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

Funded by
NCN (Poland), project UMO-2018/29 / Z / ST10 / 02986
NSFC (China), project 71961137011
FFG (Austria), project 870234

UNCNET

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

D5/1: Draft concept of urban agricultural nitrogen flows

Due date of deliverable: **31/01/2020** Actual submission date: **25/02/2020**

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

Organisation name responsible for this deliverable: **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

Based on a general scheme addressing urban N flows within UNCNET, this report addresses flows in the agriculture sector. Urban agriculture is distinctly different to agriculture in general, as proximity to cities and the production conditions under high salaries and land prices characteristic for urban areas only allows for high value production. We find five categories (pools) to be specifically addressed, livestock and pets under animal husbandry, and cropland, horticulture and urban greens under plant production. Flows between these pools and from and to pools already defined for the general approach are discussed in detail, and the NUFER model is suggested as an appropriate tool to link diverse information from statistics and literature in a consistent way. Integrating NUFER results, into the general N flow model using the STAN software will contribute to an overall understanding of urban N flows as developed in UNCNET.

2. Objectives:

Urban agriculture is different to agriculture in general. This report – and the modelling approach developed within – aims to elaborate the characteristics of these specificities, and turn them into a N flow model. At the same time, links to the generic N flow model developed under WP2 had to be maintained.

3. Activities:

Conceptual discussions between WP5 and WP2 (responsible for the general outline of UNCNET's general nitrogen flow model) have been performed between CAS and IIASA – initially in person, later via teleconferences

4. Results:

A flow model of urban agriculture 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:

CAS – IIASA bilateral meeting at CAS (originally) and later in teleconferences. Information exchange via e-mail with UZG.

9. List of Documents/Annexes:

Annex: A draft nitrogen flow model to describe urban agriculture

REFERENCES

ANNEX

A draft nitrogen flow model to describe urban agriculture

A draft nitrogen flow model to describe urban agriculture

1) Introduction

UNCNET uses the concept of pools and flows as developed under the UNECE Task Force on Emission Inventories (Winiwarter et al., 2019). The concept needs to be refined to specifically cover the nitrogen (N) flow in urban agriculture (Fig. 1). The idea is that reactive N is being exchanged between pools in the urban agriculture, with data available on fluxes between the respective pools, and equilibria (allowing for validation) being established within each pool. Also, fixation and loss of 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. This report describes the specific sub-pools for the sector "agriculture", and explains the links to the general strategy.

