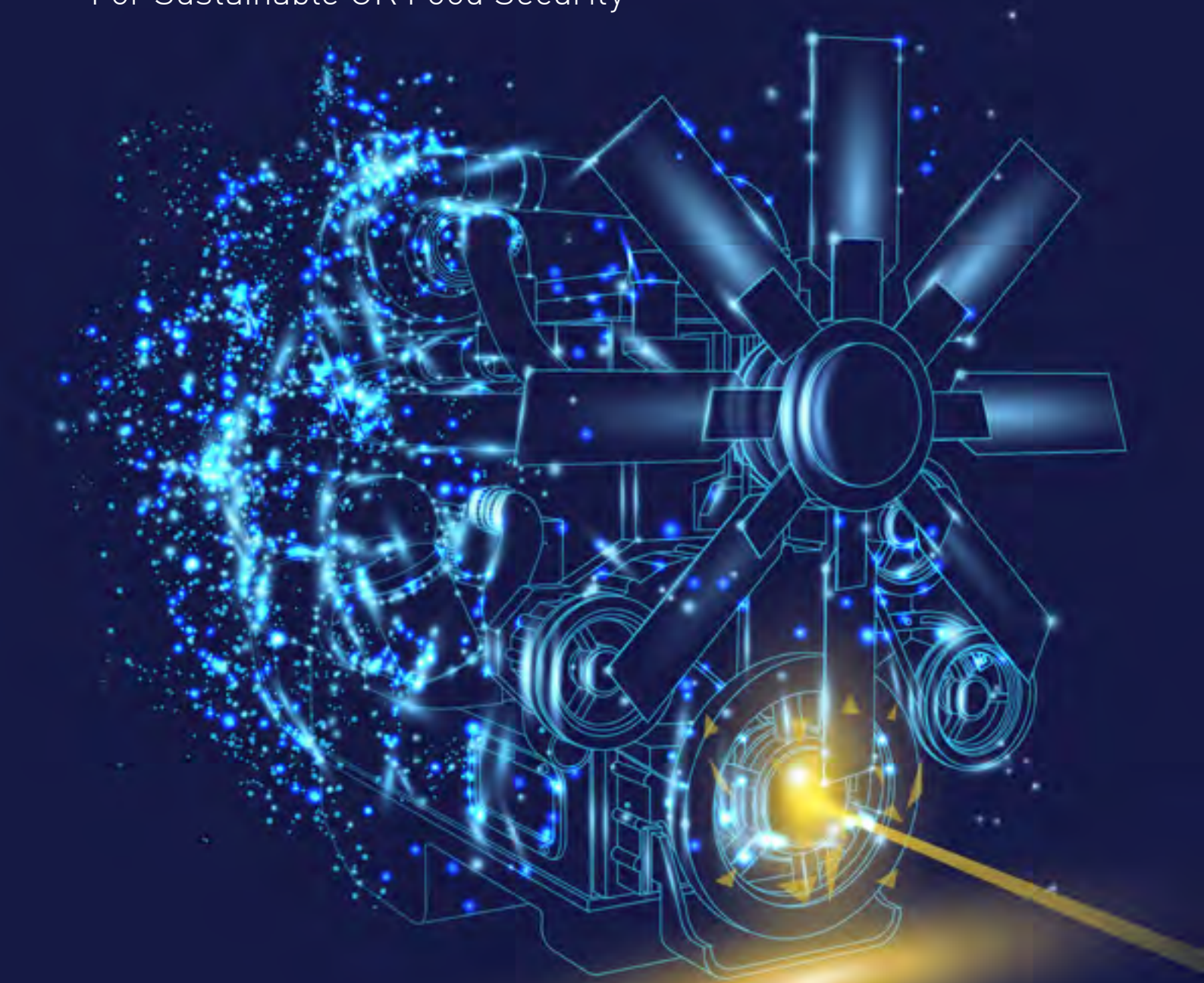
POWERING PRODUCTIVITY

For Sustainable UK Food Security



Author

a.r.u. | Peterborough

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aic 20 YEAR ANNIVERSARY

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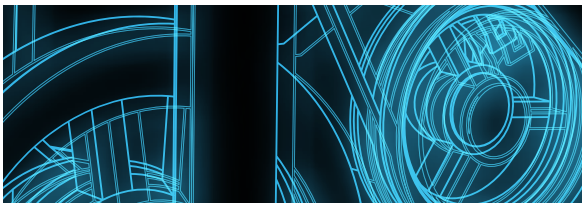
An independent report commissioned to mark the 20th anniversary of the formation of the Agricultural Industries Confederation (AIC).

FOREWORD

This independent report by the Anglia Ruskin University (ARU) was commissioned to mark the 20th anniversary of the formation of the Agricultural Industries Confederation (AIC).

The backdrop is of the UK having recently left the European Union, recovering from the shocks of a COVID-19 pandemic, a war in Europe and a cost-of-living crisis, which has seen food price inflation at its highest in many decades.



All of this has exposed the fragility of the UK's food supply and its deeply concerning lack of security.

Productivity in the agri-food industry is complicated and no one policy or innovation drives its progression. It is much like an engine consisting of many moving parts, all interrelated and reliant upon each element's ability to perform. In an ideal world, these parts work smoothly to deliver a productive, competitive, and sustainable agriculture running at optimal efficiency which drives the security of the nation's food supply.

Today, the engine of UK agriculture is not firing on all cylinders, and this report seeks to assess the components that are in need of attention, diagnose some of the causes of the sector's productivity inertia and make a series of recommendations to ensure the most efficient drive to lift productivity and competitiveness.

It is this sheer complexity which has led AIC to call for the establishment of an independent UK Food Security Committee.

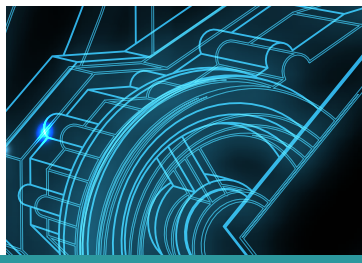
Chaired independently, this statutory body would advise the UK and devolved governments on the drivers of food security and report to Parliament on progress made in enhancing the productivity and resilience of the UK's entire agri-food supply chain – from pre-farm suppliers, farmers and growers, through to processors, manufacturers, food service and retailers.

Much like the Independent Committee on Climate Change, it would take a cross-Whitehall view of the policy direction taken by key UK and devolved government departments, aiding policy development and collaboration in support of our nation's food security.

> The oversight of such a body for the agri-food industry will significantly enhance our nation's food security for the long term, well beyond short-term parliamentary cycles.

As AIC looks ahead to the major strategic considerations for UK agriculture, so too must our wider national approach to food security. There is an open and serious question as to where our nation will find itself in the next 20 years if we fail to act now.

Robert Sheasby,
Chief Executive, AIC



EXECUTIVE SUMMARY

Agricultural production is a multifaceted process shaped by environmental factors, public opinion, food demand, economic forces, and government policies.

In 2021, the United Kingdom's agri-food sector played a pivotal role in the nation's economy, contributing an estimated £127 billion and providing employment to over 4 million individuals. Agriculture itself, constituting 9% by value of this sector, boasted a workforce of almost 500,000. Agricultural supply businesses, represented by the Agricultural Industries Confederation (AIC), form the bedrock of the UK agri-food chain, supplying essential inputs and expertise to fuel agricultural production, and market cereals, oilseeds, and pulses.

A key trend is the rise of non-food agricultural production in the UK, encompassing bioenergy, biogas, textile, construction, and pharmaceutical products. While this diversification enhances the viability of farming businesses, it intensifies the challenge to UK food security. Environmental policies and planning regulations are also increasing the pressure on food production in the UK.

Over the past two decades, the land area devoted to agricultural production has seen a modest decline of nearly 3% compared to 2002 (DEFRA, 2022a). In contrast, production has increased by 5% during the same period (DEFRA, 2022b). Simultaneously, there has been a gradual dip in self-sufficiency, down by 3% for major crops, rendering the UK more reliant on imports from the EU (comprising roughly 50% of all imports) and other parts of the world (DEFRA, 2022b). Climate change has brought about greater unpredictability into production in both the UK and globally, necessitating a shift towards decarbonising the agri-food supply chain and promoting sustainable farming practices.

The geo-political landscape has disrupted the security and dependability of the supply of goods. Therefore, ensuring the security of the UK's food supply is more crucial than ever as part of a broader sustainability agenda. A focus on achieving more predictable and reliable internal production and procurement is imperative to mitigate external supply chain shocks.

UK land use policy must harmonise with food security and broader agricultural output and sustainability. However, focusing policy and legislation on land use and production decarbonisation alone risks centring UK production on a few "low-carbon crops", increasing the need for imports and jeopardising food supply diversity. Such a scenario could lead to a poorer diet for lower-income families and an increased burden on UK health services in the long term.

The UK Government should incentivise the decarbonisation of all farming and food system aspects, not just production and land management. The agri-supply industry is pivotal in this process and can be decarbonised rapidly with new investment.

Harnessing the innovation and technology benefits of decarbonisation requires collaboration among farmers, advisers, scientists, and educators to generate the information necessary for low-carbon alternatives. A failure to do so could stall decarbonisation, exacerbate the UK's skills gap, and impede the Government's legally binding climate change commitments.

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Prioritising soil, biodiversity, water, and air protection is essential, as these elements impose substantial hidden costs on UK taxpayers, including the provision of clean drinking water and clean air. Maintaining the diversity of a nutritious diet produced domestically is crucial. This not only underpins a healthier population but also supports food supply security within the UK. Sustainability and reliable productivity in the UK, rather than a sole focus on maximising yield, are vital.

Circularity throughout the food supply chain is a fundamental aspect of decarbonisation. Incentives that promote the reuse of food and other waste streams as farming inputs and alternative energy sources should be maintained and expanded. Clarity and commitment to initiatives like renewable obligation certificates (ROCs) are critical to sustaining such circular processes.

The UK's agri-food community - which includes agri-supply businesses, farmers, manufacturers, and retailers - must collaborate with the Government to equip the entire supply chain with the technology, skills, and support necessary for a truly sustainable industry. Government incentives are required to spur stakeholder investments. Public awareness of the importance of a sustainable future, championed by the agri-food community, should be a part of broader engagement efforts to reconnect the UK public with food production and the environment it depends on.

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This independent report lays bare UK agriculture's hugely complex productivity picture, with readily competing and contradictory objectives and outcomes. Greater focus, direction, and co-ordination is needed.

Recommendations for enhancing UK food security

The UK would benefit from the oversight provided by a statutory body established by government to operate independently beyond short-term parliamentary cycles. This report therefore calls for the establishment of an independent UK Food Security Committee.

Such a body could advise the UK and devolved governments on national and strategic food security by taking account of the wide-ranging issues which determine agricultural productivity. It is this productivity which fundamentally underpins the nation's food security.

Summary of actions

The key findings of this independent report culminate in the following recommendations to bolster the UK's food security by enhancing agricultural productivity.

Land Use Strategy

Streamline government policies to create cross-departmental, comprehensive legislation that balances all facets of land management to ensure sustainable and secure food production. Implement a government funding policy that maintains and improves sustainable food production within the UK while promoting dietary diversity.

Market Access

Expand both internal and external markets to enhance agri-food business resilience and food production security.

Technology, Data and Infrastructure

Encourage and legislate investment in technology, data solutions, and infrastructure to support sustainable business practices across the food supply system.

