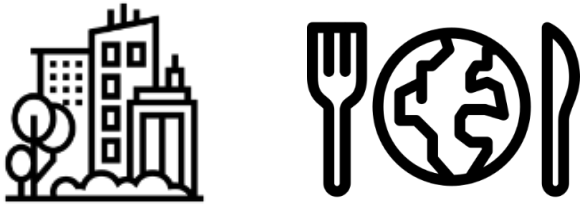
14th ISIE SEM Conference: Transforming socio-economic metabolism in times of multiple crises

Session: Transforming urban metabolism



THE URBAN BIOMASS SPRAWL:

An analysis of Vienna's biomass metabolism and its global environmental impacts

Lisa Kaufmann*, Philipp Semenchuk**, Sarah Matej*, Gerald Kalt*, Thomas Kastner***, Karl-Heinz Erb*, Stefan Dullinger**, Fridolin Krausmann*

**University of Natural Resources and Life Sciences Vienna, Department of Economics and Social Sciences, Institute of Social Ecology*

*** Department of Botany and Biodiversity Research, University of Vienna*

**** Senckenberg Biodiversity and Climate Research Centre, Germany*

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Urban land use does not end at city boundaries

- Urban areas harbor more than half of global population
- 1-3% of world‘s land is urbanized

➢ Land is scarce in urban areas

- Population must be supplied with resources, i.a. **biomass for food, energetic and material use**

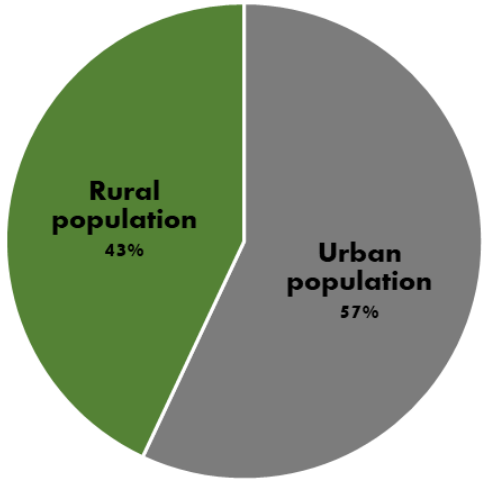
➢ Stems mainly from land use outside of city boundaries

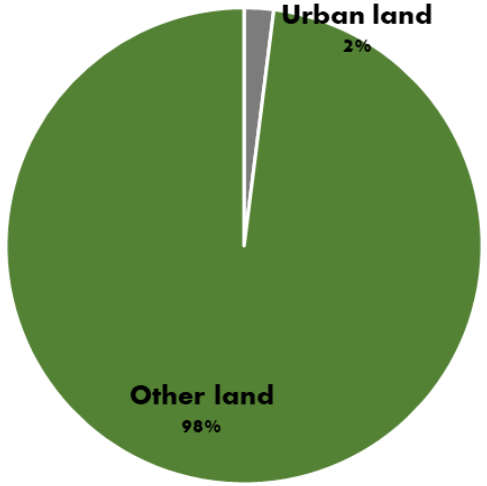
- From close and distant hinterland through complex (inter-)national supply chains

→ import-dependent

→ The production of biomass used in cities is spread over agricultural and forest areas around the world:

“the urban biomass sprawl”





United Nations, (2021); Liu et al. (2014)

- Trade generates ‘tele-coupling’:

