ELEMENTS OF KORONIVIA JOINT WORK ON AGRICULTURE

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE'S CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION – JOINT SUBMISSION OF THE CHAIR OF THE EXECUTIVE BODY, CHAIR OF THE WORKING GROUP ON STRATEGIES AND REVIEW, AND CO-CHAIRS OF THE TASK FORCE ON REACTIVE NITROGEN

This is a joint submission of the Chair of the Executive Body of the UNECE Convention on Long-Range Transboundary Air Pollution (the UNECE Air Convention), the Chair of its Working Group on Strategies and Review and the co-Chairs of its Task Force on Reactive Nitrogen. We welcome Decision 4/CP.23, calling for the Subsidiary Body for Scientific and Technological advice (SBSTA) and the Subsidiary Body for Implementation (SBI) to jointly address issues related to agriculture, and are pleased to submit views on elements to be included in that work.

The UNECE Air Convention has developed an integrated multi-pollutant, multi-effect approach with its Gothenburg Protocol to mitigate air pollutant emissions and their associated impacts. The Convention includes agriculture both as a source of air pollution emissions and as a receptor impacted by air pollution. The Convention is built on a foundation of scientific expertise and advice, and undertakes significant scientific work related to the effects of air pollution.

In addition, the Convention's Task Force on Reactive Nitrogen works to enhance understanding of the integrated, multi-pollutant nature of reactive nitrogen, particularly in relation to air pollution in the context of the nitrogen cycle. In this regard, it assesses emissions, transport, budgets, fluxes and effects of nitrogen, develops technical and scientific information and emissions abatement options on nitrogen in the context of the nitrogen cycle, and provides technical information on nitrogen budgets and the effects of human diets on nitrogen use and emissions and associated synergies between environment, agriculture, health and diet.

This submission also recognizes the work to date of the SBSTA, the SBI as well as the Intergovernmental Panel on Climate Change (IPCC) on agriculture and the role of nitrogen-related emissions in climate change, and sees an opportunity to build on this body of work.

The UNECE Air Convention's 2016 Science Assessment Report (SAR) highlights the importance of taking an integrated approach towards addressing multiple environmental effects. The policy review group created to develop a policy response to this report identified three strongly interrelated policy fields that should form the basis for integrated policy development under the UNECE Air Convention going forward:

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- Ozone-nitrogen-climate-biodiversity interactions;
- Nitrogen management; and
- An integrated approach for the development of air pollution and climate change policies and measures.

There are major benefits that could be realized by developing a joint approach to several issues, including to addressing emissions from agriculture that cause air pollution and climate change. Some agricultural emissions have a radiative forcing impact, affecting climate, and are also impacted by climate change. At the same time, the solutions to control of air pollution emissions from agriculture are closely coupled to the need for increased climate resilience.

Bringing forward scientific and technological advice on nitrogen efficiency to the broader global climate mitigation community could enable Parties to the UNFCCC to develop targeted strategies to address nitrogen-related climate forcing (e.g., N_2O, O_3) while achieving important local and regional co-benefits.

We recommend that the links between agriculture, climate change and air pollution be considered as part of the joint SBSTA/SBI work program on agriculture across four themes:

- **Ammonia (NH_3) and nitrogen oxides (NO_x) emissions in relation to nitrous oxide (N_2O) and the wider nitrogen cycle**, where there are key opportunities for mitigation strategies to link co-benefits between climate, air pollution and water pollution,
- **Possible impacts of climate change on the nitrogen cycle in the context of agriculture**, where there are major risks for increasing nitrogen pollution of both air and water,
- **Interactions between tropospheric ozone, climate and agriculture**, where agricultural practices have an impact on climate by emitting climate relevant species such as N_2O and methane, and climate warming may affect emissions of precursor gases, altering the spatial distribution of air pollutants.
- **Necessity for increased cooperation and knowledge sharing**, exploiting new developments in across the nitrogen policy arena through the recent establishment of the International Nitrogen Management System (INMS).

We further recommend that the UNECE Air Convention and the Framework Convention on Climate Change cooperate to share information, expertise and strategies for agriculture to lay the foundation for such an approach, and that as a first step, the Conventions consider organizing a joint expert meeting or workshop.