Research and Development

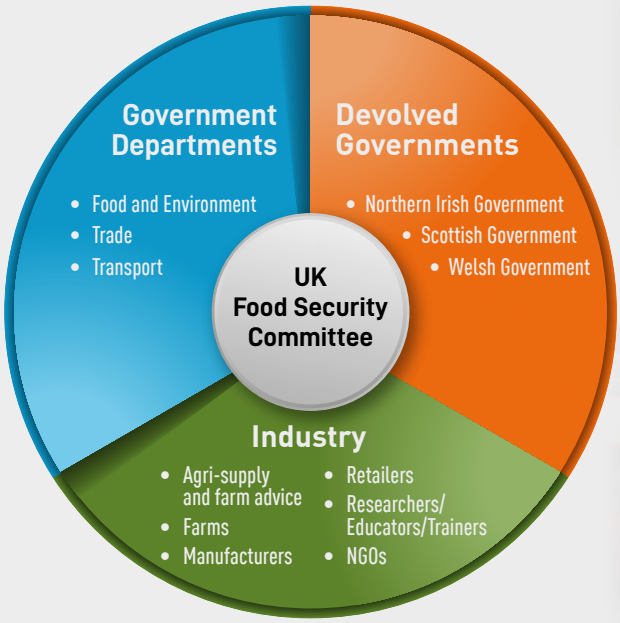
Promote interdisciplinary research to enhance the resilience, efficiency, and sustainability of production. Foster agricultural systems research that consolidates on-farm practices into transferable knowledge.

Training, Skills, and Advice

Develop training and education programs to equip the workforce with the skills needed for sustainable agricultural practices, including support for the proposed doctoral training centre for agricultural systems research.

Sustainability and Social Development

Support the development and adoption of sustainable practices in UK agriculture, encompassing social aspects.



1.1 Potential Output

In 2021 the agri-food sector in the United Kingdom accounted for a total estimated £127bn or 6.2% of the national economy (DEFRA, 2023d), an increase of 13% from £115bn since 2020 (DEFRA, 2022c). The sector employs just under 4.2 million people (1 in 8 jobs in the UK) and accounts for £254bn of consumer expenditure. Within this, agriculture contributes £7.6bn to the UK economy, with a total labour force on commercial holdings of 467,000 (DEFRA, 2022b). However, above all these statistics is the fundamental fact that the agri-food sector is essential to the health, functioning and livelihoods of the whole population of the UK. Food production in the UK is against a background of declining national health (NHS, 2022) with close links to social deprivation, and an increase in food poverty (Francis-Devine, et. al., 2023), which cost the UK economy £27bn a year including £6.1bn to the National Health Service (NHS).

The Members of AIC represent many key sectors within the agri-supply industry - Animal Feed, Crop Protection & Agronomy, Fertilisers, Grain & Oilseed, and Seed; contributing more than £14bn (IPO, 2016; DEFRA, 2023a; DEFRA, 2023b; DEFRA, 2023c; AIC, 2023) to the UK economy on top of the £127 billion within the agri-food sector. The activities of AIC's Membership is very much the foundations of the agri-food sector, supplying the inputs and expertise to drive the sector forward. The agricultural supply industry is responsible for supplying much of the intermediate consumption linked to agricultural production, valued at around £18.8bn in 2021 (DEFRA, 2022b).

1.1.1 Current Production

Agricultural production in the UK uses 17.2 million hectares, covering 71% of land in the UK (DEFRA, 2022b). While land use declined between 2021 and 2022 by just under 3%, production rose by 5% in the same period (DEFRA, 2022c), following the general trend since 2002. There has also been a small but steady decline in self-sufficiency down 3% for most crops, making the UK more reliant on imports from the EU (around 50% of all imports) and the rest of the world (DEFRA, 2022b).

Between 2021 and 2022; cereal crops area increased by 5.7% to 3.2 million hectares and oilseed crops decreased by 15% to 352,000 hectares. Over the same period, the total number of cattle and calves decreased by 0.1% to 9.6 million, beef and dairy herds remained largely unchanged at approximately 1.5 and 1.9 million animals respectively, total pig numbers increased by 5.3% to 5.3 million and sheep and lamb numbers increased by 0.8% to 33.0 million.

The value of harvested production in 2022 was: wheat £2.7bn, barley £1.2bn, oilseed rape £488m, sugar beet £216m, vegetable production £1.7bn, and fruit production £917m (DEFRA, 2022b). The value of production linked to animals was beef and veal £3.3bn, pig meat £1.4bn, mutton and lamb £1.5bn, poultry meat £2.9bn, milk and milk products £4.8bn, and eggs £818m.

In addition to food production, there is a growing amount of land devoted to bioenergy production (DEFRA 2021a). In 2021, 121,000 hectares of agricultural land in the UK were used to grow crops for bioenergy, just under 2.1% of the arable land in the UK. 30% of land used for bioenergy was for biofuel (biodiesel and bioethanol) in the UK road transport market with the remainder mostly used for heat and power production. In 2020, UK grown crops produced 293 million litres of biofuel for the UK road transport market and just under 7.2 million tonnes oil equivalent of plant biomass were used to produce electricity and heat in the UK.

1.1.2 Farm Expenditure and Profitability

There is tremendous variability in Farm Business Income (FBI) in the UK, 16% of UK farms failed to make a positive FBI in 2020/21, while 28% of farms have FBI of over £50,000, which is similar to pracademic data from 2018/19 (Defra 2020). UK total income from farming in 2021 was £5.9 billion, up £756 million (14%) from 2020. Costs increased in 2021, but these were outweighed by increases in total livestock and total crop outputs, resulting in the third highest total income from farming, in real terms, since 2000 (DEFRA, 2022b). However, the prices paid for farm produce meant that only the larger operations were likely to make a positive and significant FBI; highlighting the impacts of variability in output and prices of production and inputs on farm businesses. Variability is a key factor in the profitability of farming with tremendous variability based on the type of agricultural production (DEFRA, 2022b) as well as the size of operation.

Global market volatility caused by the coronavirus pandemic in 2020 and war in Eastern Europe in 2022 have caused increases in prices of many inputs. This may have influenced decisions on some inputs based on price.

Defra reported (DEFRA, 2022b & 2023d) that, against 2020 prices, the majority of costs increased in 2021 and 2022, particularly spending on animal feed, which increased by £2.5 billion (45%), and fertilisers, which increased by £1.6 billion (150%). Seed costs fell by £115 million over the same period, down 13%. This is seen as a returning to more typical levels following unusually high costs in 2020. Even considering the higher inflation in 2022 (5%) prices have risen rapidly over the last two years, outstripping volume of inputs.

The volume of all inputs has decreased by 0.3%. This small decrease is the result of a mixed pattern of increases and decreases in 2021 and 2022. The inputs that saw the largest percentage increases were plant protection products (6.3%), fertilisers (4.5%) and animal feed (3.3%). Whereas those with the largest percentage decreases were seeds (-12%), other goods and services (-5.6%) and total maintenance (-4.5%).

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1.1.3 Trends in Production

There have been gradual declines in the area of production of almost all crops since 2002 with an average decline of 3% *(Figure 1)*, a trend of decline of over 20% that extends back to the 1980s (DEFRA, 2022a). Cereal production has fallen below 100% of demand in recent years *(Figure 2)*. This is against a background of steadily rising value of cereals since 2000 and the dramatic increase of 46% in 2022 *(Figure 2)* due to the war in Ukraine and extreme weather events. One notable exception is bioenergy crops *(Figure 3)* where land area has almost doubled since 2010 to around 120,00ha (DEFRA, 2021a).

Figure 1: Cereal production per year by area, value and weight production between 1984 and 2022 (DEFRA, 2022a).

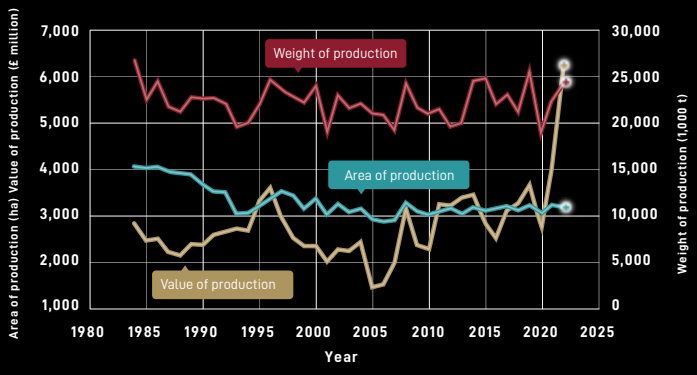


Figure 2: Cereals value per tonne of production and production as a % of demand between 1984 and 2022 (DEFRA, 2022a).

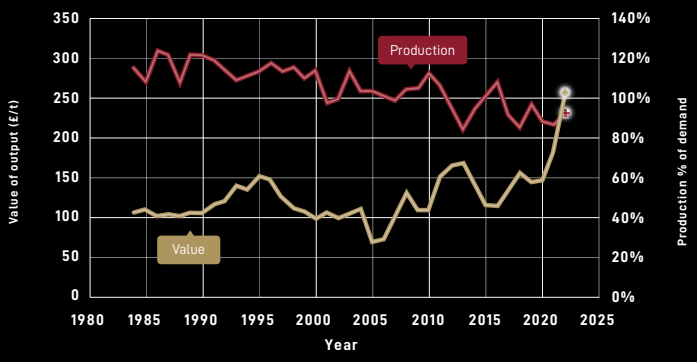
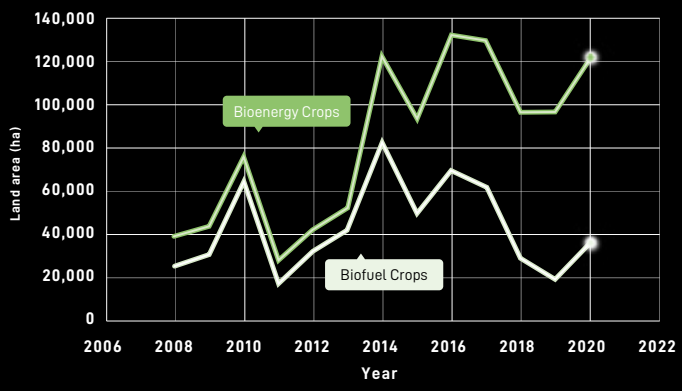
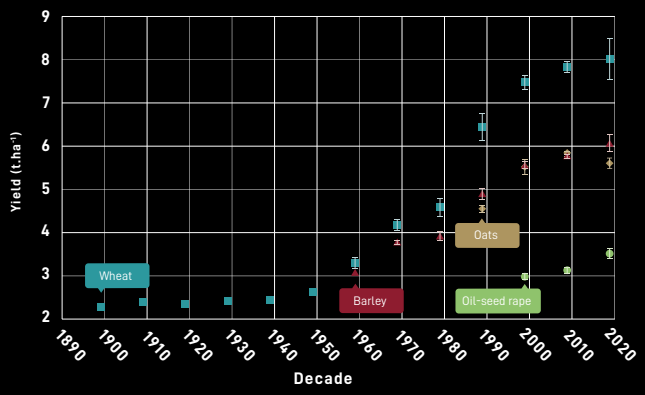


Figure 3: Land area used for bioenergy and biofuel crops 2008-2020 (DEFRA 2021a)



The reduction in land use has been buffered by the steady increase in productivity of crops since the 1940s, particularly in cereals *(Figure 4)*. The combination of innovations in crop breeding, crop nutrition and crop protection have brought about a fourfold increase in productivity during the eight decades of research and development. Each one of the areas of research would have brought about a significant increase in yield but it was the combination and implementation of all three, by farmers and their advisers, that brought about the dramatic increase particularly during the 1980s and 1990s.

Figure 4: Improvements by decade in average yield of wheat (blue squares), barley (red triangles), oats (biege diamonds) and oil-seed rape (green circles). Bars represent variance of means for each decade (data taken form DEFRA, 2022a).



