Eco-systems of agricultural landscapes
and sustainable land use: Livestock systems

05 - Livestock Environment Interaction - 4

The Water Footprint

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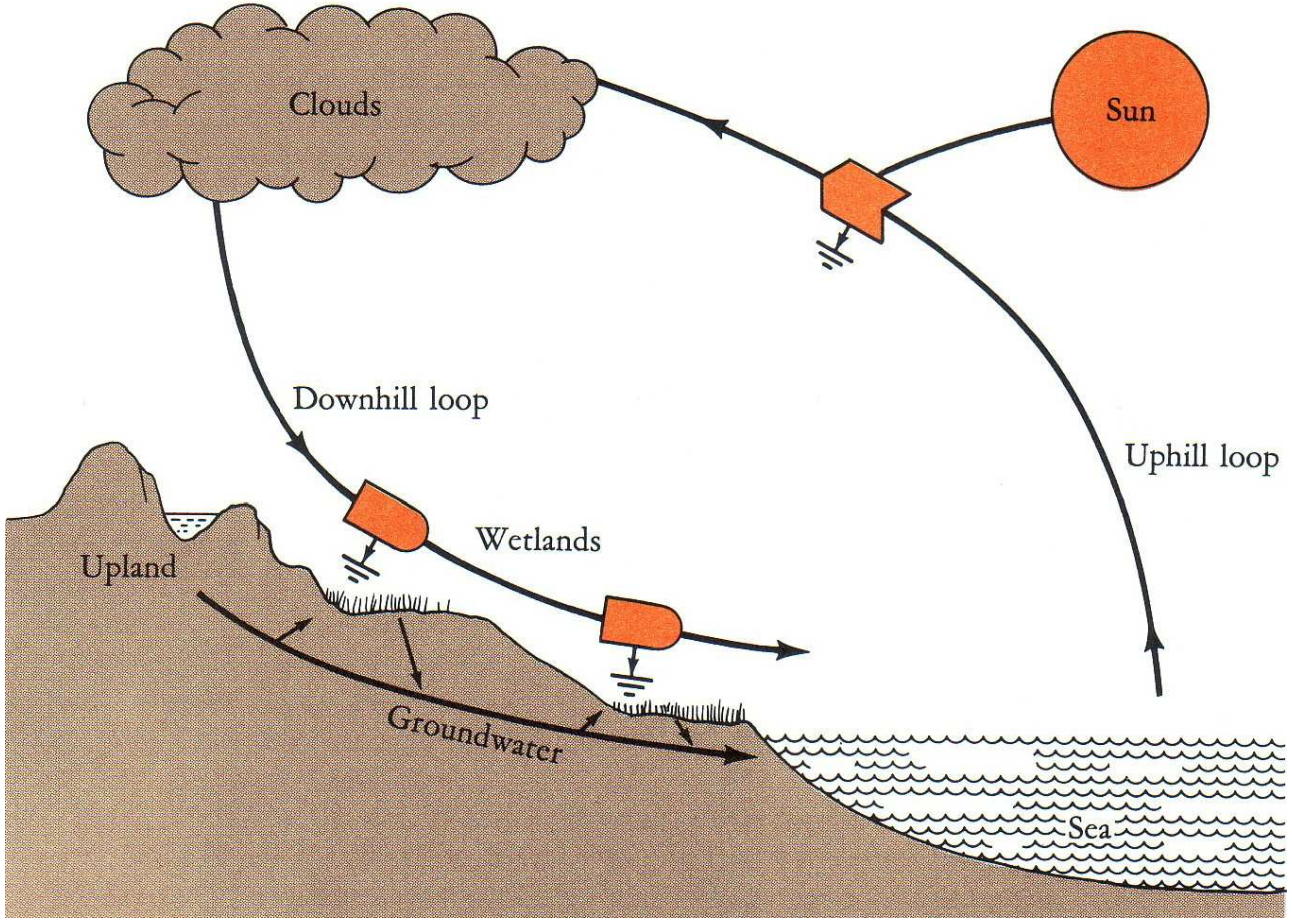
Global water cycle (simplified)



Source: Eugene P. Odum, 1998

Importance of water to livestock: what do we know?

- 90 % of all molecules in the body are water
- approximately 70 % of animal body weight is water, it varies by species and body part
- maintaining water balance is critical for survival, it is also closely linked to digestion and thermoregulation

