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Review of International Water Use Methodologies and Application to Australian Agriculture

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Presentation Overview

- Review several methods for assessing water use in an outside LCA field in context of Australian agriculture.
- Explore basic methodology issues & inventory processes to integrate water use into LCA.
- Focus on definitions & quantification of water use, rather than impact assessment.

Background – Key Points

- Water scarcity growing concern worldwide.
- Stress on water reserves increase dramatically in next 30 – 40 years.
- Competitive uses – agriculture, environment, domestic and industrial.
- Australia has adequate water reserves – not easily accessible in areas of high demand.

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Most competitive use is in Murray Darling Basin

1,059000 sq.km
1365 km north to south
Runoff = 4% rainfall (23,609 GL)

- Flows reduced by 61%
- River ceases to flow to ocean 40% time (<1% before extraction)

Background – Key Points

- Methods that are appropriate for Australian ag. need to provide information at product level for:
  - use of competitive surface & ground water resources
  - use of tradable water resources
  - use of rainwater resources
  - environmental impacts of usage.

Background – Key Points

- Australian Bureau Statistics (ABS) – have an established method for defining water use.
- However at product level – water usage data from field of VW or WF – different definitions.
- Ag. industries commissioning LCA want various outcomes:
  1. Robust data to inform general public.
  2. Inform govt. and promote better water initiatives.
  3. Identify risks and opportunities for water use efficiency.
  4. Precise terminology (discuss competitive and non-competitive uses)..

Literature – water use for beef

Water Required L/kg beef	Methodology	Functional Unit and System Boundary	Country	Reference
105,400	Not defined by author	Unclear – Pasture and grain fed cattle, likely includes upstream impacts (breeding)	USA	Pimentel *et al.* (1997)
15,000 – 70,000	Not defined by author	1 kg of meat, boundaries are unclear	not known	Gleick, in Gleick *et al.*(2009)
43,000	Not defined by author	Unclear – Grain fed cattle.	USA	Pimentel *et al.* (2004)
17,112	VW / WF – methodology defined	Boneless beef [1]	Australian average	Hoekstra & Chapagain (2007)
15,497	VW / WF – methodology defined	Boneless beef [1]	World average	Hoekstra & Chapagain (2007)
27 – 540	LCA – water use defined as extracted water [2]	Carcass weight	Australian southern beef production	Peters *et al.* (2010)

[1] Water use is over the slaughter animal's lifetime only and does not include upstream impacts
[2] Methodology defined by Australia's data accounting agency, the Australian Bureau of Statistics (ABS).

Literature - Water in LCA

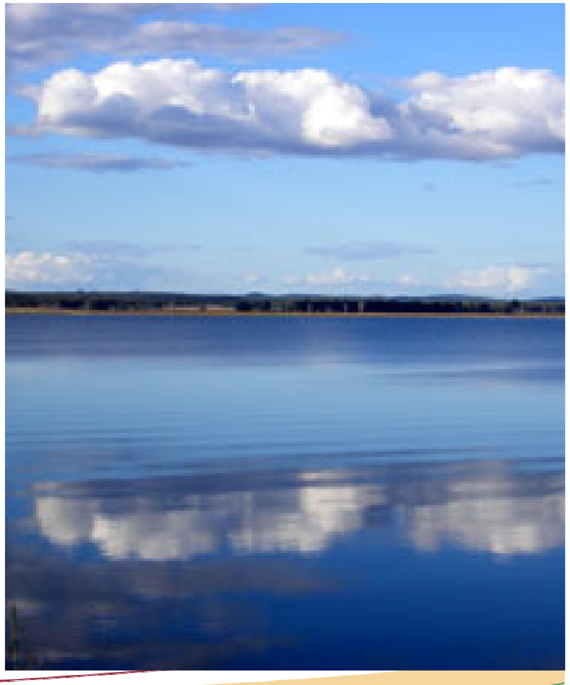
- Can be classified using abiotic resources based on regeneration potential.
  - Firstly - Deposits, funds and flows.
  - Further differentiated - In-stream and off-stream (*Owens 2002*)
    1. In-stream water use indicator.
    2. In-stream water consumption indicator.
    3. Off-stream water use indicator.
    4. Off-steam water consumption indicator.
    5. Off-stream water depletion indicator.

Literature - Water in LCA cont'd

- We suggest two additional rainfall sources
  6. Captured rainfall before entering a stream.
  7. Rainfall stored in soil for use by plants

Virtual Water / Water Footprinting

- VW (*Allan 1998*) – water required to produce tradable commodities (food) in water stressed economies.
  - Valuable contribution – water transferability - water saved by importing products
- Further improvements
  - Blue water or liquid water from ground/surface water + Green water or evapotranspiration – *Falkenmark (2003), Falkenmark &* Rostrom (2006)
  - Plus grey water (waste water) are now adopted terms in WF field - *Hoekstra et al 2003*.