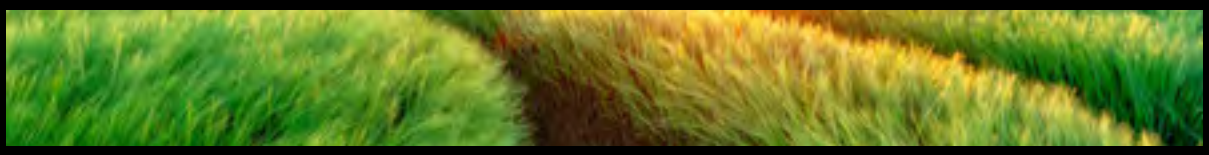
In the last decade, there has continued to be a smaller but steady yield increase but more noticeable is the greater variability in yield, particularly in wheat and barley *(Figure 4)*. This affects security of production (Section 1.2) and contributes to the uncertainty in markets with knock on effects in other areas of agriculture such as animal production, where cereals are still a major component of animal feeds (DEFRA, 2022a). As a result, the increase in cereal prices per tonne over the last two years has influenced animal feed prices *(Figure 5)* leading to significant rises in costs of production for arable farmers and feed producers *(Table 1, Figure 6)*. In pig production, feed is the single largest cost and so have a disproportionate effect on profitability *(Figure 6)*. Unlike poultry and cattle production, there has not been a proportionate rise in the value of pig meat putting pig production in a critical state.

This situation was further hindered by issues around labour and availability of processing facilities for pig meat that destabilised the supply chain in 2022. Labour shortages continue to be an issue post-Brexit and there are no indications that policy or legislation are going to be changed to address these issues.

Restrictions in recruitment through legislation stop businesses being agile and recruiting where necessary at short notice. In an environment where an industry such as agriculture is subject to dramatic changes in circumstance, agility is an essential part of viability. The risk is that as one part of the industry becomes under strain it will put strain on the whole food system – from inputs sold to farmers, to the food products sold to processors and ultimately through retail and food service to consumers.

This can destabilise the industry and cause sudden rises in inflation as was seen in 2022-23 or shortages in production to the extent that shelves are empty of produce, such as eggs, as was also seen in 2022.

Climate change and political instability in Eastern Europe have already shown the deficiency in resilience of the UK food supply chain. These problems go beyond just the logistics of getting food to people's tables, the connectivity within agricultural production, particularly between crop production and animal feeds, results in magnification of individual issues in production or the supply chain into wider supply problems affecting any number of products. The result is an insecure food supply chain, this is discussed in detail in section 1.2.



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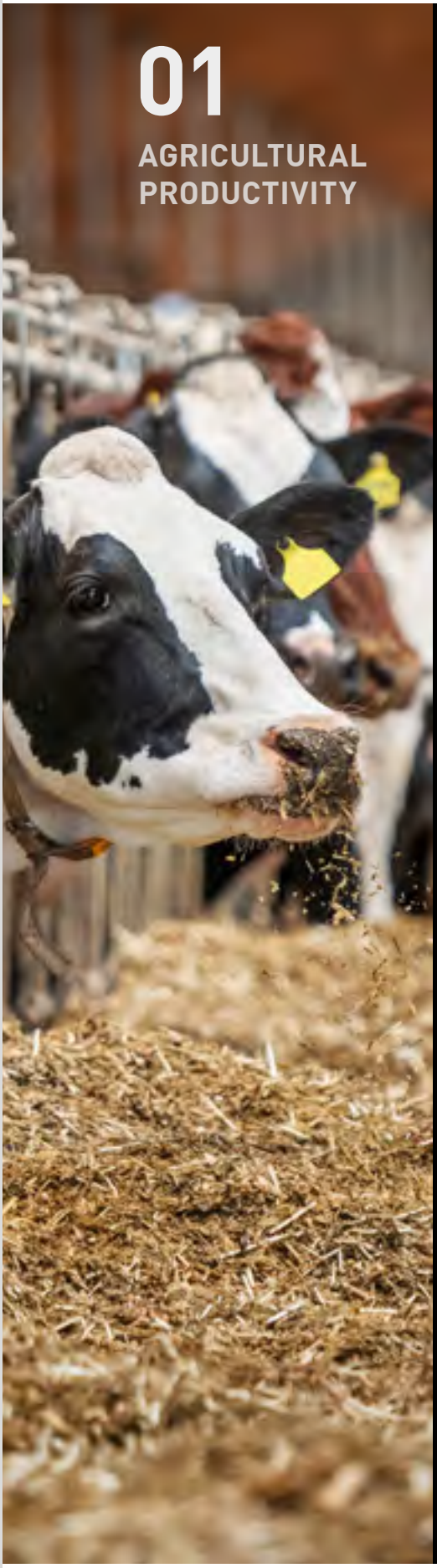
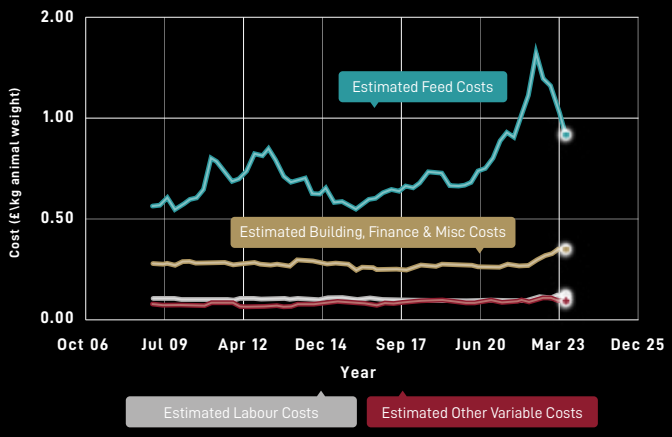


Figure 5: The cost of compound animal feeds (DEFRA 2023)

Table 1: Full economic cost of production by crop for Farmbench middle 50% (£/ha) (taken from AHDB, 2022)

Crop	2017	2018	2019	2020	2021	Five-year Average	2022 Estimate[1]	2023 Forecast[2]
Oats – Spring	913	903	891	874	907	897	1,050	**1,419**
Beans – Winter	868	917	943	951	958	927	1,052	**1,296**
Linseed – Mixed	867	916	952	1,005	973	942	1,082	**1,396**
Oats – Winter	930	967	965	1,005	1,017	977	1,189	**1,622**
Beans – Spring	907	968	1,042	996	1,018	986	1,184	**1,378**
Peas – Feed, Mixed	1,070	847	1,066	996	999	995	1,095	**1,358**
Barley – Winter	1,045	965	1,118	1,121	1,042	1,058	1,247	**1,712**
Wheat – Spring	990	1,070	1,046	1,121	1,133	1,072	1,321	**1,785**
Barley – Spring	1,041	1,098	1,083	1,108	1,083	1,083	1,268	**1,712**
Oilseed Rape – Winter	1,142	1,129	1,196	1,276	1,207	1,190	1,428	**1,968**
Wheat – Winter	1,231	1,287	1,308	1,287	1,256	1,274	1,484	**2,049**

Figure 6: Cost of production indoor pigs UK (AHDB, 2023)



Meat production has steadily increased since the 1990s due to an increase in poultry production, with production of other meats remaining relatively constant. The value of production has risen since 2000, with all products, in particular, poultry and beef gaining in value.

Figure 7: Weight of UK meat production 1985-2022 (DEFRA, 2022a)

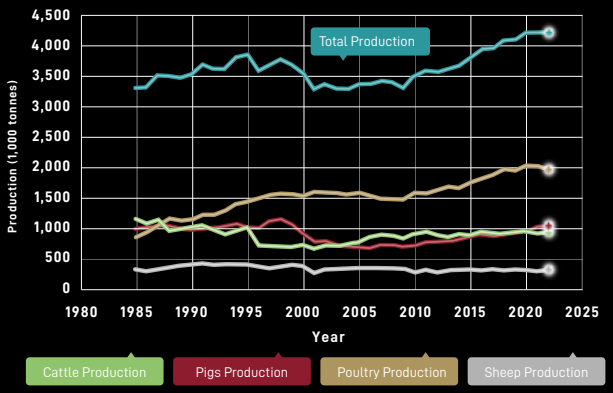
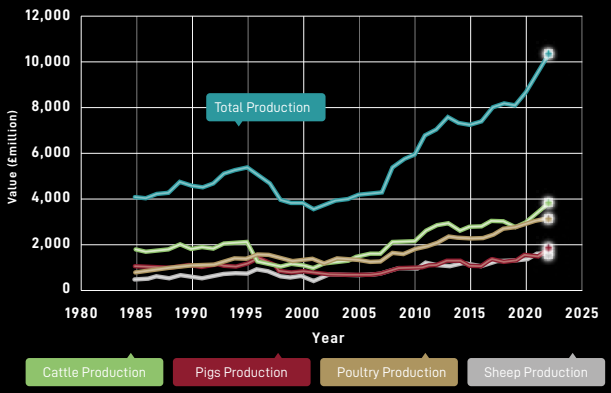


Figure 8: Value of UK meat production 1985-2022 (DEFRA, 2022a)



Since the 1960s, improvements in nutritional science have boosted the performance of livestock, dairy and egg production and animal nutrition continues to be an important part of the research and innovation of the industry. The desire to further improve productivity and the demand for reduced emissions from farmed livestock was the motivation behind AIC setting up the Feed Adviser Register in 2013. The agri-supply industry is a major driving force in the sustainability of animal production.

Figure 9: Improvements in livestock productivity over the past 40–50 years (Taken from Hume et al. 2011).

		Indicative Performance		
Species	**Trait**	**1960s**	**2005**	**% Increase**
Pig	Pigs weaned/sow/year	14	21	**50**
	Proportion of lean meat	0.40	0.55	**37**
	Feed conversion ratio (FCR)	3.0	2.2	**27**
	kg lean meat/tonne feed	85	170	**100**
Broiler chicken	Days until 2 kg are reached	100	40	**60**
	Feed conversion ratio (FCR)	3.0	1.7	**43**
Layer hen	Eggs per year	230	300	**30**
	Eggs/tonne feed	5,000	9,000	**80**
Dairy cow	kg milk/cow/ lactation	6,000	10,000	**67**

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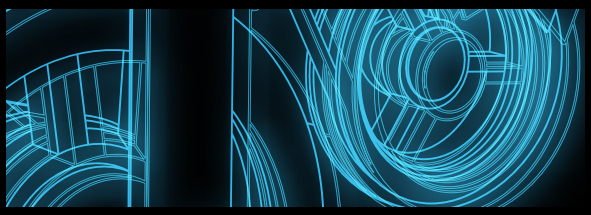
1.2 Security of Output

The diversification of land use relatively recently away from food towards bioenergy production (accounting for 1.8% of arable land in 2020), means that security of output from land also now includes fuel. It also adds an extra pressure on food production and a potential conflict between food security and energy security (DEFRA, 2021a). Food production is still the predominant use and food security the most impactful consequence of land use and output.

Food security is the balance between certainty and risk within the processes whereby food makes its way from the place of production to people's plates (DEFRA, 2021). The processes are a complex mix of social, economic and environmental activities, events and outcomes that control all aspects of the production, transport, trading, processing and consumption of food (FAO, 2023).



The UK government has identified five themes of food security (DEFRA, 2021) to evaluate and rationalise the complexity:

- **Global Food Availability.**
- **UK Food Supply Sources.**
- **Supply Chain Resilience.**
- **Food Security at Household Level.**
- **Food Safety and Consumer Confidence.**

The themes reflect UK food production, the reliance of the UK on food imports (46% imported, DEFRA, 2021); nearly 83% of the population that live in urban areas (GOS, 2021); financial pressures that many households are under (Hourston, 2022) and pressures on the nation's health from diet related issues (BMA, 2018).

The UK government recognises the importance of food security and now has a regular review of the state of the national food production and supply chain (Malik. 2022). Food security is closely linked to sustainability and is seen as one of the primary indicators of local, national and global sustainability (FAO, 2023). Food production relies heavily on climate and the weather, but also heavily on labour to produce and harvest crops but also for the care and welfare of animals. Food is an important part of livelihoods and wellbeing of all people and has a significant impact on health and economics if prices suddenly rise (Robinson, 2022). Price rises also affect the cost of inputs which can then impact production. Food prices and affordability are a good barometer of the state of a nation's economy and development (WBCSD, 2022).