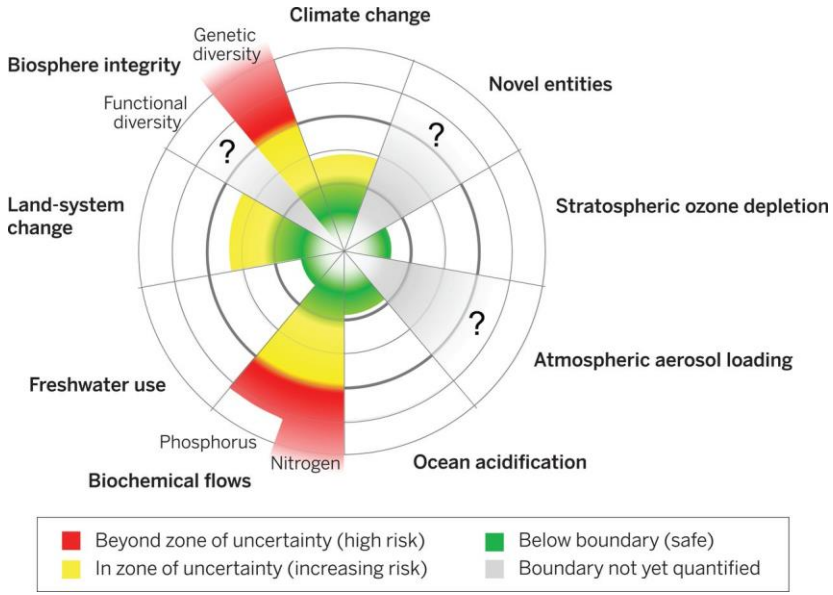
➢ describes complex distal connections, flows and feedbacks and supports to address spatial decoupling of land use (change)

- Land use sustains human society, yet with ecological consequences→ major driver of global environmental change

➢ climate change and biodiversity

  - Both part of planetary boundaries framework
  - Both transgressed the limits within humanity can safely operate

Urban biomass consumption is ‚tele-coupled‘ to global environmental impacts risking a safe operating space for human societies



Friis et al. (2016), Ellis, (2021); Steffen et al. (2015)

The case of Vienna

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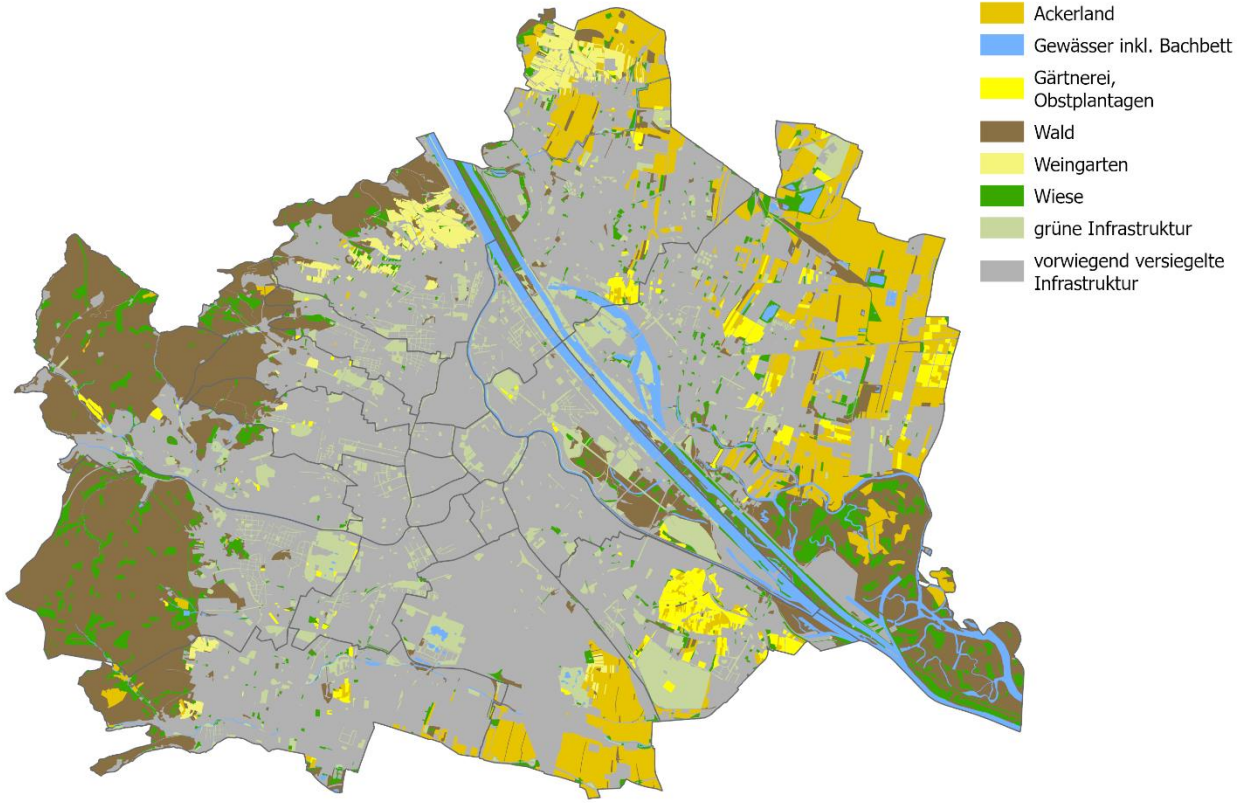