Ammonia and nitrogen oxides emissions in relation to nitrous oxide emissions

Modern agricultural activities result in significant emissions of nitrogen-containing compounds that undergo a series of complex chemical transformations. These compounds can have multiple environmental effects, including on climate, air quality, biodiversity and eutrophication. Ammonia is a major source for this nitrogen, and when emitted into the atmosphere is a criteria air pollutant that is a precursor to $PM_{2.5}$ emissions. Another significant nitrogen compound associated with agricultural activity is N_2O, a long-lived greenhouse gas.

Globally, the major source of NH_3 emissions and N_2O emissions is agriculture, in each case accounting for at least 70% of total emissions. Emissions of both gases are related to excretal losses from livestock and from fertilizer and crops. Ammonia is primarily related to volatilization from ammonium pools, while N_2O results from nitrification and denitrification processes. These processes are closely coupled through the nitrogen cycle, indicating that mitigation strategies may have unintended trade-offs if not managed carefully, while 'nitrogen smart' strategies may offer substantial synergies.

The same issues apply for nitric oxide (NO) emissions from agricultural soils, mainly from nitrification processes. The emitted NO rapidly oxidizes in the atmosphere to form nitrogen dioxide (NO_2), together constituting NO_x, which in turn contributes to tropospheric ozone (O_3) formation, contributing to global warming and adverse impacts on both human health and agricultural crops. Although agricultural soils typically constitute a smaller percentage of total NO_x emissions (<10%), the share is increasing in countries where NO_x emissions controls from transport and industry have been successful, while little effort has been placed on reducing NO emissions from agriculture.

One of the major concerns resulting from NH_3 and NO_x emissions is their contribution to fine particulate matter less than 2.5 μm diameter ($PM_{2.5}$), through the formation of ammonium nitrate. Together with other sources of $PM_{2.5}$, these components represent a threat to human health through effects on coronary and respiratory systems. Conversely, the same $PM_{2.5}$ has a net cooling effect on climate, through direct light scattering and by acting as cloud condensation nuclei. Comparison of the societal cost of these impacts by the European Nitrogen Assessment has suggested that the health costs outweigh the climate costs, so that policies focus on reducing emissions of $PM_{2.5}$ precursors.[1] Necessary emissions reductions of agricultural NH_3 and NO, therefore lead to an additional global warming contribution.

Experience of NH_3 reduction within the UNECE Air Convention shows that there are major societal barriers to achieving substantial emissions reductions from agriculture, with the result that commitments achieved under international agreements such as the Revised Gothenburg Protocol are less ambitious than for other sectors. This matches similar differentials found between agriculture and other sectors in water pollution and greenhouse gas mitigation, as for example reported by the European Nitrogen Assessment.

[1] Updated estimates of the economic valuations incorporating warming and cooling effects of nitrogen (Butterbach-Bahl et al. in the *European Nitrogen Assessment*, 2011) have been provided by van Grinsven et al. in *Environmental Science & Technology*, 2013).

Such a resistance to N_2O and NH_3 emission control from agriculture is understood to be partly related to a fragmentation of science and policies across the nitrogen cycle. By contrast, the development of common strategies across the nitrogen cycle may be anticipated to strengthen the ‘gravity of common cause’ as identified by the UNEP report ‘Our Nutrient World’.

Until now, most focus on reducing N_2O and NH_3 emission from agriculture has followed a narrative of ‘reduce pollution and climate impacts’. In fact, nitrogen losses from agriculture, especially when considering all losses (including N_2O, NH_3, N_2, NO and nitrate leaching), amount to an extremely large resource loss. This means that an emerging narrative to focus on improved nitrogen use efficiency (NUE) is offering a constructive approach that may help mobilize change in the agricultural sector.

From the position of the UNECE Air Convention, such a joined-up nitrogen perspective is being investigated as part of strategies to promote progress in clean air policies, with co-benefits for climate, water, food production etc. The approach of integrating across the nitrogen cycle could help to overcome the barriers on greenhouse gas mitigation, while delivering co-benefits for air quality etc.

Globally the nitrogen fertilizers market is worth around 300 billion USD per year, while (based on the ‘Our Nutrient World’ report) 80% of this is lost as nitrogen pollution and denitrification to N_2. This means that there is a major financial opportunity to develop strategies for increasing nitrogen use efficiency, with multiple environmental benefits. In countries where nitrogen fertilizers receive government subsidies, increased nitrogen use efficiency offers financial opportunities for both farmers and for tax payers. In the case of Europe, based on the European Nitrogen Assessment, it is estimated that the fertilizer value of nitrogen losses from agriculture approaches 25% of the cost of the EU Common Agricultural Policy budget.