Security of production both within the UK and in other countries exporting to the UK is a key component of overall security. The interconnectivity between homegrown food and imports from other countries is of the greatest importance. The UK currently imports around 46% of the food it requires (DEFRA, 2022a), this means that nearly half of the UK food security strategy must consider activities and events in other countries, most significantly

the EU, which supplies 23% of food imports to the UK. Despite the severing of political ties with the EU following Brexit the UK is still heavily reliant on imports from the EU and is impacted when climate and political events interrupt supply chains. This was seen in winter 2022-23 when adverse weather conditions and energy prices, reduced availability of fresh vegetables from Southern Europe and the Netherlands. If the UK is to become more resilient there is a need to re-evaluate the supply of food from overseas and to see it in the light of long-term security and not just pricing and current availability.

1.3 Sustainability

1.3.1 Sustainability and Food Security

The United Nations defined Sustainable Development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It calls for concerted efforts towards building an inclusive, sustainable and resilient future for people and planet (UN, 2023).

A significant part of sustainable development is focused on food and agriculture. As part of its mission to mainstream these aspects into national development strategies, the UN has developed an approach to support and accelerate the transition to more sustainable food and agriculture systems (FAO, 2018). The approach is based on five principles that balance the social, economic and environmental dimensions of sustainability, and provides a basis for developing adapted policies, strategies, regulations and incentives:

1. Increase productivity, employment and value addition in food systems.
2. Protect and enhance natural resources.
3. Improve livelihoods and foster inclusive economic growth.
4. Enhance the resilience of people, communities and ecosystems.
5. Adapt governance to new challenges.

AIC (AIC, 2020) has put forward a set of sustainable objectives for the industry for more sustainable ways of producing and managing farm inputs, more efficient distribution, and innovative new ways to farm more productively whilst protecting and building the UK's natural resources. The objectives are in line with the UN/FAO principles initially focusing on eight areas where it is looking to support and stimulate a sustainable food chain *(See Appendices)*. AIC has developed a Roadmap to review practices over the next 30 years to understand what is needed to ensure a fit-for-purpose business sector for future production (AIC, 2020).

Moving forward and guided by its Membership, AIC will add to these areas to include other aspects highlighted by the UN including social and societal aspects of sustainability within agri-supply businesses and the wider supply chain. In particular, the challenges of an aging population within the industry as a whole and the challenge of integrating new technology requires a significantly upskilled and educated workforce. With the skills gaps that already exist across all business sectors within the UK with regards to data science and technology, there will be a significant risk of impact to productivity and food security if the government and industry are not proactive in ensuring these skills are adopted into the workforce. Worldwide, the industry has significant challenges ahead highlighted by the FAO (FAO, 2018) 21 actions *(See Appendices)*.

While some of these actions are more directly impactful than others on sustainability in the UK, the connectivity of agricultural production throughout the world results in all these actions having a significant effect on UK food security. The less the UK relies on homegrown production, the more it will be susceptible to the inactions of overseas governments on these action points. This will lead to insecurity elsewhere that will impact the UK in terms of imports but will also drive economic migration that will ultimately also impact the UK and put further pressure on food security.

01
AGRICULTURAL PRODUCTIVITY

1.3.2 Sustainability, Climate Change and the Environment

Since the 1980s, the UK has steadily increased policy and legislation to mitigate climate change. A large part of this is the incentivisation and direction of businesses including agriculture and the agri-food sector to decarbonise and reduce greenhouse gas (GHG) emissions. Alongside the climate change policies, a number of other pieces of environmental policy and legislation have looked to improve the quality of soil, water and air, and reverse the decline in biodiversity. These policies have also impacted AIC Member industries, agriculture and food production.

Climate change and environmental policies have brought about a number of changes in agricultural production (DEFRA, 2022a). Since the late 1990s nitrogen and phosphate application rates have fallen. A comparison of soil nutrient balances (in kg per hectare) from the year 2000 to 2020 shows a 17% decrease for nitrogen and a 27% decrease for phosphate. While productivity has been maintained over the same period (DEFRA, 2022a) and fertiliser use has reduced (DEFRA, 2022d), It is uncertain whether the reductions in available nutrients are also part of the general decline in soil organic matter (which also supplies Nitrogen and Phosphorus) (Rusco, et al., 2021; Hawkins et al, 2022). Therefore, it is uncertain if these results show positive or negative impacts on the environment.

Estimated greenhouse gas and air pollution emissions from agriculture have fallen between the year 2000 and 2020 (the most recent data available): Nitrous oxide emissions have decreased by 16%; Methane emissions have decreased by 12%; Ammonia emissions have decreased by 10%.

Not all the changes to agriculture have been positive, with farmland bird numbers coming under increasing pressure since the 1970s (DEFRA, 2020).

The animal and dairy industries have made a significant contribution to reduction of GHG emissions with major reduction in methane and nitrous oxide *(Table 2)*.

Table 2: % Change in greenhouse gas emissions, ammonia and global warming potential achieved through genetic improvement (1988–2007) (Taken from Hume et al. 2011).

Species	CH_4	NH_3	N_2O	GWP_{100}
Chickens – Layers	-30	-36	-29	-25
Chickens – Broilers	-20	10	-23	-23
Pigs	-17	-18	-14	-15
Cattle – Dairy	-25	-17	-30	-16
Cattle – Beef	0	0	0	0
Sheep	-1	0	0	-1

Environmental policy and general industry awareness has also increased the use of organic and regenerative practices (DEFRA, 2022). The area of land farmed organically increased by 3.6% in 2022 to 507,000 hectares and the area in-conversion increased by 34% to 42 thousand hectares. There are 5,700 organic farmers and growers in the United Kingdom with 61% in England, 21% in Scotland, 16% in Wales 16% and 2% in Northern Ireland. Over 60% of organic production involves permanent pasture for animal production, and the majority of regenerative farms involved livestock as part of the rotation. This indicates the strong link between regenerative production and livestock. Regenerative systems are also part of an integrated approach to pest management within farming. The promotion of integrated pest management (IPM) by DEFRA, SEPA, the NFU and SNFU, AHDB, the Voluntary Initiative, water companies and others are part of action plans across all the devolved governments. They demonstrate not only a commitment to climate change by government and the industry but also to broader environmental policies such as water quality and biodiversity.

02 POLICY: FARMING, FOOD & ENVIRONMENT

2.1 Overview of Policy Connected to Agricultural Production

The connections between agriculture and land use, food production, environmental quality, energy production and use, health and safety, transport and labour; results in it being influenced or directly impacted by a whole range of policies coming from government, industry, non-governmental organisations (NGOs) and charities. Often these policies can overlap and work antagonistically to create difficult and sometimes impossible issues within agricultural businesses, can ultimately impact food production and other agricultural products.

Although the UK has left the EU, the close trade ties between the two means that EU legislation still has an impact on UK trade and agricultural policy.

2.1.1 Government Policy

There is currently a wealth of government policy and legislation covering land use and which have been devolved to the four home nations. Farming, food, the environment and planning, have considerable overlap between them and each devolved government has their own slightly different versions of policy and legislation in addition to UK central government policy. Although the UK has left the EU, the close trade ties between the two means that EU legislation still has an impact on UK trade and agricultural policy. The policy areas set out by the devolved legislations that have impact include:

- **Food Strategies**, that cover the security, quality, manufacture, affordability and distribution of food and the impact of diet on obesity and dietary related diseases (such as Type 2 diabetes).
- **Farming and Countryside Programmes**, which include aspects of farm payments, funding of land management and funding farm innovation, diversification, next generation support, and sustainability.
- **Environmental Improvement Plans**, which include farming activities, and which broadly follow the 10 goals within the UK Government 25 Year Environment Plan (25YEP).
- **The National Planning Policy Frameworks**, which set out the legislative control for all planning including some agricultural and food production activities, the impact on the natural environment and mitigation of impacts.

In addition to the devolved powers, there are areas of central government and EU policy that impact agriculture and food production. The most contentious is immigration. The UK still requires large numbers of migrant workers to help with agriculture and food production, since the UK left the EU most migrant workers require a visa to work in the UK. Visas cost from just over £250 for a seasonal worker and from just under £2,000 for a longer-term visa. This puts additional costs onto employing agricultural workers as well as the time taken to complete the paperwork.

Perhaps the biggest impact of UK policy is the fact that many aspects of UK agricultural policy have yet to be decided or have been substantially delayed. Since the transition period for exiting the EU finished on the 31 December 2020; the Scottish Agricultural Bill was laid before parliament on 28 September, the Northern Irish Assembly is still suspended and the Sustainable Farming Incentive (SFI) in England only started accepting application from the 18 September 2023 and the Welsh Agriculture Bill was approved by the Senedd on the 27 June 2023. While it was widely accepted that the focus of all the legislation would or will be on farming and the environment, much of the detail has not been clearly defined. This has left farming in the wilderness without a long-term plan for nearly three years, and in the case of Scotland and Northern Ireland is a continuing story (at the time of writing).

None of the planned or ratified agricultural policies are food centric, instead focusing on farming, land management, environmental impact and the countryside - this risks making them antagonistic to food security and dietary-health policies. The danger is that the agricultural systems that arise as a result of policy will gravitate towards a small number of low environmental impact crops that will severely restrict food security and further reduce diversity in the UK diet.

The sustainability of farming is also a consideration in modern production with a focus on IPM and GHG emissions in response to government policies and targets. Soil management has become a focal point for debate around these two areas, with the impact of soil health on IPM and GHG emissions a particular point of discussion. The discussions on what soil health is and the benefits to sustainability are continuing (DEFRA, 2023f), and all the devolved governments recognise the need for more research.

The data needed to evaluate the impact of crop production on greenhouse gas emissions and wider sustainability across whole farm systems is also incomplete (CHAP, 2022). The damage that excessing tillage can do to soil stability and structure are well documented (Carter, 2005). However, the effects of individual operations of ploughing against minimum or no tillage on short term greenhouse gas release are less certain (Alskaf et al, 2021).

The debates around sustainability of tillage, soil health and GHG emissions, tends to be biased towards cereals and other crops that fit well with a min. till or no till approach. This puts root vegetable crops (that require substantial tillage, in comparison) at a disadvantage, from this point of view. Root crops are also irrigated in many parts of the UK and so from a wider sustainability (water use) there is further scrutiny being put on their production. However, there is an acknowledgement (CHAP, 2022) that the scientific understanding of the impact of horticultural production is far less than that for cereals. The danger is that the lack of understanding will direct production towards what are seen as the more sustainable crops such as cereals, purely because there is more knowledge of how to produce them sustainably. This could influence the diversity of production and have and impact on food security by making the UK more reliant on outside production for horticultural produce.

02

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2.1.2 Policy Outside of Government

In addition to government regulation, the most influential policies come from retail organisations and major food brands. They are having a greater influence on farming practices through their adoption of certification schemes. Many of their policies are a response to consumer opinions and demands, but also those of major pressure groups, NGOs and charities.

The drive by local authorities to meet net zero targets is influencing planning decisions, farm tenancies and land management; all of which are impacting farming and food production. Biodiversity net gain initiatives to counter the impacts of building development can under certain circumstances use agricultural land to increases carbon capture through, for example, woodland schemes. Bioenergy projects can also be used to reduce carbon emissions whilst planting non-food crops. If these schemes become significant, they can fragment food production systems driving farmers further away from their location to rent land.

2.2 Agricultural and Environmental Land Management

Although Environmental Land Management (ELM) and schemes associated with it is a term used with English agricultural policy, there are elements in common with the Agri-Environment Climate Scheme (AECS) in Scotland, the Sustainable Farming Scheme (SFS) in Wales and the Environmental Farming Scheme (EFS) in Northern Ireland. To a varying degree, farmers are guided through a labyrinth of options available to them to improve farming sustainability by improving land management (See Appendices).

Some of the schemes are still under development and it is hard to draw conclusions as to how much commonality there will be between the different schemes, but it is already clear that the Welsh Government is leading the way in providing targeted support to farmers beyond just financial support. The Farming Connect initiative (https://businesswales.gov.wales/farmingconnect) provides a range of training, business support, working groups, projects, research and innovation that farmers from all sectors can take advantage of. This not only drives forward the changes towards more sustainable farming but also looks to ensure there is value for money for the Welsh economy from any funding directed toward sustainability.

