Dynamical resource nexus assessments: from accounting to sustainability approaches

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- Overview
- The Tamar catchment
- Multi-step evaluation of food purchase
- Results
- Conclusions

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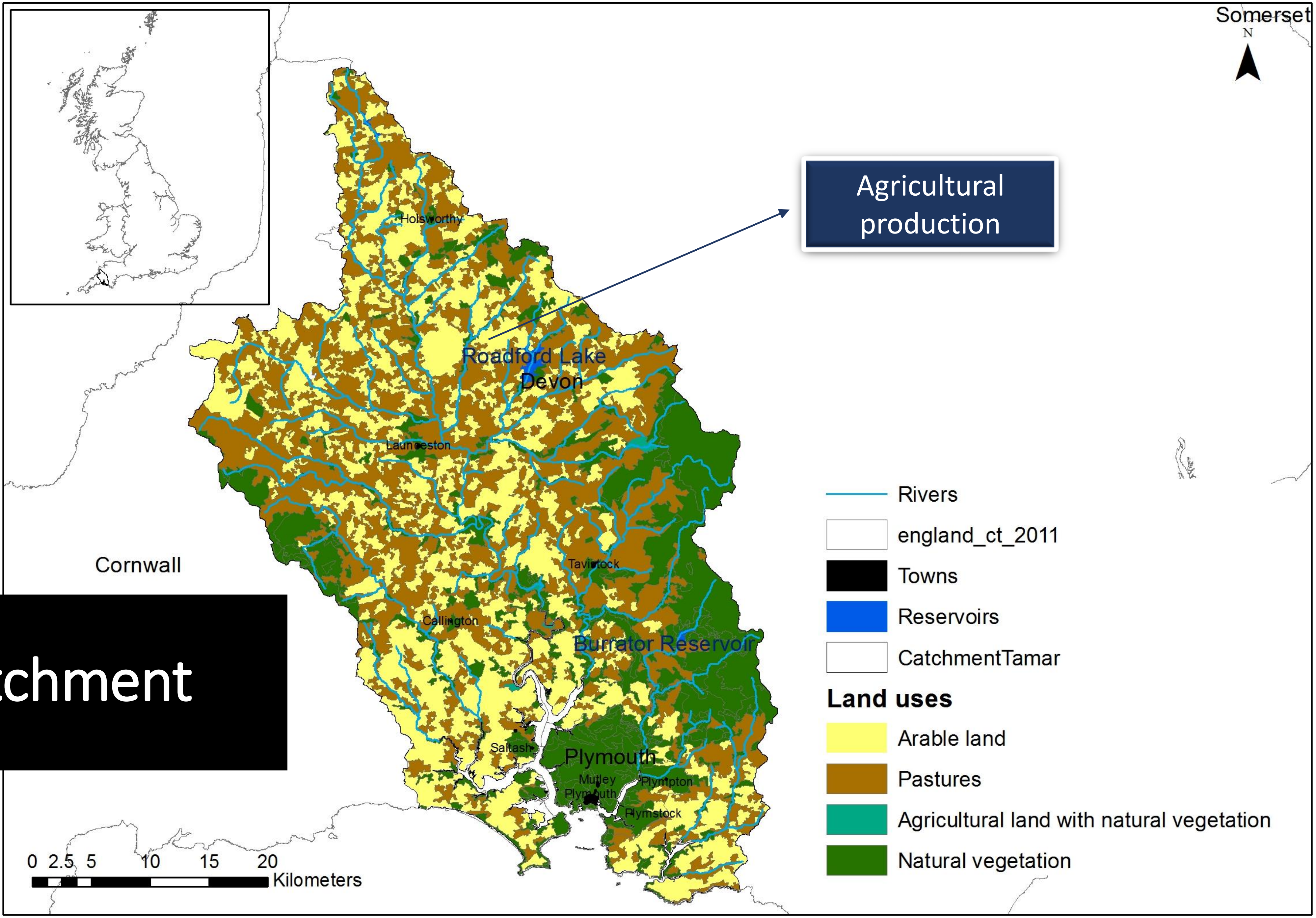
Overview

- Potential merits and limitations that life cycle assessment (LCA) has for assessing critical water-energy-food links.
- A case study with key water-energy consumption linkages for food purchase in a catchment in South West England.

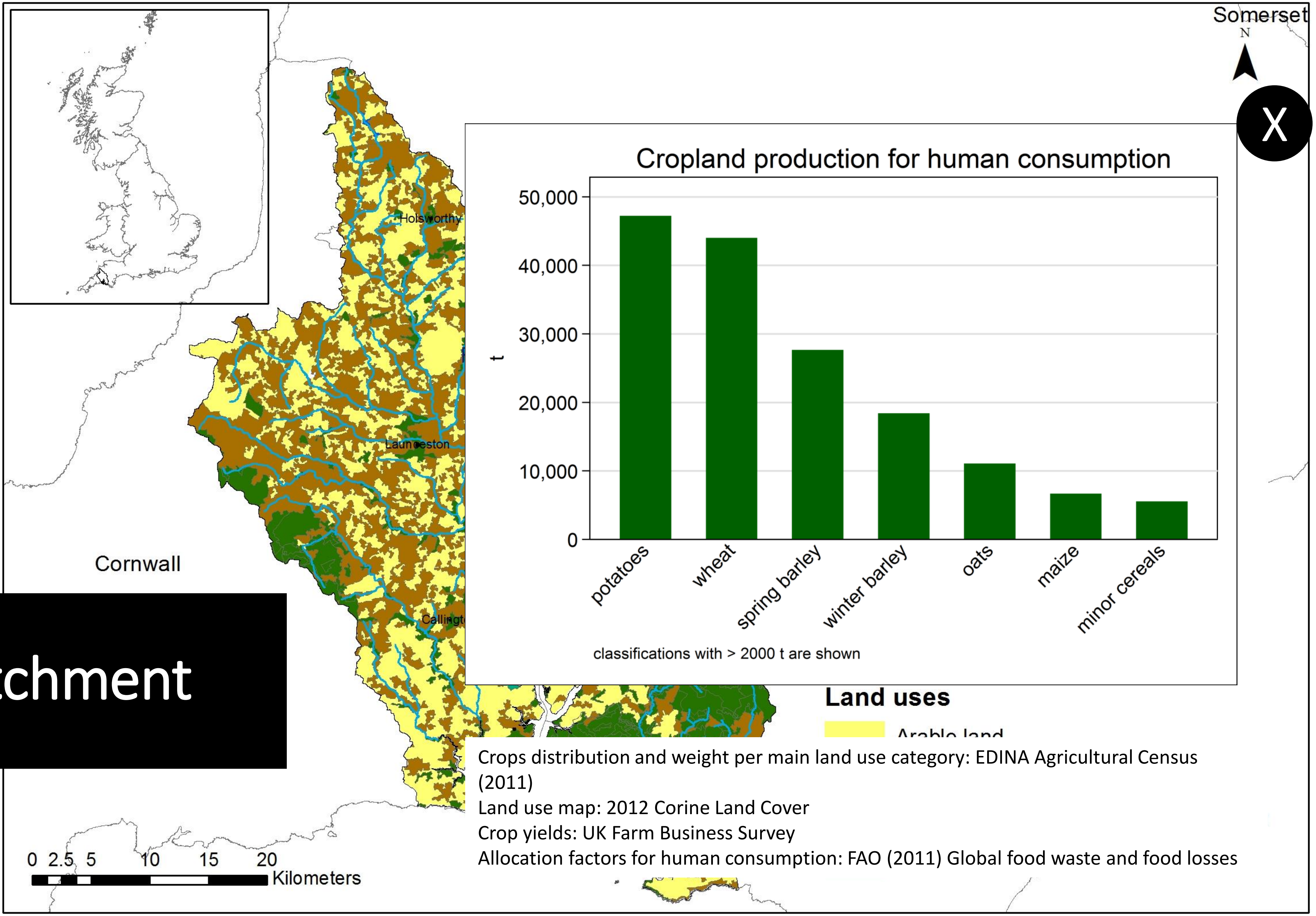
✓ The relevance of geographical and temporal contextualization of processes
✓ The dependence on embedded water and energy
✓ The weight that transport has on sustainability energy assessments

- The catchment covers a total land area of 1,820 km^2 in the South West of England
- The farmed land (included pastures), totals 136,000 ha (75% of the catchment area)

