Sustainable Agriculture and Air Pollution: reducing emissions leads to many benefits. Event at the Milan World Expo, July 10, 2015.

Workshop report.

As a contribution to the Milan World Expo, with the theme 'Feeding the planet, energy for life', the European Commission's Joint Research Centre, in close collaboration with scientists and policy makers from the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP) and other key international organisations, organized a workshop addressing the interrelationships between agriculture and air pollution. The key-objective of the workshop was to raise scientific, policy and public awareness concerning the issues, and to identify opportunities for improvements, related to sustainable agriculture and reducing air pollution. What needs to be done to create win-win situations where farmers, public health and the environment mutually benefit from improving the sustainability of agriculture? Four keynote speakers and 30 participants from science, industry and policy, attended the workshop.

Main findings

The presenters, panel members and other attendants of the workshop formed a heterogeneous group, which resulted in a high degree of complementarity of information and experiences. The key findings can be summarised as follows:

- There is little awareness among sector stakeholders and the general public, concerning the effects of agriculture on air pollution and of air pollution on agriculture. Current policy regulation and enforcement of agricultural sources of air pollution are perceived as weak, despite the high benefit-to-cost ratio of mitigation measures and a high risk associated with inaction.
- Agriculture is among the main sources of air pollution and becoming more important as pollution from industry and transport are generally subject to tighter controls. Without further action agriculture's contribution to air pollution may further increase.
- In particular, ammonia (NH_3) emissions from agriculture contribute to airborne particulate matter with serious impacts on human health; it also causes eutrophication and acidification of ecosystems. In Europe, a limited amount of specific measures can substantially reduce NH_3 emissions.
- Methane is a powerful greenhouse gas and an important ozone precursor. Future ozone changes will largely depend on methane emissions. Ozone in turn has important negative impacts on (semi-)natural vegetation and agricultural crops. Reducing methane emissions thus will have a range of positive benefits.
- Important steps towards reducing emissions were identified: Continuing outreach activities coordinated across key-organisations; demonstration of air pollution effects in early warning systems; smart technologies that evaluate environmental performance of farms including air pollution; inclusion of air

pollution in environmental labelling; and rewarding innovation in reducing air pollution in funding schemes.

Summary of keynote presentations:

1. Reactive nitrogen

Mark Sutton (CEH) showed that bringing too much nitrogen into the environment negatively affects Water, Air, Greenhouse gas emissions, and Ecosystems- also dubbed the WAGES of nitrogen. Nitrogen pollution was estimated to cost society in Europe between 70-320 billion/year, with about half of these costs related to agricultural emissions of NH_3, and run-off of reactive nitrogen in water. Analysis of the ratio of cost and benefits of emission reductions showed a 3 times larger potential to cost-effectively reduce NH_3 emissions compared to NOx (mainly from transport and industry) Unfortunately, many of the voluntary measures outlined in the UNECE Framework Code for good agricultural practices to reduce ammonia emissions, are not yet implemented in the signatory countries. Relatively simple technologies are available to reduce NH_3 emission from manure spreading. Also, increasing the nitrogen use efficiency by better integration of crop-livestock systems was proposed as a possible simple solution. Most EU countries, as well as South and East Asia were identified as regions were an improvement of the Nitrogen Use efficiency could be leading to N-savings between 100-250 kg/ha/yr, amounting globally to reducing 20 Tg N/year, and net benefits of 170 billion US$ per year. The Nitrogen on the Table report showed that a large environmental benefit could be obtained by the so-called demiterian diet (50 % less meat in diet), reducing N2O and NH_3 emissions, and losses of nitrogen to waters by up to 45 %, and requiring 75 % less imports of soy beans to feed animals.

Markus Amann (IIASA) showed that a number of regions, e.g. in Eastern Europe and Southern Europe, currently do not comply with EU legislation for particulate matter (PM10). Moreover, current measures are not sufficient to comply with the more stringent recommendations issued by the World Health Organisation. Measurements show that currently about half the air pollution in Europe is related to unregulated sources, and model analysis suggests that even in some cities up to half of the PM is from international sources. Ammonium nitrate, resulting from the interaction of NO_x emissions from traffic and industry with NH_3 from agriculture constitute the largest part of the international and national contribution to PM. Whereas there is a theoretical potential of around 20-30 % to further reduce the classical pollutant NO_x and SO_2, the potential for NH_3 is much greater- 70-80%. Currently, 80 % of the ammonia emission in Europe comes from farms with life-stock larger than 500 units, representing only 10 % of all farms. Relatively simple, and partly cost-neutral and -saving measures to reduce emissions include: 1) improving storage of manure and anaerobic digestion 2) modern application techniques of manure on soils (injecting instead of spraying) 3) avoiding urea fertilizer losses, or substitute by ammonium nitrate. Monetary analysis shows that for relatively small costs still enormous gains in health benefits and protection of nature areas can be achieved.

