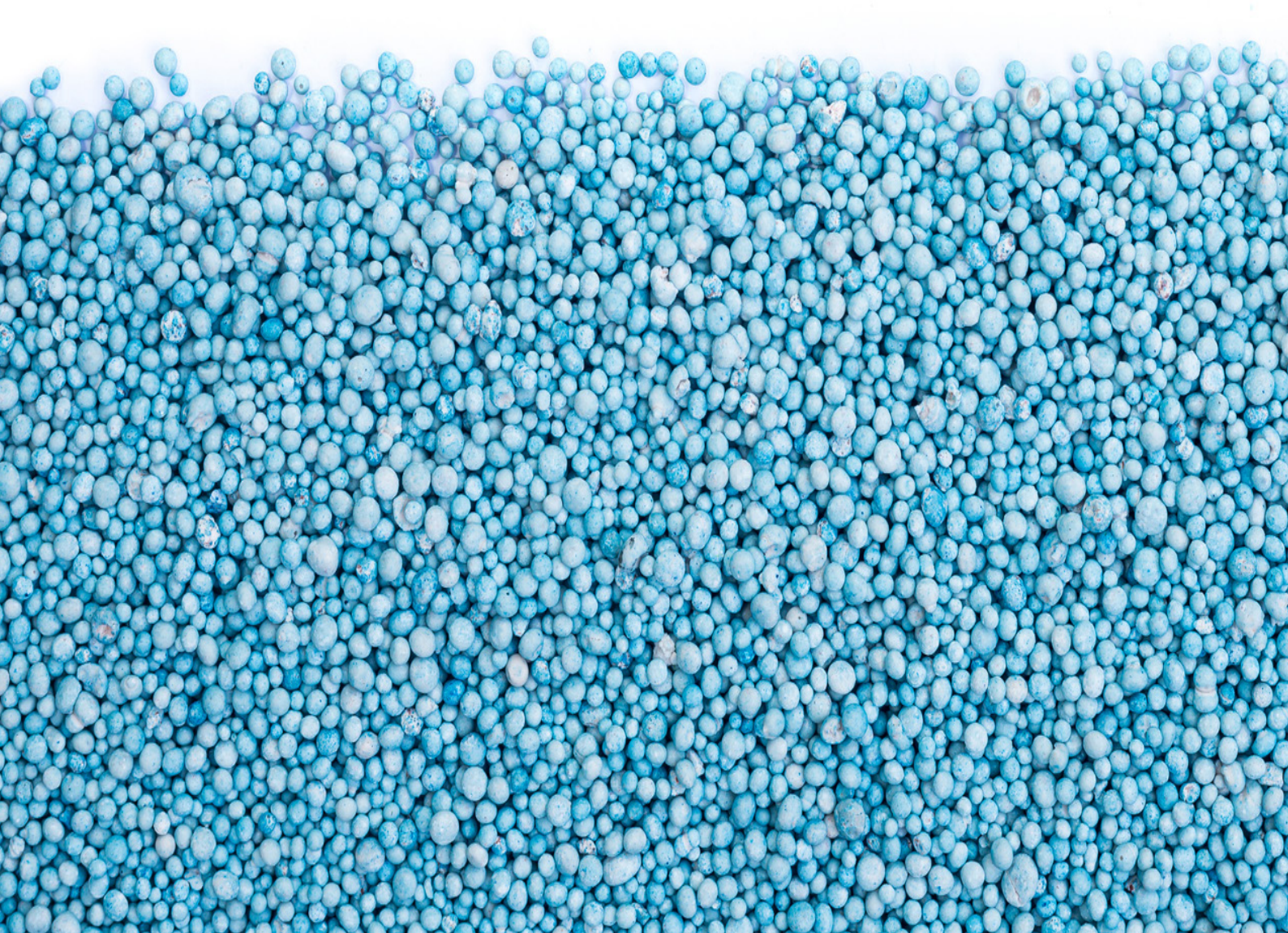
Energy&Climate
INTELLIGENCE UNIT

FARMING, FERTILISER, AND FOSSIL FUELS

How the gas crisis is squeezing Britain's farmers

March 2022



About

The Energy & Climate Intelligence Unit (ECIU) is a non-profit organisation supporting informed debate on energy and climate change issues in the UK. Britain faces important choices on energy and on responding to climate change, and we believe it is vital that debates on these issues are underpinned by evidence and set in their proper context.

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Executive summary

The tragic events playing out in Ukraine are having impacts much closer to home. The gas price crisis, driven in part by Russia restricting gas flows, is beginning to hit UK pockets hard and has caused energy bills right across Europe to rise significantly.

With potential restrictions on Russian and Ukrainian grain exports too, food prices may also be directly affected. But farmers are already feeling the pinch from the surge in gas prices and are also being impacted by rising oil prices pushing up the costs of red diesel. In the past, global fossil fuel price spikes have been followed later by food price spikes.

Ever higher gas prices are expected in turn to increase fertiliser prices. Methane is used as a raw ingredient in many fertilisers, while other types are energy intensive to produce.

The UK normally buys 38% of its urea fertiliser from Russia.[1] In early March 2022 President Putin singled out fertilisers as at risk of even further price rises, and his Industry and Trade Minister asked companies that produce them to suspend exports.

Based on 2020 figures (the latest available) the UK imports 17,700 tonnes of urea, 2,000 tonnes of potash, and 3,000 tonnes of diammonium phosphate from Russia every month.[2] Late 2021 prices for these fertilisers mean the UK is paying Russia £16 million per month, or £4m a week, for fertilisers.

