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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UNCNET

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

D2/1: Draft concept of urban nitrogen flows

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Start Date of Project: **01/04/2019** Duration: **35 months**

Organisation name of co-chairs for this deliverable: **IIASA, CAS**

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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

UNCNET takes advantage of a number of separate modelling approaches operating at different scales and spatio-temporal resolution. Extending concepts developed for national scale to urban scale means that some of the structure (mass-flow approach with pre-defined pools) needs to be maintained. The current report describes how these boundary conditions can be met by setting up a backbone structure using the STAN software (developed by Vienna University of Technology) and preparing for data exchange platforms as model interfaces, which can be populated with information from the respective test cities and extended into scenarios. The draft concept introduced here allows to gain experience, identify shortcomings and move forward towards improvements before developing the final model concept.

2. Objectives:

The UNCNET project has been established to meet several challenges associated with urban nitrogen flows. Some of these challenges are explicit (linking different environmental spheres and problem areas via a common denominator, which in this case is reactive nitrogen; optimizing flows via circular economy approaches), others are more implicit (identifying appropriate system boundaries and comparable data sources; representing trade across such boundaries; developing strategies to represent changes that are more prevalent in dynamic urban situations than for a whole country). The central model structure will need to be organized to meet these challenges. Hence, this report describes the draft version of a structure to be tested on the challenges. The structure needs to link existing models and data sets, sufficiently rigid to force datasets from different cities (in different world regions) into comparability, while still being flexible enough to learn from experience and allow improvements.

3. Activities:

Interaction with STAN developers (Oliver Cencic, Vienna University of Technology)
Creation of a STAN model with spreadsheet interface (comma delimited – csv files)

4. Results:

A complete flow model has been established in its first version – see attachment

5. Milestones achieved:

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6. Deviations and reasons:

Insignificant delay due to slow project start-up phase

7. Publications:

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8. Meetings:

Kick-off meeting at PKU
CAS – IIASA bilateral meeting at CAS

9. List of Documents/Annexes:

Annex: A draft nitrogen flow model to describe urban situations

REFERENCES

ANNEX

A draft nitrogen flow model to describe urban situations

A draft nitrogen flow model to describe urban situations

1) Introduction:

UNCNET will use the concept of pools and flows as developed under the UNECE Task Force on Emission Inventories (Fig. 1). The idea is that reactive nitrogen is being exchanged between pools in the environment, with data available on fluxes between the respective pools, and equilibria (allowing for validation) being established within each pool. Also fixation of and loss to molecular nitrogen (unreactive nitrogen) can be implemented as source/sink term. The concept is scalable, also permitting sub-pools, and has been tested successfully on national scale. Moreover, it allows for integration of activities and data collection for international protocols and conventions.