The Tamar catchment



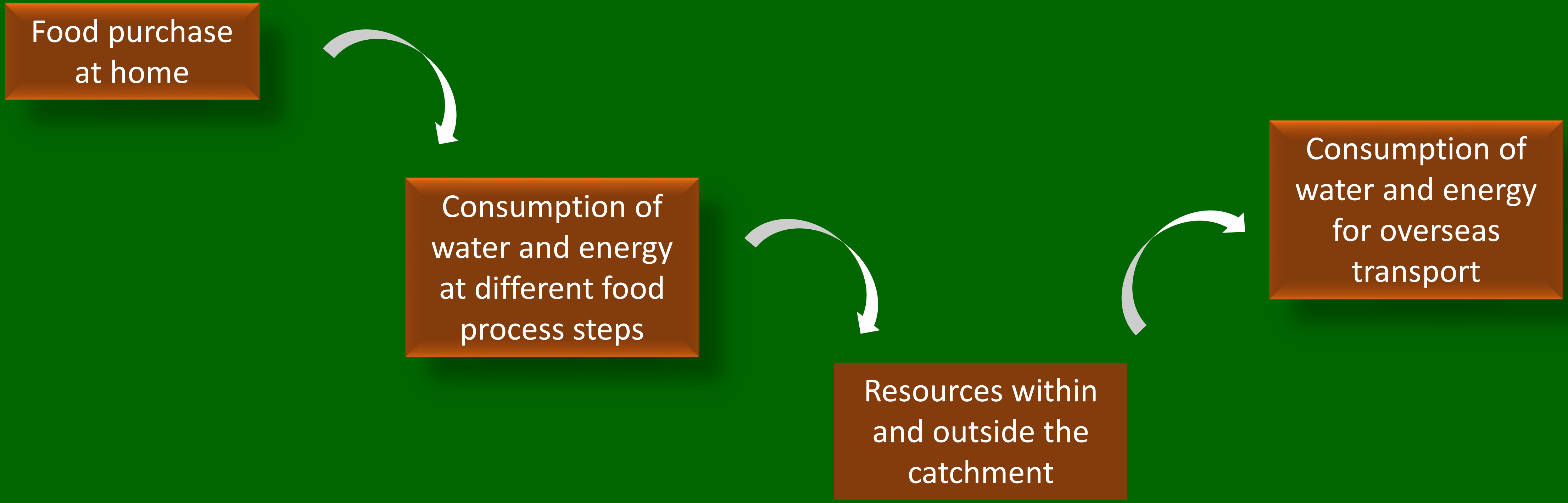
The Tamar catchment



Crops distribution and weight per main land use category: EDINA Agricultural Census (2011)
Land use map: 2012 Corine Land Cover
Crop yields: UK Farm Business Survey
Allocation factors for human consumption: FAO (2011) Global food waste and food losses

Multi-step evaluation of food purchase

Click on each box for more details



Multi-step evaluation of food purchase

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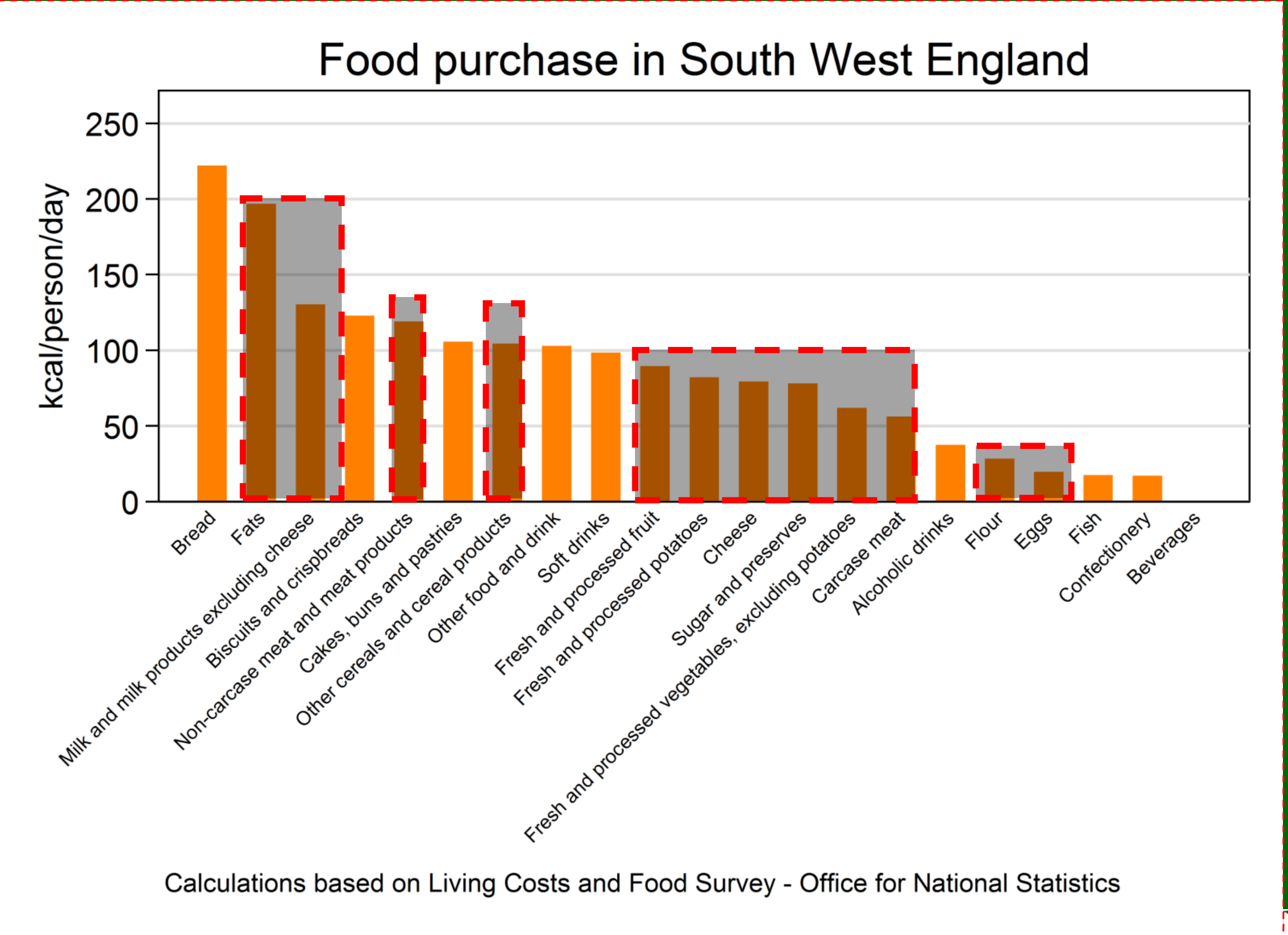
Click on each box for more details

- Inside red squares selected food categories in the study are shown
- 12 food products are selected from Agri-Footprint and Ecoinvent 3 databases (click on the graph for more info)
- Selected products comprise 60% of food purchase at home in terms of kcal



Overview | The Tamar catchment | Results | Conclusions

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Multi-step evaluation of food purchase

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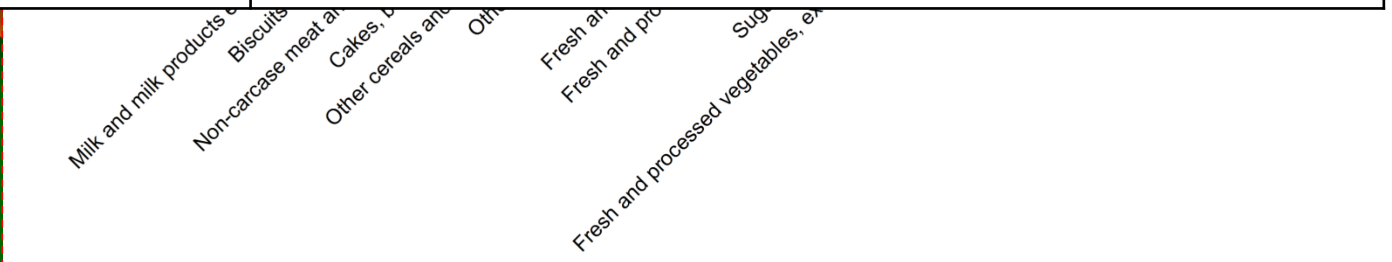
Click

	Food category	Food product selected	Food product selected in Simapro
1	Milk and milk products excluding cheese	Skimmed milk	Standardized milk, skimmed, from processing, at plant/NL Economic
2	Cheese	Cheese	Cheese, from cheese production, at plant/NL Economic
3	Carcase meat	Beef meat	Beef meat, fresh, from beef cattle, at slaughterhouse, PEF compliant/IE Economic/Economic
4	Non-carcase meat and meat products	Chicken meat	Chicken meat, fresh, at slaughterhouse/NL Economic
5	Eggs	Eggs	Consumption eggs, laying hens >17 weeks, at farm/NL Economic
6	Fats	Butter	Butter, from cow milk {GLO}| butter production, from cream, from cow milk | Alloc Def, U
7	Sugar and preserves	Sugar	Sugar, from sugar cane, from sugar production, at plant/BR Economic
8	Fresh and processed potatoes	Potatoes	Starch potato, at farm/DK Economic
9	Fresh and processed vegetables	Carrots	Carrot, at farm/NL Economic
10	Fresh and processed fruit	Apple	Apple {GLO}| production | Alloc Def, U
11	Flour	Wheat flour	Wheat germ, from dry milling, at plant/NL Economic
12	Other cereals and cereal products	Rice	Rice, late, continuous flooding, at farm/CN Economic

