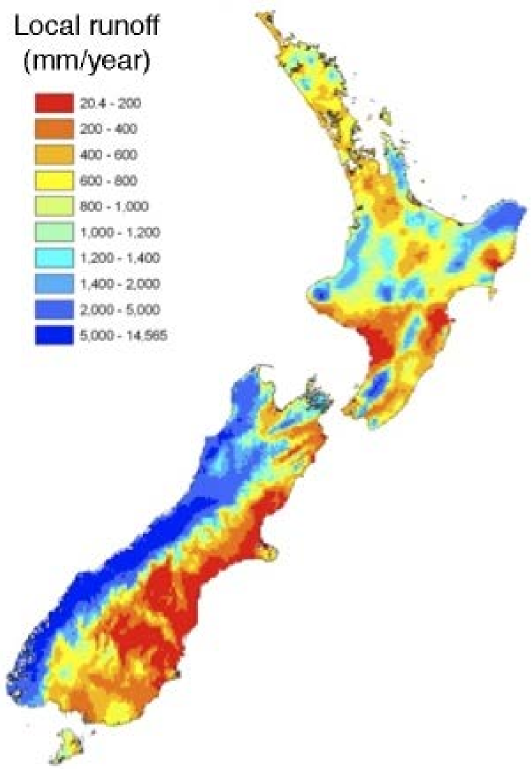
< 20% is flat and easy (gentling rolling) land includes NZs most versatile soils

Most of flat land dominated by dairying (profitable), followed by horticulture, cropping, and market gardening

Climate: Spatial Variability

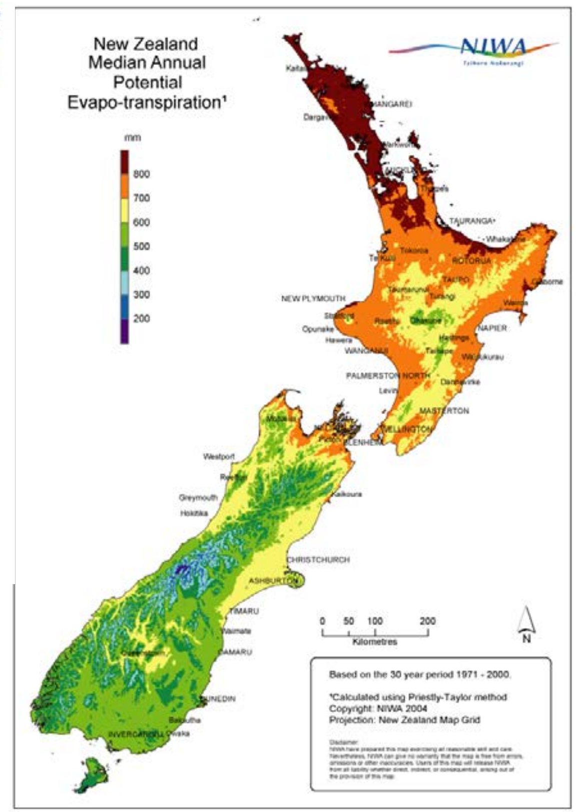
Rainfall (mm per year)





Source: Ross Woods (2011) Waiology

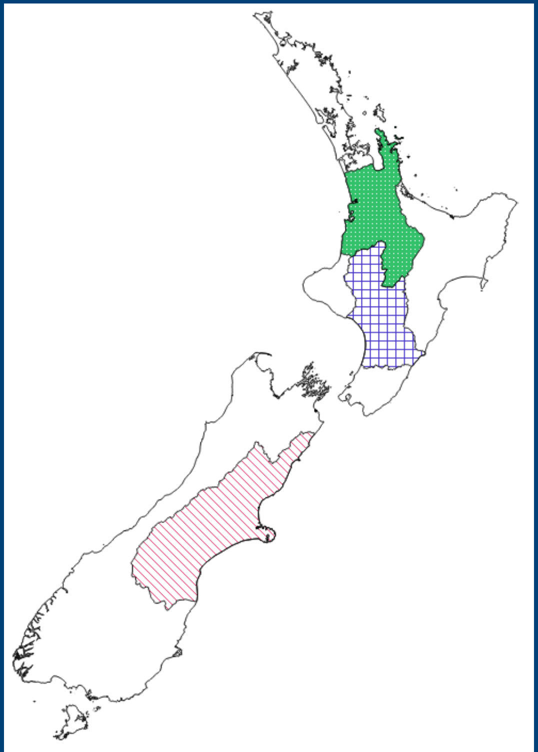
Evapotranspiration (mm per year)



Source: The State of New Zealand's Environment 1997, Ministry for the Environment, Wellington.

