WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

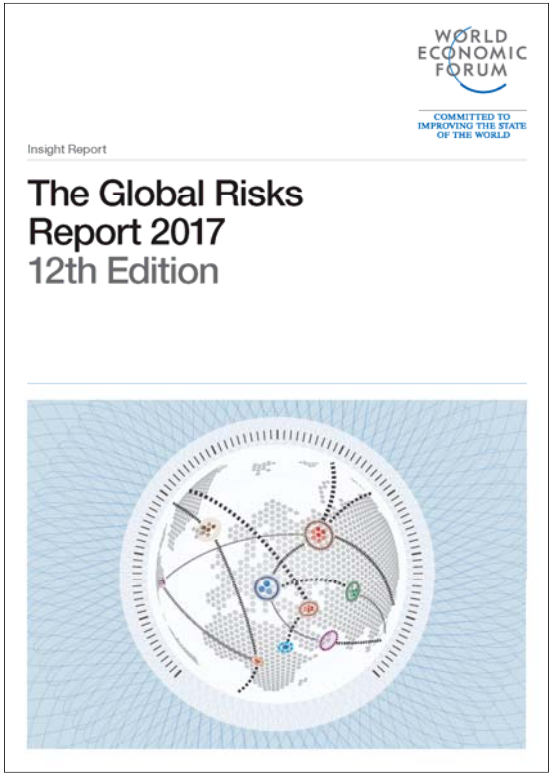
Trends in Global Risks and Innovations

Implications for the Fertilizer Industry

Dominic Waughray: Head of Public Private Partnership, World Economic Forum

TFA FIRT Technology Roundtable, New Orleans 11.15.18

The World Economic Forum Global Risks Report



- The Global Risks Report
  - Annual since 2006
  - Partners: Marsh & McLennan; Zurich Insurance
- An annual snapshot of global risk perceptions
  - Likelihood
  - Impact
  - Interconnections
  - Drivers
- Encourages view of risks as not individual but interconnected into systems (or broad areas) of concern
  - Enables nuanced discussion, particularly with regard to complexity, uncertainty and ambiguity
  - This year we focused on:
    - social/political challenges
    - emerging technologies

The 30 global risks that we track

ECONOMIC
Asset bubbles in a major economy
Deflation in a major economy
Failure of a major financial mechanism or institution
Failure/shortfall of critical infrastructure
Fiscal crises in key economies
High structural unemployment or underemployment
Illicit trade (e.g. illicit financial flow, tax evasion, human trafficking, organized crime, etc.)
Severe energy price shock (increase or decrease)
Unmanageable inflation

SOCIETAL
Failure of urban planning
Food crises
Large-scale involuntary migration
Profound social instability
Rapid and massive spread of infectious diseases
Water crises

ENVIRONMENTAL
Extreme weather events (e.g. floods, storms, etc.)
Failure of climate-change mitigation and adaptation
Major biodiversity loss and ecosystem collapse
Major natural disasters (e.g. earthquake, tsunami)
Man-made environmental disasters (e.g. oil spills)

TECHNOLOGICAL
Adverse consequences of technological advances
Breakdown of critical information infrastructure and networks
Large-scale cyberattacks
Massive incident of data fraud/theft

GEOPOLITICAL
Failure of national governance
Interstate conflict with regional consequences
Failure of regional or global governance
Large-scale terrorist attacks
State collapse or crisis (e.g. civil conflict, military coup)
Weapons of mass destruction

The 13 trends driving the global risk landscape

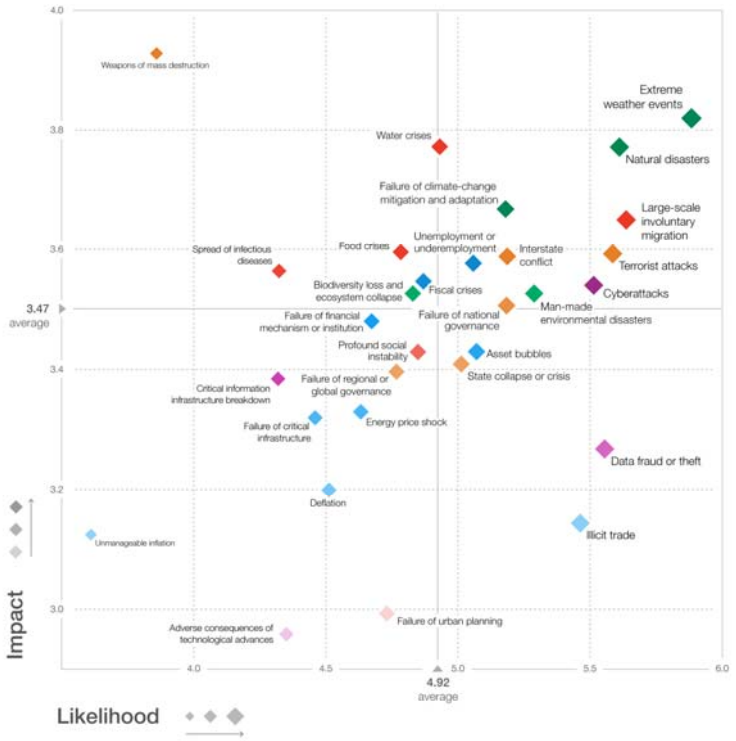
- Ageing population
- Changing landscape of international governance
- Changing climate
- Degrading environment
- Growing middle class in emerging economies
- Increasing national sentiment
- Increasing polarization of societies
- Rising chronic diseases
- Rising cyber dependency
- Rising geographic mobility
- Rising income and wealth disparity
- Rising urbanization
- Shifting power

