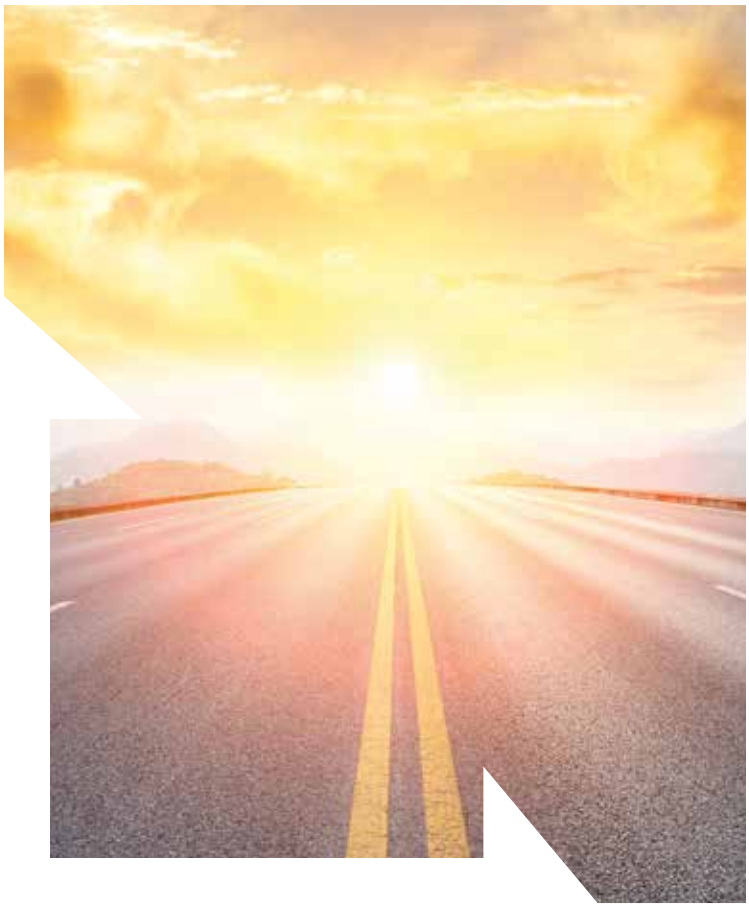
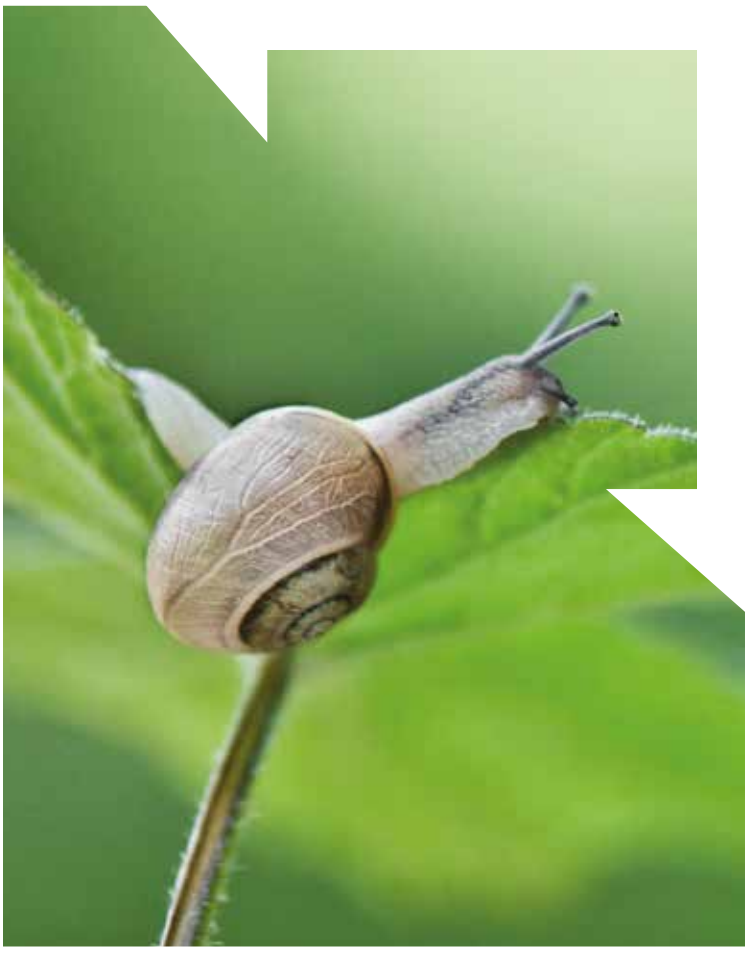




ifa2030 SCENARIOS

Digging deeper, thinking harder, planning further

CONTENTS

WELCOME

NOTE FROM IFA'S DIRECTOR GENERAL

I am delighted to be sharing the IFA2030 scenarios which attempt to capture the diverse, rich and valuable input we have received over the past year from so many IFA members and distinguished experts from outside the industry.

From my perspective, these scenarios, which depict plausible alternative futures, imply three high level takeaways for this industry which contributes to serving 20 billion meals per day today and 30 billion meals per day in the year 2050. First, given that the future will likely differ greatly from the recent past, and present us with greater complexity, we know that we can't rely on what has worked in the past when making decisions for the future. Second, this industry, like others, will be expected to run ever more responsible and sustainable businesses. Third, it behooves us to imagine and anticipate game-changing events in time to adapt, address constraints and identify opportunities, so that we may design more and better options.

The IFA2030 scenarios are intended to be used as 'conversation starters' and 'door openers' to help the industry and our stakeholders cultivate insights and inform choices. They should be seen as an effort to capture and categorize a wide array of inputs to facilitate strategic planning, rather than any sort of official IFA position paper. My hope is that IFA members will find them useful for their own strategic planning and outreach to key stakeholders.

The implications emerging from the scenarios will also help us as an association to adapt so that we may best serve our members in the lead-up to 2030 and beyond and I am excited about embarking on the next phase of our IFA2030 exercise, which will run through the end of this year.

Our 'end-game'? To remain a vibrant industry while maximizing our contribution to solving global challenges and creating opportunities for the progress of society. We look forward to and welcome your comments and critiques.

Charlotte Hebebrand
Director General, IFA

Paris, France, June 2018

ABOUT IFA

The International Fertilizer Association (IFA) is the only global fertilizer association. With a membership of more than 470 entities in 69 countries it encompasses all actors in the fertilizer value chain: producers, traders, distributors, service providers, as well as advisors, research organizations and NGOs.

IFA'S VISION

Productive and sustainable agricultural systems contribute to a world free of hunger and malnutrition.

IFA'S MISSION

IFA promotes the efficient and responsible production, distribution and use of plant nutrients.

IFA'S APPROACH

IFA provides a framework for exchange and collaboration among its members and a structure for agreeing common positions and joint actions.

THE GLOBAL FERTILIZER INDUSTRY

The fertilizer industry plays an important role in feeding the world's growing population. Mineral fertilizers are estimated to contribute to over 50% of today's food production. The industry provides direct employment for around 1 million people worldwide and produces fertilizers and raw materials valued at US$218 billion annually (2016, Integer Research conducted for IFA).

EXECUTIVE SUMMARY

OVERVIEW

As the world grows towards 10 billion people, creating greater natural resource constraints, and as new technologies change our lives and our possibilities more than ever before, the global fertilizer industry wishes to define its place in this future. To help do this, the International Fertilizer Association (IFA) embarked on a long-range strategic planning process using scenario planning methodologies.[i] They focused on the most pressing issues facing the fertilizer industry as a way to extend thinking and test preparedness; a 'wind tunnel' for designing industry-wide and company-specific approaches that are informed, robust and anticipatory.

The world would be a very different place without fertilizers. Plants need light, carbon dioxide, water and essential nutrients, which can come from both organic and mineral fertilizers, in order to grow[ii]. Mineral fertilizers contain more concentrated, consistent and readily available nutrients than organic fertilizers and enable farmers to grow more on less land. Mineral fertilizers are produced from materials mined from naturally occurring nutrient deposits, or from the fixation of nitrogen from the atmosphere into plant-available forms. Mineral fertilizers thus serve as a crucial complement to organic fertilizers and it is estimated that without them, world agricultural production could fall by as much as half and it would not be possible to feed the global population. In other words, without mineral fertilizers, we could not sustain today's population of 7.6 billion, much less a population of 8.6 and 10 billion expected by 2030 and 2050.

