

FRANCOIS BARONE  
19113943

BHAVYA GUPTA  
19073155

OLIVER H. HAULUND  
19021869

MAREK ISTOK  
19025338

MARKUS KEIBLINGER  
19020414

QUENTIN LEROUX  
19101062



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# GLOBAL FOOD SYSTEM: CHALLENGES AND SOLUTIONS

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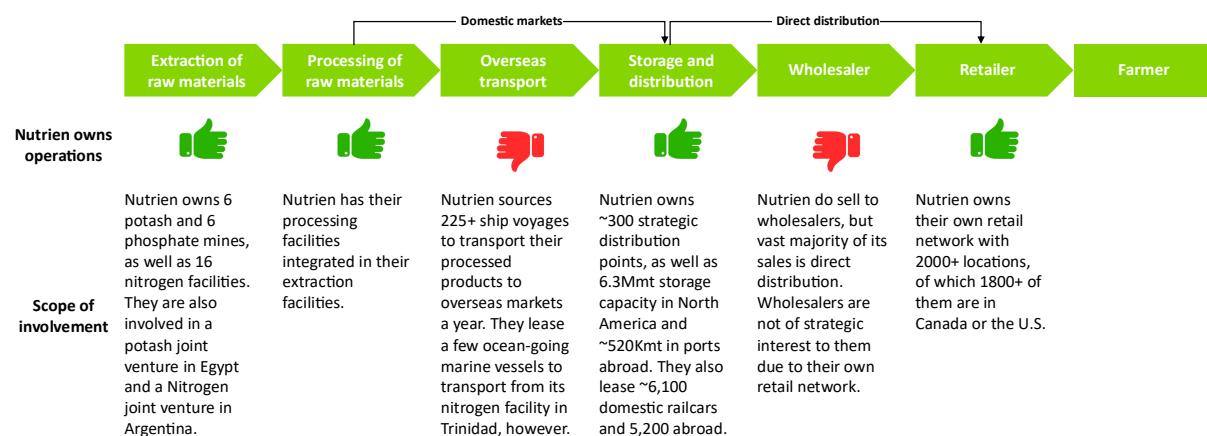
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# 1 Nutrien and the Global Food System

## 1.1 Nutrien Company Overview

Producing more than 25 million metric tonnes of nutrients a year, Nutrien is the biggest fertiliser producer globally (Nutrien, 2020a, pp. 1, 12). Its core value proposition is increasing crop yield for farmers through providing fertiliser. Their USPs are availability and expertise<sup>1</sup>. The availability stems from its extensive retail network of +2,000 retail locations primarily in North America and Australia and their flexible financing options provided through Nutrien Financial<sup>2</sup> (Nutrien, 2020a, pp. 12, 23). Expertise is provided through its +3,400 agricultural consultants that help farmers optimise their use of fertiliser, and increasingly through their digital platform functioning as a knowledgebase and predictor for the impact of relevant factors, like weather (Nutrien, 2020b) (Nutrien, 2021a).

**Figure 1 - Nutrien's activities in the fertiliser supply chain**



(Nutrien, 2019, p. 16) (Nutrien, 2020a, pp. 12, 30, 106) (The Fertilizer Institute, 2021)

Evidently, Nutrien is well integrated vertically (figure 1). It controls the full supply chain in its core markets in North America, where there is no need for overseas transport. This means that despite being upstream, Nutrien has direct customer contact, enabling it to influence how customers use fertiliser. Their retail network connects other supply chains like those of crop protection and seed products, thus also positioning them to impact problems related to these.

<sup>1</sup> See appendix 5.1 for full overview of its value proposition

<sup>2</sup> See appendix 5.2 for complete geographical distribution of retail locations

**Figure 2 - Segment descriptions and revenues**

Production				Retail			
Potash	Nitrogen	Phosphate	Crop nutrition (fertilizers)	Crop protection	Seeds	Merchandise	Services
Mining and processing, primarily granular form (highest quality)	Manufacturing and processing into: ammonia, urea, urea ammonium nitrate, industrial grade ammonium nitrate, and ammonium sulfate	Manufacturing and processing into: ammonia, urea, urea ammonium nitrate, industrial grade ammonium nitrate, and ammonium sulfate	Dry and liquid macronutrient products including potash, nitrogen and phosphate, proprietary liquid micronutrient products, and nutrient application services.	Third-party and proprietary supplied products designed to maintain crop quality and manage plant diseases, weeds, and other pests	Third-party and proprietary (Dynagro) seed product lines.	Fencing, feed supplies, livestock-related animal health products, storage and irrigation equipment, and other products	Digital Hub – providing analytical and consulting services to customers Financial services, precision ag., crop scouting, soil and leaf testing
— 13.30%	— 12.28%	— 6.27%			68.14%		1
Revenue %							

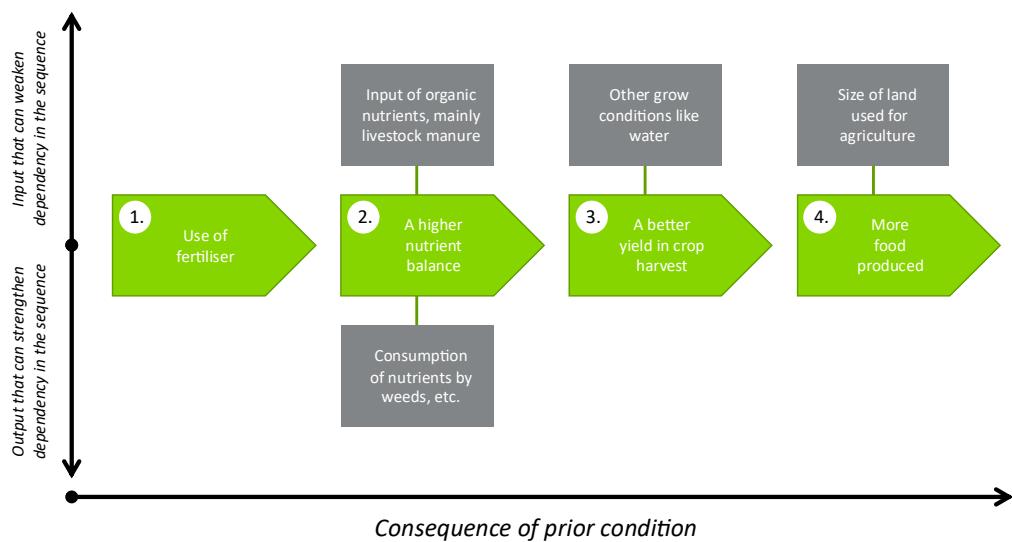
(Nutrien, 2020a)

## 1.2 The Effect of Fertiliser

Farmers use fertilisers to increase the production of crops. For crops to grow and give a higher yield<sup>3</sup>, they mainly need 17 important nutrients, of which the most important ones are nitrogen, phosphate, and potash (Fertilizers Europe, 2019). These nutrients dictate the yield following the “Liebig’s barrel” principle<sup>4</sup>, and the amount of nutrients in the soil defines the total production of crops. Therefore, it is important to maintain the right level of nutrients, which is managed with a nutrient balance – the net amount of each nutrient being added to the soil. Farmers can then use fertiliser to impact this balance, and the harvest yield artificially.

This effect is represented in figure 3, where externalities that can impact the effect are also shown in grey.

**Figure 3 - Simplified effect of fertiliser**



(Fertilizers Europe, 2019)

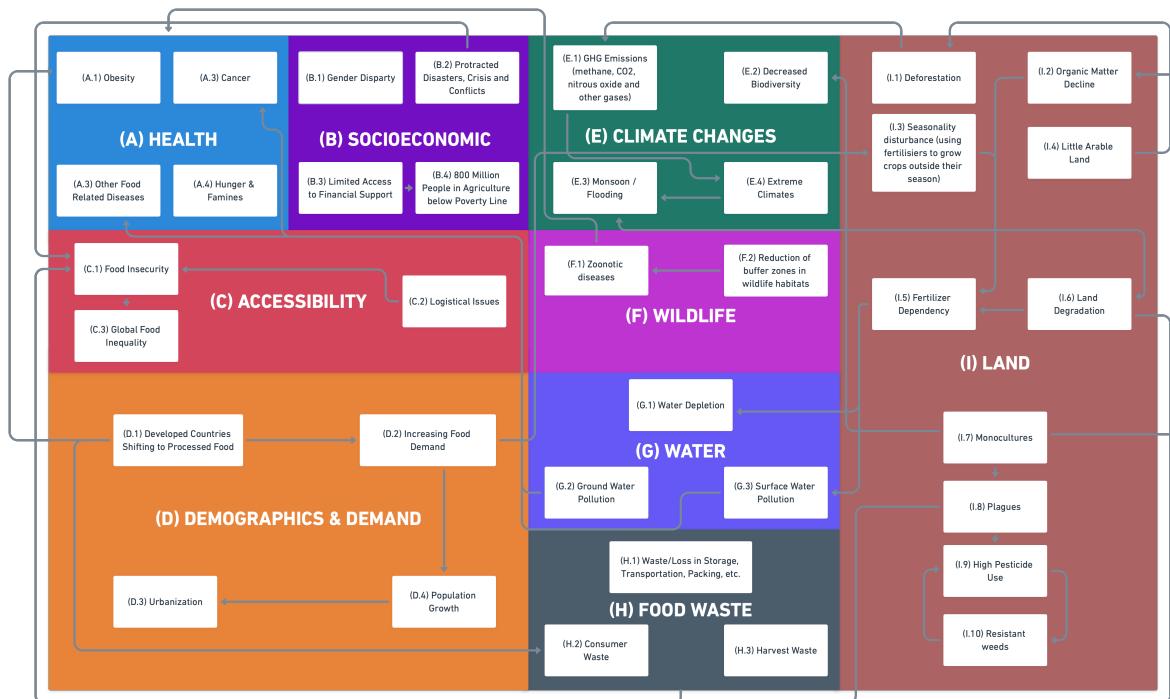
<sup>3</sup> Yield is to how much crop is harvested per area of cultivated land

<sup>4</sup> The yield being dictated by the scarcest resource, i.e., the nutrient being the least available in the soil relative to the crop's need. This means that no nutrient can replace the lack of other nutrients

## 1.3 Problems in the Global Food System

After analysing the reading materials and doing further research in Quid, we mapped 37 problems in the global food system. We split them into nine general categories, as shown in figure 4 below<sup>5</sup>. These categories either fall within social problems, A-D, or environmental problems, E-I.

**Figure 4 - Problems in the global food system**



(FAO, 2017a) (World Economic Forum, 2016) (World Economic Forum, 2018) (Smith, et al., 2019)

Not all of these problems are directly related to Nutrien. The authors assessed each of the problems based on how Nutrien is positioned to impact either negatively or positively to the problem, keeping in mind key propositions of **production activity** (mining, manufacturing, and transport), **retail** (providing access to products and services), and **product use** (how customers use the products).

<sup>5</sup> A detailed description of the approach and their relatedness to Nutrien is included in appendix 5.3 together with sources for the data in the graphics

**Figure 5 - Nutrien's problem footprint**

(C.1) P+R+U Food Insecurity	(D.2) P+R Increasing Food Demand	(B.3) R Limited Access to Financial Support	(I.4) U Little Arable Land	(I.5) U Fertilizer Dependency	(I.9) U High Pesticide Use
<b>820 million malnourished people in the world</b>  The global cost of undernourishment is estimated to be <b>\$1.4-2.1 trillion</b>  Application of fertiliser an enabler in solving this, which Nutrien is experts in	Global population expected to reach <b>10 billion in 2050</b>  Food insecurity has to be solved first, but right application of fertiliser can improve yield	<b>800 million people</b> working in agriculture <b>under poverty line globally</b>  Only 1% of bank lending goes to agriculture  Nutrien are in position to provide funding	Earth has lost more than 30% of arable land in the last 40 years  Again, Nutrien are in a position where they can go in and optimise the use of land	Fertilizer use <b>increasing by 20% in 4 years worldwide</b>  Modern farming practices make it impossible to stop  Nutrien are world-leading in supply of fertiliser, and users believe it is an only-positive ingredient	<b>90% of water</b> in the US has 1 or more pesticides  <b>34% increase</b> from 2000 globally  Kills natural bacteria  Nutrien sells pesticides in retail but it is not their main area of expertise
(G.1) P+U Water Depletion	(G.2) U Ground Water Pollution	(G.3) P+U Surface Water Pollution	(E.1) P+R+U GHG Emissions	(H.3) U Harvest Waste	How are the problems related to Nutrien?
<b>Agriculture represents 70% of global water consumption</b>  Overuse of irrigation in certain areas is caused by lack of knowledge about the seeds farmers buy, something Nutrien is positioned to change through their retail	Nitrogen levels higher than regulatory recommendations in <b>15% of US water sources</b>  Nutrien is supplying the polluting resources, and are thus in position to intervene	<b>46% of US</b> (38% of EU) water bodies are under pressure from agricultural production  Most of this is caused by overuse of fertiliser, so if Nutrien helps farmers apply fertiliser more cleverly, it can help	24% of global emissions from agriculture  Green space created which reduces GHGs	14% of food harvested globally is lost between harvest and retail  Nutrien is doing education with their farmers, and actively engages in avoiding harvest waste	<b>P – production activities</b> (how we make our products) <b>R – retail activities</b> (how we provide access to products) <b>U – product use</b> (how our customers use the products)

6

Based on figure 4, Quid and an interview with the Global Lead Food Scientist at WWF, Brent Loken, we decided to focus on Food Insecurity (C.1), Surface Water Pollution (G.3), and Fertiliser Dependency (I.5) as Nutrien seems to be impact-wise most connected with these. This was also confirmed in the interview with Brent. Supplementary, both Water Depletion (G.1) and Ground Water Pollution (G.2) are closely connected to the three main problems chosen.

<sup>6</sup> For full description of each of these sub-problems, see appendix 5.4

## 2 Transformative Innovations in the Global Food System

Figure 6 - Map of transformations

(1) Mining process	(2) Retail	(3) Product use
(1.1) Tailings management  11	(1.1.A) Water tailings management  (1.1.B) Rock tailings management  3	(3.1) Precision agriculture  (3.1.A) Total farm management  (3.1.B) Precision irrigation  49
(1.2) Water treatment  18	(1.2.A) Water desalination  (1.2.B) Water filtering  4	(3.1.C) Soil analysis and management  (3.1.D) Precision application tech  37
(1.3) Total mining solutions  7		(3.2) Chemistry  (3.2.A) Advanced fertilizers  (3.2.B) Modified plants  (3.2.C) Advanced crop protection products  2
Number of examples in the category		(3.3) Vertical farming

(Kurth, et al., 2020) (World Economic Forum, 2018)<sup>7</sup>

After identifying state-of-the-art innovations relevant to Nutrien that address the selected issues, we systematically classified them. We first focused on Nutrien's key activities as they contribute to greater impact. Then we studied existing classification models developed by experts from WEF and BCG and used search tools such as Quid and Google.

This led us to a classification into the following three categories:

1. **Mining:** The stage during which Nutrien recovers the phosphate, potash and nitrogen necessary for making fertilisers. About 39 million tons of rocks are mined annually for potash only. This can be improved by better tailings management, water treatment and upheaval of current mining methods (Nutrien, 2020a) Nutrien's revenue and includes solutions that influence grower performance, excluding production methods like platforms for certifying product quality to consumers or producers' finances (Nutrien, 2020a).
2. **Retail:** Accounts for 68% of Nutrien's revenue and includes solutions influencing grower performance excluding production methods like platforms for certifying product quality to consumers or plans to optimise producers finances (Nutrien, 2020a).
3. **Product use:** Corresponds to production's innovations that improve production's efficiency and quality of product use. The most relevant in this case are precision agriculture, chemistry and vertical farming. Precision agriculture is a set of tools used

<sup>7</sup> See appendix 5.5 and 5.6 for detailed explanation of classification design

to manage the various production aspects, such as soils, irrigation and fertilisers. Chemistry makes it possible to create new types of fertilisers, modify plants' genetic composition, and develop products to protect crops from damaging organisms (pesticides, herbicides, insecticides, etc.).

**Figure 7 – Overview of promising innovations in our classification (coloured is our focus)**

Category	Transformation	Innovation	Description
(1) Mining process	(1.1) Tailings management	(1.1.A) Water tailings management	Nirobox by Fluence Turns wastewater into steam and material by using sunshine rays. This approach makes it possible to filter the wastewater and generate energy at the same time.
	(1.1.B) Rocktailings management	FLSmidth	A way to maximize water retention from rock and clay tailings. Enables the recovery of 95% of the water in dry tailings.
		(1.2.A) Desalination	Veolia Filters saltwater with a process called Reverse Osmosis: pushing water through a membrane that lets the water through but keeps the salt. Consumes very little energy and produces very high quality water.
	(1.2.B) Filtering	BioTEQ by BQE Water	Filters sulfides out of water by adding biological elements which turn it from a liquid into a solid, which can be easily filtered out.
		Gensource Potash Mine	A small footprint, no wastewater, highly cost efficient complete potash mining solution.
	(1.3) Total mining solutions	Hellofuture by Orange	Provide farmers with an access to agricultural marketplaces, as well as providing payment, transfer, and micro-insurance/credit options.
(2) Retail	(2.1) Financial support	Yara	Yara delivered 40 000 mt of fertilizer to Africa in partnership with UN World Food Program. They are establishing a sales network in Africa as well as developing mines.
	(2.2) Business support		
(3) Product use	(3.1) Precision agriculture	(3.1.A) Total farm management	Agrivi This innovation provides precious tools on farm management, Weather Monitoring & Pest Detection, Farm Economics, Resources & Inventory and Farm Analytics & Reports.
		(3.1.B) Precision irrigation	Groguru Sensors analyze the content of soils such as their moisture, temperature and salinity. Then the model of AI helps growers when and buy how much they should irrigate.
		(3.1.C) Soil analysis and management	Teralytic Sensors are implemented in lands to determine the chemical composition of soils. Then growers can see these data and receive pieces of advice on what actions to take. This helps to fix issues of poor knowledge of soil and soil management.
		(3.1.D) Precise application technologies	Exosect by Terramera This one is a technology that delivers agricultural crop protection active ingredients to their intended targets. It prevents from crop diseases and pests.
	(3.2) Chemistry	(3.2.A) Advanced Fertilizer	Proven - by Pivot Bio Proven is a microbe that creates a symbiotic relationship with the corn plant, produce nitrogen and deliver it directly to the roots of the corn plant. This avoid Volatilization, Leaching and denitrification of Nitrogen.
		(3.2.B) Modified plants	Iden Biotechnology Iden biotechnology produces genes aimed at increasing yield, improving quality and tolerance to abiotic stress.
		(3.2.C) Advanced Crop Production	Nanotechnology (research) This innovation is a natural compound called hexanal spray used to reduce the amount of harvested products.
	(3.3) Vertical farming	AeroFarms	AeroFarms is a company that cultivates products inside warehouses containing large shelves on which soil spaces are placed. This helps to fix the problems related to the decreasing of arable farmland and the increase in population. It also makes it possible to reduce pesticides and fertilisers uses.

<sup>8</sup> For full overview of innovations mapped to our classification, see appendix 5.6

### 3 Impact of relevant Transformative Innovations

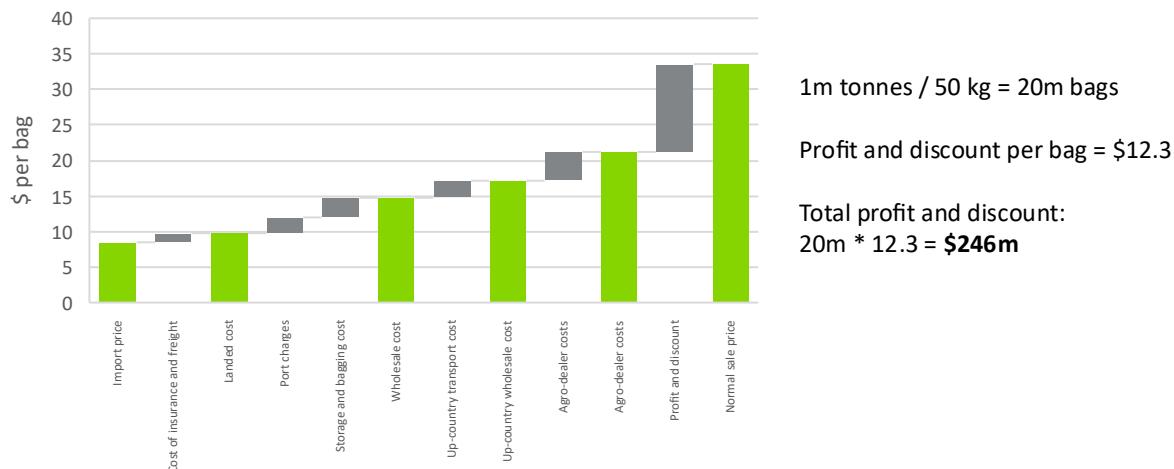
#### 3.1 Impact for Food Insecurity (C.1) – Enabling Africa to use fertiliser

The most severe cases of food insecurity are in Africa. More than 240m Africans are undernourished (Roser & Ritchie, 2013). The cost of this undernourishment for society is around \$420-630bn (FAO, 2013, p. 9).

One transformative innovation identified to tackle this is establishing agriculture retail operations in Africa and providing fertiliser access (Gilbert, 2014). Increasing the currently low use of fertiliser will increase the domestic production of food, which in turn will improve the food insecurity<sup>9</sup> (African Development Bank Group, 2020) (Kearney, 2016, p. 2).

By directly selling some of their capacity in Africa, Nutrien would cut unnecessary middlemen's cost in the advanced supply chain (Bumb, n.d.). Doing this, like Yara, Nutrien could ship up to 1Mmt of each product to Africa. At full implementation, around 39m people<sup>10</sup> would not be undernourished anymore, saving society \$65-100bn<sup>11</sup>.

**Figure 8 - Price breakdown for Nutrien nitrogen to Africa**



(Nutrien, 2020a) (Goedde, et al., 2019)

Using nitrogen as an example, the breakdown of its costs being offered in Africa has been found using Nutrien's production price, standard shipping rates, and the usual retail price in "Africa. This leaves" the grey bar "profit and discount", where Nutrien should give a significant discount, and the rest is gross profit. Suppose 1Mmt nitrogen is sold in Africa

<sup>9</sup> See the full argument and explanation behind this in appendix 5.7

<sup>10</sup> 1 tonne of extra grain from ~65kg each of nitrogen, phosphate and potash (Yousaf, et al., 2017). ~7,600kcal in 1kg of grain (International Rice Research Institute, 2007). Assuming 3,000kcal per solving 1 case of undernourishment, including waste.

<sup>11</sup> Assuming equal distribution of the cost of undernourishment in Africa: \$430-630bn / 246.4m people undernourished in the region \* 39m people not undernourished anymore

that gives a profit excluding discount given of \$246m. It can be assumed that potash and phosphate will have similar numbers.