Individual risks: environmental concerns moving to the forefront

Risks assessed by likelihood and impact over a 10-year horizon

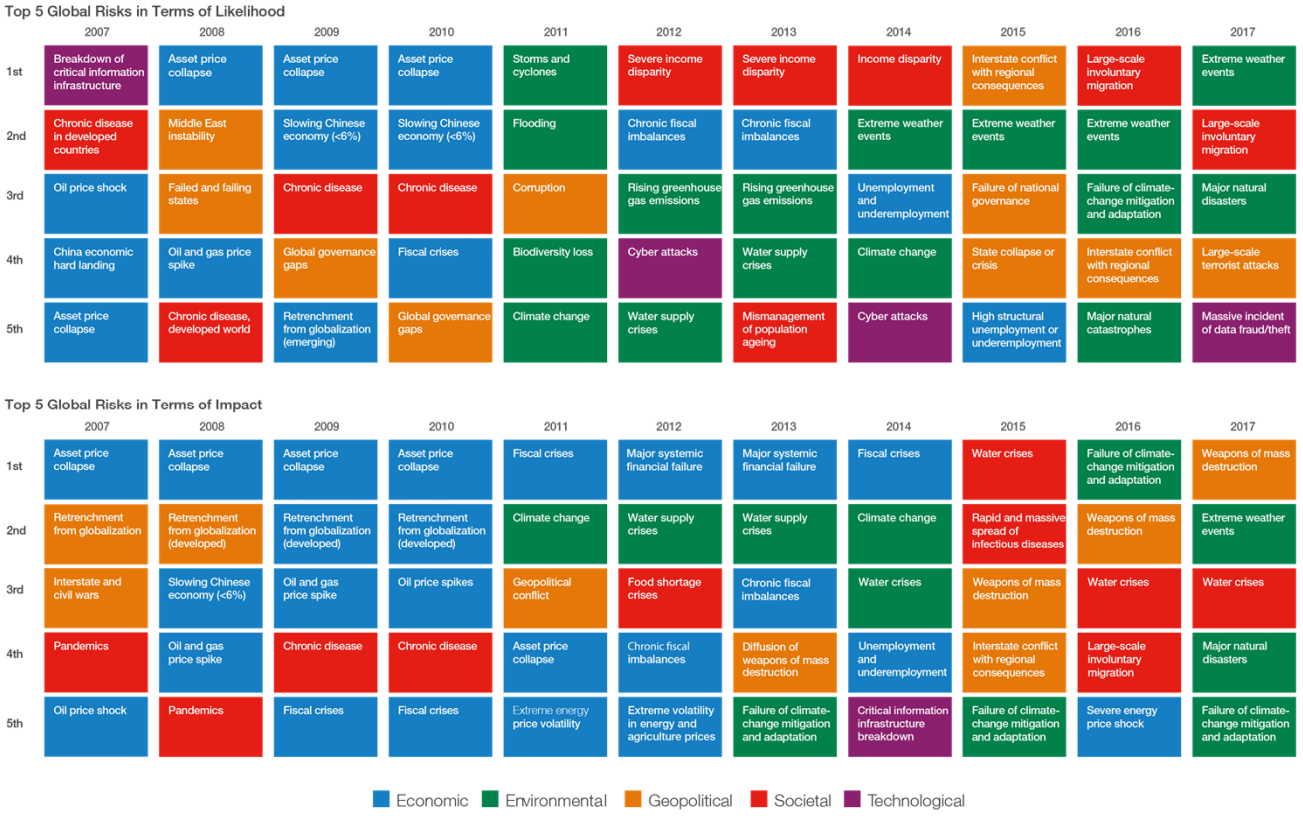
Top five by likelihood	
1	Extreme weather events
2	Large-scale migration
3	Major natural disasters
4	Terrorist attacks
5	Massive data breach

Top five by impact	
1	Weapons of mass destruction
2	Extreme weather events
3	Water crises
4	Major natural disasters
5	Failure of climate-change response



Are economic risks fading?

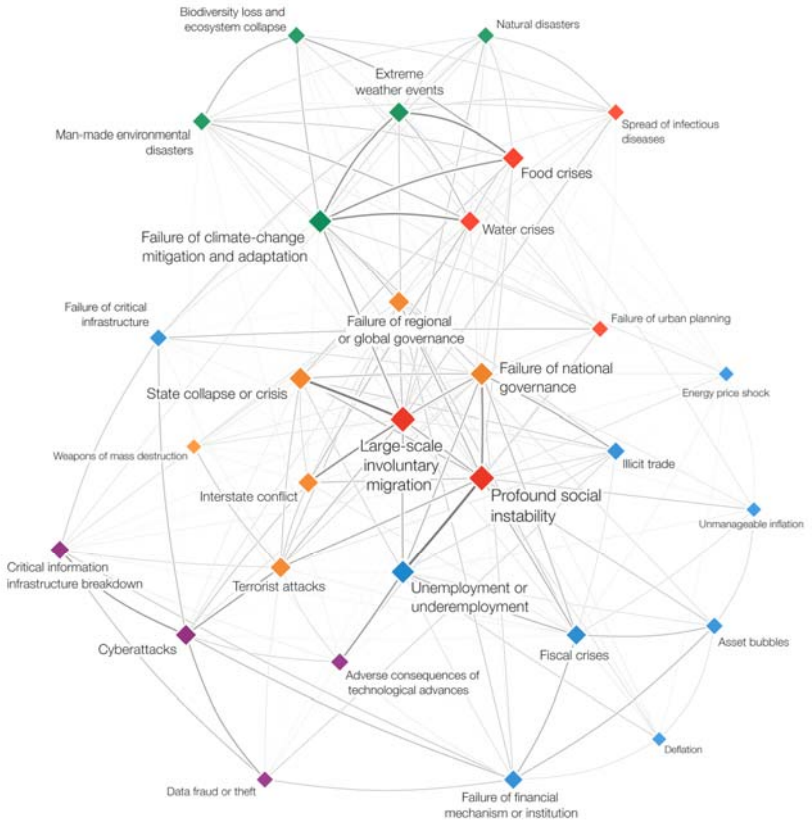
The evolution of the top-five risks



Or do economic risks sit within more complex interconnections?