STUDY FARMS

- 88 FARMS
- OVER 2 YEARS 2013 – 2015
- ACROSS 3 REGIONS



Farm Parameters	Unit	Waikato non-irrigated	Waikato irrigated	Manawatu non-irrigated	Manawatu irrigated	Canterbury irrigated
Farm count	-	42	3	18	5	20
Average grassland area	ha/farm	172	132	172	363	212
Average stocking rate	Cows/ha	3.16	3.23	2.53	2.35	3.87
Milk production (*FPCM*)	L/cow/yr	5224	5796	5052	5339	5263
Electricity use on-farm	kW h/ha/yr	482.5	559.70	482.5	564.98	608.3
Brought-in maize silage	kg DM/ha/yr	1120	1200	1130	1030	1530
Brought-in pasture silage	kg DM/ha/yr	0	0	0	0	1530
Brought-in palm kernel expeller	kg DM/ha/yr	2800	2100	2000	1800	0
Barley grain	kg DM/ha/yr	0	0	0	0	1190
Wheat grain	kg DM/ha/yr	0	0	0	0	1200
Annual rainfall	mm/ha	1053	1074	1030	857	637
Applied irrigation	mm/ha/yr	0	250	0	417	658
Irrigated Area	ha/farm	0	81	0	238	212
% irrigated	%	0	61	0	66	100

STUDY METHODS:

We evaluated two water footprinting methods, as follows:

- Water footprint and the blue water footprint impact index ($WFII_{blue}$) as recommended by the Water Footprint Network (WFN); and
- AWailable WAter REmaining characterised water scarcity footprint (WF_{AWARE}) as recommended by the Water Use in Life Cycle Assessment (WULCA)

- ➢ The functional unit was specified as one kilogram of energy corrected milk, i.e. milk corrected for fat and protein milk (**FPCM**)
- ➢ The analysis scope was limited to the direct use of water at the farm and in-direct use of water for imported feed.
- ➢ Water use outside the farm gate including transport, processing, fertiliser production, and electricity use were not considered.

leap LIVESTOCK ENVIRONMENTAL ASSESSMENT AND PERFORMANCE PARTNERSHIP

A.-M. Boulay et al.

Water TAG (2016-19)