There is a wide range of solutions to mitigating the NH_3, N_2O, NO, N_2 emissions and nitrate leaching from agriculture. Measures for ammonia are outlined in the ‘UNECE Guidance document for preventing and abating ammonia emissions from agricultural sources’ (ECE/EB.AIR/120), with further practical information provided in the ‘UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions’ (ECE/EB.AIR/129). Strategies focused on N_2O mitigation from agriculture are reported in the UNEP report ‘Drawing down N_2O’. A circular economy perspective for overall nitrogen and nutrient mitigation has been introduced in Chapter 6 of ‘Our Nutrient World’. However, there is still much more to be done, and the work of the UNECE Air Convention includes the development of future guidance for overall mitigation of nitrogen losses in agriculture, for air, water and climate co-benefits. Such activities would benefit from strengthening partnerships with relevant bodies and experts from the UNFCCC.

Impacts of climate change on the nitrogen cycle in the context of agriculture

There are several major linkages that point to an expected increase of air pollution threats under climate change, especially as these link to agriculture.

Volatilization, nitrification and denitrification processes that give rise to NH_3, NO and N_2O emissions are extremely sensitive to temperature and water availability. In principle, based solely on thermodynamics NH_3 emissions double roughly every 5 °C, or increase by 40% with a 2° C increase. In practice, interactions with water availability are more complex, so that this climate interaction is mostly not yet included in regional emissions inventories. Similar uncertainties apply with national reporting of agricultural NO and N_2O emissions from soils, which will in many cases not fully take account of climate interactions. The net result is that climate warming is likely to promote even larger emissions of these gases and positive and negative feedbacks which will need to be taken into account in regional and global models. Additional efforts will therefore be needed to avoid increased emissions of these gases in a warmer world. The difficulty of achieving such additional measures will require increased working together across the traditional divides of air and climate policy. There is growing concern that farmers respond to adverse weather patterns by using increased amounts of nitrogen fertilizer. In an unfavourable year a farmer may compensate for poor weather by adding more fertilizer to achieve a target yield. In this way, fertilizer is sometimes seen as the ‘insurance policy’ of the farmer. With climate change leading to more frequent occurrence of unfavourable conditions this could see an increased trend toward over fertilization. The problem with such a strategy is that it is naturally associated with low nitrogen use efficiency and even larger losses of nitrogen to the environment as NH_3, NO, N_2O, N_2 and nitrate leaching. In this way, climate change impacts may lead to increased emissions of greenhouse gases and air pollutants.

Interactions between tropospheric ozone, climate and agriculture

Tropospheric ozone is a key pollutant targeted by the UNECE Air Convention, due to its adverse effects on human health, agricultural crops and natural ecosystems. It is also of concern to the Framework Convention on Climate Change because it is a greenhouse gas and a short-lived climate pollutant. Mitigation of the precursors that lead to O_3 formation is therefore a priority for both conventions. The main precursors are NO_x and volatile organic compounds (VOCs), including methane, all having a significant contribution from agriculture. As discussed in the UNECE Convention’s SAR, it is expected that O_3 will begin to increase again after 2020, primarily driven by increases in global methane emissions. Agricultural emissions mitigation actions can target a number of different compounds at the same time leading to benefits for both air quality and climate change, but in some cases there can be trade-offs between them. Therefore an integrated approach, considering the effects of the range of agricultural emissions on both air quality and climate, is key to minimizing such trade-offs. This can be promulgated through increased cooperation between the two conventions.

In addition to the role of agriculture in promoting NO emission, as noted above, VOCs from agricultural activities are primarily related to the release of biogenic VOCs (BVOCs), which are naturally emitted from certain plants, especially under high temperature or stress conditions. Such emissions are also promoted by certain forest trees, with the ozone forming potential of the characteristic BVOCs differing substantially between different plant and tree species.

