Food, Farming & Countryside Commission

JANUARY 2021

Farming for Change

Mapping a route to 2030

Contents

1. Foreword

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In our 2019 report, Our Future in the Land, we made three sets of recommendations:

- **Healthy food should be everybody's business, and we need to level the playing field for a fair food system.**
- **Farming can be a force of change, with a transition to agroecology by 2030.**
- **The countryside must work for all, with a land use framework to mediate all the demands placed on it.**

Along with many others, in businesses, governments, NGOs and communities, we ask: how can we feed a growing population with nutritious food, affordably, and within ecological boundaries? Moreover, how can we reverse the damages wrought by post-war policies for industrialised agriculture, and act on the climate and nature emergencies, in a way that enables people to flourish, and enterprises and communities to prosper, now and for future generations? These are huge, global issues for which there are no easy 'silver bullet' answers. Instead, they require the shared perspectives, balanced inquiry and collaborative actions of all of us.

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Already change is happening. More and more farmers are employing agroecological or regenerative practices – from joining longstanding and well-established certification schemes like Organics, biodynamics, LEAF and Pasture for Life Association, or government-backed stewardship schemes, or networks like Farming and Wildlife Advisory Groups, or the Nature Friendly Farming Network. More people are thinking about what they eat, and where it comes from. Governments are changing the policy context in which farming takes place as we transition out of CAP and into new support schemes which prioritise public benefits.

But serious and reasonable questions persist: is it possible to feed people across the UK through agroecological farming alone? What impact would such a transition have on land use, on space for nature and biodiversity, on current and potential future farming enterprises, on food security, on food prices and affordability, on health and wellbeing, and on meeting UK net zero carbon targets, without offshoring our impacts?

The research we have commissioned from IDDRI, and introduce here, starts to answer some of these foundational and technical questions – namely, is it feasible and plausible to plan to feed the nation through a shift to agroecology? And if so, what are the implications – or trade-offs to be made – compared to other scenarios, to forge a path to a more resilient, secure, fair and sustainable food and farming system?

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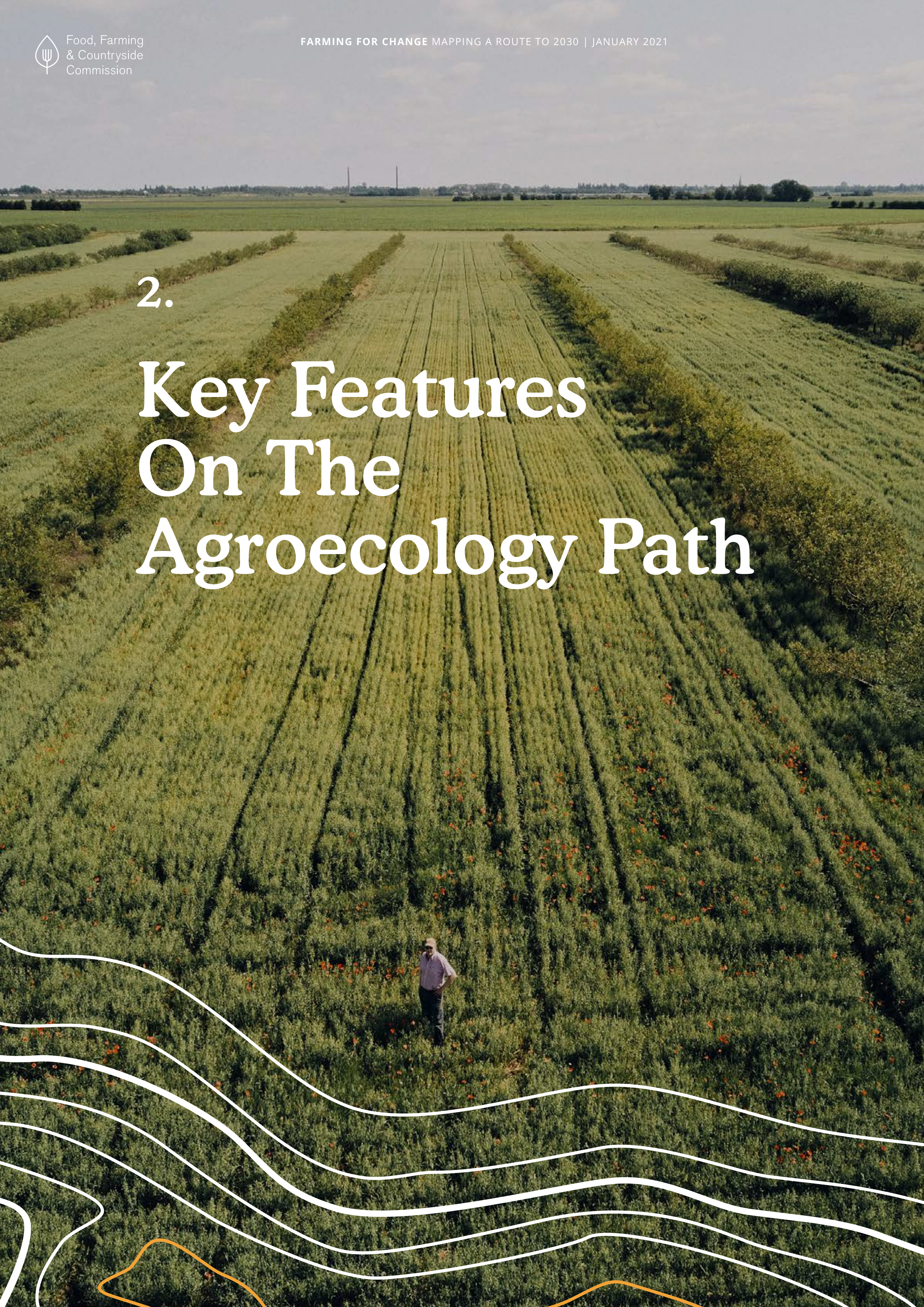
This is the decade in which significant and rapid changes must happen if we are to reverse and mitigate the climate and nature crises. It is why we set the goal of making the transition to agroecology by 2030. The IDDRI research, consistent with their work for the European region, provides data both to develop our recommendations to 2030 and to answer the related question of how agroecology will support the goal of net zero by 2050.