New ECIU analysis suggests that in 2021 British farmers may have faced an additional £160 million on their fertiliser bill (see Annex: methodology) due to the rise in the price of fertilisers, largely caused by the gas price spike.

The most recent official prices at time of publication, for January 2022, put Ammonium Nitrate at £646 per tonne and Phosphates at £667 per tonne. If these prices hold during 2022, and were farmers to use the same quantities of fertiliser as those used in 2020, the extra bill for January-December 2022 would be in the order of £480 million.

In mid-March commodities brokers were reporting Ammonium Nitrate at £925 per tonne and Phosphates at £755 per tonne. This puts Ammonium Nitrate at more than four times the price it was in 2020. This followed comments by the Russian Ministry of Industry and Trade asking producers to stop exporting fertilisers. Only a few days later President Putin warned that fertiliser prices could rise even further, in turn impacting global food price.

If reported March 2022 prices persist for 12 months (although official figures are yet to be released by industry bodies), the extra fertiliser bill for British farmers over that period could be £760 million, assuming farmers purchase and apply the same quantities of chemical fertiliser as a normal 12 month period.

However, this may be far from a normal year and farmers may cut both purchase and application of fertilisers in response, in order to reduce costs as much as possible. This shows the escalating risks for farmers, and for food security, of high-carbon fertilisers made from fossil fuels, and controlled by unstable regimes.

Rising fossil fuel prices have driven inflation across the economy, including food price increases

1 Personal correspondence and data provided by https://www.fertilizer.org/

2 Data provided by fertilizer.org

and higher costs for farmers. High fossil fuel prices have serious impacts on the food sector. In 2021 elevated gas prices forced fertiliser factories to close. These factories produce CO2 as a by-product in the manufacturing process, a gas that is vital to the food industry used both in packaging and abattoirs.

The UK's farmers have not escaped the impacts of rising fossil fuel costs. The Energy and Climate Intelligence Unit (ECIU) has calculated that high fossil fuel prices may have heaped hundreds of millions of pounds of extra costs onto farmers in 2021 alone. As most of the country has faced increasing bills for heating due to the rising cost of gas, farmers have felt the effects in different ways, but the impact is still very real.

New technologies and alternatives are being developed to help agriculture wean itself off fossil fuels such as heat pumps replacing gas boilers for heating buildings and greenhouses, electric tractors and high-tech robots for work in the fields (which can also help to make the application of fertiliser more targeted and less wasteful), as well as fossil fuel-free fertilisers. In light of these price shocks, it's likely much greater focus will be placed on these cleaner approaches with many British firms leading the way.

Fertilisers are integral to food production across the world and therefore if their price or availability changes it can negatively impact food production in every corner of the globe. Rising fuel and fertiliser costs were the main cause behind "agriflation" (the index of rising costs for farmers) in late 2021.

Some in the sector are warning that these costs may be passed onto consumers through food prices. This is not the first time this has happened. In 2008 high fossil fuel prices in turn led to high food prices. Little has changed since then and most crop farming still uses fertilisers, which are energy-intensive and use natural gas as a raw ingredient.

These extra costs on British farms are clearly unwelcome with many already struggling financially, and some only making a profit once government subsidies have been taken into account. The four countries of the UK are moving to new agricultural systems that will reward farmers for storing carbon and restoring nature alongside producing food.

There is greater interest than ever before in private markets that might also pay for these environmental outcomes. But this alone won't be enough. Farmers will also need support to break their industry's link with fossil fuels through changed farming techniques and new technologies.

Fossil fuels are driving up immediate costs for farmers but they are also contributing to climate change with British farms increasingly being hit by flooding and heatwaves. This increasingly unpredictable and extreme weather is affecting the prices of commodities farmers grow and therefore of the foods that UK consumers buy. The fossil fuel hit on food prices is a double whammy.

How do fossil fuel prices affect farmers?

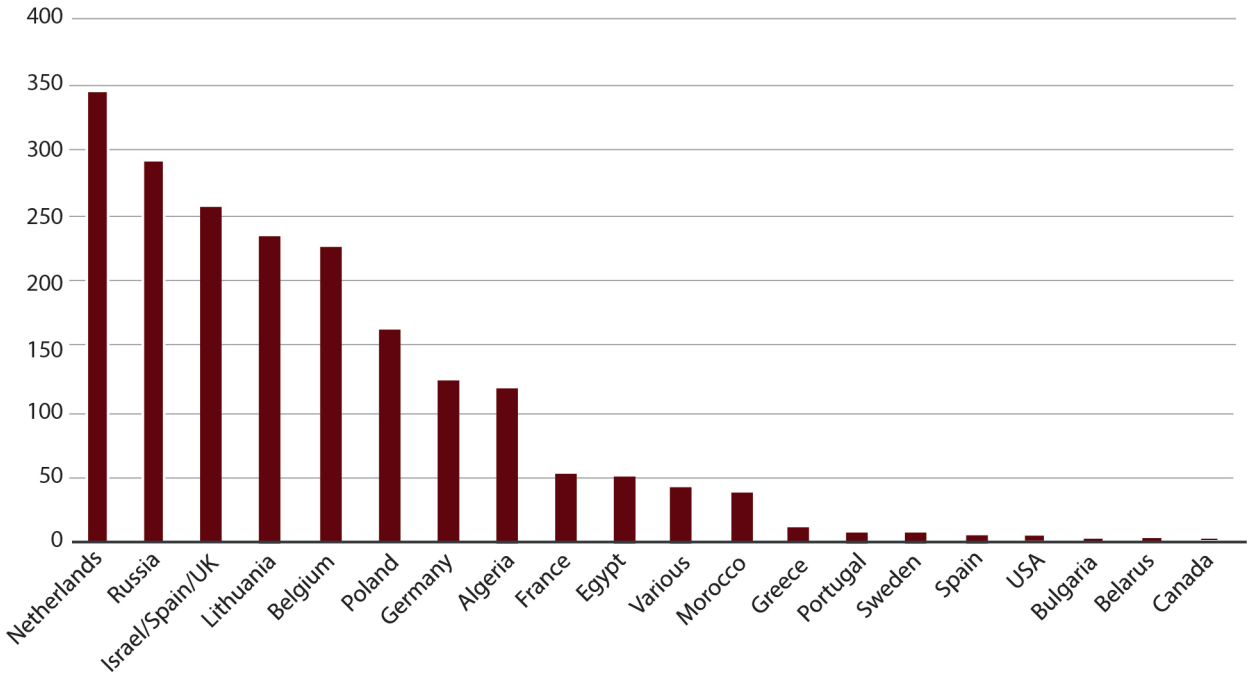
Farms are impacted by fossil fuels in different ways, from combusting them directly on the farm in machinery and vehicles, to using electricity and heat for processes on the farm such as drying grain or growing tomatoes in glasshouses, to the fertilisers produced using fossil fuels and then used in food production.