Ecological Indicators 124 (2021) 107391

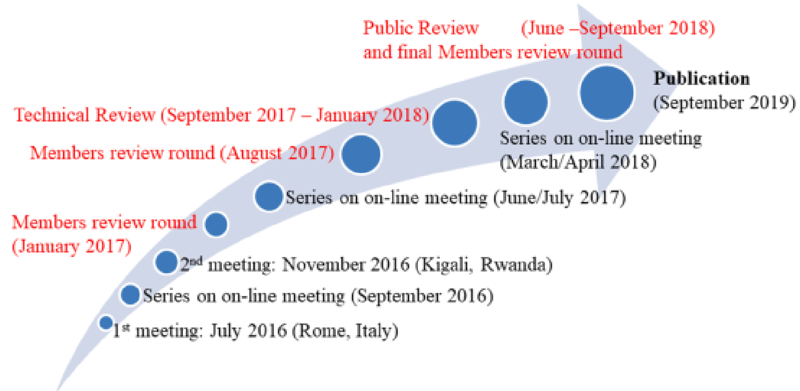
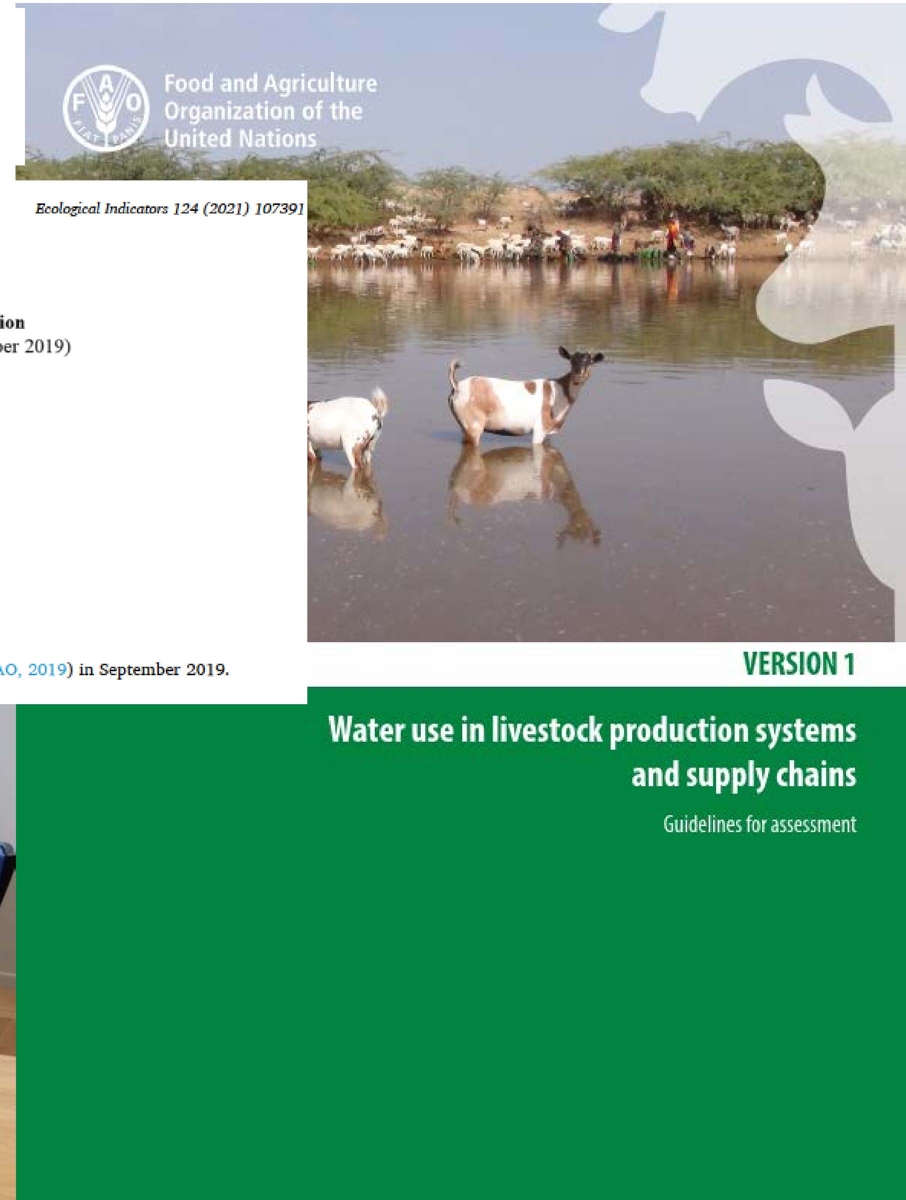


Fig. 2. Activities of the Water TAG between the first meeting in July 2017 and Publication of the Guidelines (FAO, 2019) in September 2019.



http://www.fao.org/partnerships/leap/en/

STUDY METHODS:

WFN method (Hoekstra et al., 2011)

$$WF_{Green} = \frac{ET_{green}}{Yield_{FPCM}}$$

$$WF_{blue} = \frac{\sum ET_{blue} + SDW + MPW}{Yield_{FPCM}}$$

$$WFII_{Blue} = WF_{blue} \times WS_{blue}$$

$$WS_{blue} = \frac{\sum WF_{blue}}{WA_{blue}}$$

$$WA_{blue} = R_{nat} - EWR$$

AWARE method (Boulay et al., 2017)

