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WP8: Case study results water / materials

Stephan Lutter

The material case

- Case study performed by
  - WU: Stefan Giljum, Aldo Martinez, Stephan Lutter
  - Wuppertal Institute: Helmut Schütz

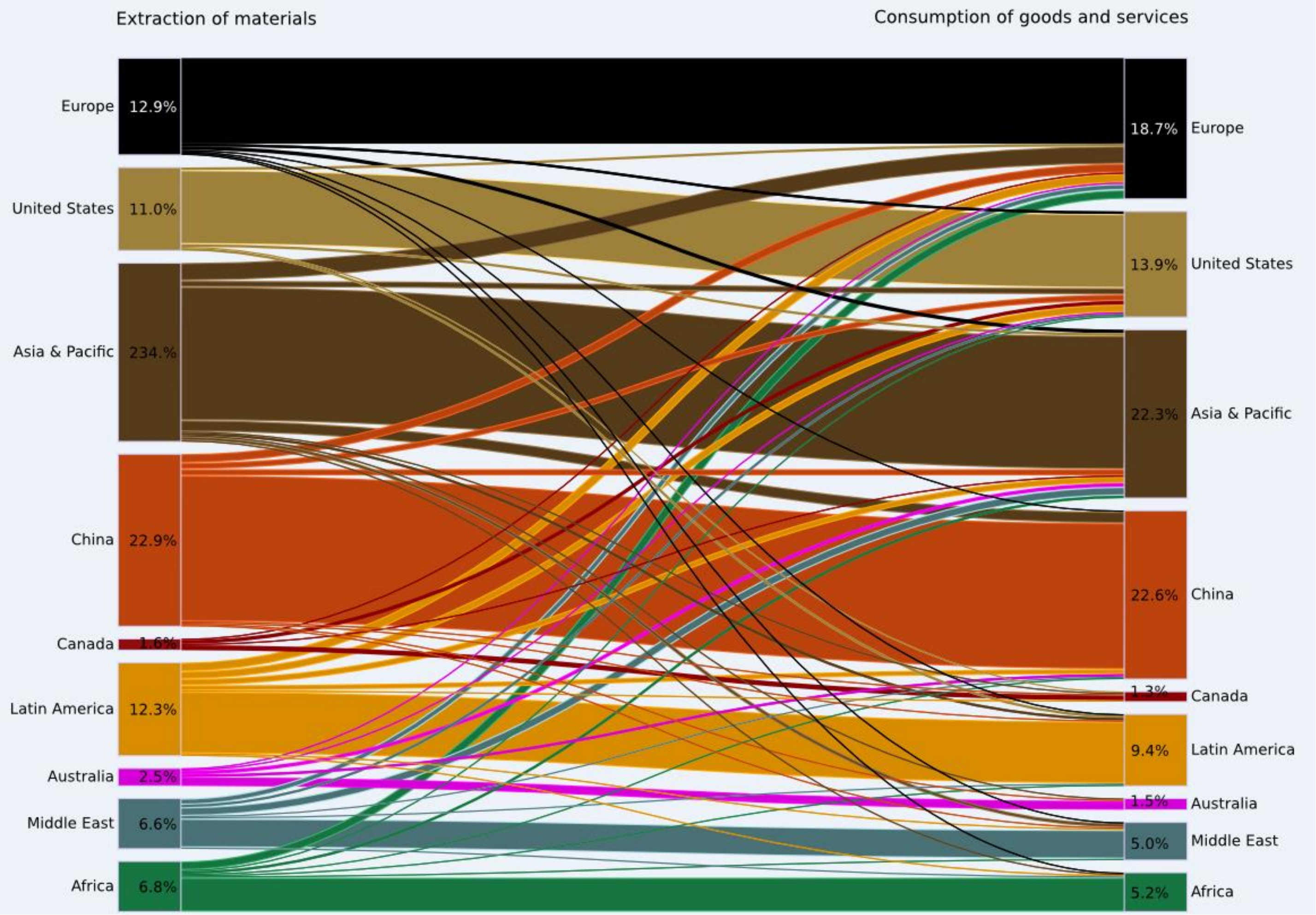
The material case: objectives

- Calculate and analyse material footprints for all EXIOBASE countries/regions
  - Raw Material Consumption (RMC) / used extraction
  - Total Material Consumption (TMC) / total extraction
- Compare the results with other MRIO-based calculations and with a coefficient-based approach following the Eurostat RMC methodology

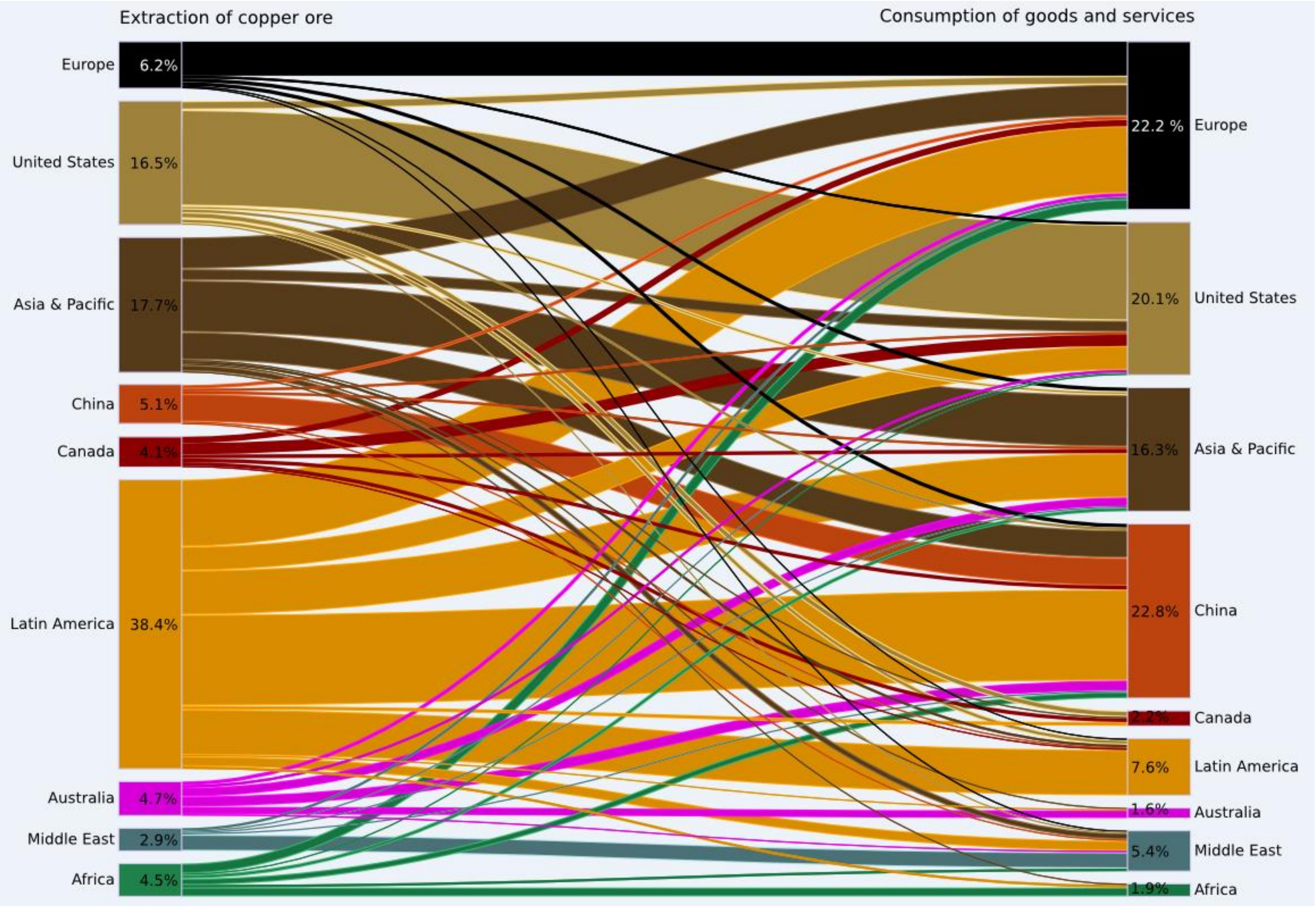
The material case: methodology

- EXIOBASE distinguishes 48 materials:
  - 23 categories related to biomass extraction
  - 10 categories of metal ores
  - 9 categories of industrial & construction minerals
  - 6 categories of fossil fuels
- Materials are allocated to respective product (or product group) in IO table
  - Some manual adjustments were required (e.g. sand and gravel extraction in India is reported under "construction work")