It is worth remembering that when New Zealand removed its subsidies to farmers in the mid 1980's it also almost doubled its research budget to support transitions and gain understanding of what needed to be done and halved its currency value to boost export opportunity (Johnson, 2001).

While the UK devolved governments have invested in innovation to meet specific needs and pinch points in production, they have not invested in the systems-based research. This is needed to gain the transferable knowledge that can help understanding of how the environment can work with agriculture to sustain both the environmental desires while maintaining and possibly enhancing food production. In New Zealand, it was this understanding of transferable knowledge that ultimately improved and boosted agricultural productivity (Johnson, 2001, Vangelis, 2007).

On the one hand development of policy has been slow, but the speed of implementation of some legislation has been raised as a concern by some stakeholders. While there is an acceptance that there is a need for dramatic change to meet the requirements to mitigate climate change, the rate of change is seen as counterproductive. Most farmers plan on at least a five-year cycle and so a policy introduced partway through plans can have a disproportionate effect of productivity. The farming sector also relies heavily on contracts, and many businesses find it hard to invest in new equipment, particularly that associated with inputs, when the regulations on their use or their cost can change dramatically at short notice. This also raises the question of sustainability and security of production as well as the food they help to produce.

2.3 Food Policy

As with agricultural policy, food strategies are devolved to the individual parliaments and assemblies of the UK. The policy in England revolves around UK Food Security and addresses health and social issues within this context. The Welsh government presented the Food (Wales) Bill to the Senedd in 2022 and is currently going through Stage 1 revision, a central part of the bill is the setting up of a Food Commission that will oversee and evaluate performance. Good Food Nation policy in Scotland dates back to 2014 and resulted in the Good Food Nation (Scotland) Act 2022 and so is the most progressive of all the parliamentary legislation. Northern Ireland released Food at the Heart of our Society - A Prospectus for Change Public Consultation Document in 2021 but has stalled under the suspension of the national assembly.

The Welsh and Scottish policies put far more emphasis on quality of production and diet than other strategies. In particular, they value local production and local supply chains, with a commitment to investing in and promoting local food supply from farm production through to the consumer.

The Government recognises the need to tackle obesity and Type 2 diabetes through a food strategy but doesn't recognise that by benchmarking security of production against a poorly balanced diet, it will perpetuate an increase in dietary problems. Instead, Government needs to set out what production should look like to encourage better diet and then benchmark against those standards. This goes all the way back to agricultural policy.

There needs to be a good understanding of what raw materials farming should be producing to ensure good diet and make sure that the required diversity of production is secure. Not all food ingredients can be grown in the UK at present or in amounts that might be considered secure. There needs to be policy that promotes investigation of feasibility of whether the UK can supply those raw materials in the future and what that might do to food security and diet in the UK.

Food security is also about making sure the practices and knowledge are in place to combat sudden impacts to the supply chain from climate change and political instability. At present, government investment is skewed towards innovation around new concepts and ideas that might revolutionise parts of the supply chain. The industry also needs to investigate systems approaches. A farming system is the result of complex interactions among many inter-dependent components, involving land, environment, labour, capital and management (Behera and France, 2023). Farming systems research involves a multidisciplinary whole-farm approach and is effective in solving the complex problems associated with sustainable production.

At present, while productivity within agriculture continues to rise, the variability of production is also increasing, and prices paid for goods are also fluctuating. This creates uncertainty and insecurity in the marketplace. Many of the technologies and data solutions that might improve security by countering the variability in production are available, however, farmers and professional farm advisers are finding it increasingly difficult to integrate data and technology solutions into farming systems. The skills to do so are lacking in the workforce and there is also competition for the same skills in other industries, such as life sciences and engineering.

Access to finance for what are, in many cases, seen as high-risk investments in untested technology is also a potential barrier not only to technology adoption but also to the organic expansion of tech companies that become more reliant on venture capital.

Education and training is the solution to these problems. However, there is a large disconnect between government funding for training and education, the agricultural industries, current practitioners in the supply chain and the younger generation that needs to be encouraged into the sector. To do this there needs to be a range of initiatives at all levels of education.

The starting point must be with younger people, with initiatives that explain the importance of farming and food within schools. The Sustainable Food Places initiative (https://www.sustainablefoodplaces.org/) is a collection of local initiatives across the UK to promote the value of food, particularly that produced locally, and a better diet. They have good engagement with schools and include farming within their delivery but could be better supported from industry to get the messages across.

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The Agricultural Universities Council (AUC) is proposing the setting up of Doctoral Training Centre produce the next generation of academics in farming systems. To break the cycle of disconnect, there needs to be the involvement and support of farming and AIC's Membership in this initiative. The AUC are also reviewing current undergraduate education and training and working with FE colleges to ensure better routes of progression.

Continuing professional development (CPD) is an integral part of the training of many professional aspects of the agri-food supply chain (for example agronomists and feed advisers) but much of this needs to be updated to include advances in technology and innovation. This is something recognised by professional bodies such as BASIS and farming standards organisations such as Linking Environment And Farming (LEAF) but needs to be supported by academics. Farming on the other hand is less well supported with CPD and this needs to be improved if farmers are to adopt technology and become innovative. The Farming Connect program in Wales (Section 2.2) shows how this might be achieved.

This also leads into the very real problem of an ageing workforce in the industry. The average age of a farmer in the UK is currently 59 with a third over 65. Only 3% are aged 35 or below (DEFRA, 2022). This, combined with the current restrictions on farm labour from overseas are drastically affecting the security of the farm labour force. In particular, the fruit and vegetable sectors that have traditionally been labour-intensive systems have suffered with pressures on resources. The population of the UK is aging, and this may be partly linked to the lack of data and technology skills in the workforce.

The UK Census in 2021, reported that 42% of farmers were 60 or older. The Lonon School of Economics (Bozek, et al, 2022) reported that there were many barriers to older people taking on digital technology. Some of these were physical limitations brough on by ageing as well as a lack of background training and CPD for those who had not had IT and other skills as part of their early education.

2.4 Environmental Policy and Planning

There is a growing recognition of the role of biodiversity and natural capital in farming and the impact of farming on them. The primary outcome of the combined legislation is an advisory environment with a trend towards the introduction of biodiversity and natural capital on more agricultural land which leads to it being taken out of production and put into less productive habitats. Advisory services are coming from either a background of agricultural production or environmental sustainability. While there is good communication between the two sectors, they need better support from the science to understand the complexity of incorporating biodiversity and sustainability into farming systems and further developed CPD for advisers. It is not clear what the overall impact is of this advice and policy but there are some case studies that indicate some change in this direction.

Role of natural capital in managing soil and water.

Impacts on air, and water quality.

Tree planting schemes as part of farm woodland schemes are easily implemented through grants for which planting can be verified and accounted for. Woodland planting is also funded by other agencies and organisations outside of DEFRA, and the Forestry Commission. Outside Defra the Woodland Trust, local government, and other organisations, also fund tree planting initiatives. The carbon sequestration of trees and relatively long-term lockup of carbon in the wood has also led to many other initiatives around woodland planting

and carbon credit schemes. Many Biodiversity Net Gain schemes, as part of local authority planning decisions also look at woodland planted on farmland to quickly get biodiversity established and carbon locked up. Other decarbonisation projects use farmland for biomass crops for energy generation, taking more land out of food production.

As part of sense checking and evidence building for this report, a number of stakeholder engagement events and interviews were undertaken. Overwhelmingly, the most common area of interest, desire to be involved but also concerns were around how best to integrate biodiversity into farming. Fragmentation of land available for farming was a concern amongst some farmers with land being taken over for woodland or biomass production and leaving less for food production. This can restrict farm tenancies and force farmers to look further afield for agricultural land. Which can impact transport and other production costs. While there is no qualitive data on how widespread these occurrences are, it does illustrate how environmental and farming policies need to be considered wholistically and not in isolation.

Changes in policy and land use will have significant impacts on the agricultural industry. The area of production will be reduced but the extent of this is unclear. With a reduced land area, it is likely the production will centre on the more profitable crops. These tend to be the same crops that can be grown with less tillage and without irrigation such as cereal and oilseed crops. Whether this will be at the expense of other crops is uncertain but would be an added pressure on horticultural production and diversity in the crops grown in the UK.

3.1 Drivers for Change

The agricultural industry is going through a tremendous period of change worldwide in response to a number of drivers. Within the UK these largely centre around the workforce, government policies as described earlier and, in particular, the focus on decarbonisation of farming and agricultural production, plus the need to maintain agricultural productivity and security in production. Weather patterns, market volatility and shifts in consumers' dietary preferences all factor too.

As well as driving change, UK policy must also support changes being driven by other factors through incentives, support and mitigation. It is essential that farming in the future is sustainable, and the agri-supply industry has shown a high level of commitment to sustainable farming. AIC and its Membership recognise that sustainability covers all aspects of the supply chain. AIC's work encompasses three guiding pillars - Productivity, Environment and Competitiveness - delivering for sustainability and contributing to the circular economy. AIC and the agri-supply industry is committed to promoting advances in social, economic and environmental aspects of productivity.

Policy and legislation needs to be able to balance all three aspects of farming and agriculture, otherwise it will become unstable and insecure. A key test of this is whether current and planned policies can be translated into practice that maintains sustainable production. Diversification and Innovation are seen as key elements to a sustainable future but again diversification must be for a positive change and innovation must support a sustainable business sector and ultimately security in production. A key element missing from the policies of all the UK government's is support for training and education that addresses the inevitable changes in agricultural production systems as they address the new skills required to meet environmental challenges and the need to integrate data and technology solutions.

3.2 Translation of Policy into Practice

The UK food strategies broadly have objectives to: decarbonise production, make production secure within the UK, maintain employment in the food industry, ensure affordability of food and improve diet. External pressures caused by climate change, fuel prices, and global political challenges have intensified the need to stabilise food security by producing food within the UK. Producing locally for local consumption can have significant impact on all government priorities (House of Commons, 2022).

All the UK devolved governments are committed to promote innovation and diversification of farming.

In England, DEFRA has initiated the Farming Investment Fund (FIF), which provides grants to improve productivity and deliver environmental benefits. Similar initiatives are available across Scotland, Wales and Northern Ireland. The FIF has had the following programs so far:

- **Farming Equipment and Technology Fund (FETF) 2023.**
- **Farming Transformation Fund (FTF).**
- **Water Management Grant Round 2.**
- **Slurry Infrastructure grant.**
- **Adding Value grant.**
- **Improving Farm Productivity grant.**
- **Calf housing for health and welfare grant.**

In addition, DEFRA launched the Future Farming Resilience Fund (FFRF) to stimulate diversification however the delivery is from within the existing network of farm advisory services and does not look outside to see how other industries might have lessons to learn from.

The governments of Scotland, Wales and Northern Ireland have taken the decision to keep the existing Basic Payments Scheme until 2025, while changes are put out to consultation. Giving greater certainty to planning and budgeting in the short term while farmers and the wider sector come to terms with the implications of proposed changes to funding.

The Welsh Government has taken a proactive response, by linking the Rural Payments Wales (RPW) to farmers through the farm advisory service Farming Connect. This not only helps farmers formulate grant applications but also provides training and mentorship for improving systems and technology integration. While this integrated approach gives farmers in Wales the kind of support they will need, it is backed up by only limited research into systems approaches and technology integration, meaning this help is ultimately limited by its lack of knowledge.