$$AMD_i = \frac{(Availability - HWC - EWR)}{Area}$$

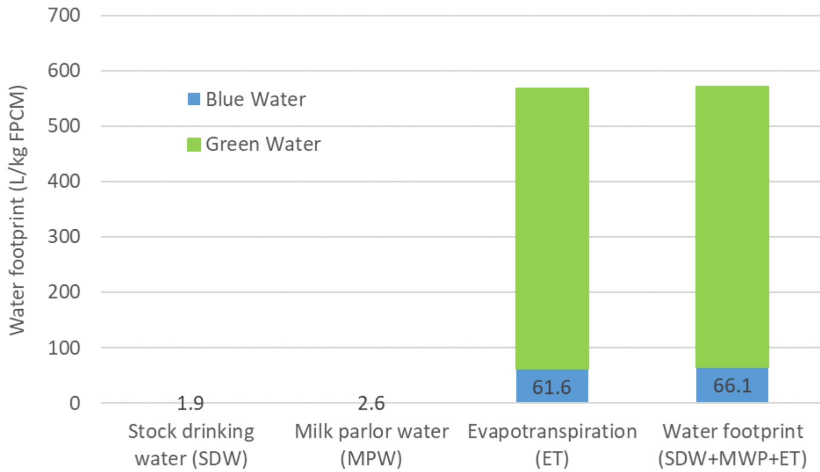
$$STe_i = \frac{1}{AMD_i}$$

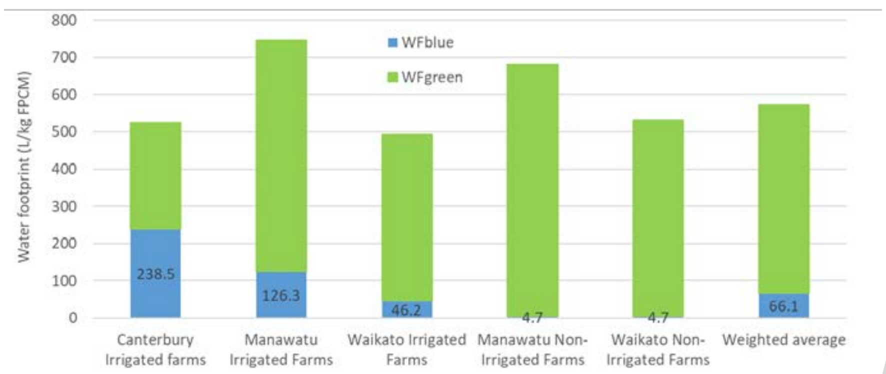
$$CF_{AWARE} = \frac{STei}{STe_{worldaverage}}$$

CF_{AWARE} to range from 0.1 to 100

$$WF_{AWARE} = WF_{Blue} \times CF_{AWARE}$$

Parameter	Global data source	Local data source
Rainfall (P) and reference evapotranspiration (ET_o)	CLIMWAT 2.0 for CROPWAT.	The National Institute of Weather and Atmosphere Virtual Climate Station Network (Cichota et al., 2008).
Green water consumption (ET_{green})	A minimum of ET_c and P_{eff} (Allen et al, 1998; Hoekstra et al., 2011)	A locally developed and calibrated soil water balance model (Scotter et al., 1979), using local climatic and soil conditions.
Irrigation water consumption (ET_{blue})	Difference between ET_c and ET_{green} (Allen et al, 1998; Hoekstra et al., 2011)	The minimum of the difference between the modelled ET_c – ET_{green} (Scotter et al., 1979) for pasture growth and maize silage, and the difference between ET_c and ET_{green} (Allen et al, 1998; Hoekstra et al., 2011) for pasture silage, barley grain, and wheat grain.
Stock drinking water use (SDW)	Estimated stock drinking water (Zonderland-Thomassen and Ledgard, 2012).	Measured stock drinking water (Higham et al., 2017a, Higham et al., 2017b).
Milking parlor water use (MPW)	Estimated milking parlor water use (Zonderland-Thomassen and Ledgard, 2012).	Measured milking parlor water (Higham et al., 2017a, Higham et al., 2017b).
Available water (WA)		A locally calibrated and validated rainfall-runoff model (Woods et al. (2006)
Rainfall variation factor (VF)		Calculated by Mellor et al. (2016) from Woods et al. (2006) GIS layer.
Environmental requirements (EWR)		Based on local water allocation limits in the Waikato region. Environmental requirements of 37% were used as is suggested for New Zealand (Smakhtin et al., 2004, Zonderland-Thomassen and Ledgard, 2012).
Water consumption (HWC)		Actual water abstractions from Aqualinc (2010) and consumptive water fraction from Shiklomanov and Rodda (2004).
WULCA – CF_{AWARE}	Global layer (WULCA, 2016).	Calculated from locally sourced data listed in this table.
WFN – WS_{blue} CF	Global layer (Mekonnen and Hoekstra, 2016).	Calculated from locally sourced data listed in this table.





