Urban Europe and NSFC

Europe – China joint call on Sustainable Urbanisation in the Context of
Economic Transformation and Climate Change:
Sustainable and Liveable Cities and Urban Areas

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FFG (Austria), project 870234

UNCNET

Urban nitrogen cycles: new economy thinking to master the challenges of climate change

D8/1b: Report from stakeholder workshop II

Due date of deliverable: **01/08/2021**

Actual submission date: **02/02/2022**

Start Date of Project: **01/04/2019**

Duration: **31 months**

Organisation name of co-chairs for this deliverable: **Brainbows (BB), E.C.O. Institute of Ecology (E-C-O)**

Authors: Markus Schneidergruber (BB), Lisa Wolf (E-C-O)

Dissemination Level		
PU	Public	☒
PP	Restricted to other programme participants (including funding agencies)	☐
RE	Restricted to a group specified by the consortium (including funding agencies)	☐
CO	Confidential, only for members of the consortium (including funding agencies)	☐

1. Executive Summary

An important aspect of the project is the applicability of the results in practice. For this reason, it is important to involve stakeholders and potential users at an early stage in the process in order to jointly develop practical approaches. In connection with the elaboration of nitrogen budgets a dialogue process with relevant stakeholders was started in the city of Vienna and the small town of Klagenfurt in Carinthia. In both cities / regions stakeholders have been identified during an intense stakeholder mapping process. The first two workshops were held virtual in November 2020 using the communication platform Zoom and the virtual whiteboard Miro. At this stage of the project, primarily the background and objectives of the project as well as first project results were presented and discussed. In addition, it was important to identify the stakeholders' requirements for the project.

Based on the results of the first two workshops, the next workshop series took take place on October 11 in Klagenfurt and on October 14 in Vienna. The two events were designed the same way, according to the methodology and structure. However, the results slightly differ. In addition to a review of the already further developed nitrogen budgets, approaches for practical implementation were primarily identified and further elaborated.

In both cities, the stakeholders were very interested in the project and showed a high willingness to actively participate. Above all, many interesting suggestions and proposals for improvement were brought forward during the workshops.

In Mai 2022 all results will be compiled in an international workshop in Vienna. The comparison of the Viennese nitrogen budget with those of Zielona Góra in Poland and the cities of Shijiazhuang and Beijing in China promises interesting findings.

2. Objectives of WP8:

- Identification of relevant stakeholders in Vienna and Klagenfurt (Austria)
- Preparation of scientific (interim) results and information for stakeholders
- Obtaining feedback from stakeholders on the project and first results in order to optimise the further course of the project
- Development of ideas, approaches for possible implementation projects/programmes and a possible applicability in practice
- Identification of further research needs and the necessary prerequisites to advance the topics further
- Elaboration of a final report with recommendations for next steps

3. Activities:

In coordination with the project management the two stakeholdermaps for Vienna and Klagenfurt, that already have been prepared for the first workshop series in 2020, have been further developed. Especially companies and stakeholders from the surrounding areas of the cities were added. Based on the mapping a total of about 50 stakeholders in Klagenfurt and 70 stakeholders in Vienna have been invited to the second stakeholder Workshop in Klagenfurt and Vienna.
The two workshops were held in October 2021, one in Klagenfurt and the other one in Vienna. The two were designed the same way, according to the methodology and structure. However, the results slightly differ. Within the project, the nitrogen budget will be calculated for Vienna, but also partly for Klagenfurt. Klagenfurt is to be seen as the pilot study area for the participatory process.

WP leaders BB und E-C-O contributed to the objectives and the deliverable.

4. Results:

The two workshops took place on October 11 in Klagenfurt (Federal State of Carinthia) and on October 14 in Vienna. Both workshops were held in German because all participants were German speaking (see also original presentation slides in the Appendix). The complete description of the two workshops is provided in the Annexes.

5. Outlook and further procedure

Mai 2022: Final event with all project partners (Beijing, Shijiazhuang, Zielona Góra)
August 2022: End of project

6. Milestones achieved:

Contribution to M2 (“Policy impacts identified”) and M5 (“Stakeholder feedback obtained”) – some delay due to the COVID-19 pandemic

7. List of Documents/Annexes:

Minutes Workshop II Klagenfurt
Minutes Workshop II Vienna

Workshop II:

Urbane nitrogen cycles: Innovative approaches, to meet the climate crisis

Minutes

Location: Lakeside Science & Technology Park, Klagenfurt

Date: 11.10.2021

Financed: JPI Urban Europe

Moderation:

E.C.O. Institute of Ecology Jungmeier GmbH
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Project title:	UNCNET – Urban nitrogen cycles: New Economy Thinking to master the challenges of climate change
Financed:	JPI Urban Europe
Moderation and minutes:	Romana Piiroja, Lisa Wolf und Daniel Zollner, E.C.O. Institute of Ecology, Klagenfurt
Supported by:	• Wilfried Winiwarter, IIASA, Laxenburg • Katrin Kaltenegger, IIASA, Laxenburg

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1 INTRODUCTION

1_1 Executive project summary

Along with climate change and biodiversity loss, nitrogen (N) is one of the three most critical issues for our global boundaries (Planetary Boundaries). We have already crossed these three boundaries and the negative impacts of this are difficult to reverse.

The project *Urban Nitrogen Cycles: New Approaches to Address the Climate Crisis* (UNCNET) addresses this acute issue. It is coordinated by the International Institute for Applied Systems Analysis (IIASA, Vienna). Project partners are the Chinese Academy of Sciences (China), Peking University (China), the University of Zielona Góra (Poland), brainbows informationsmanagement in Vienna and E.C.O. Institute of Ecology in Klagenfurt.

UNCNET investigates and compares nitrogen cycles in four cities - Vienna, Zielona Góra in Poland, and Shijiazhuang and Beijing in China. Especially in urban areas, the accumulation of nitrogen compounds leads to major problems. Ammonia and nitrate from imported food or nitrogen oxides from traffic and industry pollute air and water, accelerate climate change, impair biodiversity and endanger health. Especially in cities, many people are directly affected. On the other hand, it is precisely here that a better understanding of the interrelationships can help to make sustainable decisions and significantly improve the effectiveness of measures.

Further information: https://www.uncnet.org/

1_2 Agenda

9.00 – 9.10 Welcome

9.10 – 9.30 Introduction round & thematic location

9.30 – 9.45 Project presentation & research results

9.45 – 10.45 Group discussion: Scientific results for Klagenfurt - Villach

15 min Break

11.00 – 11.45 Plenary discussion

12.15 – 12.30 Summary and further steps

Joint Lunch

1_3 Objective

The applicability of the research results in practice and the implementation in political decision-making processes are central elements of the project. For this reason, we involve selected decision-makers and key stakeholders in the development of solutions at an early stage.

2 EINFÜHRUNG

Nitrogen is an indispensable nutrient for all living things. The use of mineral and organic nitrogen fertilizers increases yields and is widespread practice in agriculture. As a result, water and terrestrial ecosystems can be polluted and the climate, air quality and biodiversity affected negatively.

These effects are illustrated by the Stockholm Resilience Centre's Planetary Boundaries, among others. Research has been conducted on the nine Planetary Boundaries for 2 decades, and nitrogen and phosphorus fluxes in the biosphere and oceans form one of these.

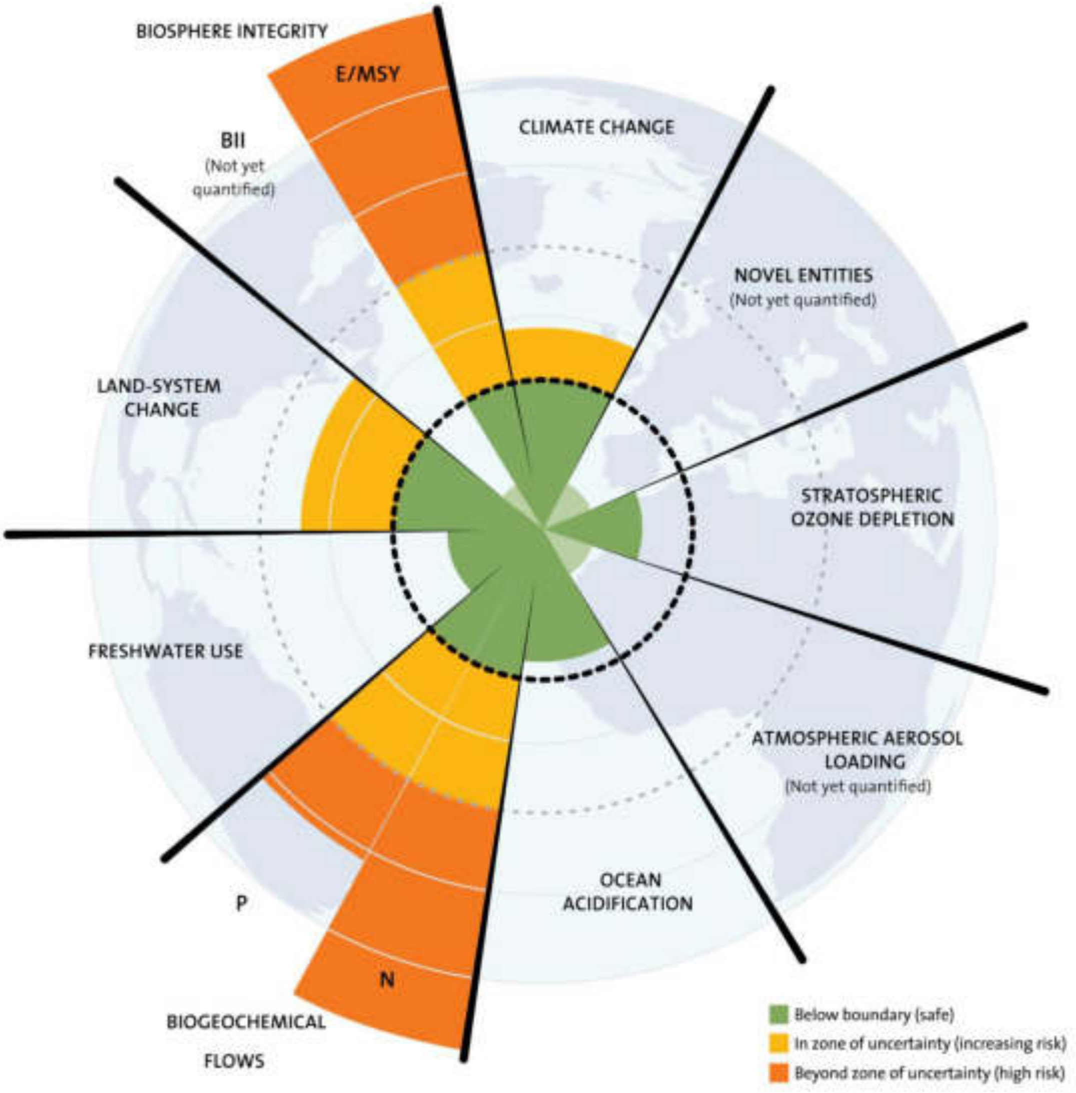

Figure 1: Planetary Boundaries (J. Lokrantz/Azote based on Steffen et al. 2015)

The bio-geochemical cycles of nitrogen and phosphorus have been radically altered by humans because of numerous industrial and agricultural processes. Nitrogen and phosphorus are both essential elements for plant growth. Therefor, fertilizer production and application are the main causes for the high-risk level.

More atmospheric nitrogen (N_2) is now converted to reactive forms by human activities than by all terrestrial processes on Earth combined. Much of this new reactive nitrogen is released into the atmosphere in various forms instead of being taken up by plants. When it rains off, it pollutes waterways and coastal areas or accumulates in the terrestrial biosphere. Similarly, a relatively small portion of phosphorus fertilizers used in food production is taken up by plants; much of the phosphorus mobilized by humans also enters aquatic systems. These can suffer from oxygen depletion as bacteria consume the algal blooms that grow in response to the high nutrient supply.

A significant portion of applied nitrogen and phosphorus enters the ocean and can cause marine and aquatic systems to exceed their own ecological thresholds.

2_1 Workshop method and questions

In contrast to the first stakeholder workshop (virtual), the second workshop for experts and decision-makers took place on-site in Klagenfurt. A plenary discussion and in the meantime small group discussions were conducted.

Guiding question:

- General impression of the graphics?
- Are the numbers realistic?
- Where are the biggest accumulations/problems?
- What can be done to close loops (e.g. "Circular Economy", "CircularXY")?

Guiding question:

- Are the topics about which information is provided appropriate?
- Are the slogans appealing?
- What information should still be developed?
- What are the biggest challenges of the future regarding nitrogen?
- How can nitrogen be communicated in an appealing way?

2_2 Plenary discussion – Part I „Agro-Food-Chain Klagenfurt-Villach“

Katrin Kaltenegger (IIASA) presents the ongoing project results:

- Presentation of the different calculations; in different cities Vienna, Klagenfurt-Villach, Zielona Gora, Shijiazhuang and Beijing;
- STAN analysis (Further information: https://www.stan2web.net/):
  - For Vienna/Lower Austria filled – data situation partly difficult;
  - For the Klagenfurt-Villach area, a separate STAN model has now been created (see Figure 2);
- Partners in Poland and China have created their N-fluxes as well;
- Next step is to compare cities: what are the potentials for applying nitrogen budgets? How can we learn from each other? Topics are also different intervention possibilities how N-fluxes can be improved or optimized and/or changed.

During the workshop, priority was given to the current research results for the greater Klagenfurt-Villach area:

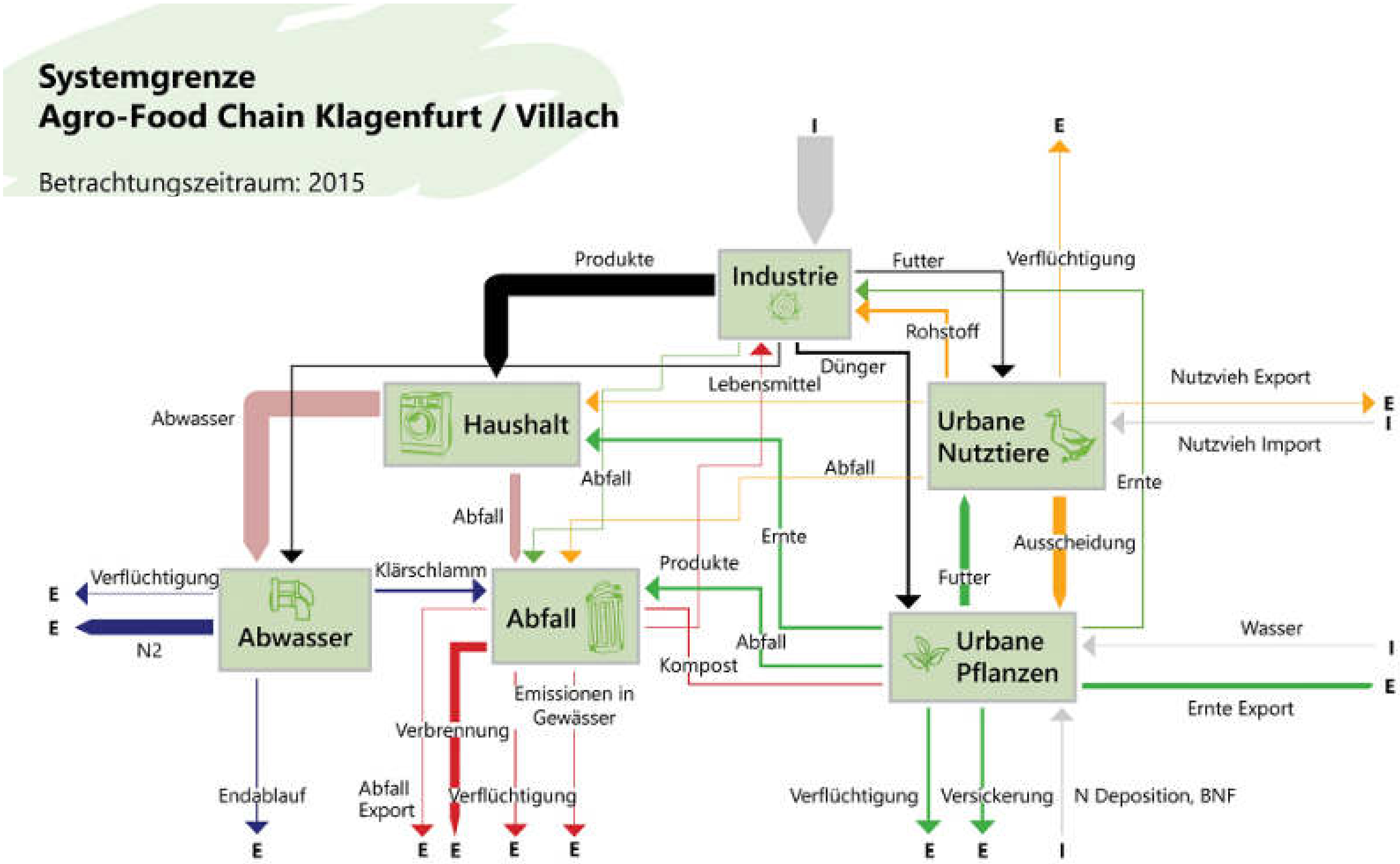

Figure 2: STAN-Modell excerpt of the Agro-Food-Chain for Klagenfurt-Villach; observation period 2015 (Draft Winiwarter & Kaltenegger)

The model is an excerpt from a more comprehensive representation with different nitrogen fluxes (see Figure 3). Common to all representations is that the thickness of the arrows stands for the amount of nitrogen fluxes. The unit of nitrogen is measured in tons of nitrogen per year (tN/a).