Strategies to increase forest biomass for carbon sequestration may also have significant trade-offs for air quality. In this way, carbon credits for forest planting linked to Land-use land-use change and forestry (LULUCF) programmes may worsen air pollution by increasing BVOC emissions and promoting tropospheric O_3 formation. Currently, such trade-offs are not addressed under the Gothenburg Protocol of the UNECE Air Convention, which excludes BVOCs from national emissions ceilings. Nevertheless, Parties need to be aware that such trade-offs exist when considering the links between climate and air pollution outcomes. While BVOC emissions are particularly associated with forest planting, they also arise from agricultural crops and bioenergy crops. For example, oil palm is associated with substantial BVOC emission and ozone forming potential. There is currently little knowledge on the ozone formation potential of BVOCs emitted from livestock excreta. Overall, there is a need for better understanding of the interactions between bioenergy policies, climate and air quality.

The impacts of tropospheric ozone on agriculture result from toxic effects leading to reduced net photosynthesis. Crop species vary in sensitivity, while the O_3 dose is especially a function of stomatal opening (which itself is a function of species, water availability, temperature and other factors). There are also known interactions between drought and ozone impacts, where chronic ozone exposure can limit stomatal closure, making plants more vulnerable.
The interactions between environmental drivers and ozone impacts on crops point to a likely worsening of ozone impacts under climate change, further exacerbating the impacts already noted connected with the nitrogen cycle. The EU ÉCLAIRE project has highlighted that nitrogen and O_3 effects are further linked, as O_3 exposure was found to reduce the nitrogen use efficiency of crops, pointing to a risk of increasing losses of N_2O, N_2 and nitrate.

Necessity of increased cooperation and knowledge sharing

The linkages between agriculture, air pollution and climate outlined in this note highlight the necessity of closer working together between the relevant bodies of the Framework Convention on Climate Change and the UNECE Air Convention. Key themes of common interest include:

- Improving understanding of the mechanisms by which climate and air pollution are linked in agricultural systems
- Consideration of how the nitrogen cycle links up multiple activities and impacts in agriculture, while offering an opportunity to further develop circular economy thinking in developing and motivating mitigation strategies

- Developing a suite of ‘nitrogen smart’ solutions, working together in developing guidance for best practices with co-benefits for air, climate, water and food security
- Identifying priorities of future risks that have so far not been fully addressed in solutions development, including climate dependence of emissions, climate driven air pollution feedbacks and possible solutions to address farmer needs

Attention is here drawn to the recent establishment of the International Nitrogen Management System (INMS) by the UN Environment Programme in cooperation with the International Nitrogen Initiative (INI), with support through the Global Environment Facility. The UNECE Air Convention is already contributing to INMS through its Secretariat and its Task Force on Reactive Nitrogen. INMS can be seen as a science support system for international nitrogen policy development, necessitating a close engagement between the relevant science and policy communities, as well as with key stakeholders. As Figure 1 illustrates, the scope of INMS offers the opportunity to promote working together across the nitrogen cycle, including among others the following linked concerns:

Water Quality: working with the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), and its contributing regional seas conventions, including the Global Partnership on Nutrient Management;

Air Quality: working with the UNECE Air Convention and other regional processes for transboundary air pollution;

Climate change: offering an opportunity to develop closer working with the SBSTA of the Framework Convention on Climate Change;

Ecosystems and Biodiversity: working with the UN Convention on Biological Diversity, especially in support of its Aichi Targets;

Stratospheric Ozone: with the success of the Montreal Protocol on reducing emissions of CFCs (and now HFCs), N_2O is now the major stratospheric ozone depleting substance. As a result, this indicates the need for cooperation with the Vienna Convention on protection of the ozone layer.