- Land area: 415 km^2
  - 12% agricultural area
  - 20% forest area
- 1.9 mio inhabitants (study year 2010: 1.7)
- ~4600 /km^2

Guiding questions

A) How much biomass-based products do the Viennese population consume for food, material and energetic purposes?

B) How much primary biomass is associated with the consumption of biomass-based products in Vienna?

C) How much land is needed for the primary biomass production and where is this land located?

D) What is the impact of primary biomass production on biodiversity? (“Vienna’s biodiversity footprint”)

E) What is the effect of dietary changes in Vienna on the biodiversity footprint?

Methodological approach

Biomass accounting (Questions A+B):

- Dataset: biomass accounting for Austria (Kalt et al., 2021)
  - comprises biomass-based products consumed in Austria incl. primary biomass and country of origin
  - Mix of methodological steps due to varying data availability for each biomass use category
  - Data sources: Energy, agricultural commodity and feed balances, agricultural and forestry production, statistics published by industry associations (e.g. Austrian paper and pulp industry), international trade databases
- Re-scaling to Vienna:
  - Downscaling according to a set of proxies: annual mean population, floor space in newly built apartments, number of employees by place of work, freight transport
  - Available data: energy balance
  - Result: urban biomass footprint (“RMC)” (not strictly mass-balanced metabolism due to data restrictions on the urban scale and considering the purpose of the study)

Global maps on vertebrate species loss

(Semenchuck et al., 2022)

Vienna’s biodiversity footprint (D):

number of vertebrate species populations disappearing per land-use area in each pixel

Area demand (C):

Spatially explicit area footprints

Global spatially explicit maps on land-use and primary biomass outputs (Yu et al., 2020)

Kalt et al. (2021); Semenchuk et al. (2022); Semenchuk et al., (under review)

Results

(A) 1.8 Mt final biomass products were consumed in Vienna (≙1.04 t dm/cap/a)