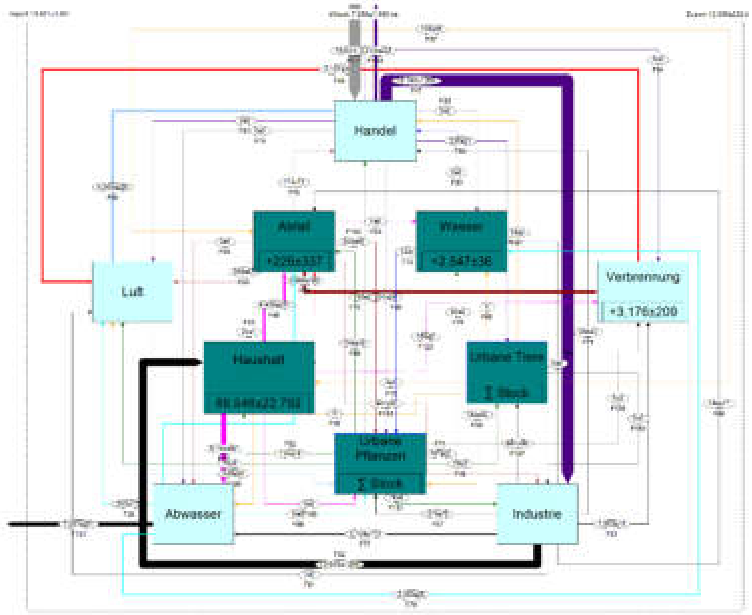

Figure 3: STAN system Vienna (City) including all N-Cycles (Example; Draft Winiwarter & Kaltenegger)

For the workshop, the "Agro-Food-Chain" for the Klagenfurt-Villach area was discussed. Urban plants include agricultural land, parks and gardens (see Figure 2); Urban animals are domestic animals as well as farm animals; Industry includes everything produced in the city (in Austria this amount is small (large share of imports) - see flow from trade to industry); In the Klagenfurt Stadt and Villach Stadt region the flows are more balanced and - as in Vienna - Klagenfurt-Villach is also a sink for reactive nitrogen.

Volatilization means that part of the applied N goes into the air as nitrous oxide or ammonia. N_2O is considered to be a highly effective greenhouse gas. The greenhouse gas potential is approx. 300 higher than that of CO_2. Leaching refers to nitrogen that passes through the soil into the groundwater (e.g. Marchfeld: nitrate value above the threshold value). Fertilizer refers only to mineral fertilizer (synthetic fertilizer from industry). The flow of fertilizer is large in relation to other flows and this is well illustrated by the model.

Questions and comments.

Wastewater treatment plants: flow from wastewater treatment plant beyond the system boundaries is the elemental nitrogen and the larger proportion that escapes into the air; volatilization is the nitrous oxide (N2O) as a greenhouse gas; surprising that so much goes into the air; good thing is that the wastewater treatment plant breaks down the nitrogen and it goes into the air; it is energetic loss, something that could actually be used more, so not a problem in the actual sense, but a potential;

Fertilizer: the question is whether you really need so much mineral fertilizer; the Haber-Bosch process is often cited; there are considerations about how to produce artificial fertilizer with hydrogen, but you need a lot of energy for it, own wind farms; advantage would be if you bring back something that is already in the cycle, so you don't have to produce it extra;

Nitrogen cycles: there are some natural nitrogen cycles. The following cycles are examples:

- *Plants* need nitrogen to synthesize proteins, such as enzymes, and DNA - nitrogen is therefore essential for metabolism. A lot of energy is needed to convert atmospheric nitrogen into chemical compounds that are also available to plants (illustrated figuratively: nitrogen oxides are formed from atmospheric nitrogen and atmospheric oxygen during a lightning strike).
- Biological fixation of nitrogen via *bacteria* that use energy from sugar to fix nitrogen. These bacteria are pushed back by others when there is enough nitrogen. The sugar is produced by plants using photosynthesis and made available to the soil bacteria via the roots (root extrudates). Over time, plants have specialized in giving such bacteria more space and the bacteria live in symbiosis with them, for example in the root nodules of legumes.

However, the difference between the natural cycle and the current global nitrogen situation are driven by anthropogenic influences that have doubled the natural cycle in the last 50 years. These include the following:

- Active *cultivation of leguminous*; for example clover cultivation to have more nitrogen in the soil.
- Process of air pollution via *combustion processes*; similar to lightning, which allows atmospheric nitrogen to react with oxygen; nitrogen oxides are directly and indirectly (as precursors of particulate matter) air pollutants and cause damage to health; however, this bound nitrogen can contribute to the growth of plants; forests grow better due to nitrogen;
- Production of *artificial fertilizer*; we are in a huge experiment; we are far beyond the natural cycle (cf. Planetary Boundaries).

Haber-Bosch process: If we shut down the Haber-Bosch plants today, the excess of nitrogen in the biosphere would decline in a few years. This is in contrast to the climate problem, where the atmosphere stores greenhouse gases such as CO2 over the long term (even after emissions end, the effects of global warming remain over the long term).

Combustion processes: Technically, the reduction of emissions of nitrogen oxides has been solved. With the help of catalytic converters in vehicles, or without catalytic converters in denox systems of power plants, emissions can be reduced by up to 95%. Appropriate limit values help to make this problem outdated.

Wastewater treatment plants: ¾ of the nitrogen in the wastewater is removed in the treatment plant, the rest goes into the flowing waters (not into the groundwater). N2 that re-enters the air through biological processes is not problematic.

Urban plants: Addition of nitrogen as fertilizer is essential for plant growth. However, in Europe only about 60-70% of the available nitrogen fertilizer is taken up (globally much less). The rest may leach to groundwater or run off to surface waters. The exact quantification is difficult, depends on local conditions (soil properties, slope, precipitation).

Urban animals: Figures include livestock and pets, also for urban areas. A combination of different statistics is used. The animal population, for which feed requirements (input) and excretion (output) are calculated, comes from a different statistic than the number of slaughters, from which meat production (output) is calculated. Another statistic provides information on live animal transports (input and output). This results in discrepancies between in- and output of the pool for urban animals.

Industry - household - wastewater: How much do things accumulate that contain nitrogen? This question is relevant also in the comparison between cities. Accumulation of nitrogen compounds is not directly environmentally relevant, but may indicate a potential of possible later release (for example, once things reach landfills and substances are released there). Regarding households, the calculation is based on consumption. Why is there no arrow from trade to household? [Note: trade = exchange between system and what is outside; trade = import/export; Billa is e.g. attributed to industry - terms still need to be refined/refined].

Nutrition: Specific questions here relate to whether we eat more than we need. What can be reduced in terms of waste? What nitrogen consumption and excretion do we get per person? There will be comparisons between the countries or project partners. Age cohorts would also be interesting here;

Feed: Is it taken into account that feed is imported and possible environmental aspects occur in the producing countries? Global trade especially of soy (from South America or U.S.A) implies such offloading of effects. UNCNET only considers physical flows (such as import of soy). If N footprints were calculated, then it would be an issue.

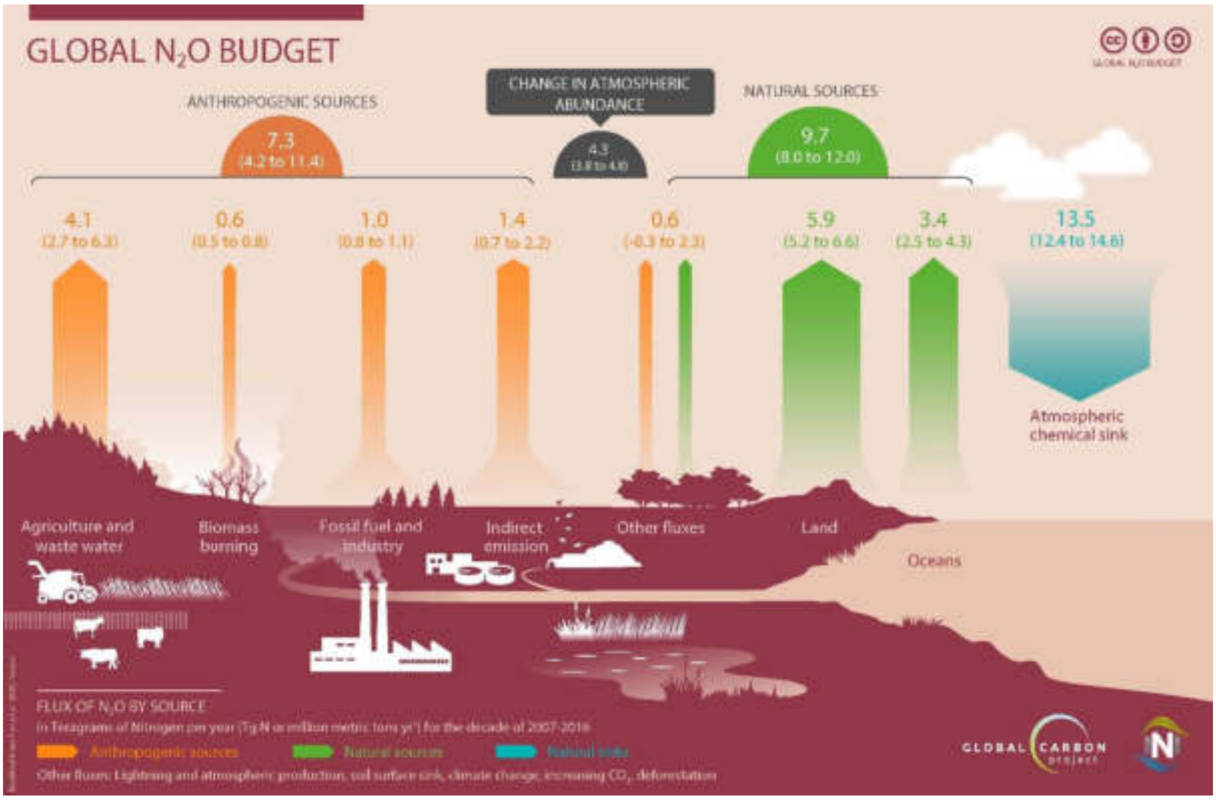

Figure 4: Global nitrous oxide budget (N_2O) (Tian et al. 2020)

Data situation: Some uncertainties exist in the figures. The model allows the data to be presented taking these uncertainties into account. Understanding how robust a statement is essential for policy decisions - statements of uncertainty are a priority here.

Budgets vs. footprints: Do national nitrogen footprints exist? We have done these calculations in other contexts in specific countries. It turns out that human metabolism is similar everywhere. Differences are in production methods, dietary habits, treatment of wastewater. Nitrogen budgets show different things than footprints. Budget shows where N release happens and where pollutants are. What remains open is what environmental impacts to estimate at various points. 1t of nitrogen can be well recycled or lead to overturning of water bodies depending on where it is found, so there is a dependence on location.

Still open questions from the lead partner (IIASA) that were discussed:

- **Composting and organic waste:** The assumption is that a lot of private composting is done. In Carinthia, residual waste ends up in the organic waste container, so composting is usually not done well. However, green waste is collected. If you have a garden, you are obliged to compost, but residents often do not. A lot of compost is carried into the forest (no data on this) or composted incorrectly. Actually, the municipality would be responsible to control this. Some is also thrown into the toilet. The EU regulation states that no organic waste may be fed to animals. Regulations are aimed at mass operations**.**

2_3 Plenary discussion – Part II Practical examples

Wilfried Winiwarter presents examples of the use of nitrogen budgets:
Please: Participants are asked to name concrete applications - the project partners are open to include them in the research process.

- There are fewer current application examples from urban areas, but more from national balances, which are then also used accordingly.

- The advantage of the scientific approach to nitrogen is that research is not so much exposed to the criticism of some sectors (e.g. economy);
- Global overall context is not queried, partial flows are queried;
- Data is backed up by creating a nitrogen budget;
- Ammonia is a problem; we can show where it comes from, can show characteristic fluxes, show what would happen if we routed fluxes differently;
- Little happens in regulating agricultural emissions because much comes from individual sources;
- Nitrogen oxides (Although the installation of catalytic converters in vehicles is relatively expensive, the problem can be considered solved);
- Emission ceilings (under EU regulation) also exist for sulphur dioxide (doing quite well), particulate matter, volatile organic compounds; each EU country may emit only a certain amount, background: emission affects EU neighbouring country;
- In progress: cost/benefit calculation of measures to reduce emissions of substances;
- Working group (Convention on Long Range Transport of Air Pollutants) led by Wilfried and colleague from Dessau to better represent impacts on sensitive terrestrial ecosystems; = there are international working groups to enforce limits; Ö has not joined the Gothenburg Protocol, as one of few countries in Europe, but is subject to EU emission ceilings anyway.
- Eutrophication: input of nutrients leads to algae growth, blocks fish respiration;
- Phosphorus and nitrogen must be seen together here; ex. Baltic Sea Helsinki Commission for the Protection of the Baltic Sea, intern. Convention HELCOM to deal with pollution of the Baltic Sea; for this purpose national nitrogen balances are also a useful tool
- INMAP (Integrated Nutrient Management Action Plan) serves as a tool for the EU to achieve the goals of the Farm to Fork Strategy and the Biodiversity Strategy. The plan makes use of nitrogen budget data;
- Problem: Defence posture of agriculture instead of efforts to contribute to global solutions. Research is striving to identify options for closing loops for agriculture as well. This also means better use of natural fertilizers when animal husbandry and crop production are more integrated; this can facilitate local use of nitrogen;
- The global accounting of nitrous oxide (Fig. 4) shows that the sources and sinks fit well and that the understanding of the processes may be better than previously thought. Nitrous oxide (N_2O) is a relatively stable gas that lingers in the atmosphere for a long time, similar to CO_2.Although primarily from agricultural sources, industrial releases are also of interest, especially because favourable measures could be taken here (but have not been implemented due to lack of legislation). For example, the production of adipic acid (needed to make nylon) accounts for 1-2% of global emissions; Visp is home to a plant that, at least until last year, released nitrous oxide equivalent to 1% of total Swiss greenhouse gas emissions - which was only detected by accident.
- The importance of agriculture, even in urban areas, can be considerable: the Chinese urban province of Beijing produces more milk than is consumed there. Although milk consumption in China is lower than in Europe, for example, the fact that urban agricultural production generates local exports is remarkable;
- Urban environmental problems also have high local impacts: Morbidity and mortality can be exacerbated by high population density.

2_4 Project output

The project results will be published as scientific results (paper), project reports and a summary of the results and sent to the experts. In addition, after the end of the project, there will be a set of cards with project-specific and topic-specific information and results. This set will be distributed to participants.

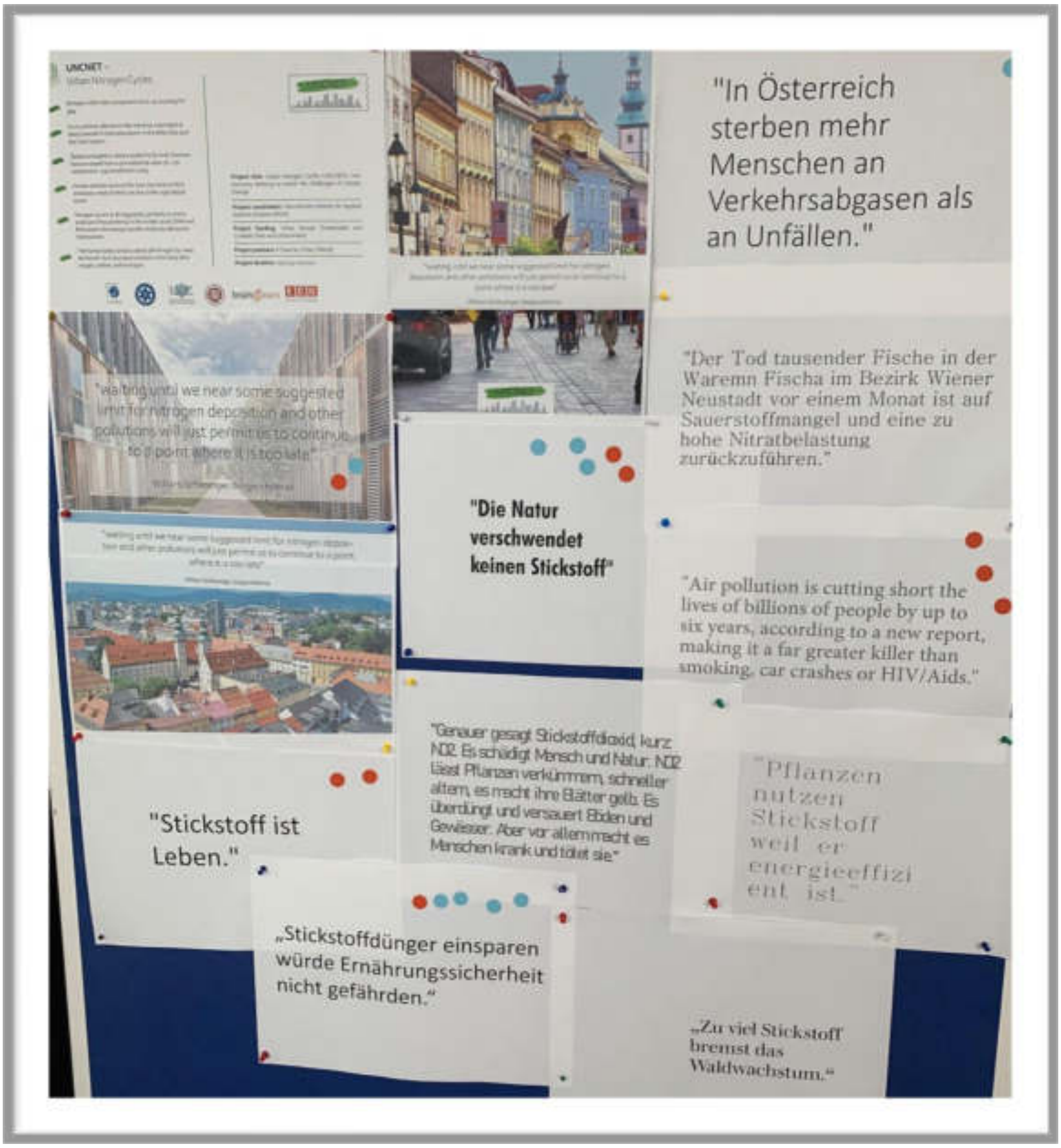

Figure 5: Reflection of the information card set and related statements

The three statements that workshop participants found most appealing were the following:

- "Saving nitrogen fertilizer would not compromise food security."
- "Nature does not waste nitrogen."
- "Air pollution is cutting short the lives of billions of people by up to six years, according to a new report, marking it a far greater killer than smoking, car crashes or HIV/Aids."