The most frequently cited risk interconnections

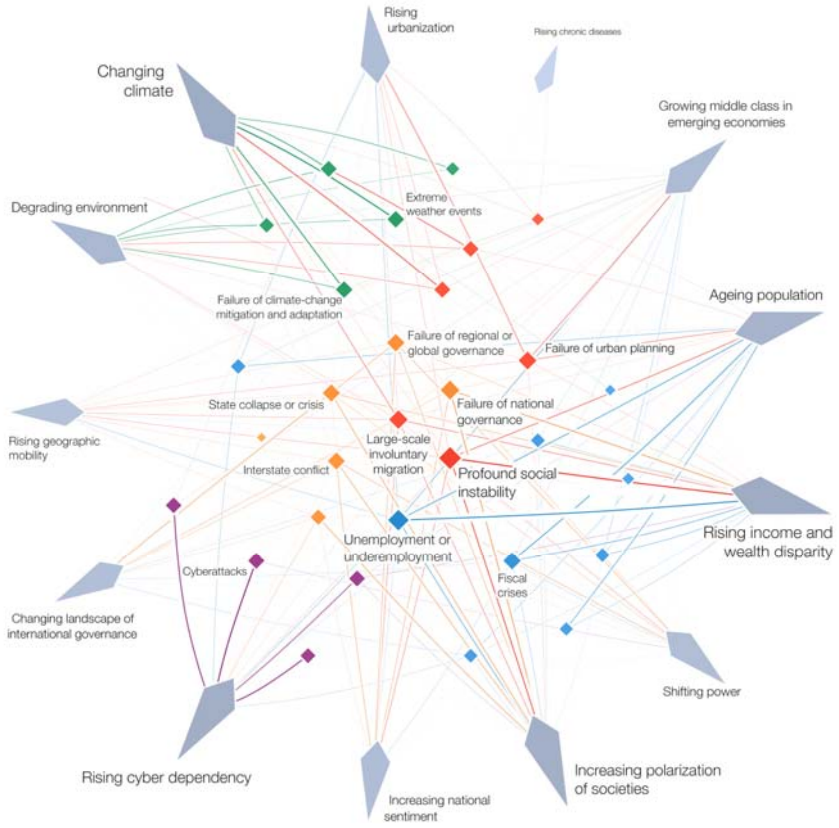
Top five risk interconnections	
1	• Unemployment • Social instability
2	• Involuntary migration • State collapse or crisis
3	• Failure of climate-change response • Water crises
4	• Failure of national governance • Social instability
5	• Interstate conflict • Involuntary migration



Inequality now interacting with climate change as the two key drivers

The trends expected to drive global events over the next 10 years

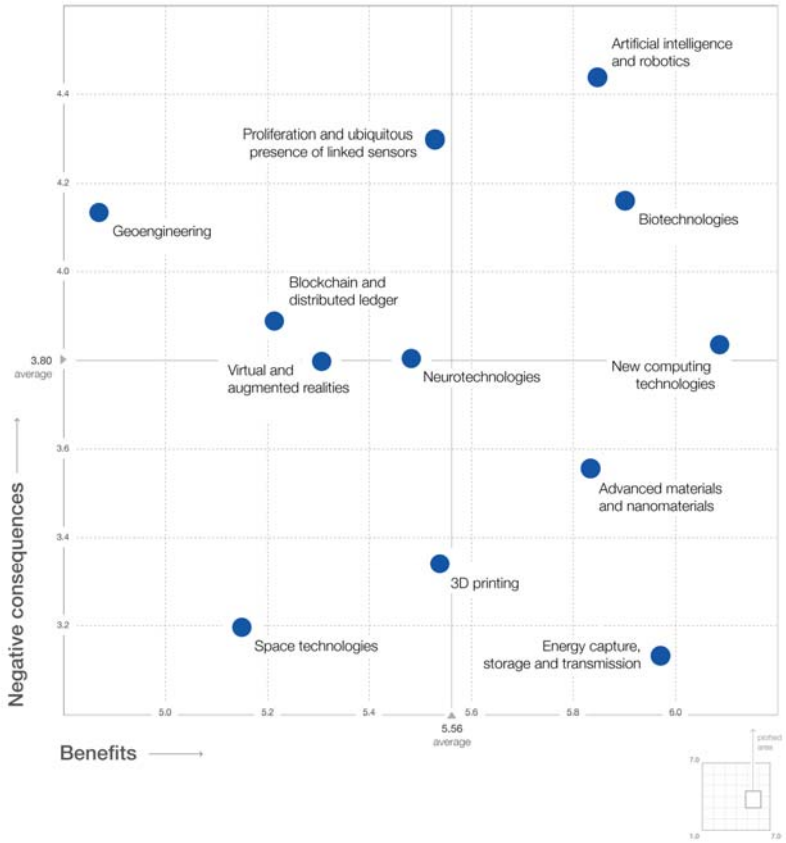
Top five trends driving developments	
1	Rising income and wealth disparity
2	Changing climate
3	Increasing polarization
4	Rising cyber dependency
5	Ageing population



Fourth Industrial Revolution points to optimism and uncertainty

Respondents assessed 12 new technologies for benefits and negative consequences

- AI, Robotics and Biotechnologies
  - Offer biggest opportunities but biggest risks
  - Opens a door for policy
- Anecdotal evidence
  - Pace and complexity of technological change is overwhelming
- Low-hanging fruit?
  - Energy storage – a renewable energy revolution for farmers?




YOUR M&S
USAID
FROM THE AMERICAN PEOPLE
WORLD RESOURCES INSTITUTE
The Nature Conservancy
Protecting nature. Preserving life.
McDonald's
wilmar
Norad
APP
Department for International Development
RAINFOREST ALLIANCE CERTIFIED
Unilever
The Consumer Goods FORUM
althelia ecosphere
GCP
GLOBAL CANOPY PROGRAMME
Terra
GLOBAL CAPITAL
MARFRIG Global Foods
the sustainable trade initiative
WWF®

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Tropical Forest Alliance 2020:

to strip deforestation out of key supply chains
to improve smallholder farmer incomes

