Chair of Ecological Systems Design, ESD

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IRCADA – USYS TdLab – IfU-ESD workshop
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Chair of Ecological Systems Design, ESD

- Chaired by Prof. Dr. Stefanie Hellweg since 2006

- Currently employing
  - 2 senior researchers
  - 1 postdoc
  - 11 PhD candidates
  - 1 secretary

- Belongs to the Institute of Environmental Engineering (IfU), Department of Civil, Environmental and Geomatic Engineering (D-BAUG)
ESD mission statement

Our mission is to model, analyze, evaluate, and improve the resource efficiency and environmental performance of products and processes, new technologies, and consumption patterns.
Research focus @ESD – *past & present*

- **Research areas – methodological foci:**
  - Systems analysis & design
    - MFA, LCA, & optimization
    - Regionalisation (spatial LCA) & temporalisation (dynamic LCA)
    - Scaling- & learning-effects in LCA
  - Risk & impact assessment
    - Water
    - Land use & biodiversity
    - Resources
    - Water & air pollution
    - Noise & accidents
    - (Nano-)toxicology
Research focus @ESD – past & present (cont’d)

- Research themes
  - Agriculture
  - Food & nutrition
  - Energy technologies & systems
  - Steel & cement production
  - Wood & bio-based products
  - Nano-technology
  - Household consumption
  - Waste & secondary resource management
Systems analysis & design
Systems analysis & design

With the aim to analyze & optimize, we model…

- Resource-intensive industrial processes (cement & steel)
- Energy technologies
- Bioenergy, bio-based materials, & the wood value chain
- Urban energy systems
- Building stocks
- Household consumption
- Waste management, e.g. MSW, food waste, industrial residues

… by integrating of MFA, LCA, & mathematical optimization
… by coupling large datasets & complex models
… by adding spatial and/or temporal resolution
Waste flow analysis in Switzerland (excerpt)

- Shredder residues: 69 kt
- Mixed wastes: 343 kt
- Waste wood: 675 kt
- Sewage sludge*: 194 kt (on dry basis)
- Separate collection: 175 kt
- MSW: 5'704 kt
- Lead batteries: 27 kt
- Hazardous waste: 1'577 kt
- Construction and demolition waste: 12'556 kt
- To cement kiln: 288 kt
- To export: 807 kt
- To industrial furnaces: 755 kt
- To MSWI: 3'724 kt
- To organic waste treatment: 851 kt
- To landfill: 1'700 kt
- To export (recycling): 178 kt
- To material recycling: 13'018 kt

Source: Melanie Haupt, ETH Zürich
Environmental optimization of use of biomass for energy

Biomass supply

Primary conversions (e.g. anaerobic digestion)

Secondary/intermediate conversions (e.g. biogas upgrading)

Tertiary conversions final service provision, (e.g. in CHP or for transport)

Competing/compensatory energy technologies
fossil + other renewables

Superstructure

Biomass supply

Primary bioenergy conversion

Secondary bioenergy conversion

Tertiary bioenergy conversion

Final energy demand
11 sub-categories
- electricity
- heat
- transport

Source: Carl Vadenbo, ETH Zurich
Food and agriculture
Chair of Ecological Systems Design
Professor Stefanie Hellweg

Freshwater Consumption
Stephan Pfister
Laura Scherer

Land Use
Stephan Pfister
Abhishek Chaudhary

Erosion & Phosphorus Emissions
Laura Scherer

Soil Compaction
Franziska Stössel

Food Waste
Claudio Beretta

Diets
Christie Walker
Water scarcity footprints

Water consumption * Water scarcity index = Water scarcity footprint

- Water availability
- Variability in precipitation
- Water consumption

FAO approach
160 crops
5’ resolution
Water scarcity footprints of wheat cultivation

Water consumption

Water scarcity footprint
Probability of increasing water scarcity
1981-1990 compared to 2001-2010
Land use impacts

- Calculating endemic species loss caused by land use (forestry pasture and cropland) for different taxa

![Map of Total Mammal Impacts](attachment:map.png)

**Total Mammal Impacts**

- 0
- $10^{-5}$
- $3 \times 10^{-5}$
- $6 \times 10^{-5}$
- $10^{-4}$
- $3 \times 10^{-4}$
- $6 \times 10^{-4}$
- $9 \times 10^{-4}$
- $10^{2}$
- $8.9 \times 10^{2}$
Land use impacts

- Calculating endemic species loss caused by land use (forestry, pasture, and cropland) for different taxa
Erosion and freshwater eutrophication

- Runoff
- Drainage
- Groundwater

\[ \text{Phosphorus emissions} = \text{Inventory} \]
\[ \text{Fertilizer} \times \text{Erosion} \]

\[ \text{SALCA} \times \text{USLE} = \text{Impact} \]
Soil erosion per land use

Unit: tonne soil / (ha · a)
Freshwater eutrophication

Global average phosphorus emissions (g P / kg crop)
Swiss food consumption

Swiss Food Consumption → MRIO → LCA

Swiss Customs Data → EXIOBASE

Freshwater Consumption & Eutrophication
Swiss food consumption

Local species loss

- 0.00e+6 - 3.75e+6
- 3.75e+6 - 7.50e+6
- 7.50e+6 - 1.50e+7
- 1.50e+7 - 3.00e+7
- 3.00e+7 - 6.00e+7

Unit: PDF m² a
Carbon footprints of Swiss food waste

kg CO₂-eq/p/a

Food loss

Treatment

-20

Apples
Other Fresh Fruits
Canned Fruits
Potatoes
Legumes
Processed Vegetables
Bread and Pastries
Pasta
Rice
Maize
Sugar
Vegetable Oils and Fats
Nuts, Seeds, Oleiferous... 
Milk/other Dairy Products
Cheese
Butter
Eggs
Pork
Poultry
Fish / Shellfish
Chocolate, Coffee, Tea
Beef and other Meat / Offal
Additional Projects in Agriculture

- Biodiversity impacts of total agriculture

- Impacts of soil compaction

- International trade analysis using trade statistics and MRIO

- Improving the global assessment of crop production (details on nitrogen & greenhouse gas emissions and pesticide application)

- Food processing and Personal diets
Education @ESD

- Bachelor study level
  - Ecological systems analysis
  - Environmental engineering seminars
  - *Waste management (given exclusively by external lecturers)*
  - Bachelor thesis projects

- Master study level
  - Advanced environmental social and economic assessment
  - Prospective environmental assessment
  - Environmental computer laboratory
  - Energy systems analysis
  - Supply and responsible use of mineral resources I
  - *Biological processes for waste treatments*
  - *Waste recycling technologies*
  - Industry internships, semester and master thesis projects
Thank you for your attention!

http://www.esd ifu.ethz.ch/