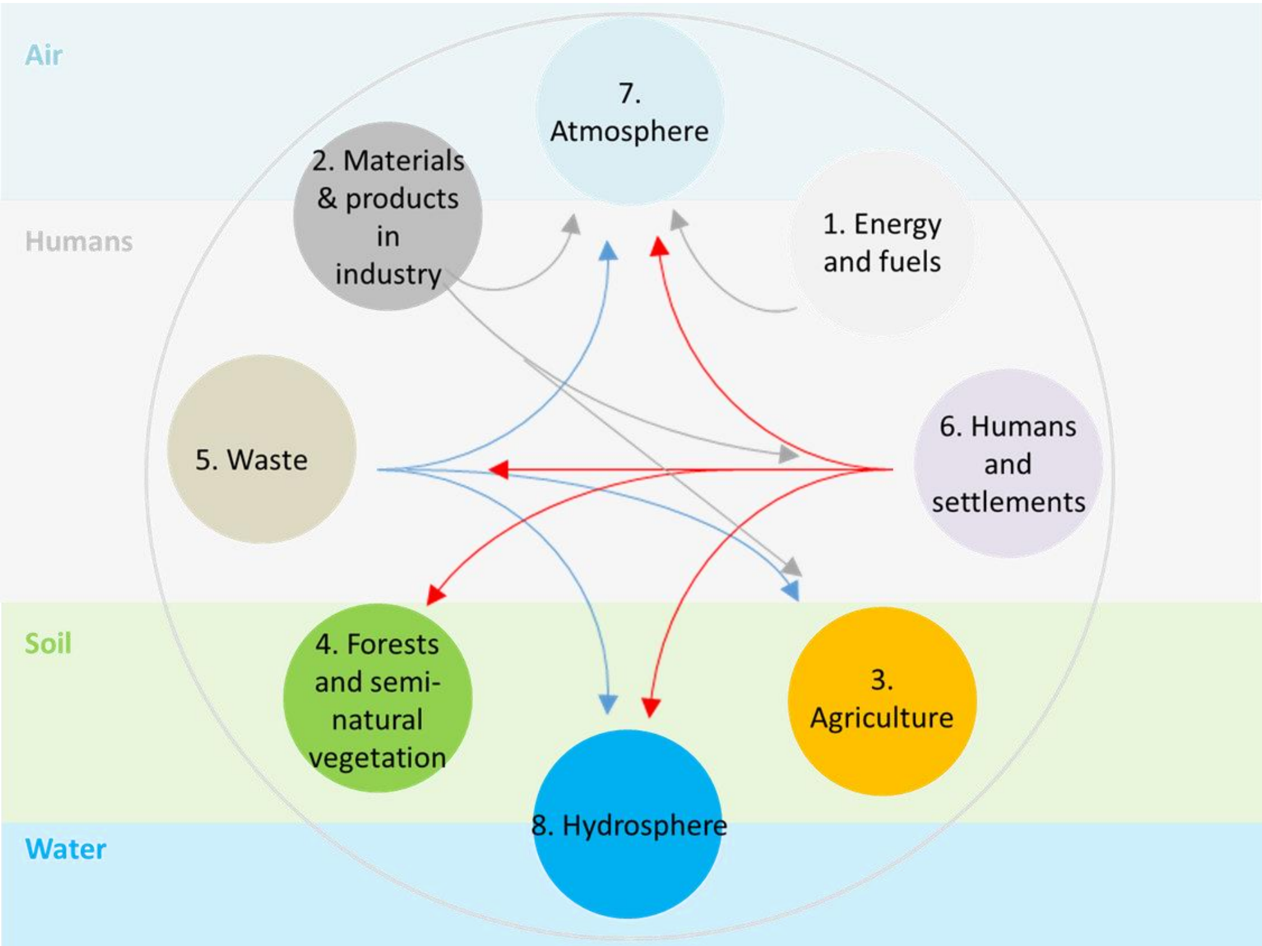

Fig. 1: Concept of nitrogen flows between eight pools

In UNCNET, nitrogen flows between environmental compartments are being quantified. Spatial extent are cities (test areas include Beijing and Shijiazhuang in China, Vienna and Zielona Góra in Europe) and the release is being quantified to all environmental media. Also a scenario component is specific to UNCNET in order to quantify possible interventions into the nitrogen cycle.

UNCNET aims to integrate N flows using the STAN model developed for material flow analysis by Vienna University of Technology. STAN is able to perform data reconciliation for flows provided with error bounds, and also error propagation. The approach may be too coarse, however, to represent all nuances of nitrogen flows, e.g. in a manure chain. Thus it may be useful to at the same time refer to alternate, more detailed approaches and link them via adequate data exchange platforms or interfaces. Specifically, the functionality of STAN to use spreadsheet files for storage of and access to data will be taken advantage of.

These other approaches formulating detailed N-flows, but not fully comprehensive, may include established models such as NUFER and GAINS. Attempts to couple GAINS and NUFER have been successful, but still no consistent model interface is available. Such interface development will be continued within UNCNET in order to improve the understanding of the manure chain with respect to N compounds, and to have a view to which extent this can be applied in an urban context. Mapping of the results to the central STAN structure then is an extra task, but it avoids the need to expand these existing models to comprehensively cover all N flows at the same level of detail.

Likewise, STAN interfaces need to be developed to link to atmospheric models to be used in the UNCNET context (GEOS-Chem, WRF-Chem). This involves aggregation (STAN will not or to a very limited extent allow for spatially explicit information within each of the test areas considered) as well as disaggregation of data in order to match grids needed for atmospheric models.

Similarly, integration of further models (soil models, vegetation models, stormwater models) can be dealt with. In all cases, the linking elements will be created by spreadsheets as established using STAN. The STAN implementation will provide the framework between all individual elements, and scales or sectoral details merged accordingly.

2) Model implementation

Extending from the original 8 pools under UNECE, the concept to be used in UNCNET was expanded by a pool "Trade", and agriculture was split into plant production and animal production. Next we defined flows that are considered relevant (Tab. 1) in order to implement a key flow structure (Fig. 2)

Table 1: Allocation of flows of reactive nitrogen considered relevant for an urban situation. Flows start from pool given in top row ("from") and end in pool presented in left column ("to"). Information on quantities is expected to derive from the pool presented in the table, mostly the "from" pool. Pool-internal flows are not considered here (dark shaded cells).