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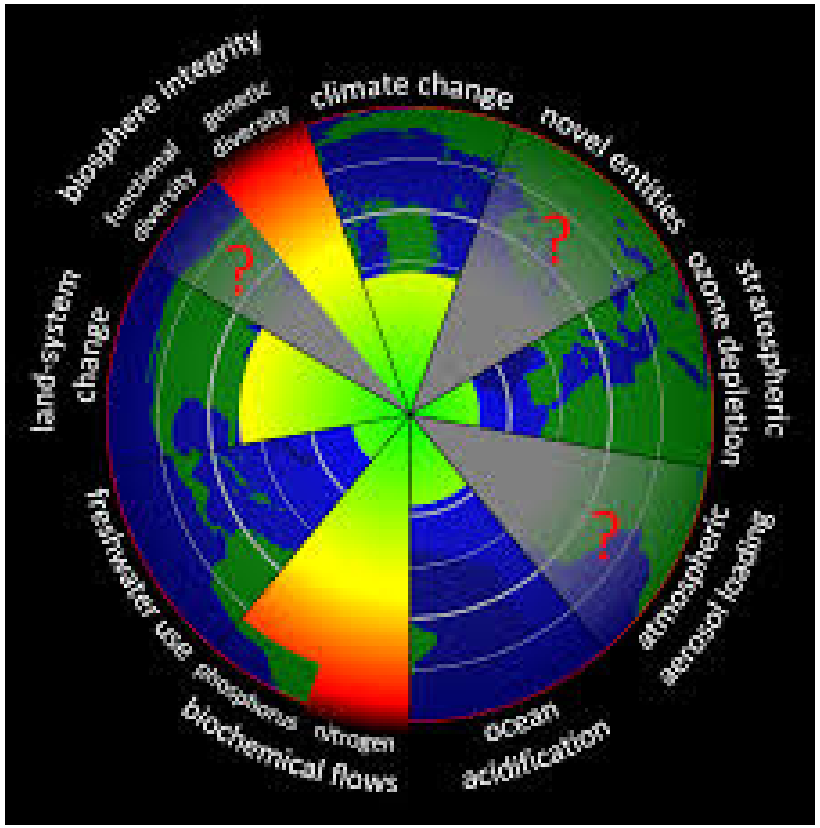
2030 Water Resources Group

2030 WRG: A public private platform to help governments with national water resources management

Now the World Bank Global Water Practice's primary public private trust fund with access to $23bn lending

WRG has 500+ partners globally: this is just in Peru

Achilles Heel for the Fertilizer Industry



Achilles Heel for the Fertilizer Industry

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“Human activities now convert more atmospheric nitrogen into reactive forms than all of the Earth's terrestrial processes combined. Much of this new reactive nitrogen is emitted to the atmosphere in various forms rather than taken up by crops. When it is rained out, **it pollutes waterways and coastal zones or accumulates in the terrestrial biosphere**. Similarly, a relatively small proportion of phosphorus fertilizers applied to food production systems is taken up by plants; **much of the phosphorus mobilized by humans also ends up in aquatic systems.** These can become oxygen-starved as bacteria consume the blooms of algae that grow in response to the high nutrient supply. **A significant fraction of the applied nitrogen and phosphorus makes its way to the sea, and can push marine and aquatic systems across ecological thresholds of their own.** One regional-scale example of this effect is the decline in the shrimp catch in the **Gulf of Mexico's 'dead zone' caused by fertilizer transported in rivers from the US Midwest.”**
http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html

A Green Salad Revolution

AeroFarms
The Future of Urban Agriculture


GINKGO BIOWORKS
THE ORGANISM COMPANY

Meat: The Future


On my way

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Thank you

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Global Risks, Global Innovations – Implications for the fertiliser industry

Keynote at the Fertilizer Institute (TFI) and the Fertilizer Industry Round Table (FIRT) Fertilizer Outlook and Technology Conference

New Orleans November 15, 2017

Dominic Waughray
Head Public Private Partnership and Member Management Committee
World Economic Forum

Distinguished Ladies and Gentlemen

Good afternoon.

I am honoured to have the opportunity to speak to you today at The Fertilizer Institute (TFI) and the Fertilizer Industry Round Table (FIRT) hosted Fertilizer Outlook and Technology Conference 2017 here in New Orleans.

My name is Dominic Waughray. I am the Head of Public Private Partnership at the World Economic Forum, the International Institution for Public-Private Cooperation.

We are probably best known for our annual meeting in Davos each year; however, our primary purpose is to be a platform for informal, global public-private cooperation helping stakeholders come together to advance the agenda on our most pressing global public good challenges

I have had the honour to build an environmental and resource security portfolio of public private cooperation at the Forum – climate change, water security etc. I also guide our agriculture, trade and sustainable development work.

I was privileged to speak about this time last year at the IFA strategic forum in Dubai. I guess I must have triggered something, because the FIRT folk asked me back to speak to you today, and sent me a list of 53 questions they would like me to address in this talk!

So I am delighted to be with you today. In the next 30 minutes or so I hope to be able to inform, provoke and stimulate discussion among you on the landscape of global risks and global innovation facing the fertiliser industry. I

also hope to offer you some reflections - from the outside looking in of course – as to what approaches the industry might consider in reaction to these forces. Together with my other colleagues who are speaking this afternoon, I hope this will help set the table for some good discussion later on. I also hope to try and take on at least some of those 53 questions!

OK, so here we go.

I will bucket my presentation into 3 areas

- First, on the global risks context for the next 5 to 10 years

- Second, where the Fertiliser Industry might be lagging behind within that context, and what might be done; and

- Third, on the scale of disruption and opportunity that technology innovation – what we at the Forum have termed the "4th Industrial Revolution" – is bringing to this global risk context, and what the Fertiliser Industry might do about that, with a brief look at how other industry sectors are coping with these rapid technology changes

So first, on the global risks context

- Slide 2: the data I will use comes from our 2017 Global Risks Report http://reports.weforum.org/global-risks-2017/

- Slide 3: we track 30 key Global Risks grouped within 5 areas – economic, societal, environmental, technological and geopolitical We ask a network of public/ private risk experts to rank them by impact and likelihood of occurrence over the next 10 years (by the way all these slides and a transcript of my talk is with the conference organisers for them to distribute to you, so no need to take too many notes while I speak)

- Slide 4: from these responses we can distil expert perceptions into the 13 trends we identify as driving the global risks landscape. These may capture most of the discrete drivers you'd expect, but then…

- Slide 5: we use perceptions of impact and likelihood to create a Global Risks Landscape – what starts to emerge here is an *interconnected* web of environmental, social and political risks, which as a cluster of issues is of pertinence to the markets and societies you as an industry work in. Slide 5 zoom: This also tells us that, despite what some politicians may think, professional analysts in the finance, investment

and scientific community already understand how important and interconnected pressing societal and environmental risks like extreme weather events, failure to adapt to climate change, water crises and natural disasters are; and how they connect with and drive more immediate geopolitical flash point issues like involuntary mass migration and interstate conflict. Issues which are pertinent to your scenarios of the future I would suggest

So, a first observation – we face a set of underlying, structural environmental and geo-political challenges which are hard for politicians to address, but are recognised as material by risk analysists. Given this, how might the fertiliser industry react, so as to get on the front foot and become less susceptible to these risks?