- Selected products comprise 60% of food purchase kcal at home



Calculations based on Living Costs and Food Survey - Office for National Statistics

Overview

The Tamar catchment

Results

Conclusions

Multi-step evaluation of food purchase

Click on each box for more details

Food pu
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- Agri-Footpint and Ecoinvent 3 databases are used
- Raw materials during the life cycle inventory, including freshwater and energy, are summarized and extracted at different process
- See an example of processes involved in a life cycle inventory for two different types of resources

Consumption of water and energy for overseas transport

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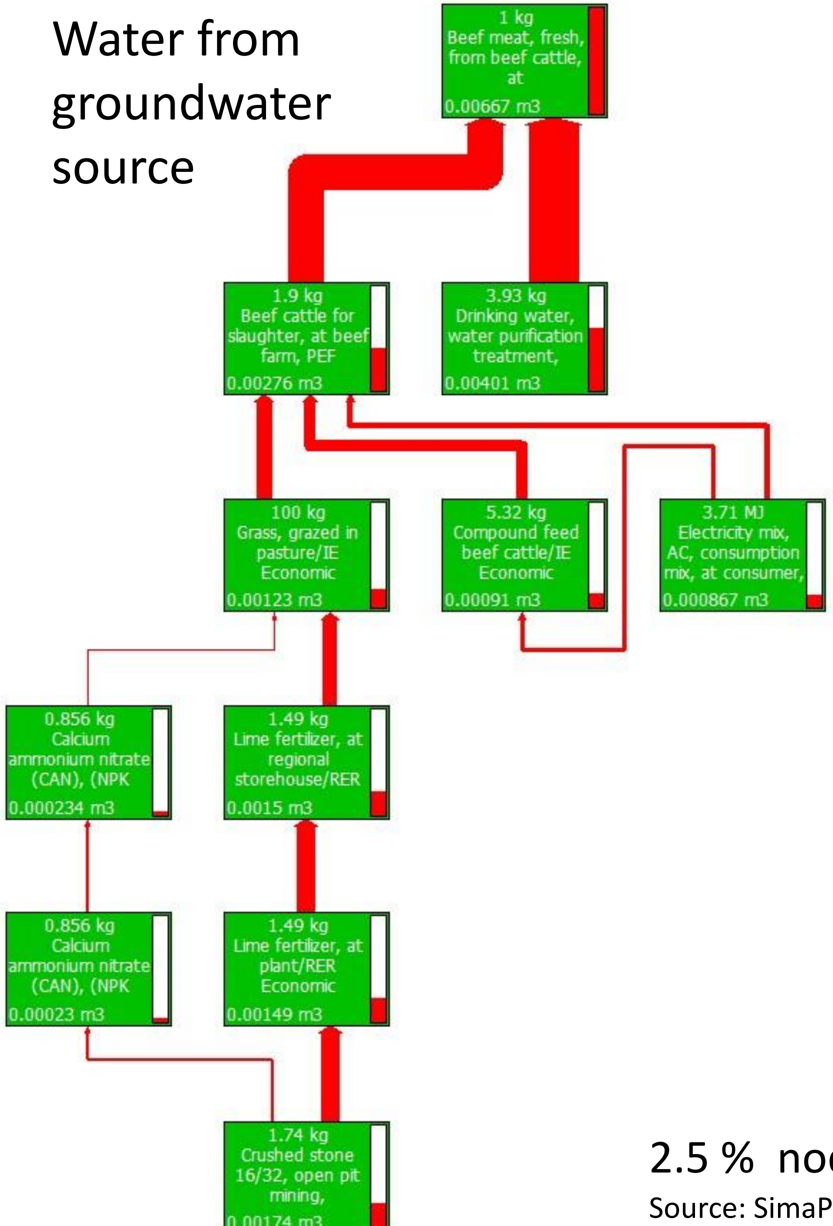
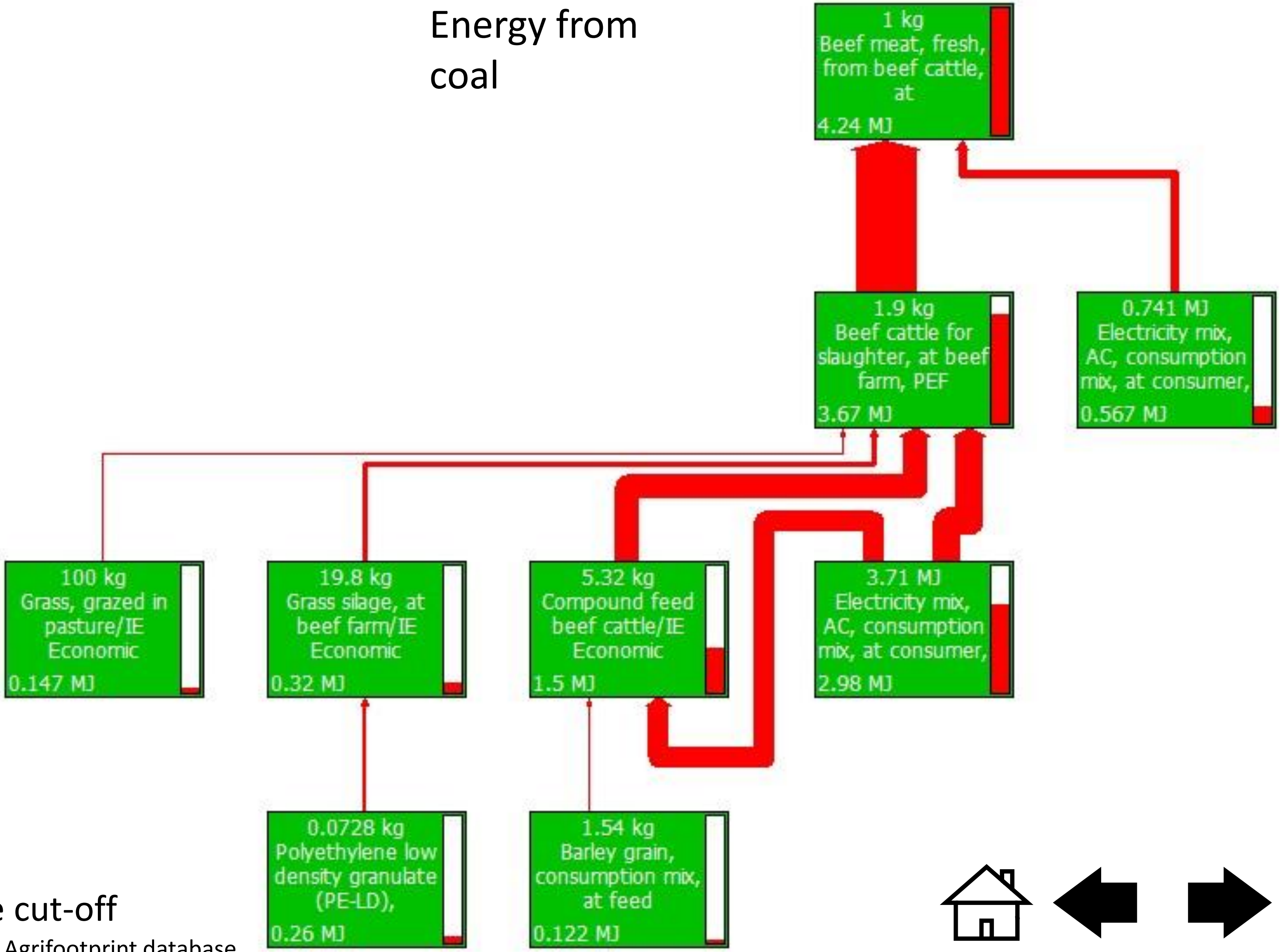
Example of a life cycle inventory for beef meat

Water from groundwater source



Energy from coal



2.5 % node cut-off

Source: SimaPro, Agrifootprint database

Multi-s

Click on each

Food purch
at home

Application of ratios to each food product *i*:

- Ratio for each *i* between imports-exports (ton) and food purchase for human consumption (ton):

$$ratio\ import_i = \frac{import}{domestic\ supply} \times \frac{(food\ supply + processing)}{domestic\ supply}$$

$$ratio\ expport_i = \frac{import}{domestic\ supply} \times \frac{(food\ supply + processing)}{domestic\ supply}$$

FAO trade balance sheets are used. Classification such as feed and seed are not considered for human consumption.