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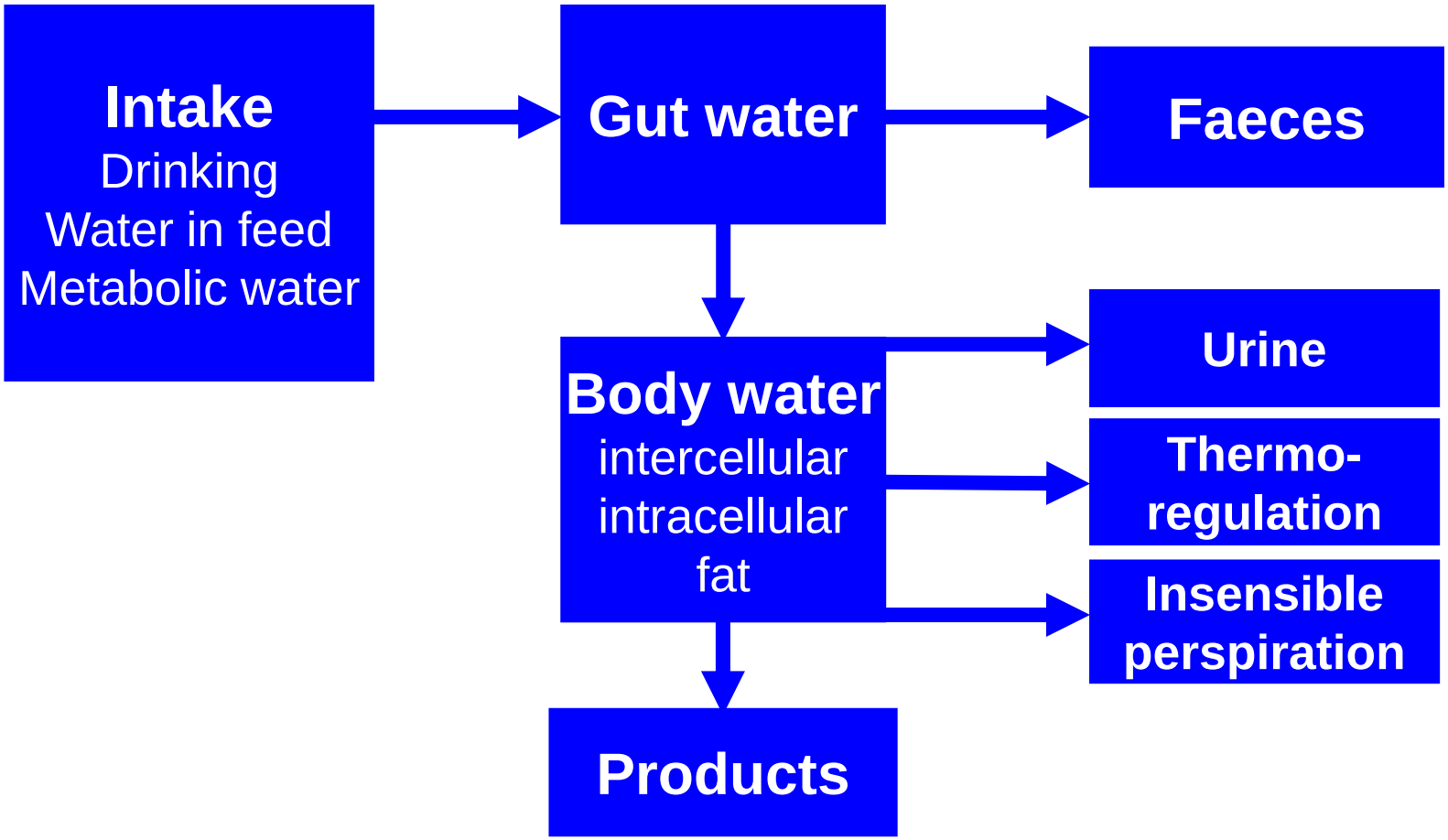
Importance of water to livestock: water turnover - what do we know?



Importance of water to livestock: Example one zebu steer at slaughter weight

(1) Drinking water

- Mean body water turnover of a zebu steer is 140 ml * l^{-1}BWP * d^{-1}
- Body water pool is 65 to 70 % of body weight
- Life time drinking water use at 4 years of age weighing 400 kg is 28 000 kg or 2.8 m^3
- Total drinking water 70 kg per 1 kg live weight

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Importance of water to livestock: Example one zebu steer at slaughter weight

(2) Water in feed

- 250 kg water evaporated per 1 kg DM grass produced
- 11 kg of grass eaten per 1 kg body weight gain
- 2.75 m^3 feed water per 1 kg of body weight
- Total feed water use at slaughter weight 1102,8 m^3 or 2.82 m^3 per kg live weight

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Importance of water to livestock: Example one zebu steer at slaughter weight

(3) Water for processing

- Dressing percentage 60 %
- Carcass weight 240 kg
- Total water use at slaughtering 0.5 m³ per carcass
- 6.18 m³ total water per 1 kg of clean dressed carcass
- 25 % bones in carcass
- 8.24 m³ total water per 1 kg of boneless beef

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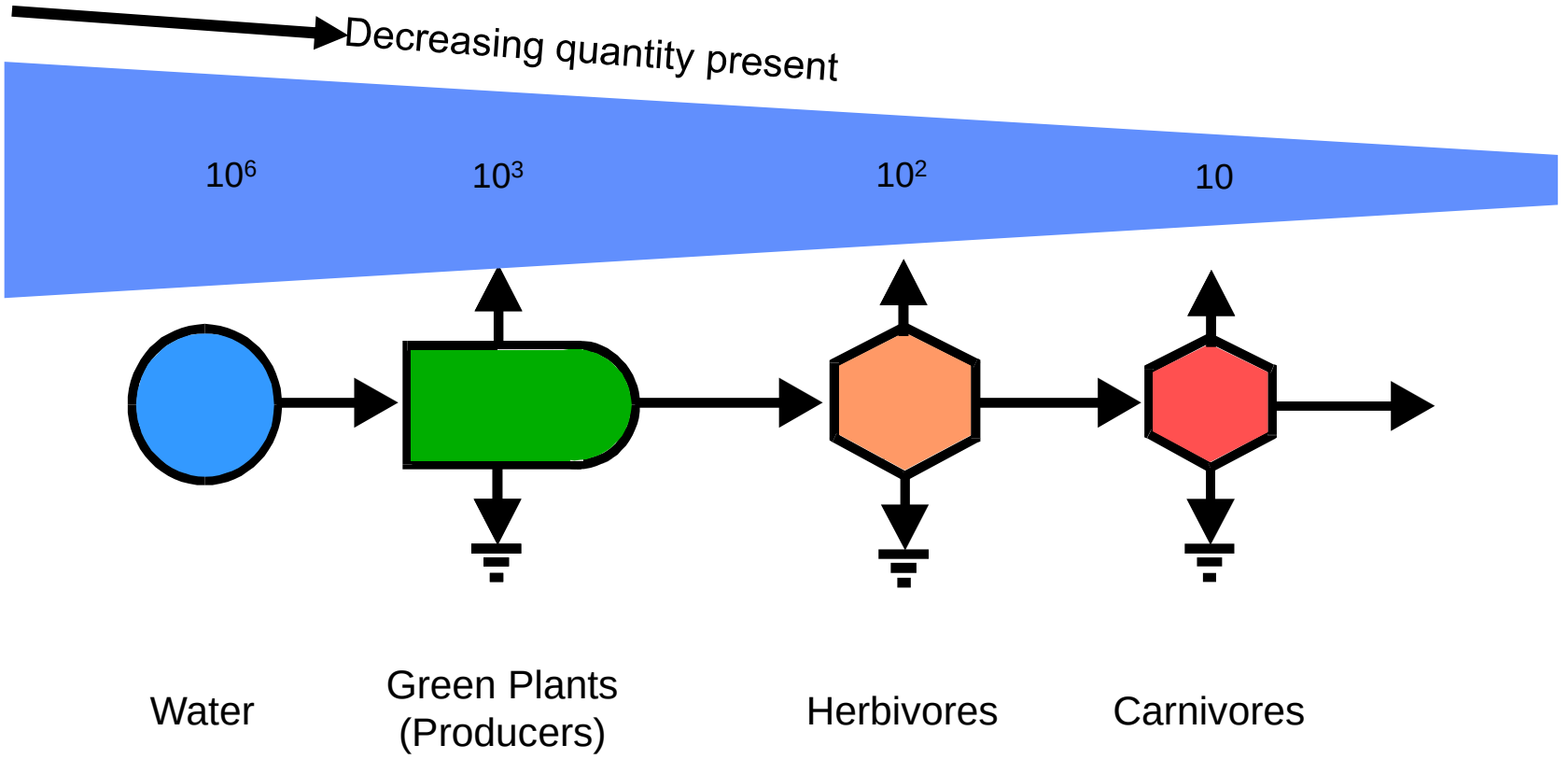
Increasing embedded (virtual) water accompanies decreasing water content in food chains