The rise in fossil fuel prices has resulted in a significant increase in costs to farmers in the past year.

The UK's fertilisers are imported from a range of countries, but the second biggest source is Russia (see Figure 1 below). President Putin has already imposed a temporary export ban on ammonium nitrate fertiliser, although the UK mostly relies on Russia for urea.

But this shows that the UK's fertilisers, and in turn its food supplies, are just as vulnerable to geopolitical tensions as its gas supplies. Increasing supplies of low-carbon fertilisers produced by innovative British companies will help to address this.

Figure 1 – UK fertiliser imports 2020 (000 metric tonnes)



Source: International Fertilizer Association

There are three main types of chemical fertiliser used by British farmers: nitrogen fertilisers, phosphate fertilisers, and potash fertilisers. These fertilisers provide nutrition to crops or the grasslands that livestock graze. In 2020, UK farming used almost a million tonnes of nitrogen fertilisers.

Some farmers use manure and slurry from livestock as an alternative, an organic form of fertiliser. Many livestock farms, for example, will use a combination of organic and chemical fertiliser.

Chemical fertilisers require significant energy inputs – making fertilisers uses 1.8% of the world's energy. The process runs at very high temperatures of 500˚C and extremely high pressures. Fertiliser production also accounts for around 1.8% of global greenhouse gases and is one of four major industries (along with cement, steel and ethylene) contributing to climate change.

Nitrogen fertilisers also use natural gas (which is mainly methane) as a raw ingredient. As a result, the prices of fertilisers for farmers increased significantly in 2021 as gas prices increased. As a result of increased fertiliser costs, British farmers may well have faced a bill for nitrogen and phosphate fertilisers almost £160 million higher than the previous year (this does not include the fertiliser categories for which price data was not available and also excludes potash fertiliser which uses different ingredients and has mostly spiked in price due to trade sanctions).

If January 2022 prices hold for the year then the extra bill could be £481 million, and if March prices hold then it could be £760 million extra. However, such high prices are likely to affect farmers' decisions, meaning they purchase and apply less chemical fertiliser than in previous years.

Table 1 – Average cost, price, and use for nitrogen and phosphate fertilisers in 2020 and 2021

	2020 average price per tonne (£)	2020 use tonnes (government estimate)	2020 total cost (£ million)	2021 average price per tonne (£)	2021 use tonnes (government estimate)	2021 total cost (£ million)
Nitrogen fertiliser	216	967,00	208.8	346	967,00	334.5
Phosphate fertiliser	286	174,000	49.7	476	174,000	82.8
Nitrogen and phosphate fertiliser			**258.5**			**417.3**

Source: AHDB GB Fertiliser Prices

The manufacture of potash fertilisers does not use natural gas but is heavily reliant on potash exports from Belarus, which have been impacted by US sanctions. Belarus is increasingly being perceived as a staging ground for military activity in Ukraine by Russia. The spike in the cost of potash fertiliser for British farmers is in part embroiled in this politics in the same way that President Putin has played a role in causing spiking gas prices by restricting flows to Europe.

An increase in demand for fertiliser has coincided with rising gas prices, compounded by additional spikes due to shortages and extreme weather. Fertiliser supply has struggled to keep up, while further shortages may yet be on the horizon if Russia imposes temporary export bans.

Farmers also faced higher energy bills in 2021 as the prices of gas and oil rose, and fuels such as Red Diesel also increased, almost 50% higher in December 2021 year on year. In February 2021 crude oil was US$56 per barrel, and a year later in February 2022 it was close to twice this around US$92.

In the past, global fossil fuel price spikes have been followed later by food price spikes. For example, in 2008 a 14% spike in UK food prices was preceded by a global spike in the price of oil which had doubled to $140 per barrel compared to 2007. There is concern that the ongoing link between fossil fuels and farming may put food production at risk in the future as oil and gas prices rise further.

How can farmers insulate themselves against future fossil fuel price volatility?

Farming does not need to remain reliant on fossil fuels and chemical fertilisers. Short term changes to farming practices can help to reduce fertiliser use while more medium term new technologies may help to produce fertilisers without reliance on fossil fuels.