The two main feasibility problems are the lack of technology to analyse nutrients already in the soil, and the ability to actually distribute and sell 1Mmt in Africa. In Yara's case, it was very challenging to deliver just 40,000mt (Yara, 2020a)<sup>12</sup>. Yet, Yara's established retail in Africa sold 0.3Mmt in Q3 2020 (Yara, 2020b). While 10x as much might be optimistic, even 40,000mt helps +1m people out of undernourishment. Technologically, the lack of access to soil testing is a threat. If soil testing is not available, the fertiliser would have to be applied without knowing the need for each nutrient, potentially resulting in waste due to the "Liebig's barrel" principle, and so would the economic feasibility for African farmers using the fertiliser. Development in this technology is thus defining whether operational innovation is feasible or not. Nutrien may look into combining it with efforts of those of Teralytic, making advanced but low-cost soil analytic hardware, to mitigate this.

### 3.2 Impact on Surface Water Pollution (G.3) – GenSource Potash Corp

Nutrien boasts 21% of the global potash capacity. During potash mining, only 30% of the potash rock we mine is used, and 70% is wasted. The 70% waste represents 27.3 million tons of waste (mostly salt) that are discharged in the environment, contributing to freshwater salinity (increase by 10x), algae blooms, and to the destruction of adjacent ecosystems.

Clean and more efficient potash extraction methods could decrease the environmental impact of potash mining activities.

GenSource Potash Corp. develops a cleaner potash mining technology based on a selective extraction process by injecting hot salt into the potash ore body and dissolving the potash to keep the salt in place while potash comes out of the ore by crystallising.

In Canada, for the Tugaske Project, the approach has revealed to be one of the lowest cost producers in the potash mining industry by being 10x more efficient than traditional mining on a similar footprint area, using 75% less water per ton of potash.

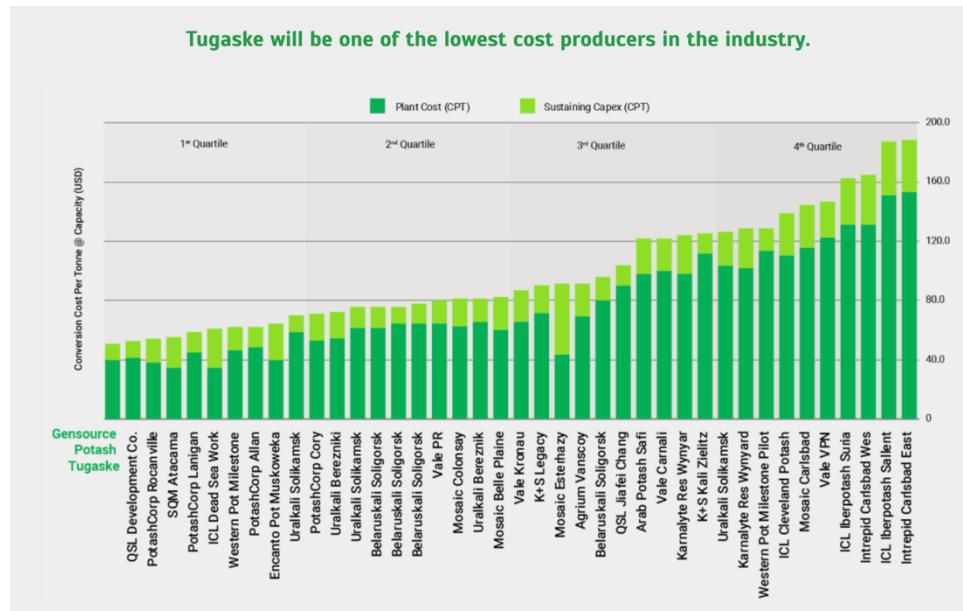
Thus, by using less water and leaving the salt in the rock, GenSource selective mining innovation contributes to depolluting the potash mining activity.

This can only be applied to new production sites. It uses fairly conventional technology elements. Additionally, the widespread adoption of cloud computing and fast broadband internet makes it possible to setup new mining outposts without having to create a separate computing infrastructure for each of them.

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<sup>12</sup> See figure 7

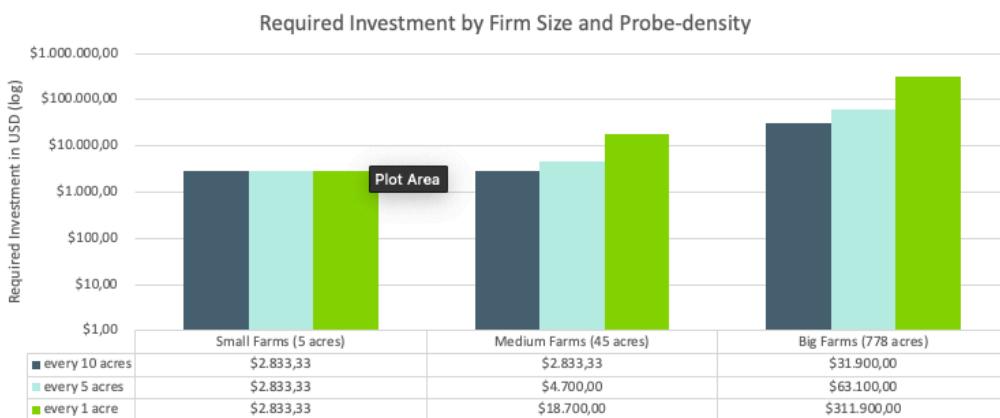
**Figure 9 - GenSource Potash Corp. outperforming competition on cost of production**



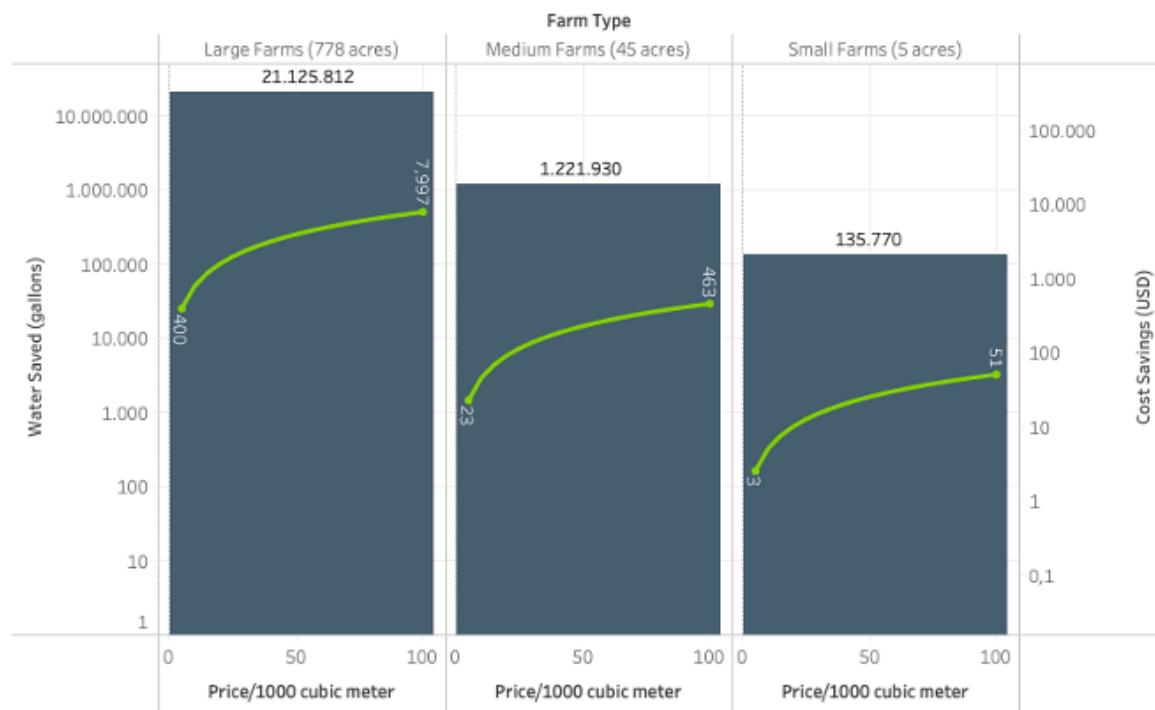
### 3.3 Impact on Fertiliser Dependency (I.5) – Teralytic

Teralytic provides an IoT System that allows for real-time soil monitoring. This helps farmers avoid the overuse of fertiliser and irrigation and could present an option for Nutrien to expand on their digital platform. Figure 10 shows the investment required by farms at different sizes, Figure 11 the potential water savings. Further, the insights will allow farmers to avoid fertiliser overuse which leads to reduced GHG emissions and further reduced costs. Since fertiliser requirements vary depending on the crop used and the estimates for the potential fertiliser-savings using such a system vary greatly as well, the impact on fertiliser has not been quantified. It is crucial to note, that in some regions (e.g., Florida), growers not using real-time soil monitoring would have the Department of Environmental Protection do the monitoring, which would cost about \$8,000 per year – already much more than the investment required by small farms.

**Figure 10 - Required Investment by Farm Size and Probe-Density**



**Figure 11 - Potential Water Savings**



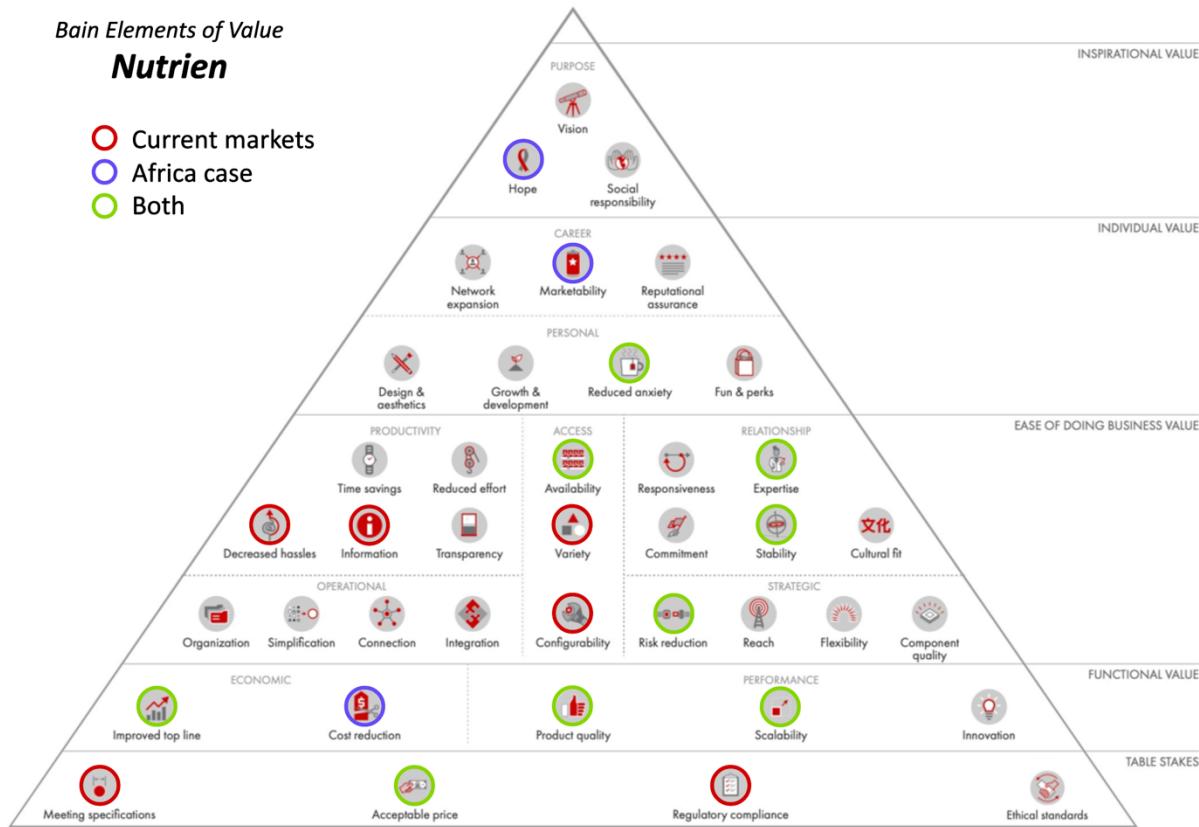
## 4 Summary

We have provided an in-depth analysis of Nutrien and its activities. We analysed 37 global food system problems, which we narrowed down to 11 that closely relate to Nutrien, but also could establish. To properly map and analyse the transformative innovations, we looked at 132 examples and classified them according to types. Finally, we provided an analysis of the impact Nutrien could have if they adapted some of these state-of-the-art transformations. After a meeting with Brent Loken, WWF Global Food Security Expert, we were pleased to see that our understandings of the problems and solutions closely agreed with his.

## 5 Appendix

### 5.1 Bain Elements of Value

**Figure 12 - Nutrien's value proposition**



When analysing Nutrien, one key factor to understand is the combination of elements that comprise its value proposition. These value proposition elements – what Nutrien is helping its customers with – essentially define their product mix and reflect its competitive advantages.

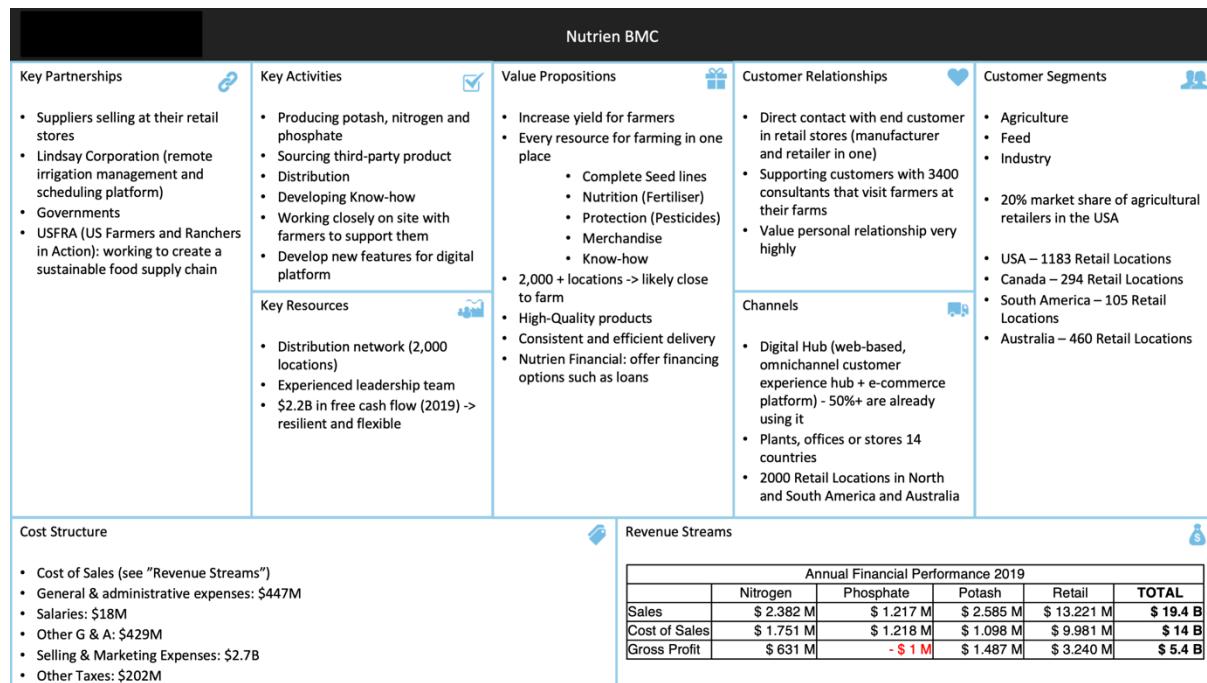
As the use of fertiliser is highly regulated in most of Nutrien's main markets (United States Environmental Protection Agency, 2019) (Canadian Department of Justice, 2020), some essential elements of value are “meeting specifications”, “regulatory compliance”, and “product quality”. Likewise, fundamental in the application of fertiliser is the improved yield resulting in “improved top line”. While these value-adding elements are expectedly common for all bigger fertiliser companies, some of the elements that make Nutrien's operations unique, and thus competitive, are the “expertise” and “information” of their consulting arm, the high “availability” in their extensive retail network, and the “stability” of their retail network being supplied by the largest crop nutrient producer by size (Nutrien, 2020a). The full overview of elements can applicable in Nutrien's current markets can be seen by combining the red and green circles in above overview.

Given expanding operations into Africa is considered in the report, the combination of value proposition elements ideal in the African market has also been explored. These are

found in the above overview by combining the green and blue circles, where the blue circles represent elements of value that are not in focus in its current markets. Interestingly, however, is the observation that only 3 of the ideal elements of value in Africa differ from those that Nutrien already “serve” in their current markets. The primary one of those three is “cost reduction” as the price of fertiliser in the African markets is currently so high that it exceeds the benefits of using it (Pais, et al., 2019). If Nutrien are to expand into some of the African markets and intervene in the problem of lack of access to fertiliser, they thus need to significantly cut the price for the farmers. The other two elements more present in the African markets are “hope” – giving the African farmers the hope that their organisation will thrive in the future despite the majority of them being very challenged currently – and making the African farmers more “marketable” by allowing them to scale their operations and gain some level of economies of scale.

## 5.2 Business Model Canvas

**Figure 13 - Nutrien BMC**



(Nutrien, 2020a)

To better understand and visualize Nutrien business model, we used a Business Model Canvas (BMC).

First, Nutrien’s value proposition is to provide high-quality agriculture products to farmers to increase their yield, and enable them to find all the resources they need for farming in one place, in more than 2,000 stores and locations in the Americas and Australia. Its key activities to deliver its value proposition to this customer segment are the production and mining of potash, nitrogen and phosphate, the distribution of third-party products in its retail stores, and develop digital agriculture to accompany the farmers throughout the entire agriculture process and to vertically integrates all activities related to farming and agriculture. To do so, it employs different distribution channels such as its digital hub (a web-based digital platform including precision and

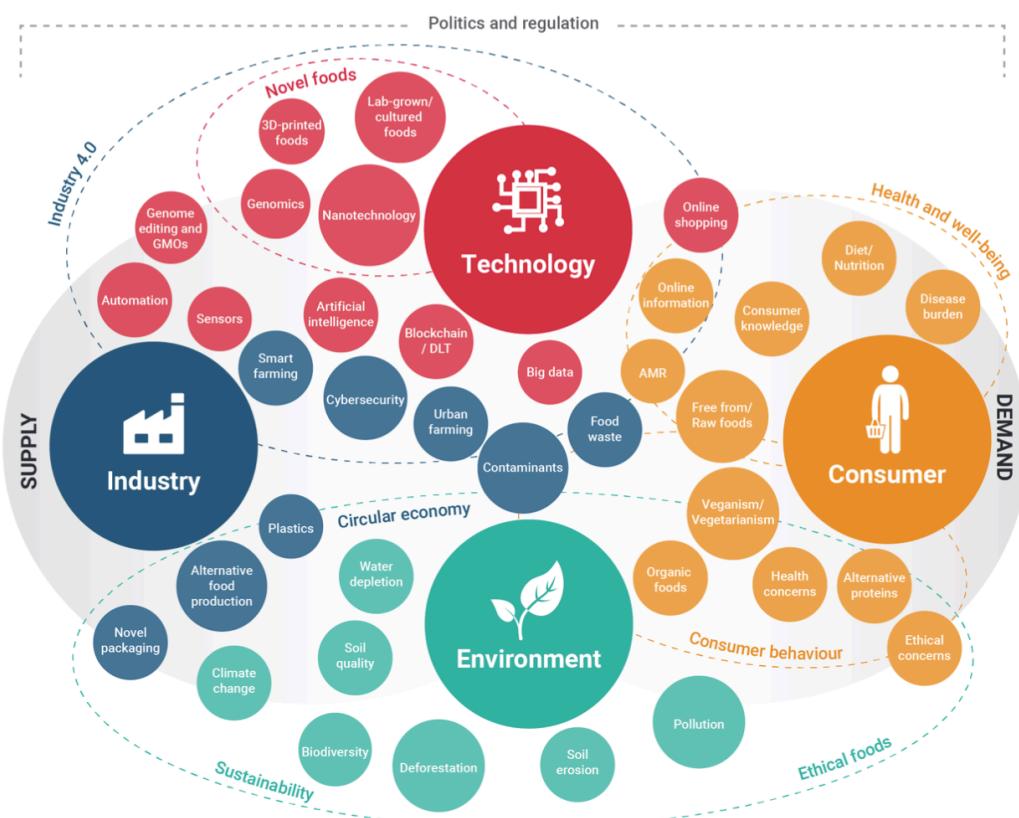
digital agriculture offers from third-party technology companies), its 2,000 retail locations in the Americas, and its production plants. To support its business model and entertain it, they keep a direct contact with their customers by providing them the expertise of more than 3000 agriculture consultants; they also develop partnerships with suppliers, mining and irrigation companies, governments.

Regarding their financial structure and their resources, they have \$2.2BN in free cash flow. Their revenue streams enable them to make \$631M gross profit on nitrogen, \$1.1487M on potash and \$3.240M on retail. However, their phosphate activities lead them to lose \$1m. Regarding their cost structure, they have to pay \$18M salaries, \$429M G&A, \$2.7BN selling and marketing expenses, and \$202M in other taxes.

### 5.3 Problems in the Global Food Industry

After analysing the recommended readings, we had a good idea of where to start. The most helpful resources were the UN FAO' video, The Future of Food and Agriculture, WEF's Agriculture and Food Security video and Innovation with a Purpose report. However perhaps the most helpful and comprehensive overview of all the problems for us was in the RAND Corporation's report, Insights into the Global Food System Risks and Opportunities and their Implications for the FSA, where they provide the problem map seen in figure 14 below.

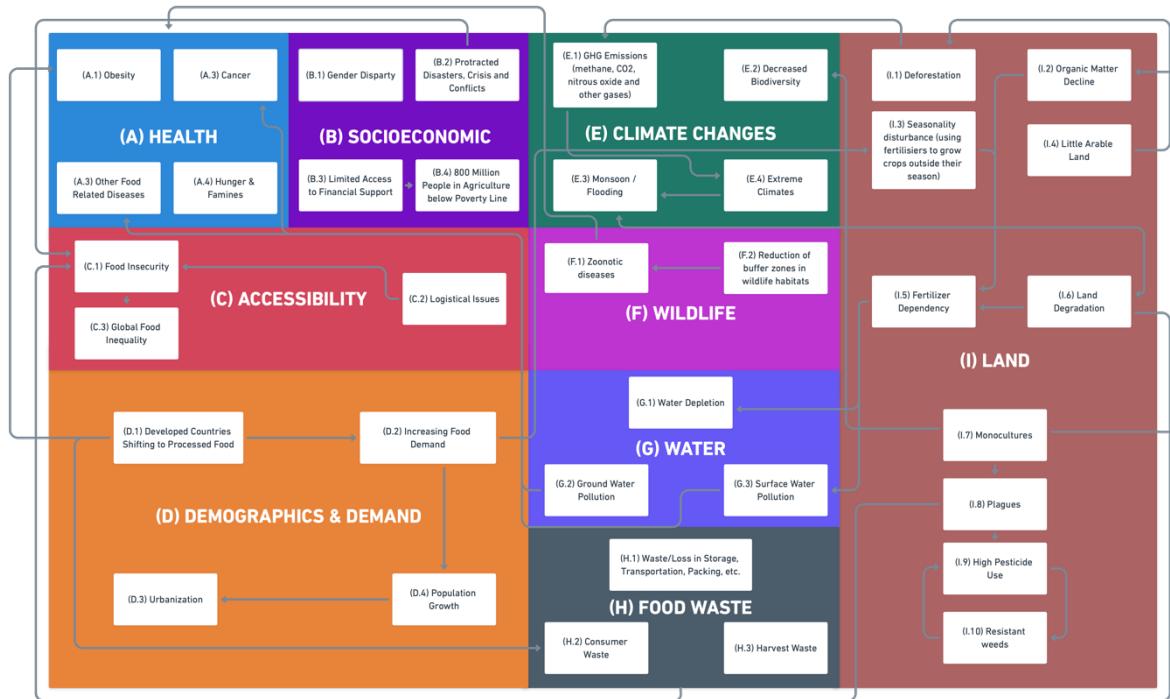
**Figure 14 - RAND Europe problem map**



Source: RAND Europe analysis

We then did some more searching using Quid and Google to fill gaps in the remaining areas. After having a comprehensive list of all the problems, we filtered the ones that were not related to Nutrien's business activities (mining and retail) or were not connected to any of our products. In the end we came up with the following problem map seen in Figure 15 below.

