Leibniz-Institut für Agrartechnik und Bioökonomie

Food and Agriculture Organization of the United Nations

Accounting for livestock water productivity: How and why?

Land and Water Discussion Paper 14

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A hybrid workshop, focused on Water use assessment of livestock production systems and supply chains

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Indicator: Water Productivity (WP)

- Productivity = Relation of Output to Input
- Water productivity [e.g. kg m^{-3}; kcal m^{-3}, € m^{-3}]

$$WP = \frac{\text{Output}}{\text{Water input}}$$

- Output [kg, kcal, €,....]
  · biomass
  · nutrition content per kg of product
  · purchase
  · ...

- Water input [m^3]
  · transpiration of precipitation
  (stemming from: infiltrated precipitation and soil water)
  · technical water
  (stemming from: ground- and surface water)
  · indirect water (water in prec-chains)

Boulay et al. (2021): Building consensus on water use assessment of livestock production systems and supply chains: outcome and recommendations from the FAO LEAP Partnership. Ecological Indicators. (Mai 2021): p. 107391.
Drastig et al. (2021) Accounting for livestock water productivity: How and why?. Technical Report. FAO, Rome.
FAO (2019): LEAP: Guidelines for water use assessment of livestock production systems and supply chains. Rom, 104 S.
Prochnow, A., Drastig, K., Klauss, H., Berg, W., 2012. Water use indicators at farm scale: methodology and case study. Food and Energy Security. 1 (1): 29-46

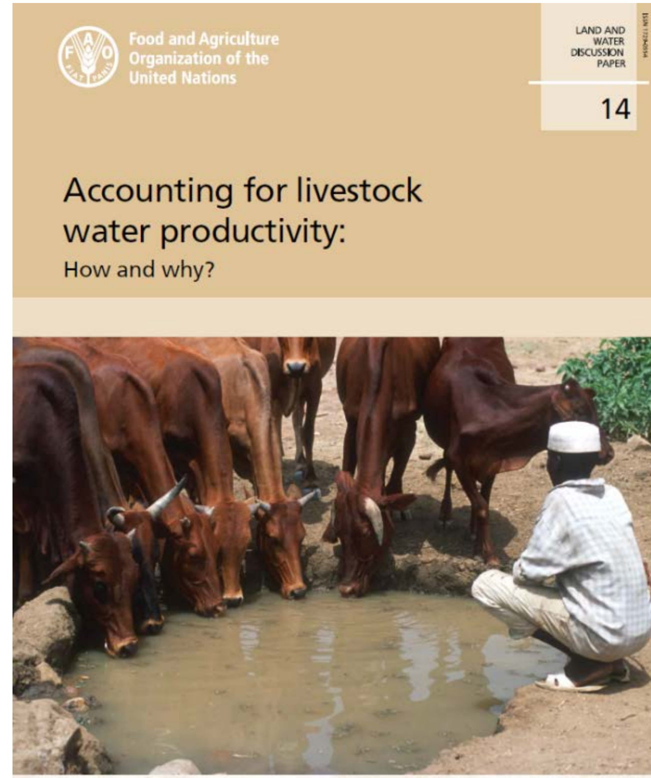
Accounting for livestock water productivity

How?

Various methods and approaches were analysed

Why?

Raising awareness
Impact assessment
Improvement of water productivity



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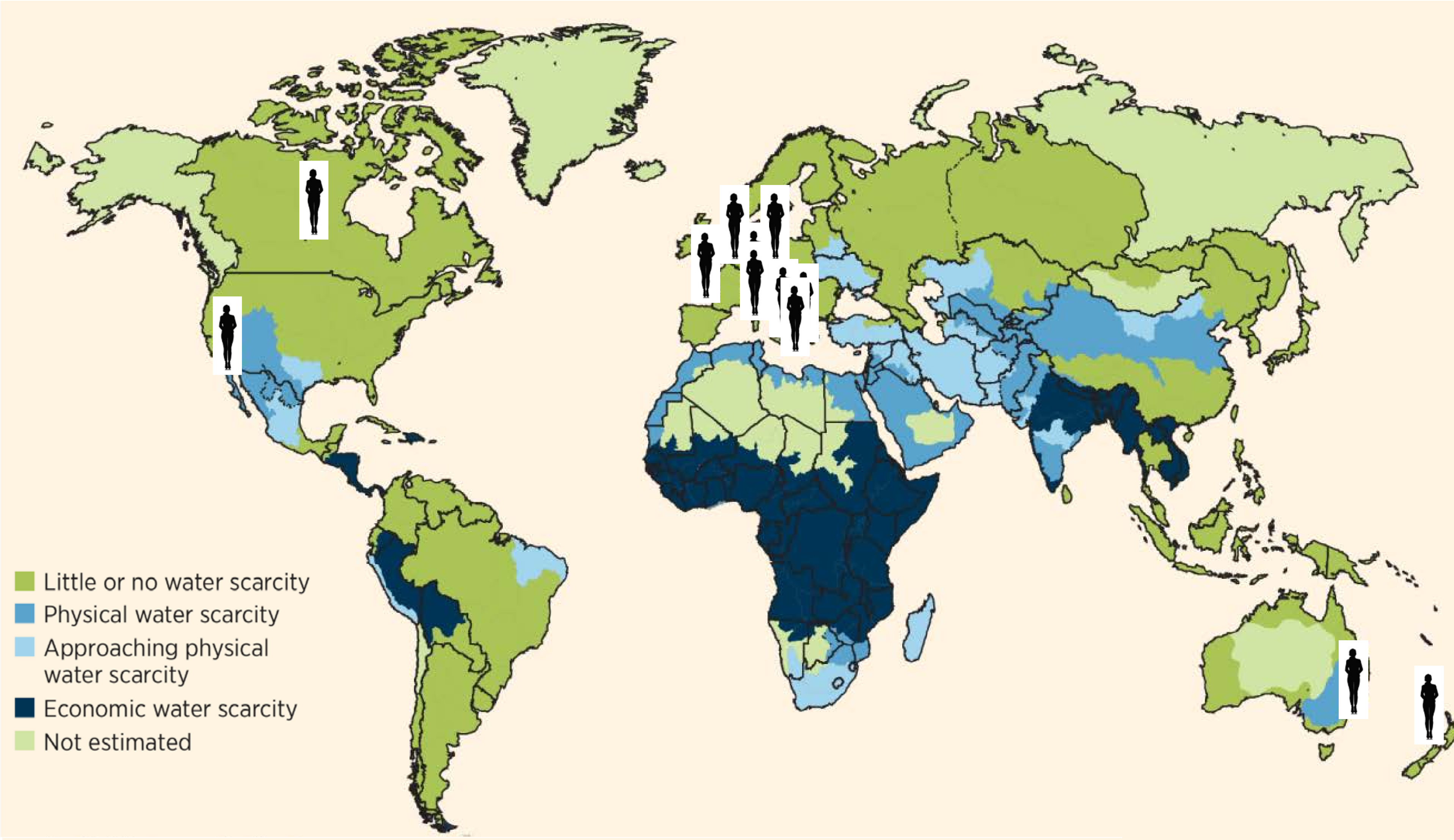