In the short term, farmers can reduce their reliance on fossil fuels and fertilisers by installing renewable energy and by cutting chemical use. For example, according to government data only 31% of farms were using solar energy in 2019.

Some farmers are already introducing farming techniques that reduce reliance on fossil fuels. For example reducing the amount of ploughing can keep more carbon locked in the soil and also reduce the use of machines and vehicles that run on red diesel.

Certain crops - called herbal leys - are made up of plant species that take nitrogen from the air and put it into the soil. This can replace the use of chemical fertilisers. Some farmers are

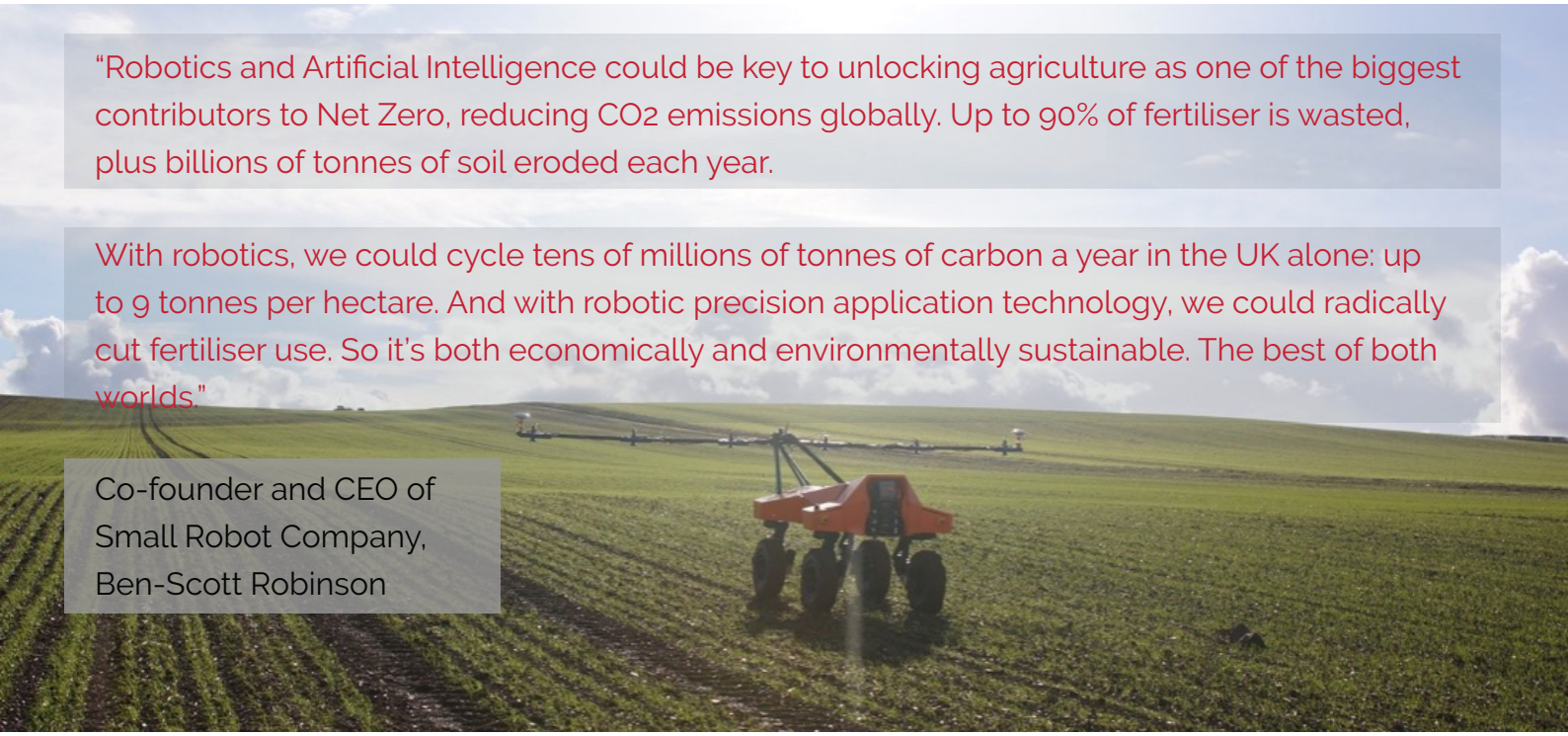
choosing not only to replace fertilisers with these leys but also to stop growing cereal crops and instead grow these leys and graze livestock on them. For example, in Fife, Johnnie Balfour, at Balbirnie Home Farms, has replaced cereal crops with these leys and now grazes cattle on them instead. The leys don't need spraying with fertiliser, and hardier cattle breeds can stay outdoors all year reducing fuel use for heating and mucking out. These measures have improved the farm's profit margin.

In the coming years the new farming system in England, which will incentivise environmental outcomes, may pay for these types of practices that cut fertiliser use and help to restore nutrients and carbon to the soil.

In the medium term, a range of net zero farming technologies are being developed to reduce farmers' use of fossil fuels for energy and fertilisers.

A significant use of energy in farming is heating glasshouses to grow fruit and vegetables. Companies, like Low Carbon Farming, are building and using glasshouses warmed by heat pumps (that run on electricity) instead of methane gas, or even using waste heat from sewage treatment plants.

Electric tractors are being developed by the world's leading farm machinery companies. Some companies, such as the Small Robot Company, are developing robotic technologies that can replace tractors when spraying fertilisers. This can reduce the impacts on soils (as they are far lighter than tractors) and reduce the quantities of fertiliser needed, as they are far more precise. These robots are expected to be commercially available in the next few years.