The global fertilizer industry has undertaken tremendous investments over the last decades to increase production in order to ensure access to this vital input for the world's farmers. The consumption of fertilizers has grown nearly six-fold between 1961 and 2015 (from 32 to 184 million nutrient tons)[iii], to keep up with a population expanding from 3.1 billion to 7.4 billion during the same period.[iv] The industry has also vastly improved its production efficiency as well as emphasized the need for efficiency at the farm level by promoting effective plant nutrition based on the "4Rs" – applying the right nutrient, at the right rate, time and place.[v]

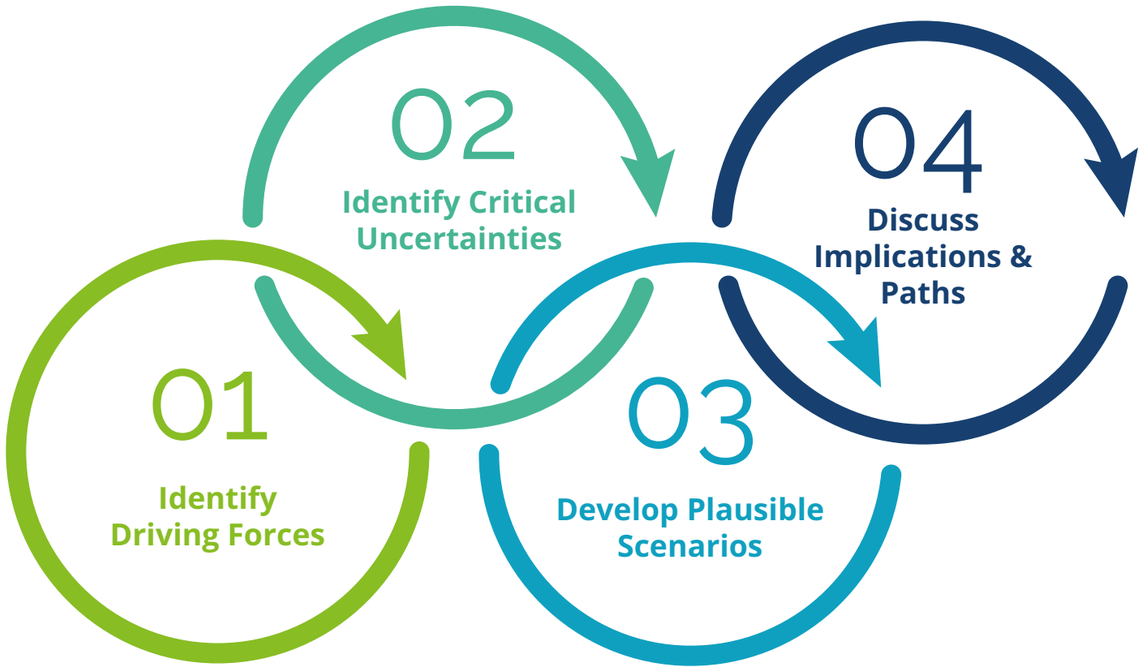
IMAGINE

Developing scenarios means thinking about alternative plausible futures and imaging what could be. This might be a world where the fertilizer industry is working closely, in lock-step with farmers, NGOs, technology start-ups, research platforms and regulators across the food value chain to improve lives and incomes by advancing innovative plant nutrient solutions. Alternatively, maybe we should prepare for a world where business has more difficult relationships with NGOs and regulators, which could hamper emerging technologies from coming on-line or jeopardize a company's license to operate?

Perhaps we can anticipate a future that is pretty much 'business as usual', driven by a reliably growing demand for fertilizers, while adapting to greater levels of ecosystem stress and nutrient deficiencies in certain regions of the world? Could we envision a future where unprecedented levels of data-driven/data-inspired technologies create a seamless information flow from the small-holder farmer to the retailer?

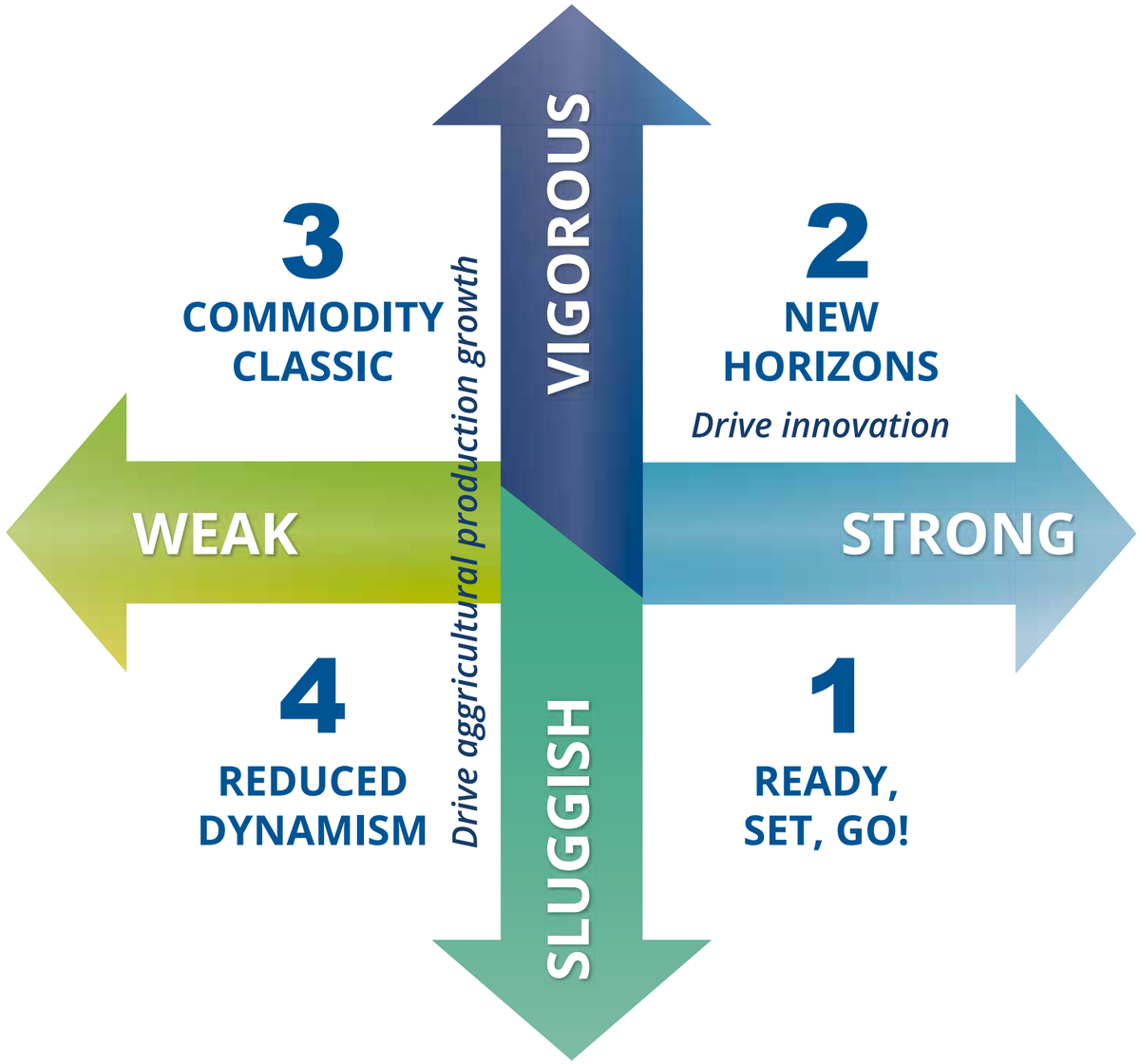
THE SCENARIO DEVELOPMENT PROCESS

Scenarios are a back-drop to strategy discussions, helping companies think about what could be, not what has been. They are not predictions or 'blue-prints' for how the future will unfold. The process typically consists of 4 phases:



OUR SCENARIOS

The IFA scenarios highlight large-scale forces – mostly not under the direct control of the plant nutrition industry - that may move the industry in different directions. Whereas we know that future agricultural production must increase to keep pace with a growing population, and that innovation is an unstoppable force, we cannot know the exact rate of change: these large-scale forces ultimately make themselves felt in either a relatively weaker or a stronger drive for innovation within the full agrifood value chain and a relatively more sluggish or vigorous growth rate of agricultural production.



OUR SCENARIOS DESCRIPTION

1 READY, SET, GO!

Sluggish growth, strong innovation

A world with more sluggish agricultural production growth but with strong drivers for innovation is a scenario we call Ready, Set, Go! In this scenario, a slow-down of agricultural production growth for a variety of reasons would happen alongside a wide variety of innovations. These innovations would unleash new and different ways of doing business, interacting socially, and producing and consuming food. In this environment, successful fertilizer industry players will offer innovative plant nutrition solutions and products, as will a range of other solution providers.

2 NEW HORIZONS

Vigorous growth, strong innovation

A world with strong agricultural production growth and high external drivers for innovation is a scenario which we call New Horizons. A greater push for innovation will unleash strong competitive forces but the ongoing strong agricultural production growth may provide greater breathing room for commodity fertilizer producers.

3 COMMODITY CLASSIC

Vigorous growth, weak innovation

A world with strong agricultural production growth and lower rates of innovation is a scenario which we call Commodity Classic. It is the one that resembles the industry operating environment of recent decades. If this environment endures, the industry will remain mostly focused on producing commodity fertilizers and enjoy strong fertilizer demand growth. Whereas this scenario does not foresee strong external pressure to enhance nutrient use performance, environmental impacts linked to ongoing inefficiencies would be compounded.

4 REDUCED DYNAMISM

Sluggish growth, weak innovation

A world with sluggish agricultural production growth and lower rates of innovation is a scenario we call Reduced Dynamism as the demand growth for fertilizers decelerates while the industry, given weak drivers for innovation, will not embark on new products and approaches. It will largely remain focused on commodities and find itself trying to outcompete other fertilizer producers. In the absence of innovative approaches to enhance nutrient use performance, environmental impacts linked to ongoing inefficiencies will be compounded, even in the absence of high fertilizer demand growth.

READY, SET, GO!

Sluggish agricultural production growth & strong innovation drivers

Lower agricultural growth driven by greater resource efficiency, reduced food waste, and breakthrough technologies leading to radical changes in the way food is produced and consumed.

Operating Context	• Food security can be achieved without significantly higher agricultural production. • Society rejects unsustainable production processes and consumption patterns as pressure mounts around natural resource stress. • High expectations, requirements for cyclical economy, efficient production processes and greatly enhanced nutrient use efficiency.
Fertilizer Demand	Robust demand for innovative plant nutrition solutions & services, relatively weaker demand for commodity fertilizers.
Growth Prospects	Mostly in specialties and broader solutions/services, fierce competition, also from non-fertilizer industry players.
Overhead Costs	Substantially higher investments in R&D, sales & distribution, HR development & recruiting.
Product Diversification Pressure	Extremely high.
Key Success Factors	Selling solutions rather than products. Innovativeness, speed, agility, product and service excellence, customer orientation.

COMMODITY CLASSIC

Vigorous agricultural production growth & weak innovation drivers

Higher agricultural production growth driven by population growth and rising incomes.