Based on the Local data used,

~ 88% of the weighted average water footprint is green water consumed.

However,

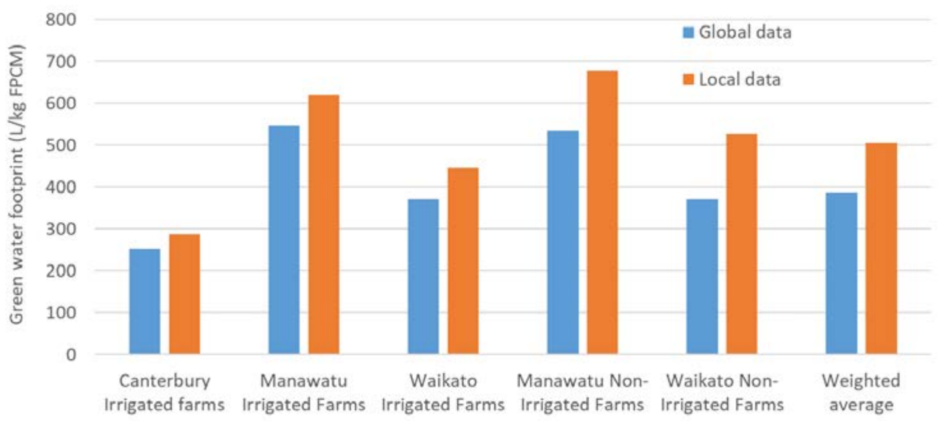
the share of green water and blue water is highly variable across the study regions

