Environmental impacts associated with freshwater use along the life cycle of animal products

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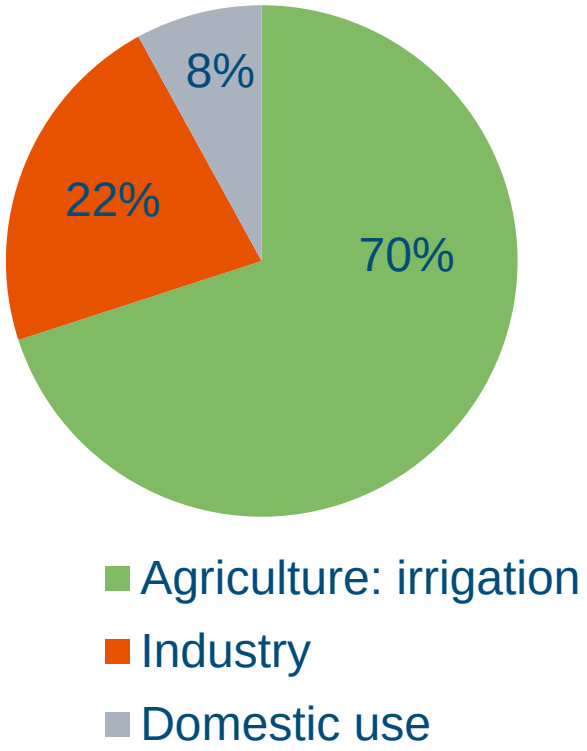
Contents

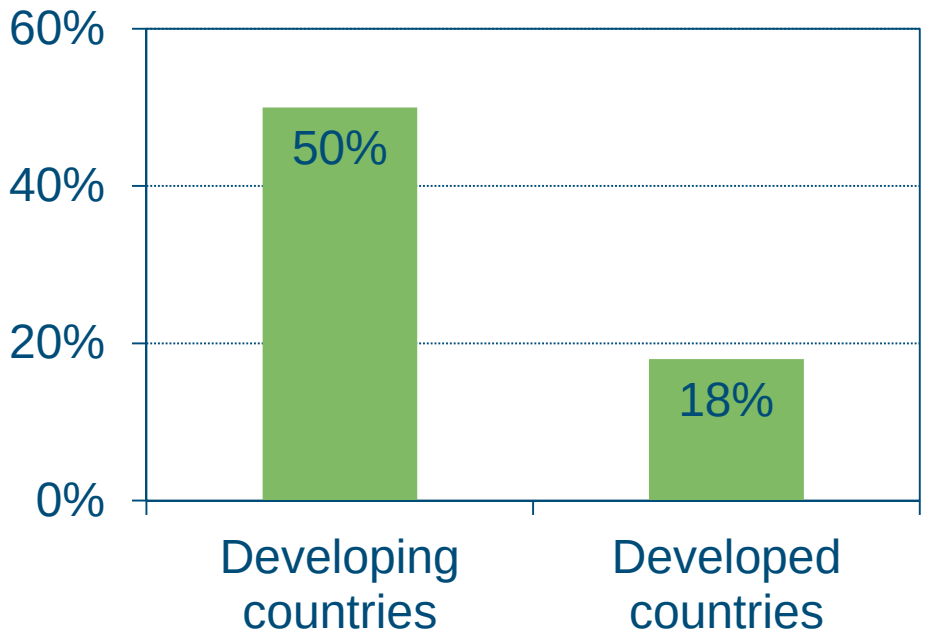
- Freshwater use: environmental impact
- Water footprint concept (Hoekstra et al. 2009)
- Water cycle
- Our approach to assess freshwater impacts along the life cycle of animal products – illustration for milk production

Environmental concern

Breakdown (Source: WWAP)



Increase 2025 (Source: GEO-4)