Operating Context	• Infrequent extreme weather events with limited and localized impact. • Consumers largely unimpressed by food fads and news headlines; regulators and NGOs focused elsewhere. • No significant increase in nutrient recycling and limited improvements in nutrient use efficiency. • Relatively little pressure to improve environmental performance, but environmental impacts linked to ongoing inefficiencies will be compounded.
Fertilizer Demand	Vigorous agricultural production growth combined with weak push for innovation results in robust demand for commodity fertilizers.
Growth Prospects	Mostly in commodities.
Overhead Costs	Business as Usual.
Product Diversification Pressure	Low, but R&D funds are available for those who wish to diversify.
Key Success Factors	Feedstock access, cost management and process excellence.

NEW HORIZONS

Vigorous agricultural production growth & strong innovation drivers

Agricultural production growth driven by innovations enabling new types of farming and greater integration of smallholders into markets.

Operating Context	• Growth fueled by innovations that expand agriculture into unfavorable climates and onto marginal and formerly degraded lands. • The importance of soil carbon sequestration increasingly recognized. • High expectations, requirements for efficient production processes and greatly enhanced nutrient use efficiency.
Fertilizer Demand	Robust demand for innovative plant nutrition solutions & services and for commodity fertilizers.
Growth Prospects	Growth opportunities in innovative plant nutrition solutions and commodities, but significant competition also from non-fertilizer industry players offering solutions.
Overhead Costs	Substantially higher investments in R&D, sales & distribution, HR development & recruiting.
Product Diversification Pressure	High but more 'breathing room' for commodity producers due to strong agricultural growth. Multitude of companies and entrepreneurs offer dizzying array of plant nutrition solutions.
Key Success Factors	Innovativeness, speed, agility, product and service excellence, customer orientation. Social and environmental sustainability as important as market share and shareholder value.

REDUCED DYNAMISM

Sluggish agricultural growth & weak innovation drivers

Lower agricultural growth driven by lower than expected population growth, and/or decline in living standards due to financial crises, global or regional geopolitical crisis and trade wars, diminishing farming profitability, resource constraints, more extreme weather events.

Operating Context	• Lack of innovative solutions to address resource constraints and improve farmer profitability. • Policymakers focus on conflicts and financial crises rather than agricultural development or resource efficiency. • No excitement about circular economies.
Fertilizer Demand	Reduced demand in terms of nutrient tons, little demand for innovative plant nutrition solutions & services, somewhat offset by reduced focus on nutrient use efficiency and limited nutrient recycling.
Growth Prospects	Limited. Fierce competition among commodity fertilizer producers; national and regional players in proximity to large markets may fare better.
Overhead Costs	Radical cost-cutting required.
Product Diversification Pressure	None.
Key Success Factors	Lowest-cost feedstock, lowest cost capital, process excellence, proximity to markets.

KEY INSIGHTS

The aim in developing these scenarios is to better understand the dynamics of change facing the industry and then, begin to work out what the implications could be for business and its stakeholders. Regardless of which scenario or combination of scenarios emerges, we see the following issues having important implications across the sector.

► INNOVATION / DISRUPTION

Innovation is seen a game changer in the industry with disruption underway as new players enter the market and innovative technologies and services hit the ground. Operational efficiency, including plant, process and logistical efficiency will remain key considerations, and customer orientation and customization and nimbleness become additional increasingly vital enablers of success.

► FARMERS / PARTNERS

The farmer is both a customer and a partner of the product and the health of farming is a prerequisite for the health of the fertilizer industry, and vice versa. Farmers' plant nutrition needs must be considered from a site and crop specific angle, and farmers in mature, maturing and emerging markets will also have different needs. The industry needs to be a champion for sound policy frameworks and investments to support the social, economic and environmental sustainability of farming. The industry needs to clearly position itself given the numerous sources of knowledge and inputs competing for farmers' attention.

► FERTILIZER DEMAND SHIFTS

This exercise does not attempt to predict future fertilizer demand, but presents several scenarios based on examining possible pathways of agricultural production growth and innovation drivers, which may impact fertilizer demand. Further improvements in nutrient use efficiency and increased recycling may lead to a relatively lower demand growth in terms of nutrient tons than experienced in the last decades, but also offer vast opportunities for balanced plant nutrition and innovative plant nutrition solutions. On the other hand, vastly underserved markets of today are already becoming significant fertilizer demand drivers both in terms of nutrient tons, but also in terms of more customized fertilizer products and application solutions.

► REGULATIONS / PRESSURES

The regulatory landscape will expand with increased focus on environmental stewardship, resource competition and protection, health and safety & security concerns, and greener and more eco-efficient farm systems, which will impact also fertilizer production, distribution and application.

► TRANSPARENCY / ACCOUNTABILITY

In the future, the fertilizer industry will face rising downstream requirements for more transparency / accountability (environment and health impacts, product traceability, safety and security).

► LICENSE TO OPERATE / REPUTATION

In order to maintain its licence to operate, innovate and grow, the industry needs to be seen as an integral part of the agriculture value chain and contributing to serving 20 billion meals per day today and 30 billion meals per day in the year 2050.

FORWARD MOTION

Our expectation is that these scenarios will be used to facilitate discussions with regulators, governments, suppliers, customers, civil society groups, educators, scientists or adjacent industries. In this context, the work will help to build a bridge between assumptions, perspectives and requirements of those external stakeholders and how the industry would or could respond to such perspectives and requirements.

Those using the scenarios will find they help focus thinking, identify shared vision and understand what's driving change. A toolkit to assist users is available on-line. This step-by-step guide will make running workshops and dialogue sessions easy, productive and rewarding. www.fertilizer.org/En/About_IFA/IFA_2030/IFA2030_Toolkit.aspx

As our experience using the scenarios builds, we will inevitably advance our thinking around how the industry, including companies and their associations, should better organize and position themselves to meet the challenges ahead. Furthermore, by keeping the different scenarios on the radar, decision makers in the industry can adopt strategies to respond to or anticipate developments and guide the pace and direction of strategic change.

In the sections that follow, we first elaborate the insights and implications, then move to more fully explain the scenarios and conclude with sections that discuss the process and issues underpinning scenario development.

INSIGHTS & IMPLICATIONS

The aim in developing these scenarios is to better understand the dynamics of change facing the industry and then, begin to work out what the implications could be for business and its stakeholders. To help advance this understanding, we captured the following set of insights, questions and quotes. Regardless of which scenario or combination of scenarios emerges, we see the following issues, taken together, as having important implications across the sector.

► INNOVATION / DISRUPTION

Innovation is seen as a game changer in the industry environment. Higher regulatory and stakeholder pressures will serve as drivers for more innovation, but disruption is also inevitable as innovative technologies and services hit the ground. Changes will occur throughout the agrifood value chain, from the provision of inputs, production, harvesting, processing, and transportation, enabled by data-savvy technologies and agtech start-ups. Operational efficiency, including plant, process and logistical efficiency will remain key considerations, and customer orientation and customization and nimbleness will become increasingly vital enablers of success.

How best does the industry pivot from current low R&D investment to higher R&D budgets and broader strategic partnerships to drive greater innovation? Who will take the innovation risks and what is the best way to monitor, engage and facilitate around the frenzy of new players, technologies and applications? How will innovation be evaluated and proven? Where is innovation most likely to have the greatest impact and, how do we ensure communication strategies are effectively reinforcing rather than undermining?

“Farmer innovation will drive fertilizer innovation.”

“The fertilizer industry in general is quite conservative, not radical enough in adopting new technologies… this has to change.”

“It’s not just all about technology… we need to innovate around the soft stuff – how we engage with NGOs, how we popularize our messages.”

► FARMERS / PARTNERS

The farmer is both a customer and a partner of the products and the health of farming is a prerequisite for the health of the fertilizer industry, and vice versa. Thinking backward from the farmer towards one’s own organization will most of the time be a fertile exercise. Farmers’ plant nutrition needs must be considered from a site and crop specific angle, and farmers in mature, maturing and emerging markets will also have different needs. Farmers are under pressure to increase the production of food while preserving the environment and they can’t do it alone. The industry needs to clearly position itself given the numerous sources of knowledge and inputs competing for farmers’ attention.

How will farmer information exchange, capacity-building and fertilizer procurement options advance in the coming years? Other non-fertilizer industry players are vying for the space of providing advice to farmers that was traditionally owned by the industry…how should the industry partner with them? How will farming be pushed to the next level in the future and what’s the role of fertilizers in that ‘lift’?

“Farmers require more customized plant nutrition to better match the specificities of their soils and crops.”

“Smallholder farms provide a great deal of global food production but face many obstacles to increasing their productivity - the dynamics of small farmer’s integration into markets and welfare up to 2030 will play an important role in determining the growth of agricultural production.”

“There will be numerous sources of knowledge jockeying for the attention of the farmer.”

► FERTILIZER DEMAND SHIFTS

This exercise does not attempt to predict future fertilizer demand, but presents several scenarios based on examining possible pathways of agricultural production growth and innovation drivers, which may impact fertilizer demand. Further improvements in nutrient use efficiency and increased recycling may lead to a relatively lower demand growth in terms of nutrient tons than experienced in the last decades, but also offer vast opportunities for balanced plant nutrition and innovative plant nutrition solutions. On the other hand, vastly underserved markets of today are already becoming significant fertilizer demand drivers both in terms of nutrient tons, but also in terms of more customized fertilizer products and application solutions. Moreover, possible solutions to water constraints or efforts to bring degraded land back into cultivation, would clearly also have an impact on agricultural production, and by extension on fertilizer demand. Last, but not least, although not the focus of the scenarios (which emphasize plant nutrition), the growing market for industrial uses of nutrients also needs to be mentioned.[vi]

► REGULATIONS / PRESSURES

The regulatory landscape will expand with increased focus on environmental stewardship, resource competition and protection, health, safety and security concerns, and around greener and more eco-efficient farm systems. The operating environment for the fertilizer industry will become less industry-neutral and more prone to rising criticisms. Industry will face rising pressures for responsible fertilizer production and application to prove its actions are environmentally sound. The industry must demonstrate and verify its commitment to continuous improvement and work hard to facilitate more and better understanding of the industry within the policy and regulatory arena.