- Ratio for each *i* of imports-exports ($) by trade partner country *j*:

$$ratio\ country\ import_{ij} = \frac{import_{ij}}{import_i}$$

$$ratio\ country\ export_{ij} = \frac{export_{ij}}{export_i}$$

Consumption of water and energy for overseas transport

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Multi-step evaluation of food purchase

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Click on each

Food purch
at home

Assumptions made for the calculation of overseas food miles

- Perishable foods (e.g., milk, eggs, vegetables) are transported by plane, the non-perishable (e.g., butter, rice, sugar) by ship.
- Plane transport: distances between London and other cities https://www.timeanddate.com/worldclock/distance.html
- Ship transport: distances between Plymouth and other ports https://sea-distances.org/
- 1 tkm Plane, technology mix, cargo, 68 t payload and 1 tkm Container ship ocean, technology mix, 27.500 dwt pay load capacity are obtained from the European Life Cycle Database (ELCD) v3.1 database

Consumption of water and energy for overseas transport

Results

Resource consumption by food product

Resource consumption distribution by processes

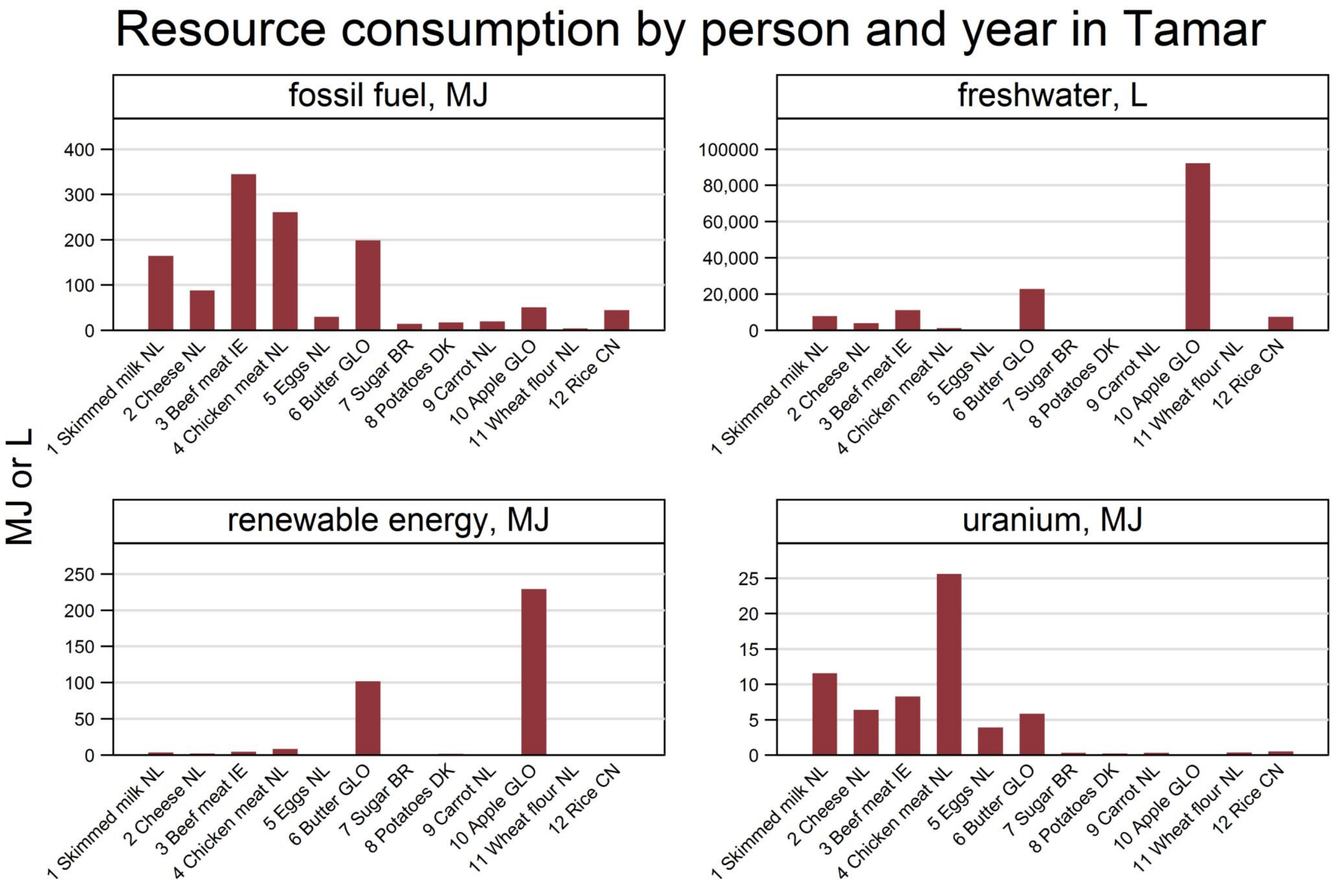
National and overseas energy consumption

National and overseas freshwater consumption

Resources consumption considering food miles

Global distribution of energy embedded in food imports

Global distribution of energy embedded in food imports



Country of production: BR (Brazil), CN (China), DK (Denmark), IE (Ireland), GLO (Global) NL (The Netherlands)

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Click here to see resource consumption by food product and 100 kcal

- Animal products are more energy intensive because of production of compound feed and fertilizers
- Freshwater consumption of food products greatly depends on irrigation

Overseas transport is not included

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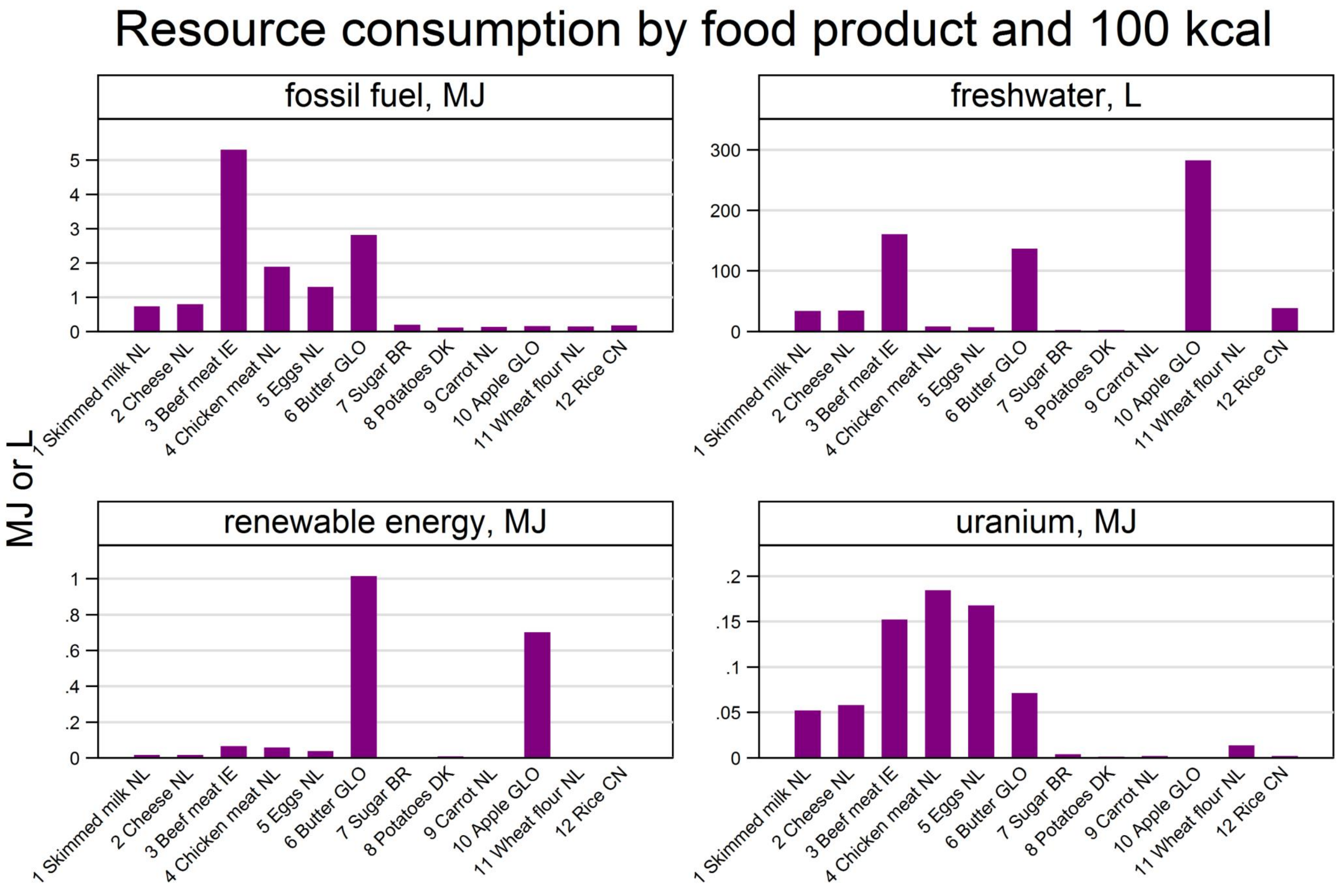
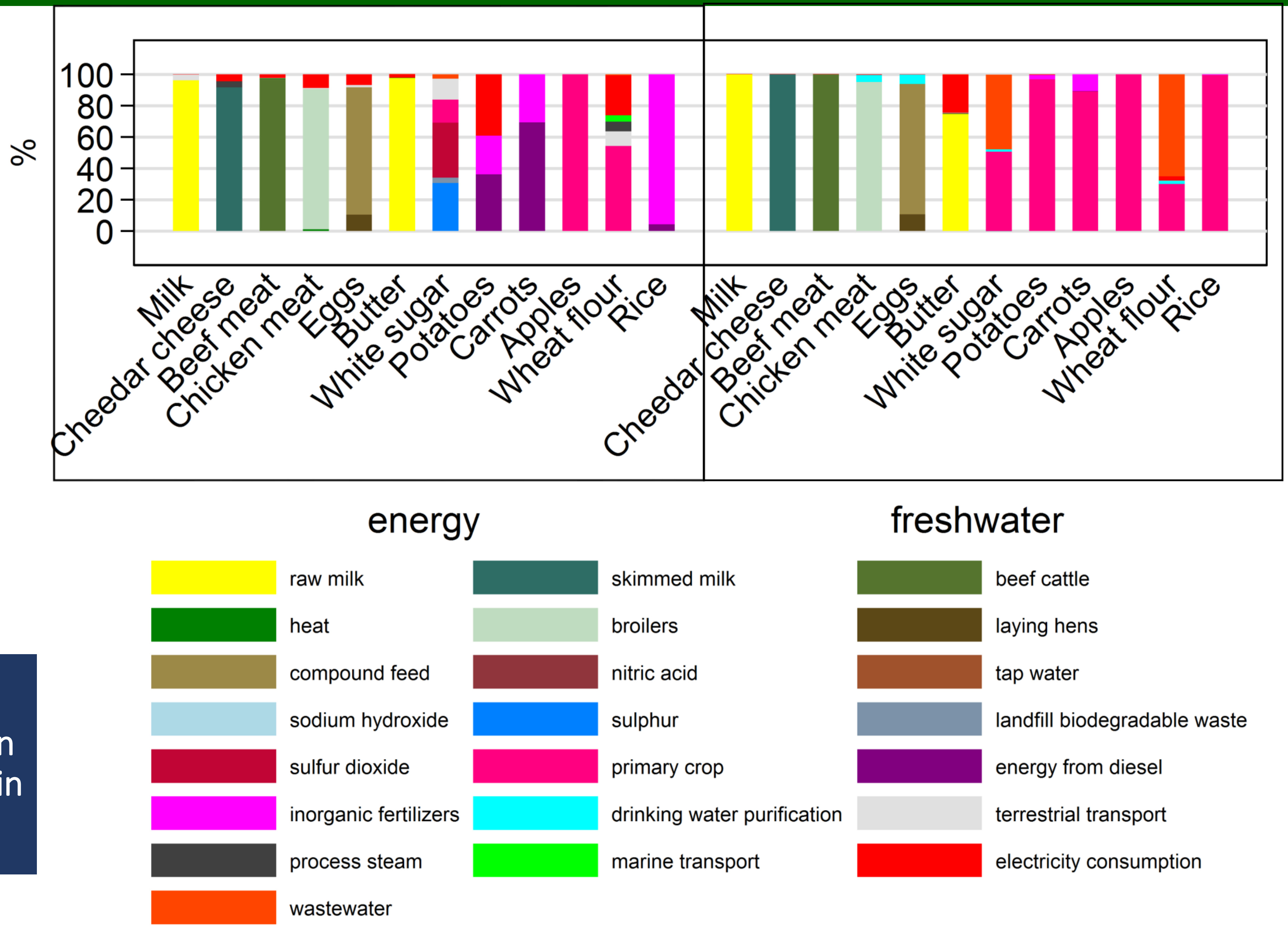