**Figure 15 - Problem map**



We split the remaining 37 problems into 9 more detailed categories. These are either social problems: (A) Health, (B) Socioeconomic, (C) Accessibility, (D) Demographics and Demand, or environmental problems: (E) Climate change, (F) Wildlife, (G) Water, (H) Food waste, (I) Land. A more general description of what we understand as these problems, and how it relates to Nutrien follows below in figure 15. If it's possible to measure the problem, the metric is highlighted in bold. We will then describe Nutrien's impact in problems most related to us later.

We understand problems as related to Nutrien if they concern with our **production** (mining, manufacturing, transport, ...), **retail activities** (providing access to products and services), or **product use** (how customers use our products). Where we have the most control over our own production and retail activities, but much less control in how our customers use our products. To drive change in product use we need to provide more guidance or better solutions to our clients.

Category	Problem	Description	Relation to Nutrien
(A) Health	1 Obesity	Obesity is one of the leading preventable causes of death worldwide. In 2016, <b>39% of adults were overweight</b> globally according to the (WHO, 2020).	Not related to Nutrien's activities.

Category	Problem	Description	Relation to Nutrien
	2 Cancer	In 2008 <b>cancer accounted for 13% of global deaths</b> , two thirds in low- or mid-income countries with poor access to proper nutrition (WHO, 2018).	Not related to Nutrien's activities.
	3 Other food related diseases	Other diseases such as high blood pressure, heart disease, high cholesterol, and others that result from a poor diet.	Not related to Nutrien's activities.
	4 Hunger and famines	<b>30 million people</b> in the world are experiencing alarming hunger (Oxfam International, n.d.).	Retail activity
(B) Socioeconomic	1 Gender disparity	Agriculture is dominated by men, often times due to issues such as landowning rights, access to resources, household labour, employment, and other causes (IISD, 2017).	Not related to Nutrien's activities.
	2 Disasters, crisis, and conflicts	One of the major causes of a lack of food and hunger (World Economic Forum, 2018).	Not related to Nutrien's activities.
	3 Limited access to financial support	More detail further.	Retail activity
	4 Poverty	Nearly <b>80% of the poor</b> live in rural areas and work in agriculture (World Economic Forum, 2018).	Not related to Nutrien's activities.
(C) Accessibility	1 Food insecurity	More detail further.	Retail activity
	2 Logistical issues	Many areas, mainly in the developing world, don't have proper access to transportation, technology, electricity, and other key logistical resources.	Retail activity
	3 Global food inequality	We have enough food globally, however we don't get it where it's needed (World Economic Forum, 2018).	Retail activity
(D) Demographics and Demand	1 Developed countries shifting to processed food	Processed foods are foods that don't need to be cooked before eating. Eating more processed foods is correlated with a higher risk of diseases mentioned higher.	Not related to Nutrien's activities.
	2 Increasing food demand	More detail further.	Retail activity
	3 Urbanisation	<b>By 2030 nearly 60% of global population will live in urban</b>	Not related to Nutrien's activities.

Category	Problem	Description	Relation to Nutrien
		<b>areas</b> (World Economic Forum, 2018).	
	4 Population growth	Global population expected to reach almost <b>10 billion people in 2050</b> (World Economic Forum, 2018).	Production and retail activities, as well as product use
(E) Climate Change	1 GHG emissions	More detail further.	Production and retail activities, as well as product use
	2 Decreased biodiversity	Agricultural practices such as high pesticide use, monoculture farming, and deforestation lead to a decrease in biodiversity.	Production and product use
	3 Monsoons / Flooding	Monsoons and rains bring massive flooding in vulnerable areas.	Not related to Nutrien's activities.
	4 Extreme climates	Unexpected and unusually severe weather or season changes.	Not related to Nutrien's activities.
(F) Wildlife	1 Zoonotic diseases	A disease caused by a pathogen that jumps from a non-human to a human, who then infect others.	Product use
	2 Reduction of buffer zones	Deforestation and urbanisation reduce buffer zones between civilisation and wildlife (World Economic Forum, 2018).	Product use
(G) Water	1 Water depletion	More detail further.	Production activity and product use
	2 Ground water pollution	More detail further.	Production activity and product use
	3 Surface water pollution	More detail further.	Production activity and product use
(H) Waste	1 Waste in transportation and storage	Nearly a third of food produced is wasted.	Not related to Nutrien's activities.
	2 Consumer waste		
	3 Harvest waste	More detail further.	Product use
(I) Land	1 Deforestation	Agriculture is the most significant driver of deforestation, contributing to a loss of 30 million hectares in 2016 (World Economic Forum, 2018).	Product use
	2 Organic matter decline	Decrease of organic matter in soil due to modern farming practices.	Product use
	3 Seasonality disturbance	Using fertilisers and pesticides to continue growing crops all year round.	Product use
	4 Little arable land	More detail further.	Product use

Category	Problem	Description	Relation to Nutrien
	5 Fertiliser dependency	More detail further.	Product use
	6 Land degradation	Repeated monoculture growing reduces presence of nutrients in the ground.	Product use
	7 Monocultures	Growing the same crop in the same place for many years in a row.	Product use
	8 Plagues	Diseases that spread between crops and damage produce.	Product use
	9 High pesticide use	More detail further.	Product use
	10 Resistant weeds	Due to an increase in pesticide use, weeds become more and more resistant to it.	Product use

It is important to realise that most of these problems are very interconnected. For example, increasing population leads to increased food demand, which leads to an increase in agricultural production. One way of increasing agricultural production is monoculture farming. Monoculture farming causes fertiliser dependency (and in turn land degradation) and high pesticide use (to avoid plagues), which leads to more resistant weeds (which lead to more pesticide). In a lot of these areas, we get into very wicked loops, and solving problems in isolation is extremely difficult if not impossible.

#### 5.4 Problems related to Nutrien

We tried to find areas, where Nutrien can bring the most impact by changing its own activities, and not having to expect someone else to follow suit with them. These are seen below in Figure 16.

Figure 16 - Map of related problems

(C.1) P+R+U Food Insecurity	(D.2) P+R Increasing Food Demand	(B.3) R Limited Access to Financial Support	(I.4) U Little Arable Land	(I.5) U Fertilizer Dependency	(I.9) U High Pesticide Use
820 million malnourished people in the world  The global cost of undernourishment is estimated to be \$1.4-2.1 trillion	Global population expected to reach <b>10 billion in 2050</b>	<b>800 million people</b> working in agriculture <b>under poverty line globally</b>  Only 1% of bank lending goes to agriculture	Earth has lost more than 30% of arable land in the last 40 years	Fertilizer use <b>increasing by 20% in 4 years worldwide</b>  Modern farming practices make it impossible to stop	<b>90% of water in the US has 1 or more pesticides</b>  <b>34% increase from 2000 globally</b>  Kills natural bacteria
(G.1) P+U Water Depletion	(G.2) U Ground Water Pollution	(G.3) P+U Surface Water Pollution	(E.1) P+R+U GHG Emissions	(H.3) U Harvest Waste	How are the problems related to Nutrien?
Agriculture represents <b>70% of global water consuption</b>  Overuse of irrigation in certain areas	Nitrogen levels higher than regulatory recommendations in <b>15% of US water sources</b>	<b>46% of US (38% of EU)</b> water bodies are under pressure from agricultural production	24% of global emissions from agriculture  Green space created which reduces GHGs	14% of food harvested globally is lost between harvest and retail	P – production activites (how we make our products) R – retail activities (how we provide access to products) U – product use (how our customers use the products)

C.1	Food Insecurity	820 million people suffer from undernourishment globally due to not having enough food (World Economic Forum, 2018). Nutrien's products could help farmers in the areas that are most impacted produce more crops and food.
		<b>Production:</b> Cover the demand for potash, phosphate, and nitrogen products. <b>Retail:</b> Ensuring access to yield increasing products in all regions. <b>Product use:</b> Provide proper guidance on how to use our products to ensure maximum yields and food security.
D.2	Increasing Food Demand	Global population is expected to reach 10 billion people in 2050. Nutrien is the largest retailer and producer of agricultural supplies and can help farmers improve their yields. Which is a must to keep up with the increasing food demand.
		<b>Production:</b> Cover the demand for potash, phosphate, and nitrogen products – so far, our capacity allows for significant increases (~ 30% reserve capacity (Nutrien, 2020a)). <b>Retail:</b> Ensuring access to yield increasing products, so farmers can produce more food to feed the growing population.
B.3	Limited Access to Financial Support	800 million people working in agriculture are living under the global poverty line (World Economic Forum, 2018). With agricultural practices becoming more dependent on technology and fertilisers, which are very expensive, farmers need access to financial support. Currently, only 1% of bank landing goes to agriculture, creating a global shortage. As a retailer, Nutrien can provide direct access to financial support to farmers, who require these products.
		<b>Retail:</b> Ensure farmers and customers have access to financial support in our stores.
I.4	Little Arable Land	Earth has lost 30% of arable land in the last 40 years due to climate change effects and urbanisation. Combined with the rising population, it's important to maximise yields from the remaining land to satisfy the global food demand. Nutrien can help farmers get the most out of their activities.
		<b>Product use:</b> Provide products and guidance so farmers can make the most of the little arable land available.
I.5	Fertiliser Dependency	Fertiliser use has gone up 20% in 4 years worldwide (FAO, 2017b). Because of modern farming practices, such as monoculture farming, it will increase even more in the future. Nutrien, as a provider and producer of fertilisers, can help farmers reduce their fertiliser use by providing alternative services and education.
		<b>Product use:</b> Provide guidance to farmers using fertilisers, as well as exploring other solutions that decrease the dependency on fertiliser (FAO, 2017b).
I.9	High Pesticide Use	90% of water sources in the US have 1 or more pesticides in them, and the use of pesticides has increased by 34% globally (USGS, 1999). While regulatory entities often check

		whether pesticide levels remain under, regulations are established for individual pesticides and not combinations. Farmers mix multiple pesticides to comply with regulations, but the health impact of these has not been examined. Nutrien, as a provider of pesticides, can provide guidance and alternative solutions to reduce pesticide overuse.
		<b>Product use:</b> 90% of US freshwater has pesticides in it (USGS, 1999). Providing proper guidance to farmers and exploring alternative solutions to reduce wrong application of pesticides.
G.1	Water Depletion	Agriculture is responsible for 70% of global water usage, mostly due to overuse of irrigation, which is caused by incorrect farming practices (growing crops that don't match with the geographical location). Nutrien, as a seller of seeds, can help by providing guidelines and advice so farmers grow viable crops.
		<b>Production:</b> Our mines and nitrogen production facilities use up 213 million m <sup>3</sup> of water in 2019 (Nutrien, 2021b). <b>Product use:</b> Farmers who use our products heavily irrigate due to incorrect plants in their region or overuse of fertilisers. Agriculture is responsible for 70% of freshwater withdrawal (World Economic Forum, 2018).
G.2	Ground Water Pollution	Nitrogen levels exceed regulations in 15% of US water sources, mainly because of high fertiliser use, which later seeps into the ground water. Nutrien can help provide advice with choosing and using the right product, so farmers don't cause unnecessary damage.
		<b>Product use:</b> Provide guidance to farmers using our fertiliser products, work with regulators, as well as explore other solutions such as organic fertilisers or alternative farming methods.
G.3	Surface Water Pollution	46% of US and 38% of European surface water is under pressure from agricultural production. Nutrien can help by providing guidance to farmers who use their products. Additionally, surface water pollution is often times caused as a biproduct of potash mining, where Nutrien is the world's largest producer. Improving their mining operations could lead to a reduction in surface water pollution.
		<b>Production:</b> Mining and production activities lead to 223 million m <sup>3</sup> of wastewater released to the surface (Nutrien, 2021b) <b>Product use:</b> 46% of US water is under pressure from agricultural production
E.1	GHG Emissions	24% of global GHG emissions is produced by the agricultural industry, some due to the production and misuse of fertilisers. Nutrien can help provide guidance to farmers, as well as make sure that their own operations (mining, production, transportation) are carbon neutral.
		<b>13.4</b> million tonnes of CO <sub>2</sub> <b>Production:</b> Nitrogen (76%), Potash (13%), Phosphate (7%)

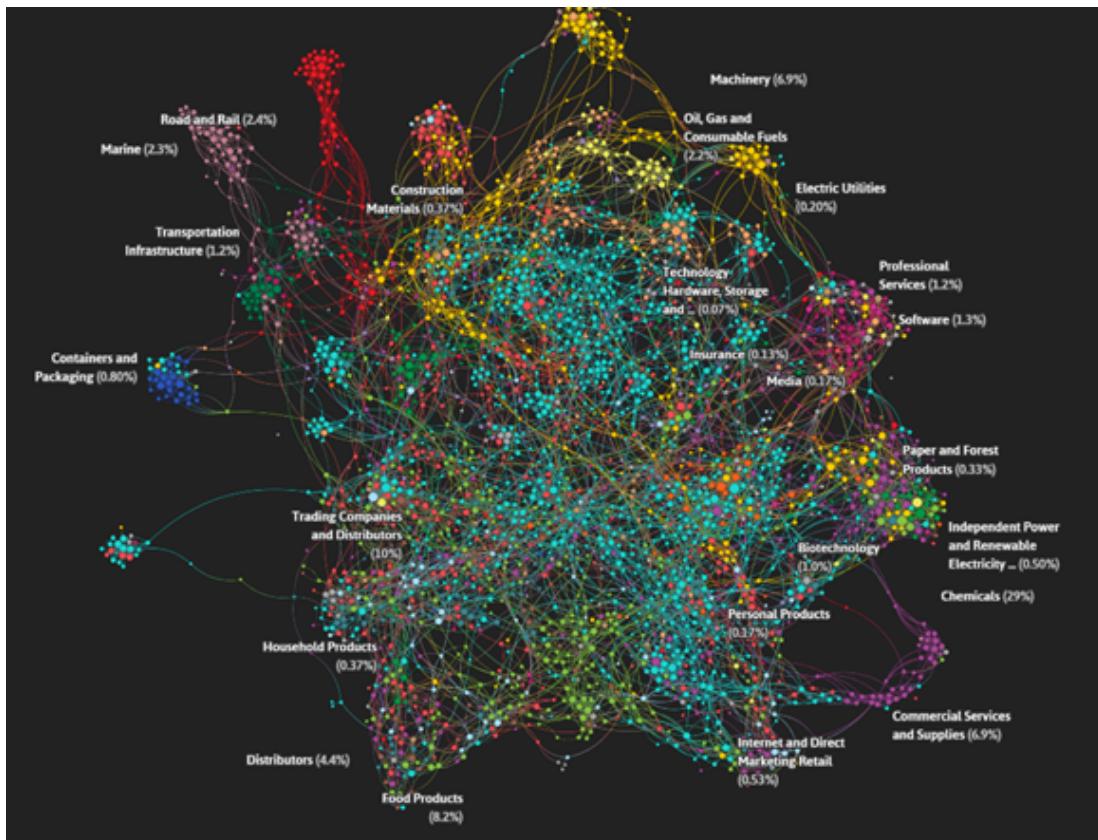
		<b>Retail:</b> 4% <b>Product use:</b> Fertilizer and pesticide use accounts for 13% of agricultural emissions (World Economic Forum, 2018)
H.3	Harvest Waste	14% of farm produce is lost between the harvest and retail. Better estimating harvest time and amount would help farmers prepare for the load. Nutrien can help with their analytics and digital farm solutions, so farmers know when and how much harvest to expect.
		<b>Product use:</b> 14% of farm produce is lost between harvest and retail (World Economic Forum, 2018)

#### 5.4.1 Using Quid to find Related Problems

1. First, we recognised the importance of looking at the scale of the agriculture and fertiliser industry and looked at the other key players in this market, i.e., our competitors, and collaborators. For this, we restricted ourselves to the USA and Canada, and those are our most valuable markets.

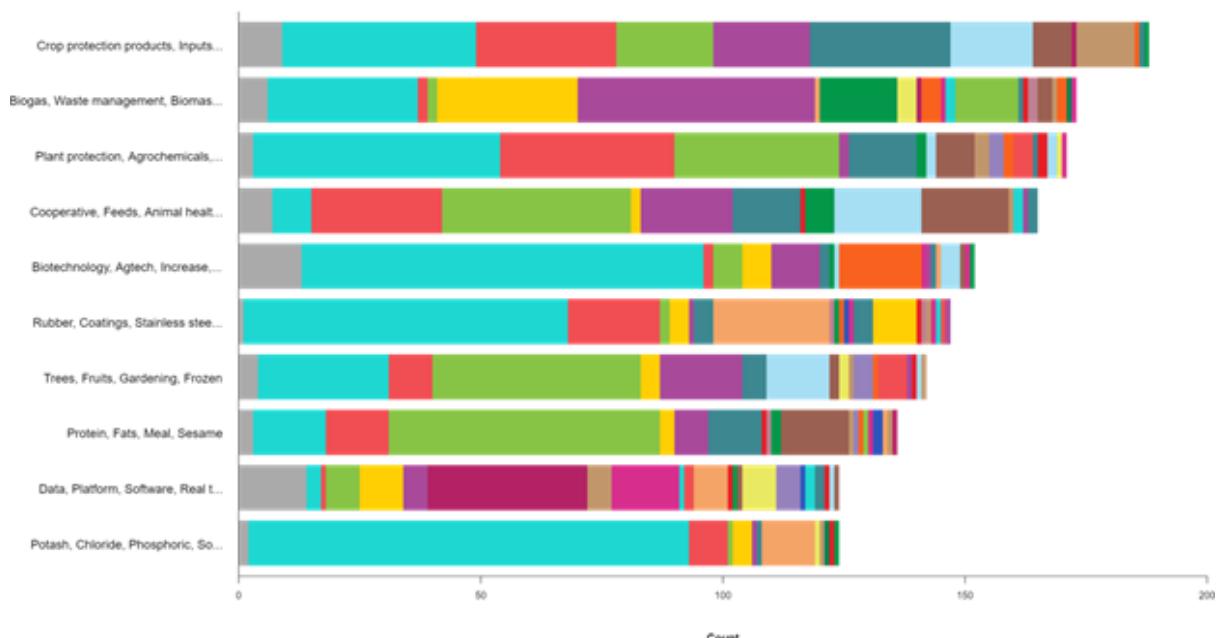
- a. Database: Companies
- b. Search: “Fertilizer”

Since this visualisation didn't yield any insightful results, we decided to cluster these by industry. The visualisation generated, as shown below, helped us understand the scale of the industry and its partners.



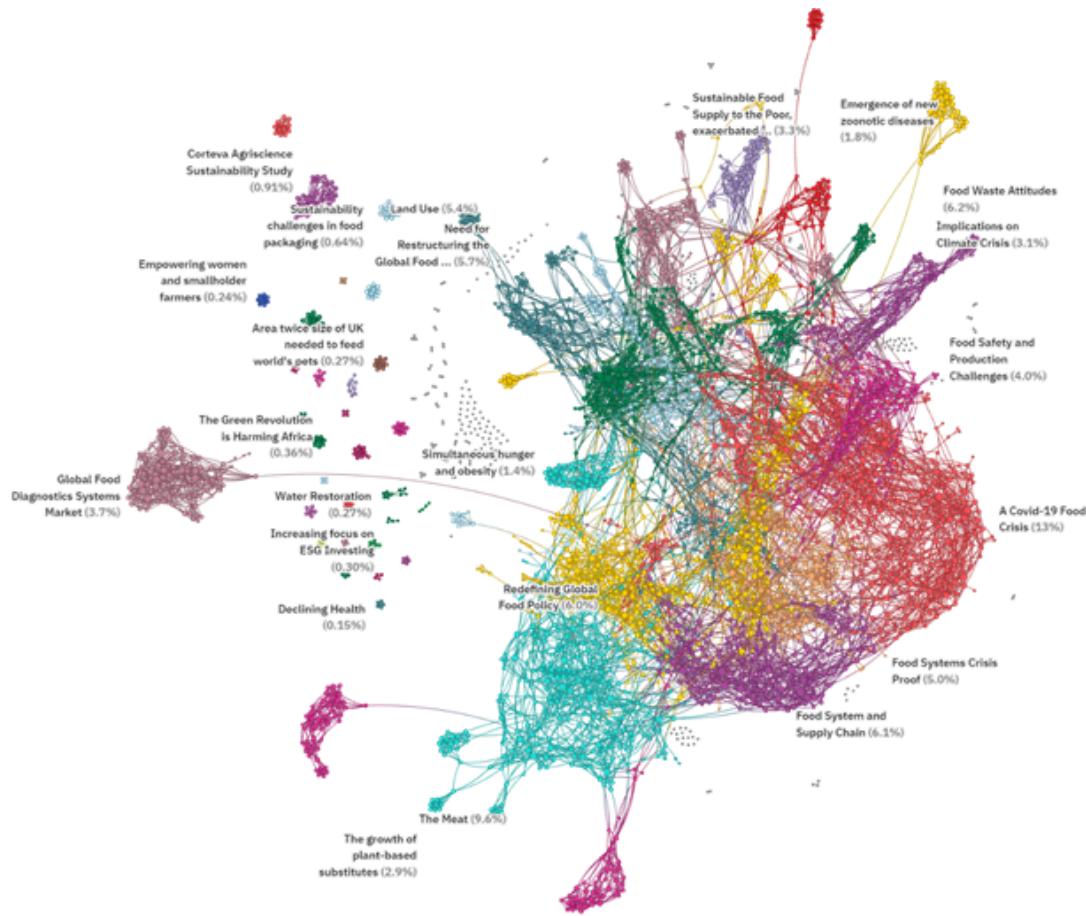
Next, for a more in-depth understanding across the clusters generated and industries these companies belong to, we added a bar chart based on the cluster name, coloured by

industry. This proved to be very insightful as we understood the key players (partners and collaborators) for the sector most relevant to us, which is potash and phosphate (the last horizontal bar). We also understood the rising trends in Agtech to know more about what innovations are developing overall in the industry, and where we can draw inspiration. This reconfirmed our focus areas which include using bio alternatives for land and water waste management and strengthen our core business offerings: potash and phosphates.