- Slide 6: Second Observation. When looked at over the last decade 2007-2017, these structural global risks like extreme weather events, climate, water crises, rising, inequality driving geopolitical issues like involuntary mass migration are proving “sticky”; policy makers can address economic risks as they come and go but these weather, climate and water issues are harder to fix. They are not going away. 10 years has not seen much material impact from political action. So again, how will an industry sector like fertilizer react to this signal? Material action likely won’t come from policy makers until there’s a crisis, by which time it will be too late.

- Slide 7: Third Observation. These aren’t softer “social” risks for a CSR or public affairs department to deal with, whilst core business continues. These are core business strategy issues - economic and geopolitical risks such as unemployment, social instability, migration and inter-state conflict are closely interconnected to these water and climate issues. Without helping decision makers address them, the market that all stakeholders reply on can collapse.

- Slide 8 – Indeed, we see inequality and climate as the key twin major drivers of the changing global risks landscape for the next decade. They work hand-in-hand with each other and both are global phenomena. Let’s boil this observation down: – what is the fertilizer industry doing to address extreme weather/ adaptation to climate change and water crisis; and how will this help lower, rather than raise inequality among farmers? Answer this, and you will have the attention of policy makers and risk analysts in the finance community. Can a response to this twin challenge form the foundation of a fertilizer industry narrative to 2030, which resonates with anxious analysts and troubled policy makers?

- Slide 9. Finally, and additionally, when we look at how risk analysts see global technology risks the final piece of the storyline for the fertilizer industry can become clearer: to help the agriculture sector strengthen resilience to extreme weather, adapt to a changing climate and lower inequality, how is the fertilizer industry helping to minimise the risks and maximise the opportunities of AI, robotics and in particular **biotechnology** for farmers?

OK so that was the first bucket on global environmental risks

What can we read? That risk analysts and policy makers would welcome a global fertilizer industry strategy or narrative that is on the front foot in addressing the two key structural risks the world faces in the coming decade, of extreme weather/climate change and rising inequality, including by harnessing game-changing technologies like biotech to help do so.

Second bucket of the talk: OK, given this risk landscape, where might the fertiliser industry be lagging behind in addressing these twin issues, and what might be done?

Specifically, is the *industry* – or leadership within the industry – working collectively and proactively together - working systemically if you like across its value chains or together in key markets and jurisdictions - on addressing these environmental, social and technology issues as a package - or are companies at best only working on some individual projects and activities? Working together triggers platforms for pre competitive collaboration, platforms that can work with multiple governments to reshape markets given the risks we face – it creates proactive scale change. Working apart creates pilot project fatigue and no systemic cut through.

What do I mean in practical terms by this?

Let's look at some examples from other sectors

Example 1: Slide 10 - leading manufacturers, processors, distributors and retailers of palm oil, soy, paper&pulp, beef recognised that their Achilles heel was deforestation: the unsustainable sourcing of these 4 commodities drives half the world's tropical deforestation; and keeps smallholder farmer livelihoods low.

(Additional information: The scale of the tropical forestry challenge is huge – 15% or so of GHG emissions, 2 billion people relying on forest related incomes, but large areas being destroyed each year driving biodiversity loss

and mass haze with huge health impacts for those downwind in cities etc. like Singapore downwind of Indonesia during the forest and peat burn season. In fact, Indonesia emitted more GHG than the US per day at the height of the forest burn in summer of 2016)

So, in addition to pursing their own projects, these companies came together through the Consumer Goods Forum to launch the “Tropical Forest Alliance” at Rio+20.

Slide 11: They used the 2015 Paris Climate Meeting as a mechanism to scale their effort and sought the World Economic Forum to help broker and structure the Tropical Forest Alliance into a specific, global time-to-goal alliance with NGOs and aid agencies in partnership, in line with the Paris Climate Agreement and SDGs. The Tropical Forest Alliance is now a global “platform” which engages government and NGOs across these 4 global value chains and in over 20 jurisdictions and countries worldwide to drive deforestation out of supply chains. It has attracted $20m to support it from aid agencies. It has become a legitimate part of the official solutions portfolio for tackling deforestation. The industry collaboration has turned a problem into a proactive partnership for action on solutions. Now, the company partners in the Tropical Forest Alliance like Cargill and Mc Donalds are seen as positive agents of change by the international community – they are partners in the process of change, helping policy makers address those structural risks from the perspective of their sector. Since 2014, there has been growth of 6% to close to 70% of global palm oil now under sustainable sourcing commitments; banks, institutional investors and global aid agencies are now working with the companies to structure the investment finance required to shift the sector. And it means the companies grow, distribute and buy more secure feedstock from more organised jurisdictions with farmers who have clear land assets which they can invest in, given a guaranteed future purchase commitment of the product. No more slash and burn of forests. Higher yields on less land. A Produce and Protect Agenda. Through strategic collaboration a problem has been turned into a solution.

Example 2: Food and Beverage Companies, like PepsiCo, Coca Cola Company, Nestlé and others around 2007-2009 saw their Achilles heel as water. They were under much pressure in India, South Africa, Mexico and other key markets as their presence was seen as bad for local water resouces, and accusations of “water robbery” were rife, especially from civil society and farmers. This was despite the fact that these companies are among the most water efficient operators in their industries. Realising pre competitive collaboration with governments would be the key to strengthen water policy frameworks, they came together to work with the IFC and World

Bank, leading water experts and with the World Economic Forum to draw in key countries and NGOs to create the 2030 Water Resources Group.

Slide 12: 2030 WRG is a public-private-civil society platform that helps governments in water stressed regions, tap into the best available knowledge to develop smart policy and projects to ensure water security as the economy grows. WRG helps governments build a better water policy framework that allows all to use what they are allocated effectively and efficiently. It addresses the water crisis and ensures continued investment in the country by large water using companies, safeguarding jobs and value chains and driving economic growth.