Some aspects of the research strengthen the case to press on with 'no regrets' actions from governments, business and citizens, actions that start the rapid progress needed in this decade. For other issues, significant questions remain that are best resolved through deliberative and inclusive discussions, balancing different needs, interests and impacts, ensuring that the voices of the seldom heard, of future generations and those without a voice are included. In publishing this research, we are aiming to contribute fresh evidence to these important debates, and are convening further exploration of the rich data in the coming weeks.

2.

Key Features On The Agroecology Path



2. Key Features On The Agroecology Path

The IDDRI modelling shows that, with the right enabling conditions, we can grow enough healthy food for a future 2050 UK population agroecologically while:

not compromising food security, nor offshoring food production and associated environmental impacts

eliminating economically and environmentally costly synthetic inputs (fertilisers and pesticides)

restoring a more mixed farming system with greater crop diversity and more biodiverse and permanent grasslands, grazed by native ruminants

nearly doubling the amount of fallow land available for environmental infrastructure (such as meadows and ponds) from 2% to 4% of agricultural area, totalling 603,000ha

releasing 7.5% of current agricultural area amounting to more than 1.2m hectares (up from 177,000ha) for more flexible use according to local and societal needs. This could be for woodland creation to support net zero ambitions, for stocking to support future export ambitions, for habitat creation and ecosystem restoration, or for increased public access.

reducing greenhouse gas (GHG) emissions from agriculture by at least 38% and with potential to offset at least 60% of the remaining emissions under certain land use scenarios such as afforestation.

This requires some choices to be made. But the model finds that we can feed a growing UK population a healthy diet through agroecology as well as maintaining some export capacity. It finds that we can free up land for other uses such as ecological restoration. It also achieves a theoretical climate impact reduction commensurate with climate-led scenarios at the European and UK levels, showing that it is theoretically possible to farm with nature, mitigate and adapt to climate change, and feed a growing population healthily.

To start the conversation, we have pulled out five critical questions, to give an insight into how the model can help test assumptions, inform policies and change practices: the diet question, the carbon question, the livestock question, the productivity question and the nature question. As well as bringing the modelling to life, these questions act as entry points to explore a model which tackles multiple issues simultaneously – and avoids single issue solutions which may have unintended consequences.

The Interconnected Challenges

While we are focusing here on the UK context, we can't ignore our global impacts, in a deeply interdependent global food system.