"Robotics and Artificial Intelligence could be key to unlocking agriculture as one of the biggest contributors to Net Zero, reducing CO2 emissions globally. Up to 90% of fertiliser is wasted, plus billions of tonnes of soil eroded each year.

With robotics, we could cycle tens of millions of tonnes of carbon a year in the UK alone: up to 9 tonnes per hectare. And with robotic precision application technology, we could radically cut fertiliser use. So it's both economically and environmentally sustainable. The best of both worlds."

Co-founder and CEO of Small Robot Company, Ben-Scott Robinson

Companies have developed new ways to produce fertilisers without harming the climate. Green ammonia uses electrolysis to generate hydrogen from water, and nitrogen from the air, instead of its usual production from natural gas. The normal process is then powered using renewable energy, making the entire process fossil fuel free. The International Energy Agency (IEA) estimates that this green ammonia process is cost-competitive with conventional processes.

CCm Technologies, a clean technology company, have developed "sustainable" fertilisers produced from captured carbon and other waste streams from other industries. While some companies are using green hydrogen produced from electrolysis which removes the need for using methane.

"Emissions from end-to-end food production are approaching 24% of total global greenhouse gases, with the manufacture of conventional fossil fuel based fertilisers being a very significant part.

"There is a growing market for alternative fertilisers such as ours, that use waste products and captured carbon dioxide to deliver solid crop yields while using at least 20% less applied nitrogen and phosphate. In real terms, the deployment of 50 of our standard production units could result in emissions savings equivalent to removing around 375,000 cars from the road each year".

CCm Technologies CEO, Pawel Kisielewski

N2 has developed a technology that can reduce the methane emissions of manure fertilisers. Using manure from livestock as a fertiliser can replace the use of chemicals. But manure and slurry normally release methane and ammonia into the air, both of which contribute to climate change.

This process, using air, electricity, and a plasma reaction, stops the methane and ammonia emissions reducing climate change and air pollution, meaning the manure is richer in nutrients and less is needed. Spreading manure after this treatment has been shown by the company to increase crop yields by 40%.

"Our solution can help farmers produce their own green nitrogen fertiliser locally with resources already on the farm. It provides green ammonia, but more importantly for the environment is the possibility to stop methane and ammonia emissions from manure management. This can have a significant impact on the environmental footprint of food production."

N2, Kåre-Gunner Fløystad

Many of these technologies are still in development. To help deploy these techniques and technologies more quickly financial incentives, private markets for carbon, research and development funding, and technology subsidies or capital grants and loans could all be used.

To date, significant amounts (around £3 billion per year across the UK) of government funding have been paid to farmers based on the amount of land they own. In the future this money is planned to be used to pay for environmental outcomes. These outcomes could include cutting greenhouse gas emissions, cutting fertiliser use, and deploying new low-carbon technologies.

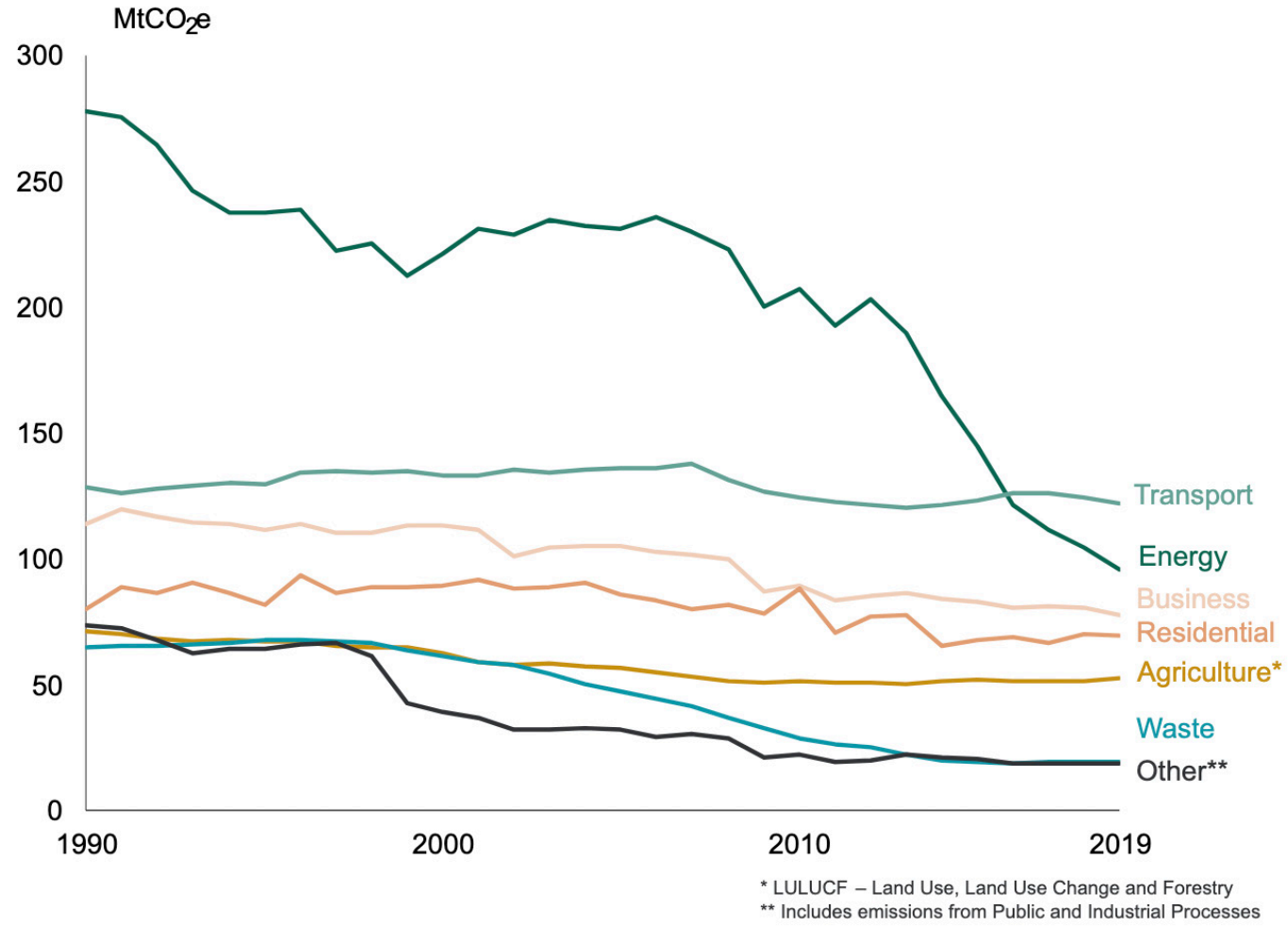
Agriculture emissions will need to fall as part of net zero