Slide 13: Now, WRG has over 500 partners worldwide and has this year become embedded within the World Bank as the key public-private multi-donor trust fund in the Global Water Practice. These companies are now seen by aid agencies and governments and many NGOs as positive champions in the water resources and SDG 6 agenda. They are helping water scarce countries sustainably secure the water they need to deliver on economic growth targets to 2030. The WRG collaboration has attracted $20m of funding, it works in 15 countries around the world, and it can tap in to the World Bank's $23bn envelope of lending to the global water sector, 11% of total WBG lending. It is not insignificant. Like TFA, WRG is a serious strategic investment in partnership to help reshape the global risks landscape these heavy water using companies face.

So these are two examples from other industry sectors, where companies came together to work across their value chains and in multiple markets, by identifying their core global risks "Achilles heel" – deforestation and water stress - which are also issues that many governments and policy makers need help with. These multi-actor alliances have repositioned the partners from the industry as problem makers to solution creators, partners in development actively helping governments and civil society to solve some of those global risks.

Furthermore these alliances really do help governments. Given the interconnected web of risks we discussed earlier, it is clear that no one government can find and scale, quickly, a non-incremental, systemic solution to these wickedly interlinked environmental and social/economic challenges. The Marrakesh Declaration on Forests at COP22 is a great example of this

Collaboration is the key.

In essence these collaborative efforts in pre-competitive cooperation are seeking to help governments "build better markets" for all, in line with the

2030 SDG agenda. Designed as platforms rather than projects, it also means scale can be achieved, as the arrangements that help to trigger good outcomes can be copied virally country by country, landscape by landscape.

So what might be the Achilles heel for the fertilizer industry against the risk landscape set out above? And having identified it, what public-private platforms might the fertilizer industry build, so as to proactively shift its position and become a recognised champion of change and the SDGs, in partnership with governments and other actors?

The issue could be climate change – noting that the agri-food sector is responsible for 30% of global greenhouse gas emissions; and that climate change increasingly threatens food systems, as weather extremes cause up to 80% of variation in agricultural production.

In this regard, a necessary thing for the fertilizer industry to do would be to lower its Scope 1 (from the source), 2 (from the purchased energy) and 3 (in the value chain) GHG emissions. This could involve looking at how product is produced, transported (by truck and ship in particular) and applied. Each industry could look at transport options for example and commit to targets. Like RE 100 or EV 100 did, there could be a F-20 whereby 20 leading Fertilizer companies agree to zero emissions in their transportation value chains for example.

This, however, would be necessary, but not a sufficient condition for reshaping the market place in line with the risks faced in the coming decade. Emissions reduction is a defence strategy, not a proactive, offense move to reshape how the industry helps governments and civil society. Reducing Scope 1,2,3 emissions would not buttress the fertilizer industry from the wider winds of change, given that interconnected risks landscape.

What do I mean?

Slide 14: With the rise of more sophisticated and segmented global environmental systems analysis, such as the Planetary Boundaries, I would argue that the Achilles Heel coming for the fertilizer industry is within the application space – specifically a push-back against historic levels of perceived phosphate and nitrate pollution from poorly applied fertilizer and its subsequent run off.

As I move about in my circuitry I sense that experts and policy makers are increasingly zeroing in on the issue of phosphate and nitrate pollution, like they have zeroed in on plastics pollution for other sectors.

Earth scientists point toward the production and application of artificial fertilizers to boost agricultural productivity – as having driven arguably the largest and most rapid impact on the nitrogen cycle for some 2.5 billion years.

Slide 15: They cite phosphate and nitrate pollution as one of the worst performing of their planetary boundary indicators. Here is the quote direct from the well reputed Stockholm Resilience Center Web Page.

The core problem asserted is that widespread nitrogen and phosphate pollution from poorly applied fertilizer has washed into our bays and coasts affecting fish stocks and creating among other impacts so called “dead zones” in 10% of the world’s oceans, which are growing by 10% a year.

Think river pollution, eutrophication of deltas, aquaculture poisoning and ocean dead zones etc. - with the fundamental challenge being levelled at the Fertilizer Industry to either transform – or to be positioned the bad guys.

Don’t shy away from this Achilles heel, embrace it.

As those other companies took head on as a sector, in collaboration, the complexity of the challenges they faced of deforestation and water access, why not as the fertilizer *industry* respond directly to the criticism of phosphate and nitrate pollution. Turn the problem into a proactive collaboration to help governments meet the challenge of climate change and rising inequality.

How? Think where pre competitive collaboration has helped change the context in those other examples. Now think of the system within which the fertilizer industry operates.

Why not structure and launch a “**Clean Bay Alliance**” – a partnership with local governments, international organisations and other stakeholders to take on some of the 375 most hypoxic coastal zones in the world, as identified by World Resources Institute, zones concentrated in coastal areas in Western Europe, the Eastern and Southern coasts of the US – including here in Louisiana perhaps, and East Asia, particularly Japan;

Place the Clean Bay Alliance within the context of the 2030 SDG agenda – an alliance designed to strengthen the resilience and sustainability of the world’s top delta’s to help promote food, environmental security and poverty reduction – the very interrelated web of environmental, economic and social risks that governments find it hard to tackle.

Perhaps hinge the actions upon the 4 Rs of your own sector: create a pre-competitive collaborative platform that leverages the knowledge of the fertilizer community to help jurisdictions grappling with agricultural run-off pollution around the world to identify the **R**ight source, the **R**ight rate, the **R**ight places and the **R**ight "time" to apply fertilizer. A PPP for RRRR!

The Clean Bays Alliance: a global public-private-civil society framework to deliver the 4Rs for environmental improvements and SDG delivery by 2030 in 50 of the world's current nitrate and phosphate pollution delta hotspots. A wide range of local civil society organisations and others (e.g. tourism and aquaculture industry) would no doubt also engage in each hotspot etc. Development agencies would help farmers adjust. By doing this you also built yourselves a new platform - a new market for 4R project trials, innovation, partnerships and knowledge-sharing and a new perception of the sector through strategic collaboration.

Third bucket of the talk - the disruption and innovation that technology brings into this landscape, and again, what might be done

We could zero in here on the potential of technology to transform your feedstock

Let's pivot slightly.

