

### Plant Nutrients and Climate Action



The fertilizer industry is fully committed to the implementation of the Sustainable Development Goal 13: **“Take urgent action to fight climate change and its impacts.”**

An active observer to the UN Framework Convention on Climate Change (UNFCCC) since 2000, the International Fertilizer Association (IFA) and its Members are dedicated to reducing fertilizer-related greenhouse gas (GHG) emissions while increasing global carbon sinks and forestalling deforestation.

The 17 Sustainable Development Goals are all interconnected and need to be implemented together to achieve a sustainable future for everyone by 2030. **The achievement of Goal 13 is tied with the achievement of the other Goals, in particular: Goal 1 (No Poverty), Goal 2 (No Hunger), Goal 6 (Clean Water), Goal 9 (Industry, innovation and infrastructure), Goal 12 (Responsible consumption and production), Goal 14 (Life under Water) and Goal 15 (Life on Land).**

### Key Messages

- Fertilizers play a crucial role in the achievement of SDG Goal 2 (No Hunger) as they contribute to 50% of the world’s food production. They will continue to be indispensable as the global population is expected to reach nearly 10 billion people by 2050, and in a context of shrinking available arable land. Achieving global food security today and in the future cannot be achieved without fertilizers.
- The fertilizer industry is nevertheless cognizant of the GHG emissions resulting from the production and application of its products, and continuously seeks to reduce them.
- Fertilizers also contribute to the achievement of Goal 13 in three important ways: first, when applied according to Fertilizer Best Management Practices, such as the “4R” Principles (applying the Right nutrient source, at the Right rate, at the Right time and in the Right place), they can help farmers **adapt to climate change** effects by strengthening crops’ resilience, while **contributing to mitigation** by reducing fertilizer-related GHGs. Third, they play an **important role in creating and preserving global carbon sinks**: by increasing productivity on arable land, they forestall deforestation; and they also increase soils’ capacity to sequester carbon by improving their Carbon to Nitrogen (C:N) ratios and maximizing their biomass production.
- In an ongoing effort to reduce GHGs from application, the fertilizer industry engages in strategic partnerships with research organizations, farmers and NGOs to advance knowledge of plant and crop nutrition and dissemination of Fertilizer Best Management Practices (FBMPs).
- Demonstrated GHG emissions throughout the world: in the United States, growers using an advanced level of 4R implementation observed reductions of N<sub>2</sub>O emissions of 14% compared to a basic level; and in India plots using FBMPs emitted approximately 1/3 of CO<sub>2</sub>-eq emissions of traditionally farmed plots.
- On the production side, fertilizer manufacturers have been putting in place Best Available Technologies (BATs) to improve their energy efficiency and reduce GHG emissions. IFA Members have also been participating in voluntary benchmarks since 2002, tracking and monitoring their energy efficiency, CO<sub>2</sub> emissions and environmental performance.

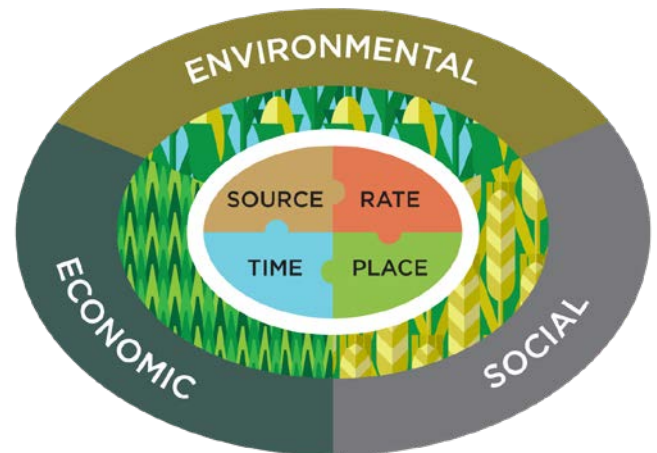
## Adaptation, Mitigation & Soil carbon sequestration

### Fertilizer's Role In Climate Change Adaptation & Mitigation

Fertilizer-related GHG emissions are estimated to account for a third of the agriculture sector's emissions and 2.5% of global GHG emissions, 1.5% of which deriving from their application. The fertilizer industry is cognizant of these emissions and committed to reducing them wherever possible.