Country of production: BR (Brazil), CN (China), DK (Denmark), IE (Ireland), GLO (Global) NL (The Netherlands)

Overseas transport is not included

- The production of primary crops (e.g., carrots) and livestock (e.g., beef) accounts for the largest proportion of energy and freshwater use
- A detailed assessment within each primary product is essential



Freshwater and energy consumption distribution by food product and main processes

Overseas transport is not included

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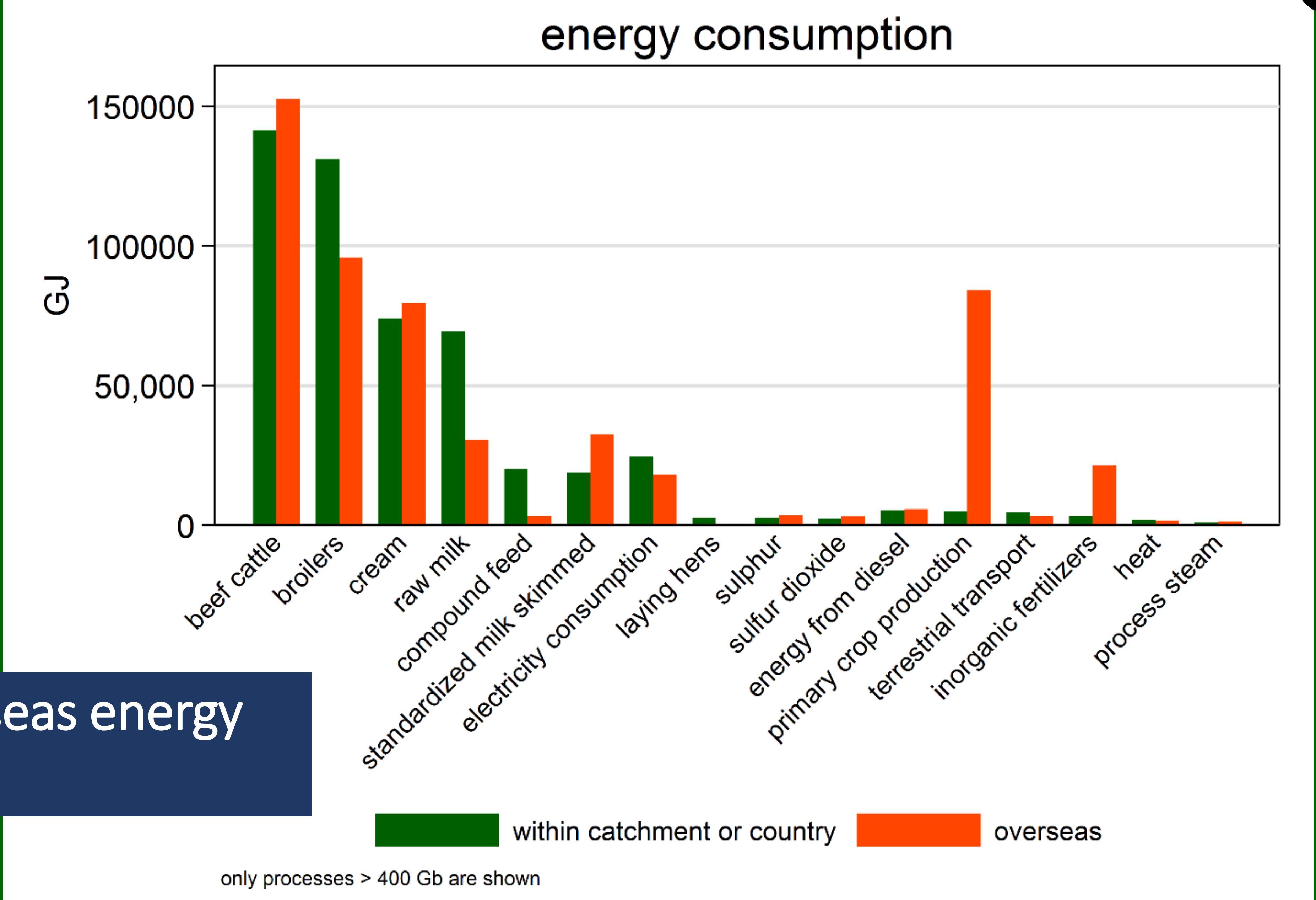
Tamar catchment imports similar amount of embedded energy (51%) as uses locally (49%)