The statements should be visible on the set of cards.

3 OUTLOOK AND NEXT STEPS

The workshop minutes will be officially sent to all participants. In addition, a summary will be sent to all originally invited stakeholders. In May 2022, the final workshop will take place in Vienna (currently planned date is May 30-31). In this context, further projects will also be considered. Information on this will be sent out by the organizers in time.

Literature

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4 ANNEX

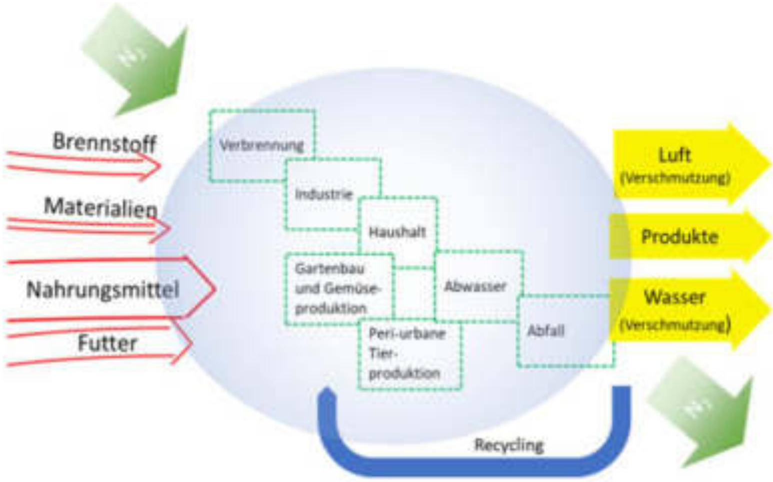
4_1 Presentation slides. E.C.O. Institute of Ecology: Introduction

brainCows E.C.O.

Planetare Grenzen

brainCows E.C.O. 10/20/2021 4

Stickstoff



Winiwarter et al., 2020

10/20/2021 brain cows E.C.O. 5

Das Projekt

- Originaltitel: ***U**rban **n**itrogen **c**ycles: **n**ew **e**conomy **t**hinking to master the challenges of climate change (UNCNET)*
- Projektkoordinator: *Wilfried Winiwarter, International Institute for Applied Systems Analysis (IIASA, Laxenburg)*
- Thema: *Klimawandel und neue urbane Wirtschaft*
- Stichwörter: *Stickstoffkreislauf, Kreislaufwirtschaft, Luftverschmutzung, Wasserverschmutzung und Abfallbehandlung*
- Theoretische und Angewandte Forschung
- Projektdauer: *März 2019 – Februar 2022 (Verlängerung bis Juni 2022)*

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10/20/2021
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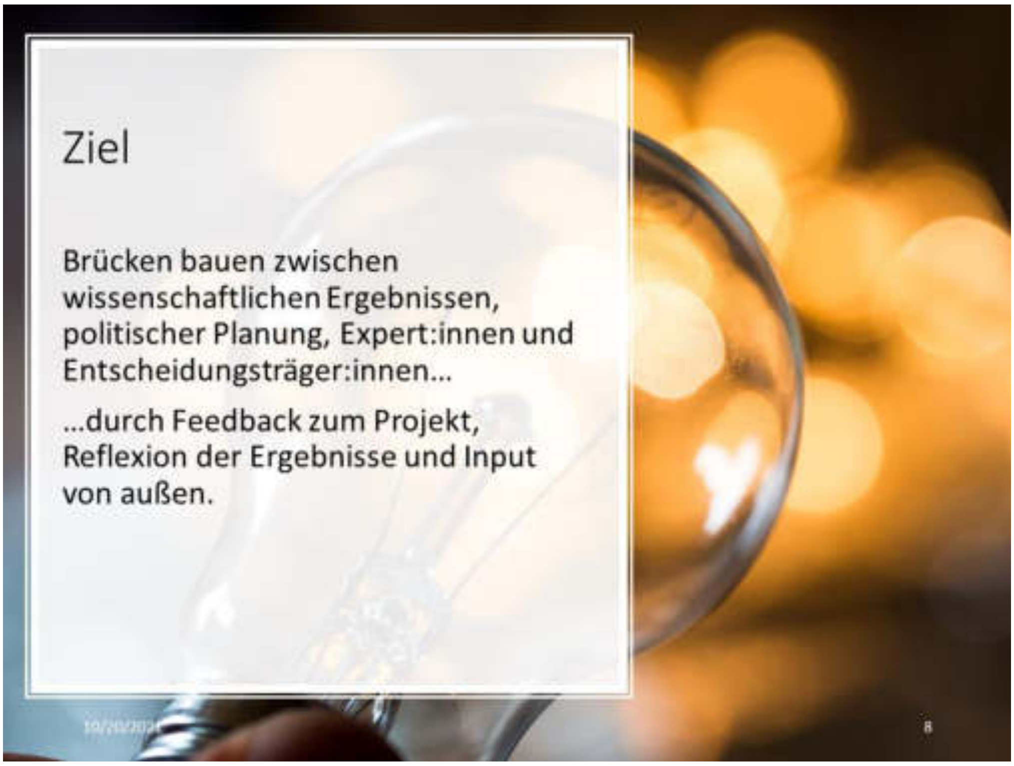


Ziel
Brücken bauen zwischen wissenschaftlichen Ergebnissen, politischer Planung, Expert:innen und Entscheidungsträger:innen...
...durch Feedback zum Projekt, Reflexion der Ergebnisse und Input von außen.
8

UNCNET

Mögliche Erkenntnisse

- Inwiefern verlaufen urbane Stickstoffströme unabhängig voneinander?
- Welche Anteile an reaktivem Stickstoff werden der Wiederverwendung zugeführt?
- Welche werden vor der Abgabe an die Umwelt unschädlich gemacht, durch Umwandlung in Luftstickstoff?
- Welche Potentiale ergeben sich im Vergleich der Städte, Auswirkungen auf die Umwelt zu mindern?
- Wo kommt es zu Akkumulationen von Stickstoff, und damit zu potentiellen künftigen Orten der Freisetzung?

brainflows E.C.O.

Partizipative Einbindung von Stakeholder:innen

- Zwei Benutzer-Workshops (in Wien und Klagenfurt), Österreich. Kleine Gruppen von etwa 10 Personen. Die Workshops werden in der Landessprache (Deutsch) abgehalten.
- Die Ergebnisse des Workshops werden in die Datenauswertung und die Modellierung von Stickstoffflüssen, wie sie in UNCNET entwickelt wurden, einfließen.
- Konferenz (Wien oder Laxenburg), 40 - 60 Personen, unter Einbeziehung aller Projektpartner. Die Konferenz wird zeitgleich mit dem abschließenden UNCNET-Treffen organisiert und in englischer Sprache abgehalten.

10/20/2021 brainbows E.C.O. 11

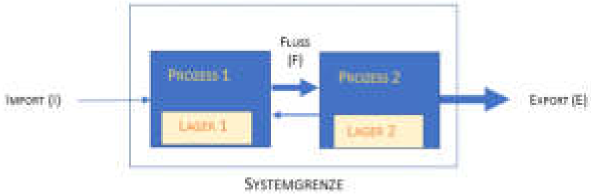
Internationaler Austausch

- Stadtplanung im Kontext der rechtlichen und sozio-ökonomischen Bedingungen einer kleineren polnischen Stadt (Zielona Góra)
- Umsetzung der Projektergebnisse in China: Wege, Strategien, Aktivitäten. Neudefinition des "Stakeholder"-Konzepts auf der Grundlage lokaler Anforderungen, Gesetze und Praktiken.
- Abschlusstreffens, um Strategien und Erfolgsgeschichten in verschiedenen Gemeinden zu vergleichen und einen Weg in die Zukunft zu finden (Folgeprojekte zur Umsetzung)

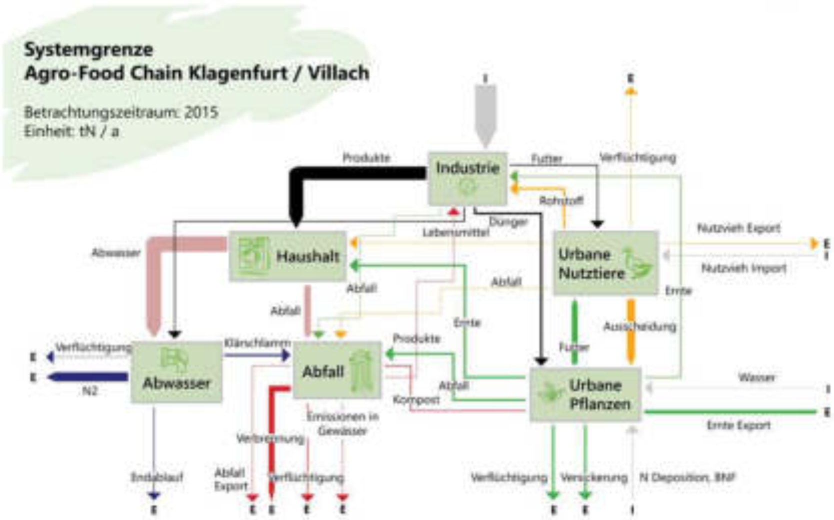
10/20/2021 brainbows E.C.O. 12

Vorgehensweise

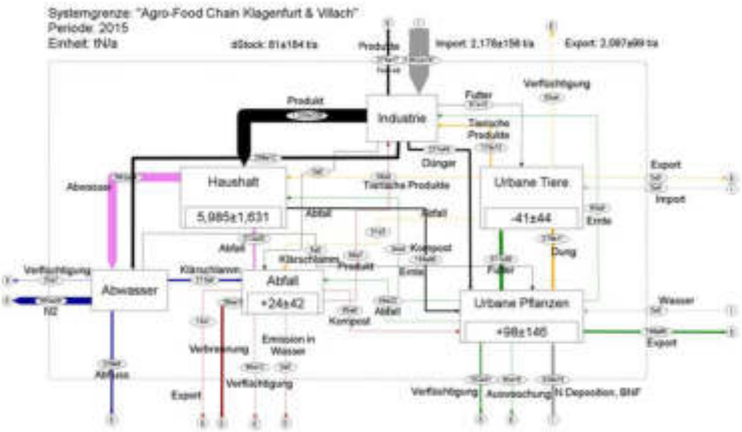
- STAN - Programm zur Stoffflussanalyse (TU Wien)
- Atmosphärisches Modell – Emissionen & Depositionen

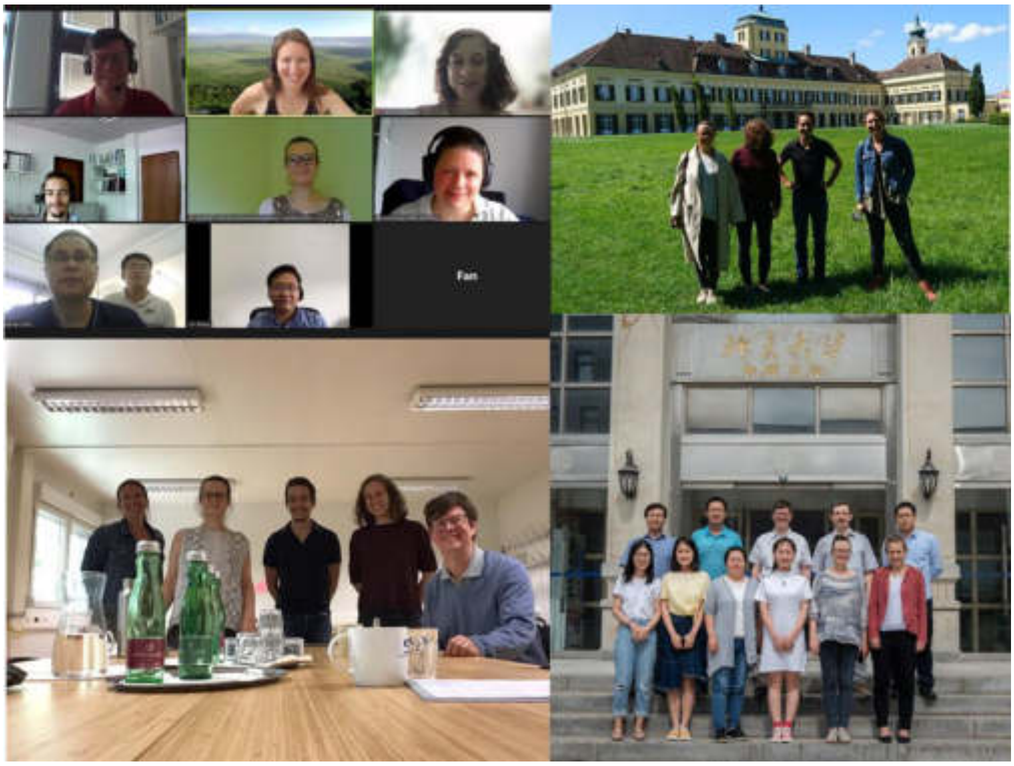


brainbows E.C.O.



brainbows E.C.O.


Systemgrenze: "Agro-Food Chain Klagenfurt & Villach"
Periode: 2015
Einheit: tN/a
Industrie
Haushalt
5,985±1,631
Urbane Tiere
-41±44
Abwasser
Abfall
+24±42
Urbane Pflanzen
+98±146
Produkt
Futter
Tierische Produkte
Dünger
Verflüchtigung
Export
Import
Ernte
Dung
Kompost
Klärschlamm
Wasser
N2
Abfluss
Verbrennung
Emission in Wasser
Auswaschung
N Deposition, BNF



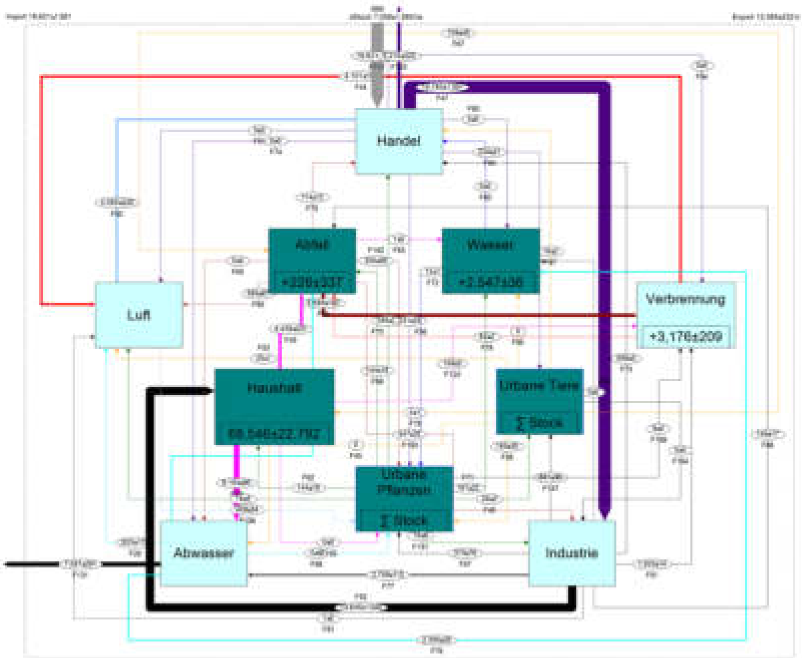
4_2 Presentation slides. Katrin Kaltenegger (IIASA): STAN-Modell (incl. Graphs)

UNCNET Fortschritt & Ausblick

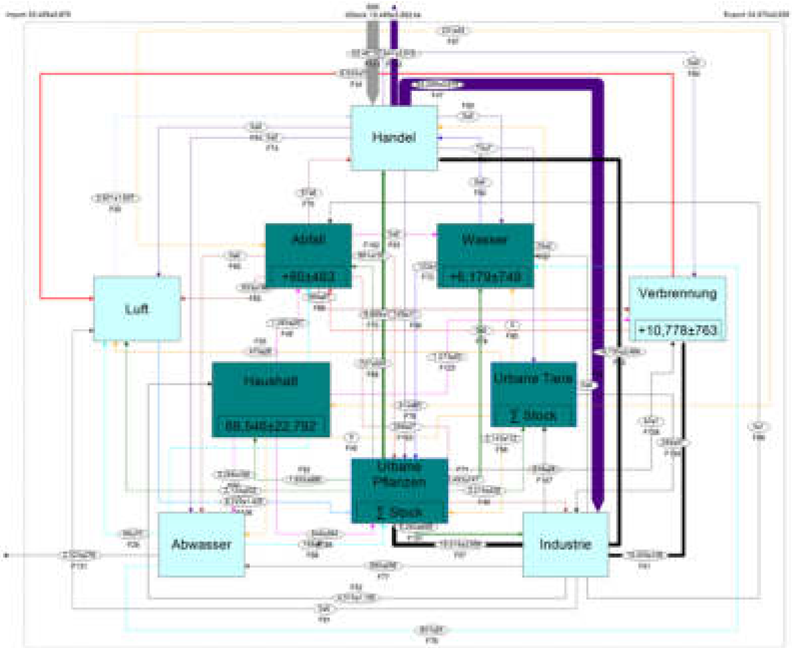
- Identifizierung Stickstoffflüsse und Stickstofflager in und aus Städte und städtisches Umland
  - Wien, Klagenfurt (& Villach), Zielona Gora, Beijing, Shijiazhuang

- Nächste Schritte
  - Vergleiche zwischen den Städten
    - Potentiale etc.
  - Berechnungen für 1995-2010, Szenarien für 2030 & 2050