Losses to the environment can be measurably minimized, and fertilizer related GHG emissions can be reduced by ensuring **a maximum uptake of needed nutrients by plants**. The application of fertilizers according to crop-and- site-specific Best Management Practices, consistent with the "4Rs" Principles (which entail applying the **right source** of nutrients, at the **right rate** needed to optimize yields for a specific crop, at the **right place** in the field, and at the **right time** they are or will be needed by the crop) helps achieve this objective, and contributes significantly to climate change adaptation and mitigation:

- First, **site-specific nutrient management allows for a correct fertilization of plants** that helps boost their health, their resilience to climate stress, and



contribute to greater water use efficiency. This is vital for farmers who want to maximize their yields in good seasons to make up for potentially severe weather events in subsequent seasons.

- They also help adapt to water-scarce environments: nutrients and water are complementary inputs, and the most limiting input will constrain plant growth response to nutrients and water. The fertilizer industry therefore encourages the adoption of "**fertigation**", a practice that entails applying fertilizers to crops with irrigation water. Fertigation makes it possible to synchronize the crops' nutrient requirements with fertilizer supply throughout their growth cycle, addressing the rate, time and place dimensions of nutrient stewardship, and preventing water from being wasted in conventional irrigation systems.

### Fertilizer Facts

- About 25 to 30% of total GHG emissions come from agriculture: 10 to 12% from crop and livestock activities on farms; 8 to 10 % from land use; and 5 to 10% from the supply chain. Fertilizer production, distribution and use are responsible for 2.5% of global GHG emissions. (IPCC, 2019)
- Fertilizers applied to crops and pastures (both mineral fertilizers and manure) were responsible for estimated emissions of 1.3 Gt CO<sub>2</sub> in 2010 (WRI, 2018). Yet, crop and livestock production have become considerably more efficient.
- For example, we now use 62% less land and emit 46% fewer greenhouse gas (GHG) emissions to produce one kilocalorie from livestock, compared with 1961. (CCFAS, 2019) Furthermore, some studies have shown a 14% decrease in N<sub>2</sub>O emissions by farmers using an advanced level of 4R implementation. (Vyn et al, 2016)
- IFA Members are also observing significant emissions reductions on their production sites, thanks to a widespread adoption of Best Available Techniques (BAT), mitigation technologies and to the recovery and re-use of CO<sub>2</sub>.

- While zero losses are not an achievable goal given that we are dealing with natural biological processes, **FBMPs nevertheless reduce GHGs from fertilizer application and are an important part of the agriculture sector's mitigation potential.** FBMPs that improve Nutrient Use Efficiency (which is defined as the proportion of the mineral and/or organic nutrient source applied that is taken up by the crop, and is calculated as an output/input ratio) can increase nutrient uptake by the plant and reduce losses to the environment. In Europe, NUE has increased significantly compared to 1990 levels while N<sub>2</sub>O emissions from agricultural soils have dropped in a significant way.

## Forests and Soil Carbon Sequestration

Fertilizers also contribute to the achievement of Goal 13 through the creation and preservation of global carbon sinks.

First, **fertilizers reduce pressure on forests and help avoid land use changes** by increasing the productivity on available arable land. This is crucial, as deforestation and land-use conversion represent 30-50% of agricultural emissions, and about 4-14% of global emissions. Thanks to advances in crop productivity and efficient fertilization, **about one billion hectares of land have been preserved from conversion to cropping between 1961 and 2005**, leading to carbon emissions savings of 317 to 590 Gt CO<sub>2</sub>-eq from not converting that area.