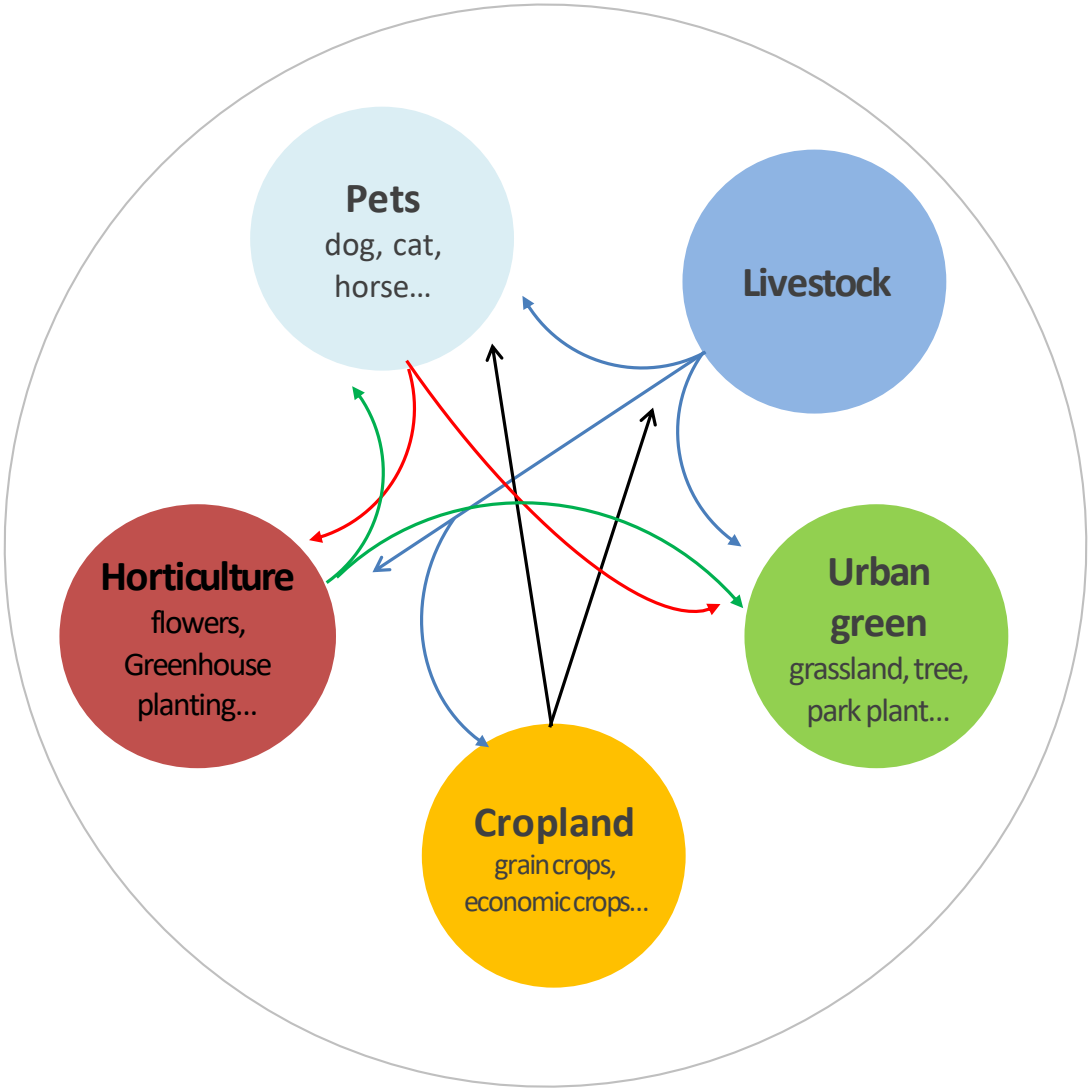

Fig 1. Concept of nitrogen flows in urban agriculture

2) Five components of urban agriculture

Urban agriculture is an indispensable part of the urban N flow, though a city relies less on urban agriculture for their food security. Here, the urban agriculture splits into 2 main systems which are (i) urban plant and (ii) urban animal production (Table 1). These 2 systems can be further categorized into 5 components or pools, which include cropland, urban green (not-for-profit) and horticulture (for profit only) for the urban plant production system, and livestock and pets for the urban animal production system, according to their functions and roles in the N circle (Fig 1). In addition to these 5 main pools, there are 6 further main pools which are out of the system boundary of urban agriculture N flow but still within the system boundary of urban N flow. These 6 main pools are N losses to air, N losses to water, waste of N, trade or transport of N across the urban boundary, urban industry, and urban households (Table 1).

Cropland is an important part of urban agriculture, which involves grain crops, livestock-based grassland, and cash crops for human consumption, such as fruit and vegetables. The urban crop production, which is also known as peri-urban crop production, strongly differs from crop production in non-urban areas, due to the higher land and labor cost in urban areas. There is more cash crop production in urban agriculture, such as the greenhouse-based vegetable and fruit production. Livestock-supporting grassland which provides the high-quality roughage for ruminant animal production may exist in some European cities on a very limited scale, and to an even smaller extent in cities like Beijing and Shijiazhuang.

The wide concept of urban agriculture also includes urban green, such as forests, public parks, backyards, private gardens and green belts. In some cities, the urban greens may contribute greatly to the urban N cycle as they also receive external N input, for example in the city of Vienna which has a lot of public parks and forests. The plants in the urban green are usually not for sale, however, some of them generate financial profits, as they attract more people to visit the parks and pay entrance fees.