The processes and chemicals used in agriculture make up 10% of the UK's emissions. On top of that is the carbon dioxide (CO_2) released from farmed soils and other land (some of which is balanced out by the carbon absorbed by forests). The Climate Change Committee and the Institute for Government have both highlighted agriculture as a weak link in the government's plans to get to net zero emissions.

The government's legally binding target is for the UK to reach net zero emissions by 2050. In the past decade agricultural emissions have stubbornly refused to fall, despite government support and industry-led efforts.

Emissions from agriculture have remained flat while other sectors of the economy have been making cuts. In 2009 the greenhouse gases for the sector were 53 million tonnes, and were unchanged a decade later. This represented a slightly higher percentage of overall UK emissions as the total had fallen.

Figure 2 – UK emissions by sector, 1990-2019



Source: BEIS, 2020

CO2 emissions are around 9% of the emissions from agriculture (but only includes the release of CO2 from machines, heating etc on farms, and not the CO2 released in the manufacture of fertilisers).

As well as CO2, farms in the UK also release methane (which makes up more than half of emissions from farming) mostly generated by livestock, and also nitrous oxide, which primarily comes from chemicals like fertilisers spread onto fields. Nitrous oxide emissions have fallen slightly since 1990 (from 17.6 million tonnes to 15 million tonnes) mainly due to reductions in the overall quantities of fertiliser used.

Attitudes to climate change on farms show that 56% of farmers are taking action to cut emissions. 67% of farmers think it's important to take action, but lack of knowledge represents the biggest barrier rather than access to finance.

There is growing interest from companies wishing to meet net zero targets or improve their corporate social responsibility. Some of them are interested in paying for measures which improve the environment, restore biodiversity, clean up water, or store carbon.

Companies such as water and sewage utilities may pay for tree planting and peatland restoration because it can improve water quality and save them money on treatment. Farmers could stand to benefit from these new markets in ecosystem services by managing their land for nature and carbon as well as for growing food. This could provide a new income stream alongside selling food and government incentives for net zero farming.

Extreme weather is also putting pressure on food prices

The burning of fossil fuels is driving climate change with more extreme weather a growing threat to farms, their yields and to food prices. Climate change is making failed harvests and shortages of key commodities or crops more likely. This puts the price of commodities up, affecting farmers, and could affect food prices as well.

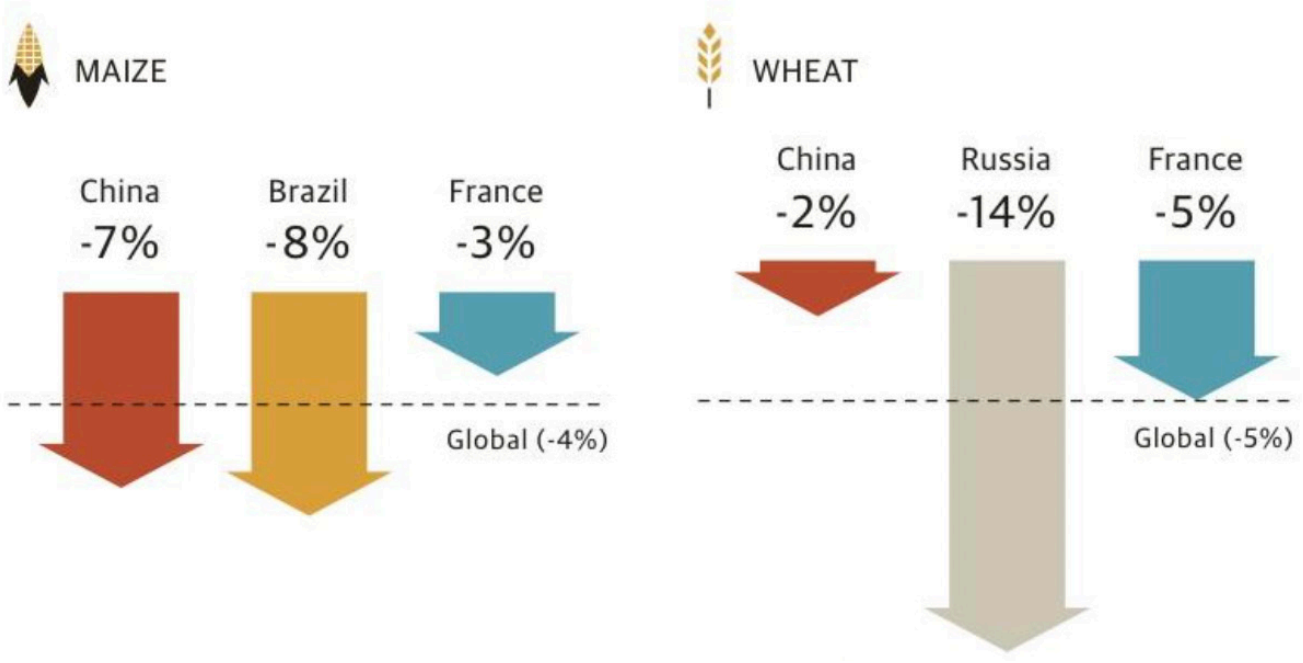
The Sixth Assessment Report by Working Group Two of the Intergovernmental Panel on Climate Change noted that climate change has already impacted on food production and in turn this is contributing to malnutrition in some countries.