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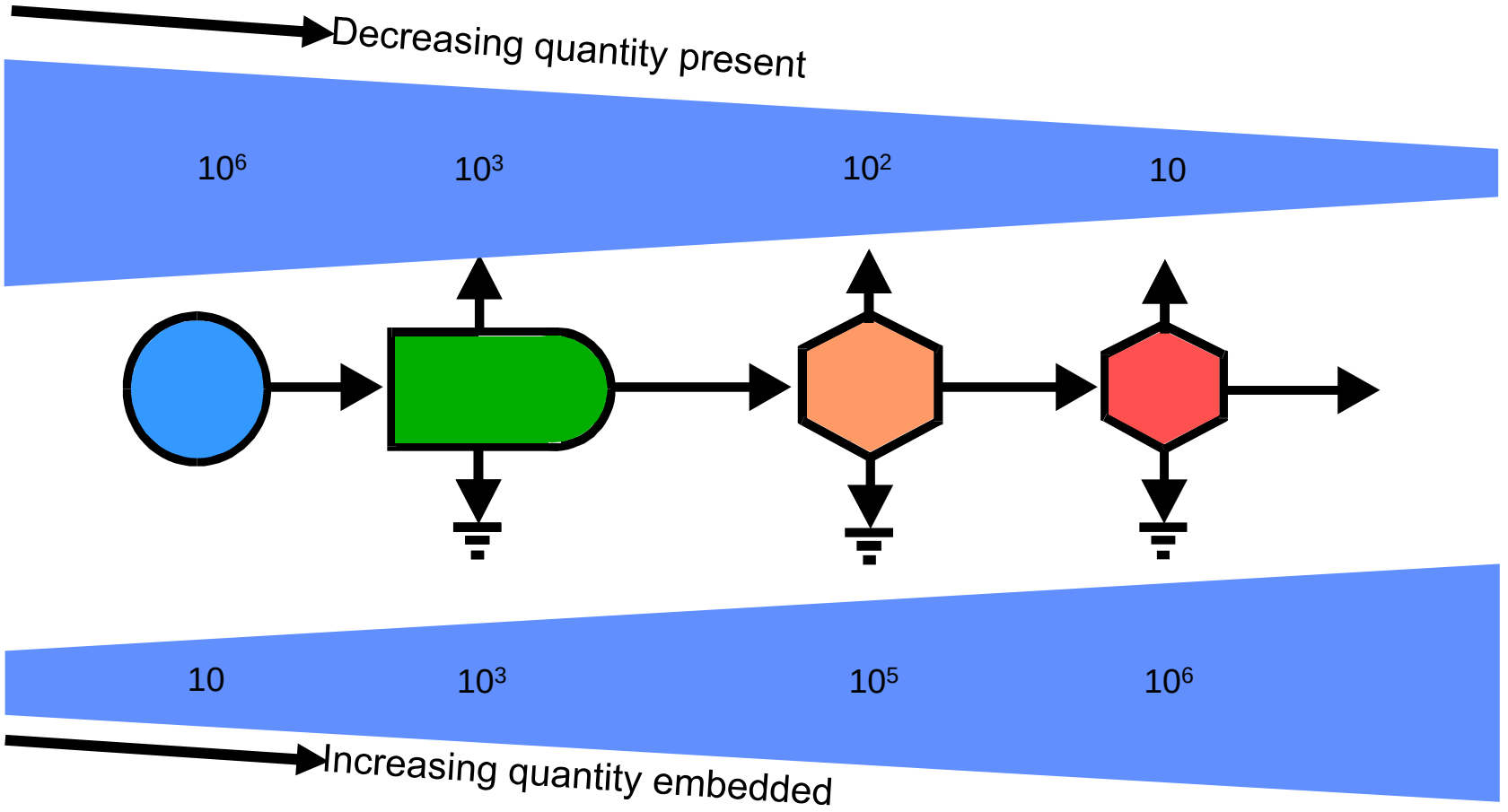

What is livestock water use efficiency?

$$WUE_L = \frac{P_L + S_L}{W_{dp} + W_{dg} + W_{dv}}$$

- Where $P_L + S_L$ are quantities or values of livestock products and services and
- $W_{dp} + W_{dg} + W_{dv}$ are quantities or values of depleted, degraded and devalued water

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Importance of water to livestock: water intake - what do we know?

Comparison of non-lactating and lactating* cows (G. Gäbel, 2000)

Water intake	non-lactating	lactating
Drinking	26	51
Water in feed	1	2
Metabolic water	2	3
Total	29	56

* 12 l milk per cow per day

Importance of water to livestock: water intake - what do we know?

Comparison of animal species (King, 1979)

Species	Water drunk [ml * kg^{-1} * d^{-1}]	Water content of diet [%]
Goat	55	29
Eland antelope	68	36
Sheep	54	26
Zebu cattle	47	15
Camel	37	34
Oryx antelope	29	13

Importance of water to livestock: water intake - what do we know?

Comparison of different grazing patterns of indigenous cattle in a tropical environment

Water intake	day	night	day & night
$l * animal^{-1} * d^{-1}$	36.0	22.7	35.5
$l * kg^{-1}$ forage	5.1	4.4	4.9
$ml * kg^{-1}$ BW $* d^{-1}$	100	62	105

Source: A.A.Ayantunde et al., 1999

Importance of water to livestock: water loss - what do we know?