Summary of keynote presentations; Ozone and methane

Lisa Emberson (SEI) demonstrated that agriculture is also negatively affected by air pollution, in particular by ozone, which affects photosynthesis, plant water uptake and nutrient uptake and causes leaf damage. Wheat, rice, soybeans and other pulses are among the most sensitive crops, with reported yield reductions of 5 to 30% in hot-spot regions around the globe. High yielding irrigated agricultural systems stand out as being

particularly at risk from ozone pollution.. Currently, about one third of the anthropogenic methane emissions are associated with agriculture, this methane contributes to large-scale ozone production, which is in turn harming crop production. The current economic damage to wheat production in the EMEP region is € 4.6 billion. and in EU countries € 3 billion. Awareness of this issue among farmers, policy makers, and public is low, although there are examples of countries where authorities issue ozone warnings to farmers to avoid ozone damage. The UNECE's ICP Vegetation is conducting out-reach activities, including informative brochures and a smart phone app where photos of ozone damage can be uploaded and documented.

Frank Dentener (JRC) showed that ozone and other types of air pollution, increase in several parts of the world, especially in Asia, due to industrial growth, increased traffic and increased consumption of livestock products, driven by population increase and change in diets. In Europe, peak ozone levels are decreasing (due to local-level reduction of air pollution) but background levels are increasing, due to hemispheric transport of air from other parts of the world. Long-term methane levels are increasing, with important contributions from agriculture. Current scientific insights identify methane emission reductions as the most important driver of reducing larger geographic scale ozone concentrations. The UNECE Task Force Hemispheric transport of Air Pollution is working worldwide with local scientists to improve the understanding of the processes, sharing data with regional networks, but also developing scenarios to identify the most effective actions to reduce large-scale ozone and other air pollutants.

Roundtable discussion:

The keynote speakers, and 4 additional panel members with policy and agricultural backgrounds attended the round table discussion. The discussion focussed on the following overarching questions: 1) Why is there lack of awareness and action? 2) What can be done now? 3) Where do we need more research?

1) Why is there lack of awareness and action?

Awareness among public and sector stakeholders is crucial to create popular support for any policy measures. Without public pressure, policy responses tend to be weak.

Interactions between agriculture and air pollution are mostly indirect, and difficult to explain to the general public and farmers. Scientific insights regarding the types of effects mentioned above come from authoritative institutional sources (e.g. UNECE-LRTAP, SEI, IIASA, JRC, CEH, FAO, UNEP, agricultural research institutes), but are hitherto scattered among multiple disciplines and acting across a variety of platforms, not main-framed in scientific assessments, nor sufficiently reaching public and farmers. This could lead to an impression of incoherence or immaturity of scientific insights, to the detriment of raising public awareness.

In some cases scientific evidence has to become more robust, for instance in assessing the possible role of ozone in dwindling yield increases, especially in irrigated regions downwind of heavily polluting source regions, implying inefficient use of land, water, nitrogen and other inputs in agricultural production. Current knowledge is not sufficiently translated in to practical solutions with demonstrable benefits. Uncertainties

in science are often used as a reason for inaction, rather than approaching from precautionary principles.

Farmers do not see the damage they suffer or cause, and are not sufficiently challenged to reduce their pressure on the environment. They feel threatened by top-down, ever more stringent and complex environmental regulations, which are often felt as unreasonable, disproportional, and incurring high administrative overhead costs to demonstrate compliance.

Policy makers are hesitant to take on more -or more complex- environmental issues, especially when public support is lacking. For instance, some of the issues have a global dimension (methane and ozone, globalisation of food and feed systems), and require policy actions beyond the usual legislative domain. Mitigation of greenhouse gas emissions to avoid dangerous climate change is a point-in-case of the difficulties of reaching global agreements. Another example is the untapped potential of agriculture to reduce the levels of fine particulate matter, one of the most threatening forms of air pollution. The perception of transport and industry being the dominant sources of air pollution, and unawareness of the magnitude and contribution of agriculturally sourced ammonia emissions to air pollution, are among reasons for not using this potential.

2) What can be done now? Outreach, societal, institutional and policy nudges

Outreach:

To raise awareness, continuous policy outreach and public dissemination by scientists and the institutions representing them is required. Outreach, capacity building, bringing out 'universal' science in a specific regional context working with local scientists, was considered to be a pragmatic, albeit lengthy, way forward. For example the reduction of global and hemispheric scale surface ozone levels, where controls are increasingly beyond the jurisdictional reach of policy makers, requires joint approaches. Scientists from the UNECE Task Force Hemispheric Transport of Air pollution, ICP Vegetation, UNEP, WMO, WHO, are currently addressing such issues, but joint outreach may strengthen the policy evidence. International co-ordination of local and regional policies will enhance the effectiveness of measures, especially when based on harmonized information.

Demonstration of benefits: In Cuba, an early warning system for ozone damage has been in place since 1992, where farmers are advised to decrease irrigation when ozone levels (originating from the USA) are high, with proven significant benefits on tobacco, salad leaf and garlic production.