Environmental consequences – scarcity

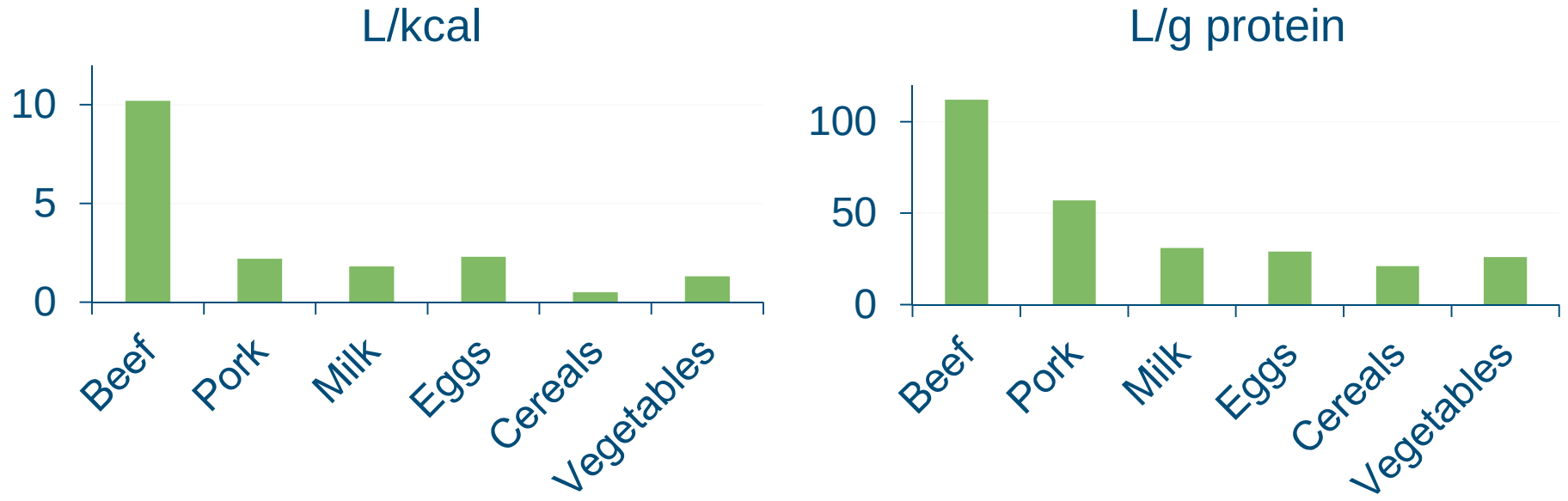
- Impact human health
  - Hygiene & consumption, malnutrition
- Impact on ecosystem quality
  - Affects biodiversity
- Impact on resource depletion
  - 60% European cities (> 100.000 citizens): groundwater use > replanishment rate
  - 1.4 billion people in river basins that are currently depleted

Scientific interest

- Development of tools to assess impacts of freshwater water use along the food chain

- Water footprint (Hoekstra et al. 2009)

Water footprint – litre per kcal or g protein



"From a freshwater resource perspective, it is more efficient to obtain calories and protein through crop products than through animal products"

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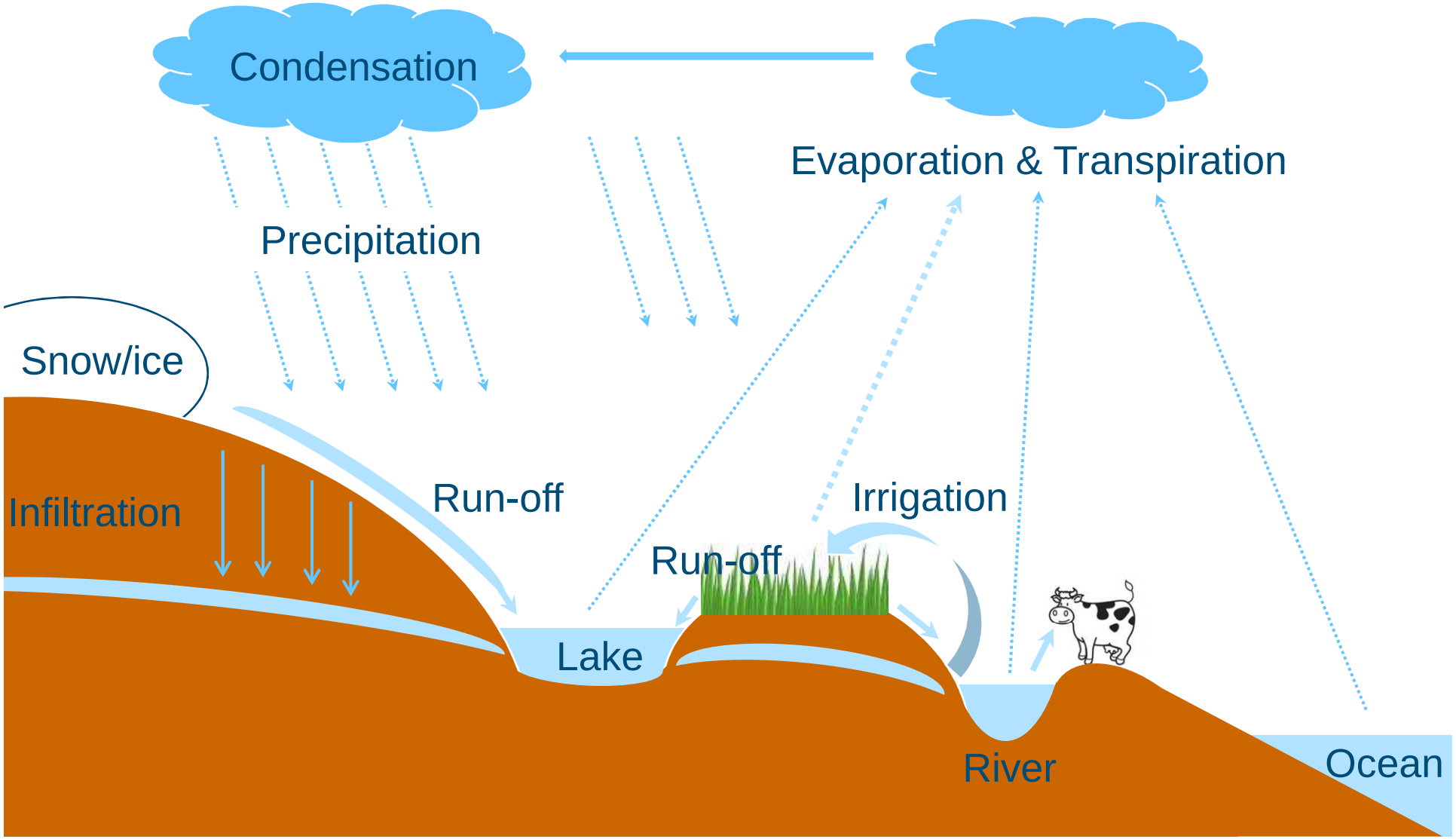
Source: Mekonnen and Hoekstra 2010