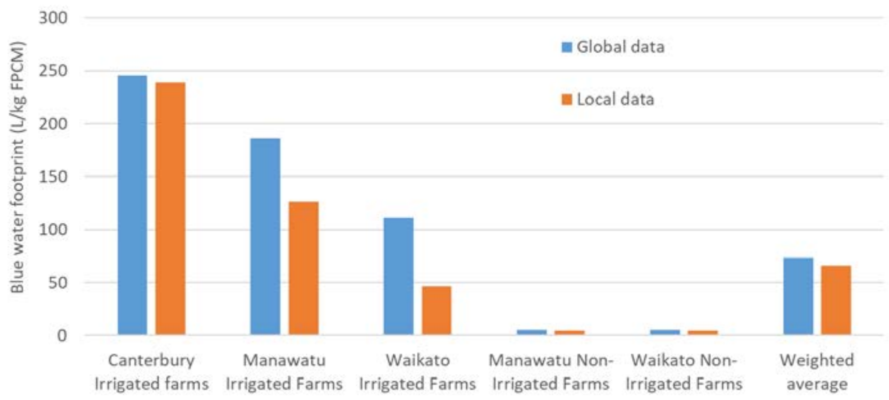
The global data model

underestimated the green water footprint,

while,

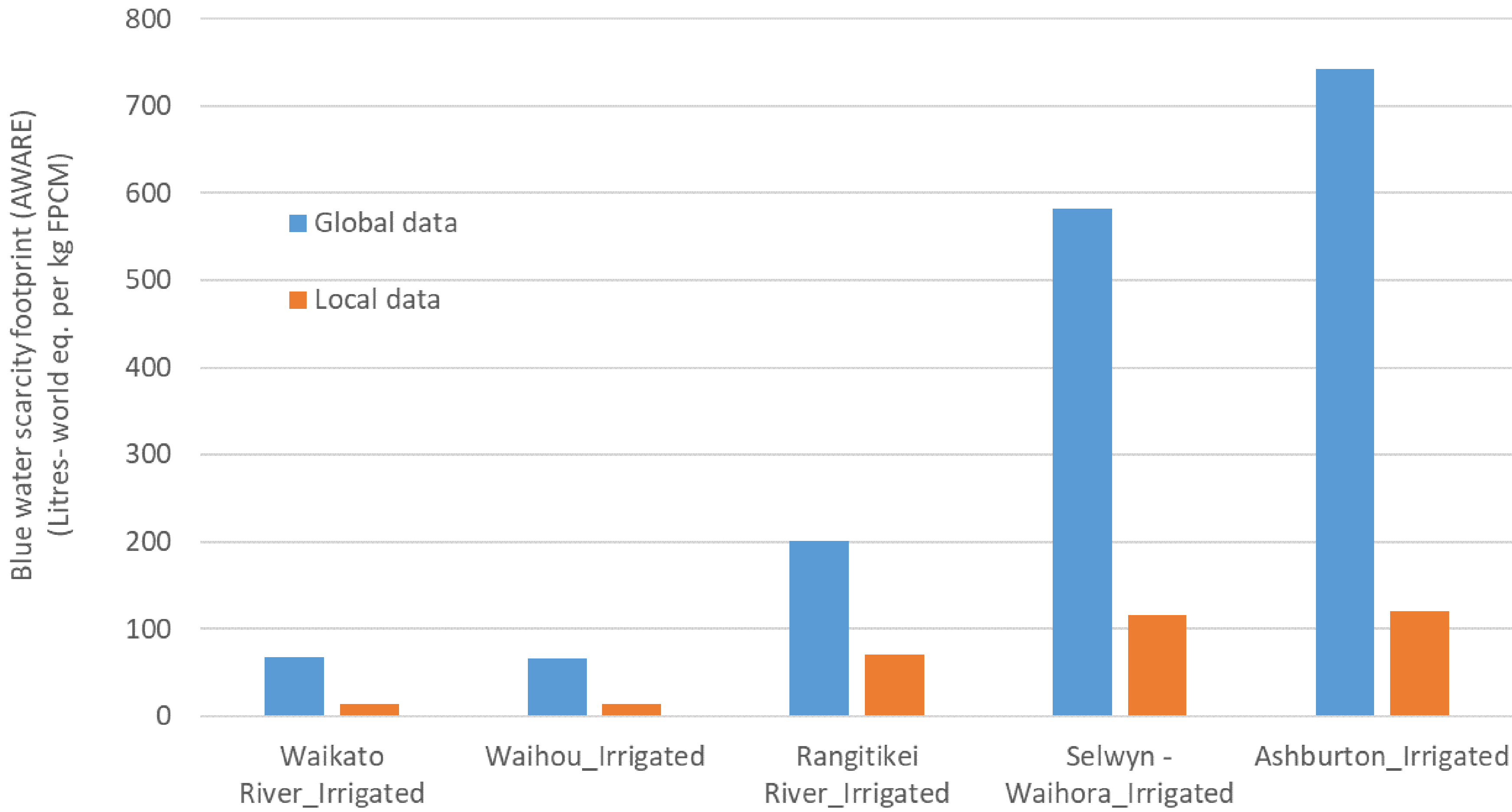
overestimated the blue water footprint.