Source: Comprehensive Assessment of Water Management in Agriculture (2007, map 2.1, p. 63, © IWMI, http://www.iwmi.cgiar.org/).

Discussion paper – 50 studies

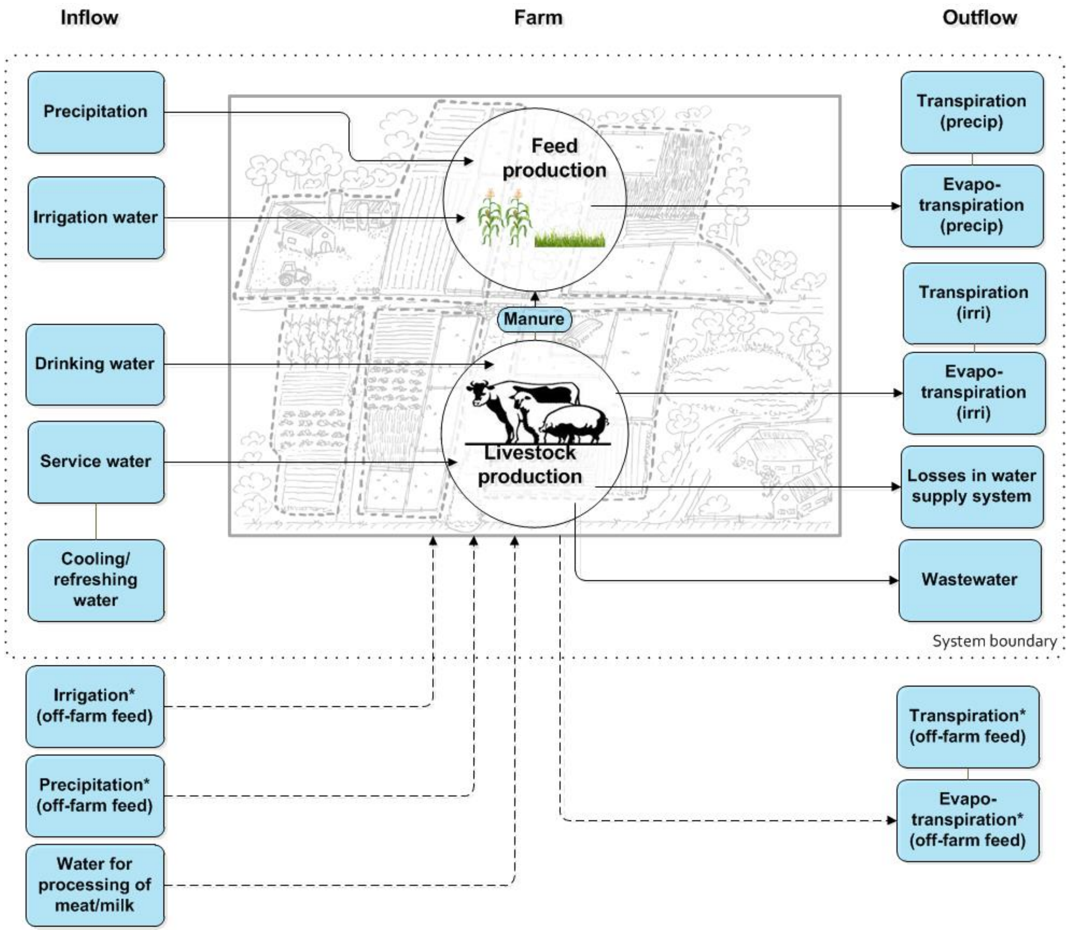
- Extensive literature search
- Additional relevant findings of research organizations, e.g. the International Center for Tropical Agriculture (CIAT), the National Institute of Agricultural Technology (INTA), Agribenchmark
- 50 studies

Study
Bekele, Mengistu & Tamir (2017)
Haileslassie et al. (2011a)
Haileslassie et al. (2011b)
Haileslassie et al. (2009)
Descheemaeker, Amede & Haileslassie (2010)
Ran et al. (2017)
Renault & Wallender (2000)
Srairi et al. (2016)
Ríos et al. (2012)
Quintero, W.M. (2014)
Atzori et al.(2016)
Beckett & Oltjen (1993)
Brown, Schreier & Lavkulich (2009)
Chapagain & Hoekstra (2003)
Chapagain & Hoekstra (2004)
Chapagain & Orr (2008)
Eady, Viner & MacDonnell (2011)
EBLEX (2010)
Hoekstra & Chapagain (2006)
Hoekstra & Chapagain (2007)
Hoekstra et al. (2011)
Owusu-Sekyere, Jordaan & Chouchane (2017)
Palhares & Pezzopane (2015)
Palhares, Morelli & Junior (2017)
Peters et al. (2010)
Singh et al. (2004)
Sultana et al. (2015)
van Breugel et al. (2010)
Mekonnen & Hoekstra (2012)
Zeng et al. 2012)
Drastig et al. (2016)
Krauß et al. (2015a)
Krauß et al. (2015b)
Prochnow et al. (2012)
Ridoutt & Pfister (2010)
Ridoutt et al. (2010)
Wiedemann et al. (2016a)
Wiedemann, Yan & Murphy (2016)
Wiedemann et al. (2015a)
Wiedemann et al. (2015b)
Wiedemann, McGahan & Murphy (2012)
Wiedemann, McGahan & Murphy (2017a)
Wiedemann, McGahan & Murphy (2017b)
Wiedemann, Yan, Henry & Murphy (2016b)
Wiedemann (2014)
Drastig et al. (2010)
Meul, Nevens & Reheul 2009)