A transition to sustainable farming systems that includes biodiversity and addresses issues such as GHG emissions requires a complete shift in the way farming operations are designed and evaluated. This requires a knowledge of how inputs, the environment, and management come together to create yield while ensuring the environment and people are not impacted. This is all against the background of the economics of production to make sure operations are financially viable. This becomes a systems-based approach to production and scientific investigations that considers the chemical, biology, physical, economic, and social aspects simultaneously. Traditionally, scientific investigation, training and delivery of services have been somewhat siloed towards areas of expertise or product sector such as the divisions between crop breeding, crop nutrition, irrigation, and pest control. When it comes to the need for a systems approach this means there is a substantial knowledge gap in how to integrate separate areas of knowledge.

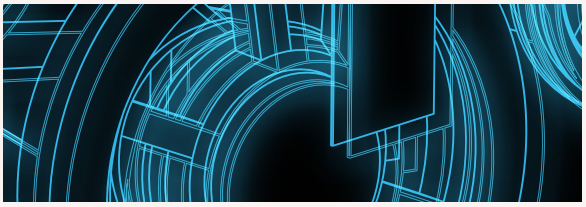
While there has been a desire for BASIS and other organisations to address this siloed approach within CPD for advisers, the qualifications are still targeted to individual areas of production and there is a shortage of academics to teach systems-based approaches. The colleges and universities that offer formal qualifications and CPD also struggle to find academics who have a background in systems based agricultural research, which perpetuate the knowledge and skills gap in areas needed to meet the challenges of integrating farming and the environment. ▶▶▶

03

FARMING SUSTAINABILITY DIVERSIFICATION AND INNOVATION

The gaps in knowledge are focusing farmers and advisers towards areas where there is a strong knowledge foundation such as cereals production, where there has been almost exponential growth in research and publications since the 1980s (Giraldo et al, 2019). The growing perception that cereals are less damaging from a sustainability perspective coupled with higher prices fuelled by the conflict in Ukraine, is further focusing production on a narrow group of crop as indicted at the end of Section 2. Grant aid needs to redress the balance to ensure a diverse range of crops are grown but research needs better connectivity to the end users in the farming industry.

While grant aid can initiate change, to get sustained improvement there needs to be incentives from UK Government for business to invest inwardly. This can be around skills and labour to take full advantage of schemes longer term and avoiding them being discarded once the grant aid is removed. The biggest changes in agriculture have come about when industry is convinced to invest in a scientific discovery; such as the adoption of crop nutrition by chemical companies following the work of Carl Sprengel and Justus von Liebig in the late 1800s or the adoption satellite guidance and autosteer systems by the major tractor manufacturers following the introduction of retro fitted systems by Leica and Trimble in the early 2000's.



3.3 Investment Incentives

The Farming Innovation Pathways (FIP) competition (in England) is typical of the kind of support through Innovate UK. Grant funding is available to:

> "Develop and support a productive, resilient, and sustainable agricultural sector. Novel solutions are needed to produce healthy food for consumption, where farms can be profitable and economically sustainable without subsidy".

While these programs are likely to boost productivity and competitiveness within defined processes on farms and are targeted towards positive environmental and welfare outcomes there is less evidence that they will lead to better business security, food security or levels of production. As was shown by the dramatic increase in cereal yields from the 1980s onwards, it is when many innovations come together to create systems improvements that the significant changes come about.

Most of the innovation that links environmental practices to farming and food production are being led by farmers themselves rather than scientific, academic or commercial bodies. Farming practices such as regenerative systems and precision input systems are being driven by an adoption of methodologies on farms in a theorise, implement, measure and reflect approach; also known as Action Research or a Reflective Approach and is a more systematic version of trial and error. While this can lead to substantive change and increase sustainability at the individual farm level, it creates case studies that are good proofs of concept but do not have the systems-based knowledge highlighted in section 3.2 that makes the knowledge transferable from one system to another. This makes it easier to transfer ideas and harder to transfer knowledge between farms since the changes create case studies unique to the farm they come from. They also divorce farmers from researchers, which makes it harder to investigate and implement new technology or understanding into systems. There needs to be an understanding of how changes to systems affect the resilience of production and the quality of crops, livestock and products.

Systems changes need to be investigated with systems research that takes into account the controlling variables. In this way scientists can work with farmers to understand how the changes made in production bring about the outcomes observed. Many scientists have become isolated from agronomists and professional farm advisers and farmers; as investment is increased in fundamental aspects of sciences such as genetics, biochemistry, and physiology and less in farming systems and productivity in the field. This has resulted in farmers and professional farm advisers conducting research as case studies and scientists pursuing research that has limited impact on agriculture unless made relevant to farms.

Fundamental science is important and should continue to be supported but support for translation sciences such as agronomy, feed efficiency, environmental science and geography that take fundamentals and integrate them into systems need to be vastly increased. Otherwise, the opportunities from fundamental innovation and research will be missed and even lost from UK agriculture.

3.4 Impact of Innovation

3.4.1 Innovation as a Tool for Sustainable Production

The long-term experiments at Rothamsted and elsewhere have clearly demonstrated that optimised productivity is the culmination of a number of innovations not just one and without the linkage between innovations in breeding, nutrition, pest control, land management and systems; then innovation in any one part will have a minimal effect on food security and productivity.

The Centre for Innovation Excellence in Livestock (CIEL), one of the initial innovation centres, created the Open Innovation Groups that brought together CIEL, academics and industry to look at key themes and priority areas for collective action to help down the carbon footprint of livestock farming. Following the merger of the Agri-tech Centres (with the exception of Agrimetrics) (UKRI,2023), there is the opportunity to widen this approach beyond livestock production.

The concept of Innovation being an amalgamation of technologies is not a new one but emphasises the need to use multiple approaches to address the complexity in agricultural production. This is part of agricultural systems research (Behera and France, 2023). In turn it is the degree of complexity in production that drives the need for innovation but also gives security to the markets that the agri-supply industry uses to provide inputs, advice and services to farmers and growers. The lack of agricultural systems research and the opportunities around agri-supply business products and services has stimulated much of the research and trials carried out by companies. But is limited to the expertise within them with some outside engagement in specialist areas.

The complexity involved in systems research requires input from multiple specialists working in a consortium. Innovate UK funding has tried to stimulate this kind of approach but there is still poor engagement between industry and the limited number of academics that work in systems research. Instead, industry still relies on internal business expertise to understand systems and only engaging with academics for fundamental science solutions.

More and more, companies are no longer merely merchanting a product but are providing or selling advice and decision support as part of the overall product package. This diversifies their businesses to some extent, which can make them more resilient but also reduces the dependency on volume of product sold as the sole source of revenue. This avoids any direct conflict with government policy or legislation that looks to reduce the use of inputs, for example the creation of Nitrogen Vulnerable Zones (NVZs) and the introduction of integrated pest management (IPM) systems.

There are many examples of excellence in innovation within the sector and in all cases the critical thing is that the innovation meets more than one challenge and is able to balance the sustainability of production with the sustainability of the supply chain. The following examples show how bringing together innovation from different parts of the agrifood sector not only solved the major challenges presented but also solved many problems outside of the sector but connected to these challenges.

03

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3.4.2 Crop Nutrition and Precision Agriculture and Yield

Within crop nutrition there has been a steadily growing realisation that the judicious use of organic and mineral fertilisers is an important part of sustainable production. The implementation of the NVZs in 1991 following the Nitrates Directive 1991 forced the agricultural sector to rethink the use of both organic and inorganic inputs. It led to revisions in the plant nutrition manual RB209 in 2000 and the introduction of MANNER and other tools to calculate nitrogen inputs from organic manures (including those derived from wastewater), both of which improved the efficiency in use of nitrogen in crops and reduced nitrogen applications. This reduced Nitrogen pollution from leaching and runoff, gave rise to improvements in the quality of surface and drinking water.

The Urban Waste Water Treatment Directive 1991 committed water companies to the same levels of control of water pollution, including Nitrogen and Phosphorus. The legislation is enforced by the environment agencies throughout the UK. However, the implementation and enforcement must be even handed and proportionate. If not, then one sector will be forced to invest more in protection than the other. Wastewater treatment and the removal of nitrates from drinking water are the major source (more than 60%) of GHG emissions for the water industry (Environment Agency, 2008). As a result, the implementation of water protection legislation by the Environment Agency can tackle three major environmental problems together, wastewater disposal, water pollution and GHG emissions. In addition, if the environment agencies and governments of the UK incentivised and enforced a concerted collaboration between farming and water companies to protect water supplies then they would solve multiple issue relating to drinking water standards, the Water Framework Directive (and parallel interpretations in Scottish and Northern Irish Law) and GHG emissions. Currently, the farmers and water companies are incentivised separately and the funding and legislation for each often works in isolation from one another.

The advent of tractor guidance systems from around the early 2000s led to improved precision fertiliser applications. This increased efficiency of nitrogen nutrition in particular and while it hasn't reduced nitrogen applications as a whole it has reduced some in-field variability in growth and yield of crops. Improvements in the understanding of crop requirements for fertilisers, in particular Nitrogen use has steadily decreased from 146 kg/ha in 2011 to 118 kg/ha in 2022 (DEFRA, 2023c). Increasing costs of inputs have contributed to the reductions in use. This may also have contributed to the reductions seen in river water since 1990 (Environment Agency, 2023).

The production of the plant nutrients, in particular mineral nitrate fertilisers, has been identified as a significant contributor of GHG emissions from agricultural productions, approximately 5% of all emissions (Gao and Cabrera-Serrenho, 2023). The use of renewable energy sources, ammonia emissions from organic waste streams as the building block for nitrate fertilisers instead of natural gas, and the trapping of CO2 emissions into largescale sequestration projects are set to decarbonise production, with fossil fuel free fertilisers available by 2025 (Yara, 2023).

Precision applications and a better understanding of crop-nutrient requirements has led to better use of other nutrients. This along with the reduced use of phosphates due to better understanding of crop requirements (DEFRA, 2023c) has contributed to a reduction in phosphate losses into water courses, another important issue in water quality (Environment Agency, 2023). Precision agricultural practices are also being used with plant protection products, with variable rate applications and spot spraying of weeds, and foliar disease a recognised technology. Many of the systems use Decision Support Systems (DSS) to help identify when and where to spray but also use artificial intelligences to identify nutrient deficiency in crops and weeds, pests, and diseases above the economic threshold for treatment.

The use of satellite and drone images as part of a DSS and the data models within them to evaluate the occurrence and extent of nutritional disorders or weeds, pests and diseases has led to wider evaluation of crops from estimating the yield and size distribution of potatoes to the evaluation of the nutrient transfer by cover crops within rotations. This has opened up the possibility of evaluating processes and rotations on one farm so that the knowledge from one farm can be transferred to another. Although there has been limited support from government for this area of research, with a focus more on commercial solutions with limited knowledge behind them.

With this methodology the understanding of productivity within less or no synthetic chemical intervention (such as organic and regenerative systems) can be transferred to conventional systems. In an arena where less and less chemical protection is available in farming, due to development of resistance to certain chemicals and increasingly stringent environmental legislation, this can be used to develop IPM strategies based on knowledge gained from systems that already work in a reduced chemical input environment.

3.4.3 Animal Feeds

The animal feed sector has a diverse range of customers in the agricultural, equine, and domestic pet markets. Animal feed markets include poultry (37%), dairy (25%), pigs (19%), beef cattle (10%), sheep (7%) and horses (2%) (AHDB, 2023). The animal feed market is worth £6.9 billion a year and the pet food market is worth £3.8 billion a year. In addition, pasture management is a significant market for the agri-supply industry. This includes the use of, seeds, fertilisers, pesticides and precision farming solutions. There have been a number of sustainability issues raised around the production and use of animal feeds, in particular, the association of soya production with the destruction of valuable biodiversity assets and a high GHG footprint. The industry has proactively worked with suppliers and agencies to ensure all soya in the UK supply chain is sustainably sourced. Feed producers have commissioned research and worked alongside academics to understand and reduce the greenhouse gasses produced from animal feeds. This has resulted in a better understanding of how the components of diet can lead to GHG emissions and how mitigation processes can come about and be implemented.