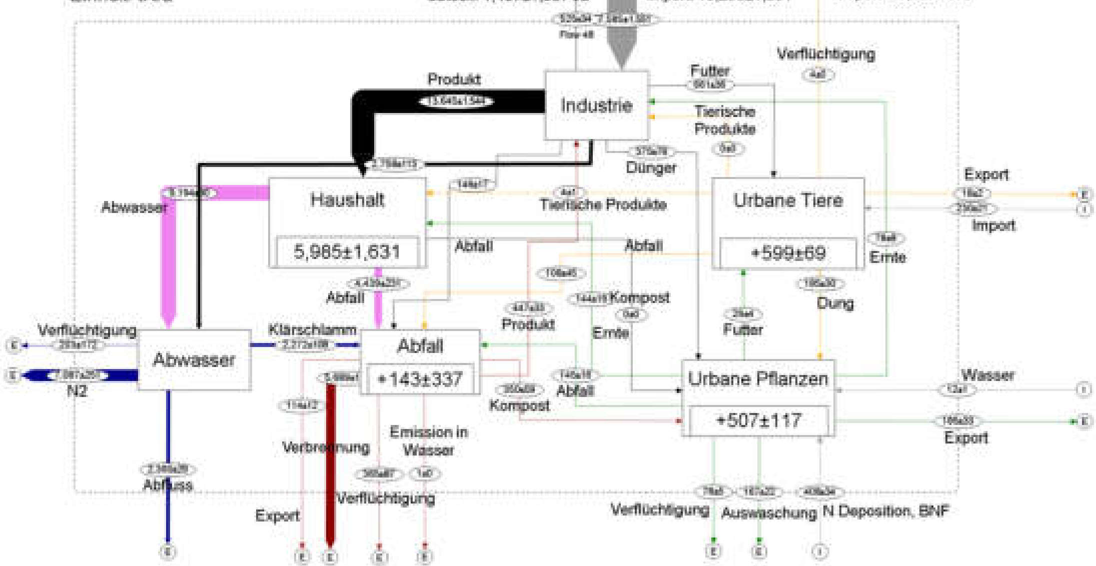
Systemgrenze: Wien
Periode: 2015
Einheit: tN/a

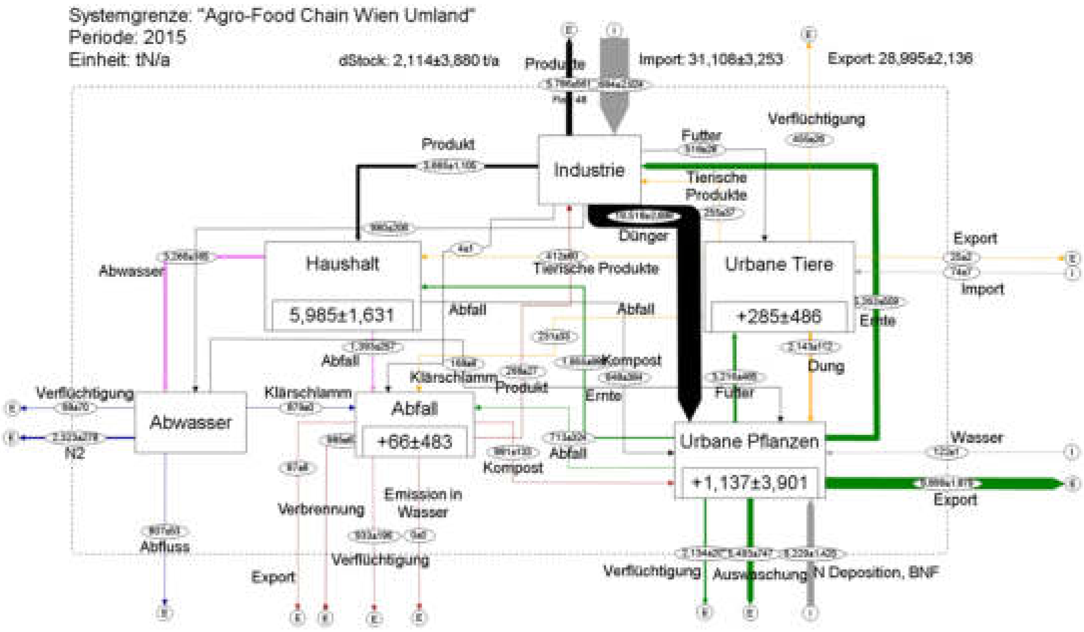


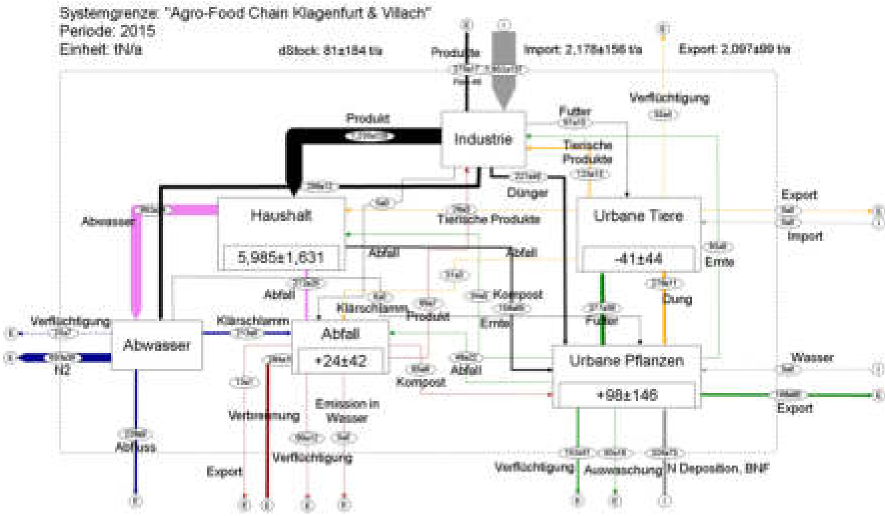
Systemgrenze: Wien Umland
Periode: 2015
Einheit: tN/a



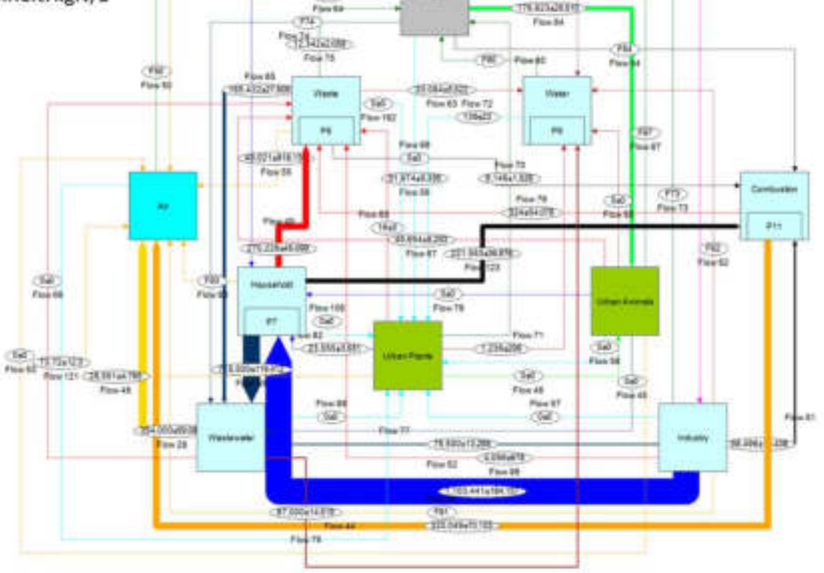
Systemgrenze: "Agro-Food Chain Wien"
Periode: 2015
Einheit: tN/a



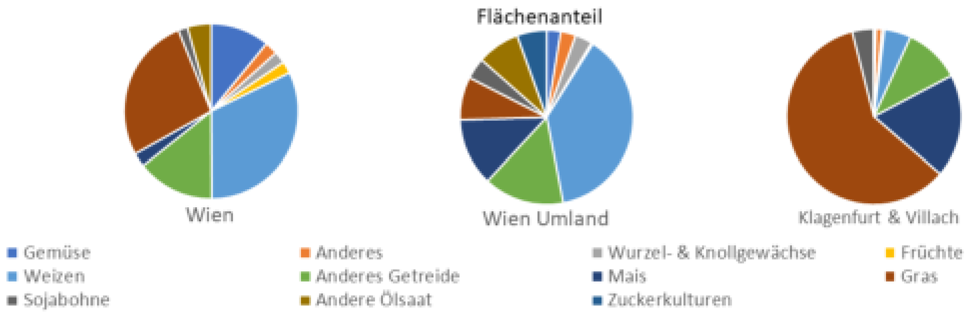

Systemgrenze: "Agro-Food Chain Wien Umland"
Periode: 2015
Einheit: tN/a
dStock: 2,114±3,880 t/a
Produkte
Import: 31,108±3,253
Export: 28,995±2,136
Industrie
Produkt
Futter
Verflüchtigung
Tierische Produkte
Dünger
Haushalt
5,985±1,631
Urbane Tiere
+285±486
Abwasser
Tierische Produkte
Abfall
Export
Import
Ernte
Kompost
Klärschlamm
Produkt
Dung
Futter
Verflüchtigung
Abwasser
Abfall
+66±483
Urbane Pflanzen
+1,137±3,901
Wasser
N2
Kompost
Emission in Wasser
Verbrennung
Abfluss
Export
Verflüchtigung
Auswaschung
N Deposition, BNF


Systemgrenze: "Agro-Food Chain Klagenfurt & Villach"
Periode: 2015
Einheit: tN/a
dStock: 81±184 t/a
Produkte
Import: 2,178±156 t/a
Export: 2,097±89 t/a
Industrie
Produkt
Futter
Verflüchtigung
Tierische Produkte
Dünger
Haushalt
5,985±1,631
Urbane Tiere
-41±44
Abwasser
Tierische Produkte
Abfall
Export
Import
Ernte
Kompost
Klärschlamm
Produkt
Dung
Futter
Verflüchtigung
Abwasser
Abfall
+24±42
Urbane Pflanzen
+98±146
Wasser
N2
Kompost
Emission in Wasser
Verbrennung
Abfluss
Export
Verflüchtigung
Auswaschung
N Deposition, BNF

Systemgrenze: Zielona Gora
Periode: 2015
Einheit: kgN/a



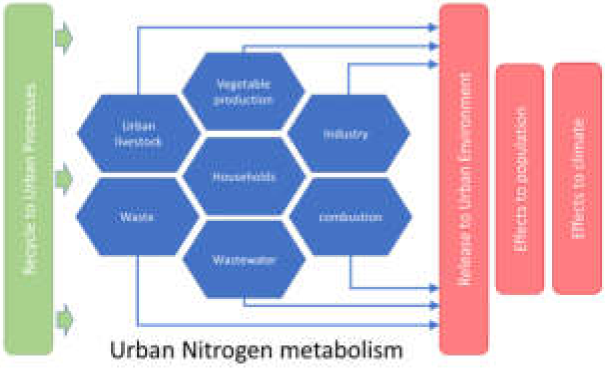
	Zielona Góra		Zielona Góra Umland		Wien		Wien Umland		Klagenfurt & Villach	
	tN	kgN/ha	tN	kgN/ha	tN	kgN/ha	tN	kgN/ha	tN	kgN/ha
Luft - Landw. Fläche (Deposition)	8	16	108	16	92	17	2.708	13	90	15
Landw. Produkte - kommerziell	6	12	405	59	176	32	9.893	47	198	33
Landw. Produkte - Eigenversorgung	24	47	101	15	132	24	1.847	9	34	0,21
Mineraldünger	31	62	420	62	327	59	19.352	92	207	34



4_3 Presentation slides. Wilfried Winiwarter (IIASA): Practical examples

Möglichkeiten von Stickstoffbudgets

- Insgesamt und für jedes der Lager („pools“) einzeln:
  - Bilanzierung
  - Abschätzung fehlender Flüsse
  - Identifizierung von strukturellen Widersprüchen
  - Zeitliche Entwicklungen
  - Benchmarking – Erstellen von und Vergleich mit Zielen
  - Vergleich zwischen Regionen, Städten



Urban Nitrogen metabolism

Regionale Beiträge zu globalen Nachhaltigkeitszielen

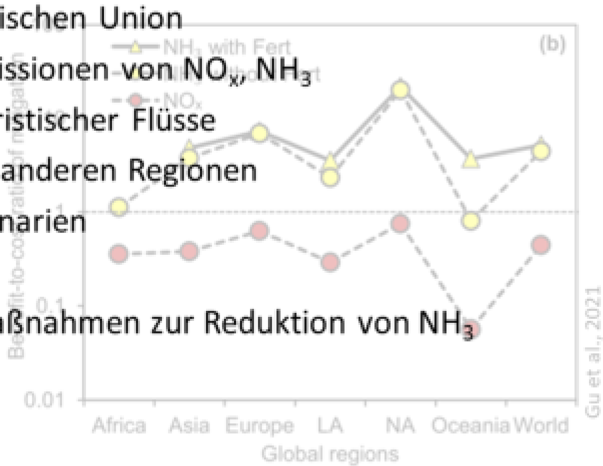
- Betrachtung pro Kopf/Einwohner: Verursacherprinzip
- Betrachtung pro Flächeneinheit: Auswirkungen (Einträge)
- Betrachtung pro Masseneinheit Produkt: Effizienz
- Betrachtung pro Einheit Wertschöpfung: ökonomische Bewertung

- Vergleich mit regional heruntergebrochenen planetaren Grenzen

Einhaltung von Emissionshöchstgrenzen

- NEC Richtlinie der Europäischen Union
- Überschreitungen bei Emissionen von NO_x, NH_3
- Identifikationen charakteristischer Flüsse
- Vergleich mit Situation in anderen Regionen
- Maßnahmenplanung, Szenarien

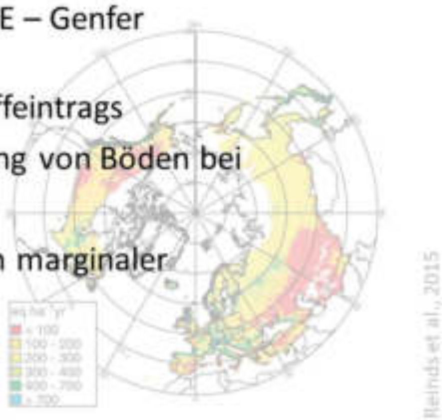
- Immenser Nutzen von Maßnahmen zur Reduktion von NH_3



Auswirkungen auf sensitive terrestrische Ökosysteme

- „critical loads" im Rahmen der UNECE – Genfer Konvention LRTAP
- Biodiversität im Einfluss des Nährstoffeintrags
- NO_x, NH_3 tragen beide zur Versauerung von Böden bei

- Datensätze über modellierte Grenzen marginaler Auswirkungen sind verfügbar



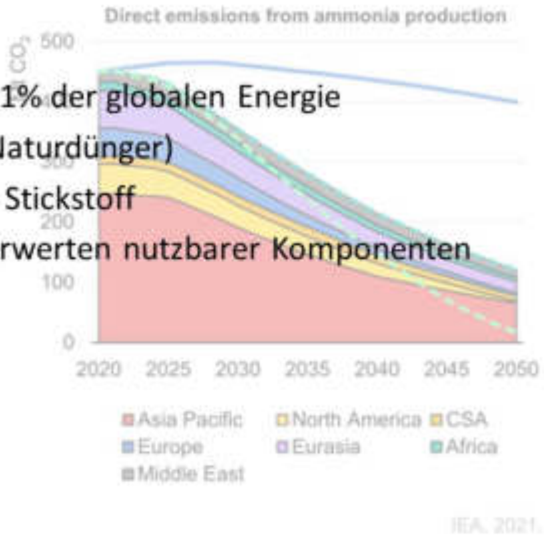
Fluviale und marine Eutrophierung

- Unterschiedliche Quellen von Nährstoffen
  - Landwirtschaftlicher Stickstoffeintrag über Grundwasser ausgewaschen
  - Intensive Viehhaltung
  - Kläranlagen als Quellen für Emissionen in Vorfluter
- Unterschiedliche Transportwege
- Atmosphärischer Transport von Luftschadstoffen
- Grund- und Oberflächengewässer transportieren Schadstoffe ins Meer, werden bei mangelnder Verdünnung sichtbar

- Integrated Nutrient Management Action Plan (INMAP)
  EU Biodiversitätsstrategie und "Farm-to-Fork" Strategie
- HELCOM zum Schutz der Ostsee – maximale atmosphärische Einträge MAI

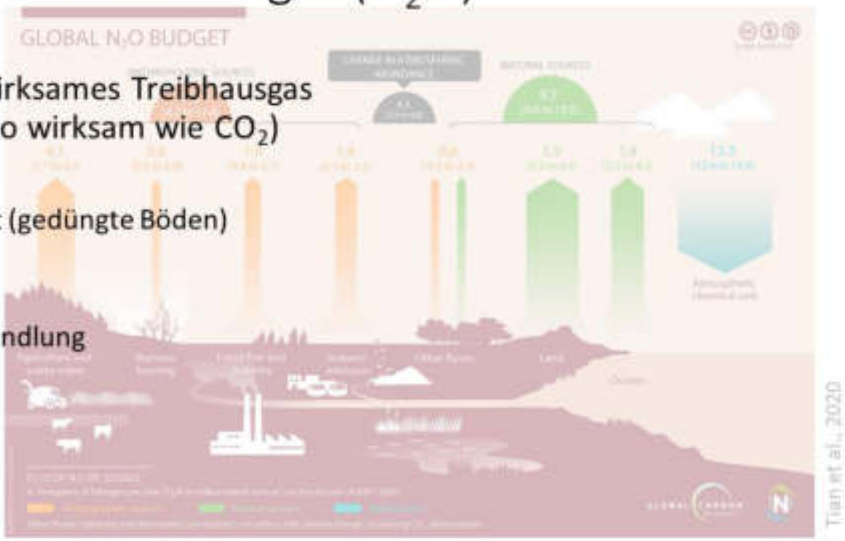
Klimarelevanz

- Düngemittelproduktion etwa 1% der globalen Energie
- Optimieren von Kreisläufen (Naturdünger)
- Rückgewinnen von reaktivem Stickstoff
- Kompostieren, Abwasser – Verwerten nutzbarer Komponenten



Direktemissionen: Lachgas (N_2O)

- Stabiles, hochwirksames Treibhausgas (etwa 300 mal so wirksam wie CO_2)
- Quellen:
  - Landwirtschaft (gedüngte Böden)
  - Verbrennung
  - Industrie
  - Abwasserbehandlung



Urbane Flüsse von Stickstoff

- Zunahme der Urbanisierung
- Einfluss der peri-urbanen Zonen
- Hohe lokale Auswirkungen
- Hohe Bedeutung von Naherholungsräumen

- Flussmodell erlaubt das Testen von Stellgrößen

Stakeholder Workshop Vienna II

Urbane nitrogen cycles:

Innovative approaches,

to meet the climate crisis

Minutes

Location: Generali Arena, 1010 Wien

Date: 14.10.2021

Financed: JPI Urban Europe

Moderation:

brainbows informationsmanagement gmbh
koellnerhofgasse 6/3/10, a-1010 wien
http://www.brainbows.com
tel +43/1/796 54 44 - 24

Project title	**UNCNET Stakeholder Workshop Vienna II**
Particpante	Gert Fister (EFA Emissionsforschung Austria GmbH) Heinz Buschmann (Klima- und Energiefonds) Ika Djukic (Umweltbundesamt) Hubert Grecht (BMK) Thomas Zak (MA22) Peter Obricht (Amt der NÖ Landesregierung) **Angemeldet, aber nicht anwesend bzw. kurzfristig abgesagt:** Christian Baumgartner (Nationalpark Donauauen) Ina Hormeier (MA18) Robert Lechner (Ökologie Institut) Lena Rücker (MA18) Lina Hofer (EVN) Johannes Selinger (17&4)
Moderation and minutes	Christian Nohel (brainbows gmbh) Magdalena Petritsch (brainbows gmbh) Markus Schneidergruber (brainbows gmbh)
Supported by	Wilfried Winiwarter (IIASA, Laxenburg, Projektleitung) Katrin Kaltenegger (IIASA, Laxenburg) Lisa Wolf (E.C.O. Institut für Ökologie, Klagenfurt) Romana Piroja (E.C.O. Institut für Ökologie, Klagenfurt)

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1 Introduction

1.1 Executive project summary

Along with climate change and biodiversity loss, nitrogen is one of the three most important issues for our planetary boundaries. We have already crossed these three boundaries and the negative impacts are difficult to reverse.