Discussion paper

Analysis of:

- Assessment goals
- Water flows included
- Methodological approaches
- System boundaries
- Main findings in each of the studies

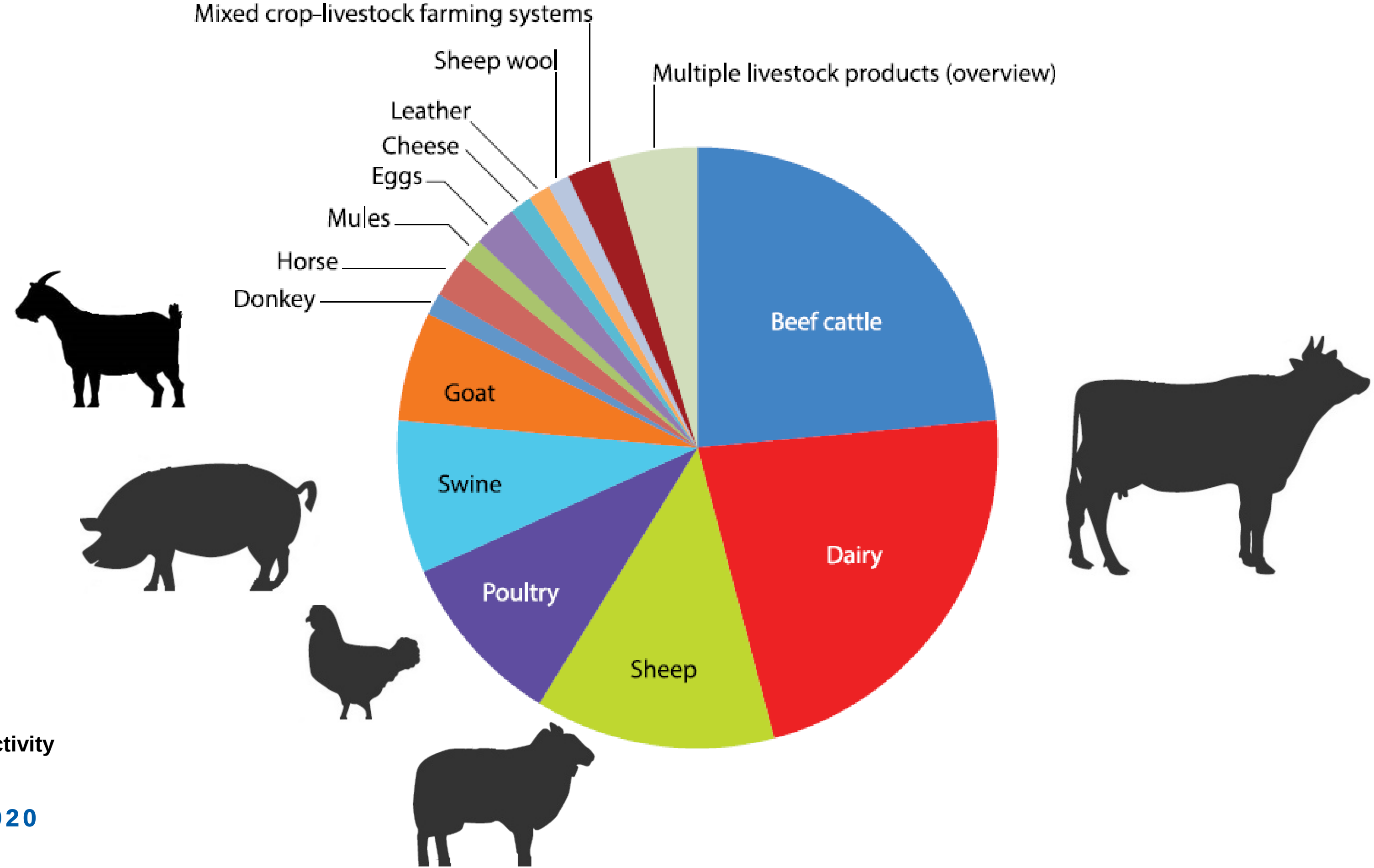


Results: Water flows taken into account

Study	Water stemming from precipitation		Technical water		
	Evapotranspiration	Transpiration	drinking	irrigation (withdrawal)	irrigation (consumption)
Bekele, Mengistu & Tamir (2017)	x				
Haileslassie et al. (2011a)	x				
Haileslassie et al. (2011b)	x				
Haileslassie et al. (2009)	x				
Descheemaeker, Amede & Haileslassie (2010)	x				x
Ran et al. (2017)	x				x
Renault & Wallender (2000)	x				x
Srairi et al. (2016)	x				x
Ríos et al. (2012)	x		x		
Quintero, W.M. (2014)	x		x		
Atzori et al.(2016)	x		x		x
Beckett & Oltjen (1993)	x		x		x
Brown, Schreier & Lavkulich (2009)	x		x		x
Chapagain & Hoekstra (2003)	x		x		x
Chapagain & Hoekstra (2004)	x		x		x
Chapagain & Orr (2008)	x		x		x
Eady, Viner & MacDonnell (2011)	x		x		x
EBLEX (2010)	x		x		x
Hoekstra & Chapagain (2006)	x		x		x
Hoekstra & Chapagain (2007)	x		x		x
Hoekstra et al. (2011)	x		x		x
Owusu-Sekyere, Jordaan & Chouchane (2017)	x		x		x
Palhares & Pezzopane (2015)	x		x		x
Palhares, Morelli & Junior (2017)	x		x		x
Peters et al. (2010)	x		x		x
Singh et al. (2004)	x		x		x
Sultana et al. (2015)	x		x		x
van Breugel et al. (2010)	x		x		x
Mekonnen & Hoekstra (2012)	x		x		x
Zeng et al. 2012)	x		x		x
Drastig et al. (2016)		x	x		
Krauß et al. (2015a)		x	x	x	
Krauß et al. (2015b)		x	x	x	
Prochnow et al. (2012)		x	x	x	
Ridoutt & Pfister (2010)			x		x
Ridoutt et al. (2010)			x		x
Wiedemann et al. (2016a)			x		x
Wiedemann, Yan & Murphy (2016)			x		x
Wiedemann et al. (2015a)			x		x
Wiedemann et al. (2015b)			x		x
Wiedemann, McGahan & Murphy (2012)			x		x
Wiedemann, McGahan & Murphy (2017a)			x		x
Wiedemann, McGahan & Murphy (2017b)			x		x
Wiedemann, Yan, Henry & Murphy (2016b)			x		
Wiedemann (2014)			x		
Drastig et al. (2010)			x		
Meul, Nevens & Reheul 2009)			x		