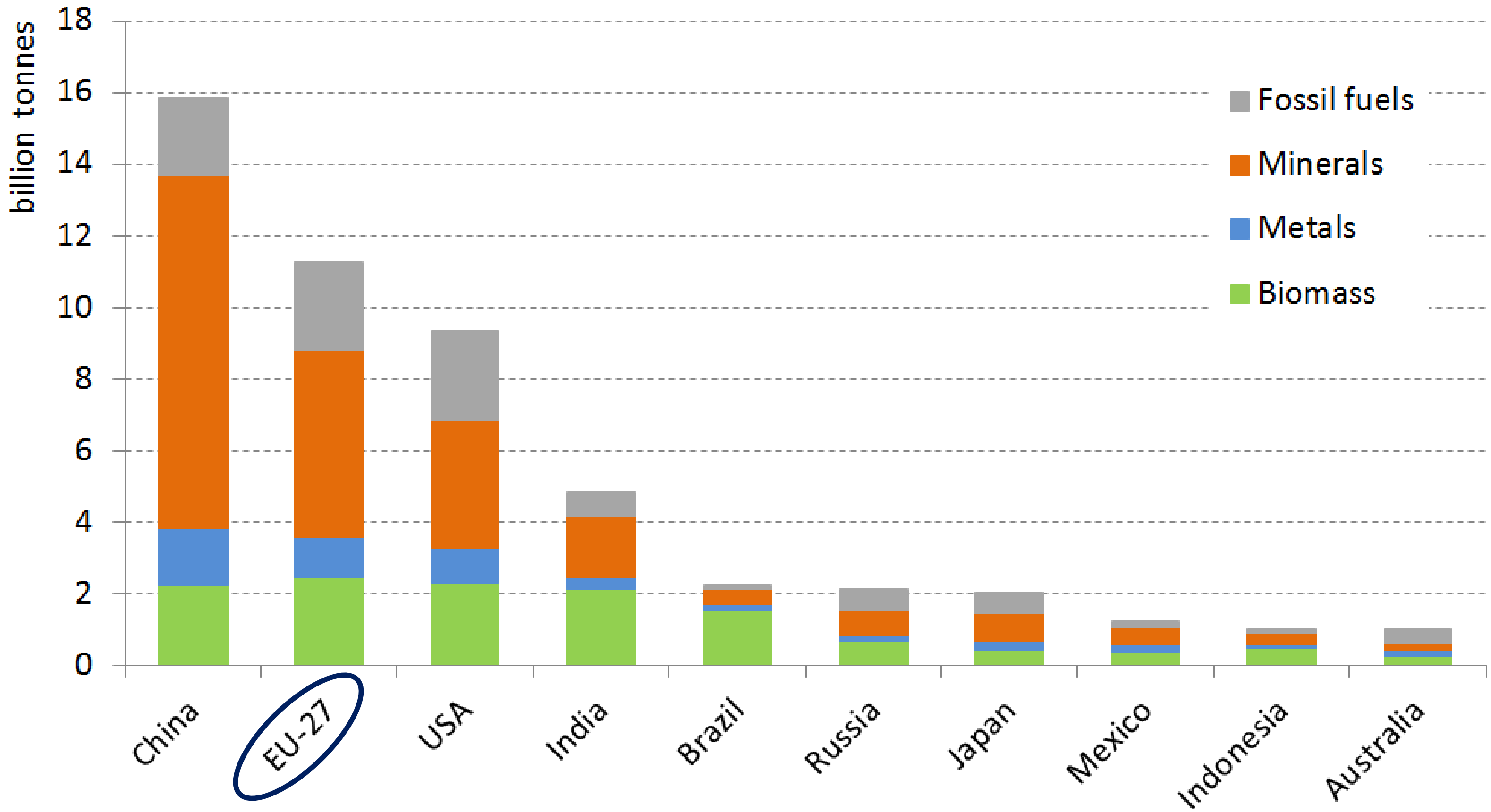
From material extraction to consumption (all materials)



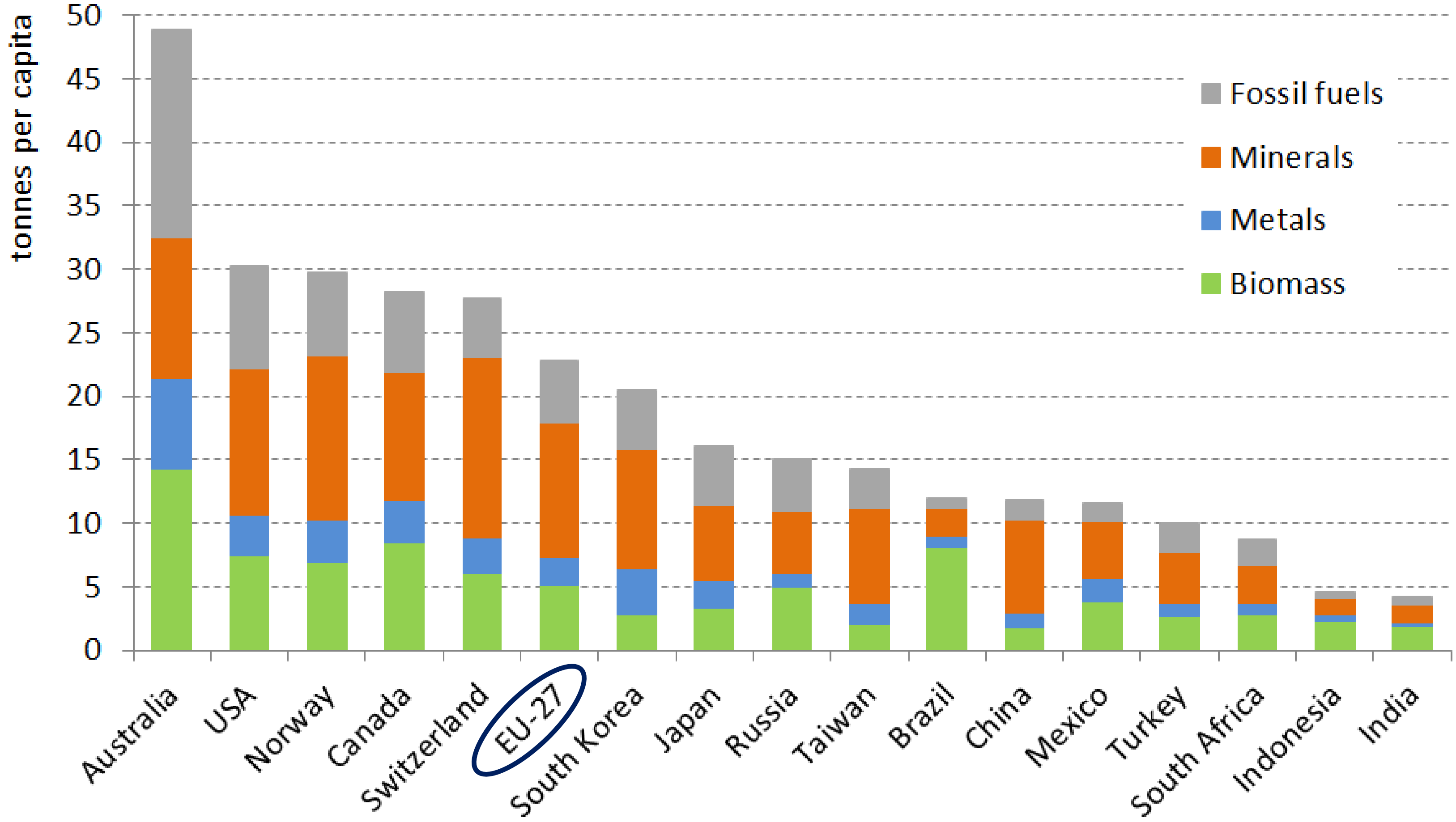
From material extraction to consumption (copper)



RMC (absolute numbers): EU-27 in Top-10 ranking



RMC (per capita numbers): EU27 + all EXIOBASE countries



EU-27 total RMC (per capita) by aggregated sector and region

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	Europe	Asia + Pacific	Latin America	Africa	Middle East	North America	Oceania	Total
Agriculture, forestry and fishing	0.6	0.1	0.1	0.1	0.0	0.0	0.0	0.9
Mining and quarrying	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Manufacturing of biomass-based products	2.0	0.7	0.4	0.2	0.1	0.1	0.0	3.5
Manufacturing of fossil fuel-based products	0.4	0.6	0.1	0.2	0.2	0.0	0.0	1.5
Manufacturing of metal- and mineral-based products	1.2	1.5	0.4	0.3	0.2	0.2	0.1	3.8
Electricity, gas and water supply	0.5	0.2	0.0	0.1	0.0	0.0	0.0	0.8
Construction	5.3	0.5	0.2	0.2	0.1	0.1	0.0	6.4
Sales and retail (incl. hotels and restaurants)	1.0	0.4	0.1	0.1	0.1	0.0	0.0	1.9
Transport and communications	0.2	0.2	0.0	0.1	0.1	0.0	0.0	0.6
Financial and business services	0.7	0.2	0.0	0.1	0.0	0.0	0.0	1.1
Other services	1.0	0.5	0.1	0.1	0.1	0.1	0.0	1.9
Total	13.2	4.8	1.5	1.4	1.0	0.6	0.3	

EU-27 metal RMC (per capita) by aggregated sector and region

	Europe	Asia + Pacific	Latin America	Africa	Middle East	North America	Oceania	Total
Agriculture, forestry and fishing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Mining and quarrying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Manufacturing of biomass-based products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
Manufacturing of fossil fuel-based products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
Manufacturing of metal- and mineral-based products	0.1	0.4	0.3	0.1	0.0	0.1	0.1	**1.1**
Electricity, gas and water supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Construction	0.1	0.1	0.1	0.0	0.0	0.0	0.0	**0.4**
Sales and retail (incl. hotels and restaurants)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**
Transport and communications	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
Financial and business services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
Other services	0.0	0.1	0.1	0.0	0.0	0.0	0.0	**0.2**
Total	**0.3**	**0.7**	**0.6**	**0.2**	**0.0**	**0.2**	**0.2**	

The material case: conclusions

- EU-27 is among the highest material-consuming regions in the world
- EU-27 is a major net-importer of materials, in particular for the case of metal ores and fossil fuels
- EXIOBASE allows identifying priority products and product groups with highest material intensities

The material case: lessons learned

- Close cooperation between teams compiling economic data (IO tables) and environmental extensions required
  - To make full use of physical data in the disaggregation procedure
  - To ensure that material extractions are correctly allocated to sectors
  - To ensure that all material extractions are represented with corresponding monetary values in the IO tables → realistic material intensities
    - Further improvement of methodology currently in DESIRE project

The water case

- Case study performed by
  - WU: Stephan Lutter, Aldo Martinez, Stefan Giljum
  - ETH: Stephan Pfister, Catherine Raptis, Chris Mutel
  - UTwente: Mesfin Mekonnen

Objectives

Step 1: Water footprint calculation with EXIOBASE

- Test EXIOBASE 2.0 and record encountered problems
- Calculate total water embodied in final consumption:
- Water appropriation and trade analysis (consumption areas and cross-country patterns)
- Focus on most relevant sectors and countries (using subnational information; Water Footprint dataset of TU Twente and ETH Zürich dataset)

Objectives

<u>Step 2</u>: Data and methodological comparison

- Evaluate Step 1's output differences for the two datasets used
- Comparisons with the following methods:
  - Water Footprint methodology
  - Life-cycle assessment methodologies
- Result: strengths/weaknesses of different methodologies, identify where methodological improvements are needed

Objectives

Step 3: Analysis of thermal and nutrient emissions

- Apply thermal emission approach using EXIOBASE (using the relevant results of WP3 and knowledge from process-based analyses of key technologies)
- Estimate the grey WF related to the emission of nitrogen and phosphorus following the WFN approach

Step 4: Developing an integrated approach and final CS report

- Final report structured as a scientific paper (easier to produce publications)

Data coverage and sources

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- Agriculture: blue and green water consumption for 13 different crops
- Livestock husbandry: Blue water use/consumption for 12 different types of animals
- Manufacturing industry: Blue water use/consumption for 53 different sectors
- Electricity industry: Blue water use/consumption for two types of water cooling systems for 7 different types of electricity production
- Domestic: Blue water use and consumption