Fertilizers also help to **build carbon sinks in agricultural soils** by improving their Carbon to Nitrogen (C:N) ratios and maximizing their biomass production, which results in higher levels of soil organic matter (SOM) and soil organic carbon (the core element of SOM). This is also very significant for climate change mitigation, as soils represent the largest terrestrial pool of carbon: they can store up to 50-300 tons of carbon per hectare; and soils of crop lands, grazing land and rangeland globally can potentially store 1.500-4.500 million tons of CO<sub>2</sub>-eq per year.

Research has found that **Integrated Plant Nutrient Management**, i.e. the combination of mineral and organic fertilizers, results in the highest level of SOC. **With IPNM, mineral and organic fertilizers play complementary roles:** mineral fertilizers supplement the nutrients provided by organic fertilizers with concentrated, consistent and plant-accessible nutrients. Organic fertilizers, when available in

sufficient amounts, provide beneficial soil organic matter that improves soils' health, fertility, structure and water retention capacity.

Finally, it is important to specify that different regions call for different measures: **fertilizer management practices, yields and soil conditions vary importantly across regions, therefore recommendations on fertilizer use and climate change adaptation and mitigation need to take these differences into consideration.** In sub-Saharan Africa (the region with the lowest fertilizer consumption in the world), a 20% increase of fertilizer use could result in more than 2 million hectares of land spared, and up to 13 million tons of carbon sequestered compared to 0.4 million tons emitted. In regions where fertilizer use and crop yields tend to be low, increasing nutrient input can create positive feedback loops between soils and crops and increase food security.

## Achieving Goal 13: The Fertilizer Industry's Partnerships and Initiatives

### Nutrient Stewardship: FBMPs Dissemination and Education

The fertilizer industry engages with multiple partners to make sure that FBMPs are applied as widely as possible. These partnerships allow IFA to receive the latest crop and plant nutrition knowledge and to disseminate it through educational webinars and communications campaigns.

In 2016, IFA and the World Farmers' Organization (WFO) published the **Nutrient Management Handbook**, in cooperation with The Global Alliance for Climate-Smart Agriculture (GACSA). This 25-page manual seeks to help farmers achieve the triple win of boosting productivity, achieving higher resilience and reducing greenhouse gas emissions.

IFA also reinforces its commitment to science-based approaches to plant nutrition through partnerships with research institutes such as **Wageningen Research & University, the CGIAR's Research Program on Climate Change, Agriculture and Food Security (CCFAS) and Rothamsted Research.**

In recent years, IFA has partnered with CCFAS to advance knowledge on fertilizers and climate change: a paper published in November 2016 examined the negative effects of fertilizer under-



use in sub-Saharan Africa (including soil mining, soil erosion and low productivity), and provided countries with policy recommendations to increase their crop productivity while achieving optimal nutrient use efficiency (NUE) to help them achieve their NDCs.

CCFAS's 2018 Working paper "*Measuring and Estimating fertilizer related GHGs*" identified several national initiatives and projects whose detailed accounting of fertilizer related GHGs could provide countries with more accurate measurements of their emissions than the default value set by the IPCC. In 2019, CCFAS published the Working Paper "*Fertiliser use and soil carbon sequestration: trade-offs and opportunities*" which found that implementing IPNM resulted in the highest levels of carbon in soils.

## Product Stewardship: The Fertilizer Industry's Safety, Health and Environment (She) Management

The synthesis of ammonia through the Haber-Bosch process, considered to be one of the most important inventions of the 20th century, has contributed enormously to food production and global food security. Nowadays, about 97% of nitrogen fertilizers are derived from synthetically produced ammonia; however the production of ammonia is an energy-intensive process that relies on hydrocarbon feedstock a raw material for the synthesis of ammonia and as a main energy source to fuel the process.

To reduce the energy consumption and GHG emissions, ammonia producers have been applying BATs and transitioned to using natural gas as main hydrocarbon feedstock which results in much lower carbon dioxide emissions compared to coal and heavy fossil fuels.

The application of BATs helps minimize energy losses (heat and steam derived from the chemical reactions and processes are no longer wasted) and improve the environmental performance of the production site (reducing waste water volumes, applying N<sub>2</sub>O abatement techniques).