- 46% materials, 29% food, 26% energy

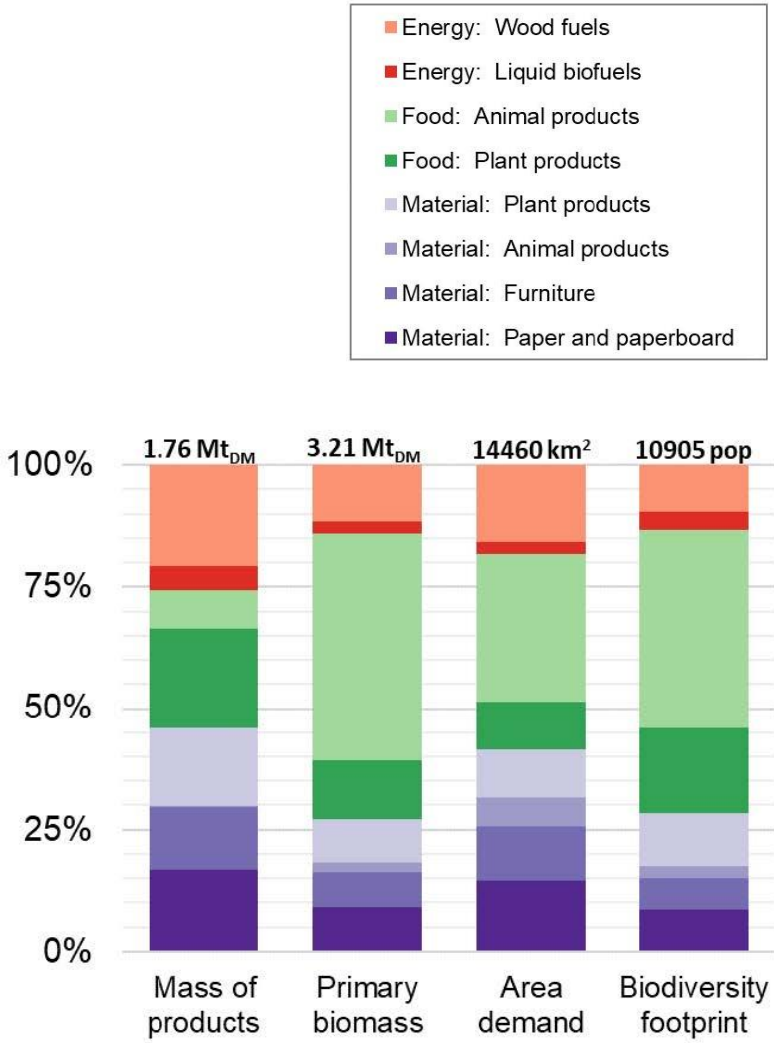
(B) The final biomass products are associated with 3.2 Mt of primary biomass (x1.8)

(C) Total area to produce all biomass products accounts to 14 460 km^2 (35xVienna)

- 38% within Austria, 43% within and 19% outside Europe

(D) Vienna's global biodiversity footprint (BDF) is 10905 impending population losses

- 13% energy, 58% food, 28% materials
  - → 43% of biodiversity footprint by animals products