- Agricultural data: ETH/Twente
- Rest: WaterGAP model (University of Kassel)

Step 1: Water footprint calculation with EXIOBASE

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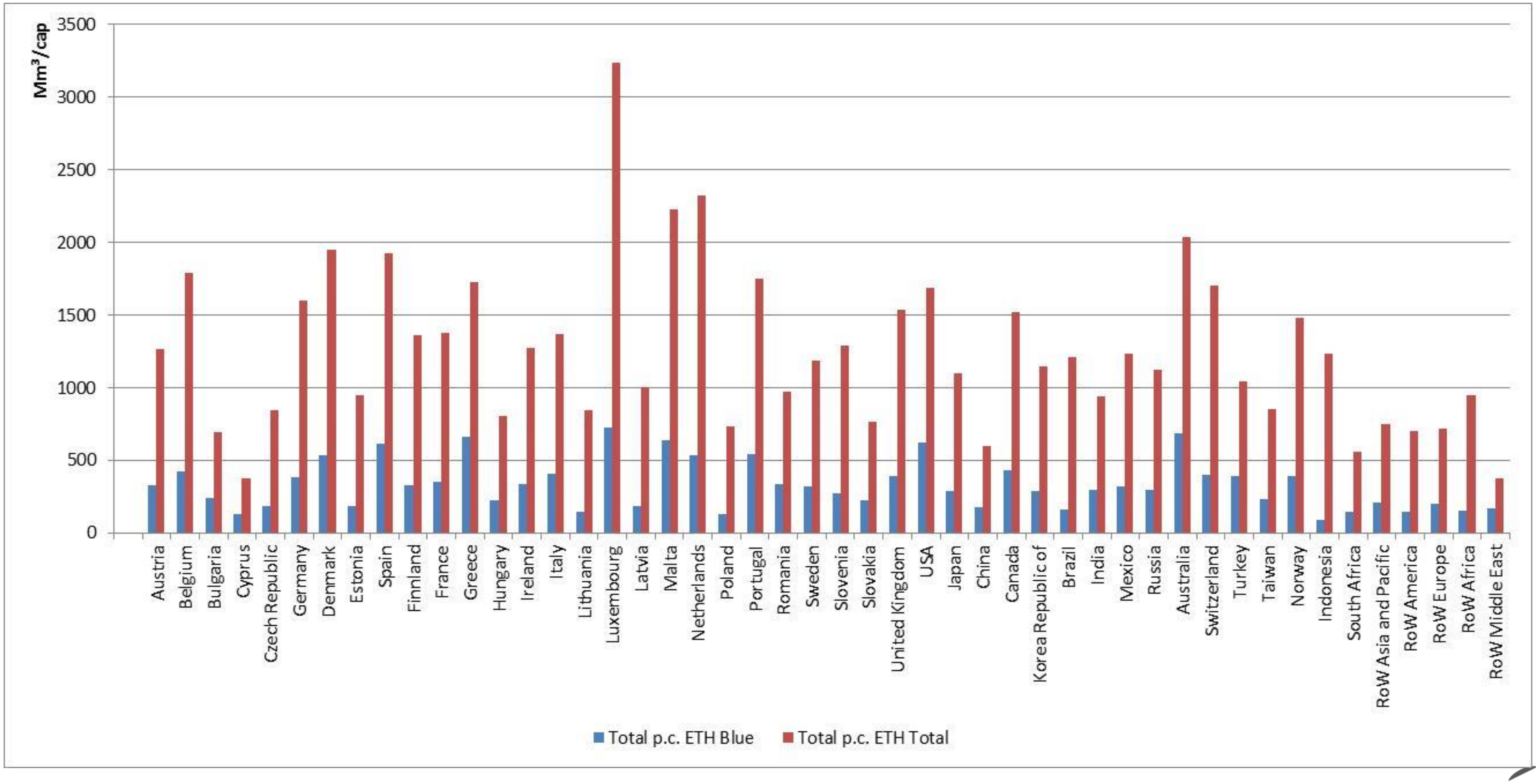
Water consumption around the World



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Step 1: Water footprint calculation with EXIOBASE

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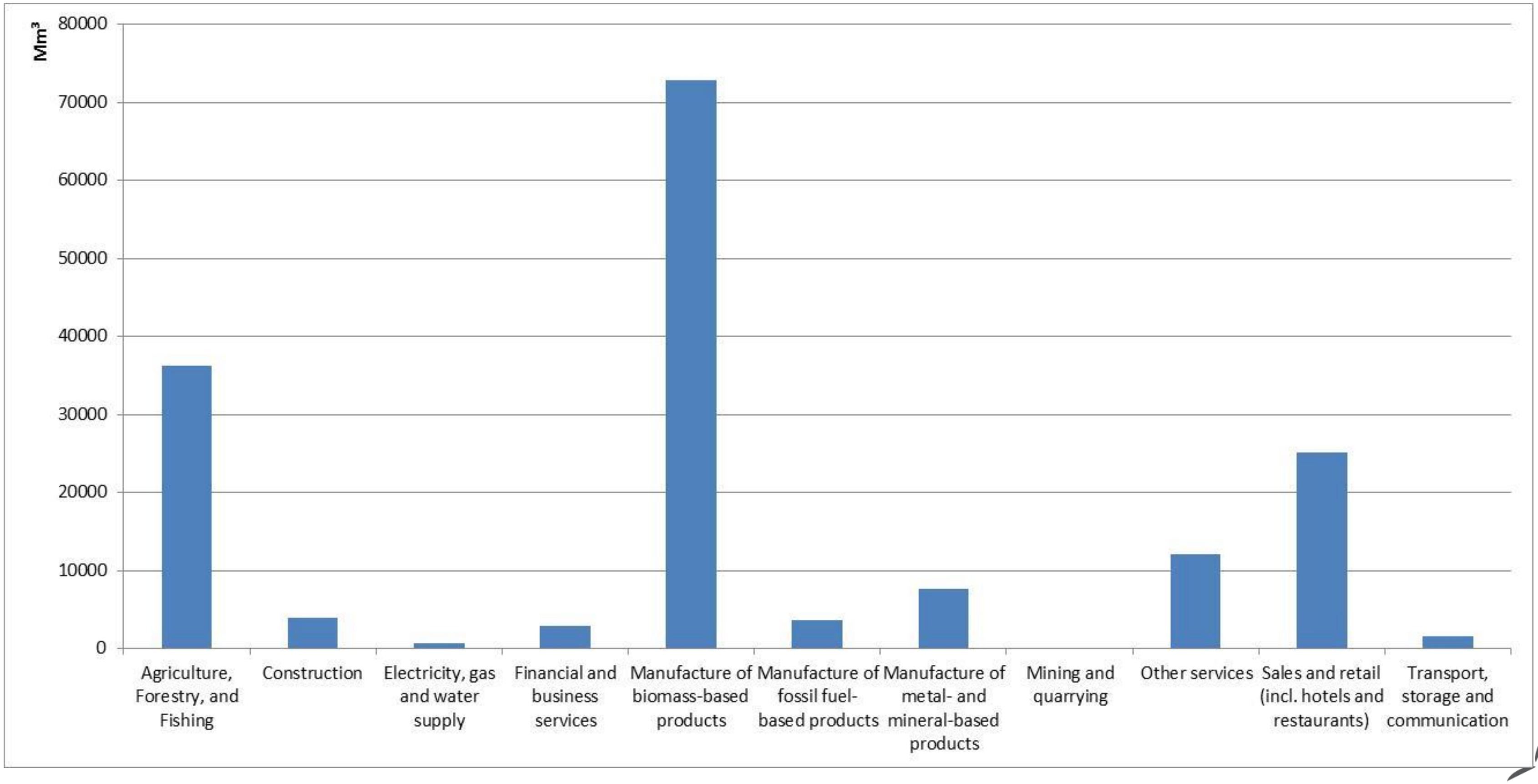
Water consumption in the EU-27



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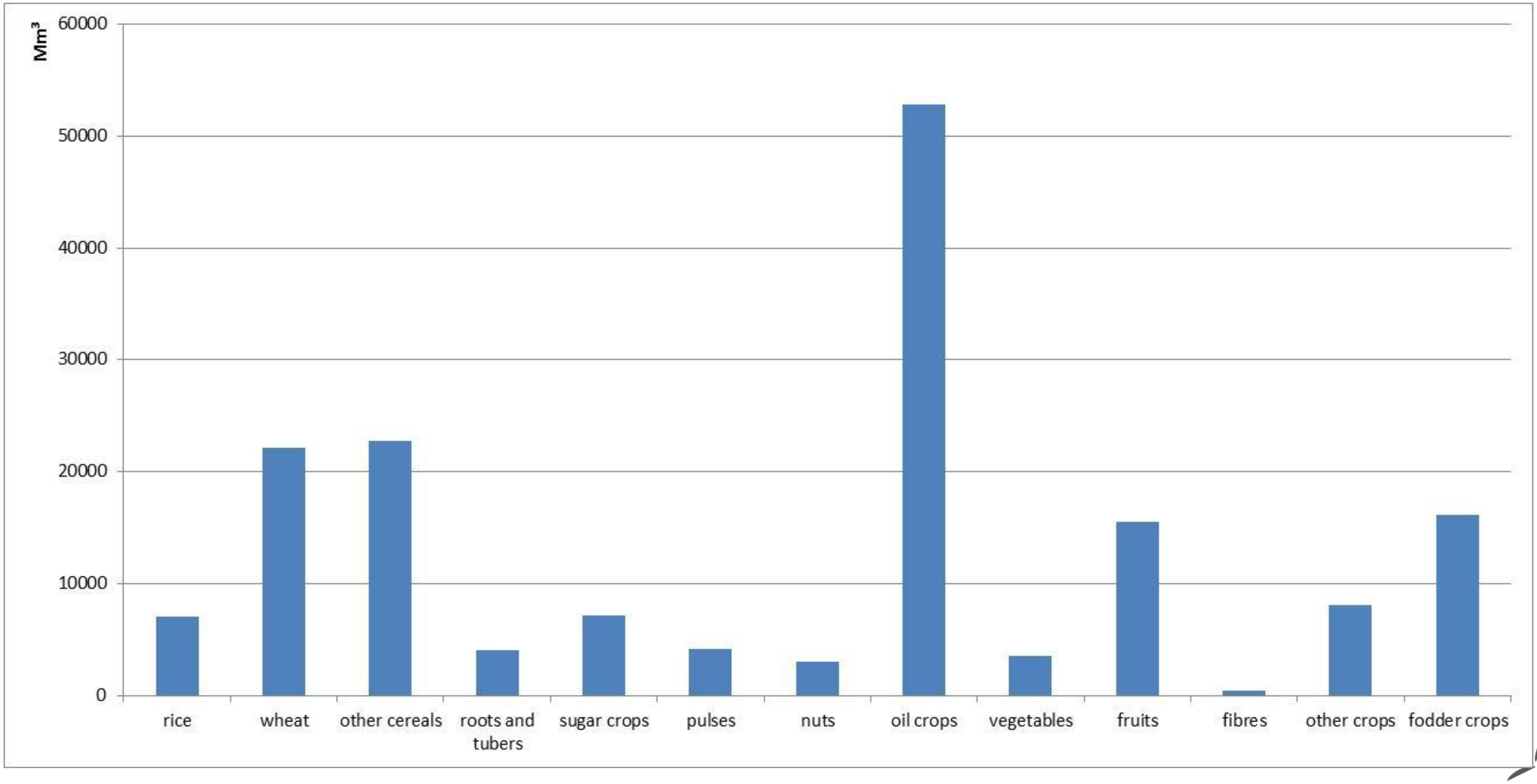
Step 1: Water footprint calculation with EXIOBASE