From: / To:	Combustion	Industry	Urban Gardens/ Agriculture / Soil	Urban Livestock	Waste	Wastewater	Households	Air	Water	Trade
Combustion		Combustion			Combustion					Combustion
Industry										Industry
Urban Gardens/ Agriculture / Soil		Urban Gardens		Urban Livestock		Wastewater			Water	Urban Gardens
Urban Livestock			Urban Gardens							Urban Livestock
Waste	Combustion	Industry	Urban Gardens	Urban Livestock		Wastewater	Waste			
Wastewater		Industry		Urban Livestock	Urban Livestock		Wastewater			Wastewater
Households		Households	Urban Gardens	Households						Trade
Air	Combustion	Industry	Urban Gardens	Urban Livestock	Waste	Wastewater	Households			Air
Water		Industry	Urban Gardens	Urban Livestock	Waste	Wastewater	Households			Water
Trade		Industry	Urban Gardens	Urban Livestock	Waste			Air	Water	

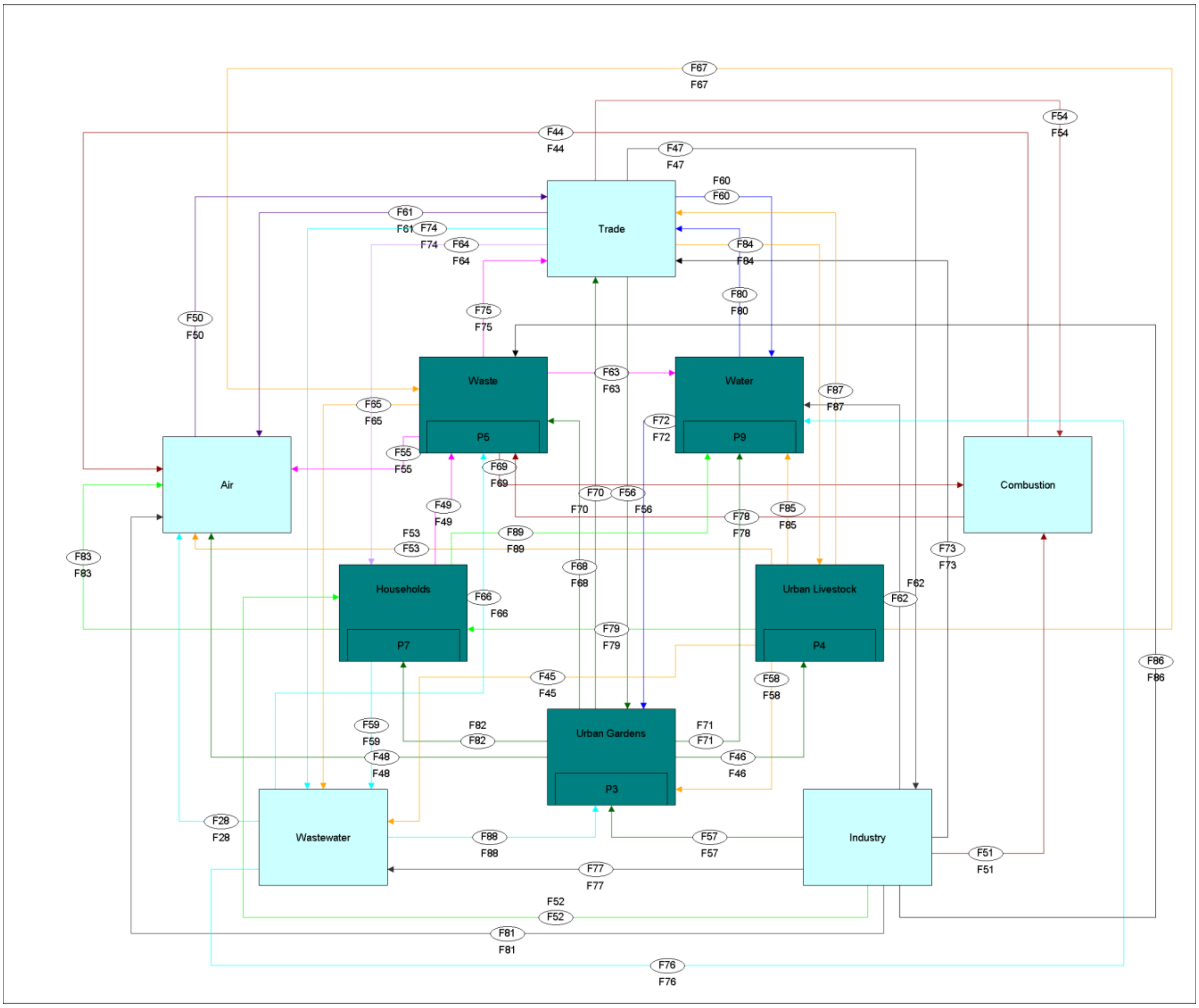

Fig. 2: STAN implementation of UNCNET core structure according to the definitions worked out in Table 1. Pools in dark color potentially also experience stock changes, i.e. significant amount of reactive nitrogen can be stored or released. The colors of the arrows reflect the way quantification of the flows can be done – pointing towards the pool providing that information.