The project Urban Nitrogen Cycles: New Approaches to Address the Climate Crisis (UNCNET) addresses this acute issue and is coordinated by the International Institute for Applied Systems Analysis (IIASA, Laxenburg). Project partners are the Chinese Academy of Sciences (China), Peking University (China), the University of Zielona Góra (Poland), brainbows informationsmanagement in Vienna and E.C.O. Institute for Ecology in Klagenfurt.

UNCNET investigates and compares nitrogen cycles in four cities - Vienna, Zielona Góra in Poland, and Shijiazhuang and Beijing in China. Especially in urban areas, the accumulation of nitrogen compounds leads to major problems. Ammonia and nitrate from imported food or nitrogen oxides from traffic and industry pollute air and water, accelerate climate change, impair biodiversity and endanger health. Especially in cities, many people are directly affected. On the other hand, it is precisely here that a better understanding of the interrelationships can help to make sustainable decisions and significantly improve the effectiveness of measures.

Further information: https://www.uncnet.org/

1.2 Agenda

8:30 to 9.00: Arrival of the guests, welcome coffee.

9.00 to 9.05: Welcome by Christian and Wilfried

9.05 to 9.15: Round of introductions (with reference to nitrogen)

9.15 to 9.30: Presentation of project UNCNET-by Wilfried

9.30 to 9.35: Stakeholder process in the project by Markus

9.35 to 10.20: Discussion round results Agro-Food-Chain Vienna / Vienna surroundings

10.20 to 10.35 coffee break

10.35 to 11.20: Discussion round application examples nitrogen budgets

11.20 to 11.45 Presentation and discussion of results

11.45 to 12.00: Summary and outlook

1.3 Objectives

The applicability of the research results in practice and the implementation in political decision-making processes are central elements of the project. For this reason, we would like to involve selected decision-makers and key stakeholders in the development of the nitrogen budget for Vienna at an early stage and jointly develop approaches to solutions.

The following objectives were pursued at the workshop:

- Info: Status Quo UNCNET - Where do we stand? What is still to come?
- Discussion of the interim results. Where are the starting points for implementation in practice (climate protection programs, air pollution control plans, biodiversity programs, etc.)?
- Obtaining feedback and expectations - your wishes for the project

1.4 Introduction to the topic

Nitrogen is an indispensable nutrient for all living organisms. The use of mineral and organic nitrogen fertilizers increases yields and is common practice in agriculture. Not least as a result, water and terrestrial ecosystems can be polluted and the climate, air quality and biodiversity impaired.

These impairments are represented, among others, by the Planetary Boundaries of the Stock-holm Resilience Centre. Research on the nine Planetary Boundaries has been ongoing for 2 decades, and nitrogen and phosphorus fluxes in the biosphere and oceans form one of them.

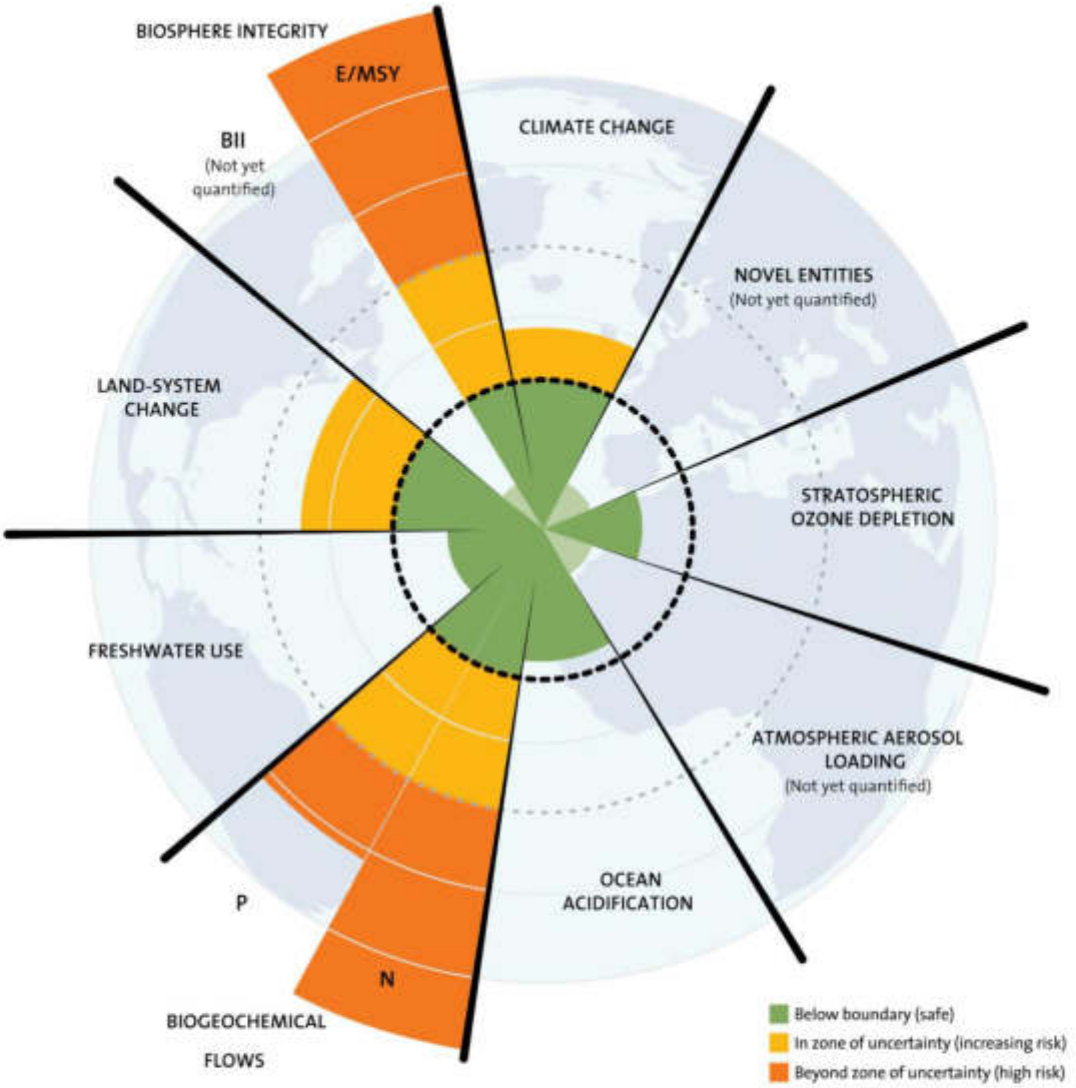

Figure 1: Planetary boundaries (J. Lokrantz/Azote based on Steffen et al. 2015).

The biogeochemical cycles of nitrogen and phosphorus have been radically altered by humans as a result of numerous industrial and agricultural processes. Nitrogen and phosphorus are both essential elements for plant growth, so that the production and application of fertilizers are the main problems.

More atmospheric nitrogen (N2) is now converted to reactive forms by human activities than by all of Earth's natural terrestrial processes combined. Much of this new reactive nitrogen is released into the environment in various forms instead of being taken up by plants. Nitrogen compounds accumulate in the atmosphere, pollute waterways and coastal areas, or accumulate in the terrestrial biosphere. Similarly, a relatively small portion of phosphorus fertilizers used in food production is taken up by plants; much of the phosphorus mobilized by humans also enters aquatic systems. The high nutrient supply allows rapid growth of algae, to the point of "algal blooms" (eutrophication), the bacterial conversion of which can lead to oxygen deficiency and the "tipping" of water bodies.

1.5 Workshop method and questions

In contrast to the first stakeholder workshop, the second workshop for experts and decision-makers in the Greater Vienna area took place in the presence of the participants. Due to the somewhat smaller number of participants, only plenary discussions were used and not small group discussions as planned.

After an introduction to the project by Wilfried Winiwarter, two discussion rounds were held. The following guiding questions were used:

Discussion round results Agro-Food-Chain Vienna / Vienna surroundings:

- General impression of the graphic?
- Questions of understanding? Is something missing from your point of view?
- Are the figures realistic?
- Can I do something with it or are there connecting points for my work practice?
- What (which data) can I contribute?

Discussion round Application examples for the use of nitrogen budgets.

- What are the biggest challenges (in terms of N) for Vienna and its surroundings?
- What is happening with nitrogen in Vienna? Where are there hotspots or problems?
- What can be done to close cycles?

- What is planned in Vienna? Where are the connecting factors for implementation in practice (climate protection programs, air pollution control plans, biodiversity programs, etc.)?
- Where is there a need for action? Can UNCNET contribute to this?

2 Results

2.1 Presentation UNCNET

Wilfried Winiwarter (IIASA) presents the UNCNET project (see attached presentation).

Supplementary to the slides of the presentation some explanations:

- UNCNET is trying to determine the fluxes of reactive nitrogen and the depots in cities. Test areas are in Europe (Vienna and Zielona Góra) and China (Shijiazhuang and Beijing).
- Normally, nitrogen fluxes are considered as "nitrogen cascade". However, due to the shorter residence time in cities, the process is somewhat different. Here, material flows are found that run parallel to each other and allow separate consideration.
- There has been contact with all partners for some time. A financing channel has opened up via the EU's "joint program initiative". China and Europe have issued a joint call for tenders; in Austria, the project is being funded by the Austrian Research Promotion Agency (FFG).
- UNCNET focuses on urban areas in order to highlight the key aspects of nitrogen in relation to environmental impacts.
- The partners are experts in specific fields: Shijiazhuang for agriculture as well as peri-urban agriculture, Poland for environmental engineering and wastewater treatment, Beijing for soil and atmospheric modeling.
- Among other things, the aim is to enable data comparisons, whereby the cities are also each compared with the surrounding countryside.
- All partners have different stakeholder processes: In Poland, for example, individual interviews take place. In China, the cooperative processing of topics together with stakeholders is rather unusual. Here, scientists make a publication, submit it via the Academy of Science, and hand over the results directly to policymakers, who take care of implementation.
- Digression to Shijiazhuang: Various measures to reduce smog have been implemented: e.g., electrically powered mopeds; conversion of building heating systems to gas. There have been massive changes and investments for this. The Chinese

government has recognized air pollution as a problem; China wants to be carbon neutral by 2060.

2.2 Plenary session part 1: Agro Food Chain Vienna/Vienna surrounding area

Katrin Kaltenegger (IIASA) presents the ongoing project results and explains the graphs Nitrogen Budget Vienna and Vienna Surround (Figure 2 and 3, see below):

- **International comparison**: We expect significant differences between Europe and China, particularly in the area of agriculture. The same applies to the area of animal husbandry, which includes livestock and pets. There are many country-specific forms of animal husbandry, for example dog farms are included in Poland.
- **Agriculture**: does not play a major role in Vienna (in contrast to the surrounding area). Central are consumption and the resulting waste.
- The colors of the arrows are pool specific, e.g.:
    - Green: urban plants
    - Yellow: urban animals
    - Pink: households
    - Black: industry and commerce
    - Blue: waste water
    - Red: waste
- Imports are everything that is used in the city or in the surrounding area and contains nitrogen, e.g. fuel, textiles, furniture, fertilizer, food, etc.
- **Focus on comparability:** We look at the different cities to see which components are comparable and which are not.
- **Waste incineration**: Waste is mostly incinerated in Vienna. Therefore, the nitrogen is released into the atmosphere or is excreted through the filter systems
- **Wastewater treatment:** Here, the nitrogen is converted into non-reactive nitrogen and can therefore be seen as a sink.
- **Loss of potential:** Overall, the nitrogen would still have significant potential for further use or reuse in the overall system. Measures to close cycles are therefore sensible.
- In the surrounding area of Vienna, agriculture plays a greater role. Especially the pool "urban plants" is relevant, mainly through field crop production. Farm animals are not so strongly represented in Vienna surroundings.
- Fertilizer is the primary imported product in the Vienna area and is a large factor. The majority enters groundwater through leaching. This fits with the data in the region's groundwater, such as the elevated nitrate value in Marchfeld.

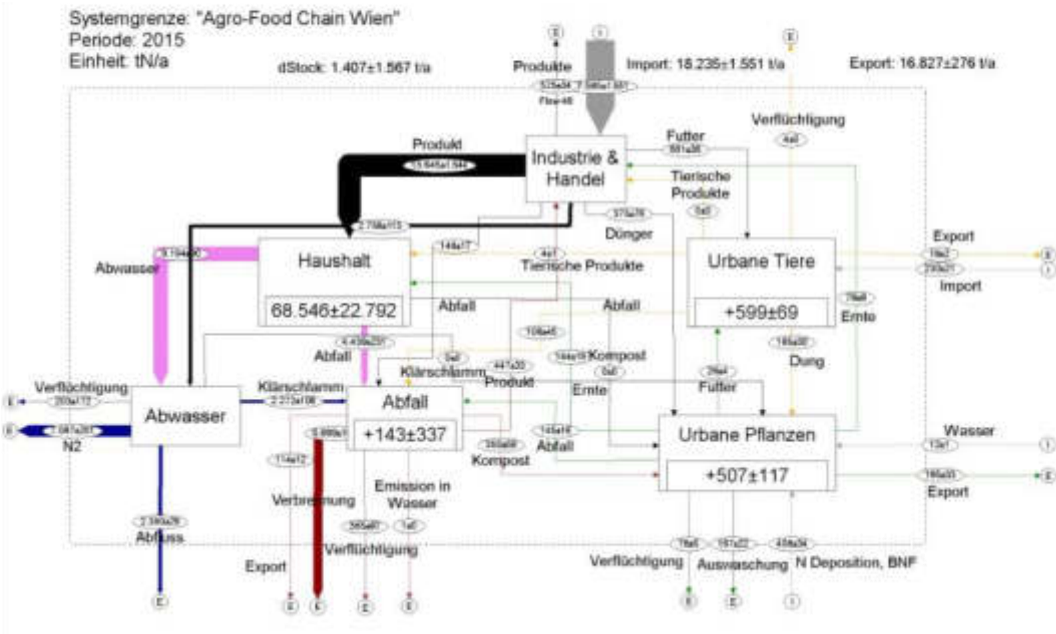

Figure 1: Agro-Food Chain Vienna

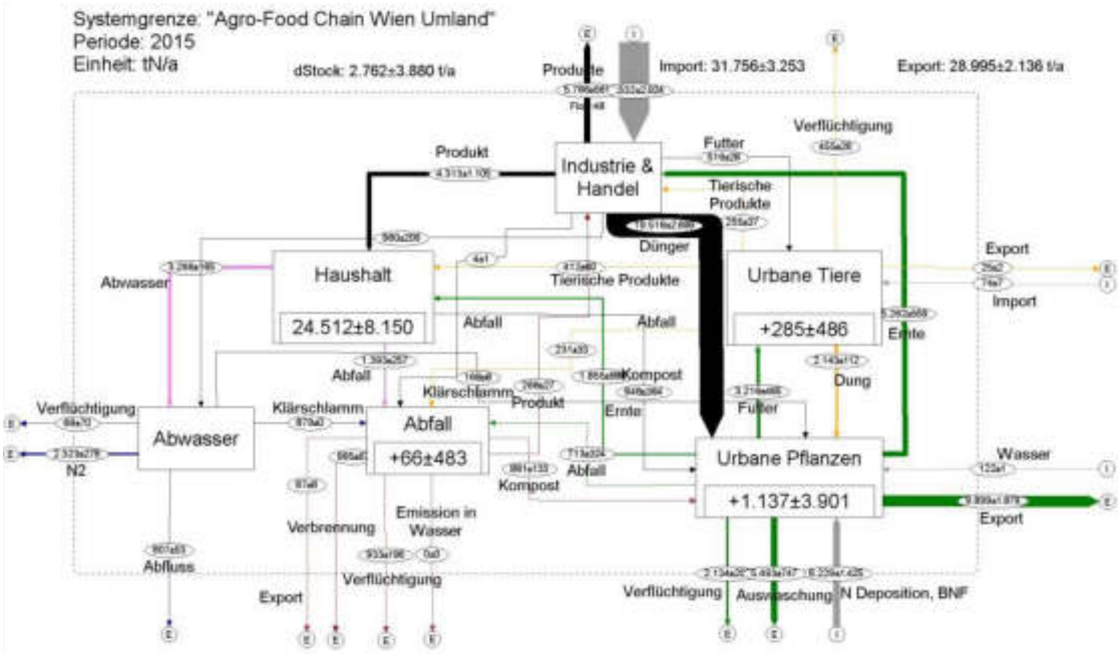

Figure 3: Agro-Food Chain Wien surrounding area

Followed by questions and discussion:

- **Question**: Are the system boundaries of Vienna and the surrounding area of Vienna related? Answer: No, in the case of Vienna the system boundary is the city boundary, in the case of Vienna Um-land a larger ring is drawn around the city. Only the nitrogen in a product is shown that crosses the system boundary. How the production takes place in the country of origin and which (environmental) problems are linked to it, does not matter. For example, meat import: when meat is imported, all kinds of nitrogen-related pollution is attached to it. This is not mapped here.
- **Question**: Is it possible to follow how the N fluxes (arrows) are distributed in a pool? Answer: Not possible to read from the graph, but there would be other de-tailed display options if there is interest. From a measures perspective, it would make sense.
- **Question**: What is delta? Response: there are sinks as in wastewater and other emissions such as leaching to soil or volatilization to air. For waste, the N is accumulated in the treatment process
- **Question**: What is the dStock? Answer: -The nitrogen sum from all pools that is stored or converted to molecular nitrogen in a sink. Therefore, the dStock is the difference between import and export across the sys-tem boundaries.
- **Question**: How can we imagine the depots concretely? Answer: Old textiles (animal fibers and synthetic fibers) are kept, plastics containing nitrogen (e.g. in furniture boards) are kept and not put into the waste stream. However, parts may go into a waste stream that has not been quantified.
- **Textiles**: are imported, stored, discarded, recycled; not so much leaching is the issue, but microplastics.
- **Transportation/mobility:** is not relevant related to agro-food chain; small value compared to household, waste, or fertilizer.
- Most of the nitrogen imports go to households and then on to waste or wastewater (blue arrow).
- **Question**: Where is the place of consumption and what can I influence? Answer: In principle, the balances distinguish between individual nitrogen compounds and the measures are adjusted accordingly, al-though not in the present graph.
- **Nitrates**: According to the EU Nitrates Directive, leaching from the soil in the surrounding area is a major problem.
- **Question**: Why is the line for incineration so thick if nothing comes in: Answer: The material flow for incineration is mainly based on sewage sludge and waste from households. In Vienna, all sewage sludge is incinerated and the ash is landfilled.
- **New perspective:** This representation allows a new level of observation. In this way, connections or problems can be recognized and analyzed from one perspective.
- **Closing loops:** Especially the type of nitrogen is relevant to discuss reuse or recycling; example surrounding area: sewage sludge is treated and reapplied to the field.
- **Balance Vienna surrounding area**: If the system boundary was extended to all of Lower Austria, the balance would probably look different. Input from animals/dairy significantly greater with greater nitrogen accumulation, as well as leaching or volatilization in this area.
- **Comparison of cities/intermediate results:** There are no results from China yet; Generally difficult because flow variables cannot be considered absolute. Depending on the flow, they are different; for waste, we take EZ number as reference; for agriculture, agricultural land and number of usable animals;

- **Coordination between project partners:** IIASA receives all data and does the analysis and interpretation together with the partners. Background information is discussed with partners, especially in the case of specifics in the individual countries. For example, in Poland, the first layer of soil is removed from areas that are to be cultivated and sold as fertilizer.

3.3 Plenary session part 2: Application examples Nitrogen Budgets

Katrin Kaltenegger (IIASA) presents a comparison between the cities of Vienna and Klagenfurt & Villach:

- **Comparison of Vienna with Klagenfurt/Villach:** Basically, the two nitrogen balances related to the agro-food chain (Vienna as well as Klagenfurt and Villach) are quite similar.
- **Export of agricultural products:** In the Klagenfurt/Villach area, more agricultural products are exported. This also has to do with what is grown. E.g. in Klagenfurt/Villach primarily grassland farming, which is not used for self-supply.
- **Mineral fertilizer application:** In the Vienna region, there is a much larger nitrogen input per area than in Klagenfurt & Villach.

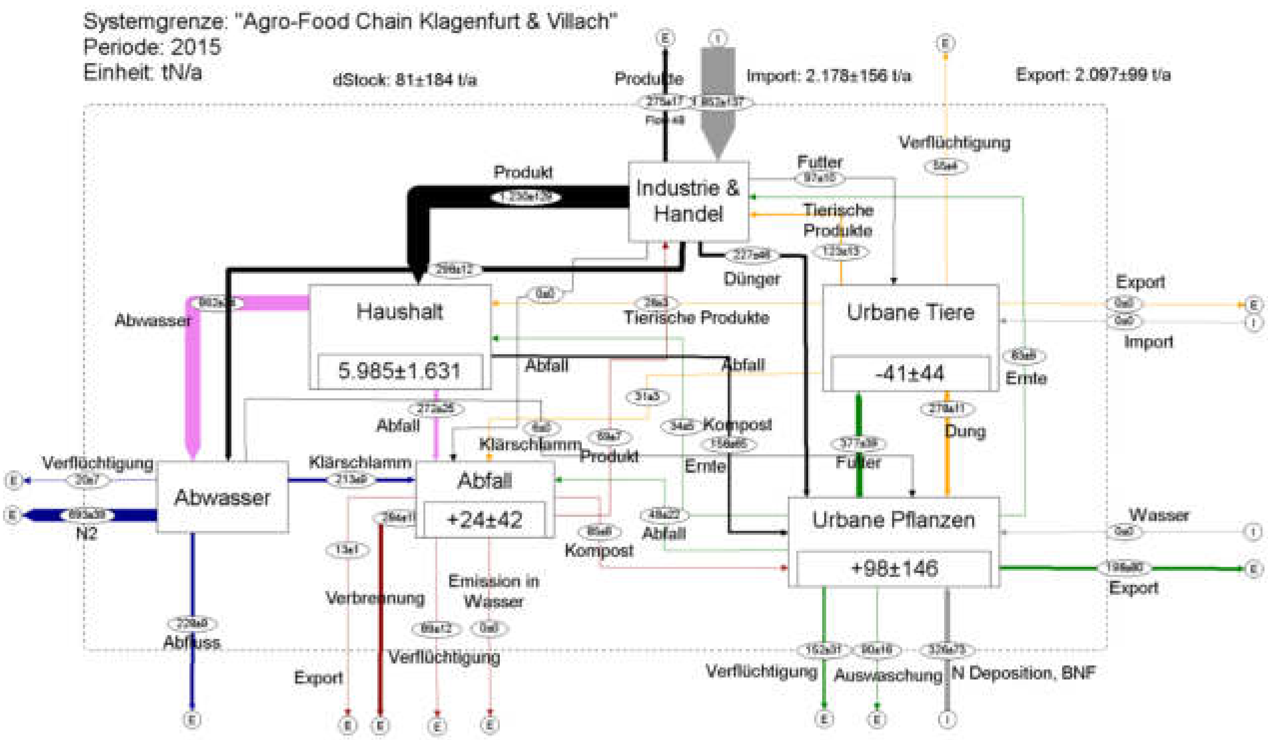

Figure 4: Agro-Food Chain Klagenfurt & Villach

	Zielona Góra		Zielona Góra Umland		Wien		Wien Umland		Klagenfurt & Villach	
	tN	kgN/ha	tN	kgN/ha	tN	kgN/ha	tN	kgN/ha	tN	kgN/ha
Luft - Landw. Fläche (Deposition)	8	16	108	16	92	17	2.708	13	90	15
Landw. Produkte - kommerziell	6	12	405	59	176	32	9.893	47	198	33
Landw. Produkte - Eigenversorgung	24	47	101	15	132	24	1.847	9	34	0,21
Mineraldünger	31	62	420	62	327	59	19.352	92	207	34

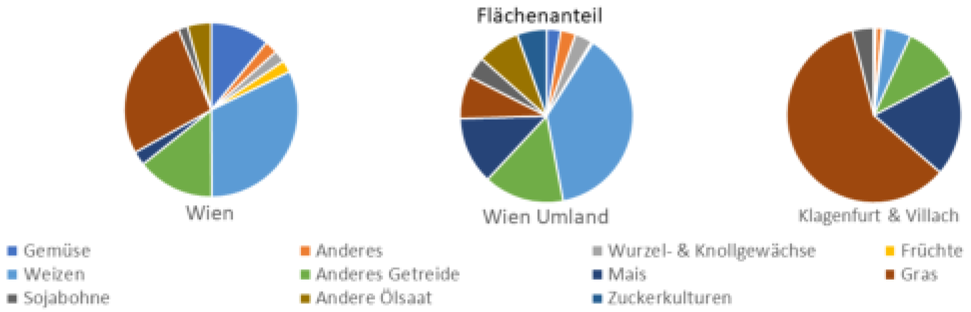

Figure 5: Vergleich Agro-Food Chain Zielona Gora, Klagenfurt & Villach

Wilfried Winiwarter (IIASA) presents application examples on nitrogen budgets.

Supplementary to the slides of the presentation (see attachment) some explanations:

- **Nitrogen budget options:**
    - The method for preparing nitrogen budgets, which is also used in the project, was developed by the "Working Group on Convention of Long Distance Transport on National Nitrogen Budgets".
    - Balanced budget: the input always equals the output plus the N depots (the changed storage amounts) in the system. Something has to happen to the reactive nitrogen, either it goes on to the next pool or leaves the system boundaries (export) or it is landfilled or converted back to N2.
    - Missing fluxes that cannot be captured with the data available are estimated.
    - Recognition of trends: The nitrogen balance serves, among other things, to show correlations, to recognize structural contradictions, and to derive trends.
    - Challenge in the project - comparability: The data of the cities should be prepared in the same way, although the basic statistical data is often very different. The project management coordinates the creation of a consistent structure of the N-budget in order to make the data comparable.

- **Regional contributions to global sustainability goals:**
    - Ad global nitrogen problems/planetary stress limits: Natural nitrogen cycle is out of balance. Conversion to reactive nitrogen has been doubled by human activities.
    - Possible indicators based on nitrogen budgets: Imports per inhabitant (polluter pays principle) or inputs per unit area (impact). Consideration: is city's contribution greater or less than another city? Than the global average?
- **Compliance with emission ceilings:** For nitrogen oxides and ammonia, there are significant exceedances in many countries; this can also be broken down to regions and cities. Nitrogen budgets are a useful tool to illustrate this and evaluate the benefits of measures.
- **Impacts on sensitive terrestrial ecosystems:** Nitrogen balances provide important information here. For example, for the critical loads of nitrogen oxides and ammonia. What quantity is still acceptable here? The Austrian Federal Environment Agency is doing a lot in this area.
- **Fluvial and marine eutrophication:** Eutrophication can lead to the overturning of bodies of water, for example in the Baltic Sea, where massive nitrogen and phosphorus inputs are causing major problems.
    - HELCOM international convention for the protection of the Baltic Sea has approached IIASA if there is national data from countries on this. Sweden is in the process of producing data, Russia is interested.
    - INMAP, Integrated Nutrient Management Action Plan (EU activity), has also approached IIASA regarding a national nitrogen balance.
- **Climate relevance:**
    - International Energy Agency agenda: how could industry function in a carbon-free world?
    - Artificial fertilizer production without CO2 probably only works with hydrogen, Haber Bosch process uses 1% of global energy, Much considering it is a single process.
    - Recovery of reactive nitrogen: today we are still far from reactivating the usable components in wastewater - big hygienic, sanitary problems; big need for research.
    - Borealis research projects on phosphorus recycling, which is currently sourced exclusively from degradable minerals, e.g. from Morocco.
    - As long as cheap natural gas is available, with low CO2 tax, it is more attractive to extract nitrogen from the air than to rely on recycling.
- **Urban fluxes of nitrogen:** Urban nitrogen budgets could also be used to plausibilize emission inventories.

Followed by questions and discussion:

- **Explanation of the Stockholm Resilience Center's Planetary Boundaries graphic (see Figure 1):** Nitrogen already has a massive impact on the environment, such as eutrophication of water bodies or loss of biodiversity. The situation is also aggravated by the fact that in many regions of the world there is no appropriate infrastructure (wastewater treatment plants, filters, etc.). We know that it will not be easy to improve the situation. However, it is also clear that if nitrogen fixation from the air (Haber Bosch process) could be stopped, the cycle would recover quickly.

- **Comparison of nitrogen problem & climate crisis:** If no new reactive nitrogen were introduced by humans, the nitrogen problem would be solved relatively quickly by natural degradation processes. In contrast to the climate crisis, even if CO2 emissions were stopped for the time being, greenhouse gases (CO2) would continue to persist in the atmosphere and continue to cause increased temperatures - which would lead, for example, to the continuous melting of glaciers. The magnitude and impact of the climate crisis will be increasingly felt in the coming decades, especially if emissions continue.
- **Awareness raising:** The nitrogen problem is hardly perceived as a threat potential by the population, but also by politicians. Although water eutrophication, overfertilization; ammonia emissions (source of particulate matter) have major negative effects on health and the environment. The main task here is to create awareness and sensitize people, for example through campaigns, public relations work or educational measures. Microplastics can serve as a successful example for raising awareness.
- **Image problem of agriculture:** Awareness-raising measures should also help agriculture to get out of its defensive position. Above all, research is challenged to offer solutions to agriculture, but also agriculture to understand its own activities in such a way that they become part of an environmentally sound solution.
- **Climate and energy regions with a focus on the circular economy:** The results of the project should definitely be made available to the climate and energy regions so that they can be inspired to do something about the issue of nitrogen. The question should also be clarified: how can the regions profit from the results? And with which measures can one produce which effect.
- **Role of the authorities:** The present project can only offer starting points for concrete activities of authorities. Political activities (ordinances, laws) are only realistic if authorities themselves commission studies. On the one hand, this would highlight the problem and lay a foundation for further planning and action.
- **International initiatives:** Germany, Sweden, Estonia, Latvia, Denmark and Switzerland have already done research in this area. In general, not many countries are involved and there is no public discourse.
- **Look at the big picture:** Measures must be well thought out, otherwise there is only a shift of problems from one area to another. In the agricultural sector in particular, nitrogen must be used in a targeted and effective manner. Here, too, awareness must prevail that nitrogen is a valuable resource.
- **Closing loops:** Currently, it is mainly end-of-pipe solutions that are successful. It is therefore more important to close the loops and to recycle or reuse reactive nitrogen. However, there are still many open questions and a great need for research, especially for the recycling of nitrogen.
- **Cooperation with agriculture:** The topic must be brought into the agricultural sector. Currently, there is already 25% organic farming in Lower Austria. It is also extremely important to cooperate with the educational sector (especially BOKU and University of Applied Sciences Wieselburg).

2.3 Project output

The project results will be published as scientific results (paper), project reports and a summary of the results or sent to the experts. In addition, after the end of the project, there will be a set of cards with project-specific and, above all, topic-specific information and results. This set will be distributed to the participants.

3 Outlook and next steps

In May 2022, the final workshop is to take place in Vienna (currently planned date is May 30-31). In this context, further projects will be discussed. Information on this will be sent out by the organizers in due time.

Literature

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4 ANNEX

4.1 Presentation slides Urban Nitrogen Budgets (Wilfried Winiwarter, IIASA)

Urbane Stickstoffbilanzen

UNCNET

- Identifizierung Stickstoffflüsse und Stickstofflager in und aus Städten und städtischem Umland
  - Wien, Zielona Góra (Polen), Beijing, Shijiazhuang (China)
  - 1995-2030, 2015 als Basisjahr
- Vermeidungspotenzial finden & offenen Flüsse schließen (Kreislaufwirtschaft)

Das Projekt

- Originaltitel: ***U**rban **n**itrogen **c**ycles: **n**ew **e**conomy **t**hinking to master the challenges of climate change (UNCNET)*
- Projektkoordinator: *Wilfried Winiwarter, International Institute for Applied Systems Analysis (IIASA, Laxenburg)*
- Thema: *Klimawandel und neue urbane Wirtschaft*
- Stichwörter: *Stickstoffkreislauf, Kreislaufwirtschaft, Luftverschmutzung, Wasserverschmutzung und Abfallbehandlung*
- Theoretische und Angewandte Forschung
- Projektdauer: *März 2019– Februar 2022 (Verlängerung bis Juni 2022)*

1/20/2022 3

Projektpartner

Klagenfurt

1/20/2022 4

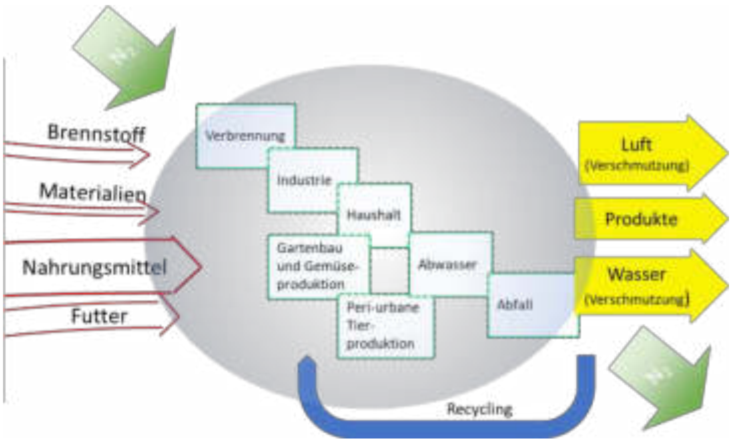
Stickstoff

- Lebensmittelproduktion– Steigerung der Ernten
- Industrie
- Textilien
- Verbrennungsprozesse