Since its introduction in 2007, the smartphone has become an essential. There are now 6 billion smartphones with 2 billion users. Mobile internet traffic is growing by 60% a year; as a result, the industry predicts there will be *5 billion* smart phone users by 2020 and who knows how many devices and apps by then, mostly on fast 3G and 4G and even 5G platforms. The first App only appeared in 2008 when Steve Jobs, the founder of Apple, enabled outside developers to create applications for the iPhone. It's now a $1.2trillion industry, bigger than the revenues from the global pharmaceutical sector. WhatsApp - created in 2009 – today sends *30bn* messages a day. News about celebrity gossip – food prices, or bad water quality – now travels fast. Imagine the possibilities by 2020, or even 2030? The smart phone itself is now a carcass - the value of the iphone is in how it's positioned as an Apple platform for the apple store apps, music and films; with Netflix and others now jostling for platform advantage.

Driving this value creation, the costs of collecting, storing and processing information have absolutely collapsed, thereby transforming both the research and business community. A standard tablet device today possesses the equivalent processing power of 5,000 desktop computers from the mod 1980s, while the cost of storing information is approaching

zero (storing 1GB costs an average of less than $0.03 a year today, compared to more than $10,000 20 years ago). This has completely flattened the costs of processing information. The first human genome took more than a decade to sequence, at a cost of $2.7 billion. That was fifteen years ago. Today, a genome can be sequenced in a few hours and for less than a thousand dollars. Relevant to your sector, you may have noticed that the Earth Bio-Genome Project was announced this year – the ultimate science project that aims to sequence all the plants, animals and single-celled organisms on Earth (the eukaryotic species) within ten years at a potential cost of $4bn. Consider the game changing potential this will have for biology, conservation and for agriculture – all life is sequenced. This project will be launched at the Davos annual meeting in January.

The World Economic Forum terms this explosion in access to a ubiquitous and mobile internet, fueled by smaller and more powerful sensors that are becoming ever cheaper for both industry and science, with impacts accelerated by artificial intelligence and machine learning as the Fourth Industrial Revolution.

The Fourth Industrial Revolution is disrupting multiple business sectors more rapidly than policy makers can keep up with.

We see many potentially transformative technological innovations emerging over the next decade or so, that will likely change the face of production, manufacturing and consumption in all markets, in ways we can't begin to fully imagine.

Imagine applying 4IR technologies to environmental management. What if wearable tech measured not only your heart and blood pressure, but also the quality of the air you were breathing, the water you drank and the amount of artificial fertiliser or pesticide residue on the food you ate or the water you shower under? And through bib data processing, the tech companies could aggregate this information make it freely accessible in the form of dynamic pollution maps identifying standards being breeched, and through the use of AI could model predictions for premature death or morbidity as a result? Think how that would transform the political and social agenda, including for your industry. What is it that William Gibson, the science fiction author of Neuromancer said? "The future is already here, it's just unevenly distributed." The environmental NGO Environmental Defense in partnership with a tech company called Aclima - who have a highly accurate, portable mini-air pollutions monitor connected to the Internet of Things - are doing pretty much just this already in Oakland, California. EDF call it the radical democratisation of environmental data. It is already changing the geography of house prices there, and showing how unhealthy the air is in public schools. Think what something similar on water quality or food quality could do to your industry.

Lets look at 3 transformative drivers, actually in play now in the industry

First Aero-ponics
Second Synthetic Biology
Third, the clean meat sector

Slide 16 First Aero-ponics – AeroFarms are a Forum Technology Pioneer Company.

Aero-ponics is the technology that grows salads in a controlled vertical farm warehouse environment instead of conventional means in a greenhouse. In a stacked conveyor belt system it uses a re-circulating nutrient/water mist, LED lighting and patented cloth (made from recycled plastic bottles) rather than soil. Data from AeroFarms shows how it consumes 95% less water than used by conventional soil-based agriculture and all inputs are completely closed loop so there are no environmental run offs. From non GMO seeds it delivers tasty greens, a 100% organic product in 12-16 days - less than half the time of the conventional growing cycle with x5 yield per square foot. Being pesticide and soil free, it also means there are no large-scale washing needs before bagging up the salad: 95% less water use. Leaders in this field are now approaching cost parity with traditional salad farming seed-to-sale supply chains. Huge potential opportunities for a lighter water footprint to agriculture, smaller supply chains and urban focus.

And it is the data on smart salad growing that companies like AeroFarms a Forum Technology Pioneer company are finding now to be the premium asset in their business.

Second, on synthetic biology

Slide 17: Another World Economic Forum Technology Pioneer is Ginkgo Bioworks based in Boston.

They are growing rose petal enzymes in the lab from the DNA of roses, simply to capture the smell, so that they can help fragrance producers of the future produce and nuance perfumes in the lab, without the need to grow or source roses or indeed other fragrant plants. They are doing the same for vanilla; thereby cutting out the need for vanilla farming, and have many more projects besides.

As well as growing the output from the plant required in the lab, the potential for such biotech to also control the plant environment in situ is also huge. Root systems that can optimize nutrient uptake; seeds coated with enzymes

to make all the key nutrients available in a smart jacket surrounding the seed, irrespective of the soil.

In fact in July of this year, and to this end, Ginko announced a new partnership with Kerry, the global taste and nutrition Company. Ginkgo will work with Kerry on more efficient production of specialty enzymes used in food.

Third, on clean meats.

Slide 18

As you know, up to 16,000 litres of water is required to produce a kilo of beef. Combined, beef and pigs are responsible for about 15% of the total water footprint for agriculture. The FAO say that cattle and beef farming is also responsible for 18% of global GHG and that demand for beef is set to grow 50% in the next two decades

This is a systemic environmental challenge – and it is not tenable that we do not solve it. A 9bn, majority urban world by 2050 will need to access safe, affordable and sustainable meat. Recall the interconnected global risks map.

Like the reimagining of fossil fuel to distribute clean, cheap, sustainable renewable electricity to all, we will also need to rethink our perception of livestock to meat for human protein consumption.

Cultured or "clean" meat is perfectly organic and non GMO, it is drawn from the same technology we use to grow skin grafts on our own bodies. Only this time, it is used to grow the perfect meat cut, multiple versions in a very different kind of vertical farm within your village or neighborhood.