Comparison of non-lactating and lactating* cows (G. Gäbel, 2000)

Water loss [l]	non-lactating	lactating
Urine	7	11
Evaporation	10	14
Faeces	12	19
Milk	0	12
Total	29	56

* 12 l milk per cow per day

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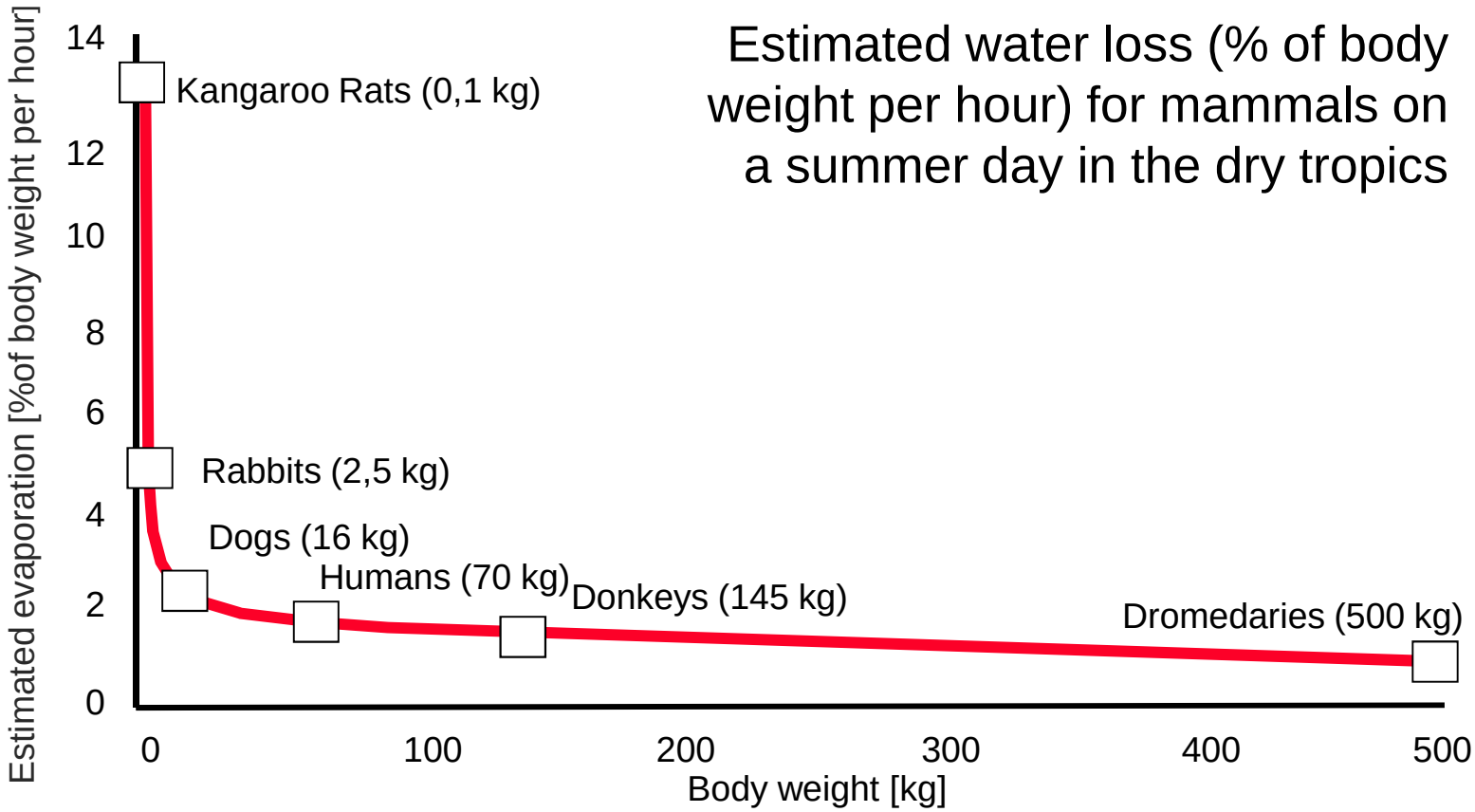
Importance of water to livestock: water loss - what do we know?



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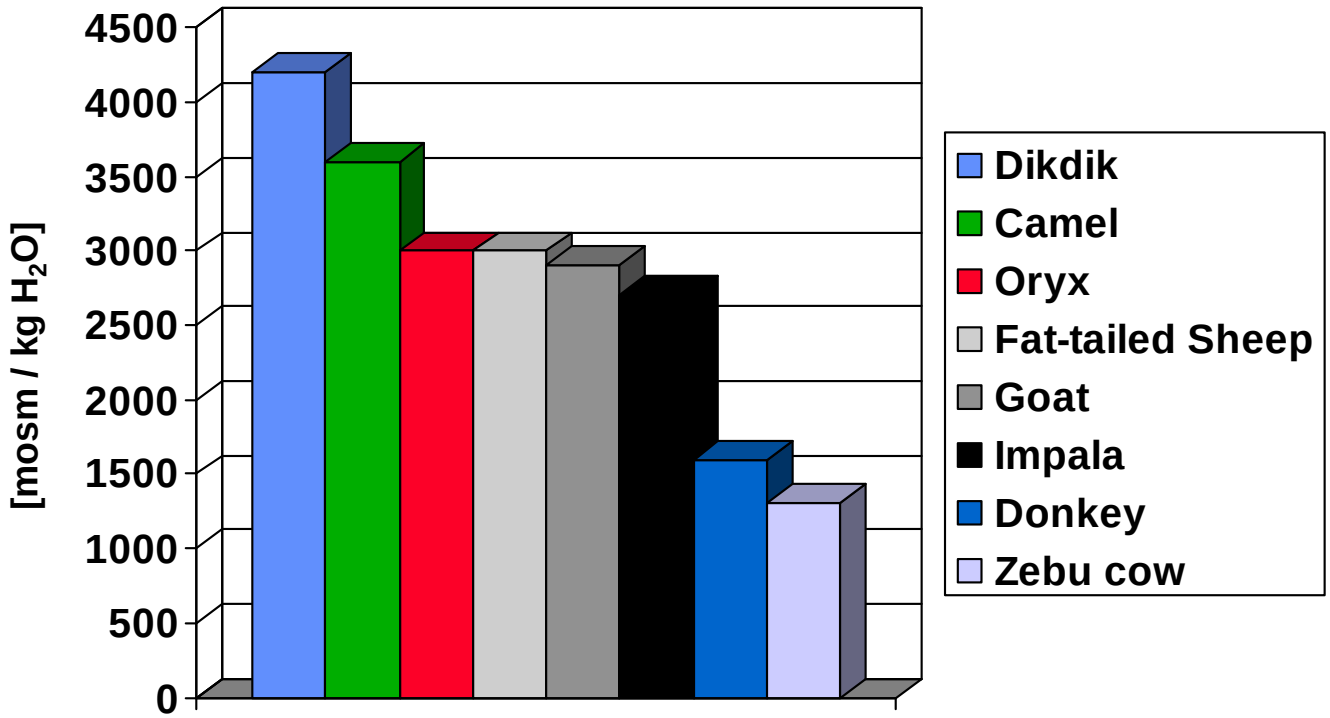
Typical urinary osmolar concentration in East African herbivores