Water consumption in the EU-27



Step 1: Spatial disaggregation

Disaggregation of water flows and impact assessment

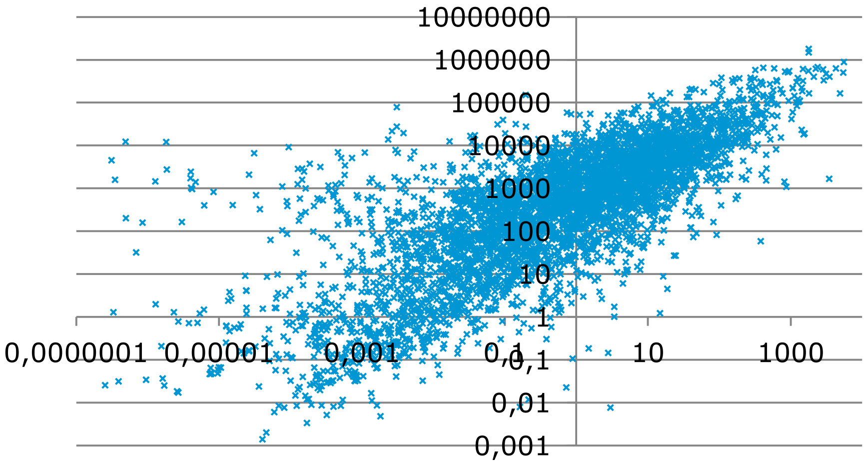
- MRIO regions have too low spatial resolutions for hydrological analyses
  - Disaggr. matrix applied to trace origins on watershed level
  - Impact assessment on watershed level is applied
- Data & methodology
  - Disaggregation is based on agricultural water consumption per sector and region
  - Impact assessment is based on 5 LCA measures (Pfister et al. 2009)
- Main results
  - Water consumption and impact assesment have low correlation

Step 1: Spatial disaggregation

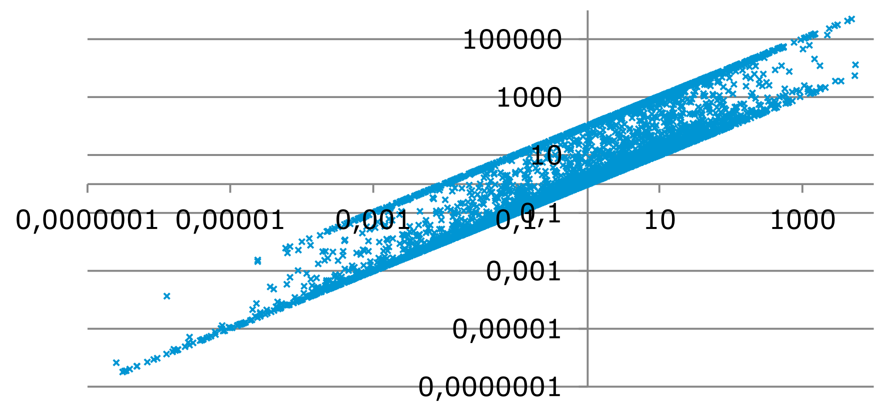
<u>Correlation blue water (BW), Green water (GW) and WSI weighted BW consumption</u>

Comparison on watershed level; BW vs WSI weighted shows a range of 2 orders of magnitude (WSI scales from 0.01 -1.00)

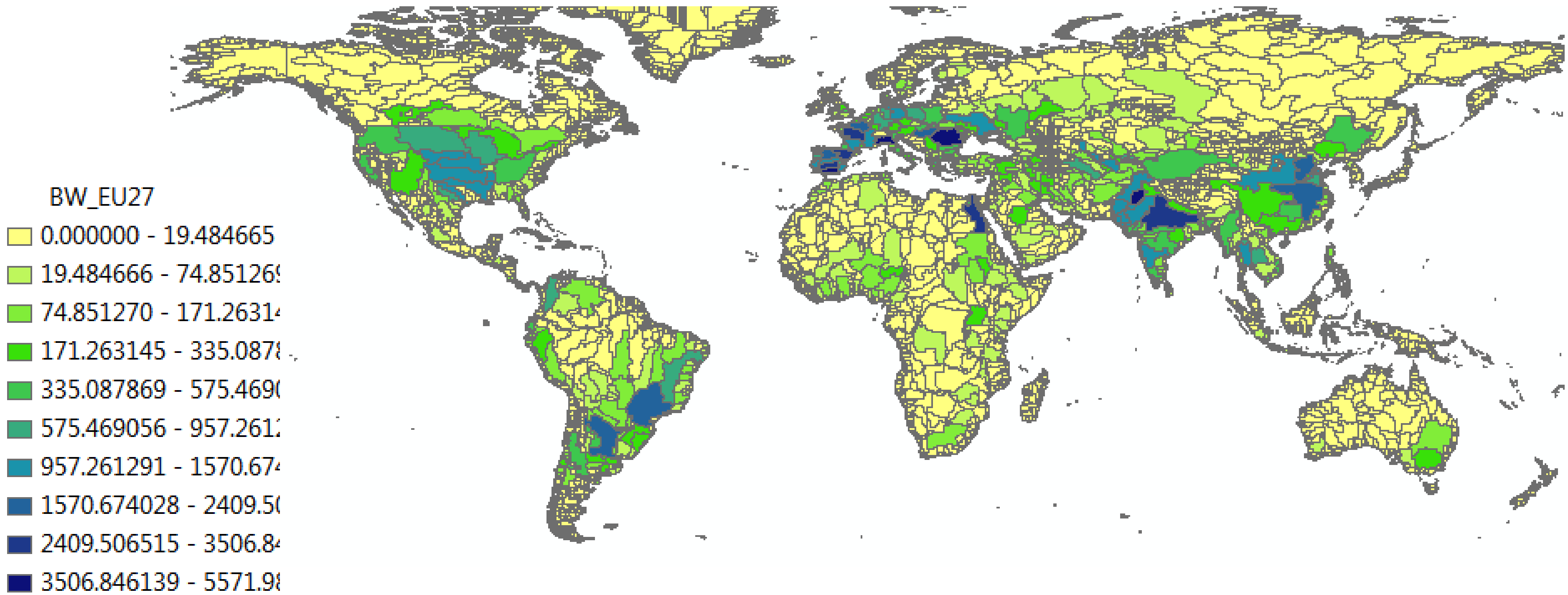
EU27 GW(y) vs. BW(x)



EU27: BW (y) vs WSI weighted BW (x)



Distribution of BW consumption induced by EU27 consumption (indicator for water use)



Step 1: Spatial disaggregation

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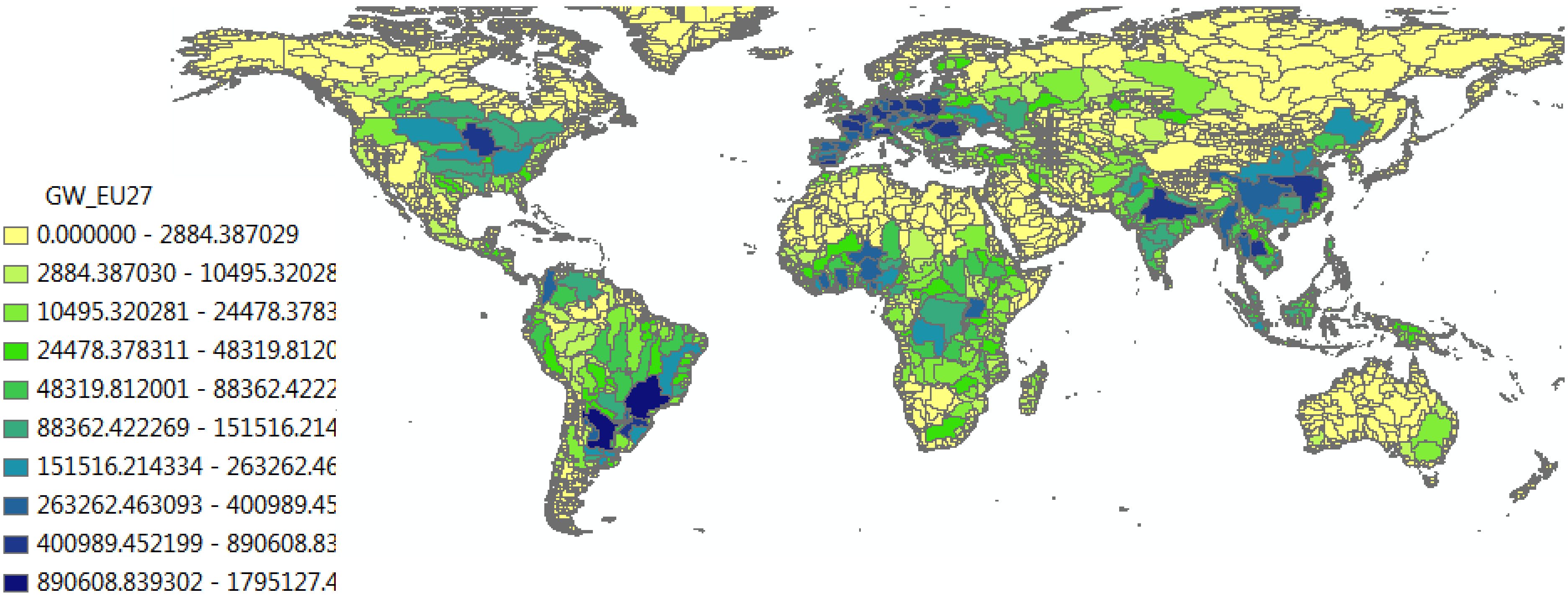
Distribution of GW consumption induced by EU27 consumption (indicator for land use)