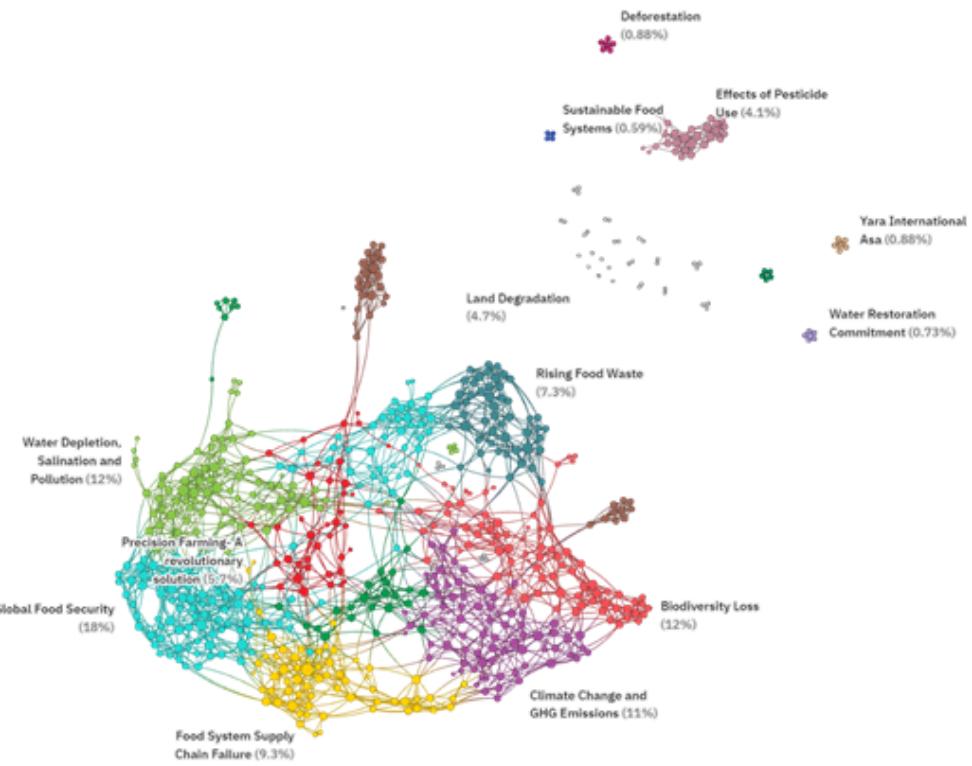
2. In conjunction with reports from McKinsey, Deloitte, WEF and other industry insights leaders, we aimed to understand the general categories of problems with the Global Food system.

- a. Database: News/Blogs
- b. Search: “global market” Food System AND ( Problems OR Issues OR hunger OR waste OR water OR land OR economy OR access OR resources OR reform OR risk )



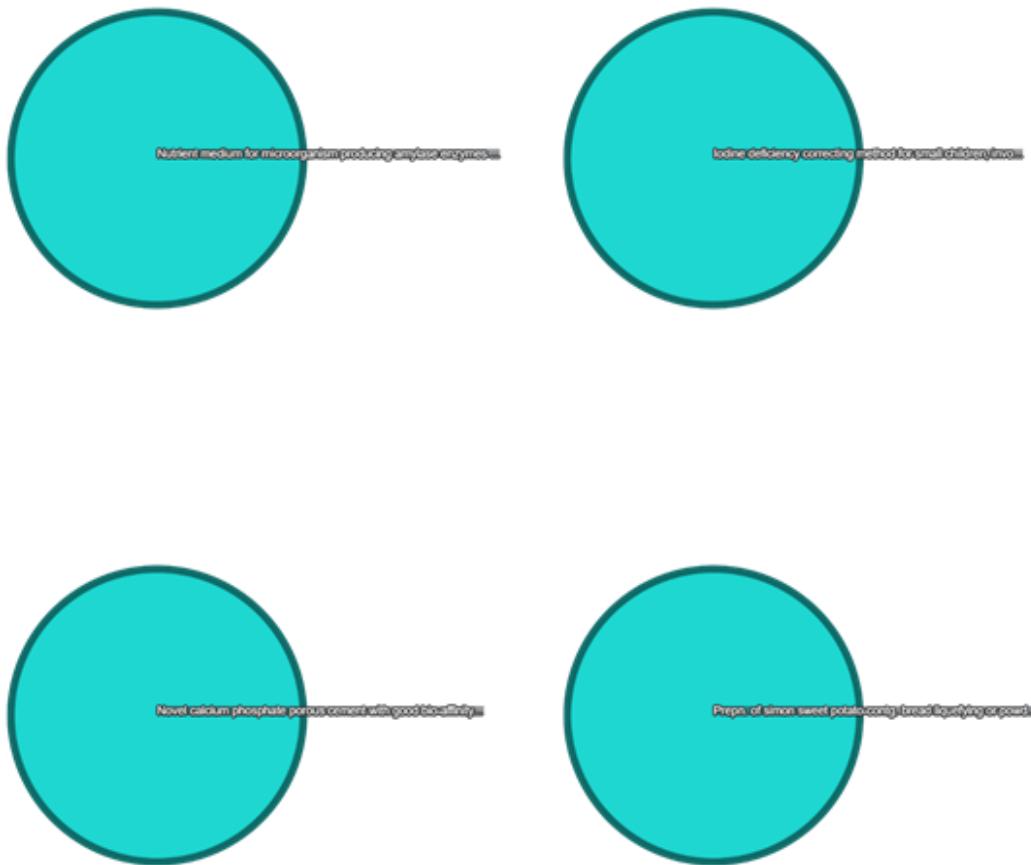
One key insight was Corteva Agriscience agronomists will work directly with farmers to enhance adoption of hybrid seed and crop protection products, and advance sustainable farming practices.

3. Post our analysis of the general problems, we wanted to find out which of these are relevant to Nutrien and the agriculture (fertilisers in particular) industry.
  - a. Database: News/Blogs
  - b. Search: “global market” Food System AND (Problems OR Issues OR hunger OR waste OR water OR land OR economy OR access OR resources OR reform OR risk) AND (Nutrien OR Fertilizer)

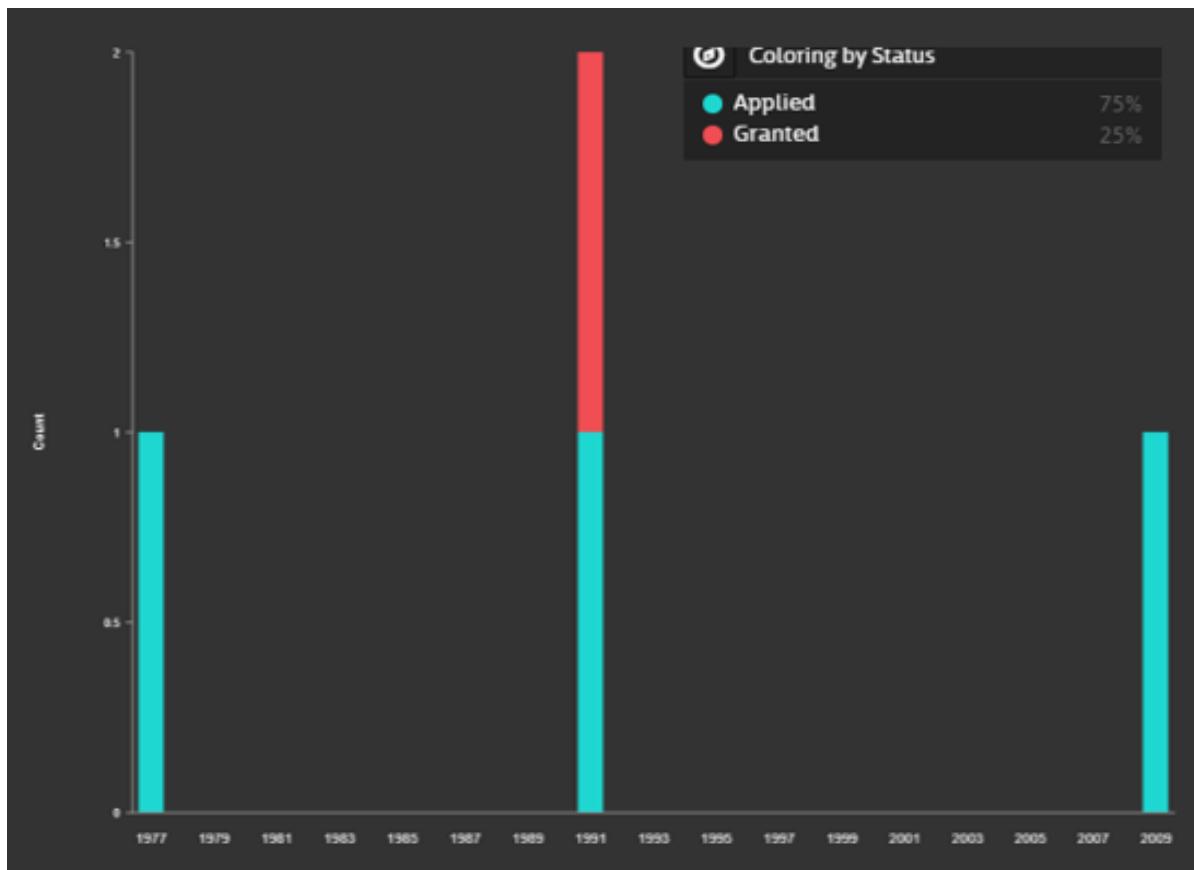


After investigating this network and combining our knowledge of Nutrien and its impact on each of these problems, as well as our interview with Brent Loken, we came to the conclusion that Global Food Security, Effects of Fertilizer and Water Depletion are three of the major problems that we have the capacity to dive deep into.

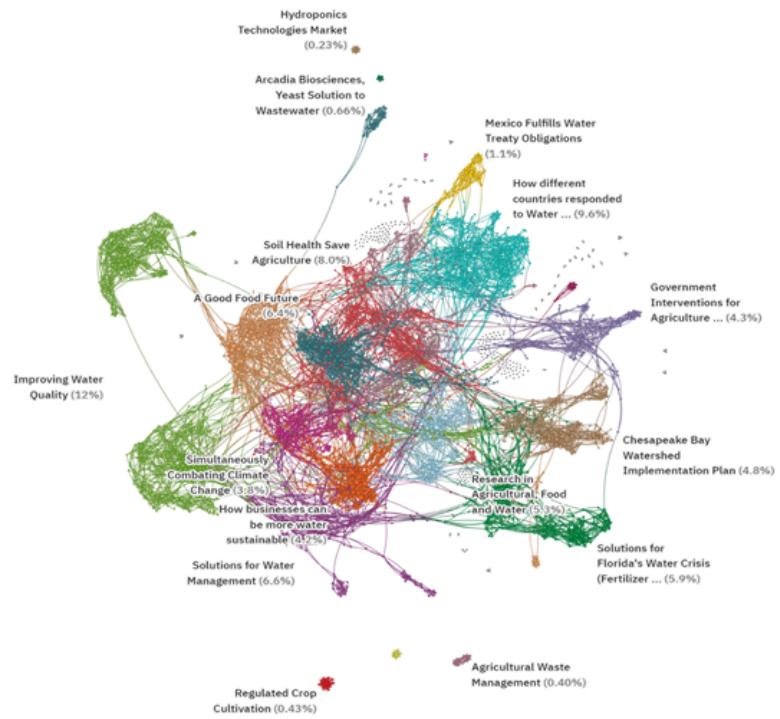
4. After we developed an understanding of Nutrien and the problems that it contributes to/solves, we wanted to know more if Nutrien actively develops new technologies or patents as it would give us a thorough understanding.
  - a. Database: Patents
  - b. Search: Nutrien



We then looked into another visualise to understand the timeline of development of these patents. Additionally, we coloured them by “status” to find out which ones they have applied for, and which patents have been granted.

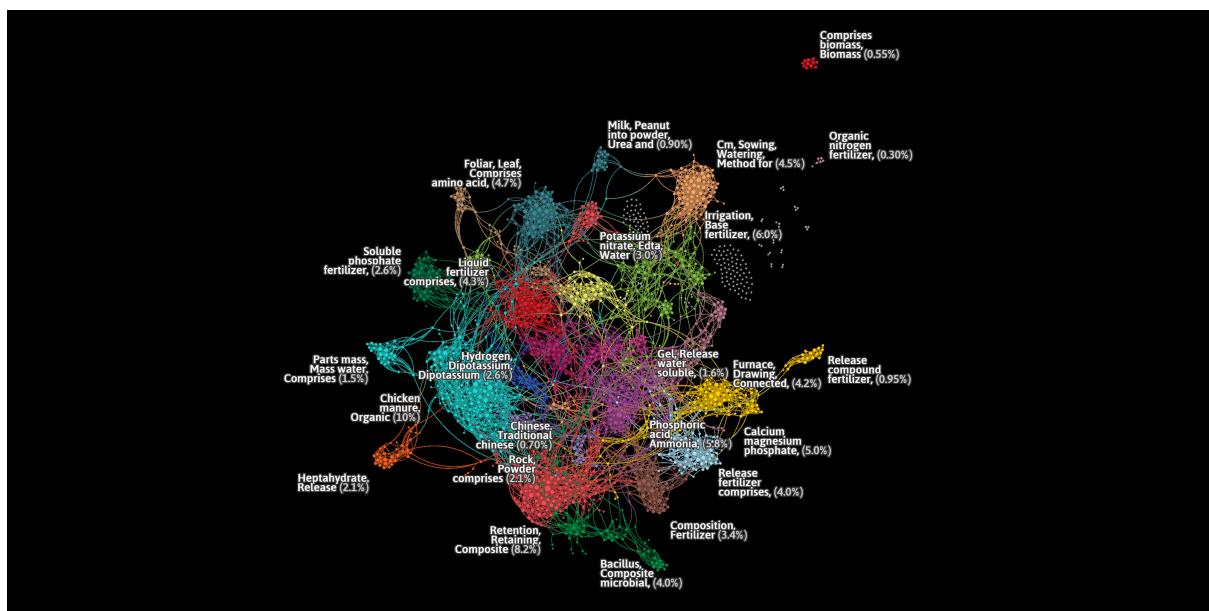


5. Next, we investigated the transformative innovations in water protection, ( G. 3) to understand the different products, services and interventions pertaining to mining and its effects on water contamination and higher levels of salinity.
  - a. Database: News/Blogs
  - b. Search: (Water Depletion OR Water Pollution OR water salinity OR tailings OR “water waste”) AND ( innovation OR transformation OR technology OR solution OR “intervention”) AND ( Agriculture OR Nutrien) AND ( Mining OR Potash OR Phosphate)



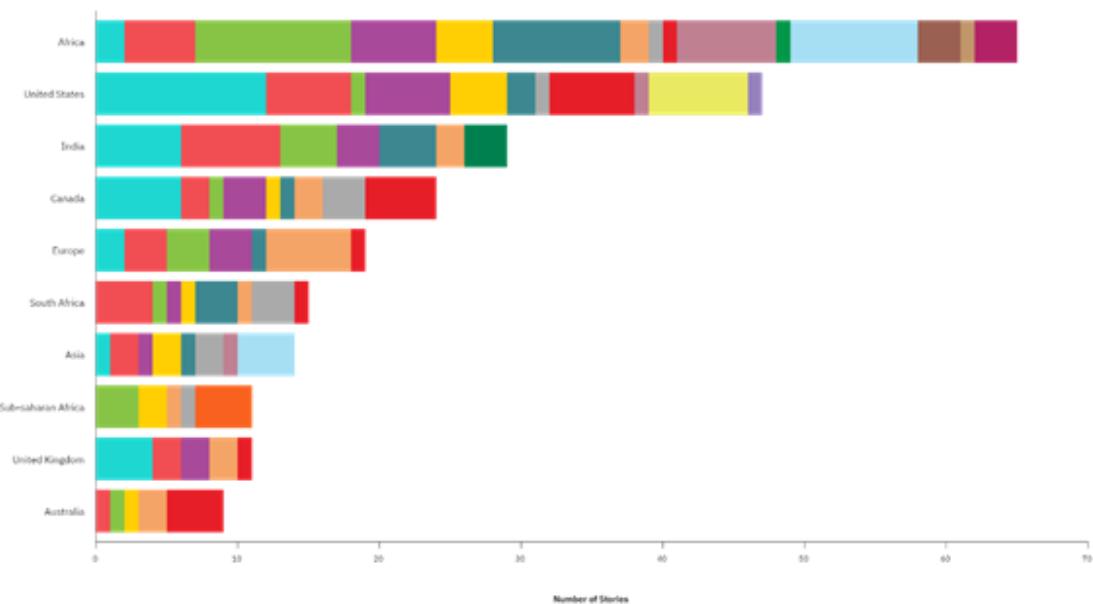
This graph helped us understand the different innovations in the space of mining and water preservation and find the ones most relevant to us.

6. To go a step further, we looked into the different patents all over the world involved with mining and fertilisers and water protection. This gave us valuable insights into more transformative innovations for this problem.
  - a. Database: Patents
  - b. Search: (MINING OR FERTILISER) AND WATER AND (POTASH OR PHOSPHATE OR NITROGEN)



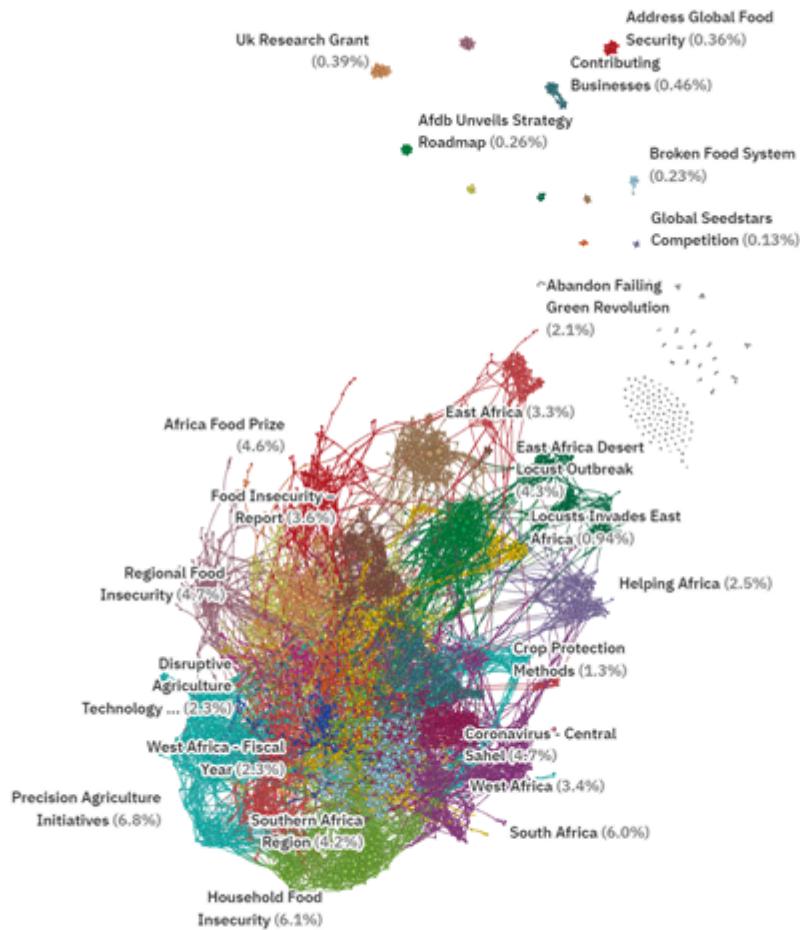
This also provided us with a perspective on organising transformative innovations into potential categories.

7. After identifying that food insecurity is a major challenge that Nutrien has the potential to solve, we wanted to proceed with finding the areas most impacted by this problem, and where there is scope for improvement. In order to be able to start our process of finding target location for food insecurity we wanted to visualise the most mentioned countries to know which ones are most relevant. We created a bar chart of our searched and displayed by Country (Primary Mention). Discrepancies in terms of "any mention" of some countries were accounted for by updating the network (thus our analysis can be concluded to be fairly relevant and accurate)
    - a. Database: News/Blogs
    - b. Search: Africa AND (Food Insecurity OR Security)



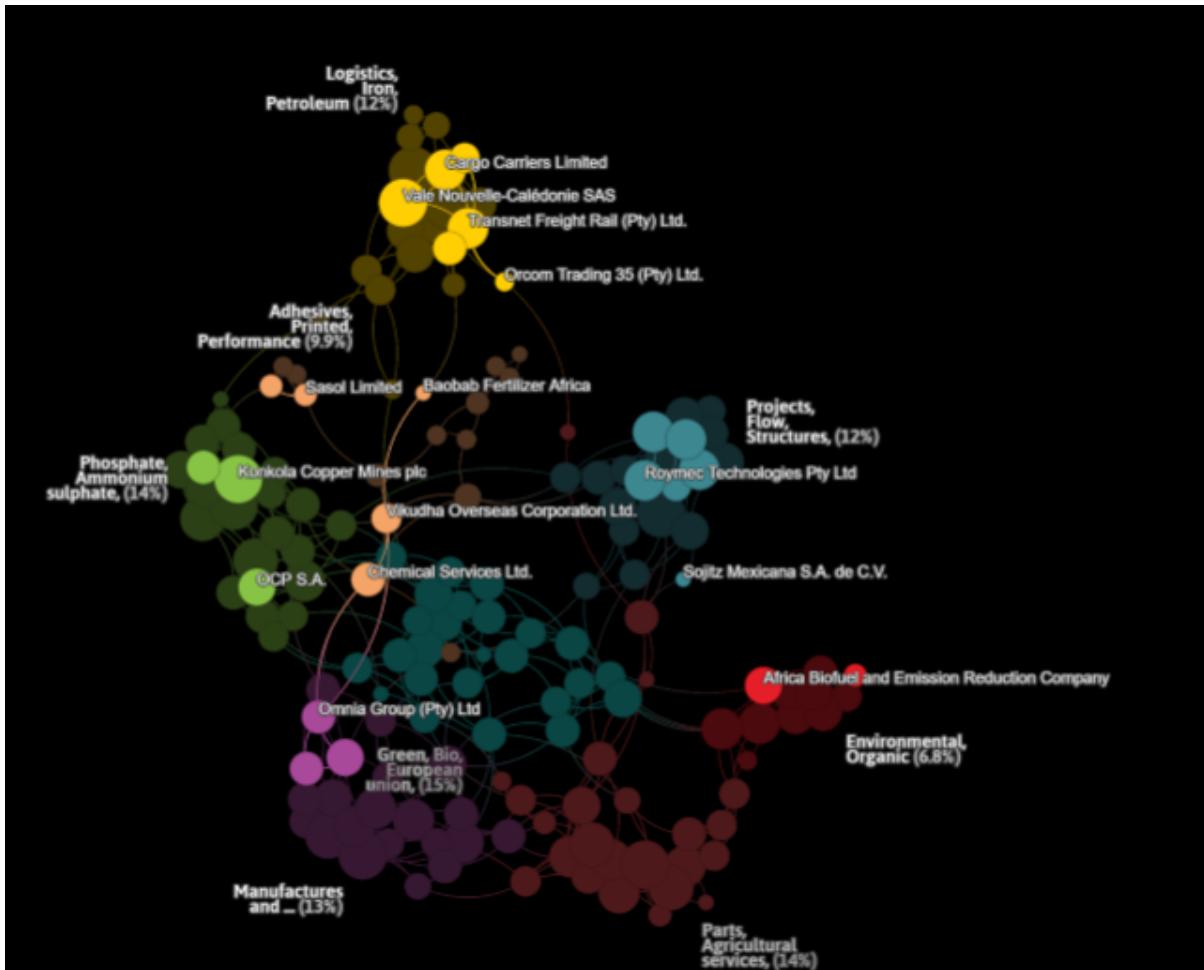
We discovered that Africa makes up a major section of this challenge, and this goes hand in hand with food insecurity in Africa identified as a global food system challenge in Quid Graph ()�.