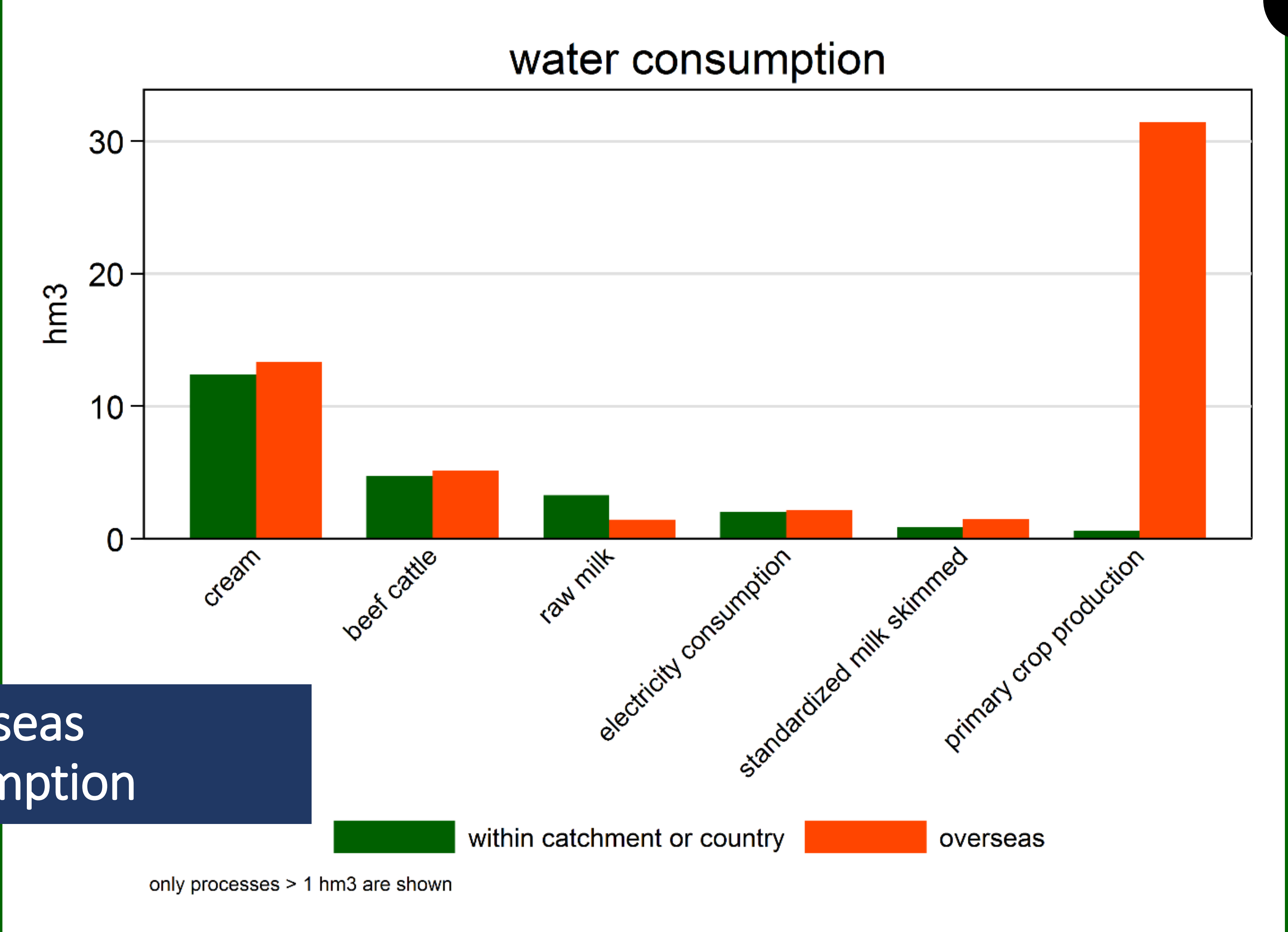


National and overseas energy consumption

Overseas transport is not included

National and overseas freshwater consumption

Tamar catchment imports more embedded freshwater (70%) than uses locally (30%)



Overseas transport is not included

- 92% energy consumption at origin of production from EU countries
- 46% energy consumption of overseas transport from non-EU countries
- With the inclusion of overseas transport total energy consumption (including production in UK) increases by 144% (from 1,133,000 GJ to 2,767,000 GJ)

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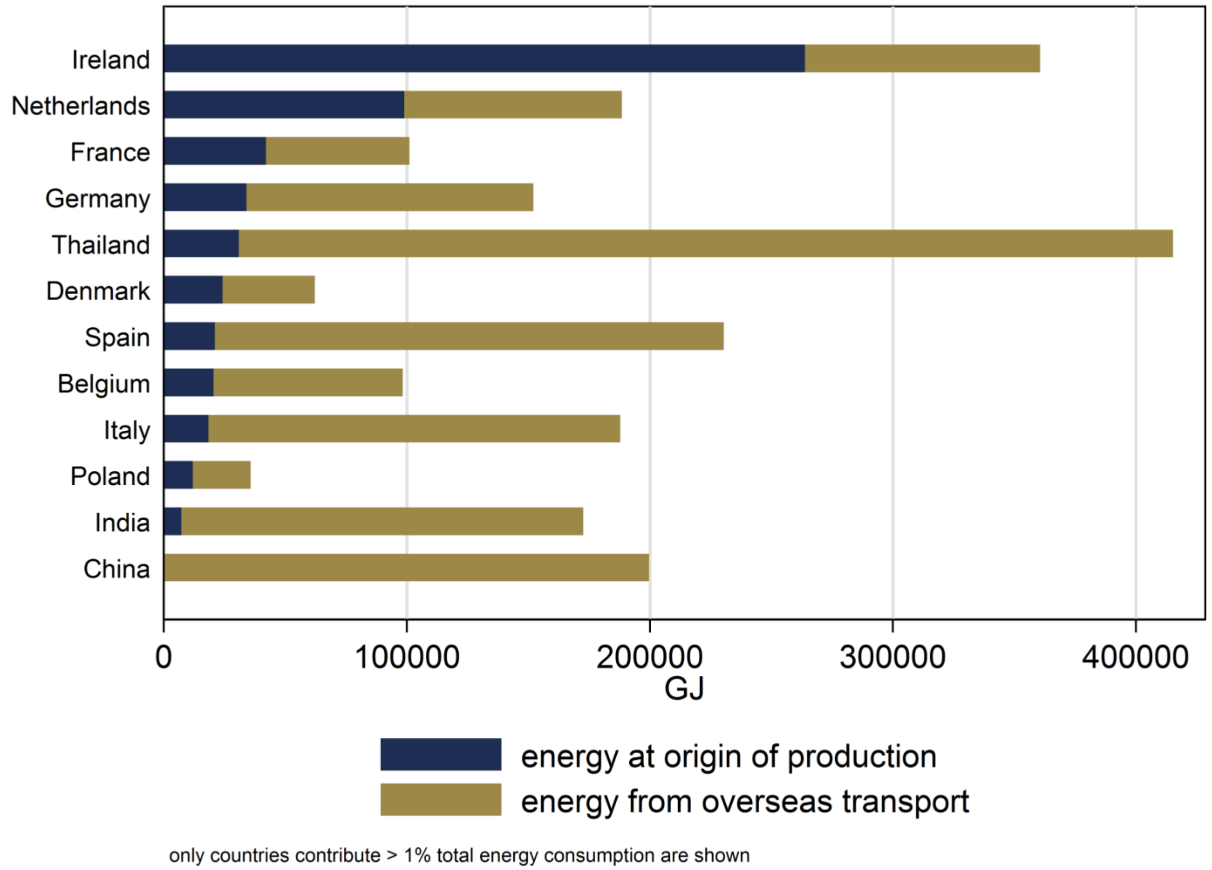