A report in 2021 by the Stockholm Environment Institute found that climate change could pose a severe risk to food security and increase food prices for consumer countries too. It concluded that "Agriculture is one of the most exposed sectors to climate change".

A 2021 report by the UN Food and Agricultural Organization warned that "the notable increase in the frequency and intensity of extreme weather-related and climate-induced events observed over the past decades poses a significant challenge to agricultural systems, given their heavy reliance on weather and climate."

Overall climate change is already negatively affecting yields of 10 staple crops, such as rice, wheat, and barley, according to researchers from the University of Minnesota. The same study found that in 2019 global hunger was increasing for the first time in a decade, with available calories falling in countries that already had problems with malnutrition.

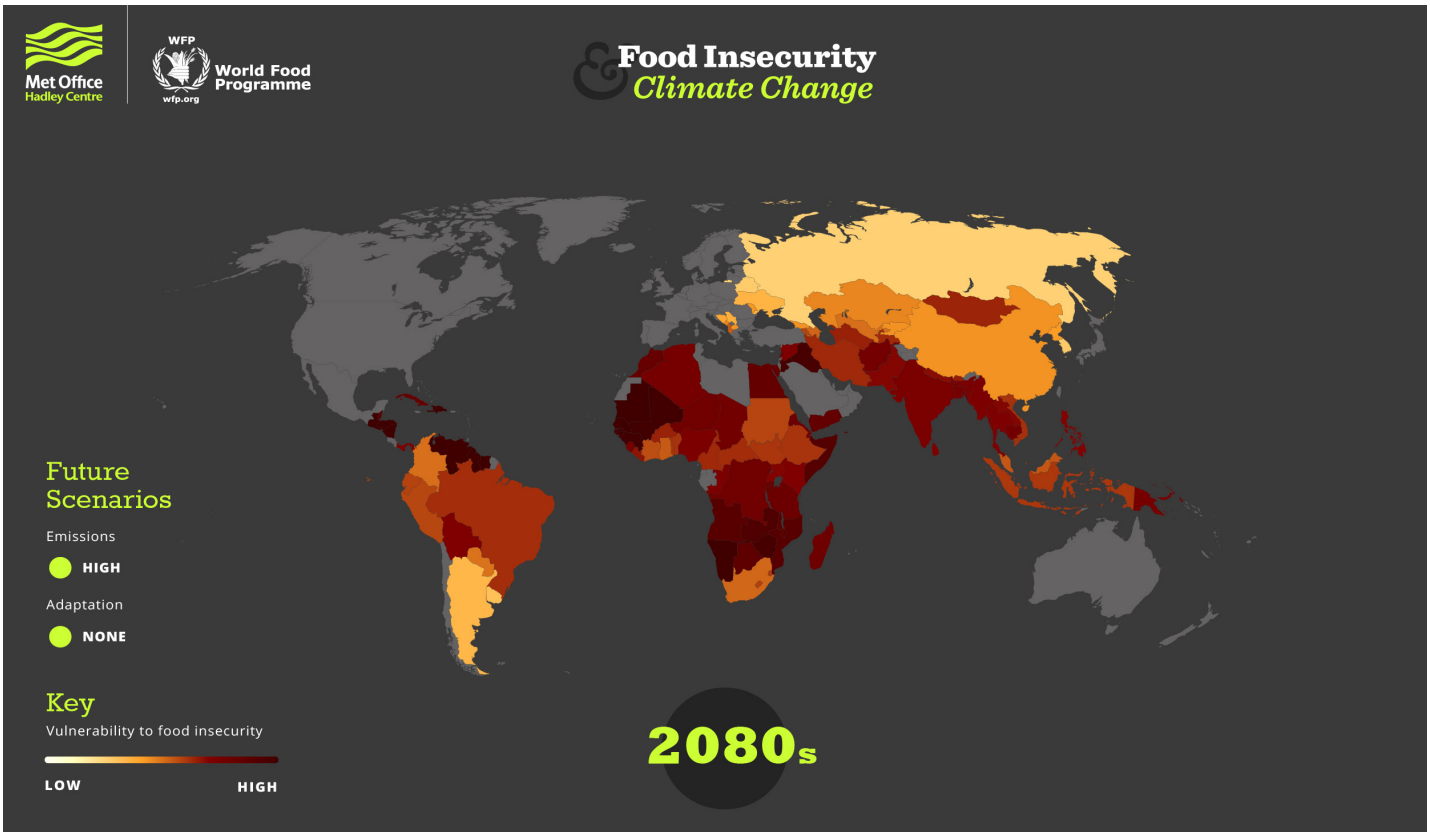
Figure 3 – Climate change, food and farming: 2010s: how climate change is affevcting crop yields



Source: Research Program on Climate Change, Agriculture and Food Security

By the 2080s food production could be severely impacted by climate change. A tool designed by the MET Office and World Food Programme shows the degree of food production's vulnerability to climate change, with no adaptation and high emissions, by the 2080s.