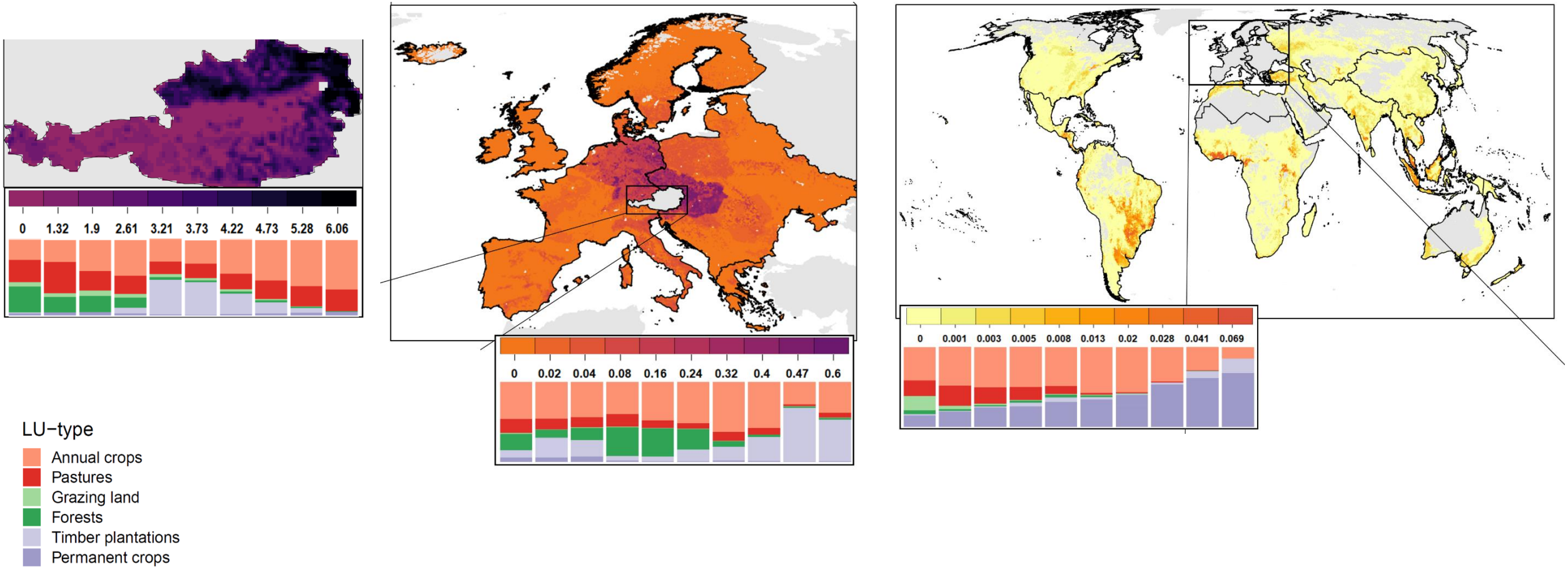


Vienna's per capita-BDF is 32% lower than Austrian average

(lower share of biomass in the energy mix and use of wood in construction)

Vienna's per capita-BDF is almost equal to global average despite consumptions levels above average

(complex interplay of factors – e.g. efficient animal production, sourcing from land with comparatively low vertebrate native species richness)


0 1.32 1.9 2.61 3.21 3.73 4.22 4.73 5.28 6.06
0 0.02 0.04 0.08 0.16 0.24 0.32 0.4 0.47 0.6
0 0.001 0.003 0.005 0.008 0.013 0.02 0.028 0.041 0.069
LU−type
Annual crops
Pastures
Grazing land
Forests
Timber plantations
Permanent crops

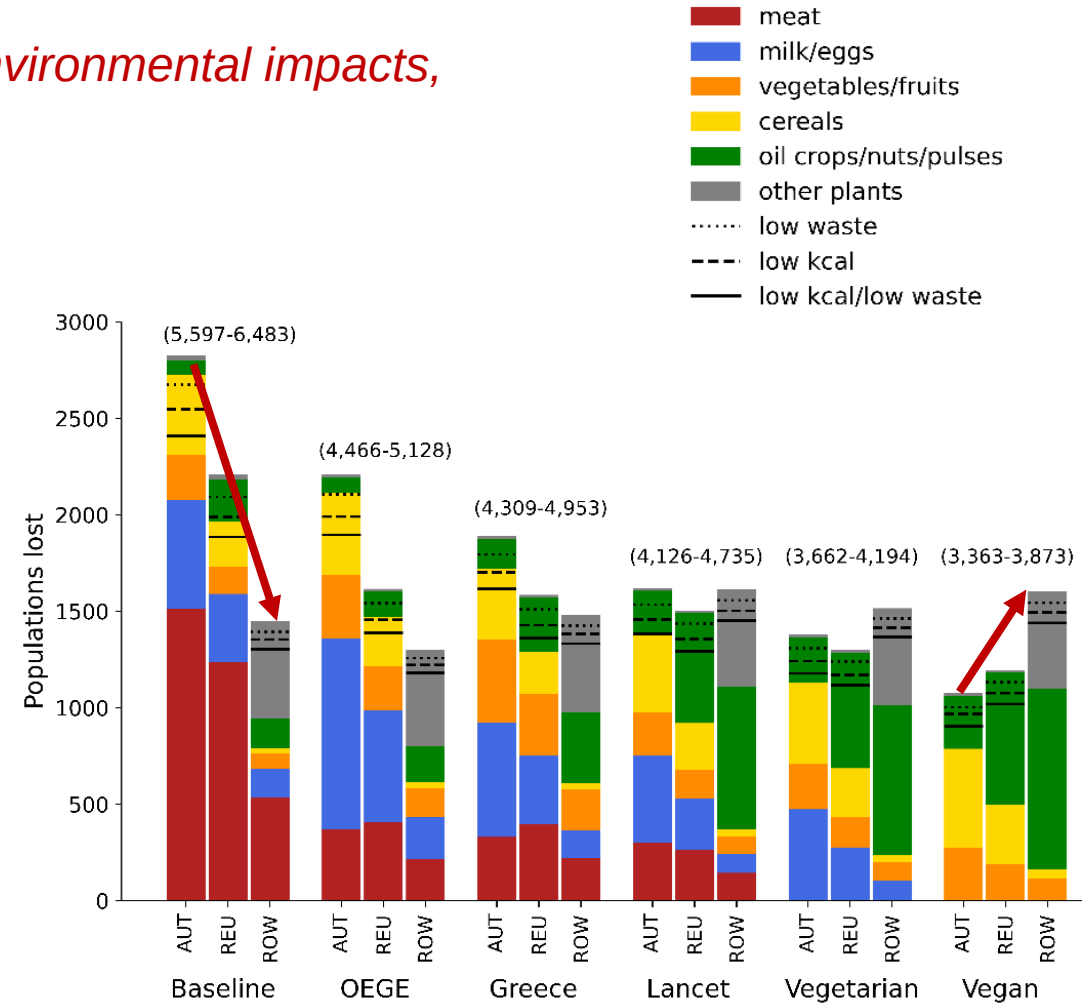
For transforming urban biomass metabolism to reduce global environmental impacts, the urban food system is an important leverage point