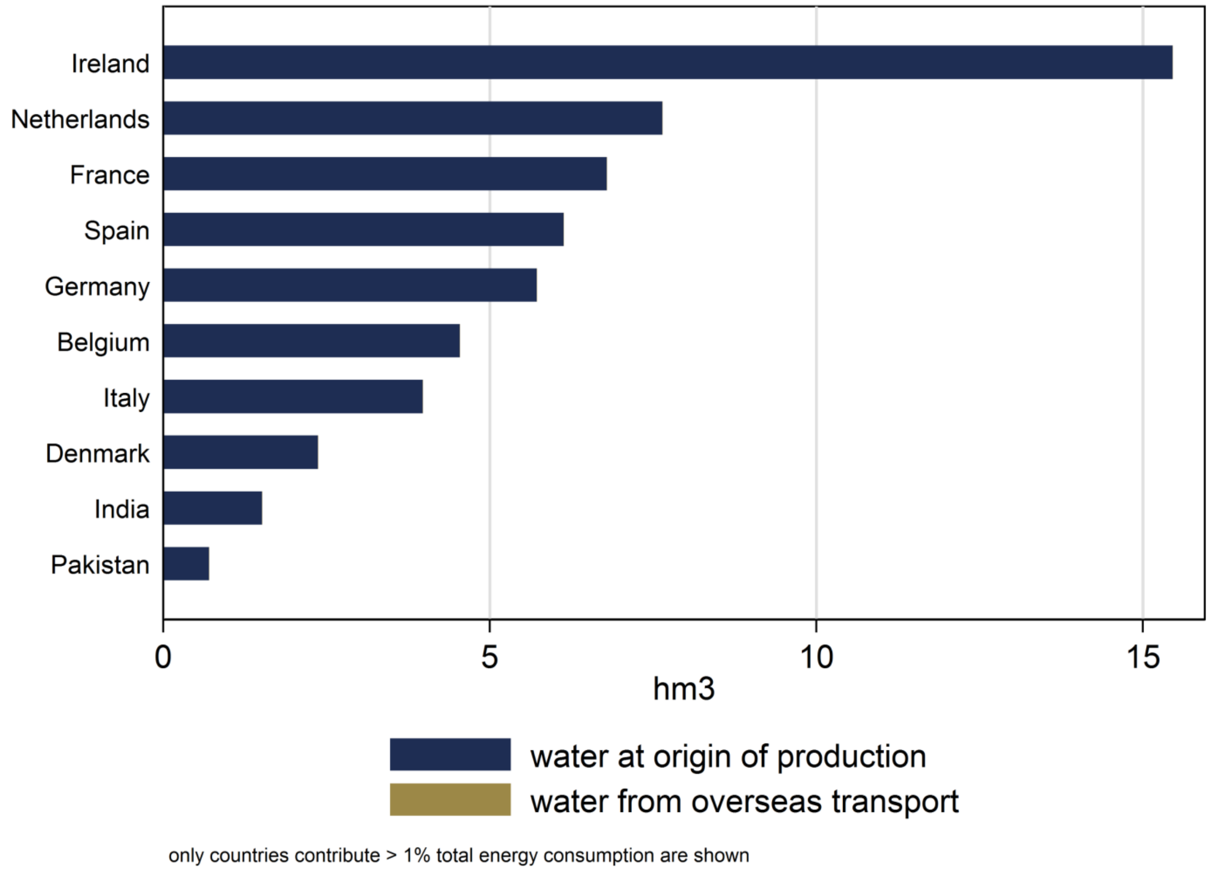

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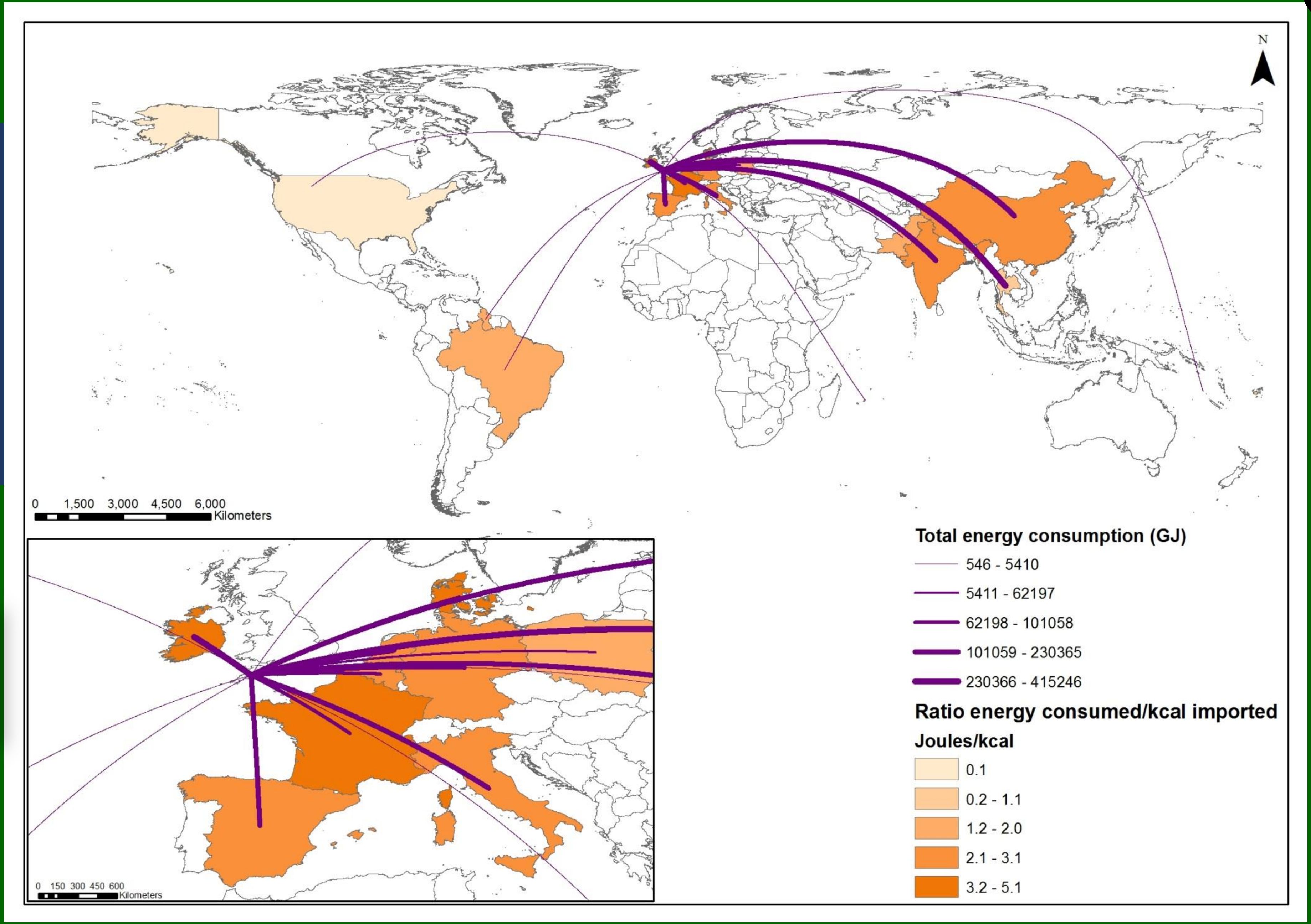
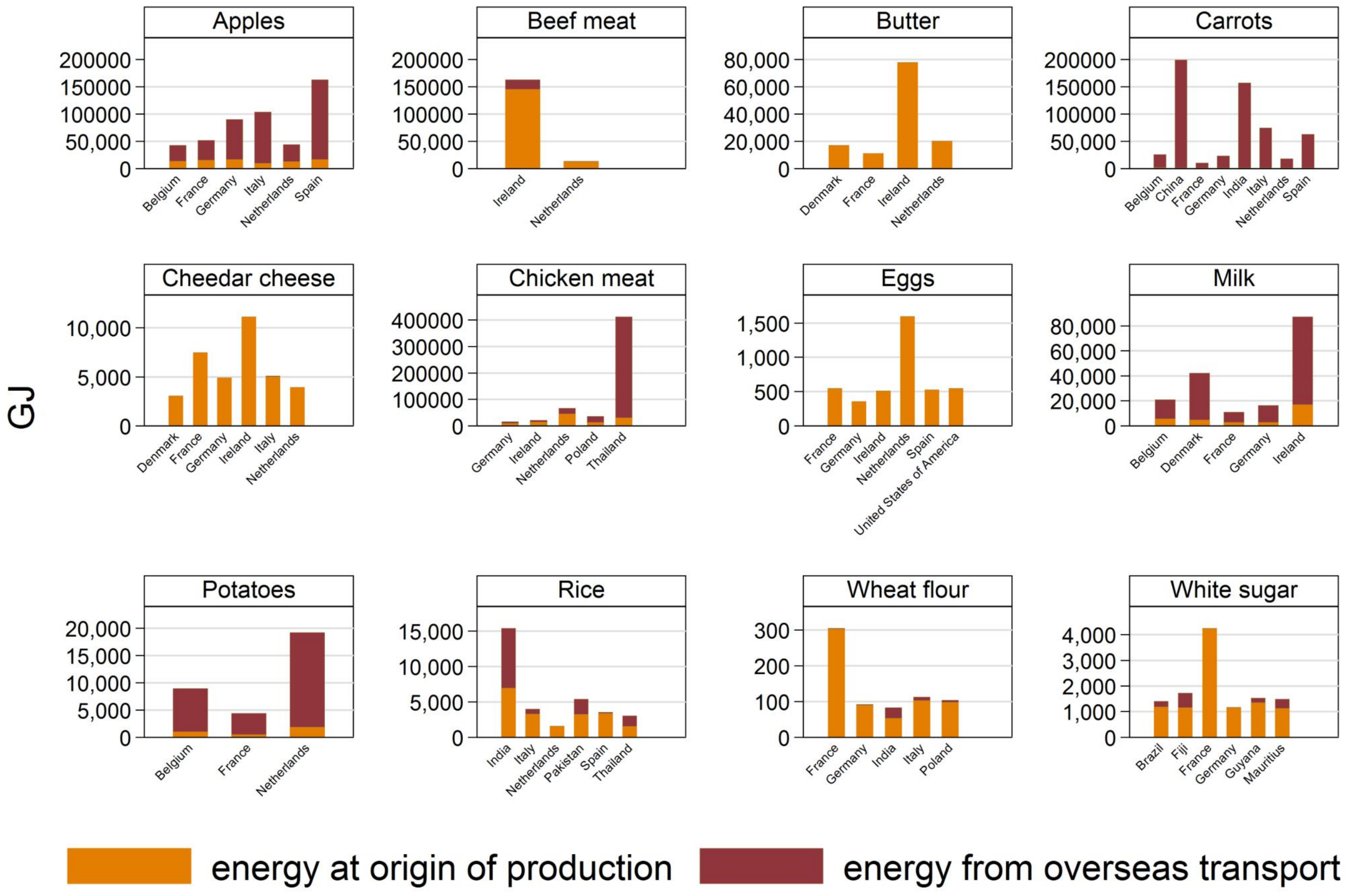
- Imports from EU are quite energy intensive due to the type of food product (i.e., beef meat) and transport