To track the effectiveness of the efforts made by the industry to improve its environmental footprint, IFA offers benchmarks to its Members to track their CO<sub>2</sub> emissions, energy efficiency and environmental performance since 2002. Performance recorded

for IFA's participating Members on the Energy Efficiency and CO<sub>2</sub> Emissions benchmark (which runs since 2004), oriented to ammonia production, indicates a continual improvement largely due to investment in plant revamps as well as new and more efficient capacity coming online. Since 2004, a **14.5% reduction in the CO<sub>2</sub> emissions rate** per ton of ammonia was observed, and the current average **net energy efficiency represents a 5.5% improvement** of the first average measured. These benchmarks show that the overall energy efficiency in the mass production of nitrogen fertilizer has been greatly improved in the last decades; nevertheless, there remains potential for incremental efficiency improvements and reduction of emissions, especially in regions where coal still prevails as the main feedstock.

IFA's Environmental Performance benchmark has been collecting industrial emissions data since 2002 from fertilizer production sites located around the world. The data confirms the efforts from the ammonia and nitric acid sectors to reduce emissions with the adoption of environmental mitigation techniques as greenhouse gases emissions rates have declined.

However, with today's BATs, the most efficient ammonia producers are very close to reaching the theoretical minimum of energy consumption within the Haber-Bosch method, so efforts to further improve the energy efficiency of the process to reach UN goals are challenging.

Industry is turning its research towards other technologies such as Carbon Capture and Storage or low-carbon production processes. IFA Members have several pilot projects that are currently in operation to assess the opportunities of a downstream industry transitioning from fossil inputs to electric inputs as "green ammonia".

**In 2019, IFA is partnering with the International Energy Agency (IEA) and the European Bank for Reconstruction and Development (EBRD) to develop a Low-Carbon Roadmap** for the global fertilizer industry. This Roadmap will help the fertilizer industry to identify additional solutions it can adopt to reduce its emissions while maintaining its competitive position as a reliable source for supporting agriculture globally. The Roadmap will also help to guide the industry's actions over the coming decades and support companies in planning for a low carbon future.

# The Fertilizer Industry's Multi- Stakeholder Partnerships, Case Studies and Initiatives

## Nutrient Stewardship

### Supporting Precision Agriculture: Nutrien Ag Solutions, North America

In 2018, IFA Member Nutrien launched its digital platform “**Nutrien Ag Solutions**”, that provides agronomic advice and services to growers through a personalized and easy to use platform. The Digital platform has been designed as an integrated platform that helps customers effectively manage their agronomic and business needs by interacting with agronomists and field service representatives. It has also been integrated with Nutrien' Echelon precision ag technology provider, to help growers' optimize their yields and use of inputs.

Precision Agriculture embraces new emerging technologies that contribute to steering the agricultural system towards a high-efficiency, sustainable, energy friendly and input optimized model. By optimizing yields with balanced inputs, precision agriculture contributes significantly to the reduction of GHGs emissions from fertilizer application.

### Providing Farmers With Best Practices Training: Fertcare, Australia

Fertcare® is a joint venture between Fertilizer Australia and the Australian Fertilizer Services Association (AFSA). Fertcare® is a training, certification and accreditation program delivered by independent third parties on behalf of the fertilizer industry. Fertcare® focuses on providing high quality advice to users of fertilizers to allow them to maximize productivity and minimize environmental and food safety risks.

Since 2014, Fertilizer Australia also runs the Fertcare® Carbon Farming Extension Program which produces summaries of the best available scientific information on greenhouse gas emissions from fertilizer application and the best ways to manage these risks. This material is provided to Fertcare® participants through workshops and is then included in the standard training material.

### Bringing Research Further: Reducing Nitrous Oxide Emissions In Tropical Regions, Brazil

Dr. Heitor Canteralla, the Director of the Soil and Environmental Resources Center of the Agronomic Institute of Campinas in Brazil and winner of the 2017 IFA Norman Borlaug Award, conducts cutting-edge work to reduce greenhouse gas emissions associated with fertilizer use in the tropics.