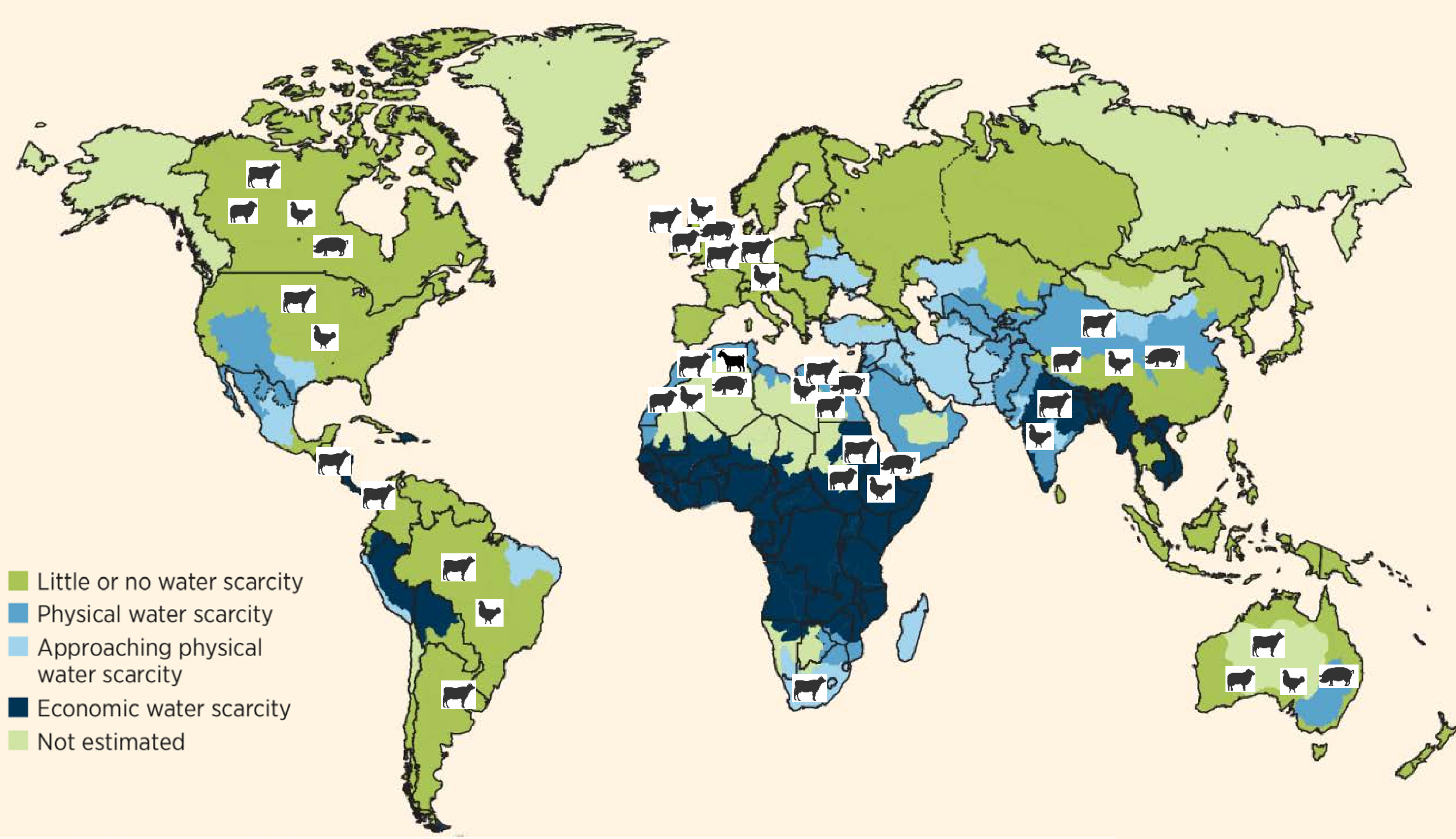
Livestock species

- Nearly half (46%) of the WP studies focused on beef cattle and dairy farms.
- Sheep, poultry, swine and goats were investigated in more than 20% of the studies.



WP: Water productivity

Countries with studies of water productivity



Source: *Comprehensive Assessment of Water Management in Agriculture (2007, map 2.1, p. 63, © IWMI, http://www.iwmi.cgiar.org/).*

Results

1. Key issue: Use of different definitions of water productivity resulted in meaningful accounting differences

- E.g. variation in the type of **output** product used (e.g. dry meat, fresh meat, protein value, calorific value, etc.)
- Inclusion or exclusion of the following water outflows as **water input**:
- Water flows associated with background processes
- Flows stemming from precipitation
- Unproductive evaporation
- Wastewater