Figure 4 – Climate change, food and farming: 2010s: how climate change is affevcting crop yields



Source: Met Office

In 2021 alone there were several examples of extreme weather affecting farming in the UK and internationally.

In the UK, harvests of orchard fruit, wheat, and potatoes were all affected by hot dry weather followed in quick succession by wet weather.

Overseas, Storm Ida, which caused loss of life from flooding in western Europe, also affected the harvest of some key crops. The UK imports significant quantities of potatoes from Belgium, Germany and especially the Netherlands. In Belgium potato prices increased by 180%.

In 2021 the harvest of spring wheat in the US was at its lowest in 33 years (since 1988) after drought and extreme heat damaged crops. The heatwave was record-setting with temperatures in Phoenix, Arizona, at 46°C for six days in a row, reaching a maximum of 47°C. Over 20% of the country was covered by the two most severe drought categories. There were wildfires in California, Arizona, Colorado, Utah, and Montana.

These weather extremes led the US Department of Agriculture to rate 68% of spring wheat crops as in poor or very poor condition. The significant decline in spring wheat crop, to its lowest in 33 years, forced countries buying US wheat to pay higher prices or turn to other countries to meet their demand. It also affected supplies available to bakers and millers in the US. The US Department of Agriculture estimated that the 2021 harvest of spring wheat was 315 million bushels, 44% lower than the previous year and the lowest since 1988.

2022 has started with drought conditions in Brazil, Argentina, and Paraguay, key producers of soybeans. Estimates of production have been cut and prices are spiking. Soybeans are a key commodity import for British farmers who use it to feed to livestock - the UK imports around 3.2 million tonnes annually. The price of soy jumped from around $490 per metric ton in early December 2021 to around $550 per metric ton in late January 2022.

Conclusion

Farmers' costs and food prices are increasingly exposed to volatility and unpredictability.

Reliance on fossil fuels, and extreme weather being driven by climate change, are the two key factors influencing this.

In the past year British farmers have been saddled with a much higher bill for fertilisers than the previous year, due to rising fossil fuel costs.

A combination of adjusted farming techniques, and promising new technologies, can help reduce reliance on chemicals, replace fossil fuels in energy and fertilisers, and, in turn, boost the UK's food security.

Annex: methodology

Extra fertiliser costs were calculated using the GB fertiliser prices tracked by AHDB https://ahdb.org.uk/GB-fertiliser-prices

Quantities of UK fertiliser were based on the British survey of fertiliser practice 2020 https://www.gov.uk/government/statistics/british-survey-of-fertiliser-practice-2020

The quantity of fertiliser used each year varies slightly but is generally steady. The figure for the quantity used in 2020 is a government estimate. The 2021 is an extrapolation assuming that the amount used held steady and was the same as 2020. It assumes that farmers did not replace chemical fertilisers with organic fertilisers in response to price rises, while in reality this may have happened.

Natural gas is used as a raw ingredient in producing nitrogen-based fertilisers. It is also used to make the ammonia used in the production of phosphate fertilisers. Therefore it can be considered to be a major influence on the costs of both of these types of fertiliser.

Potash fertilisers use a different process and raw ingredients and have therefore been excluded.

The average prices of phosphate and nitrogen fertilisers in 2020 and in 2021 were calculated using the AHDB dataset for those months where a figure was available and excluding N/A months. This average price was multiplied by the quantities of these types of fertilisers used in the UK in 2020, and it was assumed that the same amount was used in 2021.

Different types of farm will be able to buy at different times of the year and so the true price paid will vary from farm to farm. For example arable farms can often buy fertiliser early and store it whereas many livestock farms do not have this capacity and may have had to buy later in the year at higher prices.

Nitrogen fertilisers

Average price in 2020 (across AN UK, AN imported) £216 per tonne

Average price in 2021 (across AN UK, AN imported) £346 per tonne

Average price January 2022 (across AN UK, AN imported) £646

March 2022 price £925

Nitrogen use 2020e 967,000 tonnes

Nitrogen use 2021a 967,000 tonnes

Nitrogen use 2022a 967,000 tonnes

Nitrogen spend 2020 £208.8m

Nitrogen spend 2021 334.5m

Nitrogen spend 2022 (January price) £624m

Nitrogen spend 2022 (March price) £894m

Phosphate fertilisers

Average price 2020 (Diammonium phosphate, Triple Super Phosphate) £286 per tonne

Average price 2021 (Diammonium phosphate, Triple Super Phosphate) £476 per tonne

Average price January 2022 ((Diammonium phosphate, Triple Super Phosphate) £667

March 2022 price £755

Phosphate use 2020e 174,000 tonnes

Phosphate use 2021a 174,000 tonnes

Phosphate use 2022a 174,000 tonnes

Phosphate spend 2020 £49.7m

Phosphate spend 2021 £82.8m

Phosphate spend 2022 (January price) £116m

Phosphate spend 2022 (March price) £131m

Total difference between 2020 and 2021 is £158.8m

Total difference between 2020 and 2022 (at January prices) is £481.5m and (at March prices) £768m.