Water cycle


Condensation
Evaporation & Transpiration
Precipitation
Snow/ice
Infiltration
Run-off
Irrigation
Run-off
Lake
River
Ocean

Water footprint

Green water

- evapotranspiration feed crops & water embodied in crops

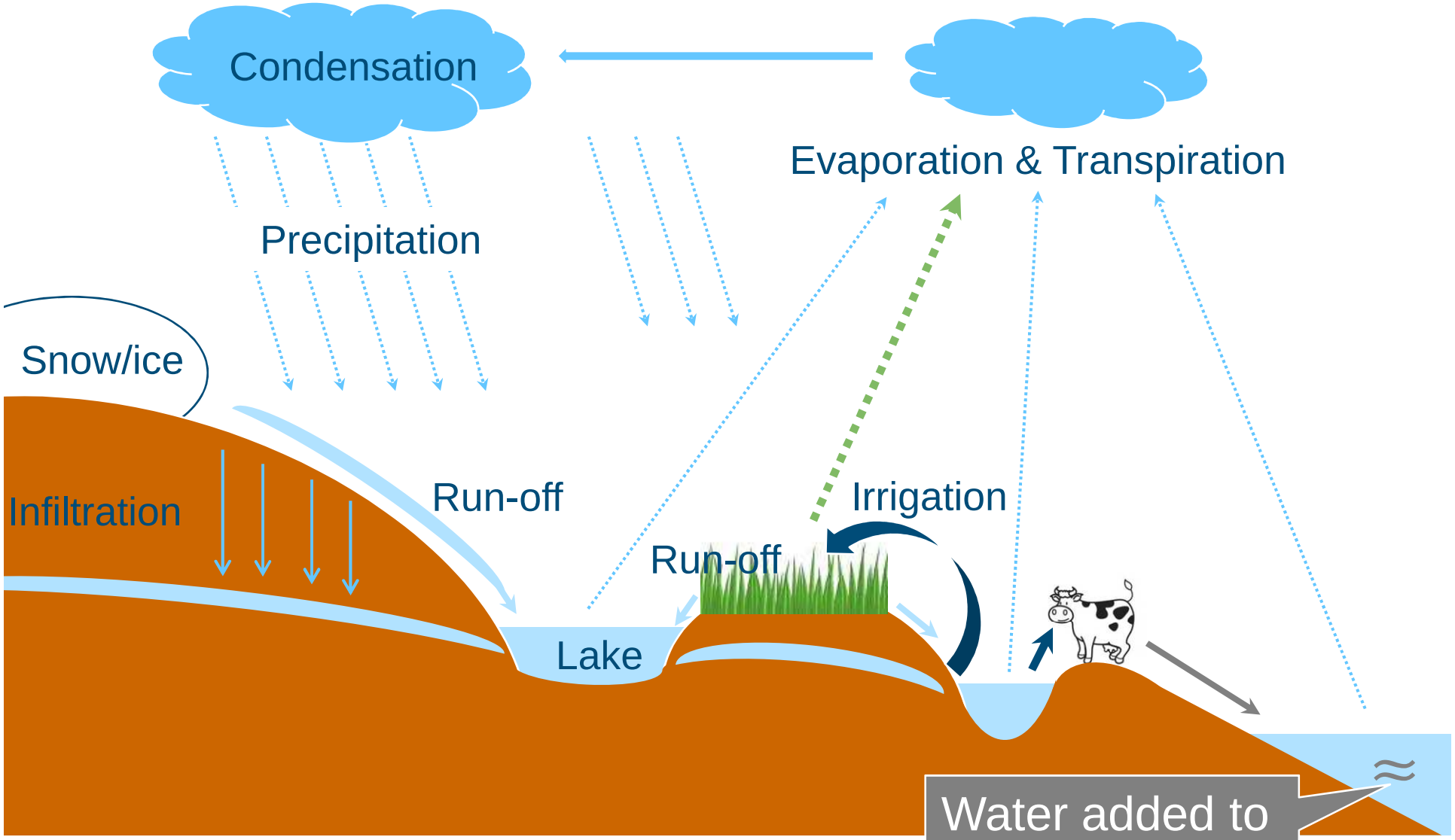
Blue water

- ground- & surface water for irrigation, drinking, industry

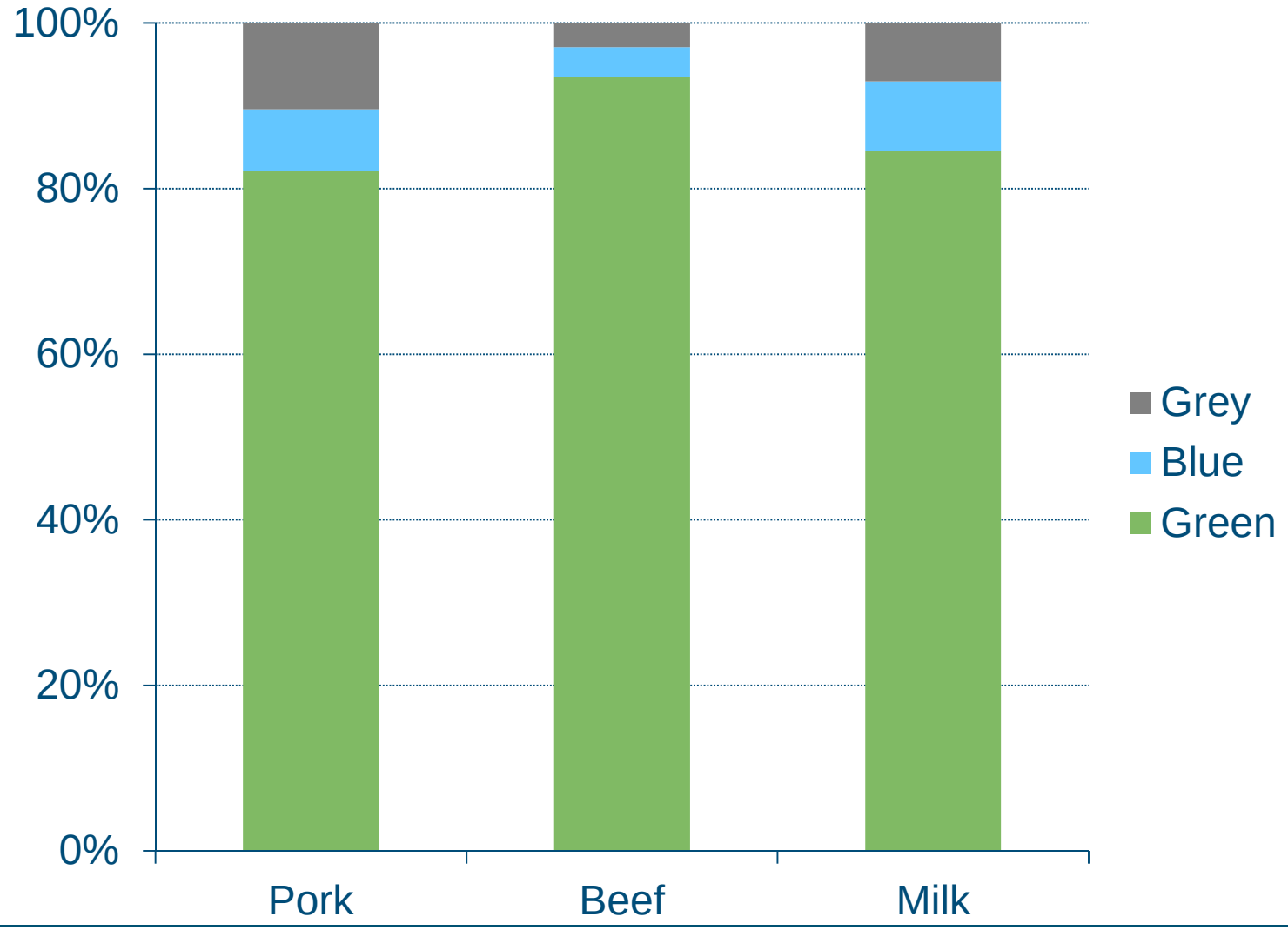
Grey water

- virtual water to dilute load of pollutants

Water cycle


Condensation
Evaporation & Transpiration
Precipitation
Snow/ice
Infiltration
Run-off
Irrigation
Run-off
Lake
Water added to dilute pollution

Water footprint



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Impact associated with green water use?

- Green water use: NO IMPACT
- Only possible change in green water availability

Impact associated with blue water use?

Blue water use

- human health
- ecosystem quality
- resource depletion

Impact associated with grey water use?

Virtual amount of water required to assimilate pollutants based on ambient water quality standards → indirectly measures, e.g. aquatic toxicity or eutrophication

Incorporate in these impact categories in an LCA!