Dr. Cantarella's work focuses on minimizing emissions of N<sub>2</sub>O during the production of key Brazilian crops such as citrus fruits and sugarcane for ethanol production. He is also one of the first scientists to assess the nitrous oxide emissions associated with the production of ethanol, the biofuel which now powers 40 percent of vehicles in Brazil. His research showed that nitrous oxide emissions could be reduced by up to 95% by applying urea fertilizer to sugarcane with compounds that slow down the conversion of ammonia to nitrate (known as nitrification inhibitors).

### Measuring Emissions, Tracking Progress



#### *Field-To-Market, United States*

Field-to-Market is a multi-stakeholder initiative that provides its members with a common framework to measure environmental and socio-economic indicators that can be applied at different scales, from the farm to national

level. One of the environmental indicators is GHGs, which include CO<sub>2</sub>, methane and nitrous oxide emissions. In 2017, Fieldprint Calculator emission factors included measurements from the national N<sub>2</sub>O emissions estimating tool, USDA'S DAYCENT, which captures sensitivity of emissions to crop, Land Resource Region, soil texture and farmer-applied N rates.

A research conducted in 2016 (Vyn et al.) using Field-to-Market found that at an intermediate level of 4R implementation, a 7% decrease in N<sub>2</sub>O emissions from the basic level was observed; while at Advanced/Emerging level of 4R implementation, N<sub>2</sub>O emissions were reduced by 14% compared to the basic level.

### *The Nitrous Oxide Emissions Reductions Protocol (Nerp), Canada*

Fertilizer Canada has recently proposed that federal and provincial governments implement a national 4R Climate-Smart Protocol, also known as the Nitrous Oxide Emission Reduction Protocol.

The Nitrous Oxide Emission Reduction Protocol (NERP) is a Nutrient Stewardship-based approach to mitigate N<sub>2</sub>O emissions from fields, that was approved for use in 2010 in the Canadian province of Alberta. NERP allows for farmers to claim carbon credits by adopting 4R nitrogen practices. The 4Rs can be applied at three levels: Basic, Intermediate and Advanced. Fertilizer Canada's goal is to achieve 20 million acres under 4R Nutrient Stewardship by 2020, which represents 20 % of Canada's crop land. Research shows that implementing NERP-based nutrient management practices may result in a 15-25% reduction of Nitrous Oxide emissions compared to baseline practice emissions.

### *The Cool Farm Tool, Europe & Global*



The Cool Farm Tool is a farm-level carbon foot printing tool that is run by the not-for-profit Cool Farm Alliance. GHG emissions from fields are estimated by including general information about soil and climate, and a set of management options on the farm which includes fertilization, pesticide and herbicide use, residue management, machinery and energy use. GHG emissions are reported in CO<sub>2</sub> equivalents (CO<sub>2</sub>eq) per ha of crops.

The CFT allows for farm-level, management and climate-sensitive N<sub>2</sub>O emissions from fertilizers to be calculated based on simple data such as fertilizer type, rate, level of inhibitors, crop and yield, soil and climate and study locations.

A research conducted by WWF in India in 2010 used the Cool Farm Tool to compare GHG emissions from cotton farm plots that implemented traditional cultivation against plots who implemented FBMPs; it found emissions due to fertilizer application reached 3,312 kg CO<sub>2</sub>-e/ha for plots using traditional cultivation, and 1,642kg CO<sub>2</sub>-e/ha in plots using FBMPs.

## **Product Stewardship**

### **The Carbon Footprint Calculator, Fertilizer Europe**

The Carbon Footprint Calculator can be used as a stand-alone module to calculate the GHG generated during the production of fertilizers. By selecting basic assumptions and filling in own values related to raw materials, transportation, energy, plant specifications and product specific data, the user calculates the total carbon footprint, expressed as 'ton CO<sub>2</sub>-equivalents / ton product'. This estimate includes both direct and indirect emissions.