What metrics will regulators require to verify performance? Who will measure them?

“ Even people who should know better do not understand that fertilizers are different than pesticides or GMOs. ”

“ We are going to see a lot more attention paid to the impacts that fertilizer production and application have on the environment. ”

► TRANSPARENCY / ACCOUNTABILITY

The fertilizer industry will face more requirements for greater transparency / accountability (environment and health impacts, product traceability, safety and security). This will be technology enabled and largely driven by down-stream players (retailers, manufacturers and consumers) and other stakeholders (NGOs, regulators, academia). Furthermore, there is a broad range of stakeholders who expect to know from the industry how it intends to contribute its fair share of problem solving to many of the global challenges, including food security, poverty alleviation, protection of the environment, climate change adaptation and mitigation, and more, as outlined in the Sustainable Development Goal Agenda. The industry, both collectively and individually needs to be prepared and willing to respond to these stakeholders. The better the dialogue and communication with either regulators, or civil society groups, or academia to name only three, the better are the expected results for the industry under any future.

How well-prepared is the industry to demonstrate its accountability and to manage this information, communication and engagement tsunami?

“ No doubt there will be demand for proof of no adverse effect of new products. ”

“ Greater levels of transparency mean we have to get better at communicating. ”

“ The industry can do more to promote efforts to advance global food security and environmental stewardship through partnerships, and as such play a vital role in the SDG agenda. ”

► LICENSE TO OPERATE / REPUTATION

An issue that will only grow in relevance is that of reputation and how the industry is perceived by external stakeholders. Despite the critical role fertilizers play in feeding the world and contributing to improving people’s lives, fertilizers are not well-understood. Unless addressed, the industry’s license to operate, innovate and grow will be impeded. The industry needs to be seen as an integral part of the agricultural value chain and contributing to serving 20 billion meals per day today and 30 billion meals per day in the year 2050, while continuously reducing its environmental footprint. Today it is not seen this way.

What needs to happen at the industry, company and association level to shift perception and reputation from a potential liability to a secure asset? What are the costs of in-action?

“ When people ask, I prefer to tell them I work for a petrochemical rather than a fertilizer company, to avoid a negative reaction. People don’t even know what we do! ”

“ We don’t want to be seen as the ‘next tobacco’ or ‘next coal.’ We really need to figure out where we want to be and who we want to be - what’s our ‘public face’? ”

IFA2030 SCENARIOS

In this section we explain each of the four scenarios, elaborating on how each of the 'futures' came about, what some of the implications could be and, who might the winners and losers be should each scenario take shape. In principle the scenarios apply to all geographies and all subsectors of the industry and yet, not all regions and subsectors are likely to experience the same kind of future. Different scenarios or combinations thereof may come to pass in one region rather than another, or different subsectors within the same region. For this reason, we do not rate the scenarios in terms of likelihood, or desirability.

The fertilizer industry is capital intensive and utilizes its production assets for many decades. A planning horizon for the year 2030 is therefore not far away. Many of the underlying forces operate on an even longer term. The scenarios are meant as a guide to informing strategy and decision making over the medium-term planning horizon of industry participants. For some participants medium term could mean two to five years, for some it could mean ten to twenty years.

We know that the industry is subject to a wide variety of forces, which often tug at different and mutually exclusive directions. Most of these forces are not under the direct control of the plant nutrition industry. We also know that future agricultural production must increase to keep pace with a growing population, and that innovation is an unstoppable force, but we cannot know the exact rate of change: these large-scale forces will ultimately make themselves felt in either a relatively weaker or a stronger drive for innovation within the full agrifood value chain and a relatively more sluggish or vigorous growth rate of agricultural production. As in any long-range forecasting exercise it is therefore impossible to predict with any near precision which future will arise.

As these two dimensions are MECE (mutually exclusive/comprehensively exhaustive)[vii] they therefore create four prototypical scenarios, providing outlines and characteristics of truly different futures.

READY, SET, GO!

Slow growth, high innovation

A world with more sluggish agricultural production growth and strong drivers for innovation is a scenario we call Ready, Set, Go! In this scenario, a slow-down of agricultural production growth would happen alongside a wide variety of innovations, which would unleash new and different ways of doing business, interacting socially, and producing and accessing food. Innovative solutions to increase nutrient recycling and enhance nutrient use efficiency lead to lower fertilizer requirements, compounding the impact of slower agricultural production growth, resulting in relatively lower fertilizer demand in terms of nutrient tons.

HOW COULD SUCH A WORLD COME ABOUT?

► In the world of Ready, Set, Go!, the slower growth of agricultural production would primarily arise from a high rate of socioeconomic innovativeness, leading to dramatic resource efficiency gains. Innovation in economic processes, business models and societal arrangements, triggered by planetary resources becoming either factually scarce (e.g., water scarcity), or by regulatory action restricting the use of or access to mineral and energy resources, would press for greater resource efficiency and reduced waste throughout the whole value chain. It's a world were hydroponic agriculture, vertical farming, stepped-up algae- or insect-based protein production, alternatives to animal-derived proteins, or even new and innovative synthetic foods grown in the laboratory rather than in the fields, may be reaching industrial scale. Significant improvements in crop and food storage and distribution, or significant efficiency gains could reduce waste along the agrifood supply chain. In this scenario, food and nutrition security can be achieved without significantly higher agricultural production growth.

► The broad-scale advent of breakthrough technologies that are currently coming on-line, could lead to radical changes in the way food is produced, altering farming and production practices. These are difficult to predict but may come at a dizzying rate. While the traditional field farmer model will not disappear, the new society will build new farming business models. It can be debated whether the synthetic meat printing kiosk operator in the center of a city can be called a farmer, but this operator will do the same as the traditional livestock producer: provide protein food.

► The breakthrough technologies in genomics, artificial intelligence, augmented reality and robotics do not just make existing processes and products faster and easier, they create new conditions in which new ways of living and new urban cultures unfold. This new society also creates new food habits.

► This new society rejects a life style which is not perceived as environmentally sustainable and enforces standards of total transparency and traceability, available in real-time through blockchain encoded-information embedded in the food products that are bought in the super markets (and/or delivered on-demand by robots and drones), or which are consumed in restaurants or snacks on-the-go. Civil society will investigate health concerns related to how and where their food is produced and may place a greater scrutiny on inputs.

► It is also a world with exciting new products and new value chains, where innovation is called for and celebrated, where challenges that seemed unsurmountable can be solved with a simple click. This is a world where new opportunities open up, and where pioneers and adventurers can make their fortunes. As a result, many business models will live, side-by-side, complementing each other and being symbiotic to each other. It is a world of great variety and maximum complexity.

WHAT MIGHT BE THE IMPLICATIONS FOR THE FERTILIZER INDUSTRY?

► Despite lower agricultural production growth, nutrients will remain vital. A world that rapidly creates for itself a new society, fueled by breakthrough technologies from communication, biology and mechanics, will still need to eat. Algae, insects and laboratory-grown food also need nutrients. ‘Cityscapes’ provide vertical agriculture which require even more nutrients because there is no natural soil. Microbial synthesis of food in reactors need still more nutrients because there is not even the sun to serve as an energy source.

► However, given a significant shift in diets, a reduction of food waste throughout the food value chain, enhanced application effectiveness of fertilizer through, for example, precision farming and improved genetics, and higher degrees of recycling of organic sources (from manure and sewage sludge), the combined effect of this scenario may result in reduced demand growth in terms of nutrient tons than that experienced historically. This trend would be reinforced by technological breakthroughs of a ‘game-changing’ nature, such as crops genetically modified to fix nitrogen or require less fertilizers or a capacity to “trap nutrients” to avoid their dispersion in the environment.

► While there will surely continue to be a need for fertilizers, plant nutrition, both in traditional and possibly new types of food production system, will need to be ever more precise and efficient given the scrutiny of civil society, regulators, food manufacturers. More precise proof of the impact of farmers’ best management practices (4Rs), and information about the carbon footprint of both fertilizer production and application will be demanded.

► By 2030, the greatest value may be found not by selling a product, but by selling a specific solution. For instance, in this world, modern progressive farmers may not be buying fertilizers anymore. They might instead be buying a guaranteed amount of photosynthetic conversion efficiency from a fertilizer expert. It is then up to this expert to use data analytics to specify exactly how and when to apply the plant nutrients needed to be applied to the fields (or the vertical gardens). This data analytics expert makes his money by buying the right kind of fertilizers and finessing their application through superior data sensing and processing. This expert may be sitting physically in Bangalore or downtown New York, commanding a fleet of field robots to handle the actual nutrient dispersion. Fertilizer sellers would need to create a strong and convincing offer in order to keep part of the value creation pie for themselves. E-commerce and Blockchain would expand and facilitate transactions from mines to fields. New distribution systems will integrate product delivery and expert advice, with close linkage to other crop inputs.

► Given that large-scale fertilizer plants have life-times of 40 years or more, it could well be that the existing fleet of production facilities is by and large sufficient for the next 30 years, with some upgrades and replacements, but no significant net growth of production capacity. Sluggish fertilizer market conditions would lead to rising competition for innovative mining/manufacturing processes and products, to reduce costs, preserve margin and secure customer bases. New competitive processes that have the potential to replace the Haber-Bosch ammonia synthesis process, could lead to stranded assets in the nitrogen segment.