Source: Maloiy (1972)

Total Water Use by Livestock

- Drinking water intake is less than 1% of water used for production
- Water for production of feed is most important
- Feed for maintenance is about 3% of live body weight per day in most herbivores
- Feed for growth, reproduction and lactation is extra
- Other water uses
- Water degraded and devalued by livestock production
- Other impacts of livestock production on water sources

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Water for livestock feed: Some issues and questions

- Crops require 200 to 800 g of water to produce 1 g of dry matter
- Potatoes, sugar cane, elephant grass require approximately 500 g/g
- If crop residues are the only feed, is crop water **NOT** part of livestock water use?
- How much water used by animals is essential for enabling crop production?
  - animals needed for ploughing and other cultivation tasks
  - animals needed for transport of crops to market

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Other livestock water uses

- How much water is needed or used to:
  - maintain hygiene, animal health and food safety
  - process animal products (slaughtering, meat packaging, dairying)

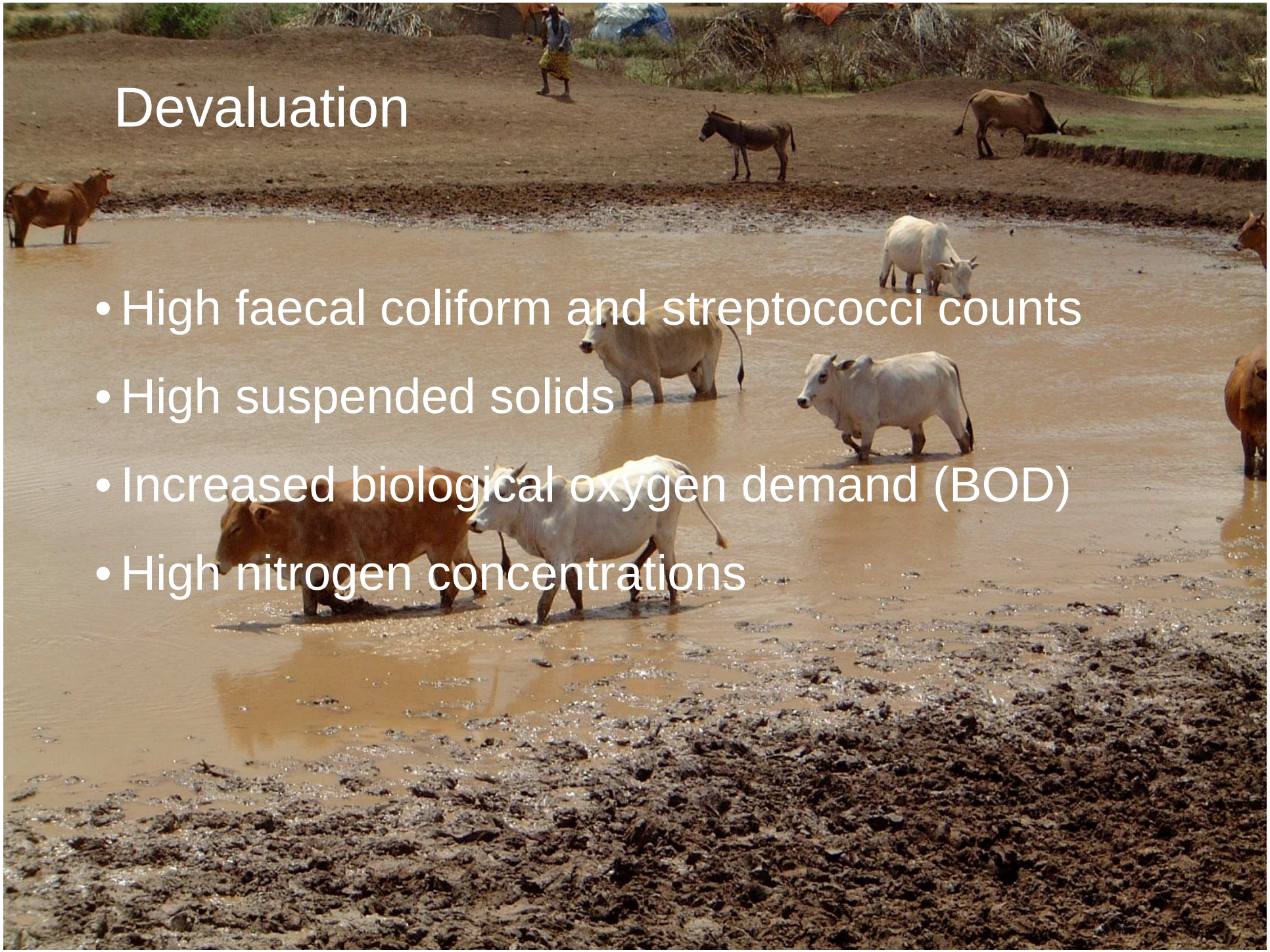
- Can waste water safely be used to produce feeds?