Soya is a major component of monogastric animal feeds in the UK and there are longstanding concerns on the provenance of some soya supplies and links to deforestation and other environmental impacts. More than 50 UK retailers, animal feed suppliers, merchants and trade associations have either signed or supported the UK Soya Manifesto that directs the agri-food industry to set a deforestation and conversion-free commitment with a cut-off date of January 2020 or earlier, to be fully implemented by 2025.

Waste is another major environmental issue within the agri-food supply chain, currently 30% of all food produced is wasted (WFP, 2020). The use of co-products in animal feeds can significantly decarbonise production but also divert valuable resources away from waste streams (FAO, 2013). Most commonly, co-products have plant-based origins. They originate from a wide variety of crops, including cereals, vegetables, and fruits. The primary crop is processed by the food or beverage manufacture, where they extract the nutrient, they need. What is left is the co-product. This is not needed by the food manufacture, however, these co-products often have a high nutrient density, which makes them a perfect nutritional choice to include in many livestock rations. More than that, it means all the valuable nutrients from the crop are fully utilised.

03

FARMING SUSTAINABILITY DIVERSIFICATION AND INNOVATION

3.4.4 Water Management

Managing and using water resources is an important part of all farming systems but is also a critical part of the production processes of many of the farming inputs and the processing of produce. So the wider impact of food and farming on water resources can be highly significant, The UN estimates that around 70% of drinkable water is used in farming worldwide compared to the production of GHG to which farming only contributes 11% (UN, 2023). The degree to which farmers use water is partly controlled by the return they get from its use. In livestock production, water is critical to keeping animals alive. The sensitivity of crops to water stress and the higher the value of the crop results in most of the water applied to crops in the UK being used in horticulture and potatoes through irrigation.

Irrigation Management is an important area for innovation, in particular the use of sensors to monitor soil moisture deficit, the flow of water through irrigation equipment, the accuracy of delivery to crops, the rate of water loss from crops and the effects water stress on yield (Obaideen et al, 2022). Many of the sensors on the ground are combined with automatic weather stations and satellite data, to track changes in weather and the amount of rainfall and where it actually falls. This is particularly important during storms that can lead to very localised precipitation and therefore water inputs. Satellite and drone data is also being used to look at the impact of irrigation or drought on yield and to schedule irrigation based on the economic impact. With some crops such as potatoes controlling irrigation can be extended to the impact of certain micro-organisms that causes problems with skin finish such as scabs. Irrigation control can also determine crop quality such as dry matter content of potatoes for frying (Irena and Mauromicale, 2022).

Production of fruit and vegetables undercover is more and more reliant on hydroponics and controlled environment production. This has reduced the amount of water used and removes almost all the release of nutrients into the environment. The introduction of aeroponic production in glasshouses, where water and nutrients are routinely sprayed onto the roots uses at least 80% less water than a hydroponic system and less energy. Compared to field level irrigation of commercial vegetable crops the water savings are significant.

Water use in production, ultimately requires sustainable water resources that can be used for all aspects of water use, from farming to food processing and ultimately cooking in the home. The agri-food sector is a primary innovator in the sustainable use of water in manufacturing. In many processes compressed air is used instead of water to clean most of the residue left during processing (Nehler, 2018), with water only used in the final clean. Processing and packaging plants tend to remove solids from water and recover some nutrient such as phosphates, which can be returned to farming as fertiliser. These processes ensure that water is as clean as possible before being treated and ensures circularity and waste reduction in processes.

3.4.5 Energy Use

Energy use is an important part of sustainability across the whole agri-food supply chain from the production of inputs to the disposal of domestic food waste. Energy gives opportunities for circularity in the food system, for example, the production of energy from the incineration of chicken manure and straw, or the use of food waste to make biogas and bioenergy.

Energy is used in every part of production, manufacturing, cleaning, drying, transport, storage, and disposal. As a result, small energy savings throughout the supply chain result in significant reductions in energy use. With some energy use still contributing to greenhouse gasses, the reductions in use also contribute to net zero targets for both the industry and government. AIC Members are actively seeking green energy for production, a significant area of development is the creation of processes using green hydrogen in fertiliser manufacture (Pagani, et al, 2023).

The use of chicken manure as an energy source also contributes to biosecurity linked to avian influenza. The disease has had a great impact on the poultry industry over the last five years, with 3.8 million commercial birds lost in the UK. The poultry market is the single biggest market for animal feed (accounting for 37% of all animal feeds in the UK, AHDB, 2023) and the most important in terms of meat production. The virus is spread through bird faeces, and while energy facilities don't take litter from birds known to be infected, the presence of asymptomatic infected birds in the population means that incinerating manure is likely to be controlling the spread of the disease (ECDPC, 2023).

Farms give a unique opportunity for diversification in energy use since they have substantial land areas to use. This broadens the range of green energy available to AIC Members and creates circularity in the economy. This is particularly apparent when inputs are used to grow bio energy crops. The largescale introduction of solar panels can be integrated with agricultural production as agrovoltaics, the combination of agriculture and solar energy production. It is now common to see sheep in amongst solar panels and they can be fed on herbal leys that improve biodiversity. The agri-supply industry is supporting this transition through providing advice and the seed used to create specialist leys and the feeds to supplement animal production. The use of the energy produced by industry creates circularity in the economy. This can accelerate decarbonisation of the sector. Wind power also adds to green energy production. There are currently restrictions on where onshore turbines can be located in the UK with a ban on large turbines in England but many farms are looking to have smaller facilities to supplement energy use.

This opens up the possibility of decarbonising heavy farm machinery and haulage. There would still need to be the hydrogen infrastructure to provide fuel but research at Cranfield University has indicated that this could be small-scale on-site production linked to on-farm solar or wind power.

04 PRODUCTION SECURITY

4.1 Food Security

Food production in the UK, Europe and further afield is already impacted by climate change. Periods of extreme heat, intense rainfall and drought are frequently experienced and has already exposed the fragility of UK food supply. The UK reliance on imports, particularly fruit and vegetables lead to fluctuations in the rate and quantity of supply, influenced by changes in availability at source due to climate change, the distance of the source to the UK, labour market pressures, the mode of transport, logistical pressures and import/export restrictions. A reliance on imports has also fuelled inflation (ONS, 2023).

Instability in the market creates a nervous supply chain, with agri-supply business customers less likely to take risks and more likely to make pragmatic and conservative choices about their purchases. In fact, insecurity of markets can have a deep and long-lasting effect on investment into all parts of the agri-food supply chain that will have impacts on all the government initiatives around farming, food and the environment.

From an economic and environmental perspective, this makes food security the most important part of the industries' and governments' desires to become more sustainable. Without market security and consistency of policy, none of the stakeholders will invest in the necessary changes, and progress will be slow. Innovation can help by allowing farms and businesses to diversify and increase output but there needs to be substantial support from governments and the supply chain to de-risk opportunities to allow farming to enter markets that will make production more secure. This de-risking can be through:

- **Grant aid to diversify production and stimulate innovation.**
- **Preferential purchasing of locally supplied produce.**
- **Better intelligence and connectivity of supply chains.**
- **Investment in infrastructure.**
- **Security/capacity to invest.**
- **Sustainable and resilient solutions in other areas such as energy production.**
- **More connected, relevant, and continuous training and education.**

These de-risking strategies will allow farming businesses to enter new markets and grow businesses sustainably. Farmers and agri-food businesses are natural entrepreneurs and problem solvers, but they are not given the opportunity or support to realise their potential. This in turn limits productivity but also the opportunities of businesses that supply and purchase from them. Numerous surveys have shown that the public value farming with 90% feeling it is important for the UK economy (NFU, 2023). This perceived public value placed on farming has wide-ranging impacts from attracting young people into the industry to importantly being a barrier to investment. Meeting the challenges around how food security can also maintain and extent the diversity in food production and diet (Section 4.2), develop new and transferable Green Skills and also transform the image of the whole agri-supply chains of farming and food in the UK. The ambition to make contributing in any way to feeding the nation should be something that is exciting to those leaving education and an attractive employment proposition.

04

PRODUCTION SECURITY

Reduce the long and complex supply chains.

Diversification of urban food sources.

Improve food quality by increasing essential micronutrients.

Bring investment and desirable jobs to neighbourhoods.

Rejuvenating derelict buildings and vacant warehouses.

4.2 Grant aid to diversify production and stimulate innovation

A review by the Department for Science, Innovation and Technology (DSIT, 2023) investigated innovation diffusion and adoption in the UK, the barriers to increasing spread and uptake of innovation and what further research or potential solutions should be explored.

The key findings of the report were that innovation diffusion and adoption (IDA) takes place within a fragmented, complex and poorly intra-connected ecosystem, with many different stakeholders, organisations and structures influencing IDA. Success in innovation is measured on the creation of a product or an idea not it's integration into the marketplace, with little dialog between innovators and end users, sometimes referred to as the knowledge gap between blue sky thinking and commercial implementation. Closing this gap by bringing "blue sky" within reach of business could bring major successes.

The report identified areas where IDA could be improved but did not recognise the need to upskill end users so that they could take advantage of innovation. In addition, the report did not identify how to fund the systems integration operations needed to adopt new technology. There is also an urgent need to be able to assess the likelihood of success of innovation.

In UK agriculture, the biggest requirement for innovation is to understand and manage the impact of changing farming systems to enhance biodiversity and decarbonise, at the same time as securing domestic food security. This is directly driven by the governments' farming and environmental legislation. This requires integration of multiple technologies and data capture to create transferable knowledge. How this can be done has yet to be put forward in a convincing way and needs the agreement and collaboration of industries throughout the supply chain including farming. It has already been highlighted that successful innovation comes about when multiple ideas are focused around a common theme. Systems approaches are rarely funded or seen as innovative within the UK.

4.3 Preferential purchasing of locally supplied produce

There has been a growing call for more food to be produced and sold locally. The concept is a key part of the Welsh Government's food strategy and has also given rise to more than 80 Sustainable Food Places across the UK. Farming has also identified the opportunity with over 1,500 farm shops now present in the UK. Many of them specialise in local produce and food products and it had been an economically important diversification for many farms.

These local retail outlets need access to a diverse range of food goods, and this requires diversity to be maintained at the wider farm level. A number of initiatives have looked to further diversify the range of crops grown in the UK, but this kind of innovation is not widely recognised by funding bodies or supported by innovation grants. With new vertical production systems becoming available based on smaller scale flexible production, it is possible to widen the range of crops that can be grown in the UK and avoid the issues of profitability associated with larger vertical systems, which have traditionally been tied into larger contracts with national food companies. These new systems are seen as unsupportable as a product because they are not optimised and are therefore unprofitable at the product development stage. There needs to be a coming together of innovation around energy use, plant breading, logistics and supply chain management to optimise alternative production system and make them sustainable. Field based production and traditional controlled environment production have had decades of support to help optimise them and new systems will require the same support if they are to be successful.

There has been a great deal of interest in the potential to install vertical farms in urban buildings. Worldwide, there are around 204,387m^2 of indoor, which is expected to increase almost tenfold to 2 million m^2 in the next five years (Bayer, 2023). The advantages of growing food in urban areas (Dace and Packard, 2022) are seen as:

- **Vast reductions in, the long and complex supply chains that bring food to cities, which are vulnerable to extreme weather, political instability and pandemics. It is estimated that by 2050, two-thirds of the world's population will live in cities and will consume 80% of all food produced.**
- **Diversification of urban food sources, thereby increasing food resilience.**
- **Improve food quality by increasing essential micronutrients like vitamins and minerals, while dramatically minimising the use of pesticides or inorganic fertilisers and taking up much less land than required by conventional agricultural methods.**
- **Bring investment and desirable jobs to neighbourhoods.**
- **Rejuvenating derelict buildings and vacant warehouses by converting them into new businesses that provide local skilled jobs in comfortable, climate-controlled settings, drawing in a new pool of workers.**

Largescale facilities have struggled to compete with other forms or controlled environment production, partly because they strayed from the targeted local markets, they were best suited to. Also, many urban buildings will have restrictions on access and will be on short-term leases, with potential for large rises in rents and rates. Farms offer a unique opportunity for vertical farming in that around a third have redundant farm buildings that could be used for urban production. These are often owned by the farmer or on longer leases, which secures long-term production. Vertical production can be smaller to supply smaller high value products locally. This can be an added extra revenue form redundant farm buildings.