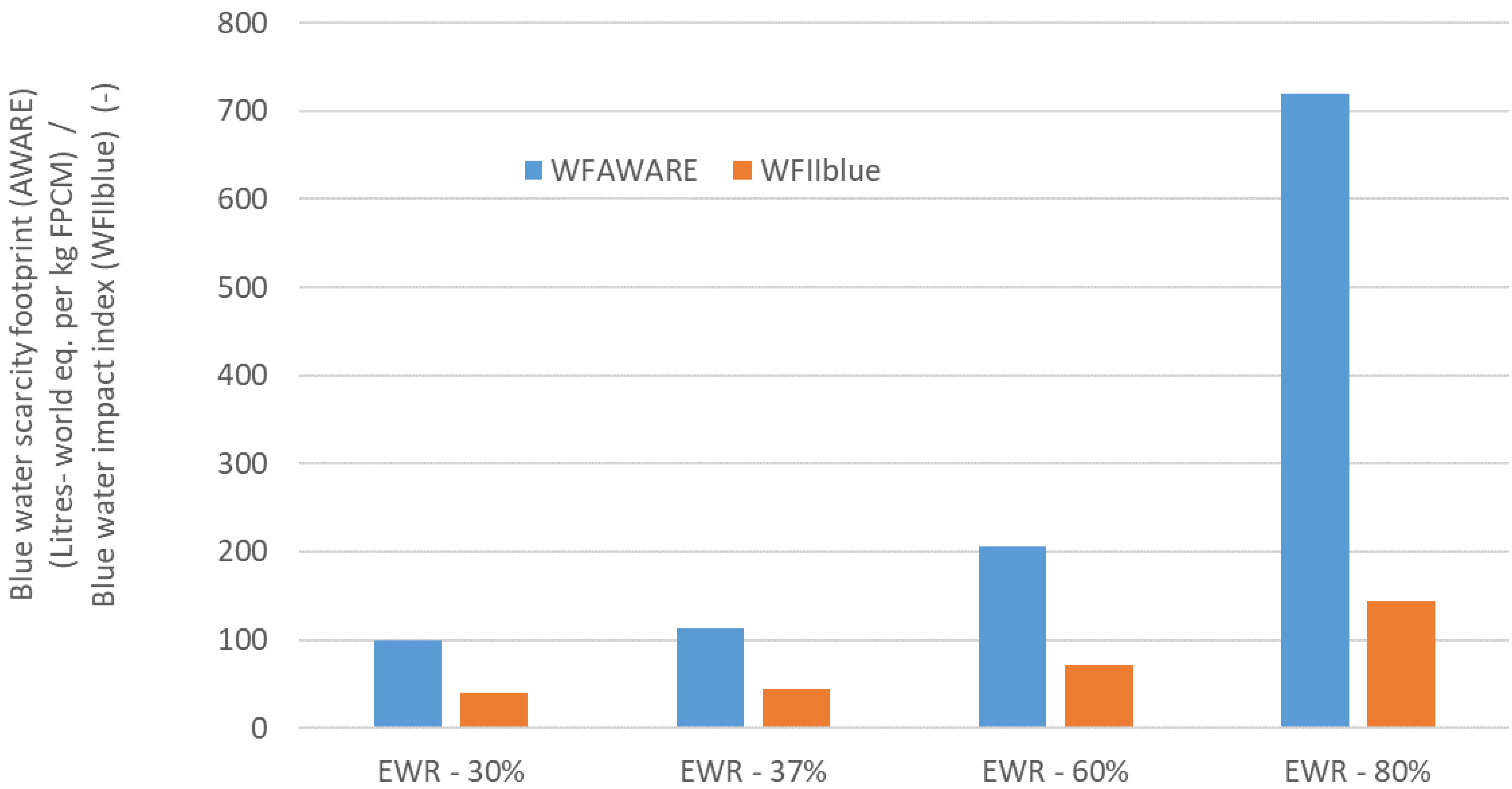
Characterized blue water impact index ($WFII_{blue}$) (as per WFN method) of irrigated dairy farms in different catchments

Characterized blue water scarcity footprints (WF_{AWARE}) (as per AWARE method) of irrigated dairy farms in different catchments



Sensitivity of $WFII_{blue}$ (Hoekstra et al., 2011) and WF_{AWARE} (Boulay et al., 2017) to environmental water requirement (EWR) scenarios

An example analysis of irrigated farms in Canterbury Region



However, both the $WFII_{blue}$ and WF_{AWARE} methods ranked the blue water footprint of farms in a similar order..

Concluding Remarks

The case study results suggests that :

✓ effects of different models, data sources, and spatial scales on quantification of livestock water footprints can be very large, ‘as shown in this case study for pastoral dairy farming in New Zealand conditions’

✓ need to be careful when drawing comparisons between livestock water footprints estimated by different models and data inputs over different spatial scales

✓ global data model resulted in considerable uncertainty in the characterization factors and characterized blue water footprints of dairy farming across different regions of New Zealand

✓ a robust quantification of livestock water footprints require well-defined local data inputs and water footprint calculation models to establish benchmarks and inform practices for water footprint reductions