Horticulture is constituted of different types of flower production and lawn planting, which strongly differs from urban cropland and urban green. Here, horticulture only represents flower production for profit. There are large areas of lawn planting nearby Shijiazhuang city, the capital city of Hebei province. This system highly relies on frequent irrigation and fertilization and usually brings high profit. There are also a lot of commercial flower production facilities in Beijing, as there is high demand for flowers to decorate the city on important holidays. Flower production also differs from the traditional urban cropland, as it is mainly taking place in greenhouse systems, and highly relies on organic fertilizers instead of synthetic fertilizer which are commonly used in urban cropland.

Cities play a dominant role in the consumption of animal-based products, hence, livestock production, in some cities, is more likely located around the urban area to be closer to the place of consumption. High transportation costs are also responsible for livestock production locating in urban areas. This is especially true for the pig and poultry production. However, urban livestock production, also faces stricter

environmental regulations than rural production as well as higher labor costs leading to no or little urban livestock production in some cities, such as Vienna.

Due to increasing economies, there is an increasing trend of raising pets, such as dogs and cats. These pets rely on high protein and animal source food diets, which hence have large impacts on the urban N circle. In some parts of Europe, horse-riding has become a popular sport of city dwellers and keeping horses a source of income for local farmers in the vicinity of urban areas.

3) N flows between different sectors, and external sectors

In defining the N flow between different sectors, we also connect to the other main pools in the urban N flow which were developed within the UNCNET project (Table 1). Cropland is linked to many other sectors, one of which is livestock production which provides manure and food for pets. It is however also linked to the air and water sector due to N losses to these media. In addition, cropland also exports some crop products beyond urban borders (Table 1). The main N inputs into urban cropland are mineral fertilizer, livestock manure (or human excreta), N deposition, biological N fixation (BNF), and irrigation. Mineral fertilizer is mainly added to the urban system via external input through trade, as only few N fertilizer manufacturing companies were allowed to be built in the urban area, due to environment protection. The majority of livestock manure is locally produced due to the higher transportation cost, however, part of composted manure might be imported from outside due to its higher dry matter content and hence relatively lower transport costs. All the human excreta applied is coming from the city (in form of sewage sludge from wastewater treatment). BNF occurs with legumes found in cropland or as well as grassland. Additionally, there are wet and dry depositions of N to the cropland. N input to cropland through irrigation is common in China, due to higher nitrate concentration in the surface and groundwater. N leaves the cropland mainly through crop products, which are subsequently used within cities for consumption as food for humans and pets, or feed for livestock. Some of the crop products may also be exported. N also leaves the cropland as losses via air emission, losses to water or accumulation in the soils (Table 1).

The input to horticulture is similar to the N input to cropland, except for the BNF and N deposition in the flower production system, as flowers usually don't have the capacity to fix N from the air, and as they are usually grown in greenhouse systems they are not exposed to N from atmospheric deposition. However, the lawn planting has the same N input as the cropland, and it relies highly on frequent irrigation and fertilization. The main output of horticulture are flowers, which are disposed of after big city level celebration or household use. The main output of lawn planting is grass and soil, as soil is always harvested together with the lawn grass. These products will partly be an input to the urban green sector or will be exported outside the city. There are also N losses during the growth of horticultural plants to the air and water (Table 1).

Urban green links to the air and water sectors due to N losses, and also links to the mineral N fertilizers input from outside via trade or urban N fertilizer manufacturing companies. There are also other N inputs to the urban green system, such as BNF, livestock manure, deposition and irrigation. Meanwhile, some part of pet excretions may also drop in the grassland when walking on the grassland, gardens and parks. Meanwhile, some of the harvested biomass may go to waste, such as leaves on the surface of roads. In addition, N may accumulate in the urban green system, which e.g. is the case for growing trees.