Possible impacts of livestock production on water resources (1)

Depletion, degradation, devaluation of water

- Sinking ground water levels through deep wells operation
- Evaporation/seepage from storage facilities
- Reducing run-off through water harvesting and local storage
- Non-consumptive contamination, increasing hygienic risks, general health risks


Degradation
Evaporation and seepage



Devaluation

- High faecal coliform and streptococci counts
- High suspended solids
- Increased biological oxygen demand (BOD)
- High nitrogen concentrations

Public health implications

Possible impacts of livestock production on water resources (2)

Soils, hydrology and habitat

- Livestock production affects soil moisture through
  - soil compaction, change of ground cover and run-off
  - change of soil organic matter and water holding capacity
- Contamination of soils, ground and surface water
- Over-grazing and loss of bio-diversity
- Habitat destruction, ground water recharge potential
- Trail and sheet erosion, sedimentation

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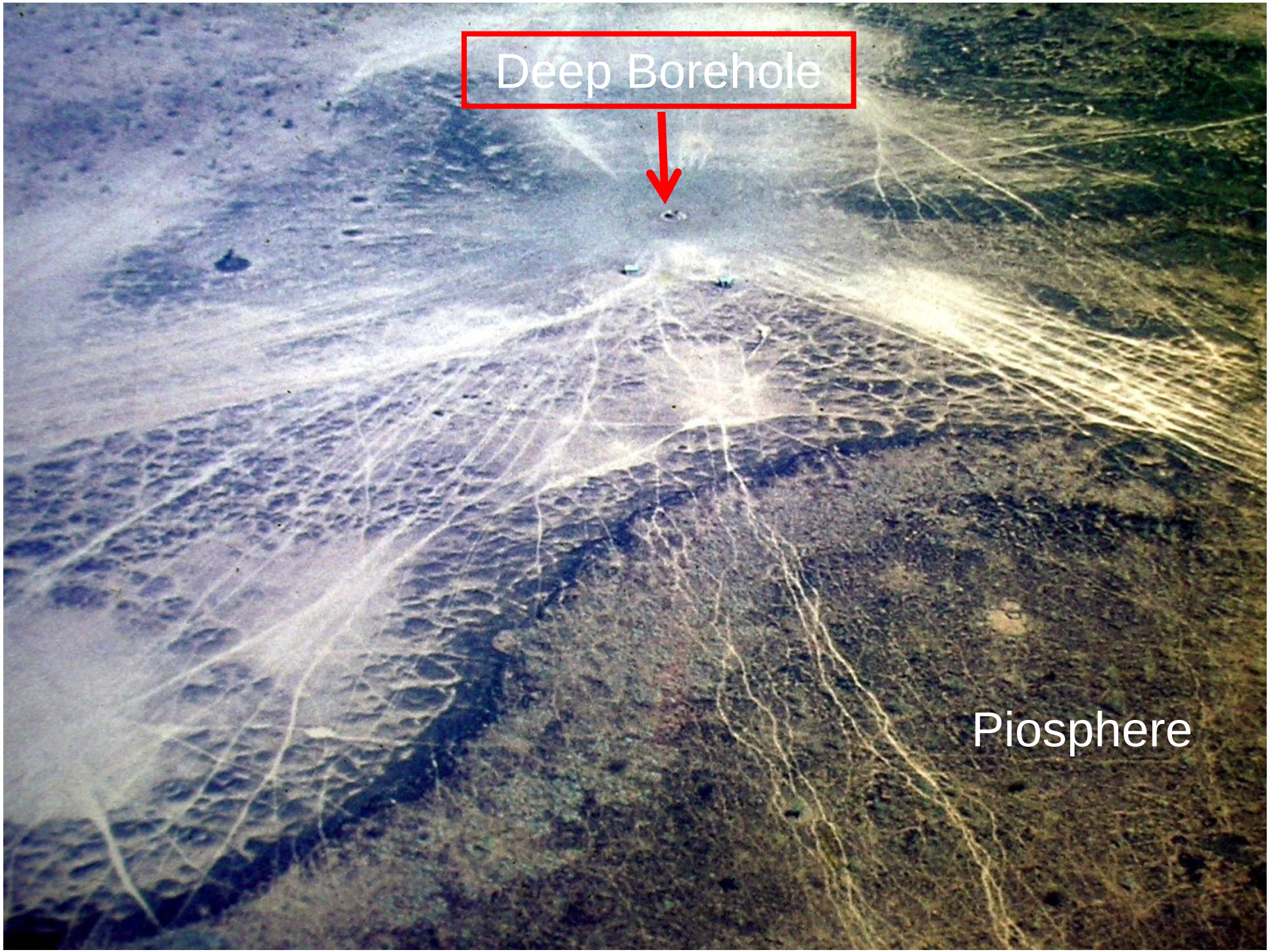
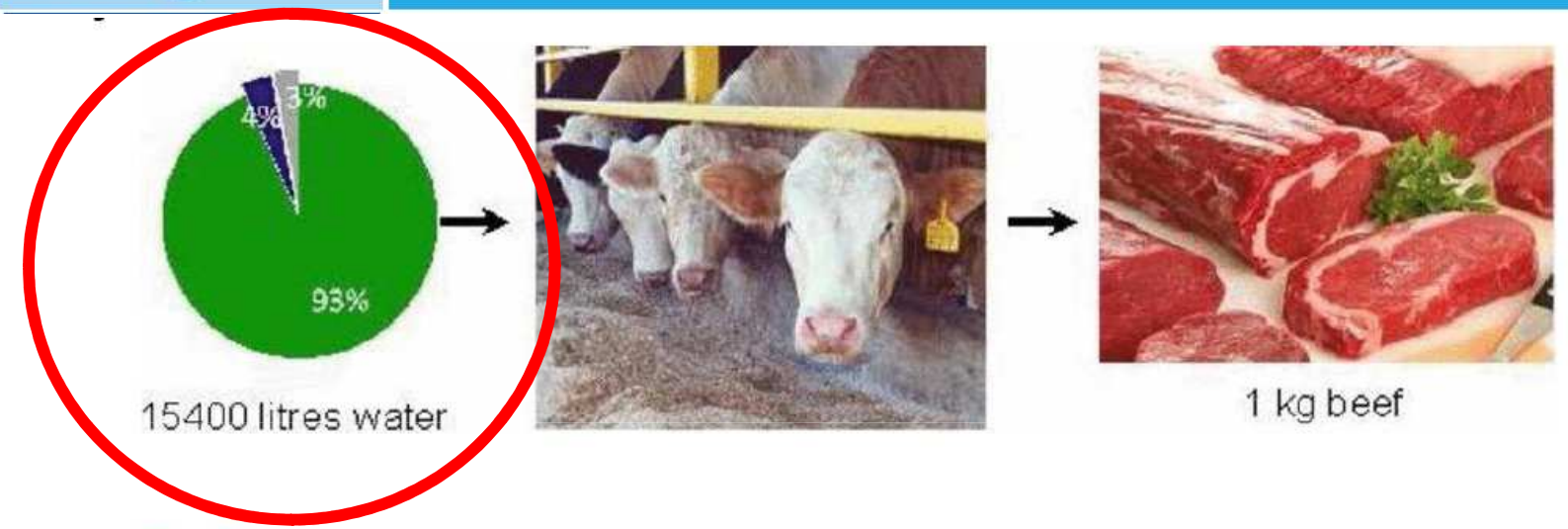