► In the Ready, Set, Go! world, technology facilitates greater transparency which in turn builds trust and bridges among key players including NGOs and regulators. However, as many more products and services become available, the industry would need to be prepared for societal questions about and suspicions of new and unproven processes and products.

WHO ARE THE LIKELY WINNERS AND LOSERS IN THE WORLD OF READY, SET, GO?

► While commodity fertilizer will certainly still be needed, and access to feedstocks and process excellence continue to be important, the greatest rewards will flow to players with agronomic expertise who excel in customization, and benefit from excellent logistical connections to farmers.

► This is a world where nimbleness, speed and agility outdo size and scale. This is a world where quality means far more than quantity. This is a world where providing the exact right kind of nutrient, at exactly the right time, in exactly the right place and at exactly the right rate, is the entire and only ‘name of the game.’ Fertilizer producers who cannot vouch that their products are used efficiently may be asked to pay to remediate nutrient losses to the environment.

► Given the strong drivers for innovation, the fertilizer industry will need to ensure that it can take the lead on enhancing plant nutrient efficiency (by outcompeting or partnering with other parties, i.e. biotech, big data, or precision ag companies), as there are many other players putting forward solutions. If fertilizer companies can position themselves as plant nutrition stewards, they can experience drastic growth rates and possibly higher margins for highly specialized applications of nutrient packages. Likewise, the industry may be able to place itself in the ‘pole position’ to lead the creation of recycling systems of plant nutrients or integrate close-loop systems in manufacturing. Companies who can cater to customer needs also beyond plant nutrition, i.e. improve nutritional security through biofertilization with micronutrients, and/or provide farmers with holistic sustainable agricultural solutions will reap the biggest benefits. Winners will need to excel at proving and marketing the value of their products and services amidst a dizzying array of offerings to farmers.

► Financial capital investments will flow from feedstock access and investments in production efficiency to customer access and expand from process excellence to product excellence. Human capital talent will similarly be attracted to companies that excel for customer and products, rather than companies that are built around supply and processes.

► Technology adopters that achieve differentiation will be winners in a Ready, Set, Go! world, particularly if they develop innovative partnerships.

WHERE ARE THE QUESTIONS COMING FROM AND WHAT MIGHT THEY IMPLY?

Farmers: *“Which market disruption technology should I try first?”*
NGOs: *“You are big, and your pockets are deep … #MeTooEnvironment.”*
Regulators: *“We don’t want to regulate farms – it’s easier to regulate industries.”*
Tech-entrepreneurs: *“How do I harvest big data and access information flows and the systems they ride on?”*

NEW HORIZONS

Strong growth, high innovation

A world with strong agricultural production growth and high external drivers for innovation is a scenario which we call New Horizons. A greater push for innovation will unleash strong competitive forces but the ongoing strong agricultural production growth provides greater breathing room for commodity fertilizer producers.

HOW COULD SUCH A WORLD COME ABOUT?

► As in Ready, Set, Go!, there are many of drivers of innovation resulting in new models of food production and solutions being developed by a myriad of players.

► In this scenario, however, the strong push for innovation is combined with higher rates of production growth resulting from advances in agricultural systems and a vastly improved integration of smallholder farmers into input and output markets. Innovations in irrigation and agricultural technologies facilitate greater agricultural production in unfavorable climate areas and marginal or degraded lands.

► Higher agricultural production growth is also triggered by a recognition that increased rates of photosynthesis may be the fastest and in the short-term most effective route to provide a carbon sink for CO2 currently in the atmosphere and the only way to reach ambitious greenhouse gas reduction commitments.

WHAT MIGHT BE THE IMPLICATIONS FOR THE FERTILIZER INDUSTRY?

► Increased recycling and a strong focus on reducing nutrient losses to the environment is counterbalanced by the need for more fertilizer in new farming models.

► A relatively stronger demand for fertilizers, in turn, will provide fertilizer producers with resources to pursue innovative products and modes of application, since relatively less efficient fertilizer production systems and high nutrient losses to the environment resulting from fertilizer application will become increasingly unacceptable. Competition to demonstrate environmental sustainability for both production and application will likely be fierce, but not as fierce as under the Ready, Set, Go!, since higher agricultural growth rates can help facilitate this transition.

► There is room for commodity fertilizer producers to continue adding production capacity at a continuous pace. However, buzzing around this traditional core will be a multitude of companies and entrepreneurs who provide various kinds of services and products to the farmers to fit their very specific needs for serving the new food tastes and health and environmental expectations of a new society.

► In New Horizons there will be greater pooling of farm and other data and a digital revolution resulting in significant changes in transportation and logistics.

WHO ARE THE LIKELY WINNERS AND LOSERS IN THE WORLD OF NEW HORIZONS?

► Although this highly innovative world will lead to new and very different types of farming methods, nutrients will still be required. If materials for food come from urban cityscape vertical gardens, from laboratories, from insects and algae, or from reactors in which fungi swim in a nutrient soup, fertilizers will remain an important input into food production. Moreover, vastly improved agricultural processes driving agricultural production growth, keep fertilizer demand in nutrient tons relatively strong.

► Plant nutrition experts who can figure out how to develop specialized products, market and deliver these in customized ways will be in a winning position. That said, there continues to be demand for commodity fertilizers, which provide, after all, the base for more specialized solutions and will still be applied given the relatively strong fertilizer demand in nutrient tons. Technological processes (Haber-Bosch) could be mothballed and replaced by new technologies with accelerated R&D investments. New technologies could be developed to by-pass current process for producing phosphatic and potassic fertilizers, leading to lower by-product waste, higher resource efficiency, higher nutrient recovery and wider range of customized products.

► In a New Horizon future there will be new and innovative products as well as distribution channels. It is clear that precision agriculture and data-driven analytics will be key and play a big role in this world.

WHERE ARE THE QUESTIONS COMING FROM AND WHAT MIGHT THEY IMPLY?

Farmers:	*"How do I make well-informed decision on the advantage of a wider range of products, especially as I become more specialized?"*
NGOs:	*"Show me the data … I want to validate your numbers."*
Regulators:	*"Quantitatively, how has this process or product reduced nutrient losses to the environment?"*
Tech-entrepreneurs:	*"How do I encourage investment in my disruptive agtech innovation?"*

COMMODITY CLASSIC

Strong growth, low innovation

A world with relatively stronger agricultural production growth and weak innovation drivers is a scenario which we call Commodity Classic, as it is the one that resembles most closely the operating environment of the industry over the last decades. Commodity fertilizer production retains its importance and there are less competitive pressures given the higher agricultural production growth and decreased focus on more efficient plant nutrition solutions. Whereas this scenario does not foresee strong external pressure to enhance nutrient use performance, environmental impacts linked to ongoing inefficiencies will be compounded.

HOW COULD SUCH A WORLD COME ABOUT?

► In this world, agricultural production continues its steady growth path, driven by the two underlying forces of population growth and prosperity growth. The forces of steady growth of the past continue without interruption. Higher agricultural production growth is also required as there are no breakthroughs on solutions to reduce food waste.

► Extreme climate change induced weather events occur only infrequently with temporary and localized impacts, and cross border global commerce continues to thrive despite some localized trade barriers or isolated pockets of worsening security.

► While concerns about nutrient losses to the environment will not disappear, they remain minor given the overriding need to feed an ever growing and increasingly affluent global population in a context of limited availability of arable land. Policymakers understand that higher levels of agricultural production require that farmers have access to sufficient fertilizers at affordable prices. Consumers remain largely unimpressed by fads and news headlines: at the end of the day, each citizen of the world needs a meal, preferably three times per day, and preferably a meal that is healthy, nutritious and enjoyable.

WHAT MIGHT BE THE IMPLICATIONS FOR THE FERTILIZER INDUSTRY?

► In Commodity Classic, commodity fertilizer producers benefit from robust fertilizer demand growth given the high agricultural growth, reinforced by lagging progress towards recycling and enhanced nutrient use efficiency. On the assumption that the vital global trade links remain intact, fertilizer producers with access to abundant and relatively low-cost feedstock will increase their profits. Process excellence continues to be an important element of success.

WHO ARE THE LIKELY WINNERS AND LOSERS IN THE WORLD OF COMMODITY CLASSIC?

► The captains of this industry continue to steer the industry adequately by adding capacity as necessary, by opening up new resource supplies as required, by creating logistics frameworks to deliver the huge tonnages involved and enabling necessary returns on capital for the entire fertilizer value chain. There is little reason or incentive to change that structure. Extending the same level of farm productivity to all the farmers in the world requires neither Facebook nor nano-specialty fertilizers. As in the past, the laws of investment cyclicality will provide some years with slight global overcapacity followed by years of improved margins. The next 30 years would be much like the past decades.

► The most important pathways to value creation remain access to low cost feedstock, low processing costs and optimized distribution systems. This is a function of size of the production facility, process know-how excellence and value chain integration incentives. Since a cost-efficient size of a facility today costs above USD 1 billion, this represents a barrier to entry to casual prospectors. Only seasoned players or developers with strong business cases would have access to such capital. Proving oneself worthy of such huge investments is therefore the second most important pathway to value creation. Marketing and sales skills are less vital for success: the product mostly finds its own way to the customers.

► Despite the reduced push for innovation, the basic profitability of the industry is strong enough to allow companies to make the necessary investments in ensuring more precise fertilizer application, if they so wish, and such companies could be in a strong position to take the lead on enhancing fertilizer efficiency if there is limited competition from other players (i.e. biotech or biostimulants industries, or precision agriculture) given the relatively low drivers for innovation. Companies that proactively make these types of investments will be much better prepared when policymakers and consumers may ultimately become more concerned about addressing the environmental impacts of a Business as Usual scenario.

WHERE ARE THE QUESTIONS COMING FROM AND WHAT MIGHT THEY IMPLY?