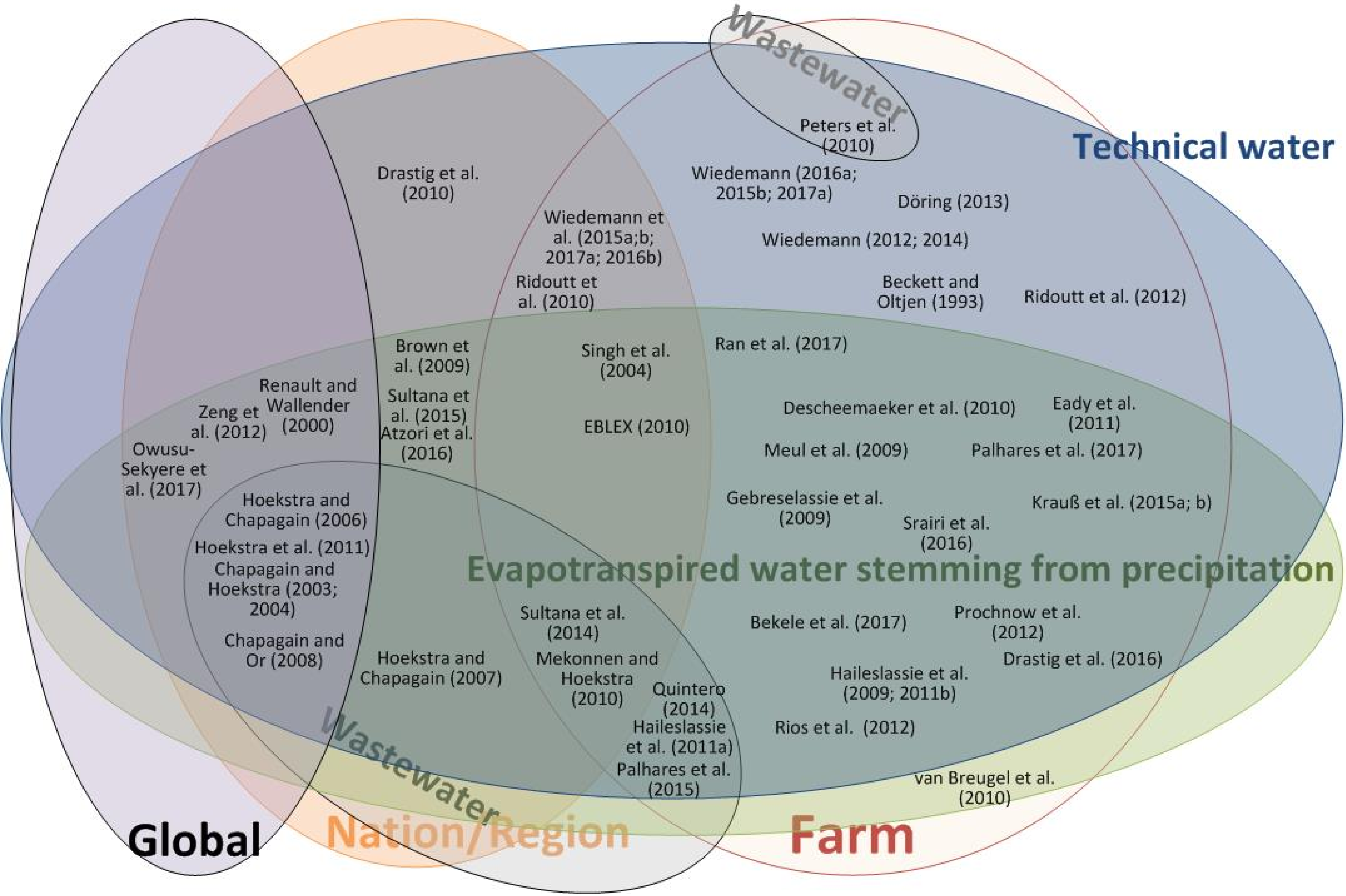
2. Key issue: Missing uncertainty assessment

Results - Main categories

The assessment approaches fell into three main categories:

- Volumetric/virtual water footprint (WFPa), e.g. Hoekstra *et al*., (2011) based on the virtual water concept (Allen, 1998)
- Water scarcity footprint (WFPb) LCA-based/ISO 14046:2014
- Water productivity (WP) e.g. Rockström and Barron, (2007); Descheemaeker, Amede and Haileslassie (2010); Molden *et al*. (2010); Kebebe *et al*. (2015); Haileslassie *et al*. (2009).

Specific Results: Methods – included Water flows (Input)



Specific results: Methods – included Water flows (Input)

- Evapotranspiration stemming from precipitation (33 Studies; $WFP_{volumetrisch}$)
- Only technical water (14 Studies; $WFP_{scarcity}$)
- Waste-water (11 Studies; mainly $WFP_{volumetrisch}$)

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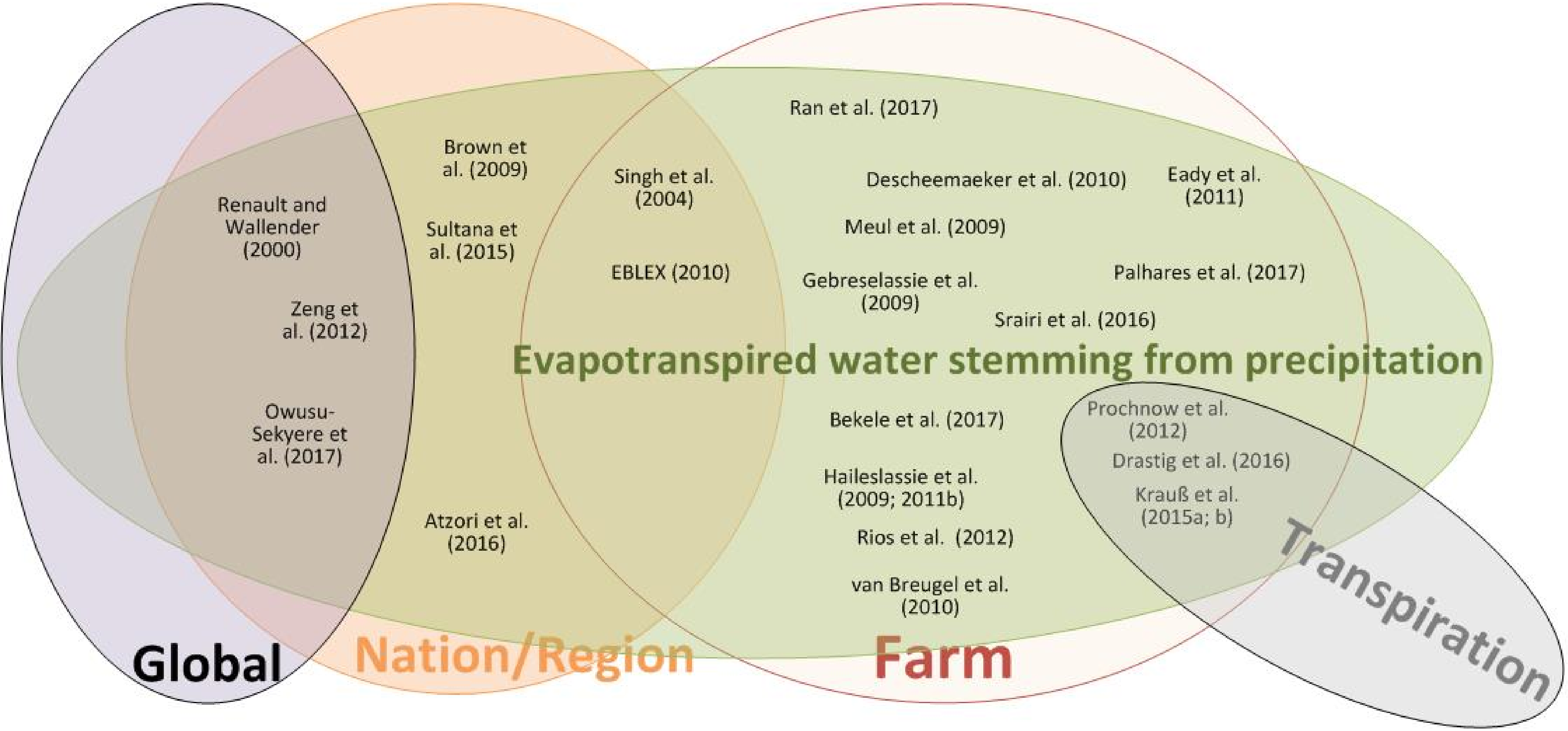
Meths – included water flows (Input)