Our aim

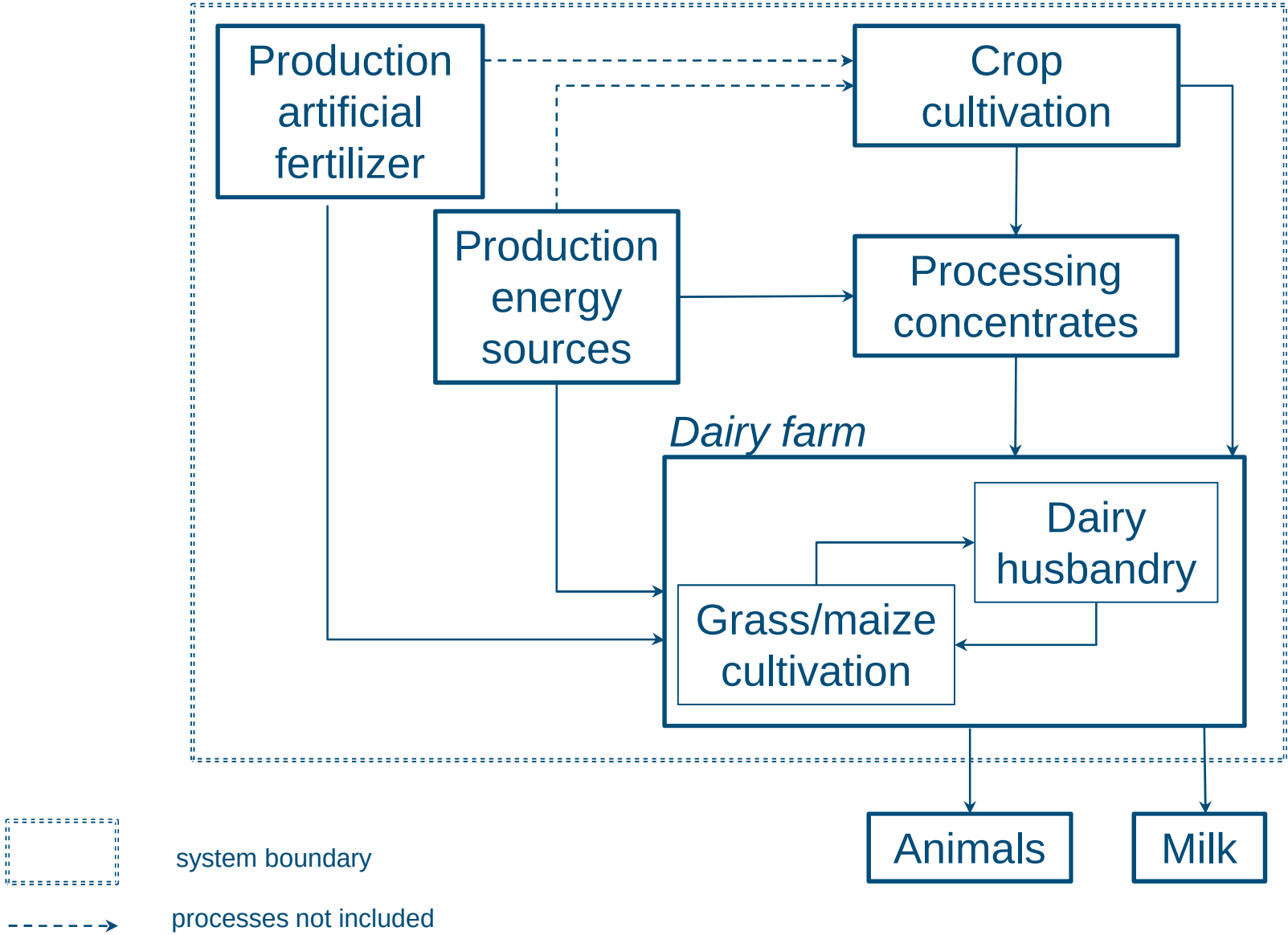
Develop an approach to assess environmental impact associated with water use along life cycle of an animal product

- Blue water use & change in green water use along life cycle of animal products

- Impact on human health, ecosystem quality and resource depletion

  → national characterization factors (Pfister et al. 2009)

Milk production – model farm Noord-Brabant



Irrigation requirement crop cultivation

Grid Data

↓

Exact location

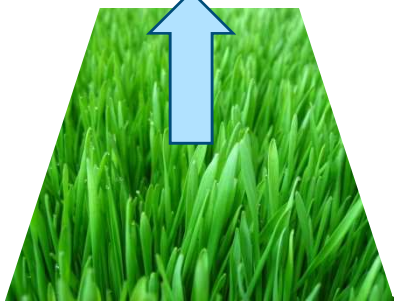
↓

Climate

Radiation, T, wind speed , humidity

Penman–Monteith equation

ET_0 (mm/d)



Well watered grass

Crop dependent

$\mathbf{ET_0 \times K_c}$

ET_p (mm/DM crop)

Optimal agronomic conditions

Irrigation requirement crop cultivation

ET_p (mm/DM crop)

Soil dependent

$K_s \times ET_p$

Optimal agronomic conditions

Yield response function

Doorenbos & Kassam (1979)