Farmers:	*"How can I ensure cost-effective, reliable access to fertilizer inputs to help me increase my yields year after year?"*
NGOs:	*"How can we get the industry to focus on other priorities besides ramping up production?"*
Regulators:	*"How can we balance this high fertilizer demand with environmental measures?"*
Tech-entrepreneurs:	*"What can I do to stimulate R&D around here ...?"*

REDUCED DYNAMISM

Slow growth, low innovation

A world with sluggish agricultural production growth and low rates of innovation is a scenario we call Reduced Dynamism as the demand growth for fertilizers decelerates while the industry, given weaker drivers for innovation and reduced profits, will not embark on new products and approaches. It will largely remain focused on producing and selling commodities and find itself trying to outcompete other fertilizer producers. In the absence of innovative approaches to enhance nutrient use efficiency, environmental impacts linked to ongoing use inefficiencies will be compounded, even in the absence of high fertilizer demand growth.

HOW COULD SUCH A WORLD COME ABOUT?

► Sluggish agricultural production growth may result from lower than expected increases in global population and income growth, or from a failure to address water scarcity, land degradation or to cope with and rebound from more frequent extreme weather events. Global economic policy failures could also pave the way for such a world: a strong rise in trade barriers, diminishing farm profitability or a prolonged financial crisis creating capital shortages, leading to inhibited growth potential of agricultural production, in particular among small-scale farmers. Regional conflicts and possibly world-scale conflicts may also take a serious toll on the agricultural sector.

► These serious challenges would not be mitigated in a meaningful way by breakthroughs at the farm level: solutions to address widespread water scarcity or bring degraded land back into production are not found.

► Policymakers may find themselves fully occupied with financial crises or conflicts and forced to put agricultural development or resource efficiency on the back burner. Financial or technological aid to farmers is not forthcoming, the private sector has limited funding for R&D, and the current excitement around circular economies and new foods has proven themselves to be niche phenomena so there is little incentive to innovate.

WHAT MIGHT BE THE IMPLICATIONS FOR THE FERTILIZER INDUSTRY?

► Difficult economic conditions do not allow farmers to make the necessary investments in productivity enhancements, on which fertilizer demand growth depends. The commodity fertilizer industry will face decreased fertilizer demand growth, but this is somewhat mitigated by society's lagging interest in promoting a circular economy and less pressure to enhance nutrient use efficiency.

► Given relatively weaker drivers for innovation, the fertilizer industry is not incentivized to jump onto a different 'bandwagon' of a new world of plant nutrition, and competition in the commodity space is fierce. The industry may experience considerable competition that would lead to consolidation towards a much smaller number of regional or global players. Accordingly, many uncompetitive companies may disappear, and many production facilities would close.

► Should there be serious impediments to trade however, the end result might be a shift away from large international players to more regional and national companies. While this would not lead to more net global production capacity addition, there could be increasing production capacity to meet fertilizer demand in regions, which can no longer rely on imports. Rising trade barriers would impact fertilizer affordability, lead to countervailing actions and isolate domestic markets from the international scene. New opportunities at the regional and domestic level may emerge, in particular if significant investments occur at the regional level to unlock fertilizer demand.

WHO ARE THE LIKELY WINNERS AND LOSERS IN THE WORLD OF REDUCED DYNAMISM?

► Amidst consolidation and shrinkage, four 'ace cards' in the deck will continue to define who the (few) winners will be. This includes those with: a) access to the cost-competitive feedstock; b) access to lowest cost capital to drive the acquisition game; c) access to process excellence know-how so that the production facilities run at the very low cost of production and; d) access to improved transport, distribution and logistical infrastructure. Players that don't have these four advantages, or only one of them, will likely disappear as separate entities. To the extent that fertilizer production and distribution becomes less global, companies who are situated in large consuming or in local captive markets will be the most successful. Also, production facilities located closer to feedstock will have a marked advantage.

WHERE ARE THE QUESTIONS COMING FROM AND WHAT MIGHT THEY IMPLY?

Farmers: *"How will my children make a decent living from this farm?"*
NGOs: *"How can we improve the access of smallholders to productivity-enhancing inputs?"*
Regulators: *"What can we do to stop this barrage of trade barriers?"*
Tech-entrepreneurs: *"We're not sure there's much action around here."*

DRIVING FORCES

In this section, we provide the background on how we derived these four plausible futures. These themes are foundational and underpin the scenarios, forming the basis for the Y and X axis, and subsequently, the four quadrants from which the scenarios emerged.

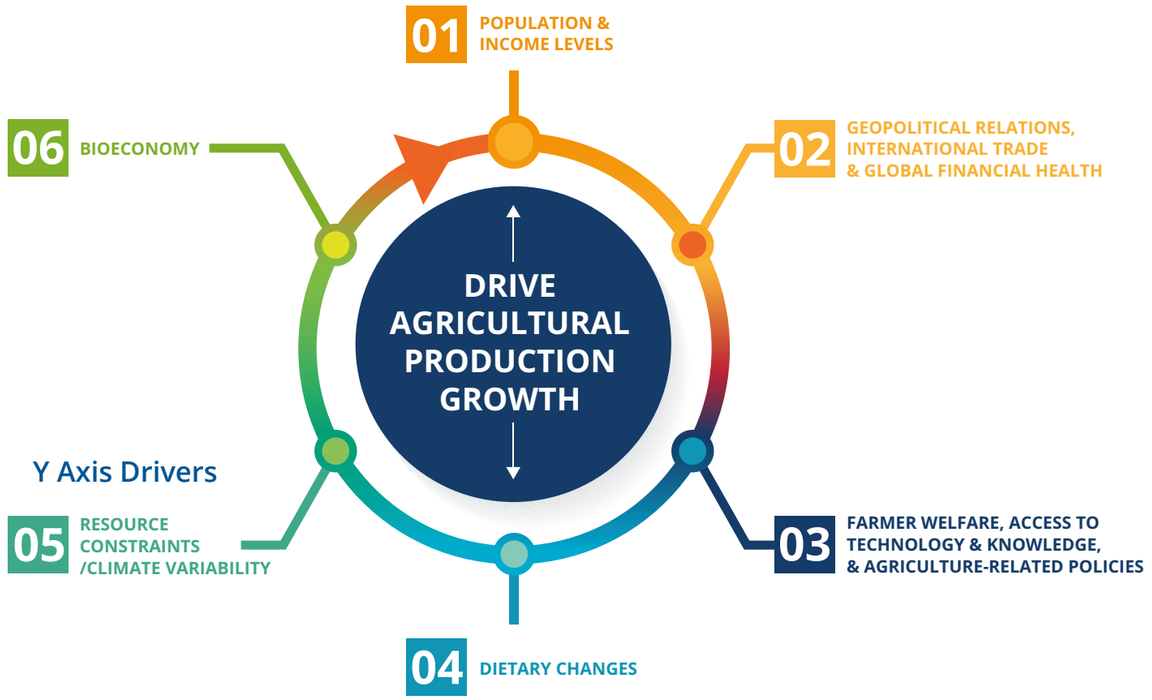
Along the Y axis, there are factors which could drive agricultural production growth (at relatively higher or lower rates) and along the X axis, factors which could drive innovation within the full agrifood value chain (to a greater or lesser extent). Whereas we know that future agricultural production must increase to keep pace with a growing population, and that innovation is an unstoppable force, we cannot know the exact rate of change, which may differ depending on how the underlying factors play out.

We begin with listing some factors which – depending on how they unfold - could trigger relatively greater or relatively more sluggish agricultural production growth. Participants identified a range of issues that could lead to relatively higher or lower agricultural production growth rates. We clustered these inputs under the headings as follows:

► Y1. POPULATION AND INCOME LEVELS

The world's population is expected to reach 8.6 billion by 2030 (and 10b by 2050) thus making it an important driver for agricultural production growth. More than half of the growth between now and 2050 is expected to occur in Africa. Asia is expected to be the second largest contributor. Populations in America and Europe are not expected to change dramatically.[viii] It must be noted, however, that there are variations among these projections, which could result in relatively higher or lower growth than anticipated. Moreover, participants spoke about hopefully unlikely but nonetheless possible catastrophic events, such as a major public health crisis or global conflict, which may impact future population levels.

AGRICULTURAL PRODUCTION GROWTH SPECTRUM (Y AXIS)



Diets change significantly as the extreme poor move out of poverty; improvements in income are expected to contribute to greater food demand and agricultural production. However, the extent of income growth is difficult to predict. In particular, it remains to be seen whether the global community can truly end hunger and all forms of malnutrition by 2030, as called for in the UN Sustainable Development Goals agenda. It is instructive to note that current expert estimates for food demand by 2050 range quite widely between 50% to over a 100%.

► Y2. GEOPOLITICAL RELATIONS, INTERNATIONAL TRADE AND GLOBAL FINANCIAL HEALTH

Many contributors to the scenarios expressed concern that worsening geopolitical tensions could ignite trade wars. Given the dependence of the global food system on relatively uninhibited product flow, even a moderate increase of trade barriers could lead to disastrous breakdowns of efficient market functions with multiple ripple effects. Other geopolitical 'flash points' raised by participants included concern about increases in civil and regional conflicts, mass displacement/migration, and a prolonged harsh and widespread financial crisis.

All such events – should they come to pass - would slow down economic growth and inhibit investments for supporting agriculture, and improving agrifood distribution and logistics channels, and by extension, would impact the growth potential of agricultural production.

► Y3. FARMER WELFARE, ACCESS TO TECHNOLOGY AND KNOWLEDGE, AND AGRICULTURE-RELATED POLICIES

Agriculture can only flourish with healthy farming sectors, which, in turn, depend on good farmer linkages to input and output markets as well as access to know-how and technology, and a conducive policy environment.