Some key biotech Startups Manufacturing Animal Tissue, include

- Gelcor, San Leandro, California, Biotech production of animal gelatin
- Perfect Foods, Berkeley, California, Animal-free dairy products
- Clara Foods, San Francisco, Laboratory generated egg whites
- Memphis Meats, San Leandro, California, Lab cultured beef and pork
- Mosa Meat, Maastricht, Netherlands, Created first in vitro hamburger
- SuperMeat, Israel, Developing cultured chicken liver

The cost of production has fallen an incredible 30,000 times in five years. In 2013, it was around $325,000 per pound ($715,000 per kilo) to make it in a lab (the famous burger patty); in 2015 it was $44 per pound ($97/ kilo); in July 2017, a company came in at $11.36 per pound. ($25/ kilo)

As a result, clean meat products could be in our stores within the next five years, perhaps the Tesla equivalent of “ultra meat” at least to start with.

Mark Post, whose stem cell burger created an international sensation in 2013, recently announced that his company, Mosa Meat, would be selling lab-grown beef in four to five years. Memphis Meats is developing a way to produce meat directly from animal cells without the need to feed, breed or slaughter actual animals. The team also predicts it’ll have products available for purchase within five years, and has accelerated its progress significantly in the last six months. SuperMeat, an Israeli start-up, is even trying to create kosher lab-grown chicken

In theory, the stem cells could provide a lot of meat. Assuming unlimited nutrients and room to grow, a single satellite cell can undergo 75 generations of division during three months. That means one turkey cell could turn into enough muscle to manufacture over 20 trillion turkey nuggets. And surveys suggest about half of vegetarians would eat meat if it came from a lab.

So this could be a transformative trend for the global meat industry, and - as a result - for the fertilizer sector. The global meat industry is a $675 billion business.

Think of the potential this technology offers

Cultured meat farms in urban areas offering affordable product, but requiring just 2% of the land of the global livestock industry today, relieving 25% of the pressure on global agricultural water demands by 2030, and producing just 4% of the GHG produced by today’s global herd.

Yields for other farm crops could grow, as the link between “every 7kg of grain to provide feed for every 1kg of meat”, which currently drives the US grain and industrialized livestock system, is severed.

The coming together of a food resource revolution and the 4IR technology revolution, in a manner that helps address many of the interconnected social and environmental risks we face, and delivers on several of the SDG targets.

China is already moving, signing a $300m in September of this year to buy clean meat from Israel

This is why the Forum is launching a project called Meat: the Future – to bring together technology companies, policy makers, investors and those from the industry and their regulators to explore how such an innovation could be scaled to meet the wider societal and environmental challenges,

but in a safe, affordable and sustainable manner. Arguably a fertilizer company could move fast and switch to become a future meat company.

In relation to this exciting agenda for new technology innovation in the food and environment system, the Forum runs a number of initiatives, which you are welcome to join or to find out more about them. There is an agri-tech dialogue; an investigation into transformation and innovation game changers across the food system; a deep dive into advancing the new meat agenda, especially from an environment and SDG agenda by 2030; and finally there is a wider program looking at harnessing the 4IR for the environment. All of which are anchored in our Center for the 4th Industrial Revolution in San Francisco, CA.

Within this innovation context, one could also form a club of companies to look at the feedstock component for the fertilizer industry.

Unthinkable as it might be, unless one remains nimble to the changing risk and technology context, the fertilizer industry could find itself not only lagging, but at risk of wholesale disruption, similar to what's happening in the auto industry.

Slide 19: Without innovation to recognise the wider environmental and social risk landscape the industry now operates within, reliance on the Haber Bosch process could become the fertilizer industry's equivalent of the auto sector's reliance on the Internal Combustion Engine – a rock solid industrial innovation that drove progress in the 20th century, but that has become not fit for purpose for the mid 21st.

The internal combustion engine and the related industrial and political vision of everyone driving and owning their own car, is now rapidly giving way to the rise of electric, shared and autonomous vehicles. Ownership of a gas driven car morphs into the need for a portfolio of mobility *solutions* designed in sync with the wider system of liveable cities, sympathetic to people's financial needs and in line with wider environmental issues – not just pollution, also congestion and smart materials use and reuse. This change is happening faster than many thought – France, UK, China and India this year setting hybrid and electric vehicle targets by 2040; Volvo and Land Rover/Range Rover becoming this year the first automakers to commit to making the full switch. It is the beginning of the end for the internal combustion engine and the industrial-economic systems it created.

Similarly, and rather than being disrupted by a Tesla equivalent, can the fertilizer industry itself - or a group of leaders from within it - engage in a full life cycle analysis of alternatives to the Haber Bosch process, such as

bacteria cultures that can be converted to gas and have the ammonia extracted from it, in ways that save emissions etc. Finding a few key government partners to work with, partnerships could be formed to get new fourth industrial revolution technologies to scale, such as Germany and China did to accelerate the solar industry. This could form a whole new dimension to applying the 4 Rs. Noting too, how the digitisation of agriculture is also changing the sector rapidly – with the value of Monsanto in collaboration with John Deere becoming as much about the data on farming practices that they are now collecting and processing, as the goods and services they are selling. Digitising a 4R application revolution worldwide

This is not impossible. I would argue such initiatives are only possible but they are essential, if the sector is not to lag or be seen to lag. Other powerful 20th century industrial sectors are doing similar things. Total, BP, Shell, Saudi Aramco, ENI, Statoil among others from the oil and gas industry have formed an informal club. The Oil and Gas Climate Initiative. They have recognised the environmental impact of their product and have created a $1bn co-financed innovation investment fund to collectively build new innovations – to build a new market – together (In this case tackling and close looping methane emissions and reinventing CCS). This has attracted the support of the international community and major governments - an innovation from a club of leaders within the industry, who recognise the changing global risks landscape within which they are operating.

In a similar fashion, can the fertilizer industry – or a group of you within it – proactively respond, as the risk landscape and technology innovation context surrounding you changes equally rapidly?

So, I have

- Explored the global risks context for the next 5 to 10 years
- Discussed where the Fertiliser Industry might be lagging behind within that context, and mooted some ideas for industry collaboration innovation; and
- Third, raised the scale of disruption and opportunity that technology innovation – what we at the Forum have termed the "4th Industrial Revolution" – is bringing to this global risk context, and where some areas of potential disruption might be for the Fertilizer Industry

I will leave you with a final thought from Jack Welch

"Change before you have to."

Thank you (5700 words)