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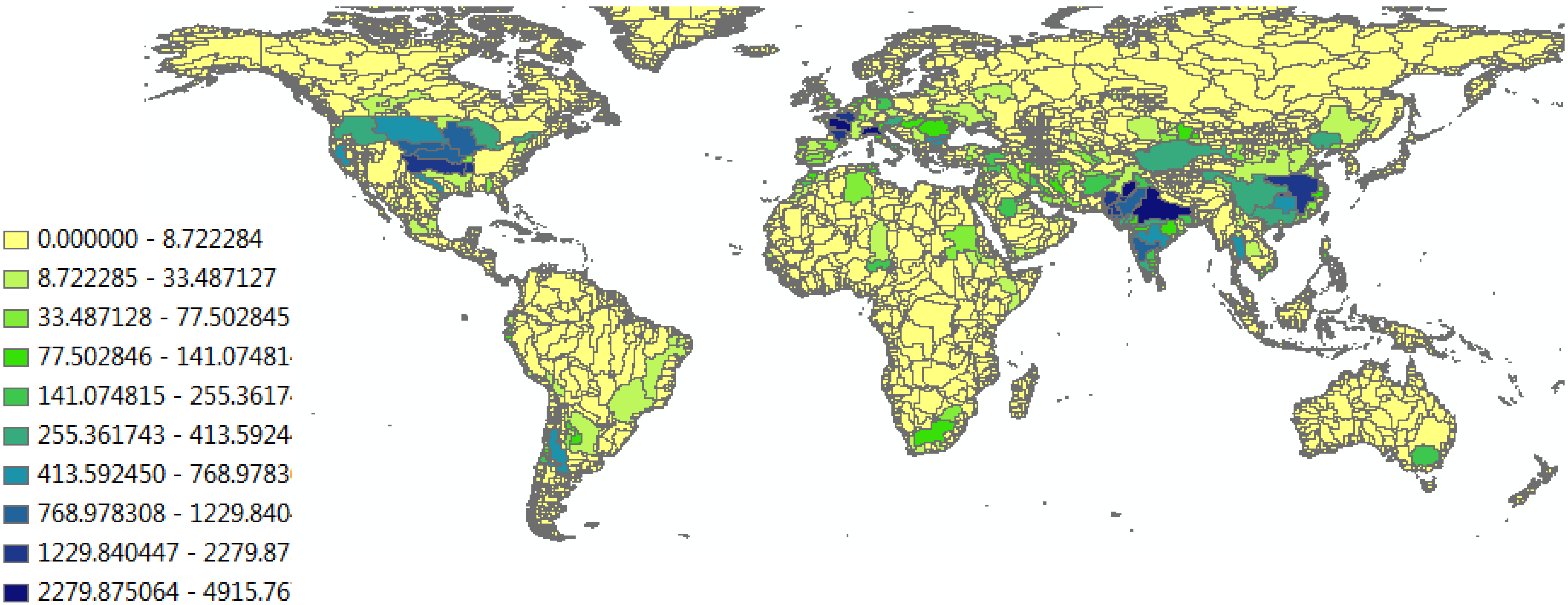
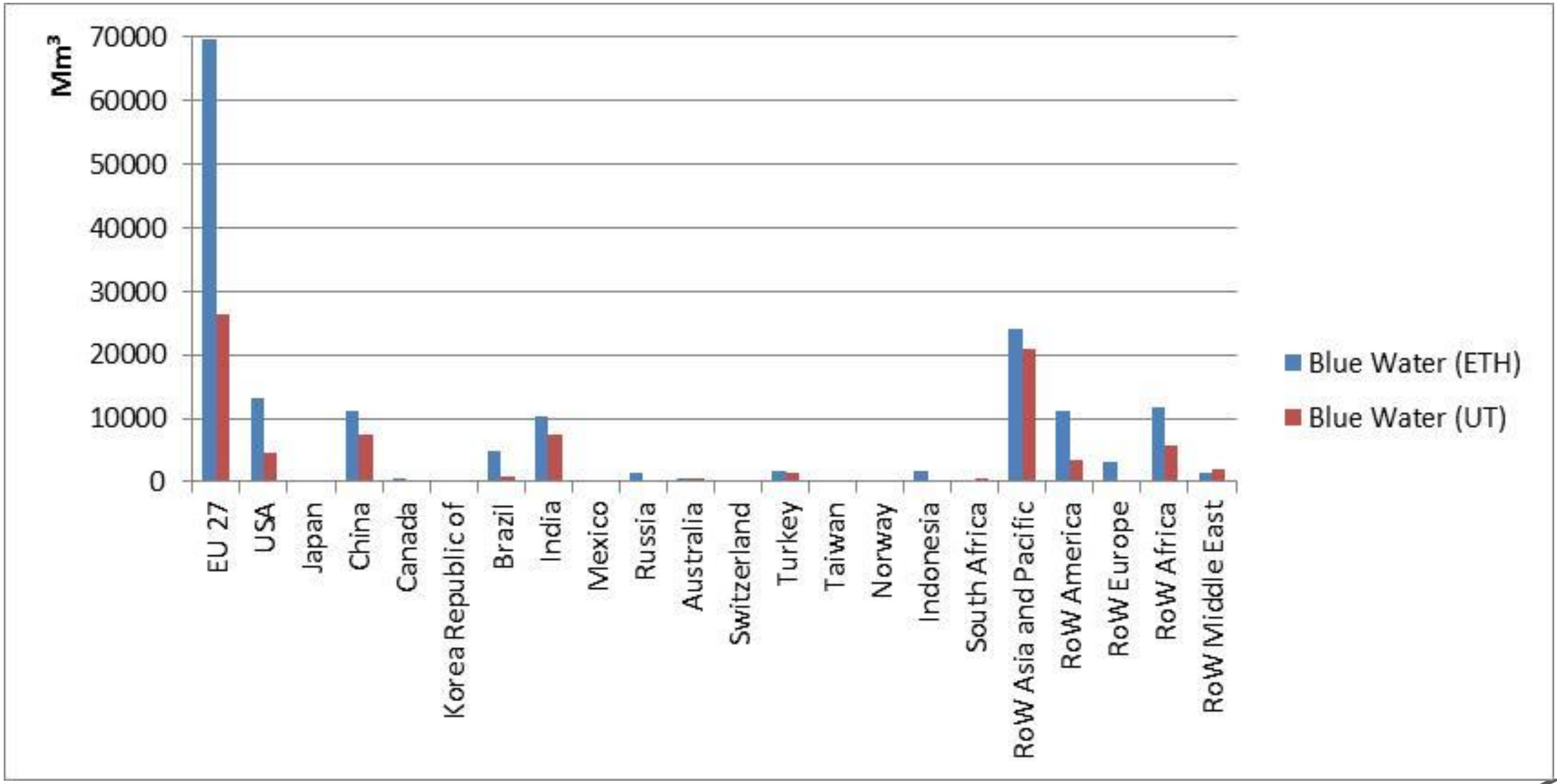
Step 1: Spatial disaggregation

Distribution of WSI weighted BW consumption induced by EU27 consumption (impact indicator)