The livestock sector is linked to all the sectors in urban agriculture except for the waste sector. The main N input to the livestock production includes live animal and feed. Part of this feed comes from urban cropland, however, the majority of feed was imported from outside the city. The main output of urban livestock production are the final animal products, such as meat, milk and eggs, as well as manure N excretion. The majority of the animal products was served as food for humans or feed for pets in the urban area. Meanwhile, parts of the animal products are exported to regions outside the city, although the total amount may be small. As the city usually faces stricter environmental protection policies, the potential for livestock production is limited. Part of manure N is exported to cropland, urban green and horticulture, which require nutrients and organic matter to fertilize the soils. Part of manure N is exported to adjacent regions which has higher demand for organic nutrient resources. And part of the manure N is lost to air as NH_3 or to water as discharge of manure with or without treatment (Table 1). Some of the manure N excretion goes directly to the waste water treatment plant, but the amount could be negligible.

Pets mainly contributed to N flows in urban green via manure excretion. However, fractions of N excreted in urban green may emit to air and leach to water (Table 1). Meanwhile, excreta of pets may go to waste, when left on urban surfaces like roads or wasteland. Most of the N input to the pets is the imported feed. However, parts of the feed could also come directly from the urban produced crop and animal products, as some of the families feed the pets with raw fresh meat or the same meals as human had (Fig 1, 2). Pets excrete in the household and some of the N excretions goes to the wastewater treatment system.

N losses may deposit to land where they contribute to the growth of crops, hence linking the cropland, horticulture and urban green sectors. This is similarly true for the water sector, which contains high amounts of N and links to cropland, horticulture and urban green (Table 1). Trade links many sectors, such as synthetic fertilizers to cropland, feed to livestock, food to pets, fertilizer to horticulture and urban green (Table 1). For detailed N flows between different sectors in the urban agriculture see Fig 2. The urban agriculture N flow will be simulated using the NUFER-model, a mass balance based static model, and the results transferred for integration in the STAN model described in Deliverable D2.1 (Winiwarter et al., 2019).

Table 1: Allocation of flows of reactive N considered relevant for urban agriculture. Flows start from the pool given in top row ("from") and end in the pool presented in left column ("to"). Information on quantities is expected to be derived from the pools presented in the table, mostly the "from" pool. Pool-internal flows are not considered here (dark shaded cells). Relationship with and between "Other" pools (gray shades) are described in more detail in UNCNET Deliverable D2.1 (Winiwarter et al., 2019).

From:		Urban Plant			Urban Animal		Other						
To:		Crop-land	Horti-culture	Urban green	Live-stock	Pets	In-dustry	Waste	Waste water	House holds	Air	Water	Trade
Urban Gardens	Cropland				Livestock		X		X	X	X	X	X
	Horti-culture			Urban green	Livestock		X	X	X		X	X	X
	Urban green		Horticulture		Livestock	Pets	X		X		X	X	X
Urban Livestock	Livestock	Cropland											X
	Pets	Cropland			Livestock			X					X
Other	Industry												
	Waste		X			X							
	Waste-water				X	X							
	House-holds	X	X		X	X							
	Air	X	X	X	X	X							
	Water	X	X	X	X	X							
	Trade	X	X	X	X								