8. We sought to understand more about the food landscape in Africa and identify clear examples of innovations in the area of food insecurity in Africa.
    - a. Database:News/Blogs
    - b. Search: Africa AND Food Insecurity AND ( innovations OR technology OR product OR service OR intervention OR Solutions )



This search yielded multiple beneficial results in terms of focus areas (West Africa, South Africa), some of the contributing factors (locusts attack, failing green revolution, climate change) and most importantly, innovations (Precision Agriculture, Advanced Fertilizers, and Vertical Farming). This further strengthened our conviction that Nutrien could help Africa through the use of its advanced fertilisers.

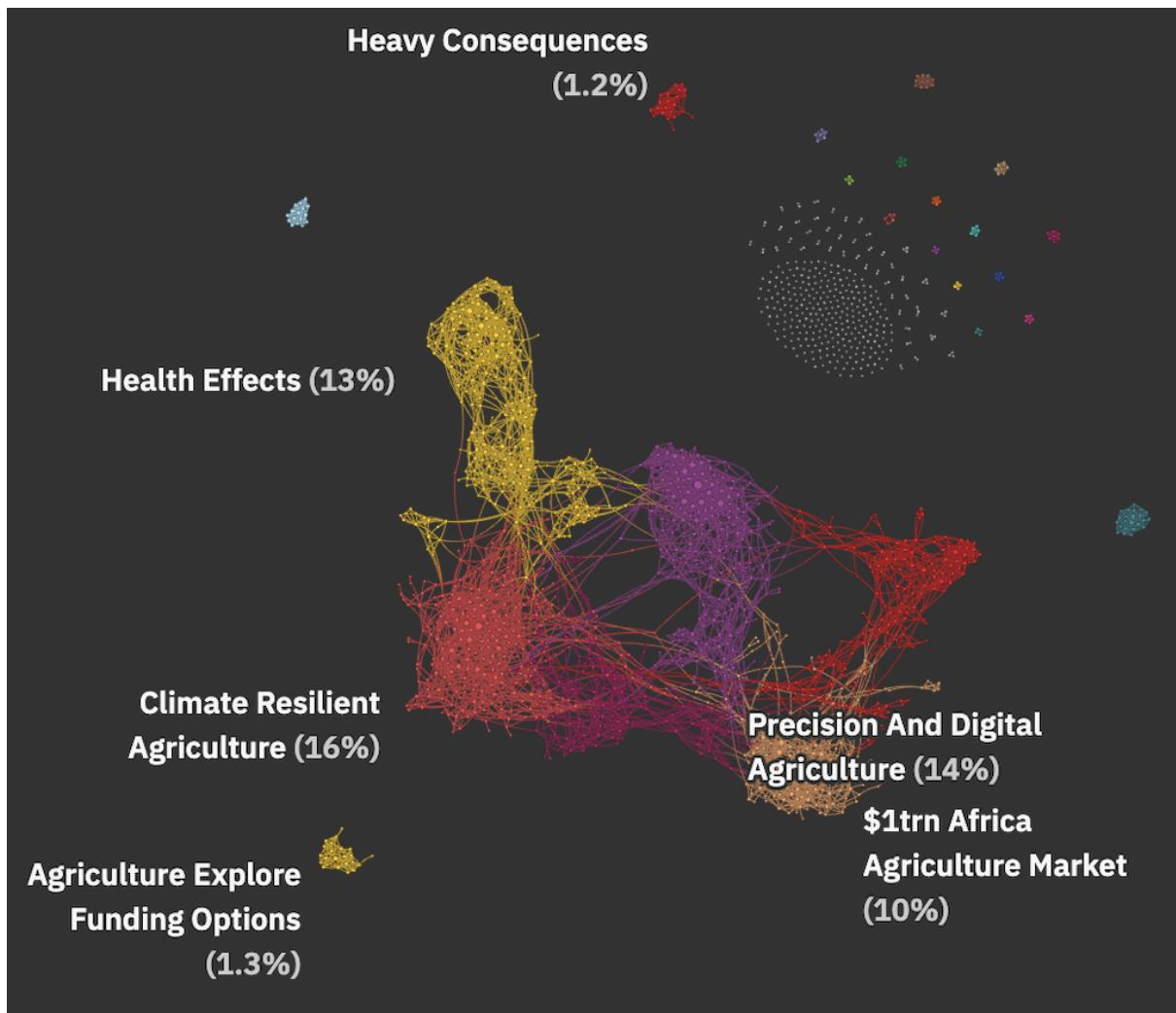
9. To take our analysis of the innovations in Africa a step further, we looked at the key players in the Africa food insecurity innovation market. Within our broad search, we filtered out the types of fertiliser and activities relevant to our search as mentioned above. We then put a tag onto these categories, so it becomes easier to identify the companies most relevant to us. The highlighted companies below are the ones that are worth looking into in Africa from our standpoint.
  - a. Database: Companies
  - b. Search: (“Fertilizer” OR “agricultural retail” OR “Food Insecurity”) AND AFRICA.



10. In order to categorise our innovations, we tried to look at different categories of food technology in the quid companies database. While this search is not very specific to our business (fertiliser and ag retailing), it does give us a good idea of the possible innovation categories to pursue, including, but not limited to AI, cloud solutions, robots, and logistics.

However, after much consideration, we concluded that it was more appropriate to categorise our applications by the components related to our business-like mining, retail and product use.

11. We generated this graph with the aim of finding opportunities and solutions for the global food industry.
- Search: "Food industry" OR ("Global Food System" OR "Food system" OR "Agriculture") AND "Problems" OR ("consequences" OR "impact" OR "effects")



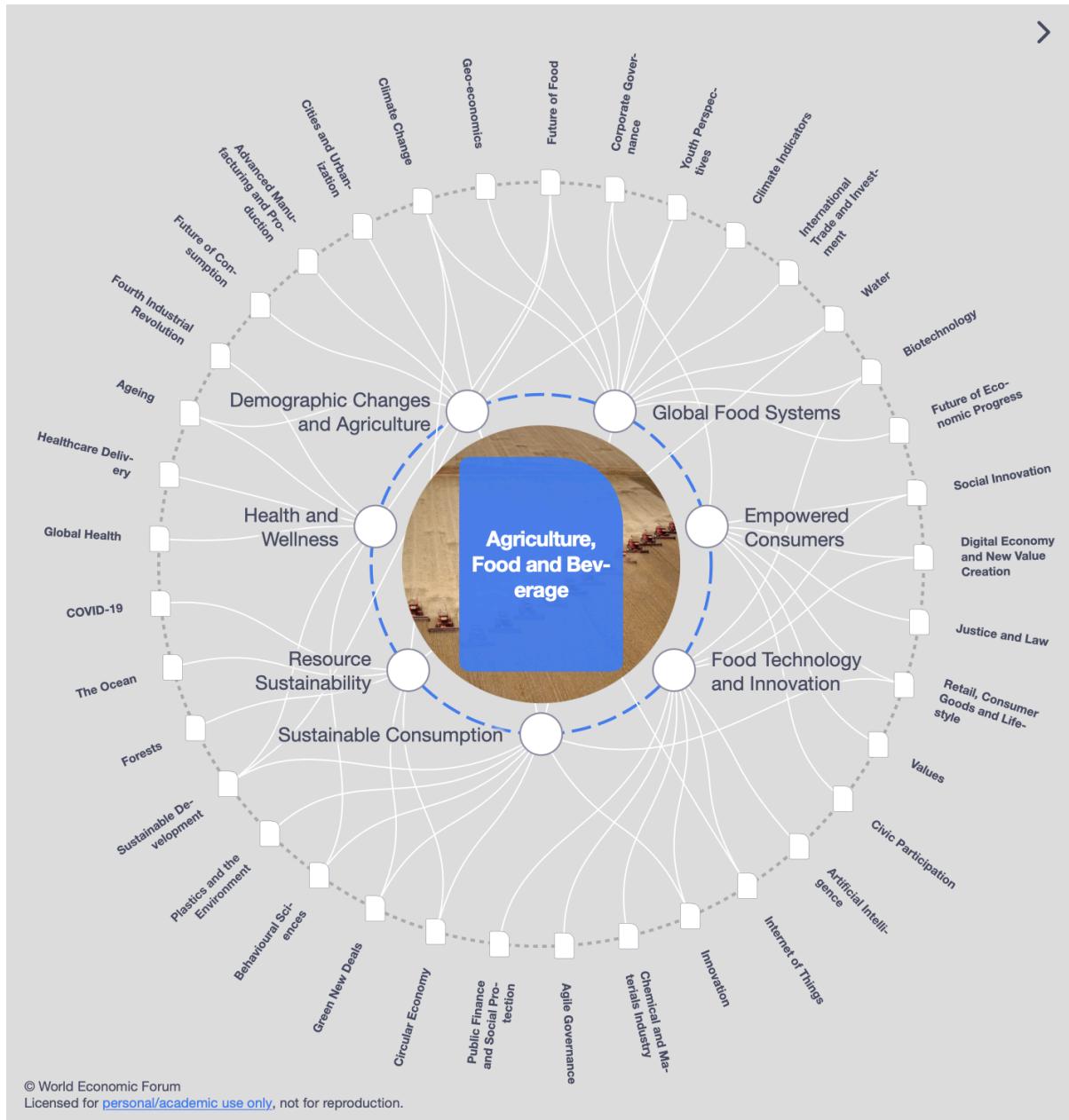
After refining the network map, we found that Precision and Digital Agriculture was an important factor of the global food system. This finding led us to consider precision agriculture as a transformative innovation for our 3<sup>rd</sup> problem of fertiliser misuse and overuse.

## 5.5 WEF Transformation Maps

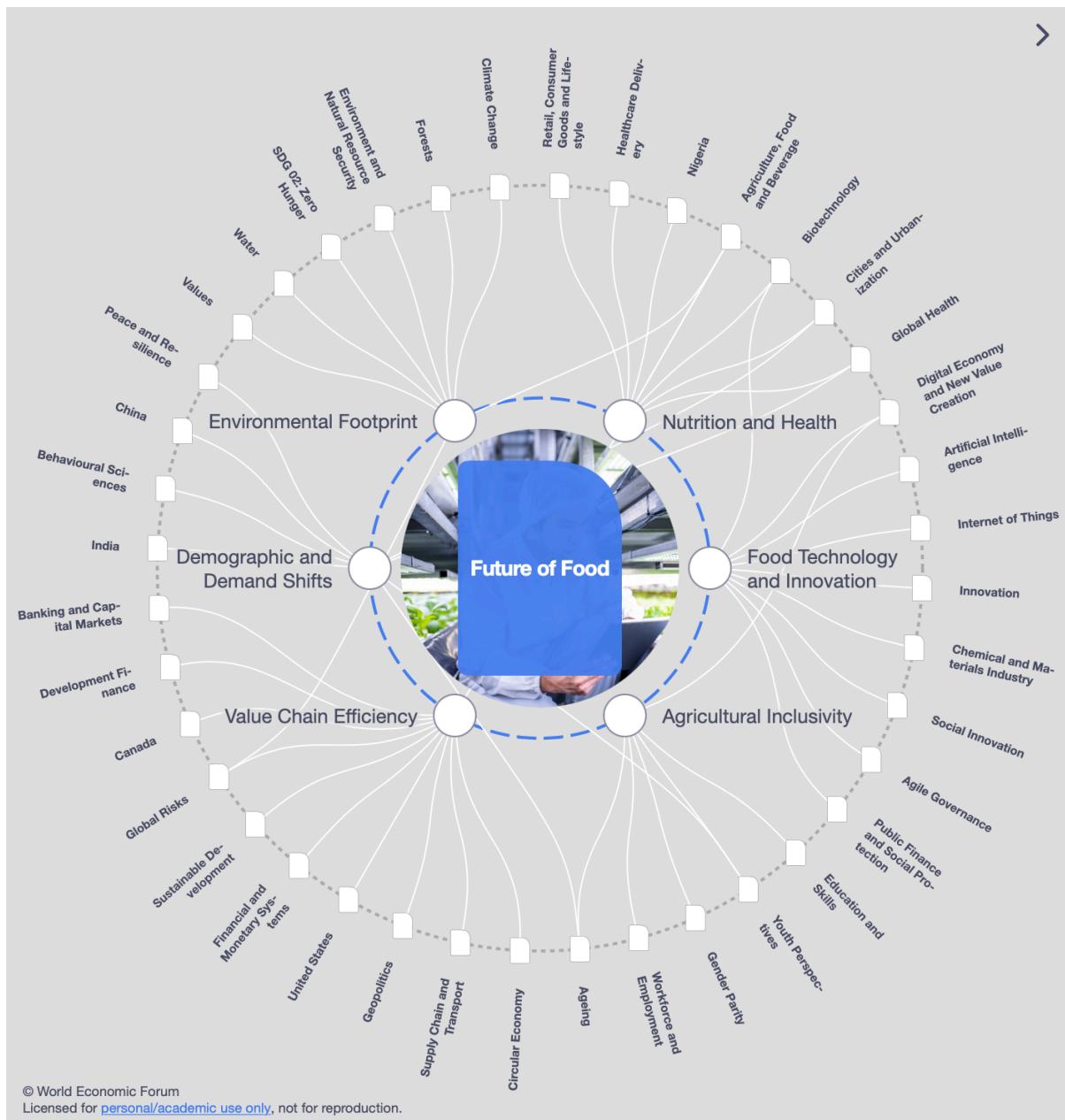
The World Economic Forum transformation maps for Strategic Intelligence give insights and contextual intelligence on the world most important issues and drivers of change.

Four transformation maps have guided our research on the food ecosystem.

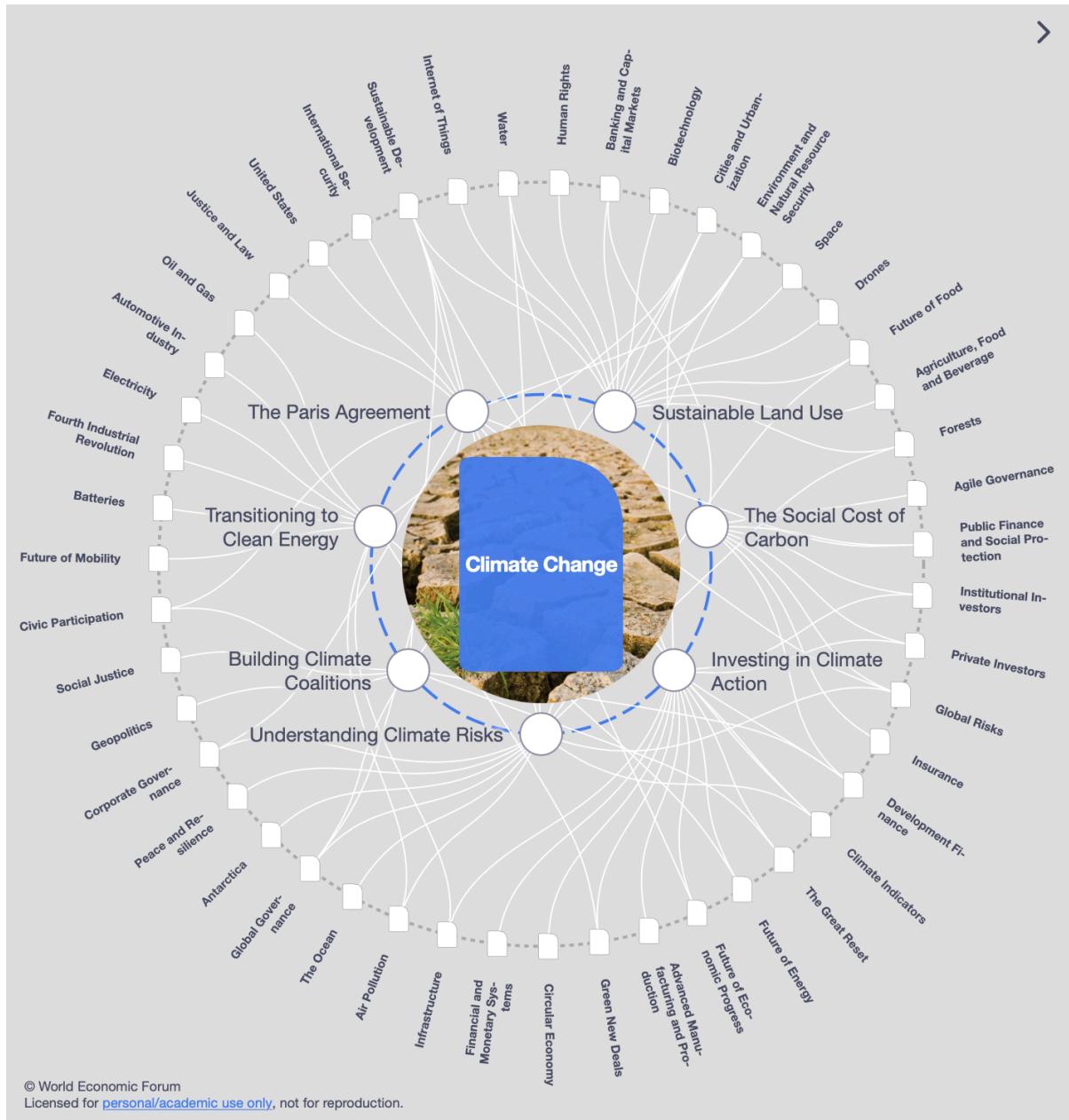
The first map is the 'Agriculture, Food and Beverage' map. For our report, this map shows the importance of issues related demographic changes (such as climate change) or to the global food systems (such as the future of food and water).



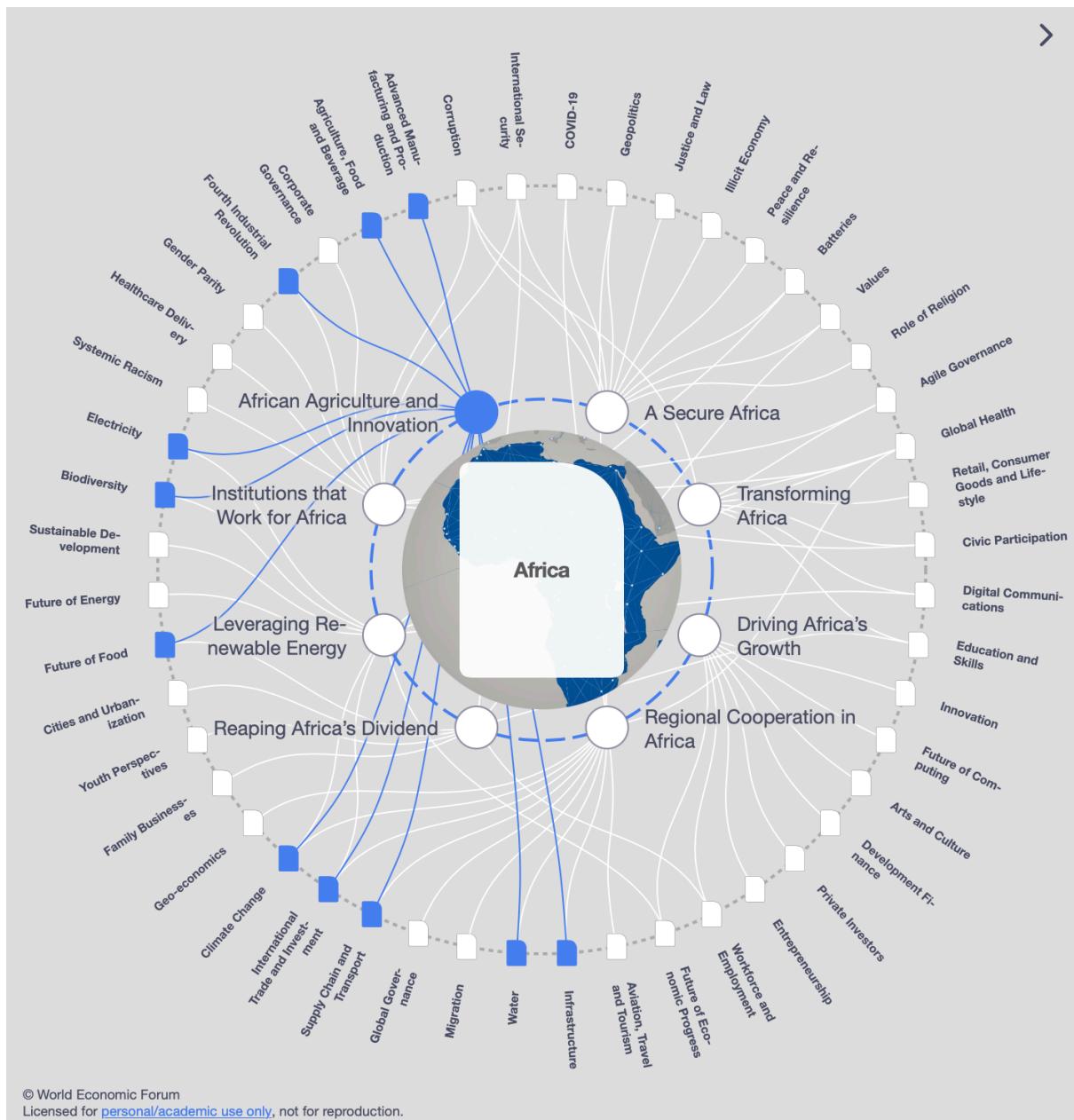
The second map is the 'Future of Food' transformation map. It conducts us to investigate the Internet of Things, biotechnology and chemicals for the food industry.



Then, our research conducted us to investigate issues to 'Climate Change' such as water, and other issues still related to the 'Future of Food'.



Finally, we have decided to launch some research on the African continent. The most concerning issue related to Africa for Nutrien is 'Agriculture and Innovation'. It led us to consider the issues of supply chain and transportation, infrastructure, or even water.