### **The Circular Economy Program, OCP**

Since 2008, IFA Member OCP has implemented a highly ambitious industrial strategy “the OCP Circular Economy program” that addresses both climate change mitigation and adaptation.

On the mitigation side, OCP has invested in clean energy (70% of its energy needs are met with co-generation or wind power, and  $\frac{3}{4}$  of its plants are now served by wind power), an innovative phosphate pipeline (between mines and plants, that has cut emissions by 400kt CO<sub>2</sub>/year); Best Available Technologies (which, on one site, have increased electrical production by 15% while reducing fresh water consumption by 25%, sea water consumption by 40% and have reduced SO<sub>2</sub> emissions by 70%) and in a carbon bio-sequestration project (which entails the afforestation of arid or semi-arid zones: 4.5 million trees have already been planted). In addition, OCP is a partner of a project to develop “green ammonia”, i.e. ammonia produced by renewable energy rather than fossil fuels.

On the adaptation side, OCP has invested in the use of “non-conventional water”, i.e. waste water treatment and reuse. It no longer uses groundwater and 80% of the water used in its mines is recycled.

### **The Nitrous Oxide Elimination Project, Egypt**

Since 2006, IFA Member Abu Qir and Carbon Austria have implemented a project to reduce nitrous oxide emissions resulting from the production of fertilizers, under the umbrella of the Kyoto Protocol and its the Clean Development Mechanism (CDM).

According to the project's results, an annual reduction of about 1.035 million tons of CO<sub>2</sub>-eq each year is achieved, which amounts to about 17 million tons of CO<sub>2</sub>-eq between 2006-2018.

It is one of the largest projects in the African continent and the Arab world and one of the largest international projects in this regard.

### **Testing Green Hydrogen Technology In Fertilizer Production, Australia**

IFA Member Yara is conducting a feasibility study with energy provider ENGIE with the objective to design a green hydrogen plant integrated with Yara's existing ammonia plant in Pilbara, Western Australia. The Pilbara region is the ideal location for the study, with plenty of sun and seawater – key ingredients to producing renewable hydrogen. Reaching the goal will significantly reduce the plant's CO<sub>2</sub> emissions. Reducing the costs associated with producing, storing, transporting and deploying hydrogen is crucial for its environmental impact. Integrated projects like the green hydrogen plant at Yara Pilbara allow for a real-world, real-time analysis of costs and processes.

### **US Industry GHG Emissions Reductions, TFI Report**

Each year, US fertilizer association TFI publishes its “State of the of the Fertilizer Industry Report”. Its 33 Members voluntarily contribute their data to the Report, representing the entire fertilizer value chain. In 2017, the Report showed that the US fertilizer industry captured and reused 25% of GHG emissions; invested \$4.3 billion to advance innovation, improve infrastructure, and enhance the sustainable production of fertilizer; reclaimed 1.4 billion gallons of water and recycled another 461.9 billion gallons of treated wastewater; and captured 111 million GJ of waste heat to generate onsite energy or return energy to the grid.

### Recommended further reading:

- Stirling CM. 2018. Accounting for mitigation of N-fertiliser emissions at national and project scales. CCAFS Working Paper no. 230. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: [www.ccafs.cgiar.org](http://www.ccafs.cgiar.org)
- Hijbeek R, van Loon MP, van Ittersum MK. 2019. Fertiliser use and soil carbon sequestration: opportunities and trade-offs. CCAFS Working Paper no. 264. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: [www.ccafs.cgiar.org/publications](http://www.ccafs.cgiar.org/publications)
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### About the International Fertilizer Association:

The International Fertilizer Association (IFA) promotes the efficient and responsible production, distribution and use of plant nutrients to enable sustainable agricultural systems that contribute to a world free of hunger and malnutrition. IFA is the only global fertilizer association with a membership of more than 470 entities, encompassing all actors in the fertilizer value chain from producers through traders and distributors, as well as service providers, advisors, research organizations and NGOs.

**[www.fertilizer.org](http://www.fertilizer.org)**