Step 2: Methodological comparison

Comparison agricultural water consumption



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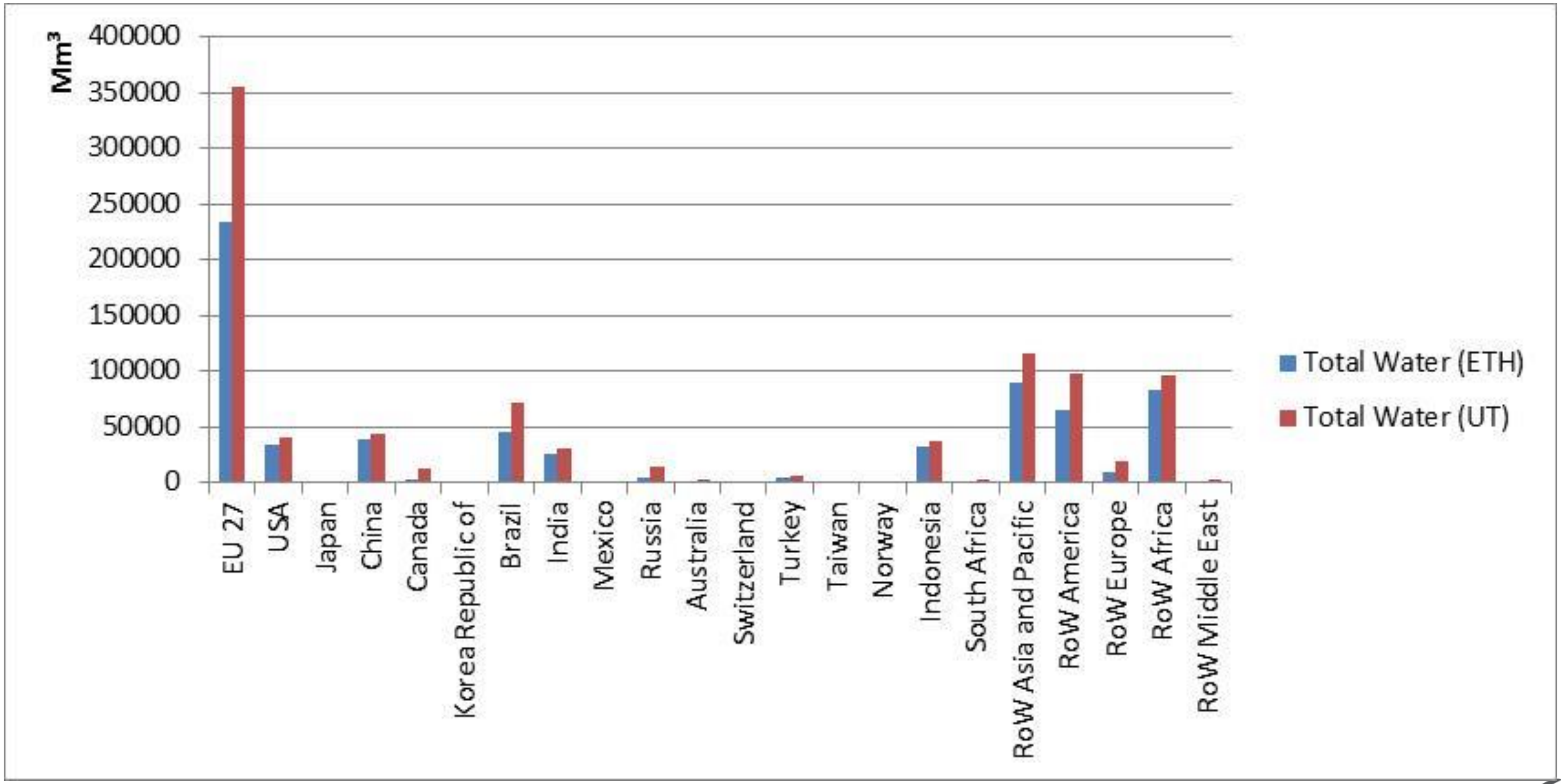
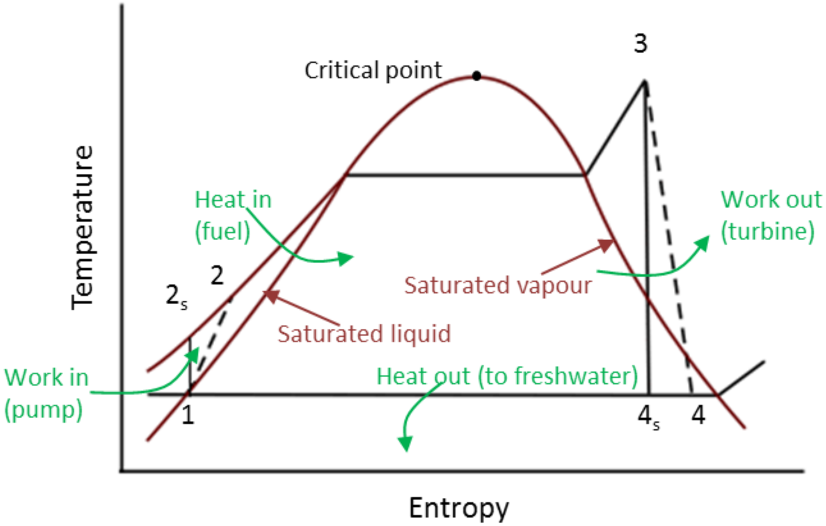


Step 3: Thermal emissions to freshwaters

- Scope
  - Calculation of total heat rejected to freshwater bodies from thermal power plant cooling water
  - Quantification of freshwater thermal pollution (TJ) resulting from country consumption and trading

Step 3: Thermal emissions to freshwaters

- Data & methodology
  - Technology data for power plants worldwide → World Electric Power Plants database.
  - Heat releases to freshwater from thermal power plants were calculated by estimating the thermal efficiency of each power plant, based on the Rankine cycle



$$\eta_T = \frac{\eta_{s_1}(h_3 - h_{4_s}) + \eta_{s_2}(h_5 - h_{6_s}) - (h_2 - h_1)}{(h_3 - h_2) + (h_5 - h_4)}$$

$$Q_{freshwater} = \frac{\frac{W_{gross}}{\eta_m \cdot \eta_e}(1 - \eta_T)}{\eta_T}$$

Step 3: Thermal emissions to freshwaters

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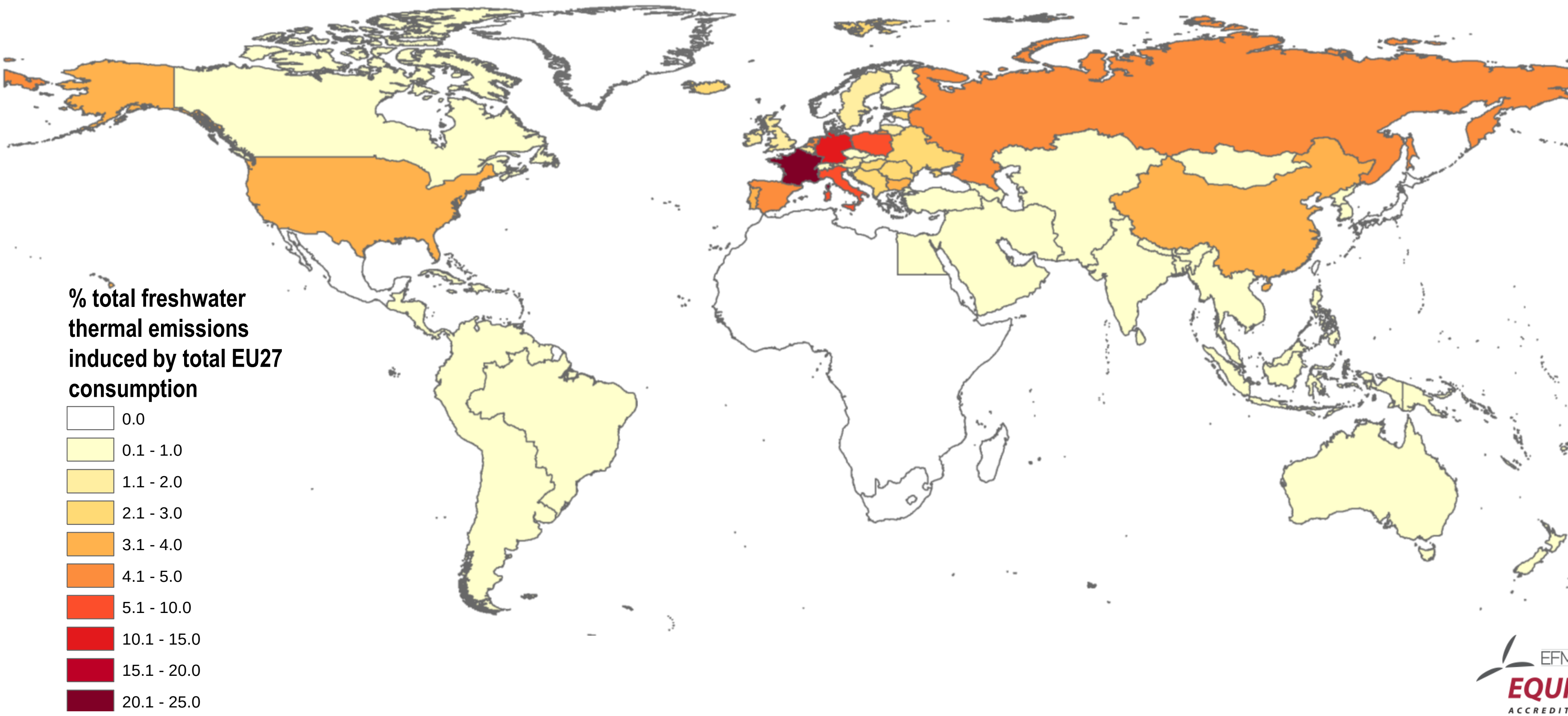
Thermal emissions induced by total EU27 consumption