Deep Borehole
Piosphere

Water Footprint

Water Footprint NETWORK

Introduction



Global Water Footprint Standard

The Global Water Footprint Standard – developed through a joint effort of the Water Footprint Network, its partners, and scientists of the University of Twente in the Netherlands – has garnered international support from major companies, policymakers, NGOs and scientists as an important step toward solving the world's ever increasing water problems. The standard is contained in the Water Footprint Assessment Manual. Download Press Release [28 Feb 2011].

More info on the Global Water Footprint Standard.
Download The Water Footprint Assessment Manual.

The amount of water used to grow food

[in litres evapo-transpired per kilogram product]

	USA	France	China	India	Japan	World
Wheat	1,390	660	1,280	2,560	1,350	1,790
Rice	1,920	1,270	1,370	3,700	1,350	2,380
Maize	670	610	1,190	4.350		1,390
Beef	10,060	7,740	12,600	14,379	9,540	9,680
Pork	3,370	1,940	2,520	7,560	4,080	3,680

Sources: de Fraiture et al (2004), Chapagain and Hoekstra (2003), Renault and Wallender (2000)

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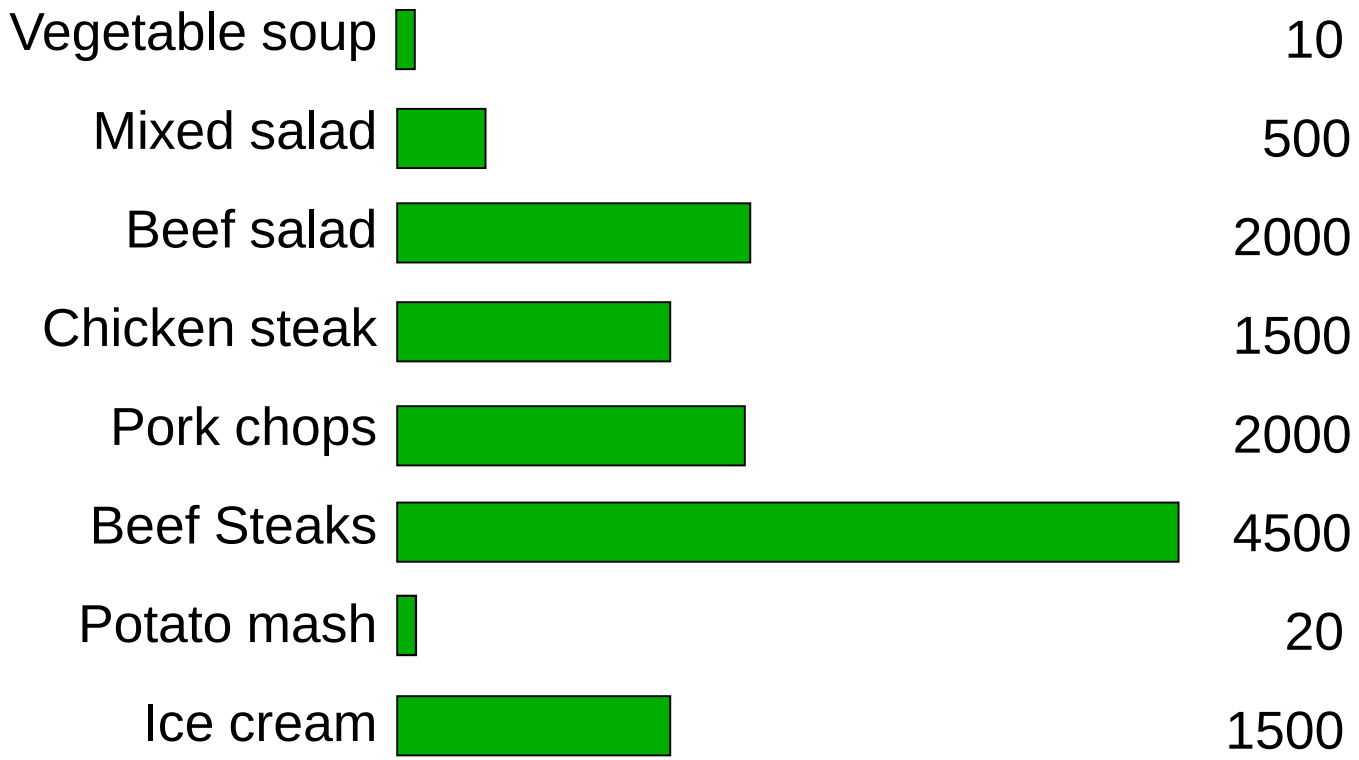
Water cost of a continental menu [l/dish]



Source: IHE, 3rd World Water Forum, 2003

Estimated water volume [litre/ha/year] at different trophic levels in pastoral beef production

(* at the end of the growing season)

Pasture type	mean annual precipitation	water in standing herbaceous biomass*	water in beef produced
Semi-arid tropical native pasture East Africa [1]	~ 3×10^6	~ 1.5×10^3	~ 0.4×10^2
Humid sub-tropical native pasture Argentina [2]	~ 11×10^6	~ 4.8×10^3	~ 0.7×10^2
Temperate extensive pasture Germany [3]	~ 5.5×10^6	~ 3.7×10^3	~ 1.1×10^2

Data sources: [1] Schwartz and Walsh (1994), [2] Feldkamp (2004) [3] Schwartz, unpubl.