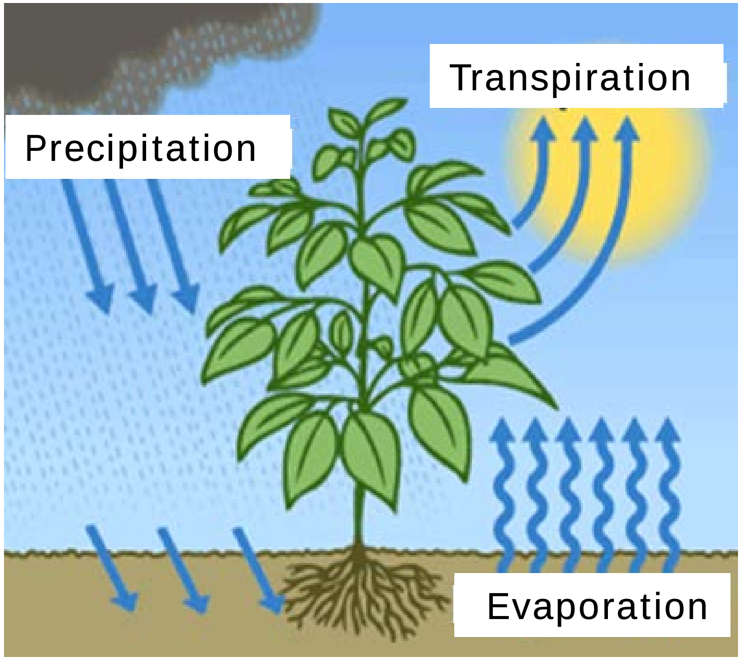


Evapotranspiration or transpiration stemming from precipitation on three scales

Included water flows (Input)

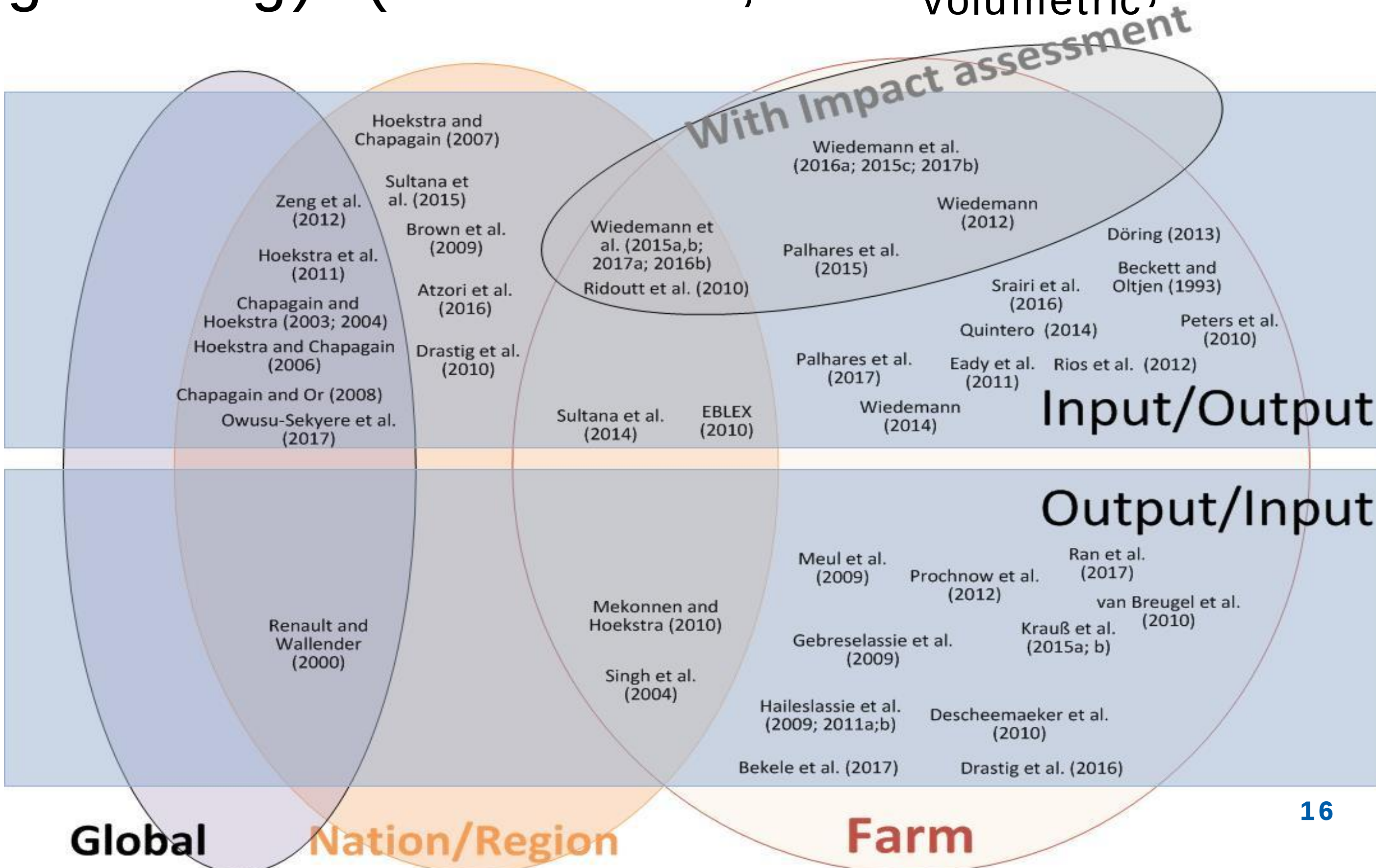
- Transpiration stemming from precipiation (4 studies; FWP)
- What is so special about transcpiration?