Modern technologies, i.e. smart phones (http://icpvegetation.ceh.ac.uk), satellite observations, micro-devices, all may be used to measure the 'greenness' of an agricultural production system and its contribution to pollution. Use of social media related to demonstrating and improving 'green' performance of farmers could also be considered. However, such tools are still dealing with teething problems, affecting acceptance and adoption. Examples of possible issues encompass: 1) Typically tools address a single issue, potentially leading to conflicting advice among tools for different issues or unwanted side effects (e.g. advice on fertilizer application on specific dates may lead to air pollution peaks 2) Different tools, even when addressing the same issue,

often use different indicators (sometimes with the same name), leading to confusion. 3) Ownership of data and fear that data may be used against farmers interests. 4) Using the technologies requires extra efforts for which farmers are usually not rewarded, or only rewarded in the long term or indirectly.

Framing and branding of issues. Instead of presenting this as "yet another issue", using synergies with other topics. For example, Climate Smart Agriculture is currently strongly promoted by organisations such as FAO and is taking off in Africa and Asia. It aims to implement better management practices to increase sustainable productivity, to reduce impacts on climate and to reduce vulnerability to climate change. The concept could include also air pollution.

Policy:

The tragedy of the commons (overall impact of a sector versus individual farmer) regarding agricultural production and pollution is addressed mostly by governmental regulations. Innovative policies are required in which the sector feels part of the solution. How can individual farmers and the agricultural sector at large be lured into improved practices? To what extent can transformation of agricultural production systems be steered? Several ways forward were indicated.

Reward innovation. Innovators are of all times. Already in 1799, Erasmus Darwin, the grandfather of Charles Darwin, suggested manure injection as a way to reduce nutrient losses. Also now there are farmers that pioneer and engage in innovative approaches. Innovative, environmental friendly, approaches need to be rewarded, and used to move the sector into this direction. Involving farmers requires flexible policies to get buy-in from farmers. Farmers would like to see that their efforts are rewarded in simplification of policies. A balanced approach between flexibility and demonstrable performance needs to be found. The 'greening' of the Common Agricultural Policy (CAP) in Europe was mentioned as an example where more emphasis on environmental performance could nudge towards reducing impacts on air and water pollution, biodiversity and climate. The European Innovation Partnership for Agricultural Sustainability and Productivity was mentioned as mechanism to incentive early innovators to drive environmental performance quickly forward

Development of farm-level certification (green labelling) schemes, evaluating farm-scale performance regarding air and water pollution, resource use, GHG emissions, biodiversity, may provide incentives to both farmers, industries, retailers and consumers, to make informed decisions on food choices. In Europe, and other developed and developing regions, farming is more and more developing to industrial scales, with specific opportunities to deal with environmental issues. Large food-industries are already developing schemes evaluating aspects of their production chain. On the other hand, there are examples of biodynamic certification schemes, which, however, do not evaluate air emissions. Inclusion of air pollution in green labelling, should be considered in the context of simplification of certification schemes, to enhance consumer awareness and acceptance.

Finally, policy making would benefit from better understanding of the (multiple) benefits of measures to mitigate air pollution and of the costs of inaction. Rather than

framing air pollution and agriculture as a completely new topics, building on and expanding existing knowledge and issues, will increase the likelihood of action.

Need for further research:

In some fields scientific knowledge is mature enough to be communicated, e.g. the impacts of too much nitrogen, and the need to reduce nitrogen, although better quantification of the benefits and risk of reducing nitrogen is still needed. Exemplary case studies, and integrated system understanding (e.g. the Integrated Nitrogen Management System approach) need to be further developed.

In other cases disciplinary, cross-disciplinary or integrated research needs to strengthen the message. For example, robust understanding of the best practices for agriculture to adapt to high ozone levels cannot be formulated yet, due to lack of knowledge. Crop-models, used for seasonal yield forecast, as well as for long-term climate change simulation, generally do not include ozone. Inclusion of ozone and crop growth in process-based integrated assessment models is needed to better quantify the role of ozone as a factor affecting agricultural production, and required for assessment of agricultural management options to adapt to and optimise resource use in response to high ozone levels (e.g. adapted varieties, crop calendar, water management, nutrient management, etc.). Such developments are needed for instance to address fundamental issues such as why in e.g. Europe and North America the gap with theoretical yields is not further closing. Currently, there is also very little understanding of the interactions of nitrogen and ozone.

Another example where more knowledge is needed, is developing better understanding of the role of NH_3 in the formation and impacts of particulate matter, especially in developing countries.

Integrated system research is needed to better understand and quantify processes effects of adaptation and mitigation options. This has been difficult to establish because of the complex approach required, transcending domains and disciplines and scales from global to local and from minutes to years, to assess the interactions involved.

Typical questions that have to be addressed are the specific opportunities of specialized production systems, versus integrated livestock and crop production systems, on farm, national and international scales. Can environmental measures within a specific boundary lead to spill-over effects elsewhere, and lead to overall deterioration of the global environment? All this research needs to be translated in practical recommendations.

Further information and conference lectures are available via:

https://ec.europa.eu/jrc/en/event/conference/sustainable-food-production-and-air-pollution