## 5.6 List of Innovative Transformations analysed

### 5.6.1 Food Insecurity (36 examples)

Example	Category	Transformation	Short Description	Link
Adapt-n (Yara)	Product use	Precise application tech	Computer modelling system predicting precise crop application rates using weather data, field conditions, best soil management practices	<a href="https://agfundernews.com/fertilizer-giant-yara-acquires-adapt-n-nitrogen-modeling-tech.html">https://agfundernews.com/fertilizer-giant-yara-acquires-adapt-n-nitrogen-modeling-tech.html</a>
Aero Farms	Product use	Vertical farming	Aeroponic technology providing perfect conditions for indoor vertical farming, precision farming and productivity	<a href="https://aerofarms.com/">https://aerofarms.com/</a>
Agrimetrics	Product use	Precision irrigation	Satellite data Ai imagery help farmers make estimations of water balance, when and where to irrigate	<a href="https://agrimetrics.co.uk">https://agrimetrics.co.uk</a>
Agrineo	Product use	Soil analysis and management	Crop proposition, cultural monitoring and piloting	<a href="https://agrineo.fr/nos-services">https://agrineo.fr/nos-services</a>
Agripredict (Zambia)	Product use	Precision agriculture - Soil analysis and management	Artificial intelligence platform using a single smartphone photo to detect the presence of pests or diseases. Forecast the probability of invasions by pests, predict possibility of adverse weather patterns such as drought, floods and cold fronts.	<a href="http://www.fao.org/faostories/article/en/c/1170362/">http://www.fao.org/faostories/article/en/c/1170362/</a>
Agroecology: Biological pest control	Product use	Chemistry - Advanced crop protection products	Chemical-free biological control for insects and pests devastating crops. For instance, by introducing a wasp that naturally control the infestation.	<a href="https://www.resilience.org/stories/2019-07-11/agroecology-as-innovation/">https://www.resilience.org/stories/2019-07-11/agroecology-as-innovation/</a>
Agroecology: participatory plant breeding	Product use	Precision agriculture - Total Farm management	Identify most productive and desirable seed varieties, improve them through seed selection and farm management. This process can include the use of fertilisers	<a href="https://www.researchgate.net/publication/22862550_Participatory_plant_breeding_The_best_way_to_breed_for_sustainable_agriculture">https://www.researchgate.net/publication/22862550_Participatory_plant_breeding_The_best_way_to_breed_for_sustainable_agriculture</a>
Agroecology: push-pull technology	Product use	Chemistry - Modified plants	Scientifically proven mix of crops to push pests away from food crops and pull them out of the field.	<a href="https://www.researchgate.net/publication/23362527_Push-pull_technology_a_conservation_agriculture_approach_for_integrated_management_of_insect_pests_weeds_and_soil_health_in_Africa_UK_government%27s_Foresight_Food_and_Farming_Futures_project">https://www.researchgate.net/publication/23362527_Push-pull_technology_a_conservation_agriculture_approach_for_integrated_management_of_insect_pests_weeds_and_soil_health_in_Africa_UK_government%27s_Foresight_Food_and_Farming_Futures_project</a>

Example	Category	Transformation	Short Description	Link
BioHP	Product use	Advanced fertilisers	Microbial inoculant for dry fertiliser (containing Plant Growth Promoting Rhizobacteria) for root growth and plant vigor	<a href="https://plantresponse.com/app/uploads/2020/04/PRI_BioHTech_US_FY20.pdf">https://plantresponse.com/app/uploads/2020/04/PRI_BioHTech_US_FY20.pdf</a>
BioPath	Product use	Advanced fertilisers	Bioactive containing organic and inorganic compounds that produce enzymes and organic acids	<a href="https://plantresponse.com/app/uploads/2020/04/PRI_BioPathTech_US_FY20.pdf">https://plantresponse.com/app/uploads/2020/04/PRI_BioPathTech_US_FY20.pdf</a>
Brightseed	Retail	Modified plants	AI to index edible plants around the world to discover previously unknown nutritional benefits	<a href="https://brightseedbio.com/">https://brightseedbio.com/</a>
Decentralised food system in Mozambique	Retail	Business support	Information and communication technologies to link smallholder producers to institutional markets and promote development of food supply system	<a href="https://www.researchgate.net/profile/Israel_Klug/publication/320243267_Implementation_of_decentralised_food_procurement_programmes_and_the_impact_of_the_policy_institutional_and_legal_enabling_environment_the_case_of_PRONA_E_and_PAA_Africa_in_Mozambique/links/59d70a74aca27213dfa03b9b/Implementation-of-decentralised-food-procurement-programmes-and-the-impact-of-the-policy-institutional-and-legal-enabling-environment-the-case-of-PRNAE-and-PAA-Africa-in-Mozambique.pdf">https://www.researchgate.net/profile/Israel_Klug/publication/320243267_Implementation_of_decentralised_food_procurement_programmes_and_the_impact_of_the_policy_institutional_and_legal_enabling_environment_the_case_of_PRNAE_and_PAA_Africa_in_Mozambique.pdf</a>
eLocust3 (global)	Product use	Advanced crop protection products	Monitor and detect most dangerous migratory pest species in the world such as the desert locust. Information, communication and satellite technologies into a monitoring and warning system.	<a href="http://www.fao.org/fao-stories/article/en/c/1170362/">http://www.fao.org/fao-stories/article/en/c/1170362/</a>
Exosect	Product use	Advanced crop protection products	Technologies delivering agricultural crop protection active ingredients to their intended targets.	<a href="https://www.terramera.com/newsroom/terramera-acquires-exosect-crop-protection-technology-ip">https://www.terramera.com/newsroom/terramera-acquires-exosect-crop-protection-technology-ip</a>
Howgood	Retail	Business support	Data company to help understand nutritional, environmental and social impact of food products and their production process.	<a href="https://howgood.com/">https://howgood.com/</a>
HelloFuture by Orange	Retail	Financial Support	Access to market place: platforms/sites that link agricultural sellers with industry. B2B agricultural online marketplaces	<a href="https://hellofuture.orange.com/en/innovative-services-that-are-supporting-agriculture-in-africa/">https://hellofuture.orange.com/en/innovative-services-that-are-supporting-agriculture-in-africa/</a>

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Soft Precision Tech	Product use	Precision application tech	Soft precision agriculture: microdosing techniques (apply small quantities of fertilisers during planting or after plant emergence)	<a href="https://www.fertilizer.org/Public/About_Fertilizers/Fertilizer_Topics/Innovation.aspx">https://www.fertilizer.org/Public/About_Fertilizers/Fertilizer_Topics/Innovation.aspx</a>
ICL Innovation	Product use	Advanced fertilisers	Precision ag solutions and new innovative sustainable crop enhancers for crop productivity	<a href="https://agfundernews.com/how-fertilizer-companies-are-using-technology-to-stay-relevant.html">https://agfundernews.com/how-fertilizer-companies-are-using-technology-to-stay-relevant.html</a>
Kakaxi	Product use	Total farm management	AI platform that collects and analyse remote images and ambient data to help farmers and food suppliers to manage their crop and activities far from where they are	<a href="https://kakaxi.me/">https://kakaxi.me/</a>
Kakaxi	Retail	Business support	Blockchain for transparency and food traceability related to the production process and commercialisation of food products	<a href="https://kakaxi.me/">https://kakaxi.me/</a>
Microsoft (India)	Product use	Total farm management	Digital agriculture for farmers using AI Sowing App that sends sowing advisories to farmers on the optimal date to sow.	<a href="https://news.microsoft.com/en-in/features/ai-agriculture-icrisat-upl-india/">https://news.microsoft.com/en-in/features/ai-agriculture-icrisat-upl-india/</a>
Nanotechnology (research)	Product use	Advanced crop protection products	Natural compound called hexanal spray to reduce the amount of harvested products	<a href="https://www.idrc.ca/sites/default/files/sp/Documents%20EN/CIFSRF-Call-5-1-Backgrounder-ENG.pdf">https://www.idrc.ca/sites/default/files/sp/Documents%20EN/CIFSRF-Call-5-1-Backgrounder-ENG.pdf</a>
Nobel Prize: Innovation Mapping for Food Security	Product use	Precision agriculture - Soil analysis and management	Mapping approach re-imagining smallholder farming techniques to grow, where and how: Using data and IT, the map tells the farmer what best crops to grow in a specific area, what type of specific fertilisers, crop protection technique, or infrastructure?	<a href="https://www.agropolis-fondation.fr/2019-Olam-Prize-for-Innovation-in-Food-Security-Innovation-Mapping-for-Food?lang=fr">https://www.agropolis-fondation.fr/2019-Olam-Prize-for-Innovation-in-Food-Security-Innovation-Mapping-for-Food?lang=fr</a>
Orange	Product use	Precision agriculture - Total Farm management	Information services for farmers: SMS, call centres, app. Weather forecasting info, price of produce, technical advices.	<a href="https://hellofuture.orange.com/en/innovative-services-that-are-supporting-agriculture-in-africa/">https://hellofuture.orange.com/en/innovative-services-that-are-supporting-agriculture-in-africa/</a>
Organge Money	Retail	Financial Support	Financial services: Orange Money = mobile banking. Money transfers for farmers and agri industry. Paid financial services, microcredit, climate microinsurance, microsaving solutions (under development and experimentation)	<a href="https://hellofuture.orange.com/en/innovative-services-that-are-supporting-agriculture-in-africa/">https://hellofuture.orange.com/en/innovative-services-that-are-supporting-agriculture-in-africa/</a>

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Organic fertilisers in Ethiopia	Product use	Advanced fertilisers	plant- or animal-based materials such as manures, leaves, compost	<a href="https://l.facebook.com/l.php?u=https%3A%2F%2Fwww.tandfonline.com%2Fdoi%2Ffull%2F10.1080%2F23311932.2019.1669398%3Fbclid%3DIwAR21Rd1e1NzKosWGjtWD6-EqAnYL-GLzixHc-8Rvp8zTroE-tdDoXbPEI&amp;h=AT2whwRnVpOIE8IkPT-RRXmsNHW0QHeu-49307aR5Ro3g5BRP1VaWPu0tVXPi8-5UyIdo02RXER9oTg2VT_0YkHP--EVLvhYldrIC9Lh4cTWtMKZQienOFNi0ig5BfGUZ_noFONadLpYZMC6YtAVSL">https://l.facebook.com/l.php?u=https%3A%2F%2Fwww.tandfonline.com%2Fdoi%2Ffull%2F10.1080%2F23311932.2019.1669398%3Fbclid%3DIwAR21Rd1e1NzKosWGjtWD6-EqAnYL-GLzixHc-8Rvp8zTroE-tdDoXbPEI&amp;h=AT2whwRnVpOIE8IkPT-RRXmsNHW0QHeu-49307aR5Ro3g5BRP1VaWPu0tVXPi8-5UyIdo02RXER9oTg2VT_0YkHP--EVLvhYldrIC9Lh4cTWtMKZQienOFNi0ig5BfGUZ_noFONadLpYZMC6YtAVSL</a>
PebbleLabs	Product use	Advanced crop protection products	Directed biotics: eliminates pathogens using a probiotic approach with natural biological molecules boosting animal and plant immune system.	<a href="https://www.pebblelabs.com/directed-biotics/">https://www.pebblelabs.com/directed-biotics/</a>
Plant growth promoting rhizobacteria (PGPR)	Product use	Advanced fertilisers	Microorganisms, biocontrol agents, producers of plant hormones, alter the plant physiological processes (e.g., Azotobacter, Azospirillum, Azoarcus)	<a href="https://www.intechopen.com/books/biostimulants-in-plant-science/application-of-bacteria-as-a-prominent-source-of-biofertilizers">https://www.intechopen.com/books/biostimulants-in-plant-science/application-of-bacteria-as-a-prominent-source-of-biofertilizers</a>
Power Pac	Product use	Advanced fertilisers	Plant growth promoting rhizobacteria producing enzymes and organic acids	<a href="https://plantresponse.com/app/uploads/2020/07/PRI_PowerPacTech_US_FY20.pdf">https://plantresponse.com/app/uploads/2020/07/PRI_PowerPacTech_US_FY20.pdf</a>
PowerCoat	Product use	Advanced fertilisers	Microbial inoculant for dry fertiliser (containing Plant Growth Promoting Rhizobacteria) for root growth and plant vigor	<a href="https://plantresponse.com/app/uploads/2020/04/PRI_PowerCoatTech_US_FY20.pdf">https://plantresponse.com/app/uploads/2020/04/PRI_PowerCoatTech_US_FY20.pdf</a>
Rhizobium bacteria	Product use	Advanced fertilisers	Bio-inoculant for symbiotic association with legume plants, forming nodules in the roots of the plant	<a href="https://www.intechopen.com/books/biostimulants-in-plant-science/application-of-bacteria-as-a-prominent-source-of-biofertilizers">https://www.intechopen.com/books/biostimulants-in-plant-science/application-of-bacteria-as-a-prominent-source-of-biofertilizers</a>
Seed biology place: Seed BioTechnology	Product use	Modified plants	Mechanical seed enhancements: mechanical techniques including polishing off or rubbing off seed coat or fruit coat, and sorting the seeds by size classes or seed density.	<a href="http://www.seedbiology.de/seedtechnology.asp">http://www.seedbiology.de/seedtechnology.asp</a>
Sodour Ahrar Sharq Company: Biofortification	Product use	Advanced fertilisers	Nano chelated iron fertiliser (synthesised based on novel nanochelating technology, agronomic traits and yield)	<a href="https://www.nature.com/articles/s41598-020-60189-x">https://www.nature.com/articles/s41598-020-60189-x</a>

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Telangana government in India	Retail	Financial Support	Insurance Scheme: grants farmers with money to support farm investments and purchase farm inputs.	<a href="http://www.fao.org/faostories/article/en/c/1170362/">http://www.fao.org/faostories/article/en/c/1170362/</a>
UPL	Product use	Advanced pesticides	Seeds, herbicides etc	<a href="https://www.upl-ltd.com/downloads/UPL_Sustainability_Report_2019-20.pdf">https://www.upl-ltd.com/downloads/UPL Sustainability Report 2019-20.pdf</a>
Urban Crop Production	Product use	Vertical farming	Factory engineering and indoor plant biology for indoor farming, plant factories under LED light anywhere on the planet	<a href="https://urbancropsolutions.com/">https://urbancropsolutions.com/</a>

### 5.6.2 Water Depletion and Pollution (42 examples)

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Perforene graphene filter	Mining process	Desalination	Improves flow of water and lower energy cost of desalination	<a href="https://www.theguardian.com/global-development-professionals-network/2017/feb/13/global-water-crisis-innovation-solution">https://www.theguardian.com/global-development-professionals-network/2017/feb/13/global-water-crisis-innovation-solution</a>
Drinkwell	Product use		Water ATMs for arsenic and fluoride affected communities through patented filtration technology	<a href="http://drinkwellsystems.com">http://drinkwellsystems.com</a>
Oneka	Mining process	Desalination	Wave-powered desalination for autonomous drinking water production targeting small island communities.	<a href="https://www.onekawater.com">https://www.onekawater.com</a>
Vassar Labs	Product use	Precise irrigation	Water management and forecasting platform for state government agencies	<a href="https://www.vassarlabs.com">https://www.vassarlabs.com</a>
Veracet	Mining process	Desalination	Platform to identify the source of contamination in water.	<a href="https://www.veracet.com">https://www.veracet.com</a>
CarboPlus	Mining process	Filtering	removes micropollutants at a very low cost by adsorbing them using activated carbon.	<a href="https://www.saur-uk.com/technologies/carboplus/">https://www.saur-uk.com/technologies/carboplus/</a>
Saur	Mining process	Filtering	reducing forecast error for water with predictive models	<a href="https://www.saur-uk.com/technologies/aquavision/">https://www.saur-uk.com/technologies/aquavision/</a>

Example	Category	Transformation	Short Description	Link
Hampton Roads Sanitation District (HRSD) Struvite Recovery Facility	Mining process	Filtering	recovers phosphorus from wastewater recycle streams	<a href="https://www.wwdmag.com/suffolk-struvite-recovery-facility-project">https://www.wwdmag.com/suffolk-struvite-recovery-facility-project</a>
University of Virginia (UVA) Bay Game	Product use	Precise irrigation	Using Simulations to Manage Watersheds	<a href="https://www.virginia.edu/baygame/">https://www.virginia.edu/baygame/</a>
Salinity gradient solar ponds (SGSP)	Mining process	Total mining solution	utilise salinity gradient solar pond (SGSP) technology to supply industrial process thermal energy	<a href="https://www.osti.gov/servlets/purl/756432">https://www.osti.gov/servlets/purl/756432</a>
SRC	Mining process	Rock tailings management	How to control H2S and salt ++ from potash mining	<a href="https://www.src.sk.ca/blog/potash-mining-challenges-and-solutions-dealing-hydrogen-sulfide">https://www.src.sk.ca/blog/potash-mining-challenges-and-solutions-dealing-hydrogen-sulfide</a>
Tapira mining and beneficiation complex	Mining process	Total mining solution		<a href="https://wedocs.unep.org/bitstream/handle/20.500.11822/8071-Environmental%20Aspects%20of%20Phosphate%20and%20Potash%20Mining-20011385.pdf">https://wedocs.unep.org/bitstream/handle/20.500.11822/8071-Environmental%20Aspects%20of%20Phosphate%20and%20Potash%20Mining-20011385.pdf</a>
Hatch	Mining process	Water tailings management	Processing brine from potash solution mining	<a href="https://www.hatch.com/Expertise/MetalMinerals/Potash">https://www.hatch.com/Expertise/MetalMinerals/Potash</a>
Gensource Corp (ppt)	Mining process	Total mining solution > solution		<a href="https://gensourcepotash.ca/mining-innovation/">https://gensourcepotash.ca/mining-innovation/</a>
Clay Analyzer	Mining process	Rock tailings management	real-time measurements of the active clay content in oil sands and mine tailings.	<a href="https://www.newswire.ca/news-releases/canada-invests-in-innovative-technology-for-the-canadian-mining-industry-864320351.html">https://www.newswire.ca/news-releases/canada-invests-in-innovative-technology-for-the-canadian-mining-industry-864320351.html</a>
SMER (Innovare)	Mining process	Rock tailings management		<a href="https://www.freepatentonline.com/9822013.html">https://www.freepatentonline.com/9822013.html</a>
K+S, kainite crystallisation and flotation plant (KKF)	Mining process	Water tailings management	additional valuable materials can be extracted from previously unusable salt solutions	<a href="https://www.kpluss.com/en-us/press/ks-topics/potash-mining-water-protection/">https://www.kpluss.com/en-us/press/ks-topics/potash-mining-water-protection/</a>
Rezatec	Mining process	Filtering	Thanks to geospatial AI: Manage water quality across watersheds by identifying pollution (land cover classification, land use on pollution levels, risk areas), reducing downstream treatment (estimates of diffuse pollution loads)	<a href="https://www.rezatec.com/solutions/water-utilities/">https://www.rezatec.com/solutions/water-utilities/</a>

Example	Category	Transformation	Short Description	Link
Chile Desalination Plant	Mining process	Desalination	Desalination and making fresh water accessible to others	<a href="https://www.teck.com/news/stories/2020/building-the-first-large-scale-desalination-plant-for-mining-in-chile-s-tarapac%C3%A1-region">https://www.teck.com/news/stories/2020/building-the-first-large-scale-desalination-plant-for-mining-in-chile-s-tarapac%C3%A1-region</a>
Gu et al.	Mining process	Water tailings management	better understand groundwater circulation, and thereby prevent mine water disasters.	
BioDAF	Mining process	Water tailings management	Waste water treatment	<a href="https://www.biodaf.com">https://www.biodaf.com</a>
TSSE	Mining process	Desalination	Highsalinity brine water treatment	<a href="https://www.engineering.columbia.edu/pres-releases/ngai-yin-yip-radical-desalination">https://www.engineering.columbia.edu/pres-releases/ngai-yin-yip-radical-desalination</a>
Saline agriculture	Mining process	Desalination	Plant things that want a lot of salt nearby	<a href="https://www.salineagricultureworldwide.com/saline-agriculture">https://www.salineagricultureworldwide.com/saline-agriculture</a>
aqua4d	Mining process	Desalination	electricity into water so it dissolves better and goes through soil	<a href="https://aqua4d.com">https://aqua4d.com</a>
GivePower	Mining process	Desalination	Solar powered desalination and water purification	<a href="https://www.givepower.org">https://www.givepower.org</a>
MetsoOutotec	Mining process	Total mining solution	Tailings management, dewater the tailings + filter	<a href="https://www.mogroup.com/mining/">https://www.mogroup.com/mining/</a>
Teck	Mining process	Total mining solution	Tailings management, surveillance and placement	<a href="https://www.teck.com/responsibility/sustainability-topics/tailings-management/">https://www.teck.com/responsibility/sustainability-topics/tailings-management/</a>
Ecolab	Mining process	Rock tailings management	Tailings management, water absorption	<a href="https://www.ecolab.com/solutions/tailings-management#f:@websolutions=[Tailings%20Management%20for%20Effluent,Tailings%20Management%20for%20PM]&amp;f:@webapplications=[Influent%20and%20Effluent%20Water_Process%20Management]">https://www.ecolab.com/solutions/tailings-management#f:@websolutions=[Tailings%20Management%20for%20Effluent,Tailings%20Management%20for%20PM]&amp;f:@webapplications=[Influent%20and%20Effluent%20Water_Process%20Management]</a>
FLSmidth	Mining process	Rock tailings management	Talinings management, water absorbtion	<a href="https://www.flsmidth.com/en-gb/customer-stories/customer-stories-mining-2020/hzl-zawar-dry-tailings-management">https://www.flsmidth.com/en-gb/customer-stories/customer-stories-mining-2020/hzl-zawar-dry-tailings-management</a>
FAO: Agricultural Stress Index System	Product use	Precise irrigation	Monitore area with high likelihood of water stress/drought at global, regional level	<a href="https://reliefweb.int/report/world/artificial-intelligence-best-practices-agriculture-can-help-bridge-digital-divide-while">https://reliefweb.int/report/world/artificial-intelligence-best-practices-agriculture-can-help-bridge-digital-divide-while</a>

Example	Category	Transformation	Short Description	Link
Groguru	Product use	Precise irrigation	AI, soil sensors measuring soil moisture, temperature, humidity, salinity; make AI-based recommendations about when and how to irrigate the crops.	<a href="https://www.groguru.com/">https://www.groguru.com/</a>
WaterBit	Product use	Precise irrigation	Automated irrigation thanks to monitoring and data analysis, control irrigation	<a href="https://www.waterbit.app/products/">https://www.waterbit.app/products/</a>
Nutrient Remediation	Mining process	Total mining solution	Putting layer into ground to protect water from making contact with contaminated region	<a href="https://www.youtube.com/watch?v=W1tmz895n14&amp;list=PLwsfnkzf7bW6CD08Mn_K7P4p7fJolcn5z&amp;index=8">https://www.youtube.com/watch?v=W1tmz895n14&amp;list=PLwsfnkzf7bW6CD08Mn_K7P4p7fJolcn5z&amp;index=8</a>
Veolia	Mining process	Desalination	Membrane desalination process called Reverse Osmosis: push water under pressure through a membrane that lets the water goes but retains the salts and impurities	<a href="http://www.veoliawater-solutions/desalination/desalination-technologies/#:~:text=Desalination%20is%20a%20well%20established,water%2C%20ultrapure%20or%20potable%20water.&amp;text=This%20mainly%20involves%20the%20production,a%20heat%20source%20for%20evaporation.">http://www.veoliawater-solutions/desalination/desalination-technologies/#:~:text=Desalination%20is%20a%20well%20established,water%2C%20ultrapure%20or%20potable%20water.&amp;text=This%20mainly%20involves%20the%20production,a%20heat%20source%20for%20evaporation.</a>
Veolia	Mining process	Water treatment - desalinisation	Thermal solution using multiple effect distillation (vapour compression): water evaporator	<a href="http://www.veoliawater-solutions/desalination/desalination-technologies/#:~:text=Desalination%20is%20a%20well%20established,water%2C%20ultrapure%20or%20potable%20water.&amp;text=This%20mainly%20involves%20the%20production,a%20heat%20source%20for%20evaporation.">http://www.veoliawater-solutions/desalination/desalination-technologies/#:~:text=Desalination%20is%20a%20well%20established,water%2C%20ultrapure%20or%20potable%20water.&amp;text=This%20mainly%20involves%20the%20production,a%20heat%20source%20for%20evaporation.</a>
Columbia University	Mining process	Water treatment - desalinisation	Temperature Swing Solvent Extraction: solvent enabling to separate the salt from the water and extract it	<a href="https://pubs.acs.org/doi/10.1021/acs.estlett.9b00182">https://pubs.acs.org/doi/10.1021/acs.estlett.9b00182</a>
US National Academy of Science	Mining process	Water treatment - desalinisation	Solar-thermal desalination: nanoparticles focusing on sunlight, photothermally membrane, high heat creates high pressure that separate the salt from water.	<a href="https://www.pnas.org/content/116/27/13182">https://www.pnas.org/content/116/27/13182</a>
BioteQ	Mining process	Water treatment - filtering	ChemSulphide patent: sulphide precipitation adding biological source of sulphide to wastewater to transform metal from a liquid into a solid.	<a href="https://www.biowate.com/">https://www.biowate.com/</a>