Implementing the concepts in STAN (Fig. 2) automatically provides the spreadsheets required for data exchange. In this case, six individual spreadsheets have been created. Tables 2 and 3 contain the definitions of pools and flows, which are to be populated by data provided for the other tables.

Concepts shown here need to be tested with real data. This is the task of UNCNET WP's 3 – 6 and may lead to confirmation of the approach or allow for useful adaptation and improvements.

Table 2: Description of individual pools in in UNCNET model draft model concept (file “processes.csv”)

Short symbol	Name	Remarks	Stock	TCs	Sub system
P9	Water		True	False	False
P8	Air		False	False	False
P7	Households		True	False	False
P6	Wastewater		False	False	False
P5	Waste		True	False	False
P4	Urban Livestock		True	False	False
P3	Urban Gardens		True	False	False
P11	Combustion		False	False	False
P10	Trade		False	False	False
P1	Industry		False	False	False

Table 3: Flows in UNCNET model draft model concept (File flows.csv)

Short symbol	Name	Remarks	From	To
F28	F28		P6,Wastewater	P8,Air
F44	Flow 44		P11,Combustion	P8,Air
F45	Flow 45		P4,Urban Livestock	P6,Wastewater
F46	Flow 46		P3,Urban Gardens	P4,Urban Livestock
F47	Flow 47		P10,Trade	P1,Industry
F48	Flow 48		P3,Urban Gardens	P8,Air
F49	Flow 49		P7,Households	P5,Waste
F50	Flow 50		P8,Air	P10,Trade
F51	Flow 51		P1,Industry	P11,Combustion
F52	Flow 52		P1,Industry	P7,Households
F53	Flow 53		P4,Urban Livestock	P8,Air
F54	Flow 54		P10,Trade	P11,Combustion
F55	Flow 55		P5,Waste	P8,Air
F56	Flow 56		P10,Trade	P3,Urban Gardens
F57	Flow 57		P1,Industry	P3,Urban Gardens
F58	Flow 58		P4,Urban Livestock	P3,Urban Gardens
F59	Flow 59		P7,Households	P6,Wastewater
F60	Flow 60		P10,Trade	P9,Water
F61	Flow 61		P10,Trade	P8,Air
F62	Flow 62		P1,Industry	P9,Water
F63	Flow 63		P5,Waste	P9,Water
F64	Flow 64		P10,Trade	P7,Households
F65	Flow 65		P5,Waste	P6,Wastewater
F66	Flow 66		P6,Wastewater	P5,Waste
F67	Flow 67		P4,Urban Livestock	P5,Waste
F68	Flow 68		P3,Urban Gardens	P5,Waste
F69	Flow 69		P5,Waste	P11,Combustion
F70	Flow 70		P3,Urban Gardens	P10,Trade
F71	Flow 71		P3,Urban Gardens	P9,Water
F72	Flow 72		P9,Water	P3,Urban Gardens
F73	Flow 73		P1,Industry	P10,Trade
F74	Flow 74		P10,Trade	P6,Wastewater
F75	Flow 75		P5,Waste	P10,Trade
F76	Flow 76		P6,Wastewater	P9,Water
F77	Flow 77		P1,Industry	P6,Wastewater
F78	Flow 78		P11,Combustion	P5,Waste
F79	Flow 79		P4,Urban Livestock	P7,Households
F80	Flow 80		P9,Water	P10,Trade
F81	Flow 81		P1,Industry	P8,Air
F82	Flow 82		P3,Urban Gardens	P7,Households
F83	Flow 83		P7,Households	P8,Air
F84	Flow 84		P10,Trade	P4,Urban Livestock
F85	Flow 85		P4,Urban Livestock	P9,Water
F86	Flow 86		P1,Industry	P5,Waste
F87	Flow 87		P4,Urban Livestock	P10,Trade
F88	Flow 88		P6,Wastewater	P3,Urban Gardens
F89	Flow 89		P7,Households	P9,Water