- Only the fraction that is used for plant transpiration contributes to biomass production



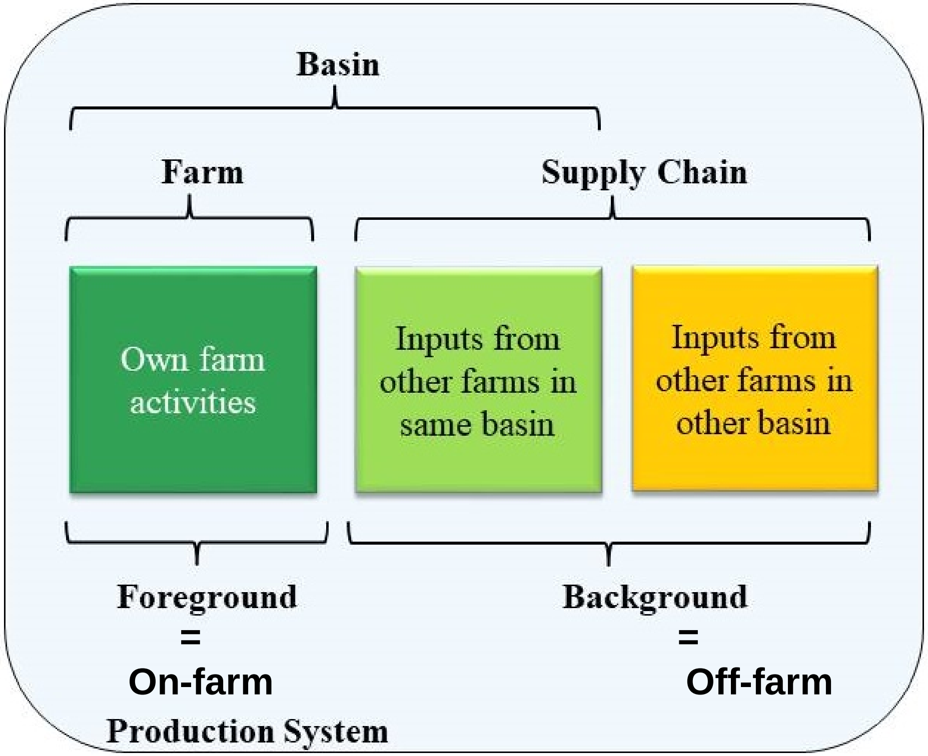
Input/Output or Output/Input

- Output over Input defined as calculation as water productivity (e.g. kg/m³), (15 Studien; $WFP_{volumetric}$, $WFP_{scarcity}$)
- Input over Output defined as calculation as water footprint (e.g. m³/kg). (34 Studien; $WFP_{volumetric}$, $WFP_{scarcity}$)