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Canadian Mines	Mining process	Water treatment - filtering	Selenium Removal Solutions	<a href="https://www.waterworld.com/international/wastewater/article/16200908/unearting-mining-water-technology-innovation">https://www.waterworld.com/international/wastewater/article/16200908/unearting-mining-water-technology-innovation</a>
Nirobox	Mining process	Tailings Management - Water	Mirrors focusing sun's ray on a water tower to superheat salt. The salt is then used to create steam to propel turbines for power generation.	<a href="https://www.fluencecorp.com/nirobox-desalination-plant-contract-win-mayotte/">https://www.fluencecorp.com/nirobox-desalination-plant-contract-win-mayotte/</a>
Fluence	Mining process	Tailings Management - Water	Decentralised treatment plant: Smart packaged units: advanced wastewater treatment and desalination delivered on site, and movable to other sites.	<a href="https://www.fluencecorp.com/smарт-packaged-treatment/">https://www.fluencecorp.com/smарт-packaged-treatment/</a>
Fluence	Mining process	Total Mining solutions	Smart Operations Software Suite to provide real-time information, remote monitoring of units, optimise operating and maintenance cost of water desalination installation	<a href="https://www.fluencecorp.com/smарт-operations/">https://www.fluencecorp.com/smарт-operations/</a>

### 5.6.3 Fertiliser Overuse (53 examples)

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Teralytic	Product use	Soil analysis and management	Sensors are impleted in lands to determine the chemical composition of soils. Then growers can see these data and receive pieces of advice on what actions to take. This helps to fix issues of poor knowledge of soil and soil management.	<a href="https://teralytic.com">https://teralytic.com</a>
Targeted Fertilising	Product use	Precision agriculture - soil analysis and management	mapping yield data and current soil samples, data is uploaded to computer in tractor which automatically (GPS) adjusts the rate at which fertiliser is applied	<a href="https://grist.org/food/fertilizer-is-a-major-pollutant-why-doesnt-the-government-regulate-it-as-one/">https://grist.org/food/fertilizer-is-a-major-pollutant-why-doesnt-the-government-regulate-it-as-one/</a>

Example	Category	Transformation	Short Description	Link
Proven - by Pivot Bio	Product use	Chemistry - Advanced fertiliser	Nitrogen fixation on plants' roots	<a href="https://www.pivotbio.com">https://www.pivotbio.com</a>
DJI T Series Spreading System 2.0	Product use	Precision agriculture - soil analysis and management	spreading fertiliser with drones	<a href="https://www.thedroneproshop.com/products/dji-agras-t-series-spreading-system-v2-0">https://www.thedroneproshop.com/products/dji-agras-t-series-spreading-system-v2-0</a>
Scanner by AgroCares	Product use	Precision agriculture - soil analysis and management	Determine the chemical composition of soils and feedstuffs	<a href="https://webshop.agrocaries.com/agrocaries-scanner-device.html">https://webshop.agrocaries.com/agrocaries-scanner-device.html</a>
LaserAg	Product use	Precision agriculture - soil analysis and management	Soil and tissue testing	<a href="https://www.laserag.com/technology/">https://www.laserag.com/technology/</a>
Gene modification	Product use	Chemistry - Advanced fertiliser	to get more nutrients out of soil or need less in the first place	<a href="https://www.nationalgeographic.com/science/2020/10/farmers-are-facing-a-phosphorus-crisis-the-solution-starts-with-soil/">https://www.nationalgeographic.com/science/2020/10/farmers-are-facing-a-phosphorus-crisis-the-solution-starts-with-soil/</a>
Stenon	Product use	Precision agriculture - soil analysis and management	Determine the chemical composition of soils and feedstuffs	<a href="https://stenon.io/en/">https://stenon.io/en/</a>
Vultus	Product use	Precision agriculture - soil analysis and management	Calculate precision nitrogen recommendations, analyse crop's health and check crop's water stress	<a href="https://www.vultus.io/how-does-it-work/">https://www.vultus.io/how-does-it-work/</a>
Greenback	Retail	Business Support	Soil rating thanks to soil sampling and algorithm linked to satellites It provides Biodiversity Index, Carbon Index and Integrity Index that can be used or showed to customers	<a href="https://www.greenback.green/en">https://www.greenback.green/en</a>

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Soil Carbon Co.	Product use	Chemistry - CO <sub>2</sub>	Soil Carbon CO. develop formulations of microbial fungi and bacteria to capture carbon from the atmosphere on a gigaton scale and return it to the soil.	<a href="https://www.soilcarbon.co/technology">https://www.soilcarbon.co/technology</a>
AGvisor Pro	Product Use	Precision agriculture - soil analysis and management	AGvisorPRO app, provide farmers, ranchers, and agri-businesses with a seamless way to connect with ag industry experts.	<a href="https://agvisorpro.com">https://agvisorpro.com</a>
Agricolus	Product use	Precision agriculture - soil analysis and management	AGRICOLUS is a cloud platform created to support and optimise the work of farmers and agricultural operators	<a href="https://www.agricolus.com/en/">https://www.agricolus.com/en/</a>
Autonomous Pivot	Product use	Precision agriculture - precise irrigation	The platform utilises proprietary proximal soil and crop sensing, deep learning, and artificial intelligence for autonomous farming decisions. The company wants to enable growers to feed the planet by turning the install base of centre-pivot irrigation systems into an army of autonomous AI farming robots.	<a href="https://www.autonomouspivot.com">https://www.autonomouspivot.com</a>
Kapsera	Product use	Chemistry - Advanced fertiliser	Kapsera has developed a unique technology based on the latest advances in microfluidics to replace conventional intrants such as with natural solutions that are environmentally friendly and safe for consumers.	<a href="https://www.kapsera.com/en/">https://www.kapsera.com/en/</a>
Scan World	Product use	Precision agriculture - soil analysis and management	Hyperspectral imagery on a global scale	<a href="https://www.scanworld.be/#solution">https://www.scanworld.be/#solution</a>
Verdi	Product use	Precision agriculture - precise irrigation	Next Generation Hyper-Precise Irrigation	<a href="https://verdiag.com">https://verdiag.com</a>
Growencia	Product use	Chemistry - Advanced fertilizer	Create and manufacture organically derived plant biogrowth stimulants	<a href="https://growcentia.com">https://growcentia.com</a>
Soil essentials	Product use	Precision agriculture - soil analysis and management	SoilBio is an indicator of soil health. It tests to understand the biodiversity of soils and measure the quality for long-term, good soil management.	<a href="https://www.soilessentials.com/service/soilbio-test/">https://www.soilessentials.com/service/soilbio-test/</a>

Example	Category	Transformation	Short Description	Link
Novihum	Product use	Chemistry - Advanced fertilizer	NOVIHUM® is produced from widely-available raw materials – brown coal (lignite), ammonia and oxygen. NOVIHUM® is chemically active but slow to decompose, providing a complete and balanced supply of carbon, nitrogen and humic substances for years to come.	<a href="https://novihum.com/technology/">https://novihum.com/technology/</a>
Agrivi	Product use + Retail	Total farm management	Complete farm Management	<a href="https://www.agrivi.com/en/farm-management">https://www.agrivi.com/en/farm-management</a>
Agroptima	Product use + Retail	Total farm management	Farm Management	<a href="https://www.agroptima.com/fr/lapplication-agricole/">https://www.agroptima.com/fr/lapplication-agricole/</a>
VitalFields	Product use	Total farm management	VitalFields offers online tools from planning, operational management to compliance reporting for farmers.	<a href="https://www.digitalfoodlab.com/en/foodtech-database/vital-fields">https://www.digitalfoodlab.com/en/foodtech-database/vital-fields</a>
Exosect by Terramera	Product use	Precision application tech	Technologies delivering agricultural crop protection active ingredients to their intended targets.	<a href="https://www.terramera.com/newsroom/terramera-acquires-exosect-crop-protection-technology-ip">https://www.terramera.com/newsroom/terramera-acquires-exosect-crop-protection-technology-ip</a>
Evologic Technologies	Product use	Advanced fertilizer	Grow hairy roots, phytochemical and biological seeds (such as Mycorrhiza fungi), biostimulants	<a href="https://www.evologic-technologies.com/about.php">https://www.evologic-technologies.com/about.php</a>
Agribody Technologies	Product use	Modified plants	Agricultural biotechnology and genetics: genetically modified, genome edited crops (changing of the expression or activity level of genes)	<a href="https://www.agribodytech.com/">https://www.agribodytech.com/</a>
Atmonia	Product use	Advanced fertilizer	Sustainable nitrogen fertilizer: Electrochemical process that utilizes patented catalysts for ammonia production.	<a href="https://atmonia.com/">https://atmonia.com/</a>
Agrineo	Product use	Soil analysis and management	Crop proposition, cultural monitoring and piloting	<a href="https://agrineo.fr/nos-services">https://agrineo.fr/nos-services</a>
WiseCrop	Product use	Total farm management	Farm Management	<a href="https://www.wisecrop.com/en/">https://www.wisecrop.com/en/</a>
GrainSense	Product use	Total farm management	Grain quality analyser (for oats, rye, rapeseed, maize and soybean, and wheat, barley): protein, moisture, carbohydrates and oil contents from crops)	<a href="https://www.grainsense.com/">https://www.grainsense.com/</a>
Rootility	Product use	Modified plants	Biotechnology: Breeding system for selecting high performance abiotic stress tolerant root.	<a href="https://www.linkedin.com/company/rootility/about/">https://www.linkedin.com/company/rootility/about/</a>

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Skudu	Product use	Soil analysis and management	sKudu developed groundbreaking technology based on data used to put farmers in control of their fertilizer supply chain.	<a href="https://skudu.co.za">https://skudu.co.za</a>
Azotic	Product use	Advanced fertilizer	Azotic Technologies Ltd was established to develop and commercialise a natural nitrogen technology.	<a href="https://www.azotictechnologies.com/about-us/azotic-technologies/">https://www.azotictechnologies.com/about-us/azotic-technologies/</a>
Koch Agronomic Services	Product use	Advanced fertilizer	ANVOL and AGROTRAIN above ground nitrogen stabilizer to optimize nitrogen availability	<a href="https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/">https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/</a>
Koch Agronomic Services	Product use	Advanced fertilizer	Granule with high concentration of nitrogen, enzyme and nitrification inhibitor technology to protect nitrogen below ground (SUPERU, AGROTAIN)	<a href="https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/">https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/</a>
Koch Agronomic Services	Product use	Advanced fertilizer	CENTURO: EPA-approved nitrification inhibitor for anhydrous ammonia (for below ground)	<a href="https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/">https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/</a>
Koch Agronomic Services	Product use	Advanced fertilizer	NITAMIN: flexible fertilizer, crop-safe liquid nutrient source for foliar applications in row crops, vegetables and fruits. Applied to plant leaves and deliver nitrogen.	<a href="https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/">https://kochagronomicservices.com/solutions/agricultural-nutrient-efficiency/</a>
Monsanto	Product use	Modified plants	AI to scan the sequences of seeds which have most desirable characteristics, and to find the perfect conditions for seed germination (heat, moisture level). Cross-mutation analysis.	<a href="https://apro-software.com/artificial-intelligence-in-agriculture/">https://apro-software.com/artificial-intelligence-in-agriculture/</a>
SeedGerm	Product use	Modified plants	Image analysis and machine learning to test the phenotypes of seeds to determine which are the bests for which crops.	<a href="https://www.earlham.ac.uk/seedgerm-next-generation-phenotyping-platform-quantify-crop-seed-germination-and-seedling-vigour">https://www.earlham.ac.uk/seedgerm-next-generation-phenotyping-platform-quantify-crop-seed-germination-and-seedling-vigour</a>
Peat (Germany)	Product use	Soil analysis and management	Plantix: Visual perception from drones, AI and deep learning algorithm to monitor health of the soil before planting and during the growth process. The software suggests ways to rectify the problem to the farmer.	<a href="https://peat.technology/">https://peat.technology/</a>
CropDiagnosis	Product use	Soil analysis and management	Drone technology to scan whole field and assess irrigation and nitrogen levels in the soil.	<a href="https://www.cropdiagnosis.com/portal/crops/en/home">https://www.cropdiagnosis.com/portal/crops/en/home</a>

<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Trace Genomics	Product use	Soil analysis and management	AI and machine learning based technology to digitizing the living soil, analyse the soil biology with soil DNA extraction, to inform better decision.	<a href="https://tracegenomics.com/#/">https://tracegenomics.com/#/</a>
Rowbot	Product use	Precision application tech	Image-based robotic solutions for row crop agriculture. AI solution that detects how much fertilizer will be needed by collecting plant data during growth.	<a href="https://www.rowbot.com/">https://www.rowbot.com/</a>
Bosch: Plantect	Product use	Total farm management	AI and IoT kit to assist the farmers in each steps from determining correct levels of sunlight to humidity monitoring.	<a href="https://www.bosch.com/stories/">https://www.bosch.com/stories/</a>
John Deere Blue River Technology	Product use	Precision application tech	See and spray' method: AI machine learning combined with computer vision to seek out weeds in the field which affect crop growth, and remove them. Instead of spraying the whole crop, they target specific weeds.	<a href="http://www.bluerivertechnology.com/">http://www.bluerivertechnology.com/</a>
Geopard Agriculture	Product use	Soil analysis and management	VRA maps, imagery, soil, yield and topography data analytics to monitor field, farm and region. Indicates vegetation indices.	<a href="https://geopard.tech/">https://geopard.tech/</a>
Teralytic	Product use	Soil analysis and management	Wireless NPK sensor for detailed soil quality data: 26 sensors reporting soil moisture, salinity, aeration, respiration, air temperature, light, humidity	<a href="https://teralytic.com/">https://teralytic.com/</a>
Gamaya	Product use	Soil analysis and management	Remote sensing, hyperspectral imaging, AI for crop intelligence.	<a href="https://www.gamaya.com/">https://www.gamaya.com/</a>
Tillo App	Product use	Total farm management	Collect, analyse, share and export farms data on smartphone, tablet or desktop	<a href="https://www.tillo.app/">https://www.tillo.app/</a>
TieUp Farming	Product use	Total farm management	Cloud-based software solution for horticultural agribusiness. Centralize agri data, visualize map, track and forecast future harvests, record and manage day-to-day production.	<a href="https://www.tieupfarming.com/">https://www.tieupfarming.com/</a>
((Centricity))	Product use	Total farm management	Vertically integrated suite of field data collection applications, infrastructure blocks (APIs and framework) and AI (ML) for data collection, privacy and selective data mediation	<a href="https://centricityglobal.com/#top">https://centricityglobal.com/#top</a>

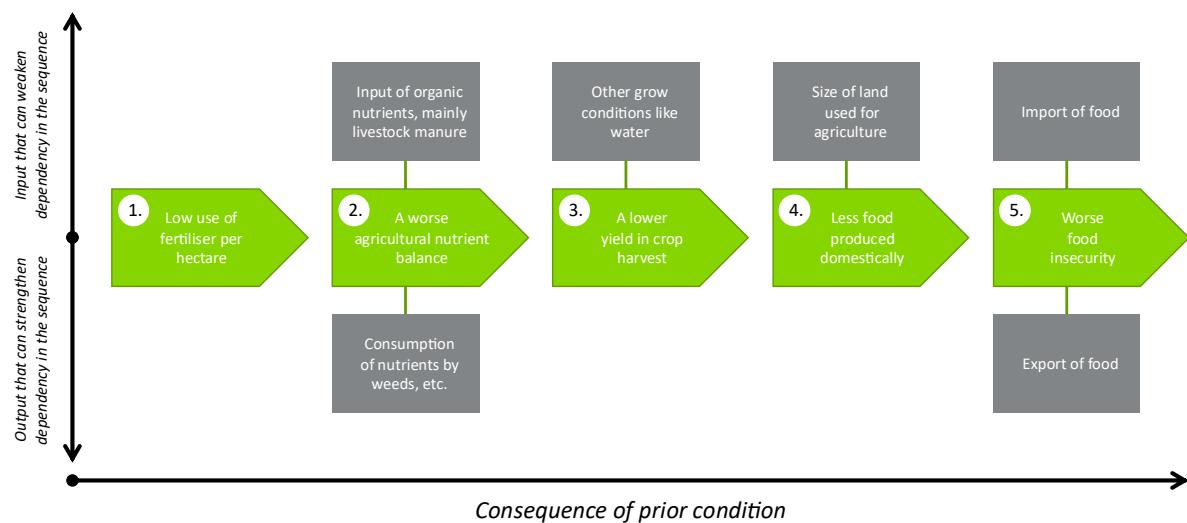
<b>Example</b>	<b>Category</b>	<b>Transformation</b>	<b>Short Description</b>	<b>Link</b>
Iden Biotechnology	Product use	Modified plants	Portfolio of candidate genes for yield increase, quality enhancement, abiotic stress tolerance.	<a href="https://www.potatopr.com/companies/iden-biotechnology">https://www.potatopr.com/companies/iden-biotechnology</a>
Iden Biotechnology	Product use	Modified plants	Portfolio of biological products, plant biostimulant products, biopesticides for agronomic use	<a href="https://www.potatopr.com/companies/iden-biotechnology">https://www.potatopr.com/companies/iden-biotechnology</a>
Benson Hill	Product use	Total farm management	Cloud biology: culmination of data, ML, AI with biology, working like a GPS for plant scientists and breeder.	<a href="https://bensonhill.com/">https://bensonhill.com/</a>
Equinom	Product use	Modified plants	Non-GMO golden trait seeds: superior plant-based protein and nutritious crop varieties. Computational science with data-driven breeding method.	<a href="https://www.equinom.com/">https://www.equinom.com/</a>

## 5.7 Case for Access to Fertiliser being a Problem in Africa

Another major fertiliser producer, Yara, expanded into Africa in 2015 by acquiring GreenBelt Fertilizers, one of the major fertiliser distributors in Malawi, Zambia, and Mozambique. This entity was later integrated into the Yara Group, but it helped increase the revenue from NOK 95,343m to NOK 111,897m between 2014 and 2015. In 2017, Yara developed potash mines in Ethiopia to produce 600,000 tonnes of Potash Sulphur per year. Last June, the company started a campaign to provide 40,000m tonnes of fertiliser in Africa in partnership with a United Nations food programme.

The consulting company, Kearney, has identified providing more access to fertiliser as a key enabling factor in solving the food insecurity in the region (Kearney, 2016). This is backed up both other organisations working within the area in the region, like the African Development Bank Group (African Development Bank Group, 2020). Figure 17 below represents the logic of this argument.

**Figure 17 - Argument for solving some food insecurity with fertiliser**



(Fertilizers Europe, 2019) (Kearney, 2016)

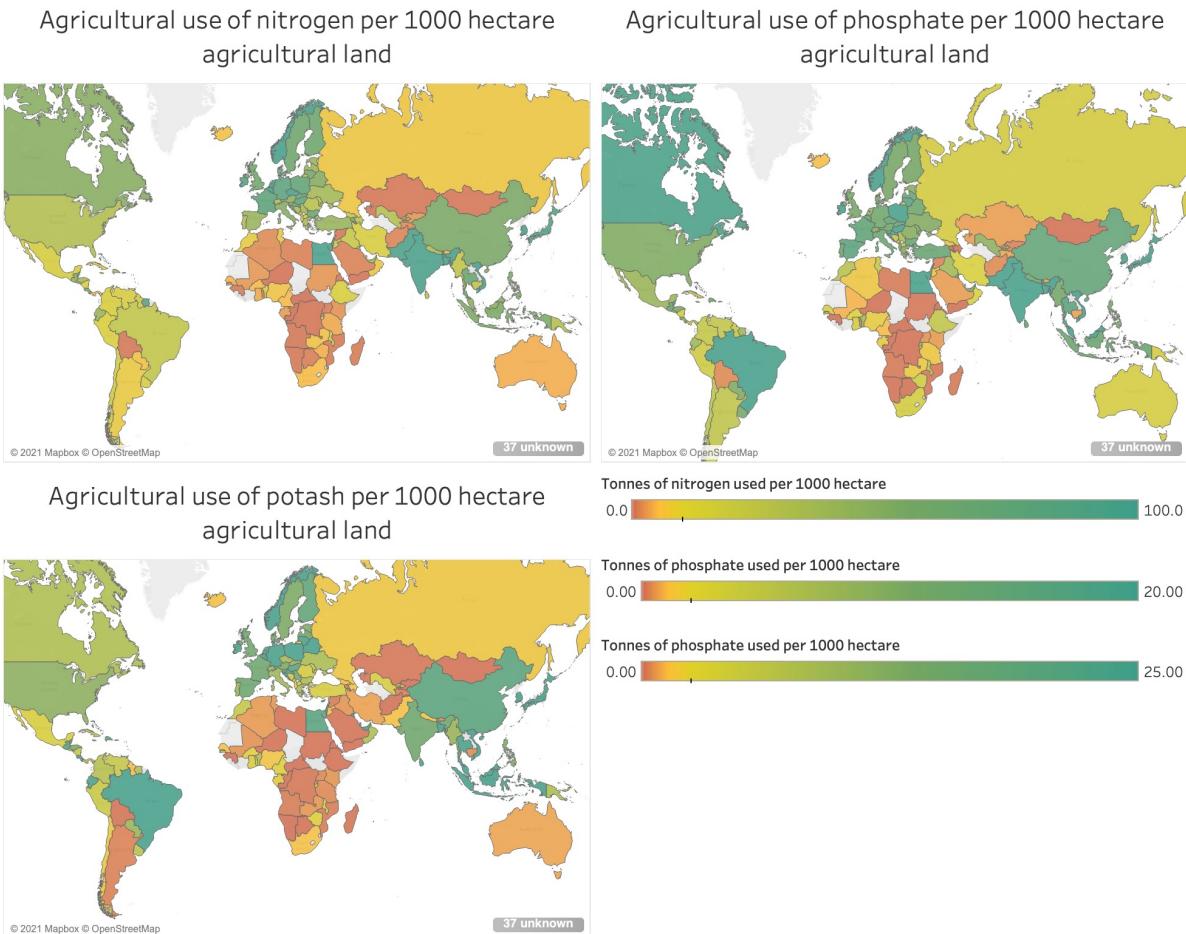
In this figure, it is shown how the low use of fertiliser in Africa (step 1) leads to worse food insecurity in the region (step 5). This logic follows that of figure 3 in section 1.3 of the report, simply adding step 5 using the knowledge from Kearney that domestic food production improves the food security of a country (Kearney, 2016).