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Virtual Water / Water Footprinting

- Early WF / VW looked at retrospective analyses for crops, livestock DM requirements for pasture water & drinking water intake retrospectively.
- Prior to the distinction of blue/green/grey water sources, VW/WF results led to erroneous conclusions, e.g. where WF was considered as water 'extracted' from a surface or ground water source.

Virtual Water / Water Footprinting

- Majority of the WF for ag. products in Australia is green water - very different opportunity costs and impacts.
- WF methodology has expanded rapidly:
  - addressed many early problems
  - adopting more rigorous inventory framework
  - incorporated terms to differentiate water sources (e.g. *Hoekstra et al. 2009*)

Suggested Modified Approach

- Several authors proposed modified WF / LCA approach for estimating water use for agricultural products (*Ridoutt et al.(2009a, b), Pfister et al. (2009), Milà i Canals et al. (2009) and Ridoutt & Pfister (2010)*).
  - Identify need for more detailed inventory methods (differentiation between blue and green water).
  - Authors propose excluding green water from the impact assessment (*Ridoutt & Pfister (2010) and Pfister & Hellweg (2009)*), with weighting factor to indicate the impact of water use.
    - Useful approach for LCA, not received as accepted modification to the WF concept by leading WF researchers.

Handling Green Water

- Several authors (*Ridoutt et al. (2009), Mila i Canals et al. (2009) and Ridoutt & Pfister (2010)*) suggest green water categorised under land use category in LCA.
- Ridoutt *et al.* (2009) identifies the following limitations:

  i. changes in water productivity for rain-fed production systems **cannot** be identified,

  ii. studies **not able** to identify systems that maximise the calorific/nutritive value per unit of water consumed.

Handling Green Water cont'd

- We contend - report as an independent resource due to importance for global food production.
- Green water can be stored (for short period) in soil and used for alternative crops/ livestock production on same land: independent measure of green water efficiency is meaningful.
- Where to - more research required to develop impact categories and indicators, with methodology development for land use.

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Water Engineering

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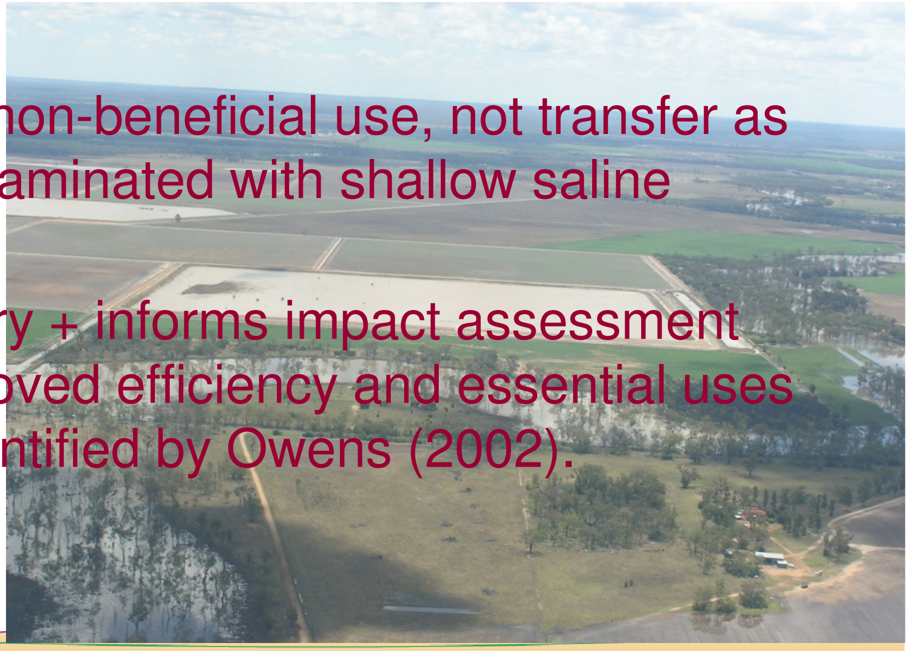
- Water engineers - water balance of inputs and outputs in a defined system to identify all flows.
- Vary greatly in their degree of complexity and the accuracy of results
- Complicated by confusion between ‘transfers’, ‘uses’ and ‘losses’.
- Water balances are useful in their comprehensive coverage of both beneficial uses and losses.
- Water balances/partial water balances created at the local, regional & catchment level in Australia - data from these used to create an inventory of water use for a product.

Farm Scale Water Balances

- Area of greatest impact for water use is often here!
- Can provide detailed inventory data at the farm & identify '**beneficial**' / '**non-beneficial**' uses → may lead to higher water use for some irrigated products (storage evap. & seepage).
- Retrospective water use estimates based on evapotranspiration for plant growth & drinking water requirements - will not include **non-beneficial uses**.
- Seepage losses to groundwater is a non-beneficial use, not transfer as many Australian systems will be contaminated with shallow saline aquifers.
- FSWB give a more complete inventory + informs impact assessment phase + allows identification for improved efficiency and essential uses – report with sources & indicators identified by Owens (2002).