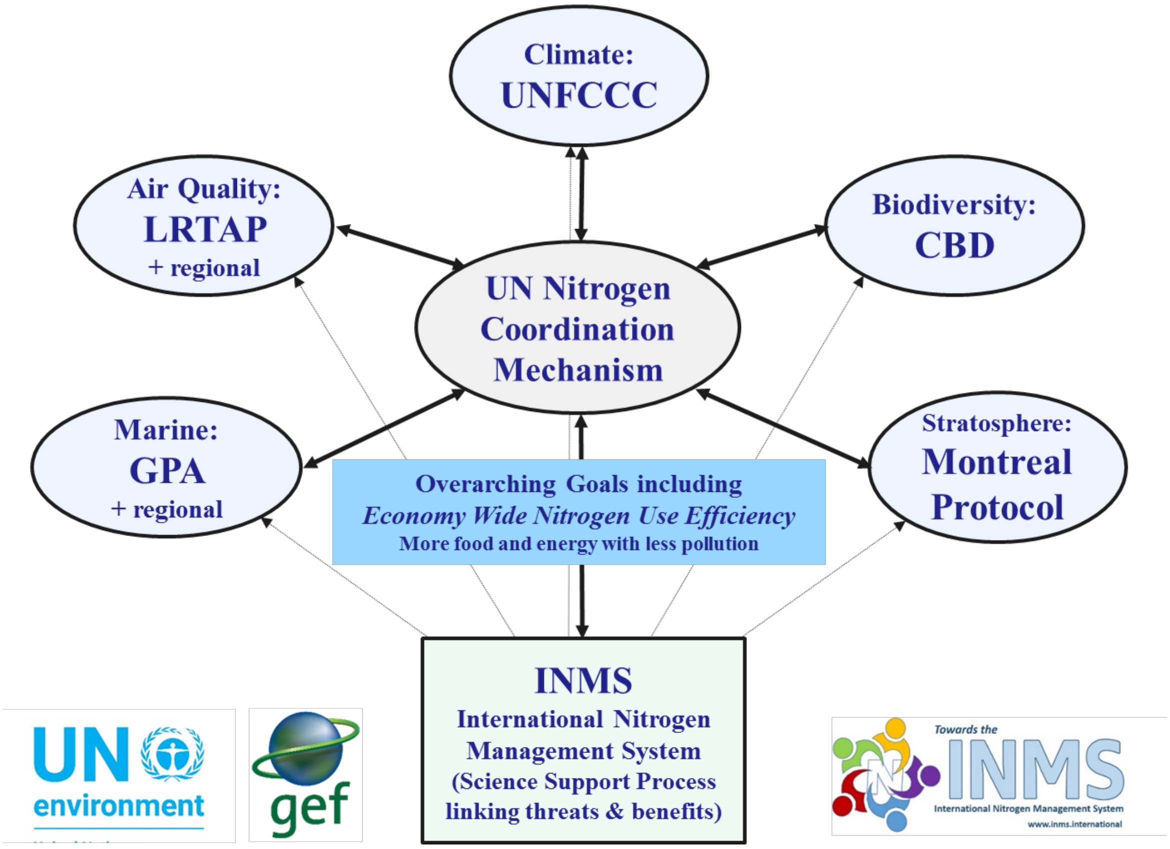

Figure 1: Summary of the Nitrogen Policy Arena, showing major relationships between INMS, key multi-lateral environmental agreements and noting the position of a possible 'UN Nitrogen Coordination Mechanism'.

For other acronyms, see main text.

Other links include supporting delivery of the sustainable development goals, while building partnerships with other key bodies such as the Food and Agriculture Organisation, the World Meteorological Organisation, academia, business and civil society.

While clearly shown on Figure 1, there is currently no 'UN Nitrogen Coordination Mechanism' in existence, but countries may wish to further discuss and establish such a mechanism.

As part of this discussion, attention is drawn to the recent adoption of the resolution entitled "Preventing and Reducing Air Pollution to Improve Air Quality Globally" adopted at the third session of the United Nations Environment Assembly (UNEP/EA.3/Res.8, December 2017), which includes a clear emphasis on making these links with agriculture: "*4. Further encourages governments to pursue synergies and co-benefits between national clean air policies and policies in key areas such as… agriculture and to take advantage of synergistic effects of efficient nitrogen management on reducing air, marine and water pollution.*"

In addition, a draft nitrogen resolution, prepared under the auspices of the South Asian Cooperative Environment Programme (SACEP) has recently been adopted by the Governing Council of SACEP (c. 23 March 2018).

The UNECE Air Convention is working closely with INMS as a mechanism to stimulate greater cooperation across human management of the nitrogen cycle, which provides a matching opportunity for engagement by the SBSTA of the Framework Convention on Climate Change.

We also suggest that the governing bodies of the UNECE Air Convention and Framework Convention consider convening a joint workshop or expert meeting under the auspices of the SBSTA to further develop mutual understanding across these issues, which is vital if we are to make substantive progress in joining up solutions for climate and air pollution mitigation and adaptation.