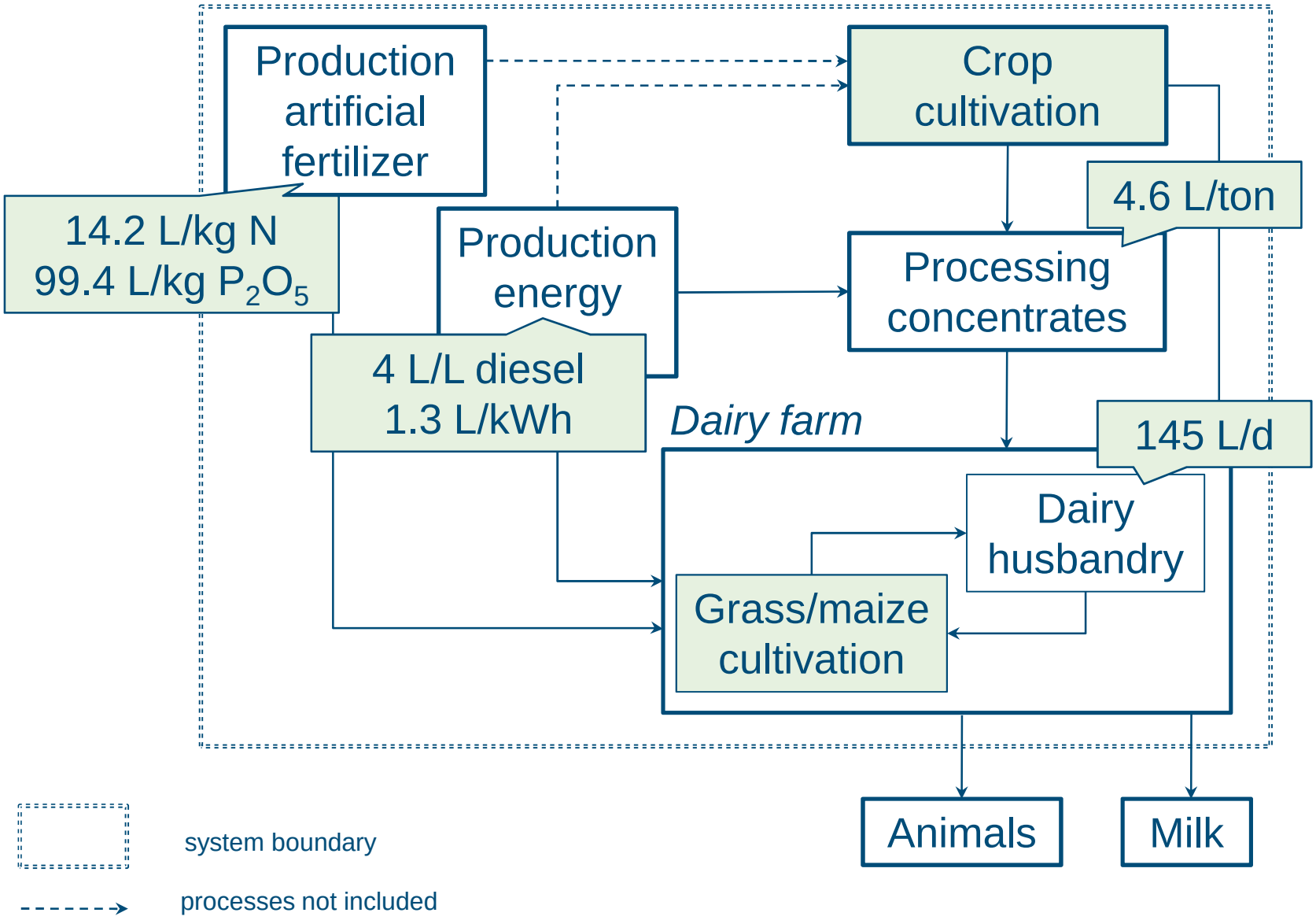
Rainfed ET_{rf}

Yield → **Actual ET_a**

IF $ET_{rf} \leq ET_a \rightarrow$ **No irrigation**

ELSE $\rightarrow$ **Irrigation** $= \frac{(ET_a - ET_{rf})}{\text{Irrigation efficiency}}$

Other blue water requirements



Changes infiltration & run-off

- No changes due to changes in crop management
- Changes due to transforming forest/Cerrado into soy bean land
  - 3.08 % recently transformed (Prudencio da Silva et al. 2010)
  - Change in green water use: 440 kL

Impact assessment

National blue water extraction

Change green water availability

×

Characterization factors

Country	Human Health *(10^{-9} DALY/L)*	Ecosystem *(10^{-3} m^2 ·yr/L)*	Depletion (kJ/L)
Germany	0.0	0.155	0.0
Belgium	0.0	0.157	0.0
France	0.0	0.146	0.027
Netherlands	0.0	0.138	0.0
Brazil	0.02	0.089	0.045
Argentina	0.036	0.475	0.954
Thailand	0.159	0.132	0.0
USA	0.002	0.310	1.870
India	2.240	0.397	1.870