Extracted Water

- ABS define water use as distributed water use + self-extracted water use + reuse water use.
- Distributed (purchased) and self-extracted (not purchased) water use - water supplied from engineered delivery systems.
- Identified as being drawn from either a surface or groundwater source - similar to ‘off stream’ indicators (*Owens 2002*).
- Assume all uses are consumptive for agriculture.
- Useful for identifying characteristics regarding transferability.
- ABS data - generally considered transferrable between industries and the environment .
- Major omission from ABS definition: water sourced from direct capture of rainwater on-farm prior to reaching a stream or river

Classifying Additional Water Sources?

Transferability score	Source descriptor	Spatial descriptor	Volume descriptor	Example of water source
Score 1	direct capture, non-transferrable non-competitive water use	Transferrable within < 10 km	< 5 ML	On-farm storage dam – only transferrable within local area and use limited to livestock drinking water.
Score 2	Non-transferrable competitive water use	Transferrable within < 5 km	< 100 ML	On-farm irrigation storage dam or groundwater aquifer – transferrable within local area for multiple uses.
Score 3	Non-transferrable competitive water use	Transferrable within < 20 km	> 100 ML	On-farm irrigation storage dam or groundwater aquifer – transferrable within local area for multiple uses.
Score 4	Transferrable competitive water use	Transferrable within > 10km	> 5 ML	Transferrable via river system or local aquifer

Australian Red Meat – Case study

- Peters *et al.* (2010) - ‘water use’ defined as ABS def’n (extracted water).
- Ranged from 27 – 540 L / kg of beef (carcass weight). 27 L is below drinking water requirements for beef cattle (~130 L / kg carcass) – on-farm dam water omitted.
- More comprehensive assessment - water balances for each property to define all water flows (inc. rainfall) + categorised water use by quality change related to water movements.

Australian Red Meat – Case study

- >97% of the water used in the grazing beef system derived from rainfall on the property - **not** comparable to a green water due to differences in methodology (water balance vs retrospective estimates from pasture consumption).
- Illustrates most Australian grazing system water use is mainly green water, and that most blue water could be classified as 'score 1 – 'direct capture, non-transferrable water use'.
- Data re-assessed to classify both extracted and direct capture water use (score 1)

blue water use increased order of magnitude, as 'score 1' water use includes evaporation losses from small storages.

Australian Pork – Case study

Source	Indicator	Transferability score	Use	Beneficial/non-beneficial	L/finisher pig
Farm storage	Off – stream consumption	Score 4	Evaporation off storage	non-beneficial	106
Groundwater – deep aquifer	Off-stream water depletion	Score 3	Drinking water	beneficial	603
Groundwater – deep aquifer	Off-stream water depletion	Score 3	Cleaning	beneficial	419
Groundwater – deep aquifer	Off-stream water depletion	Score 3	Maintenance / administration	beneficial	8
Farm storage	Off – stream consumption	Score 4	Evaporation off storage	beneficial	218
Direct capture of rainfall	Non-transferrable competitive water use	Score 2	Rainwater on effluent ponds	non-beneficial	243
Total					**1,597**

Summary of Case Studies

- Attempt to give more detailed water inventory.
- Results could be assessed under several different frameworks or with a number of impact assessment methods.
- Major limitation to the approach - time required to compile inventory - limits the number of supply chains that can be studied.
- Water - fluctuating resource, results may vary widely:
  - Between supply chains
  - Between seasons.

- Preferred option in future research – “Hybrid” with catchment scale ‘extracted water use’ and water balance data.

Conclusions

- Water assessment inventory methodology - rapidly expanding field.
- This paper contributes to this discussion using examples from animal agriculture and irrigation in Australia, where water stress and competitive supply are a serious issue for both the government and agricultural industries.
- We suggest that LCA studies adopt the water descriptors used for water footprinting (blue, green and grey water).

Conclusions cont'd

- To improve water assessment at farm level – use a water balance approach.
  - Identify water using the indicators provided by Owens (2002) or local indicators (ABS).
  - Incorporate other water sources captured directly from rainfall with 'transferability' scores and descriptors to further classify and differentiate between water sources.
- Additional detail required for on-farm water balances justified - dominance of farm in the supply chain for agricultural products.
- For LCA to inform supply chain managers of the *non-beneficial* uses and the potential for improvement in efficiency, a water balance is useful.

Conclusions cont'd

- Because of the importance of green water in global food production, must be considered as a resource by LCA.
- As noted by other researchers – green water intrinsically linked to land use and further methodology development needs to reflect these linkages.
- *However,* we believe it should still be treated as a resource with appropriate classification.
  - Enable LCA studies to identify more efficient products and management practices associated with green water resources.

- End -

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