04
PRODUCTION SECURITY

4.4 Better intelligence and connectivity of supply-chains

At the same time that farming systems are being asked to change and become more sustainable, companies, organisations, governments and the public want to know more about the way food is produced and where it comes from. They need to understand where the agri-food industry is in terms of its decarbonisation targets, or the degree to which biodiversity has been introduced into farming systems requires data to be collected and verified. Governments and companies still need to know what farms produce is available where and when as part of their supply chain management processes. This all combines to make a large data environment that must be added to, maintained, validated, cleaned, stored and analysed. In the case of farming and the environment, the distribution of government funds relies on a robust data system. With the four nations of the UK all having their own, each will need an adequate system to deliver the information required. Food security requires an in-depth understanding of where when and how food is produced in the UK and overseas. Intelligence and connectivity in supply chains already rely heavily on data solutions and this will increase in the future.

To meet the needs of the future, there needs to be large scale investment from both industry and the government in data technology. Rural areas are still under supplied when it comes to high-speed broadband, and this is a major limitation of transferring data from the farm to businesses and government, as well as implementing technological solutions on farms. There also needs to be an upskilling of the existing workforces so that they can take advantage of technology and data solutions. Continuing professional development (CPD) is a key part of the professional services within agri-food but is not a common element of farming. Farmers need to be included in CPD programmes, this is made more important by the fact that across all industries, nearly half of all businesses find it hard to recruit people with data skills and so the existing workforce needs to be upskilled.

The agricultural industry has a long-term issue attracting young people into the industry and studying subjects allied to agriculture and food at university, with numbers of applicants dropping year on year and the number of available courses shrinking. The agri-food sector as a whole and government need to address these issues and look at how young people can be encouraged to join the industry.

Circularity within the supply chain can help to improve efficiency of production and also be part of the decarbonisation strategy of the industry. Circularity can be achieved within individual processes that make up the supply chain but also across the whole supply chain.

4.5 Investment

Investment in the agri-food sector needs to be a partnership between government and industry. Government can help the sector by improving infrastructure. Improved digital infrastructure will greatly increase connectivity in the supply chain. This will help increase financial, carbon and water efficiency but will also help the government address issues around food security. Transport is another area where government investment can improve efficiency, through better connectivity of ports to the road and rail network and more electric vehicle charging points. Investment in hydrogen and electrical infrastructure can also help on farm productivity whilst reducing GHG emissions.

The agri-food industry needs to invest more in training and education. It recognises the need to modernise its work force around technology integration and digital skills but has been slow to respond.

Bioenergy production and biofuel production are important and growing markets for the agri-food sector including AIC Members. Sources come from crops grown specifically for energy and biofuel production, but also the use of byproducts and wastes to produce energy through incineration and via biogas production from anaerobic digestion. They form part of the green energy market and the price of the energy produced is supported by Renewable Obligation Certificates (ROCs). The scheme has incentivised UK renewable electricity generation since 2002. However, stations that were accredited in the early years of the scheme will only receive support until 2027. The potential for removal of the support could destabilise the renewable energy markets but also makes it impossible for existing power stations to plan for investment with such a short period of support.

Bioenergy production also plays an important role in sustainable waste disposal. It deals with potentially hazardous waste materials such as chicken manure, which can be contaminated with avian flu, and organic wastes that can produce lager amounts of greenhouse gases in landfill. The energy production systems can also contribute towards zero carbon fertilisers as a byproduct.

It should also be noted that the bioenergy market does compete for land with food production, and this is another area where cross functional policy and research needs to be considered.

4.6 More connected, relevant, and continuous training and education

A review of the UK-wide educational provision around horticulture, agriculture and food production shows there is still a great deal of choice around agriculture Further Education (FE) and Higher Education (HE) in most regions. However, when it comes to Horticulture, there are only six formal courses in HE and 12 at FE that provide training in commercial horticultural production. Many of the courses do not have a well-developed digital skills element, a key part of modern agri-food businesses and very few approach technology integration as a learning outcome.

When it comes to professional qualifications and Continuous Professional Development (CPD), most opportunities in agri-food are around practical skills with very few opportunities to pick up technology and data skills. The Help to Grow programme has introduced an opportunity for agri-food businesses to upskill. The programme is a 90% government-funded management course that is a blended programme combining interactive, online sessions with face-to-face learning that:

- **Enhances management and strategic capabilities.**
- **Produces a growth plan for businesses.**
- **Builds resilience to future shocks.**
- **Teaches how to innovate in business.**
- **Facilitates adoption of digital technologies to boost productivity and operational agility.**
- **Develops value proposition and reach into growth markets.**
- **Improves employee engagement and responsible business practices.**

The programme also provides mentoring and onward training schemes, and this could be expanded to other areas of the agri-food sector.

05 CONCLUSIONS

The collective role of the agri-food industry is more important than ever in the face of the challenges from climate change, the public, government in the UK and wider geo-political issues.

Food production in the UK is at a crossroads. Security of production, sustainable land use, and maintaining productivity could quite easily be at odds with each other as the pressures on the amount of land in production, the need to decarbonise and the fragility of production in other parts of the world all influence how land should be used. Agriculture faces uncertainty from many directions and policy and legislation needs above all else to soften these blows. This is particularly important with smaller producers that are impacted when margins are low since they do not have the volume of turnover to make operations sustainable. Many of the smaller producers (both in terms of production and turnover) contribute to the diversity of the UK diet, to horticultural production and livestock. Without them the UK diet and national health would suffer unless supplemented by imported goods.

UK food production is a complicated mix of internally produced and imported goods. In addition, the agri-food supply system is complex in its demands and supply to customers. Added to this is the array of pressures on land use for food, nature, housing, energy, industry and transport and health. Many of these are cross-departmental responsibilities of government but this is complicated by the devolvement of responsibilities to the individual governments of the home nations. There is a need for intergovernmental, interdepartmental, interdisciplinary research and thinking to come to the best consensus.

Currently, research and policy around the environment, farming and food have become detached and do not align to get the best out of the land from all aspects. In addition, some agricultural research is siloed into specialist areas such as plant breeding, animal genetics and plant protection product development. There needs to be interdisciplinary research into the systems that make use and integrate these technologies. This needs to be backed by government policy and support that has the same joined up thinking.

Innovation and research needs to bring together knowledge and products that can improve farming systems and generate sustainable income not just solve a singular problem. To support this, policy needs to focus more on circularity and how factors such as the energy used in industrial production can be created on the land that uses the inputs generated or that the inputs come from co-products following processing of land-based products. This tackles decarbonisation from three aspects, more efficient use of inputs, reductions in water use and reductions in the use of fossil fuels.

Education and training for the future has been identified as an urgent action point to upskill the current workforce but also to encourage and foster new talent. This is made more critical by the aging workforce across the sector. Education needs to be revitalised from primary through to post graduate and needs to include the development of professional skills as well as formal qualifications. The development of the Agricultural Universities Council (AUC) as a focal point for education and teaching research is of great benefit to the industry but needs the support of commercial organisations and the collaboration of educational bodies and organisations at all levels. Funding of the AUC is currently from charitable sources and relies heavily on academics donating their time. The industry needs to recognise the value of the AUC and ensure the opportunity for change is not missed.

This report has sought to define the issues which will shape land use and food security in the coming years. It is a hugely complex picture with often competing and contradictory demands alongside the uncertainty of wider geo-political impacts. Currently there are many players operating within and influencing across this landscape, but there is a lack of co-ordination. As we have seen with climate change and the formation of the Climate Change Committee, there is a need to provide focus, leadership and accountability.

> **AIC are therefore calling for the creation of an independent UK Food Security Committee (UFSC). This will be a statutory body established by government, but independent of it, operating beyond the scope of short-term, election cycles.**

Much like the Climate Change Committee, the role of the Food Security Committee will be to advise the UK and devolved governments on national and strategic food security.

With representation from right across Whitehall - including Food and Agriculture, Business, Trade, Treasury, Health, Energy, Education and Planning departments - as well as the devolved administrations and agri-food supply chain, this Committee will report regularly to Parliament.

It will take a cross-United Kingdom, cross-departmental view of the many factors and complexities that impact our country's food security.

Its work will outline food security indicators and take assessment of domestic production levels, consumer trends, international trade flows and strategic risks in both food and critical inputs.

06

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07
APPENDICES

7.1 UN/FAO eight areas to support and stimulate a sustainable food chain

1. Delivering £1.5 billion of farm innovation and R&D over the next 30 years.
2. A seed industry investing in providing the diversity of seeds and variety performance required in the coming decades including plant breeding for traits that can perform in changing climates and for emerging interest in bioproducts.
3. A fertiliser industry decarbonising its production emission footprints and driving Nitrogen Use Efficiency with a focus on soil health and overall nutrient balance on farms.
4. Animal feed mills, moving entirely to green energy with a fair tax relief system.
5. Crop protection commitment to integrated pest management and new technology.
6. Trade assurance schemes to source and trade sustainably.
7. Processing, storage and distribution of agri-supply materials committed to zero emissions while maintaining safe and secure supply chains.
8. A community of 5,000 accredited crop agronomists and feed advisers that will collectively expand their skillset to support farmers to make intelligent farm and land management decisions.

7.2 FAO (FAO, 2018) 21 Action Points for Agri-Food:

1. Facilitate access to productive resources, finance and services.
2. Connect smallholders to markets.
3. Encourage diversification of production and income.
4. Build producers' knowledge and develop their capacities.
5. Enhance soil health and restore land.
6. Protect water and manage scarcity.
7. Mainstream biodiversity conservation and protect ecosystem functions.
8. Reduce losses, encourage reuse and recycle, and promote sustainable consumption.
9. Empower people and fight inequalities.
10. Promote secure tenure rights.
11. Use social protection tools to enhance productivity and income.
12. Improve nutrition and promote balanced diets.
13. Prevent and protect against shocks: enhance resilience.
14. Prepare for and respond to shocks.
15. Address and adapt to climate change.
16. Strengthen ecosystem resilience.
17. Enhance policy dialogue and coordination.
18. Strengthen innovation systems.
19. Adapt and improve investment and finance.
20. Strengthen the enabling environment and reform the institutional framework.
21. Impacts of arable production on sustainability/ sustainable production.

7.3 DEFRA Funding Repository

The DEFRA website (https://www.gov.uk/government/organisations/rural-payments-agency) is a text and document-based information repository that covers all aspects of the three major initiatives covered by ELM, the Sustainable Farming Incentive (SFI), Countryside Stewardship (CS) and Landscape Recovery (LR).

The SFS website (https://www.ruralpayments.org/topics/all-schemes/agri-environment-climate-scheme/) is also document-based. Given that there is a high proportion of people within the land-based industries that require additional learning support, non-text versions of the documents such as information videos would have been a good addition to the website.

EFS website (https://www.daera-ni.gov.uk/topics/rural-development/environmental-farming-scheme-efs) does have videos as well as text versions of the documents.

While the SFS scheme is still undergoing some consultation, the Welsh Government has provided additional support through their Rural Payments Agency by expanding the Farming Connect initiative (https://businesswales.gov.wales/farmingconnect/). Under this programme, farmers are given support and mentorship to guide them through the application and implementation processes and is by far the most progressive of the environmental farming programmes.

NOTES

ARU Peterborough
University House
Bishops Road
Peterborough, PE1 5BW

Tel: **01245 493131**
Email: **business@aru.ac.uk**

Agricultural Industries Confederation Ltd
First Floor, Unit 4 The Forum,
Minerva Business Park,
Lynch Wood, Peterborough, PE2 6FT.

Tel: **01733 385230**
Email: **enquiries@agindustries.org.uk**

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