- Human health (malnutrition)
  Disability adjusted life years (DALY)
- Ecosystem quality (species)
  m^2 yr vegetation damage
- Resource depletion
  depletion factor x energy desalination (kJ)

(Pfister et al. 2009)

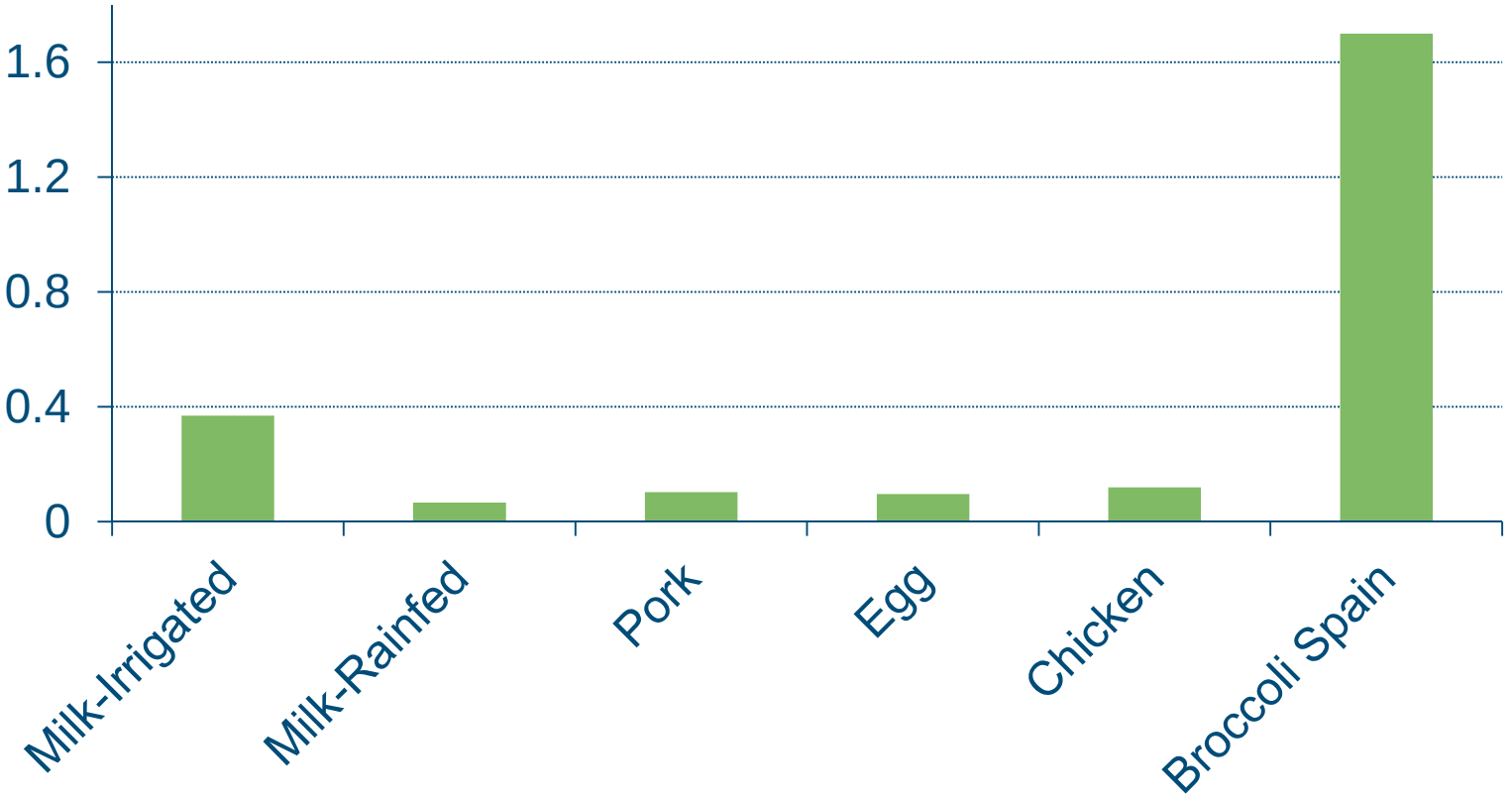
⇨ IMPACT

Impact per kg FPCM (fat-protein-corrected milk)

Stage	Blue water (L)	∆ Green water (L)	Health (10^{-9} DALY)	Ecosystem (10^{-3} $m^2 \cdot yr$)	Depletion (kJ)
Grass	36.8	0	0	7.1	0
Maize	13.6	0	0	2.6	0
Concentrates	10.3	0.25	0.8	2.2	6.7
Drinking/Cleaning	5.4	0	0	1.0	0
Energy/Fertilizer	0.3	0	0	0.1	0
Transport	0	0	0	0	0
Total	**66.4**	**0.25**	**0.8**	**12.9**	**6.7**

- Water use mainly results from irrigation of grass/maize
- No impact on HH and RD in the Netherlands

Impact ecosystem quality ($m^2 \cdot yr$ / kg protein)



Conclusions

- Water footprint quantifies volumes and not associated impacts
- Impacts of water scarcity are site-specific
- Our approach gives insight into site-specific impacts of water use in animal production chain
  - Accurate data: yield, soil type, root depth

Recommendations

- Use of site-specific rather than national characterization factors will further refine assessment

- Build data-base with region-specific information (e.g. yields – soil – watersheds)

Thank you for your attention!