The SDG agenda calls for a doubling of agricultural productivity and incomes of small-scale food producers, particularly women, "including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment." (SDG 2). This is a noble and ambitious goal, but its success is far from guaranteed. Sub-Saharan Africa, for example, could, with the right type of policies and investments, become a significant agricultural powerhouse by 2030, whereas policy failures could make it difficult for farmers to make the necessary investments in productivity enhancements.

Improving access to input and output markets and farm logistics through greater value-chain linkages would create a big boost in agricultural production and reduce post-harvest losses so prevalent in developing country agriculture.

One estimate indicates that if some 275-350 million farmers could gain access to mobile-based services by 2030, some additional 250-500 million tons of food could be produced,[ix] and the numbers would be larger if other emerging technologies could be utilized in the value chain, such as Big Data, Blockchain, and improved logistics and traceability.

Innovations in the agrifood value chain, including in farming, can certainly unlock new agricultural demand. Key to this will be access to and affordability of digital tools, connectivity, computing systems, artificial intelligence, and open-source software. Aerial images from satellites or drones, weather forecasts and soil sensors are making it possible to manage crop growth in real time. Farmers are using cell phones to check market prices before selling to middlemen, and market traders can accept payment in mobile money.[x]
A further important production boost would be achieved by greater access of smallholders to insurance products, whose costs may decrease with improved data and analytics.

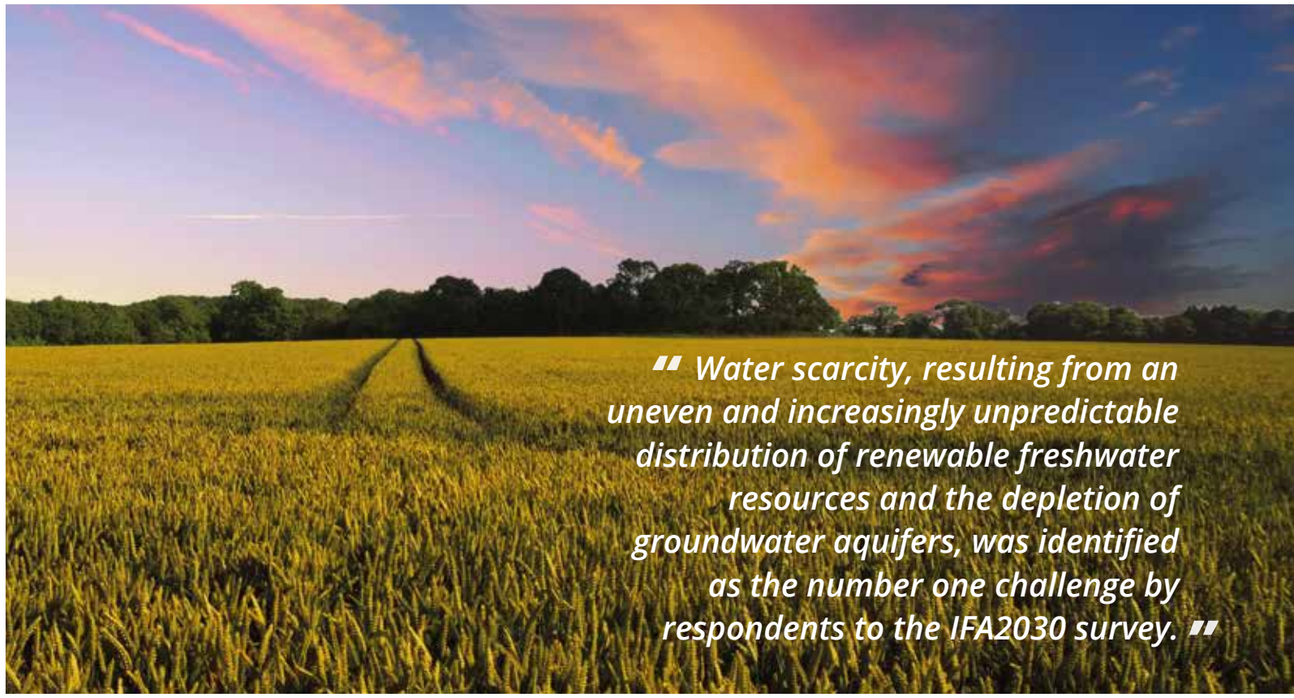
Agricultural policies also impact agricultural production, i.e. the access provided to finance, the provision of agricultural (including input) subsidies; financial support to farmers based on set-aside or other environmental schemes; possible carbon offset payments to farmers to compensate them for improved environmental performance.

► Y4. DIETARY CHANGES

Whereas income growth is coupled, in particular, with increased demand for livestock products, it cannot be ruled out that the well-entrenched trend of falling per capita meat consumption in Europe and North America, primarily for health reasons, might accelerate and spread to emerging economies. It is also important to note vast regional differences in diet in emerging economies, with large majorities, for example, the 1.4 billion Indians choosing a mostly plant-based diet. Alternatives to animal-based proteins are also being heralded as a pathway to more sustainable food systems, with some voices advocating for a "Demitarian Diet" which consists of halving the amount of animal products one consumes and replacing these products with plant-based foods. Needless to say, should such dietary changes ensue, they would have a significant impact on agricultural production growth (and by extension on fertilizer demand) considering that some 33% of all croplands are used for feed production.[xi]

Estimates suggest that if only 10-15% of the global animal protein consumption were replaced with alternative proteins -derived from sources with a smaller environmental footprint - i.e. insects, plants, aquaculture and cell cultures, 250-400 million hectares of land would be spared.

A shifting focus from food security (defined solely in terms of calories) towards a greater focus on nutrition (given the rise in diet-related illnesses and conditions, such as vitamin and micronutrient deficiencies and obesity) can also impact consumption patterns, agricultural production and food processing.



► Y5. RESOURCE CONSTRAINTS/CLIMATE VARIABILITY

Water scarcity, resulting from an uneven and increasingly unpredictable distribution of renewable freshwater resources and the depletion of groundwater aquifers, was identified as the number one challenge by respondents to the IFA2030 survey. Water scarcity could have far reaching impacts on agricultural productivity unless it is remediated by means such as: advances in irrigation technology; more widely available, economical desalination and water recycling and; enhanced water use efficiency, enabling plants to produce "more crop per drop."

Land and soil degradation are resource constraints that may also stifle agricultural production growth by rendering current agricultural areas unproductive, in the absence of sustained efforts to reverse land degradation and bring degraded land back into production. Increasing scarcity of arable land (and rising land costs) could have a negative impact on agricultural production growth unless they lead to more farming innovation to enhance productivity on remaining arable land.

Climate change may bring an incremental increase in temperatures and seawater levels by 2030 which jeopardize agriculture in some regions, but we may also consider land mass and regions that, due to the extreme climate conditions, were previously 'off-limits', becoming productive and cultivable land or that yields increase as a result of greater levels of carbon dioxide in the environment. The bigger potential impacts on agricultural production growth rates by 2030, however, are likely to come from extreme weather events, the frequency and gravity of which are difficult to predict.

► Y6. BIOECONOMY

Another important driver for agricultural production will be the extent to which agricultural products will be used as energy feedstocks or other non-food and non-feed purposes (i.e. biodegradable packaging, other bioeconomy products).

FACTORS WHICH COULD DRIVE INNOVATION (X AXIS)

We now discuss some factors which – depending on how they unfold – would result in relatively stronger or weaker drivers for innovation. We summarize these factors under the following clusters:

► X1. REGULATORY PUSH

Governments may resort - to varying degrees - to regulatory measures as a means to promote greater resource efficiencies, reduce waste streams, and promote a circular economy. More stringent climate change regulations, carbon taxes or carbon offsets under a potentially higher carbon price may drive significant shifts in energy mix, use and efficiency.

Participants also focused on possible regulations targeted more specifically on fertilizer production and application, i.e., more stringent environmental regulations on mining and manufacturing could press the industry to find innovative processes to reduce processing waste and emissions, better manage by-products and optimize access and use of available resources in more cost-effective ways. It was flagged that the "license to operate" of the fertilizer industry will be contingent to its ability to meet societal and environmental requirements along with technical and economic factors.

In the field of plant nutrition, governments might mandate or incentivize greater nutrient recycling from both manure and wastewater treatment facilities. Moreover, they may, to differing degrees, consider varying levels

of regulations and incentives in order to reduce nutrient losses to the environment in response to growing concerns about planetary boundaries and health concerns, water, soil and air quality concerns, as well as about greenhouse gas emissions from fertilizer application and production.

While there are environmental concerns linked to all nutrient losses to the environment, reactive nitrogen is receiving the most attention, with claims being made that nitrogen use efficiency (which measures the ratio between input of nitrogen and output in terms of nitrogen taken up in the harvested crop) of the world's famers has slipped from more than 50% in 1961 to circa 42% today and calls for an increase to 67% by 2050 in order to stay within the so-called planetary boundary for nitrogen.[xii] It is possible that currently non-binding resolutions from scientists or UN agencies eventually lead to mandatory regulations, i.e. mandating fertilizer use restrictions, nutrient balance levels or nutrient use efficiency targets.

► X2. CONSUMER/NGO/VALUE CHAIN PLAYER DEMANDS

It is increasingly accepted that in developed countries, many stakeholders will continue demanding ever greater transparency about food production and processing, and that food manufacturers and retailers will continue to respond to such pressures, a task that will be greatly facilitated by new sensing technologies and traceability schemes, for example, through Blockchain. The Ecolabel Index currently tracks over 463 ecolabels in 199 countries.[xiii] The more interesting question is the extent to which consumers in developing countries will follow suit. Demands for transparency, reporting and accountability on companies of all sorts, including from shareholders or the financial community (some institutional investors today are already divesting from fossil fuel-based projects), are likely to increase to a lesser or greater degree and may thus have varying impacts on driving innovation.

> It remains to be seen whether consumers will truly 'walk their talk' and abandon products which they perceive to be not sufficiently sustainable, causing demand for some resource intensive food products to fall dramatically. Will the current excitement around new foods, new lifestyles, new farming methods and new food production styles end up being a niche or fad phenomenon in the bigger scheme of things or lead to a fundamental change in agricultural production?