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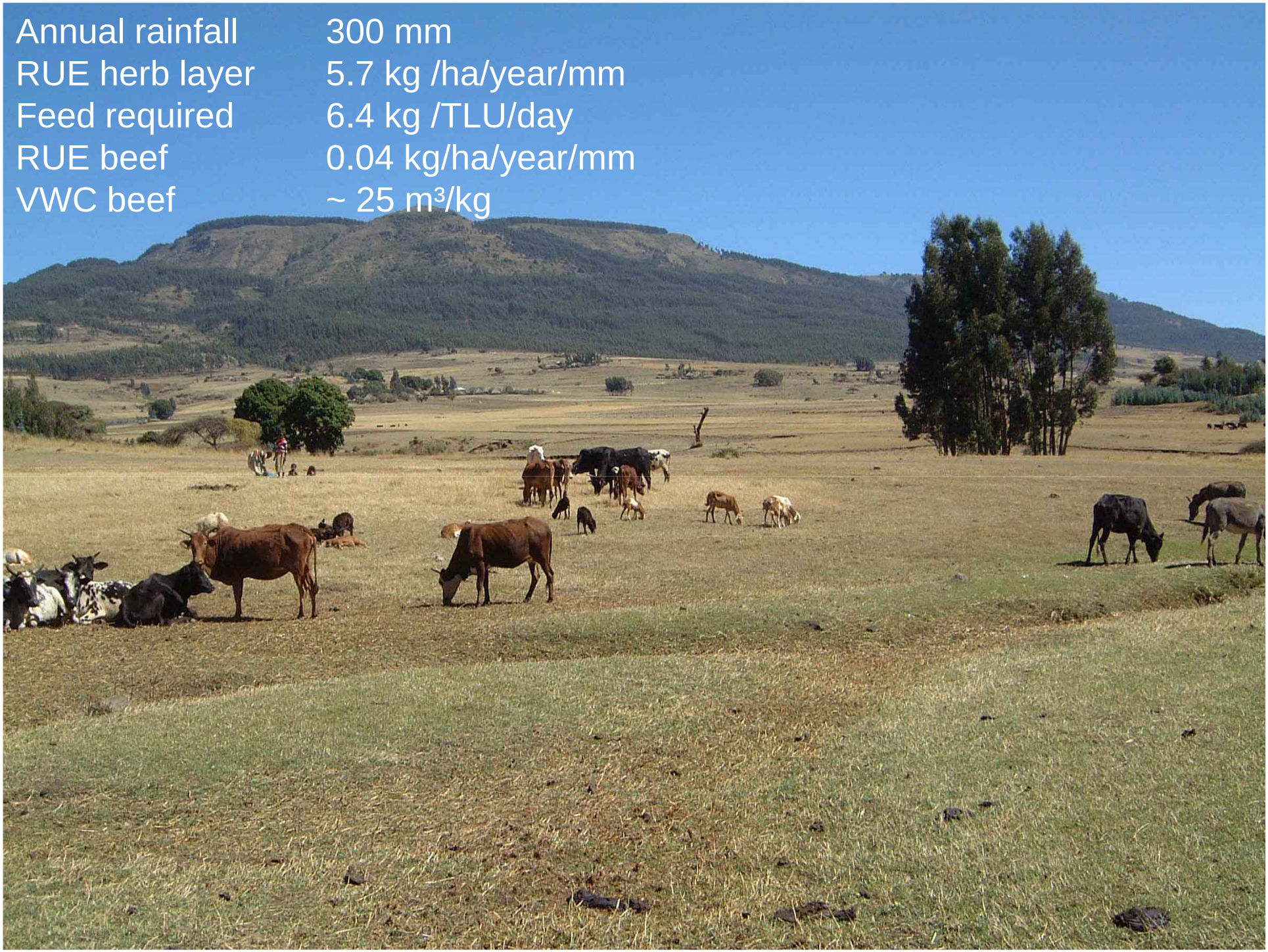
Annual rainfall 300 mm
RUE herb layer 5.7 kg /ha/year/mm
Feed required 6.4 kg /TLU/day
RUE beef 0.04 kg/ha/year/mm
VWC beef ~ 25 m³/kg

Main characteristics of BLUE and GREEN water

Type / Descriptor	Blue Water	Green Water
Sources	Surface water, accessible aquifers	Stored in unsaturated soils
Mobility	Highly mobile	Immobile
Alternative uses	Many competing	None
Opportunity costs	High to very high	Medium to zero
Major agricultural use	Crop irrigation, livestock drinking, processing, and management	Rain fed crop production, natural and derived pastures, plant transpiration

Water demand of beef production

Demand category	Source	Amount	Data quality
Drinking water	Blue water	10 - 20 % live wt/day	measurable, well researched
Water for service and management	Blue water	negligible	measurable
Water for processing	Blue water	negligible	measurable
Water for feed production	Green water	10 - 100 m^3/ kg boneless beef	assumption based, modelled

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Other considerations

Which Focus?

- Water cost of production
  (single animal)
- Water productivity
  (enterprise, farm, herd, production system)
- Water use efficiency
  (regional, basin or catchment)

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Approaches for improving water use in livestock production

- Feed related strategies includes using crop residues and other waste products for feed, increasing feed water productivity by altering feed crop choice, implementing more sustainable grazing management practices and farm-level integration of trees within crop-livestock systems to improve year-round availability of fodder and biomass for use as fertilizer and fuel.
- Water management strategies includes water conservation, strategic placement of watering points (to encourage more complete and uniform grazing and enable animals to reach otherwise inaccessible feed sources) and integration of livestock production into irrigation schemes.
- Animal management strategies includes appropriate animal husbandry and improving animal health, supported by awareness raising among livestock keepers, so that feed can be used more effectively and herders are able to get the same benefit from a smaller number of animals.

Conclusions

Beef production based on pastures, crop residues and crop processing by-products incurs no or very limited feed water costs

Virtual water content calculations of beef need to be re-examined in this light

Grain based beef production systems can reduce water costs by replacing whole grain with higher proportions of crop residues and agricultural by-products

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