Urbaner Lebensraum

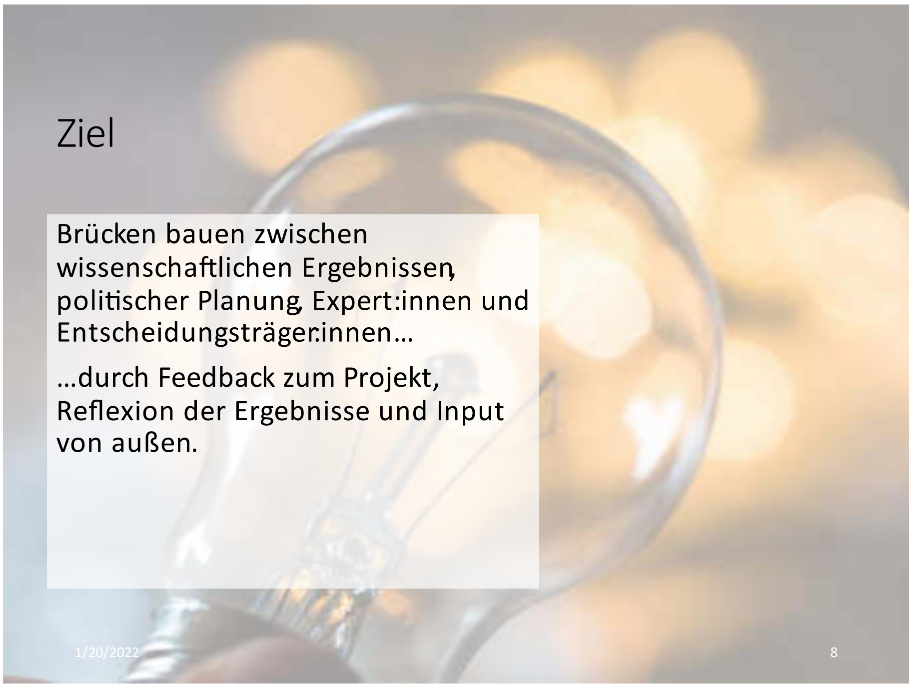
- Ort des Konsums
  - Bis 2050 Wohnort von ca. 60% der Weltbevölkerung (UN, 2018)
- Potential für Vermeidung

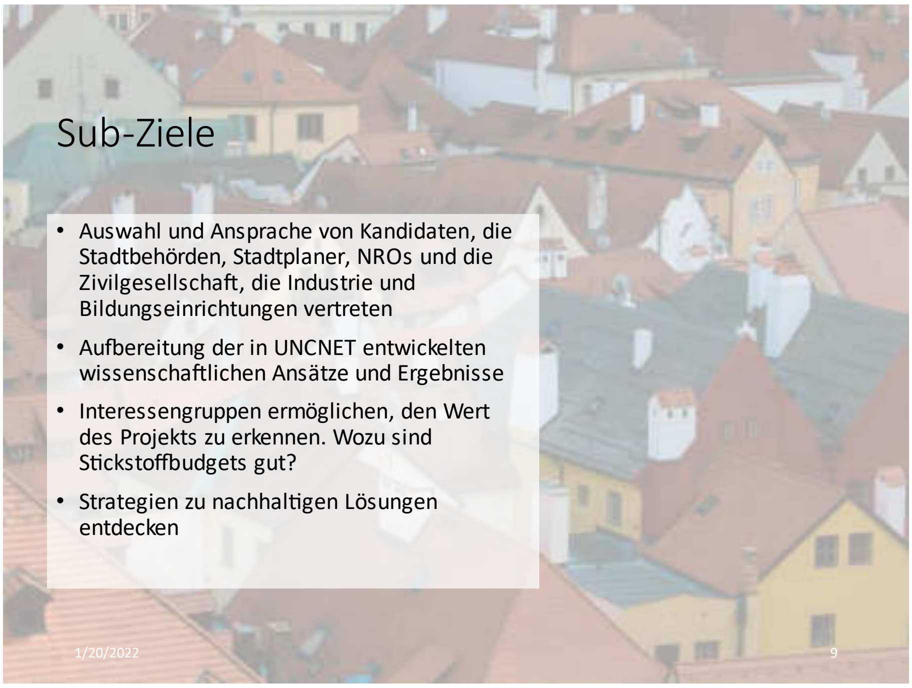
Urbane Flüsse

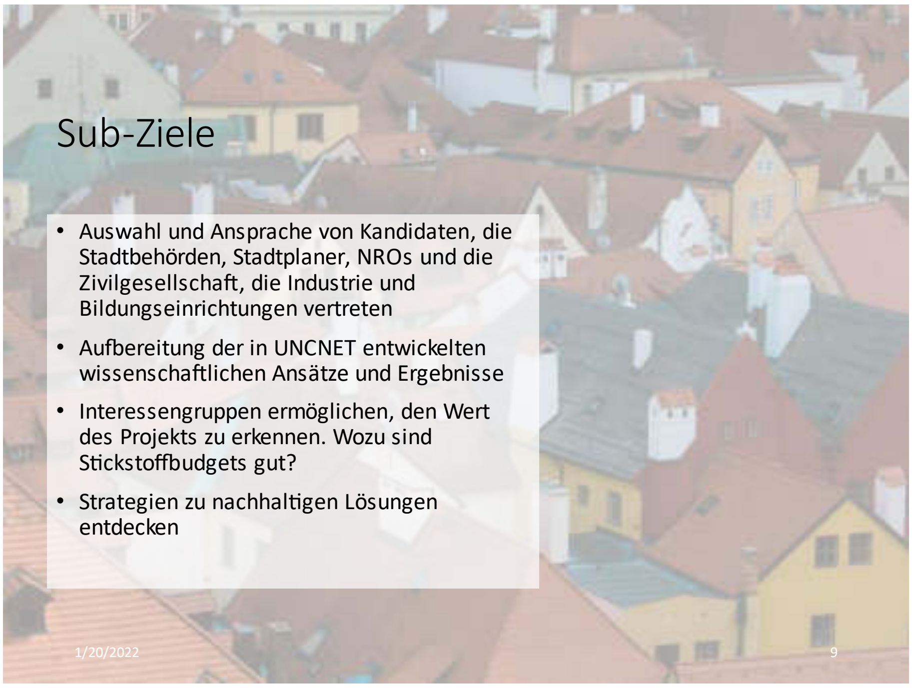


Winiwarter et al., 2020

UNCNET test areas




Sub-Ziele
• Auswahl und Ansprache von Kandidaten, die Stadtbehörden, Stadtplaner, NROs und die Zivilgesellschaft, die Industrie und Bildungseinrichtungen vertreten
• Aufbereitung der in UNCNET entwickelten wissenschaftlichen Ansätze und Ergebnisse
• Interessengruppen ermöglichen, den Wert des Projekts zu erkennen. Wozu sind Stickstoffbudgets gut?
• Strategien zu nachhaltigen Lösungen entdecken
1/20/2022
9


Sub-Ziele
• Auswahl und Ansprache von Kandidaten, die Stadtbehörden, Stadtplaner, NROs und die Zivilgesellschaft, die Industrie und Bildungseinrichtungen vertreten
• Aufbereitung der in UNCNET entwickelten wissenschaftlichen Ansätze und Ergebnisse
• Interessengruppen ermöglichen, den Wert des Projekts zu erkennen. Wozu sind Stickstoffbudgets gut?
• Strategien zu nachhaltigen Lösungen entdecken
1/20/2022
9

Mögliche Erkenntnisse

- Inwiefern verlaufen urbane Stickstoffströme unabhängig voneinander?
- Welche Anteile an reaktivem Stickstoff werden der Wiederverwendung zugeführt?
- Welche werden vor der Abgabe an die Umwelt unschädlich gemacht, durch Umwandlung in Luftstickstoff?
- Welche Potentiale ergeben sich im Vergleich der Städte, Auswirkungen auf die Umwelt zu mindern?
- Wo kommt es zu Akkumulationen von Stickstoff, und damit zu potentiellen künftigen Orten der Freisetzung?

Partizipative Einbindung von Stakeholder:innen

- Zwei Benutzer-Workshops (in Wien und Klagenfurt), Österreich. Kleine Gruppen von etwa 10 Personen. Die Workshops werden in der Landessprache (Deutsch) abgehalten.
- Die Ergebnisse des Workshops werden in die Datenauswertung und die Modellierung von Stickstoffflüssen, wie sie in UNCNET entwickelt wurden, einfließen.
- Konferenz (Wien oder Laxenburg), 40 - 60 Personen, unter Einbeziehung aller Projektpartner. Die Konferenz wird zeitgleich mit dem abschließenden UNCNET-Treffen organisiert und in englischer Sprache abgehalten.

Internationaler Austausch

- Stadtplanung im Kontext der rechtlichen und sozio -ökonomischen Bedingungen einer kleineren polnischen Stadt (Zielona Góra)
- Umsetzung der Projektergebnisse in China: Wege, Strategien, Aktivitäten. Neudefinition des "Stakeholder" -Konzepts auf der Grundlage lokaler Anforderungen, Gesetze und Praktiken.
- Abschlusstreffens, um Strategien und Erfolgsgeschichten in verschiedenen Gemeinden zu vergleichen und einen Weg in die Zukunft zu finden (Folgeprojekte zur Umsetzung)

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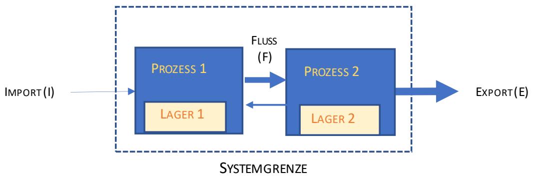
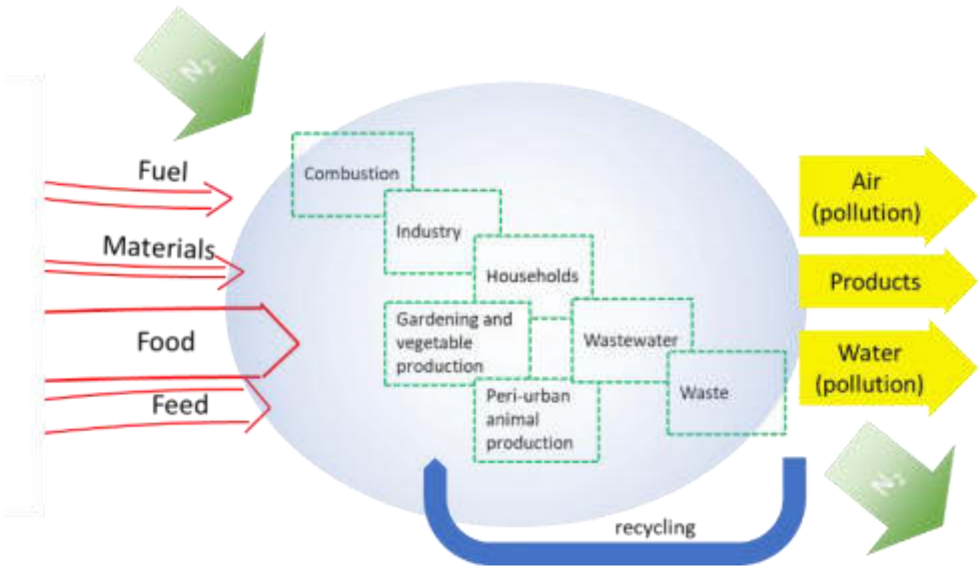
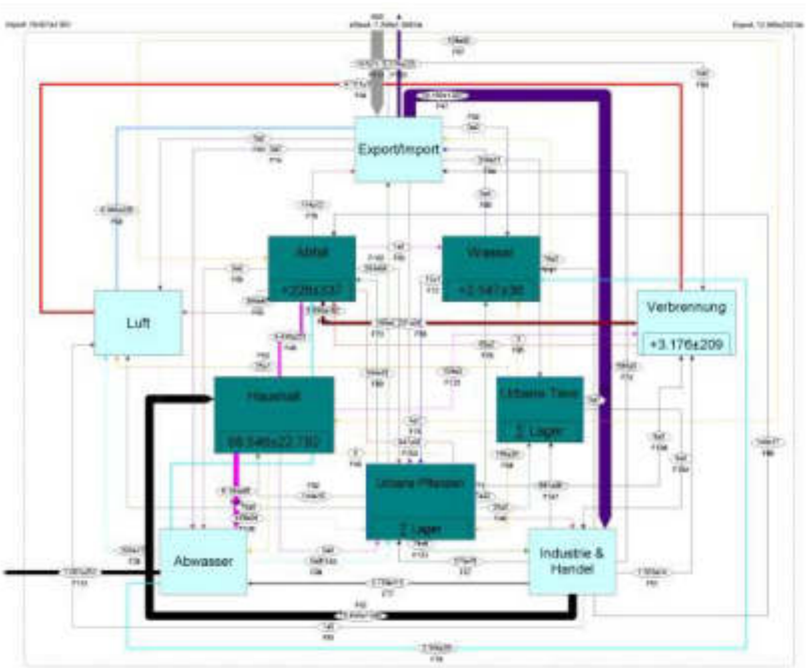
Vorgehensweise

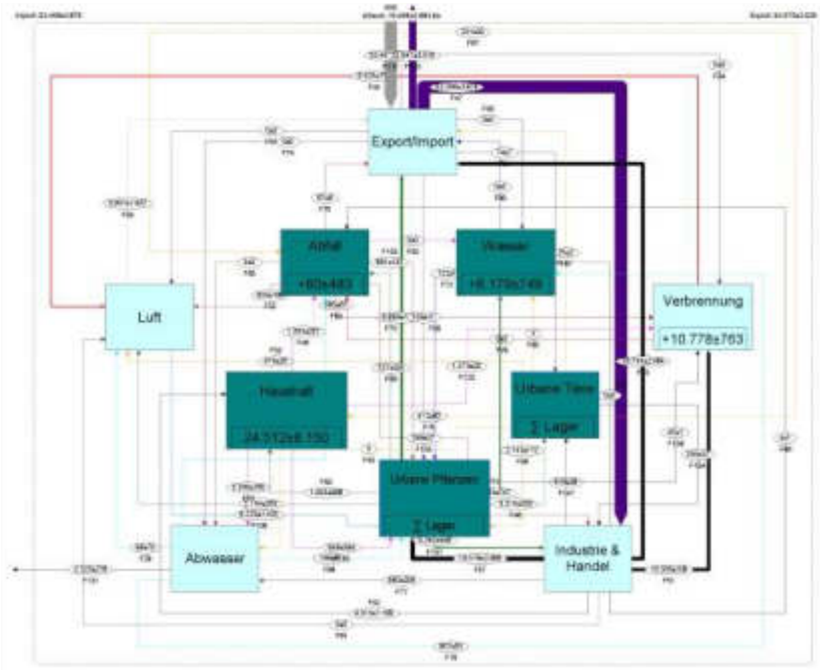
- STAN - Programm zur Stoffflussanalyse (TU Wien)
- Atmosphärisches Modell – Emissionen & Depositionen
- Bodenmodell zur Nitrat -Auswaschung



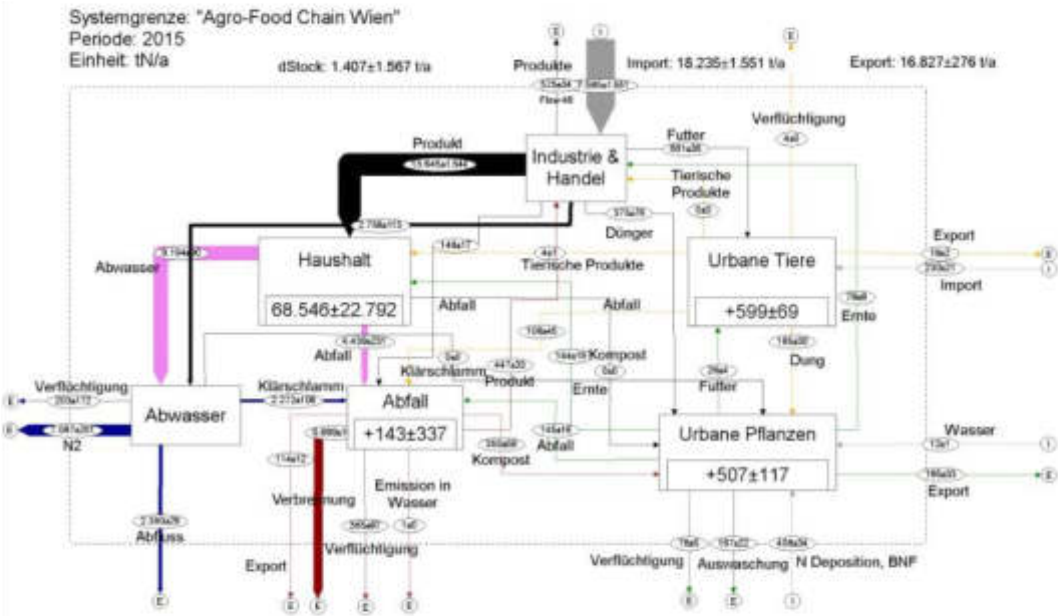
4.2 Presentation slides project results and STAN-modelling (Katrin Kaltenegger, IIASA)


N₂
Fuel
Materials
Food
Feed
Combustion
Industry
Households
Gardening and vegetable production
Wastewater
Peri-urban animal production
Waste
Air (pollution)
Products
Water (pollution)
recycling
N₂

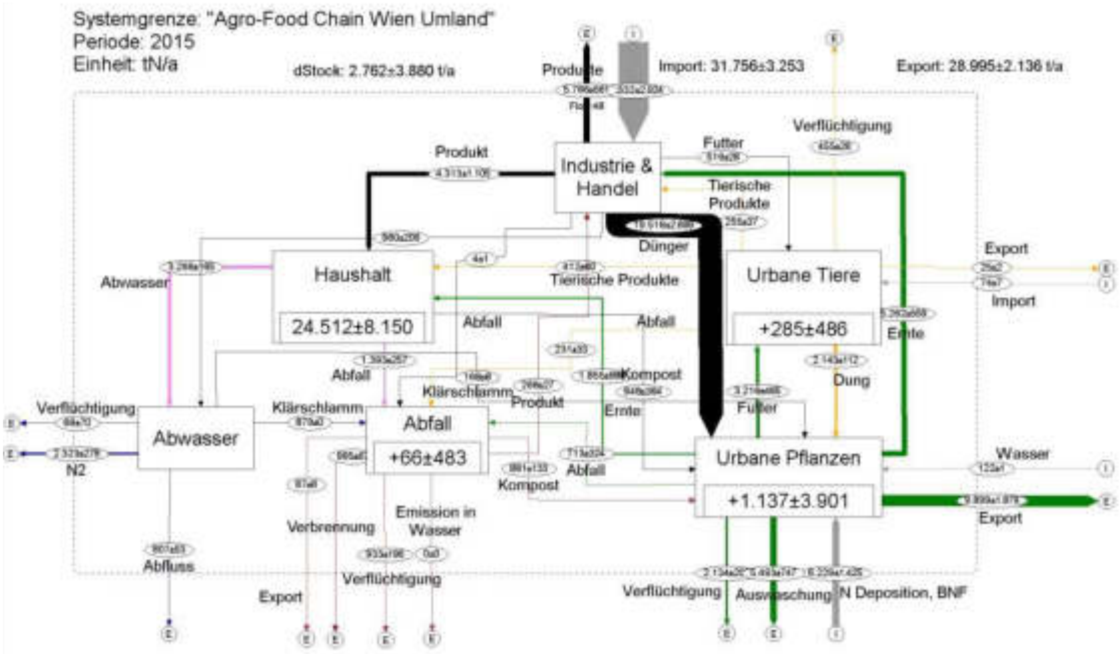

Export/Import
Abfall
Wasser
Luft
Verbrennung
+3.176±209
Haushalt
Urbane Tiere
Urbane Pflanzen
Abwasser
Industrie & Handel