The organic or "natural food" movement may grow wider. Consumers as well as food manufacturers may take a greater interest in plant nutrition, signaling concerns that on average 50% of fertilizers applied are not taken up by crops. Participants spoke of possible calls to reduce mineral fertilizers use or demonstrate improved nutrient use efficiency, but also to shift to an agricultural system less reliant on fossil fuels.

Consumer/civil society demands may also include calls for increased transparency around resource availability and use efficiencies (water, minerals, energy), as well as for safer industrial production, and thus also have an impact on fertilizer production processes, given the sector's heavy reliance on energy feedstocks and minerals.

► X3. SCIENCE, TECHNOLOGY AND DATA

Ultimately, the progress of science and technology itself drives innovation. Most of the contributors to our scenario-building process see a future in which satellite imaging and 'Big Data', dramatically improved soil and plant diagnostic tools and advances in precision farming will continue to change the world of agriculture and assist with the ongoing objective of enhancing nutrient use efficiency in particular.

> Louis Dreyfus Co, a leading agricultural commodities trader, and a group of financing banks have completed the first agricultural deal using blockchain in a further sign that the digital technology is set to change the way raw materials are bought and sold. Originally built to process bitcoin deals, blockchain is an electronic ledger which stores records of deals in digital blocks. Commodities traders are among those hoping that the technology will lead to faster, cheaper and more secure ways of settling transactions, with oil trading houses and energy groups now actively trialling platforms based on blockchain.

Ongoing improvements in fertilizer products, fertilizer recommendations and application methods, advances in nutrient recycling technologies, biotechnology (i.e. possible development of nitrogen fixing grain crops), biologicals (i.e. seed treatments that enhance or assist soil microbes in nutrient solubilization and plant nutrient uptake), and advanced types of biostimulants, which may also contribute to enhanced nutrient use performance, are likely to emerge.

Already today there is a tremendous interest among institutional investors to fund agritech start-ups, and we may well see a wave of new products and services emerging from a variety of players that promote sustainable agriculture, including more precise plant nutrition products and practices.

Participants also mention innovative systems in the area of production technologies, logistics, distribution and e-commerce, as having an impact on the agrifood value chain, including the fertilizer industry. Improved industrial production processes (i.e. advances in access to operational data, artificial intelligence, emission capture, water recycling, close-loop systems) will drive greater plant efficiencies and safety performance, although the pace of advancements is notoriously difficult to predict. One cannot rule out unexpected breakthroughs that could replace long established processes, possibly even in the ammonia synthesis process, which is heavily reliant on fossil fuels as both a feedstock and an energy source.

A new and innovative category of "synthetic foods" that come out of the laboratory and not out of the fields cannot be ruled out.

> For instance, reactor-bred proteins as meat or even vegetable substitutes enjoy double digit growth rates today, and protein substitute companies receive record sums of venture funding in the United States. Also, algae- or insect-based protein production, which are generally more energy and nutrient-efficient, may be reaching industrial scale. For all these types of new foods, traditional agricultural practices are minimized or not required at all.

Competitive pressures might spur paradigm changes throughout the fertilizer supply-chain, with distribution clusters that would be customized to market characteristics and partners' competitive advantages. Blockchain could be a gamechanger not only for removing the need for intermediaries for financial transactions but also for putting into place "smart contracts."

► X4. ACCESS TO FEEDSTOCKS

Given the importance of feedstocks for the fertilizer industry (i.e. natural gas/coal resources for ammonia production, phosphate and potash ore), the degree of possible constraints in accessing feedstocks may impact innovation. The prices of natural gas and coal are certainly likely to fluctuate between now and 2030, and may do so abruptly, and differently in various regions, impacting in particular ammonia and nitrogen producers. Governments, as some are already inclined to do, may further choose to allocate scant energy sources to power generation or other competing uses. Stringent climate change regulations may also lead to energy price increases or carbon taxes, driving a push for greater innovation, higher energy efficiencies and a significant shift towards renewable energy sources and recycling of nutrients.

While theories about peak phosphate (fast depletion of current available reserves) have been debunked, it is possible that mining (phosphate and potash) operations would become more constrained if less economic reserves must be accessed, but also if more stringent environmental safeguards are demanded, creating a pull for innovation in mining.

These 10 themes combine to support and underpin the basic framework of the scenarios.

ACKNOWLEDGEMENTS

This work reflects the culmination and distillation of hundreds of data points and dozens of conversations, all of which helped inform and shape the scenarios and the emerging insights and implications. We are extremely grateful for all of the time, thought, wisdom and humour so many people contributed.

An electronic survey of members and non-members helped immensely, and we are so grateful to the hundreds of people who took the time to craft careful responses. The survey was buttressed by a number of workshops involving IFA members and external stakeholders. A further series of workshops, in which the members of the Strategic Advisory Teams of IFA's four thematic Committees were actively involved (Agriculture, Public Affairs & Communications, Production & International Trade, Technical & Safety, Health and Environment), further finetuned the scenarios and examined their implications in their respective domains.

- IFA Secretariat workshop, Paris, 3 July, 2017
- Workshop with external stakeholders, Paris, 3 October, 2017
- IFA2030 Task Force workshop, Washington, DC, 19 October, 2017
- IFA China Consultative Group, Shanghai, 23 October, 2017
- FA 2030 Strategy Council, Task Force and Advisory Panel workshop, Zurich, 13 November, 2017
- IFA 2030 Task Force, Strategic Advisory Teams of IFA's Communications & Public Affairs and IFA's Agricultural Committees and external stakeholders, Rome, 29 January, 2018
- IFA 2030 Task Force, Strategic Advisory Team of IFA's Production & International Trade Committee and external stakeholders, Buenos Aires, 6 March, 2018
- IFA 2030 Task Force, Strategic Advisory Team of IFA's Technical & SHE Committee and external stakeholders, Madrid, 9 April, 2018

We are particularly grateful to the members of the IFA2030 Strategy Council, composed of Executive Board members and Chairpersons of IFA Committees, and their representatives serving on the IFA2030 Task Force. The scenarios are largely a reflection of the industry leaders' contributions, spearheaded by this specially-created Task Force.

To this company-based group, we added an External Advisory Panel composed of thought leaders who are fully immersed in the challenges faced by the agrifood industry. A group of experts from Wageningen University and Research, collectively serving on the Advisory Council, contributed with a review of possible food trends and developments in food production, which helped ensure our scenarios are anchored in a solid data set ensuring the plausibility of the 4 futures. (www.work-in-progress & not yet published). In addition to the members of the External Advisory Panel, the scenarios benefitted from the valuable input of other external stakeholders who participated in our IFA2030 workshops.

The Directors at IFA were strong contributors and helped facilitate quality input and expert guidance: Volker Andresen, Patrick Heffer, Yvonne Harz-Pitre and Michel Prud'homme. We are grateful to Peer Ederer, Program and Science Director Food and Agribusiness Forum at CEIBS and Wageningen University for his contributions and insights. The scenarios were drafted by Charlotte Hebebrand and Margaret Flaherty. Charlotte is the Director General of IFA and Margaret, a Professor at Business School Lausanne and Faculty with China Europe International Business School (CEIBS).

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SOURCES / REFERENCES

i IFA's Scenario Planning process was modelled after the approaches used by others including those developed by the Beverage Industry Environmental Roundtable (BIER), Leipzig Graduate School of Management, the World Energy Council (WEC), the World Economic Forum (WEF), We also drew from distinguished scholars in the field including Darden Business School professors Leslie Grayson and James Clawson.

ii Humans, animal and plants need 17 essential nutrients to survive. Beyond carbon, hydrogen and oxygen, these consist of three primary macronutrients Nitrogen (N), Phosphorus (P), Potassium (K); secondary macronutrients Sulphur (S), Magnesium (Mg), Calcium (Ca), and micronutrients (Fe, Mn, Zn, Cu, B, Mb, Cl and Ni).

iii IFASTAT

iv World Population Prospects, The 2017 Revision (June 21, 2017). United Nations Department of Economic and Social Affairs.

v Click here for more information on the 4Rs: https://bit.ly/1BcTfkk

vi It is estimated that close to one quarter of global ammonia consumption is for industrial uses. Ammonia is used in an extremely wide variety of industries, including in NOx abatement technology. IFA estimates that some 13% of phosphate rock sold in 2016/17 went towards industrial purposes, including animal feed phosphates and food/industrial phosphoric acids. IFA 2018.

vii MECE (Mutually Exclusive, Comprehensively Exhaustive). Being MECE is a structural prerequisite for aspects to become dimensions of a scenario matrix. Being MECE shall ensure that all (or most) possible outcomes are captured (comprehensively exhaustive, while none of them being redundant or linear extensions of each other (mutually exclusive).

viii Trends and developments in the global society and their impacts on plant nutrient and fertilizer needs during the next decades, not yet published: Wageningen University and Research / 2018

ix Innovation with a Purpose: The role of technology innovation in accelerating food systems transformation, World Economic Forum (2016, January). Retrieved from https://www.weforum.org/reports/innovation-with-a-purpose-the-role-of-technology-innovation-in-accelerating-food-systems-transformation

x Mobile phones are transforming Africa. (2016, December 10). The Economist. Retrieved from https://www.economist.com/middle-east-and-africa/2016/12/10/mobile-phones-are-transforming-africa.

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xii Zhang, Xin & Davidson, Eric & Mauzerall, Denise & D. Searchinger, Timothy & Dumas, Patrice & Shen, Ye. (2015). Managing nitrogen for sustainable development. Nature. 528. 10.1038/nature15743.

xiii http://www.ecolabelindex.com/

International Fertilizer Association
www.fertilizer.org