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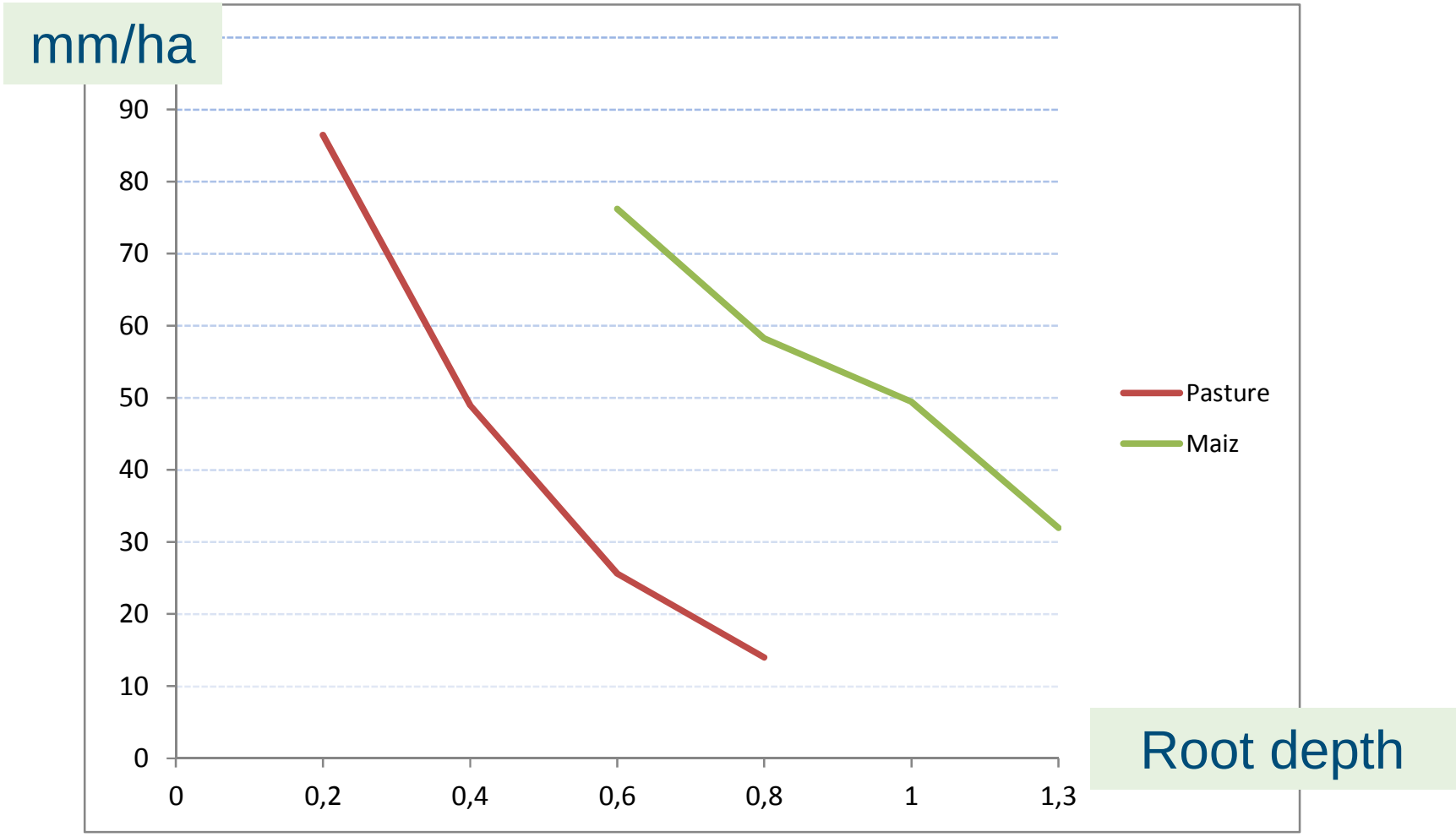
Argentina	0.036	0.475	0.954
Thailand	0.159	0.132	0.0
USA	0.002	0.310	1.870
India	2.240	0.397	2.820
Spain	**0.0**	**0.345**	**1.75**

Irrigation water for grass & maize



Blue water use from 66 L to 28 L per FPCM

Water requirement fertilizers, fuels & transport

- 5% cooling water is consumptive (95% returns)
- sea water was excluded
- turbine water was assumed to be in-stream
- Other water uses included (i.e. lake, river, well, unspecified sources)

(Ecoinvent 2004; Batlles et al. 2010)