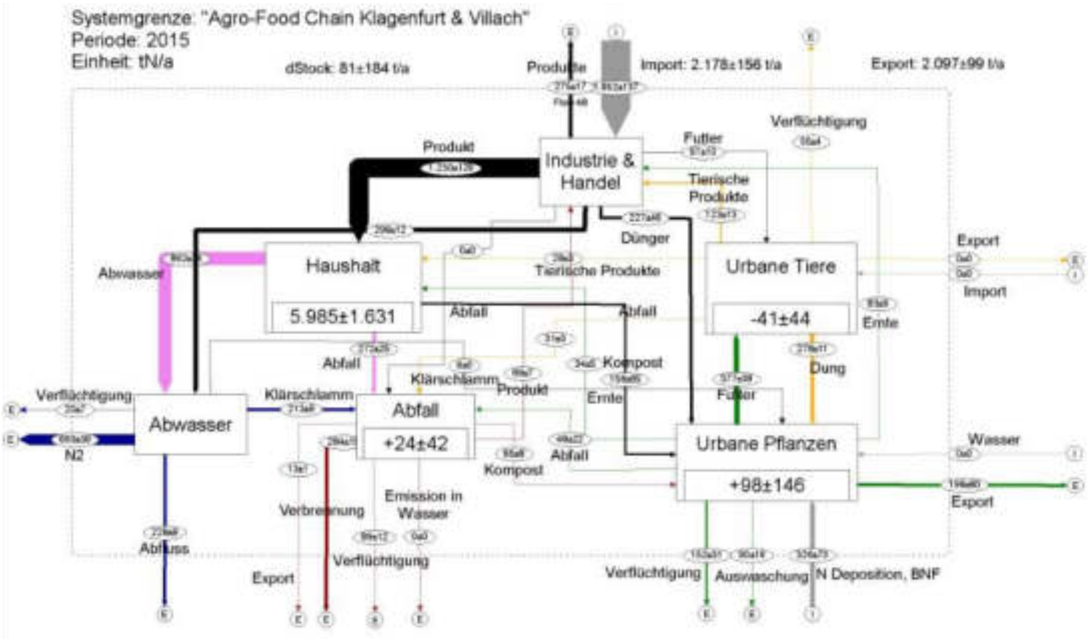


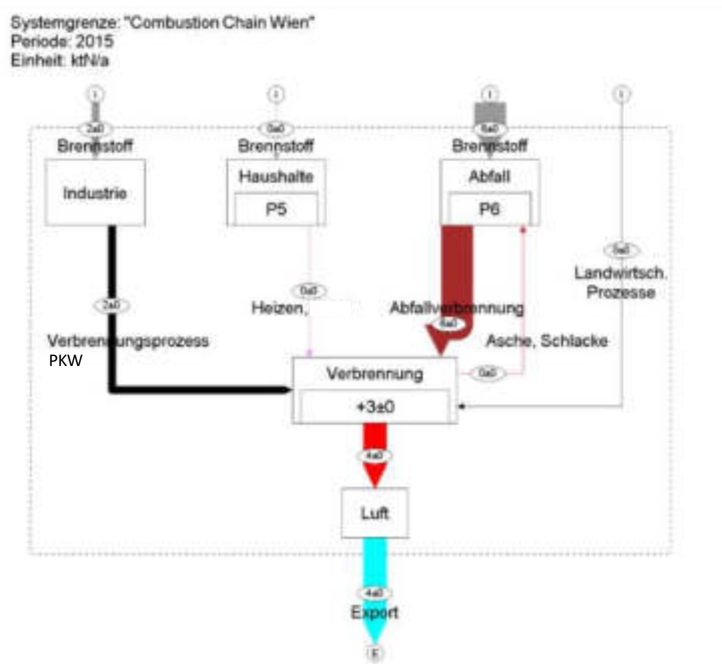
Export/Import
Abfall
Wasser
Luft
Verbrennung
+10.778±763
Haushalt
Urbane Tiere
Urbane Pflanzen
Abwasser
Industrie & Handel

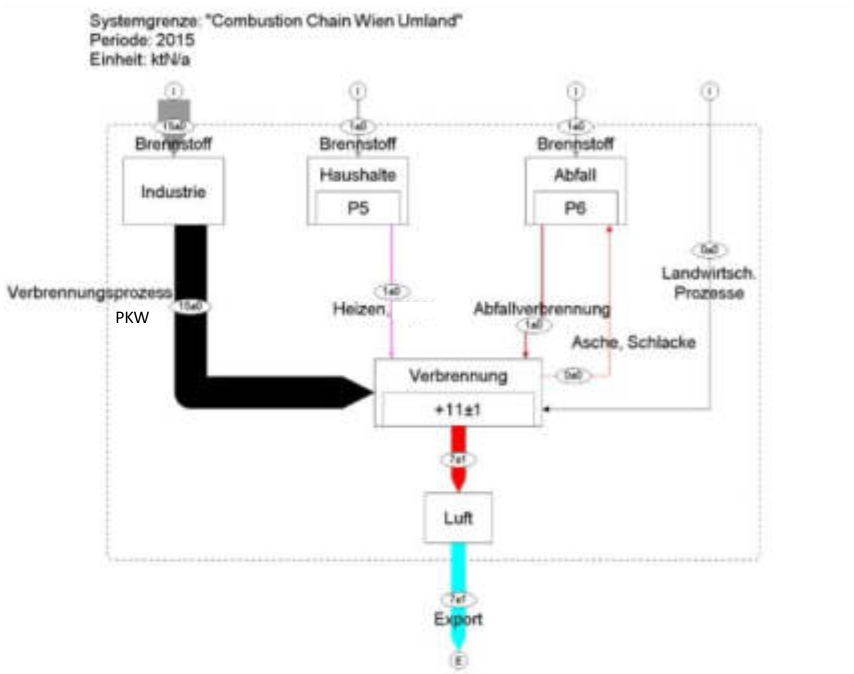


Systemgrenze: "Agro-Food Chain Wien"
Periode: 2015
Einheit: tN/a
dStock: 1.407±1.567 t/a
Produkte
Import: 18.235±1.551 t/a
Export: 16.827±276 t/a
Verflüchtigung
Industrie & Handel
Futter
Tierische Produkte
Produkt
Dünger
Export
Import
Haushalt
68.546±22.792
Urbane Tiere
+599±69
Abwasser
Abfall
Ernte
Dung
Kompost
Klärschlamm
Futter
Verflüchtigung
N2
Abwasser
Abfall
+143±337
Urbane Pflanzen
+507±117
Wasser
Export
Abfluss
Verbrennung
Emission in Wasser
Verflüchtigung
Export
Verflüchtigung
Auswaschung
N Deposition, BNF


Systemgrenze: "Agro-Food Chain Wien Umland"
Periode: 2015
Einheit: tN/a
dStock: 2.762±3.880 t/a
Import: 31.756±3.253
Export: 28.995±2.136 t/a
Produkte
Produkt
Industrie & Handel
Futter
Tierische Produkte
Verflüchtigung
Dünger
Haushalt
24.512±8.150
Abwasser
Tierische Produkte
Abfall
Urbane Tiere
+285±486
Export
Import
Ernte
Dung
Klärschlamm
Kompost
Produkt
Ernte
Futter
Verflüchtigung
Abwasser
Abfall
+66±483
Urbane Pflanzen
+1.137±3.901
Wasser
Export
N2
Kompost
Verbrennung
Emission in Wasser
Abfluss
Verflüchtigung
Export
Verflüchtigung
Auswaschung
N Deposition, BNF


Systemgrenze: "Agro-Food Chain Klagenfurt & Villach"
Periode: 2015
Einheit: tN/a
dStock: 81±184 t/a
Import: 2.178±156 t/a
Export: 2.097±99 t/a
Produkte
Produkt
Industrie & Handel
Futter
Tierische Produkte
Verflüchtigung
Dünger
Haushalt
5.985±1.631
Abwasser
Tierische Produkte
Abfall
Urbane Tiere
-41±44
Export
Import
Ernte
Dung
Klärschlamm
Kompost
Produkt
Ernte
Futter
Verflüchtigung
Abwasser
Abfall
+24±42
Urbane Pflanzen
+98±146
Wasser
Export
N2
Kompost
Verbrennung
Emission in Wasser
Abfluss
Verflüchtigung
Export
Verflüchtigung
Auswaschung
N Deposition, BNF



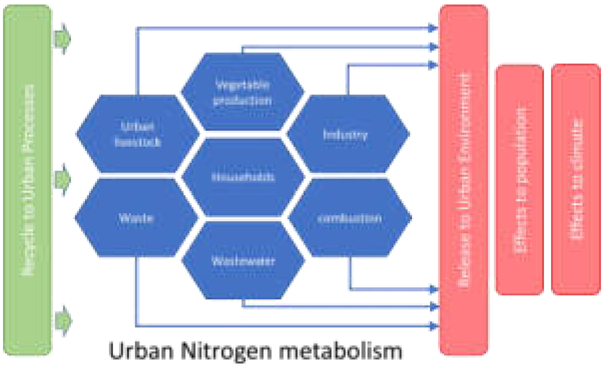


4.3 Presentation slides Use cases (Wilfried Winiwarter, IIASA)

Use cases: Beispiele zur Verwendung von Stickstoffbudgets

Möglichkeiten von Stickstoffbudgets

- Insgesamt und für jedes der Lager („pools“) einzeln:
  - Bilanzierung
  - Abschätzung fehlender Flüsse
  - Identifizierung von strukturellen Widersprüchen
  - Zeitliche Entwicklungen
  - Benchmarking – Erstellen von und Vergleich mit Zielen
  - Vergleich zwischen Regionen, Städten

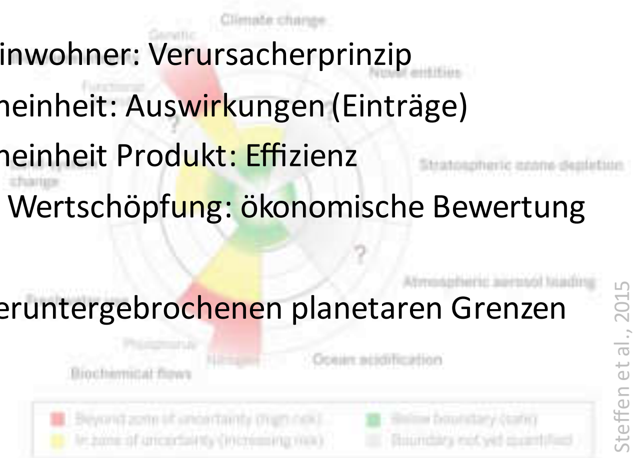


Urban Nitrogen metabolism

Regionale Beiträge zu globalen Nachhaltigkeitszielen

- Betrachtung pro Kopf/Einwohner: Verursacherprinzip
- Betrachtung pro Flächeneinheit: Auswirkungen (Einträge)
- Betrachtung pro Masseneinheit Produkt: Effizienz
- Betrachtung pro Einheit Wertschöpfung: ökonomische Bewertung

- Vergleich mit regional heruntergebrochenen planetaren Grenzen

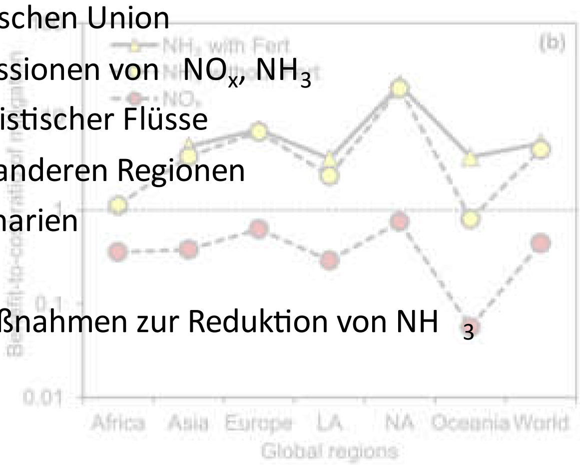


Steffen et al., 2015

Einhaltung von Emissionshöchstgrenzen

- NEC Richtlinie der Europäischen Union
- Überschreitungen bei Emissionen von NO_x, NH_3
- Identifikationen charakteristischer Flüsse
- Vergleich mit Situation in anderen Regionen
- Maßnahmenplanung, Szenarien

- Immenser Nutzen von Maßnahmen zur Reduktion von NH_3

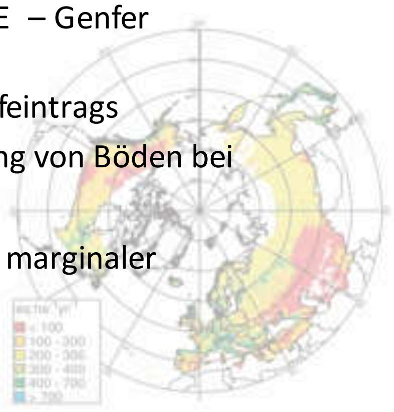


Gu et al., 2021

Auswirkungen auf sensitive terrestrische Ökosysteme

- „critical loads“ im Rahmen der UNECE – Genfer Konvention LRTAP
- Biodiversität im Einfluss des Nährstoffeintrags
- NO_x, NH_3 tragen beide zur Versauerung von Böden bei

- Datensätze über modellierte Grenzen marginaler Auswirkungen sind verfügbar



Reinds et al., 2015

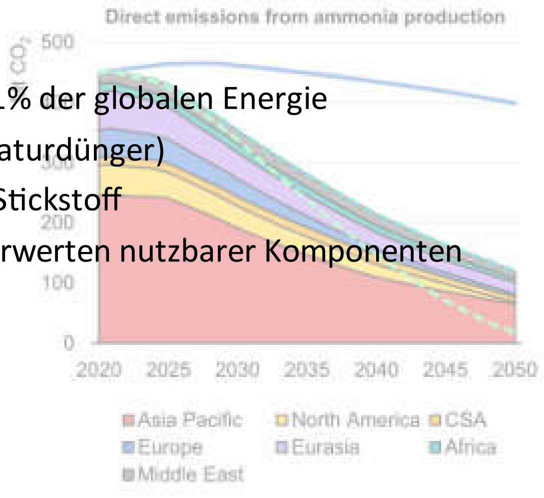
Fluviale und marine Eutrophierung

- Unterschiedliche Quellen von Nährstoffen
  - Landwirtschaftlicher Stickstoffeintrag über Grundwasser ausgewaschen
  - Intensive Viehhaltung
  - Kläranlagen als Quellen für Emissionen in Vorfluter
- Unterschiedliche Transportwege
- Atmosphärischer Transport von Luftschadstoffen
- Grund- und Oberflächengewässer transportieren Schadstoffe ins Meer, werden bei mangelnder Verdünnung sichtbar

- Integrated Nutrient Management Action Plan (INMAP) EU Biodiversitätsstrategie und “Farm-to-Fork” Strategie
- HELCOM zum Schutz der Ostsee – maximale atmosphärische Einträge MAI

Klimarelevanz

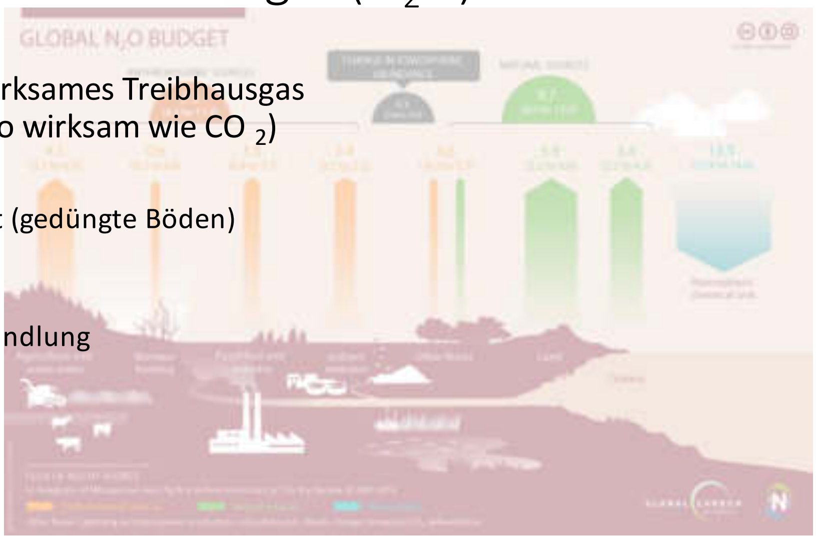
- Düngemittelproduktion etwa 1% der globalen Energie
- Optimieren von Kreisläufen (Naturdünger)
- Rückgewinnen von reaktivem Stickstoff
- Kompostieren, Abwasser – Verwerten nutzbarer Komponenten



IEA, 2021

Direktemissionen: Lachgas (N_2O)

- Stabiles, hochwirksames Treibhausgas (etwa 300 mal so wirksam wie CO_2)
- Quellen:
  - Landwirtschaft (gedüngte Böden)
  - Verbrennung
  - Industrie
  - Abwasserbehandlung



Tian et al., 2020

Urbane Flüsse von Stickstoff

- Zunahme der Urbanisierung
- Einfluss der peri-urbanen Zonen
- Hohe lokale Auswirkungen
- Hohe Bedeutung von Naherholungsräumen

- Flussmodell erlaubt das Testen von Stellgrößen