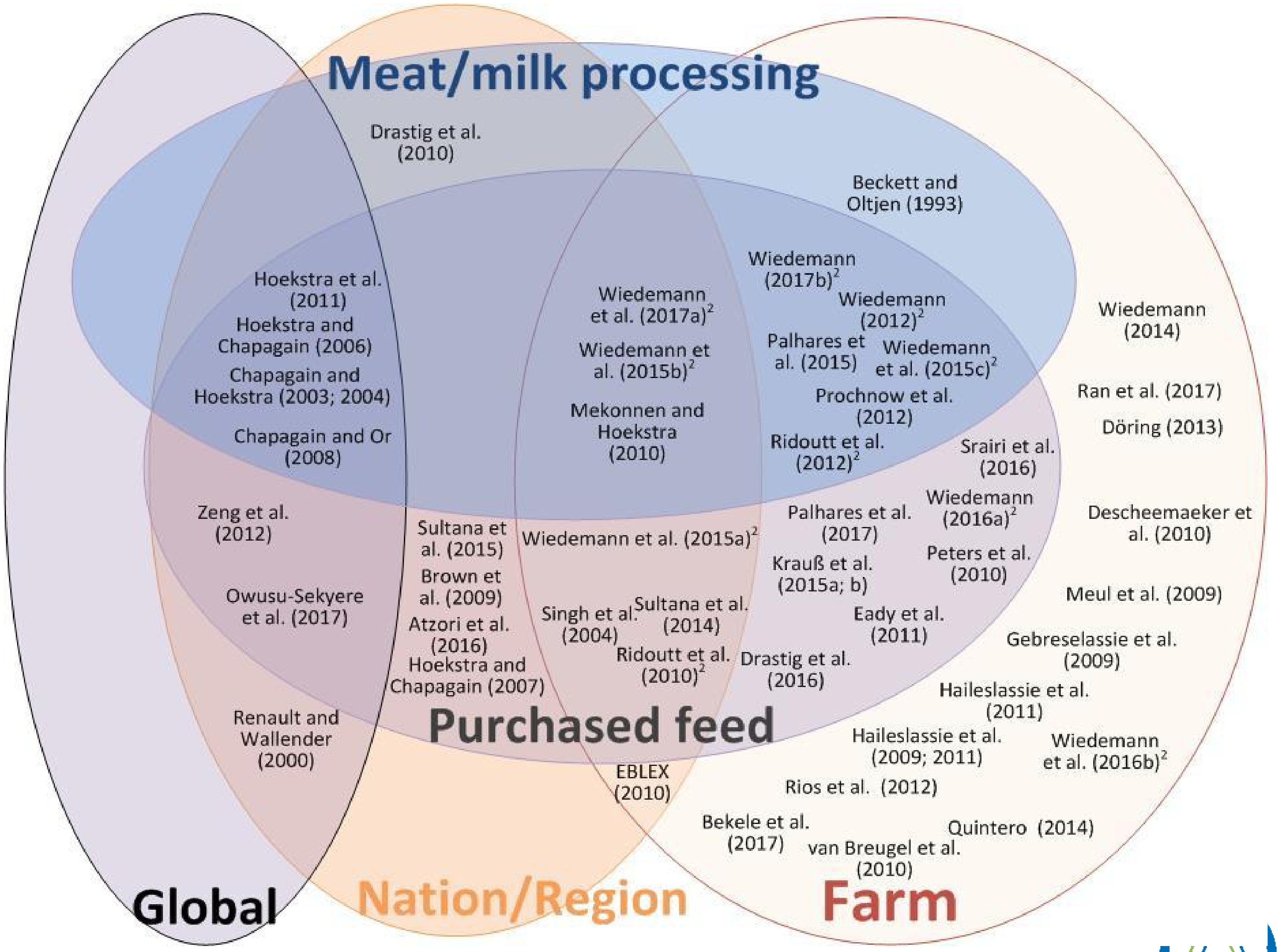


Off-farm processes

- The system boundaries defined the inclusion of off-farm processes

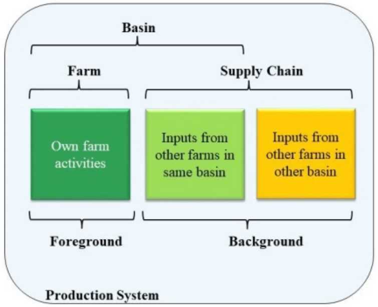


Off-farm processes



Inclusion of certain processes on three scales

Off-farm processes



- The system boundaries defined the inclusion of off-farm processes
- In more than half of the studies, "cradle-to-farm" gate was chosen as the boundary
- 32 studies included purchased feed
- 12 studies included water demand for dairy or meat processing
- Three studies included indirect water use for electricity, fuel, and fertilizer

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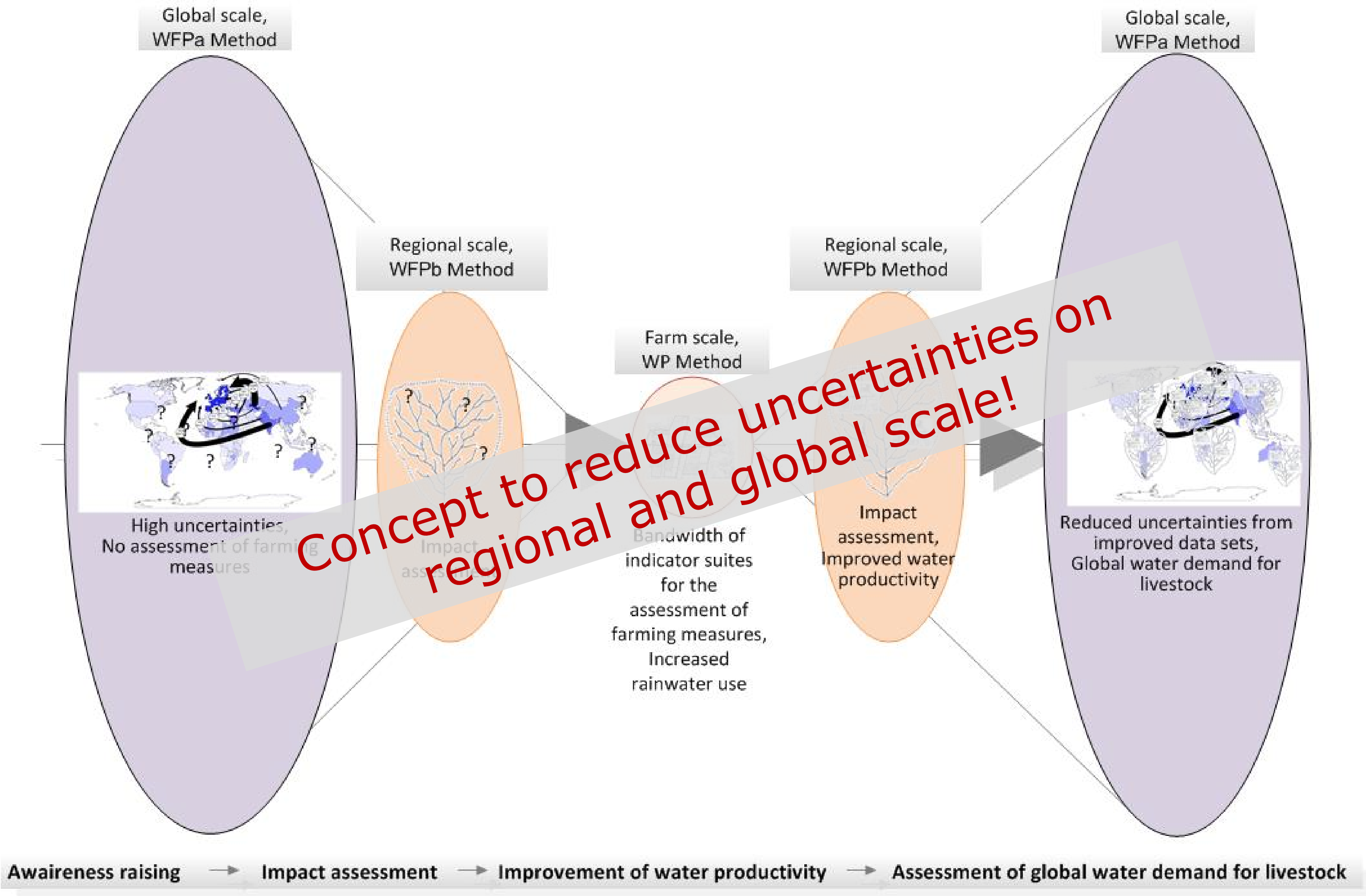
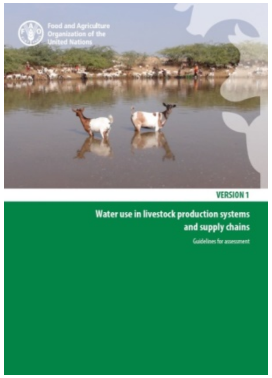
Developed concept improvement of water use in global livestock production



Outlook

How should the accounting for livestock water productivity be done?

- Use the method appropriate for the question you ask and compare the results with values from studies using the same definition of water productivity.
- It is important to report uncertainties, if possible, quantitatively or at least qualitatively.
- FAO LEAP Guidelines of the Water TAG propose a method for adding information on the percentage of green and blue water used, with each water productivity indicator seen as part of a suite of metrics.



TAG: Technical Advisory Group
Blue water: Fresh water stored in water bodies, such as water in lakes, rivers and groundwater
Green water: Fresh water that is stored as soil moisture from infiltrated rainfall and used by vegetation

FAO. 2019. *Water use in livestock production systems and supply chains – Guidelines for assessment* (Version 1). Livestock Environmental Assessment and Performance (LEAP) Partnership. Rome. http://www.fao.org/3/ca5685en/ca5685en.pdf