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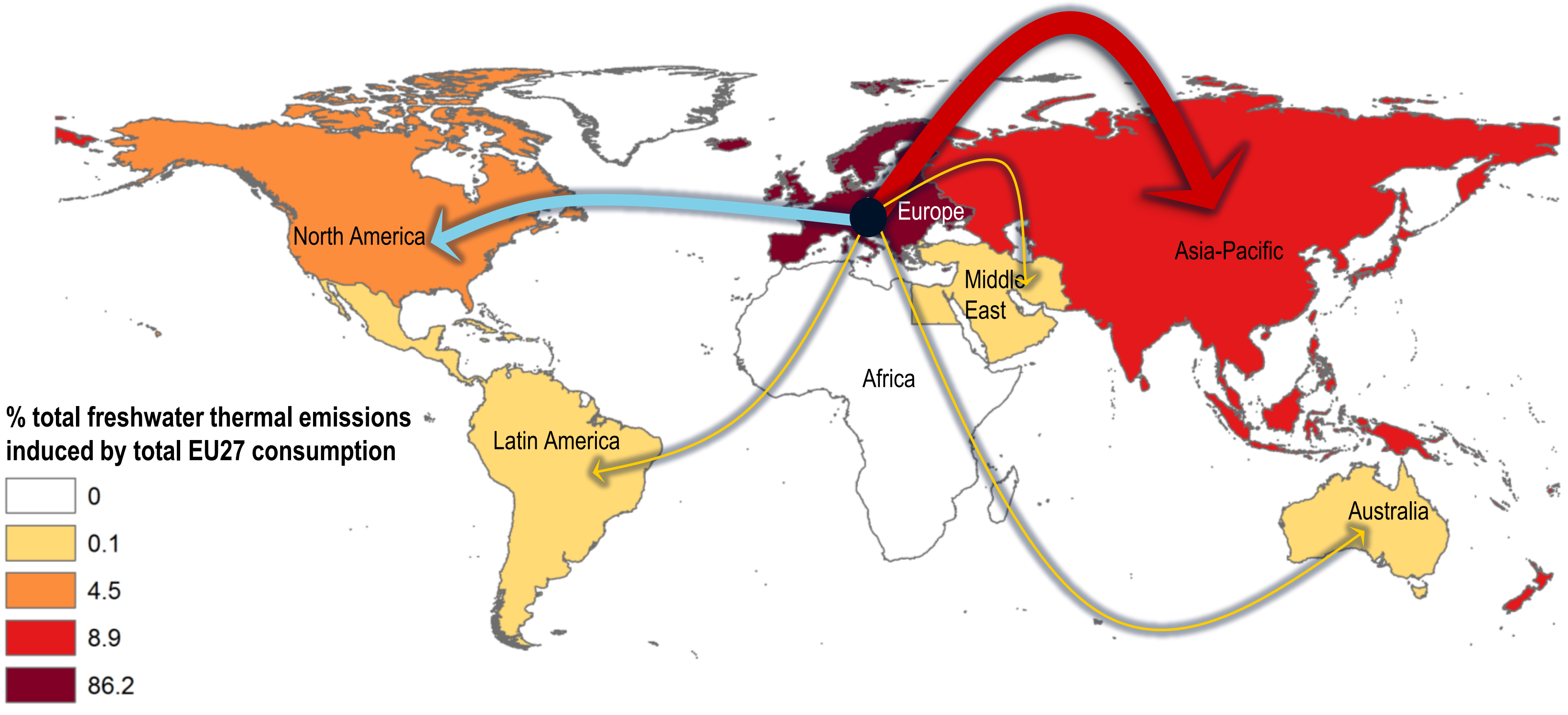
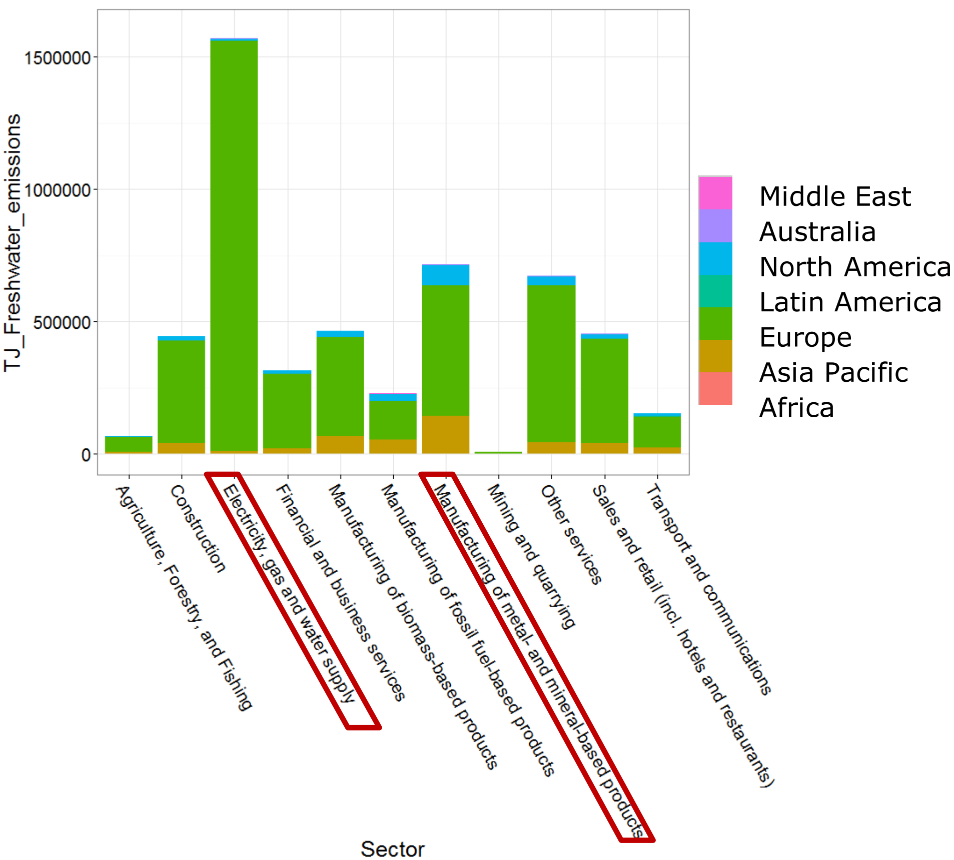
Step 3: Thermal emissions to freshwaters

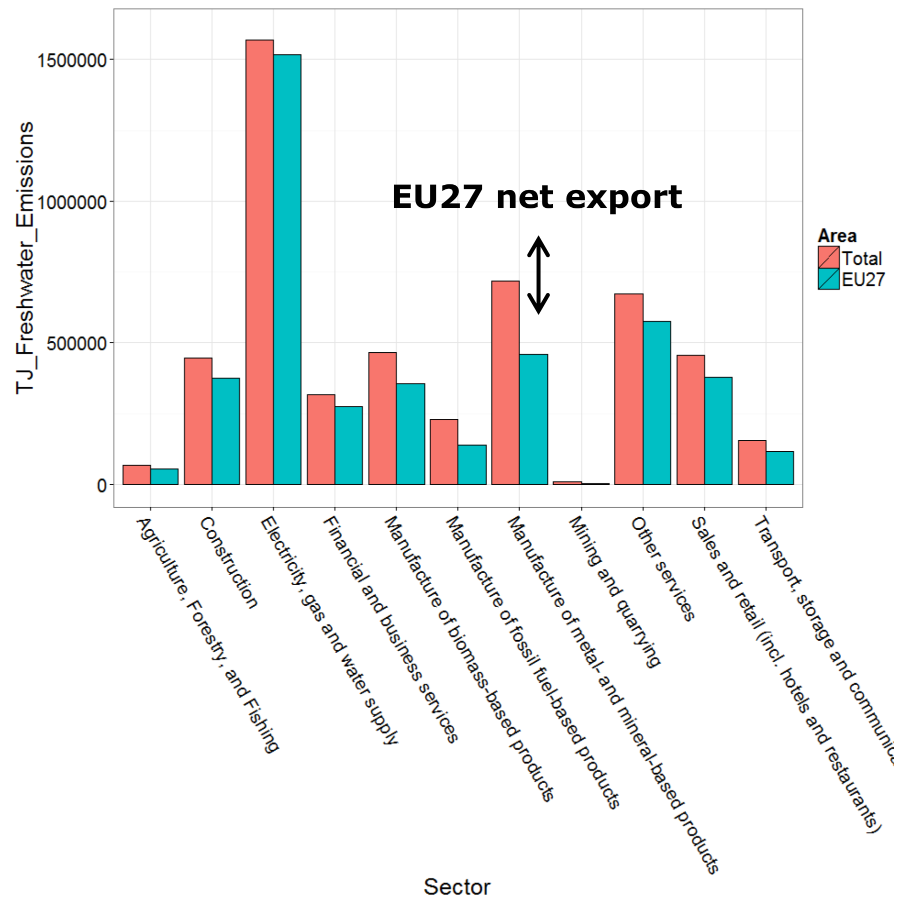
Thermal emissions induced by total EU27 consumption



Step 3: Thermal emissions to freshwaters

Sector-specific thermal emissions induced by total EU27 consumption





Step 3: Thermal emissions to freshwaters

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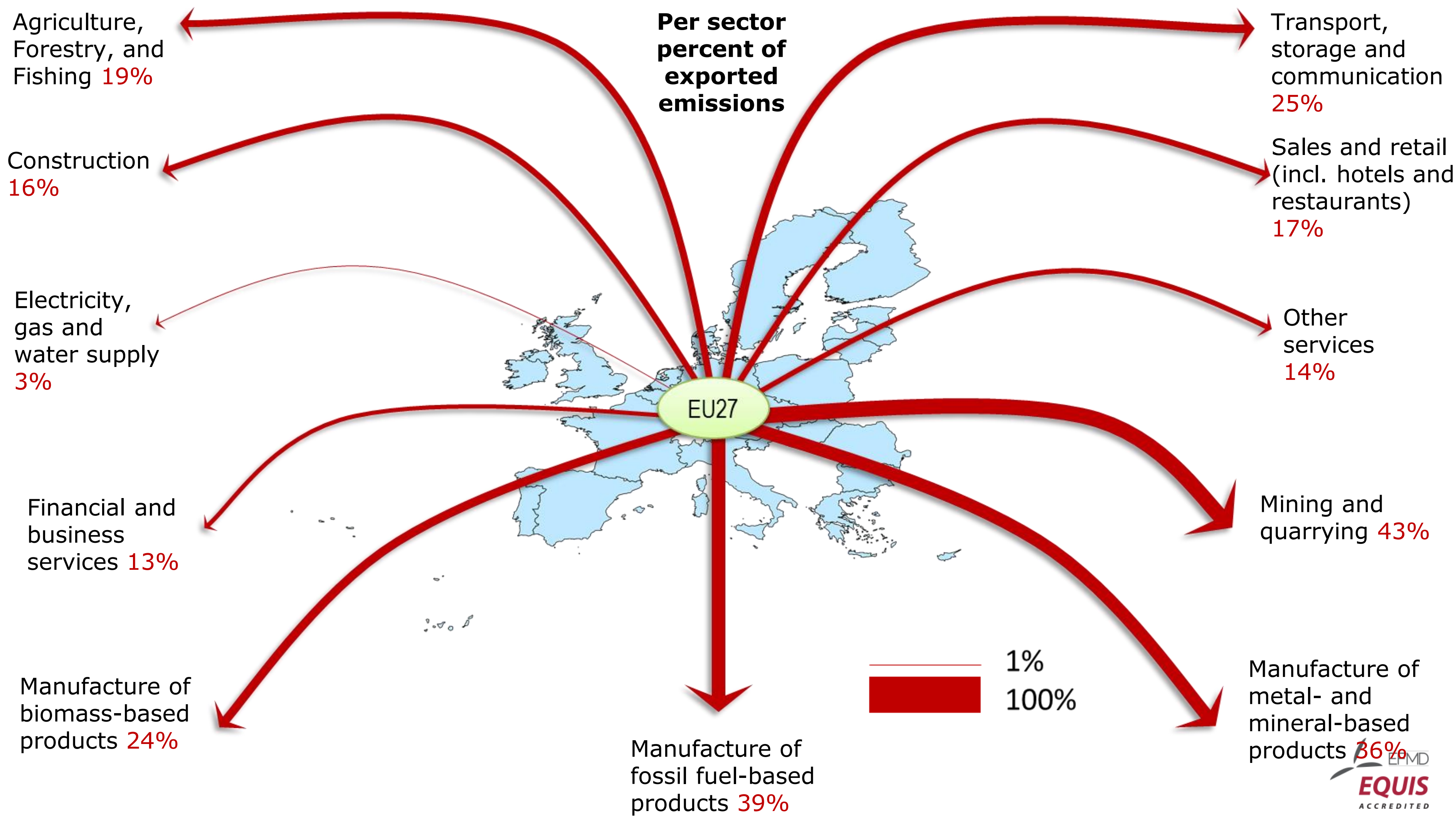


Step 3: Nutrient emissions to freshwaters

- Scope:
  - Assess global N and P emission to water
  - Cases study on the grey WF of the EU from production and consumption perspective
  - Identify priority basins and crops related to EU's grey WF of consumption (sustainability assessment)
- Definition Grey WF:
  - Volume of freshwater required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards

Step 3: Nutrient emissions to freshwaters

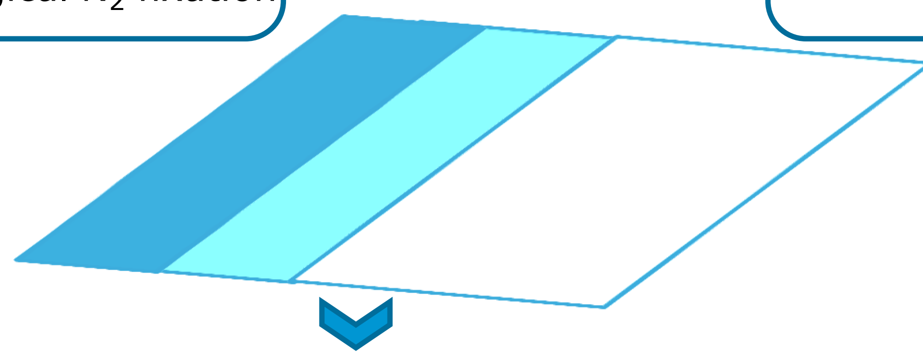
Method & data

Inputs

Fertilizer
Animal manure
N deposition
Biological N_2 fixation

Outputs

Crop & crop residue



Surface N balance → NH_3 Volatilization

Potential N loss → Denitrification

Leaching and runoff

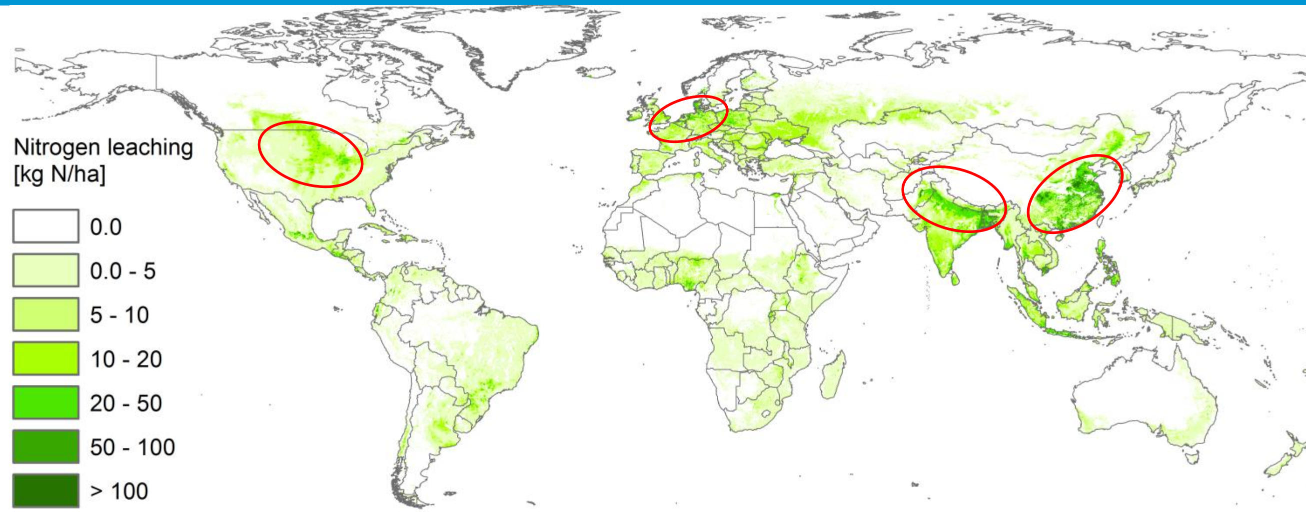
$$Leaching[N] = IN[N] - OUT[N]$$

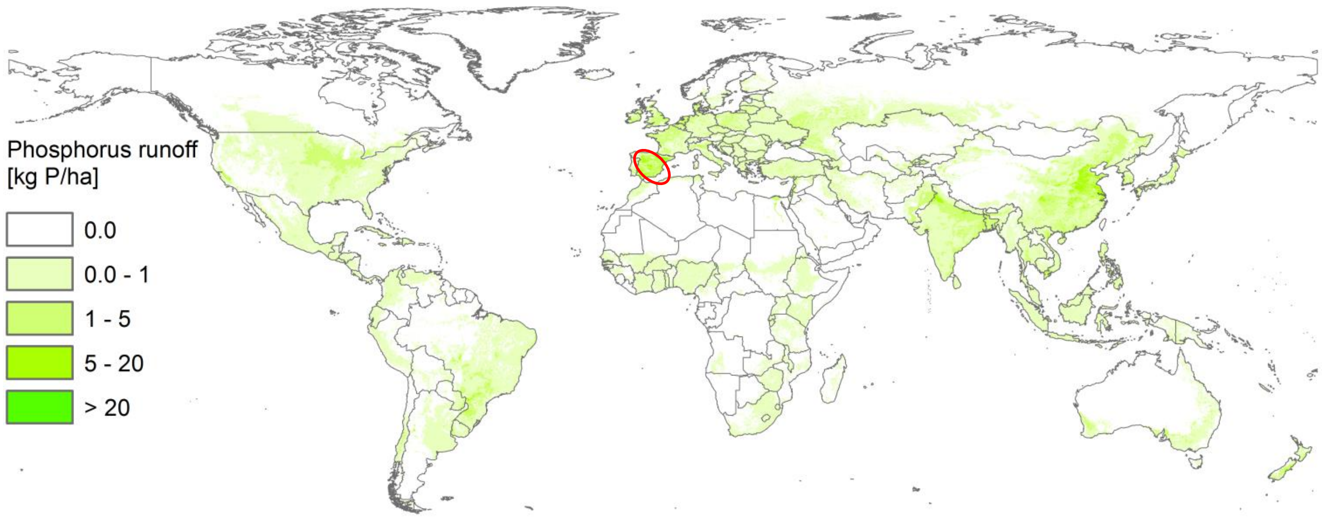
Step 3: Nutrient emissions to freshwaters

- Main results:
  - Global nitrogen emission = 31 million ton/y
  - Global phosphorus emission = 2.9 million ton/y
  - EU's grey WF of production= 1366 billion m^3/y
  - EU's grey WF of consumption= 2791 billion m^3/y (5620 m^3/capita/y)

Step 3: Nutrient emissions to freshwaters

Global N and P emission at 5x5 arc minute





Step 3: Nutrient emissions to freshwaters

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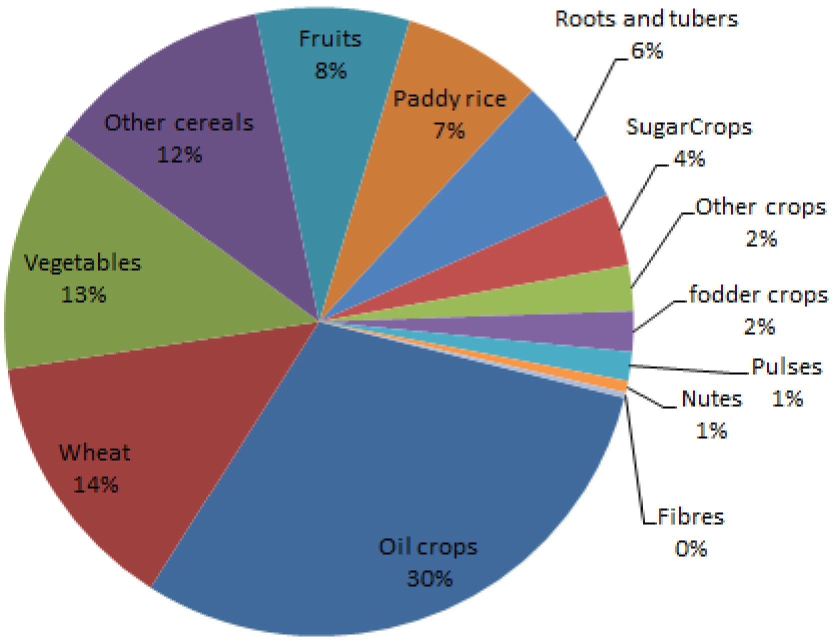
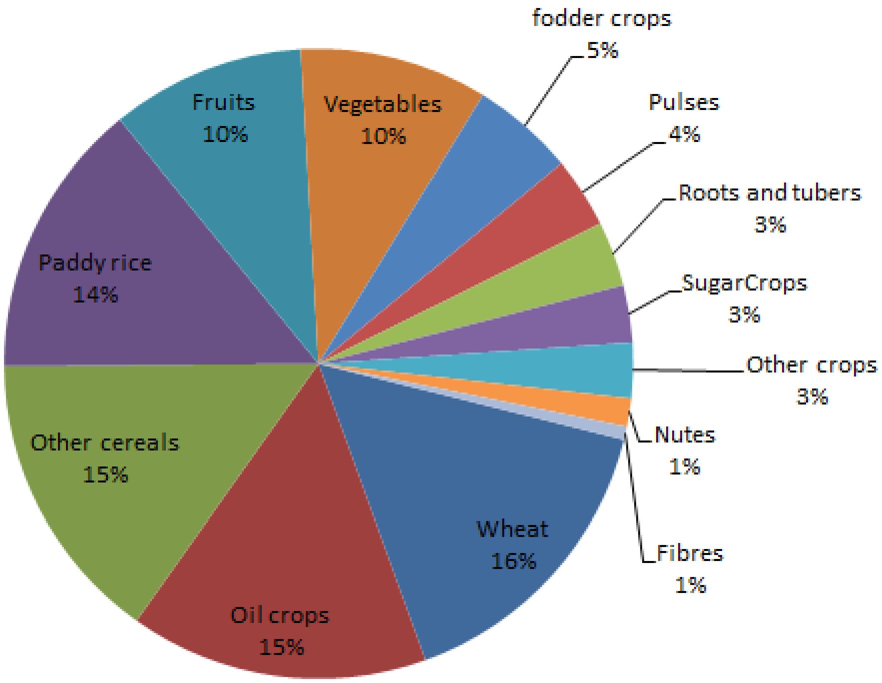
Global nitrogen emission = 31 million ton/y



Global phosphorus emission = 2.9 million ton/y



Contribution of different crops to total emission

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The water case: lessons learned

- Close cooperation between teams compiling economic data (IO tables) and environmental extensions required
- Large differences regarding availability and quality of data – no “real” data available
- Data only on very aggregated level
- Setup and application of water accounts urgently needed (Eurostat)

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