See report D2.1

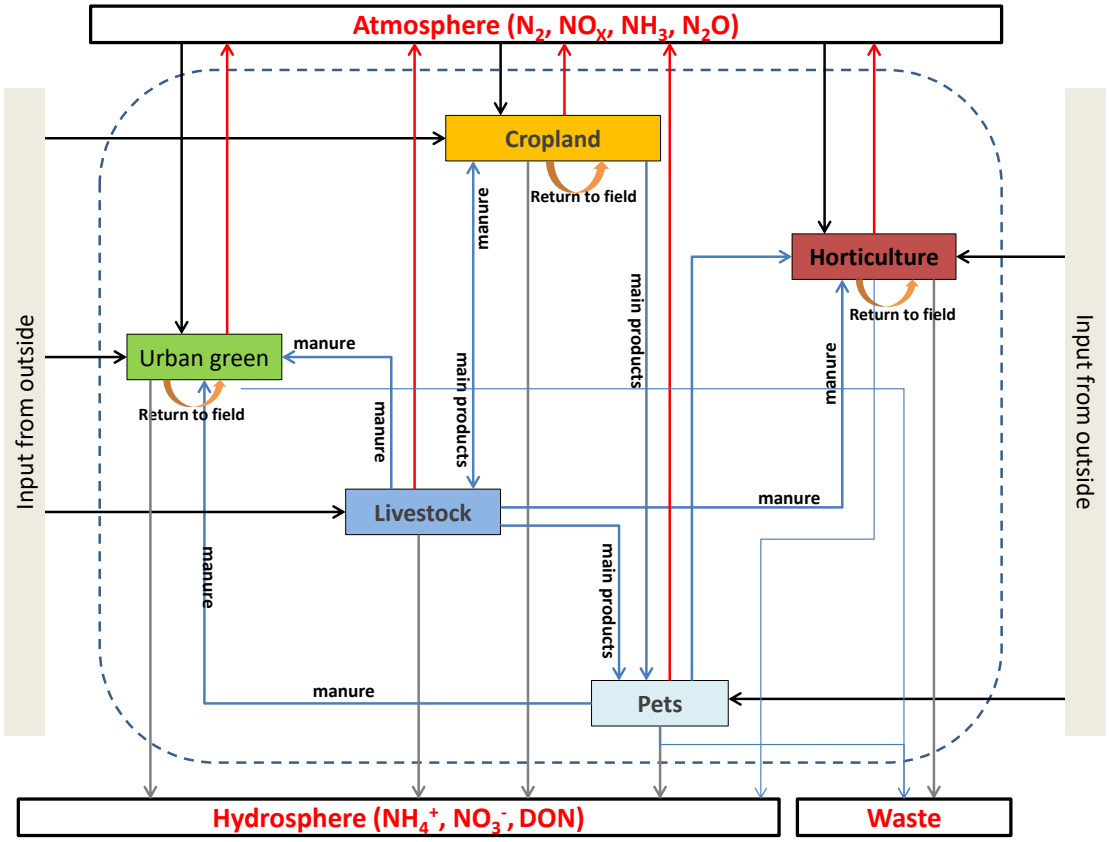

Fig 2. Detailed nitrogen cycle in the urban agriculture. The red arrow represents nitrogen output to the atmosphere; Gray arrows represent nitrogen output to soil and groundwater; Black arrows represent external input of fertilizer, feed, etc. The blue arrow represents the nitrogen cycle within urban agriculture.

4) Data availability

Activity data on harvested area, yield and total production of different crop products can be found from statistical data (e.g., statistical yearbooks) on different administrative levels, often urban and even sub-urban scale. The area and type of different urban green plants can be analysed from high resolution land use map, while the total production or growth of plants should be taken from literature. The total production of flowers and lawn grass in the horticulture sector can partially be found in statistics, and partly relies on literature and expert interviews. There is also publicly available statistical information about the livestock number and total production of different animal products. Information on the number and annual growth of pets highly rely on literature data.

Some of the input and output parameters of N in each sector can be derived directly from statistical data, such as the total N fertilizer consumption, total irrigation water use etc. Using values from higher aggregation (e.g., provincial or national data) and downscaling with appropriate surrogate information may be needed occasionally. However, most of the parameters need to be derived from literature and surveys in the crop production sector, such as biological N fixation of different crops, irrigation rates and N concentrations in the irrigation water. The average N deposition per hectare of cropland can be retrieved from within UNCNET. Also a few of the parameters of the livestock production sector can be derived from existing models, specifically using the NUFER model about the feed consumption of different animal categories, and the recycling of different organic resources

in crop production, and N losses to air and water. There is little information available on the parameters of N balances in the urban green, horticulture and pets sector. Hence most of the parameters rely on literature, expert opinions and assumptions. The trade and household consumption of crop and livestock products can be estimated through an input-output balance method, of which the human population and food consumption information can again be found in appropriate statistical datasets.

4) References

Wilfried Winiwarter, Katrin Kaltenegger, Zhaohai Bai (2019). D2/1: Draft concept of urban nitrogen flows. UNCNET report, July 2019 (www.uncnet.org).