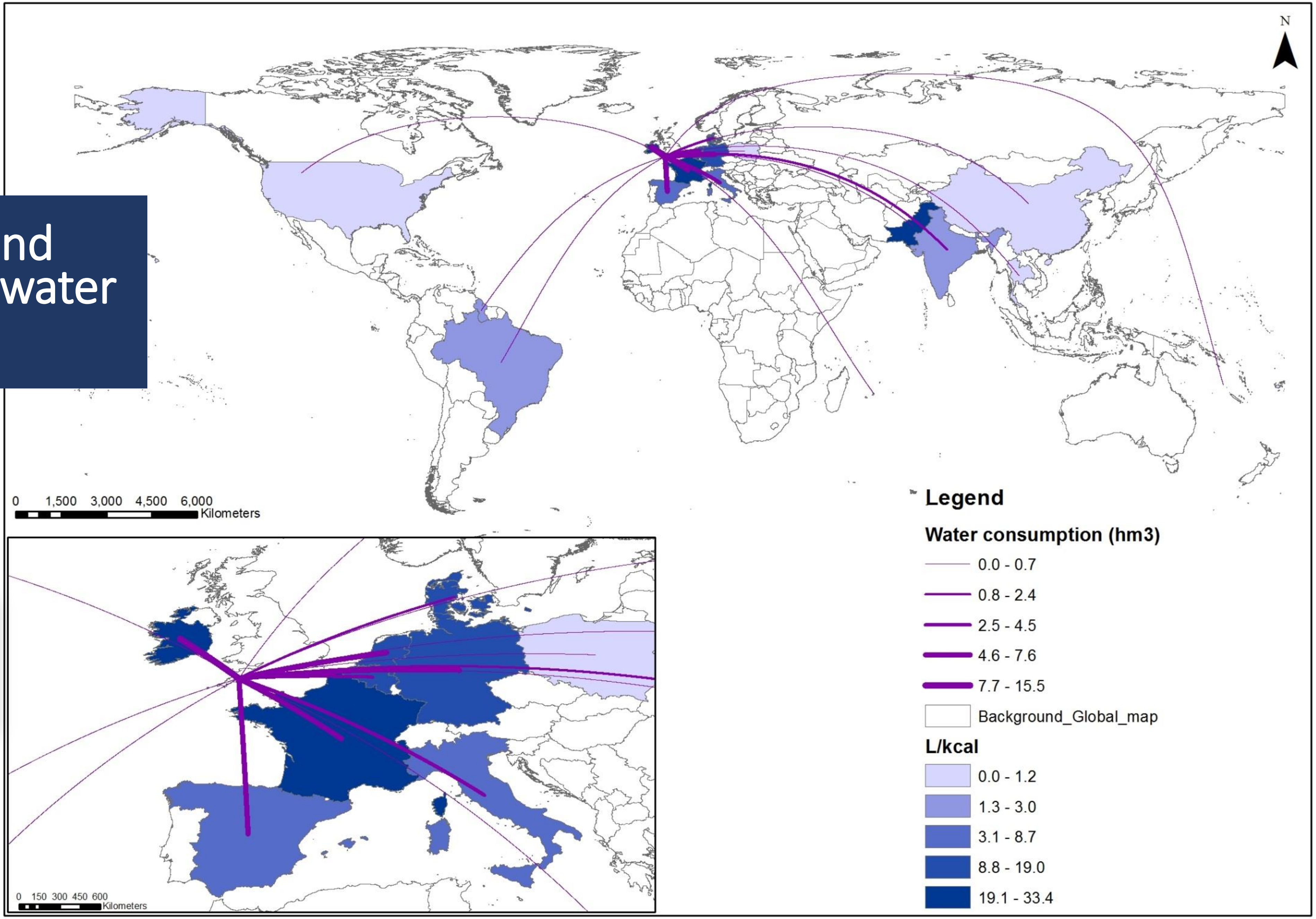


Click for total energy consumption by food product and country

- Products transported by place require more energy input



Largest volume and intensity of freshwater from EU too



Click for total water consumption by food product and country

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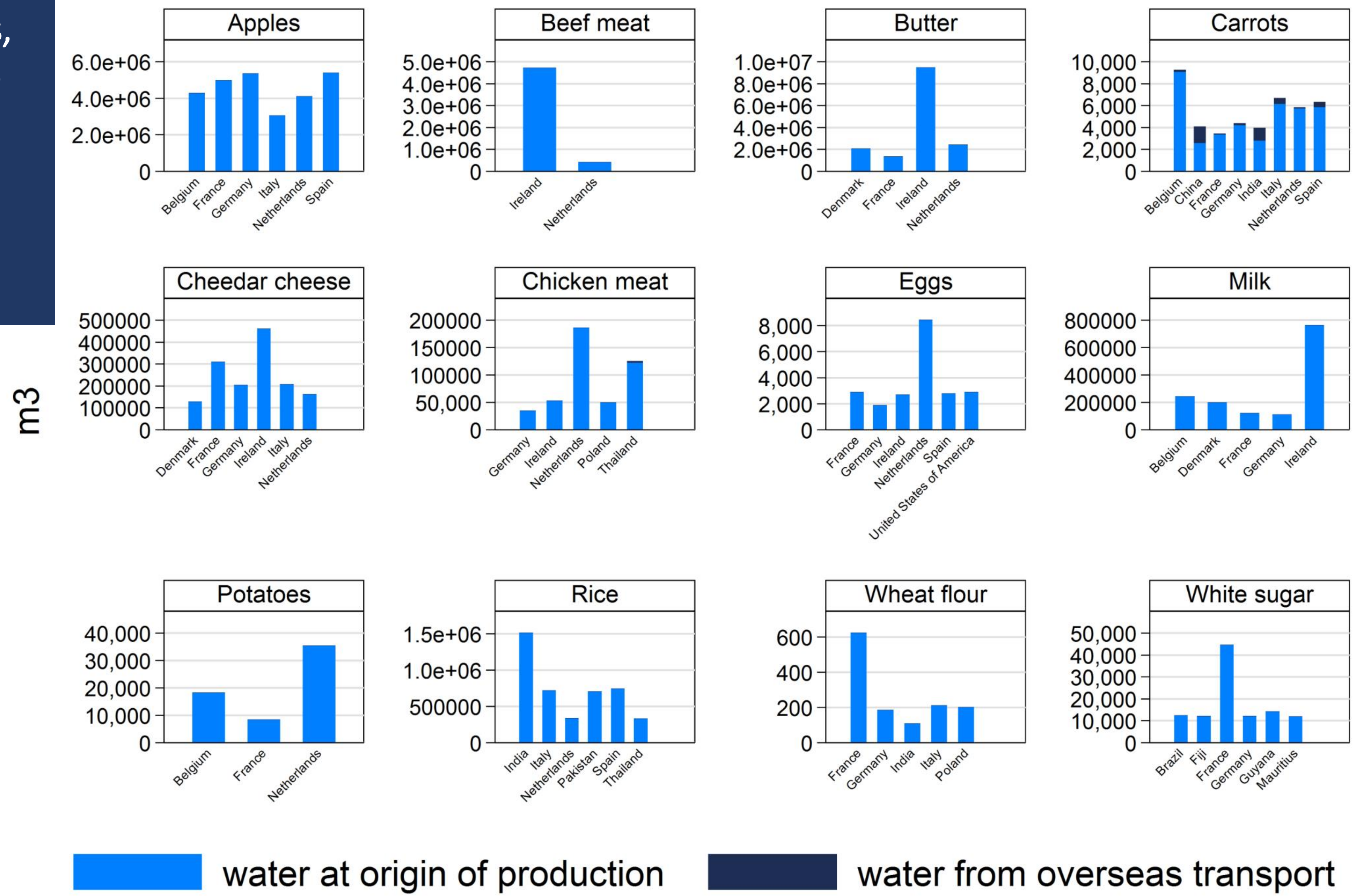
- Fruit, vegetables, meat and rice as the most demanding products from overseas



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Conclusions

- The Tamar imports about 51% and 70% of energy and water for food purchase at home, without including overseas transport
- The weight of the overseas transport is very relevant, comprising about 60% of the total energy consumption
- Improved differentiation of processes (e.g., water consumed in primary crop products) is required to identify hotspots and origins of resource use
- Freshwater values for food production need to be adapted for the country of production
- Renewable and non-renewable sources will depend greatly on the electricity mix from the country of production