To go through the impact of these steps for Africa, we see that:

### Step 1

Africa generally has very low application of fertiliser per hectare in agriculture.

**Figure 18 - Application of fertiliser per country**



(FAO, 2020)

It is seen from above figure that Africa tends to have a lot of countries with very low use of fertiliser.

## Step 2

The low application of fertiliser seen in Africa results in a poor nutrient balance in the African countries, where Libya is the only country not to deplete their soil by having severely negative nutrient balances.

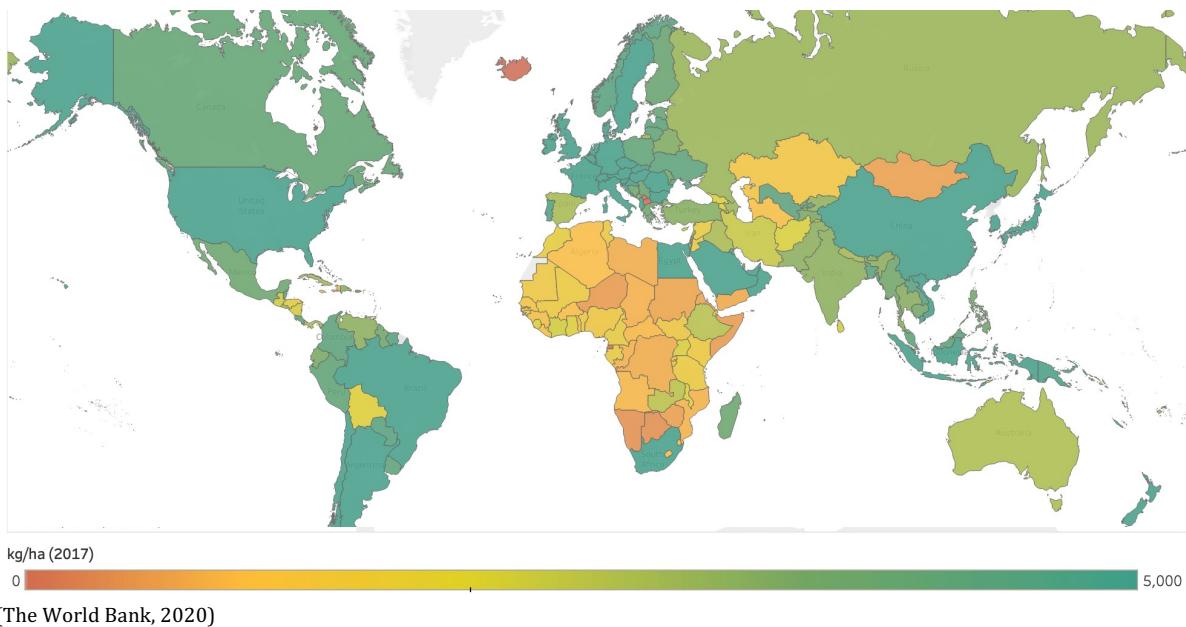
**Figure 19 - Nutrient balances in African countries**

Agricultural land depletion (nutrient balance in kg NPK/ha/year)			
High (>60)	Medium (30-60)	Moderate/Low (<30)	
Burkina Faso	Mali	Benin	Algeria
Burundi	Mozambique	Cape Verde	Angola
Cameroon	Nigeria	Central African Republic	Botswana
Côte d'Ivoire	Rwanda	Chad	Egypt
Dem. Rep. Congo	Senegal	Congo	Morocco
Ethiopia	Somalia	Equatorial Guinea	South Africa
Gambia	Swaziland	Gabon	Tunisia
Ghana	Uganda	Lesotho	Zambia
Guinea	United Republic of Tanzania	Mauritania	
Guinea-Bissau		Niger	

(FAO, 2001)

### Step 3

**Figure 20 - Yield in crop harvest per country**

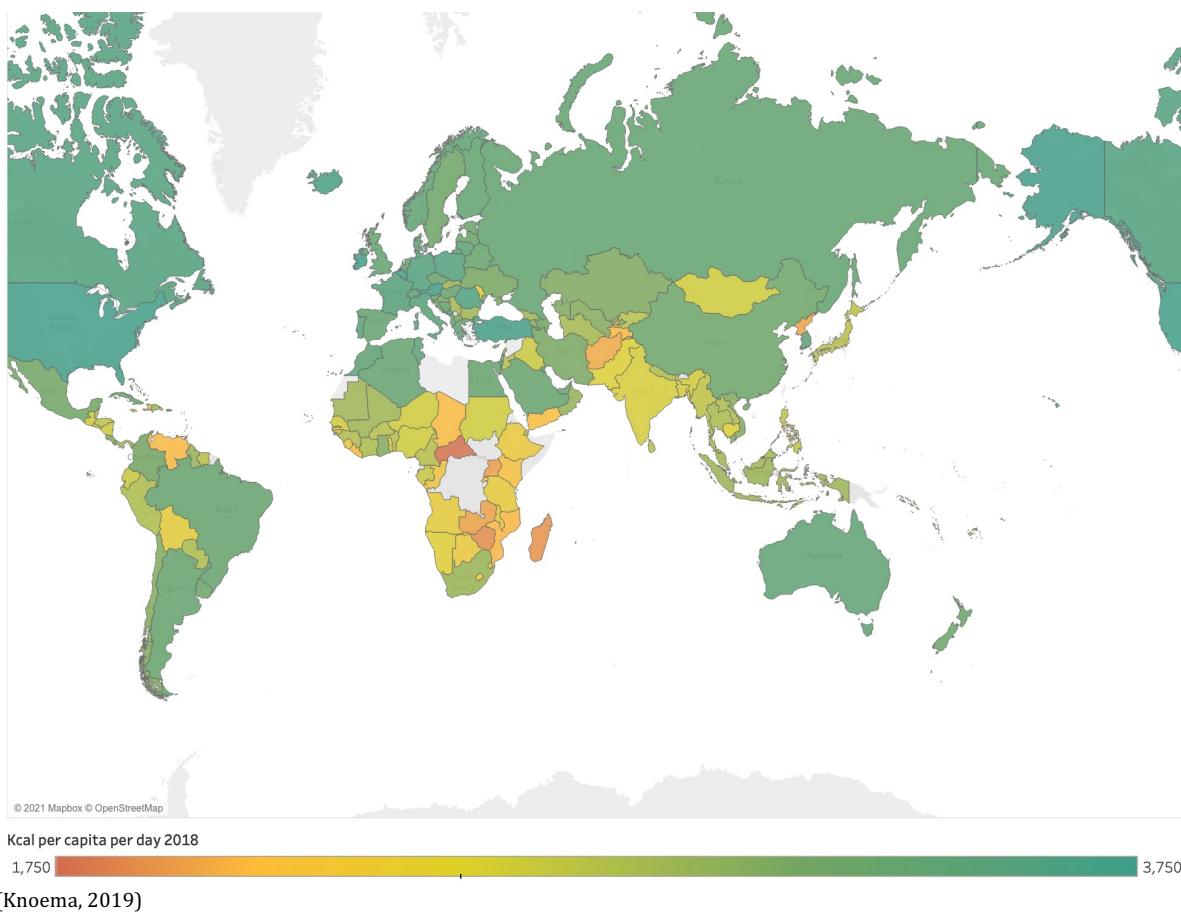


Not shockingly, the depleted land results in lower yields in the African region compared to more or less all other countries in the world.

## Step 4

The lower yield naturally is reflected in the domestic food production, and at this point in time, Africa is the only continent to be the home for countries that do not manage to produce enough domestic food to meet the recommended energetic requirements of humans. This is seen in the figure below.

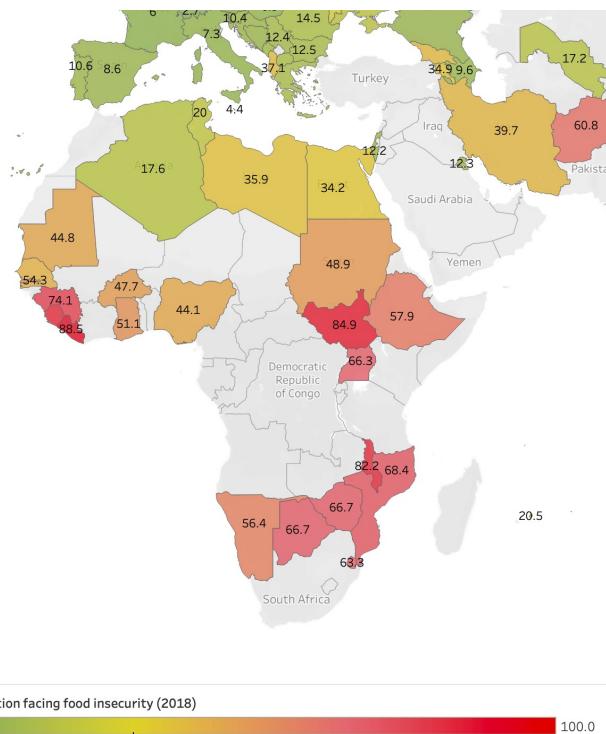
**Figure 21 - Domestic food production in energy per country**



## Step 5

In turn, this lower domestic food production leads to more severe cases of food insecurity in the region, which is evident from the figure below.

**Figure 22 - Food insecurity in Africa**



(The World Bank, 2019)

Thus, it has been proven how more use of fertiliser can improve the food security in Africa.

## 5.8 SWOT

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Largest Agricultural Retail Network (especially very well developed in North and South America)</li> <li>• One central place where farmers can get every resource, they need</li> <li>• Digital Hub</li> <li>• Largest direct-to-grower provider of products, services and solutions</li> <li>• Largest potash producer (12M tonnes of annually)</li> <li>• Third-largest nitrogen producer (10M tonnes of annually)</li> <li>• Second-largest phosphate producer in North America (3M tonnes annually)</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Very low margins on phosphate, sometimes lead to losses</li> <li>• High level of debt in proportion to EBITDA</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Precision Farming</li> <li>• Africa expansion</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Regulations</li> <li>• Exchange rate fluctuations</li> <li>• Very susceptible to potentially drastic changes in demand</li> </ul>

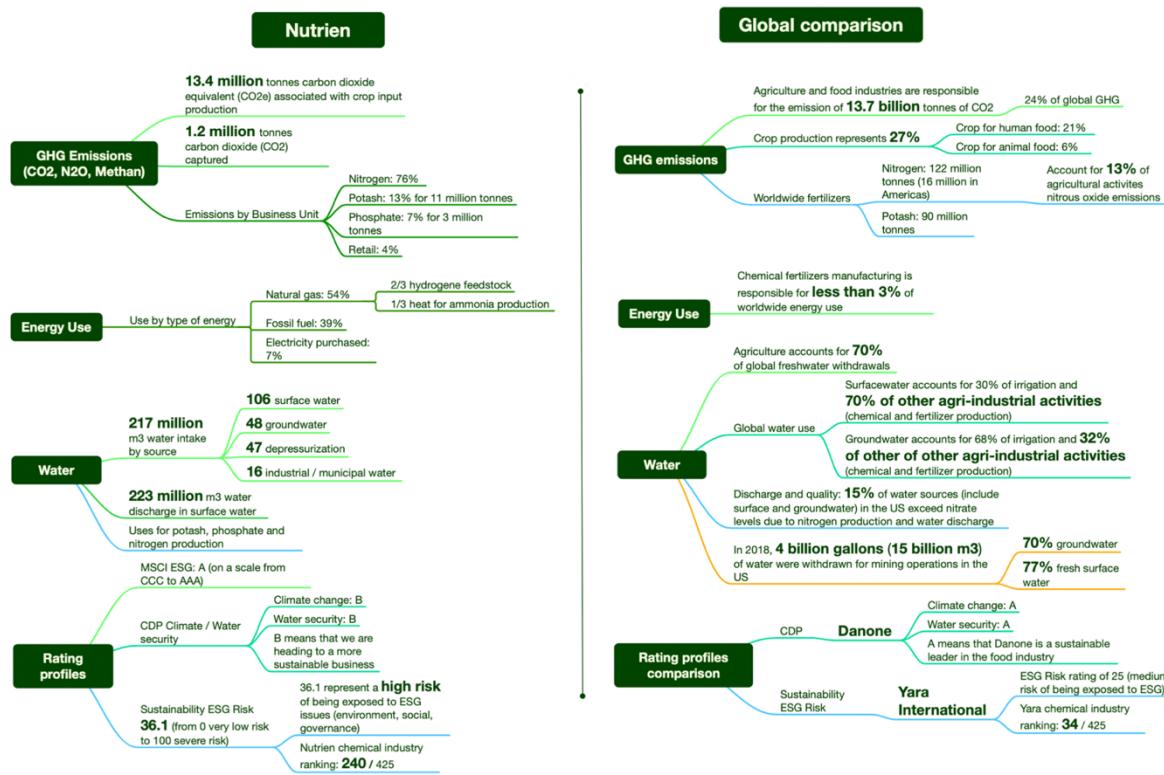
## 5.9 PESTEL

Political	Economical	Social
<ul style="list-style-type: none"> <li>1. Impact of US-China trade deal on external trade activities</li> <li>2. Political instability in the US</li> <li>3. Extensive regulations set by governments like standards for storage and transportation of the produce</li> </ul>	<ul style="list-style-type: none"> <li>1. Fluctuations in price due to weather changes, demand shifts, etc</li> <li>2. Agriculture and food sector contributes a 5.2-percent share to US' GDP. The output of America's farms contributes about 0.6 percent of GDP</li> </ul>	<ul style="list-style-type: none"> <li>1. Increase in population to 9 billion by 2050</li> <li>2. Changing consumer preference</li> <li>3. As disposable incomes rise, people shift to processed foods like meat</li> </ul>
Technological	Legal	Environmental
<ul style="list-style-type: none"> <li>1. Automation</li> </ul>	<ul style="list-style-type: none"> <li>1. Intellectual property rights in operating countries for proprietary products</li> <li>2. Policies regarding fertiliser industry</li> </ul>	<ul style="list-style-type: none"> <li>1. Global emphasis on reducing GHG emissions and environmental protection.</li> </ul>

From this PESTEL analysis, we can see that Nutrien evolves in an environment where macro factors and driving forces are influencing its business model. For instance, the price volatility of raw materials and agricultural products due to demand shifts or environmental issues can significantly affect Nutrien business model. Other important macro factors of the food industry are the growing concerns regarding GHG emissions and environmental protection (such as water pollution, land preservation). On the legal aspects, the development of biotechnologies, precision agriculture and chemicals create a highly competitive environment for companies that produce patented technologies for the food industry.

## 5.10 Nutrien Environmental Footprint and Global Comparison

Figure 23 - Environmental impact map



(Nutrien, 2020c) (Roser & Ritchie, 2013) (Fluence, 2018) (USGS, 2015) (FoodPrint, 2021) (U.S. Department of Health & Human Services, 2016) (Sustainalytics, 2021) (Nutrien, 2021c) (U.S. Environmental Protection Agency, 2020)

## Key Feedback Received and Actions Taken

### 5.10.1 Feedback to Nutrien Analyst Team

FEEDBACK	ACTION
Environmental Footprint Map is too small and it's hard to identify relevant information and conclusions from environmental footprint map -> highlight them	We enlarged the map; we highlighted the most important facts and data by putting them in bold. We changed the colours.
Add comparisons to environmental footprint map (e. g.: average ghg emissions in industry, ghg emissions of main competitors) in the appropriate measurement (ghg per ton of potash)	We added a global comparison where we compared some global, industry, market and competitor's data.

FEEDBACK	ACTION
Add a naming and numbering scheme to problem map.	We detailed further the problem map and added labelling (A1, B2, etc) to understand it better and reused the information further in the report.
Restructure Problem map as some categories is very broad	We narrowed some categories such as: water that we sub-decomposed.
Explain whether solution can only be applied to new production facilities or might there be elements of the technology that would be appropriate for retrofitting to existing locations	We highlighted how and when the solutions should be applied.
Add breakdown for each product how much we earn per ton and how much of that is profit  (important to show before proposing to change prices)	We included it as part of the BMC and other tables and detailed related to Nutrien.
Carefully separate pricing and financing as these are separate issues (if farmer can't afford to pay up front that's a different issue than the product creating less value in Africa)	We have done it for the Africa case.
Use reference examples for the impact assessment: Pick a representative country, look at food production in that country	For each cases, we based our examples on specific case studies (such as the Tugaske mine in Canada)
Show which impact we can have at different penetration levels: If 100% of farms in example country used fertiliser in the optimal way, how much of the problem are we solving;  What for 10%, 20%,...  There might be differences between the percentage jumps	We incorporated this feedback into the Africa case.
Do a deep dive into the root causes of issues we are trying to tackle.  E.g., for fertiliser use: farming practices adoption, pricing, financing, ...	We carefully analysed how the problems were caused, what were their effects and how they should be tackled.

FEEDBACK	ACTION
Break down priority problem areas into more detail: what's the state of the art	We detailed and broke down the problems we decided to tackle. We then base our transformative innovation examples on this breakdown.
Identify the state of the art is in terms of solutions to our focus problems through at least 50 example technologies per problem	We aimed to find 50 example technologies per problem but found a slightly lesser number due to our specifications and relevance.
Do not use "post-its" for the BMC	We changed it.
Add the product line-up to the value proposition of the BMC	Done.
Identify internationally recognised metrics for measuring the severity of each problem and use them for assessing the impact of the solutions	We did it in the problem part as well as the solution part in order to compare and assess the impact of the solutions proposed.
Identify customer categories and their respective problems. E.g.: Small farm in developing country, large farm in Canada, etc...	We did it, particularly for the Teralytic example.
Add explanation to why we choose specific problems to analyse in detail	We detailed the implication of Nutrien to tackle those problems and explain why we chose them.
Highlight on problem map which three/four problems we will find innovations for + explain why	We highlighted it by putting colours around the problems.
Include a short "Soil fertilisation 101" in report because the CEO would like to share the report with other people	Done.
Create an economic cost model to analyse whether our solutions are feasible.  EG: How much does fertiliser cost IN AFRICA (prices are different), how much additional profit do farmers make from fertiliser use. What about shipping cost? What about a distribution system in Africa?	We did it for each example, and particularly for the Africa case where we assessed the impact, economic feasibility of using more f

FEEDBACK	ACTION
Highlight how each solution is creating value for the person implementing it	Done for each solution, we added some numbers, data and did some graphs.

### 5.10.2 Feedback to other Analyst Teams

FEEDBACK	ACTION
Provide quantitative information to describe scale of problems.	We did it for our problem footprint.
Identify the root causes of problems and how they are connected.	We did it for our problems map in the appendix.
Be precise on which sub-problem each solution is solving.	We have detailed that in each solution. We have highlighted how each solution tackle problems and sub-problems.
Each recommendation should be based on sensible proper evidence	We have numerical and qualitative data, well-sourced for each problem and their solutions.
You must prioritise some of the problems	We have prioritised the problems and sub-problems depending on the implication of Nutrien in these problems (both as the impact and the solution)
This prioritisation must be based on a detailed breakdown of problems	We broke down a detailed problems map.
You must use metrics to scale the size of the problem, its impact, and the size of the solution	We used a lot of metrics for our environmental footprint, as well as for the problems and solutions (comparisons).
If you give the CEO a number, you must compare it with some others or give her a context so that he can make conclusions from it	We compared data and numbers to other similar or more global data to put the context of the data.
When giving a solution you must say which problem, sub-problem, sub-sub-problem it is trying to fix	We have done it, particularly for the Africa case where it implies infrastructure, supply chain, climate change, food insecurity.

FEEDBACK	ACTION
<p>It is important to quantify the impact of the company for a certain problem, but the metrics used must be well chosen. They must be relevant and must help the CEO to understand the situation in order to make conclusions</p>	<p>Quantified the impact for each problem and sub-problem. We put context, draw comparison and make conclusions.</p>
<p>This week I am not asking for any recommendations.</p> <p>The report should be made of two parts:</p> <ol style="list-style-type: none"> <li>1. A scaled map of the problems into sub-problems, appropriate metrics, scale of problems, priority problems</li> <li>2. For each of the priority problems: a systematic balanced map of the state-of-the-art of different innovations that I should know about to be fully briefed on different approaches that people are trying to different problems</li> </ol>	<p>1. Appropriate metrics, Scale of problems overall and for Nutrien</p> <p>2. We investigated the innovative solutions based on our problems</p>
<p>Group farmers by crop type and farm size and evaluate how solutions will potentially be adapted differently by them and what the results will be for them (e.g., extra yield through fertiliser use will be different depending on crop type)</p>	<p>We adapted the solution for the Africa case to a particular country. For the Teralytic solution, we adapted the solution to different scales of farms.</p>
<p>Always provide comparisons, context and scaling in conjunction with every fact to allow the reader to draw conclusions</p>	<p>We provided comparison for each section. We compared to the industry, market, competitors.</p>
<p>Have metrics and industry comparisons of contributions to each problem</p>	<p>Did it for each section.</p>
<p>Show both understanding of technical and economical understanding of problems/challenges</p>	<p>We did it in the solution part, especially for the</p>
<p>Each problem needs to be clearly defined in appendix</p>	<p>We explained all the problems from our problem map in the appendix.</p>

FEEDBACK	ACTION
Show how different problems are connected	We have connected problems with arrows
Framethe problems/solutions from the perspective of the organisation: as lost opportunity not using our product enough	Fertiliser in Africa
CleaFertilisete which problems are our priority problems	In the problem section, we have highlighted our priority problems in colour
Describe the technological and economic feasibility of each solution	We indicated the tech and economic feasibility for each solution and we added graphs to visualise it
Combine information from expert reports to build problem classification map	For our problems map we combined information from WEF transformation map, consulting firm reports, World Agri tech summit, WWF interview and other experts
Show revenue breakdown by business sections.	See in the BMC
Use Quid mainly to find examples of innovations (not that useful to look into e.g., sentiments)	We used Quid to find our examples as well as their categories. We also use other expert sources to classify the innovation such WWF interview
Categories in Quid can give us clues to the categories of innovations	We used it to find innovations and patents.
Instead of just giving large numbers for count, analyse the metrics by how analysing said category is. Degree of concentration. For example, diversification	We analysed metrics, compared it, analysed their spread.
Remember to pick and highlight points only in terms of food, not if there are factors which affect it. For example: price may affect revenue and it may not be related to the food at all	We only considered the effects and impacts related to the food industry

FEEDBACK	ACTION
<p>Relate all indirect to direct problems relevant to us and explain how they're connected</p>	<p>We have linked by arrows problem categories, problems and sub-problems. We explained how they are connected for our priority problems.</p>

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