- Almost 60% of BDF is related to food
- 43% of BDF by animal products

➢ Reducing share of animal products decreases BDF

➢ Under current trade patterns: mainly reduction in Europe

➢ A switch to vegetarian diets is the most *efficient:* highest BDF reduction per substituted calorie (2.3 populations spared/substituted kcal)



Matej et al., (in prep.)

Summary and conclusion

- Downscaling of national physical biomass flow accounting to obtain Vienna's biomass footprint
  - Sub-national level data sources are scarce (trade, urban food consumption,…)
  - Application of product/sector-specific proxies → Results have to be discussed in light of these assumptions
- Linking urban biomass consumption to a global environmental indicator (= biodiversity footprint)

- Animal products are responsible for almost one half of the total biodiversity footprint
- a shift to vegetarian diet reduces the biodiversity footprint most efficiently in terms of required change in eating habits

➢ Implies a reduction of animal production at all stages of the supply chain

➢ In urban areas, mainly processes at the end of the biomass supply chain take place

➢ Dietary change among urban population key leverage point

Implications for the City of Vienna

- Currently, Vienna's biodiversity strategies focus on territorial measures (pesticide reduction,…)
- City-level governance instruments which considers global responsibilities are limited
- Vienna's climate strategy includes the reduction of animal products
- Measures in the food sector…
  - …target, e.g. organic products (ÖkoKauf: public procurement criteria for canteens, nursing homes, schools and kindergartens) or food waste reduction (GenussBox: paper boxes for restaurants to pack leftovers for their guests)
  - …are voluntary (education programs)
- Willingness of Vienna's population to reduce consumption of animal products is small (only 12% of "meat-overconsumers" have intention to meat less)
- First city (Haarlem in Netherlands) bans meat adverts in public

Plank et al., (under review); Stadt Wien, (2022), Gugerell and López Cifuentes (2021), Boffey, (2022)

Thank you for your attention!

Lisa Kaufmann

University of Natural Resources and Life Sciences Vienna,

Department of Economics and Social Sciences,

Institute of Social Ecology,

Schottenfeldgasse 29,

1070 Vienna, Austria

lisa.kaufmann@boku.ac.at

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