Diet-related illness is spiralling. Poor diets are responsible for more than 1 in 7 deaths in the UK and have a huge negative impact on quality of life through obesity, type 2 diabetes and heart disease.[1] Obesity is the biggest risk factor in developing type 2 diabetes which now affects almost 4.5 million people in the UK (including 1 million people living with undiagnosed type 2 diabetes).[2] The impact of diet-related illness is also compromising health services and lives, with the UK-wide NHS costs attributable to obesity projected to reach £9.7bn by 2050, and wider costs to society to reach £49.9bn per year.[3] Furthermore, it is estimated that over 3m people in England suffer from undernutrition.[4]

While we are focusing here on the UK context, we can't ignore our global impacts, in a deeply interdependent global food system.

Wildlife numbers are crashing. In the UK, 15% of species are currently under threat of extinction,[5] farmland birds have declined 57% since the 1970s[6] and we are seeing widespread loss of pollinators with wild bees and hoverflies lost from a quarter of the places they were found in 1980.[7] Changes in land and sea use driven by food production are the biggest drivers of biodiversity loss, ecosystem destruction and wildlife decline.[8] In 2020, the UK government failed to meet 17 of its 20 UN biodiversity target commitments.[9] The impacts and footprint of the UK food system extend far beyond UK coasts – a significant amount of UK livestock production is currently reliant on feed from soya imports from the Americas, contributing to deforestation and the destruction of tropical forests.[10]

Climate breakdown is accelerating. In the last 60 years, the food and farming system has contributed significantly to climate breakdown with agriculture, forestry and land use accounting for almost a 5th of global emissions[10] and 10% of emissions in the UK.[11] Land, as well as being a carbon source, is also a carbon store and how we use it is critical to chances of mitigating the worst impacts of climate change. Rapid changes to the climate are already having devastating impacts on all life on earth, felt disproportionately by the poor, and are likely to undermine long-term food security through extreme weather events and increases in invasive species and pests.

In practice, what is often called 'adding value' to food and farming very often means *extracting* value from producers and *depleting* value to citizens, to the environment and to future generations.

Food security is under growing strain. The UK imports almost half of its food needs.[12] Increasingly volatile and uncertain environmental, economic, social and geopolitical conditions are at risk of undermining our long-term food security.[13] When supermarket shelves ran empty as Covid-19 first hit the UK in March 2020, it was a reminder of how vulnerable the food system is to sudden shocks. The economic fallout of Covid-19 has also increased household food insecurity among the poorest communities, and people who have become unemployed as a result of the pandemic are 2.5 times more likely to be food insecure.[15]

The diversity and resilience of UK agriculture is declining. Farm gate share of retail price has dropped 15% since 1988. In the period 2005 to 2015, 33,000 farms either closed or merged into larger holdings.[16,17] CAP payments account for on average 50% of farm income, yet more than 60% of farmers earn less than £10,000 pa.[16–18] And UK farm productivity is falling behind: 0.9% growth compared to the Netherlands (3.5%) or US (3.2%).[19] Land allocated to horticulture – the fruit and vegetables we need to eat more of – has decreased by 25% in 30 years.[20]

On the other hand, the global agri-food sector has grown to $8 trillion, or 10% of the global economy.[21] In doing so, it has become more consolidated into fewer hands. Four companies control 65% of seed production, four companies control 70% agrichemicals business – and three are in both categories.[21] The same story applies to processing and manufacturing, and in retail, where the top four UK food retailers control over 65% of the market.[21]

This consolidation of control is further exacerbated by the arrival into the sector of new, global mega-players, like Amazon, Google and Alibaba. They leverage their superior access to 'Big Data' (from the information we all give away for free every time we make a purchase or click on the internet) and are finding new ways to take a share of profit from the food system.

Taken together, the effects are far reaching, leading to fewer and less diverse farm businesses, reduced farmer incomes and autonomy, fewer resources for farmer-led innovations, more products which have serious impacts on the environment and the public's health, an increase in labour abuses, and control of important information concentrating in fewer hands.

In practice, what is often called 'adding value' to food and farming very often means *extracting* value from producers and *depleting* value to citizens, to the environment and to future generations. We now know that many of the so-called productivity or 'value adding' activities (like applying synthetic chemicals to farmland, or manufacturing and marketing ultra-processed foods) are precisely those which damage the health of people and planet the most, through global warming, environmental pollution, and escalating waste and sickness.[22]

While on the one hand, food has become cheaper and more abundant for more people than at any time in human history, it has also become one of the major causes of the climate and nature emergencies, with critical impacts on the poorest countries. In short, we cannot talk about the future of farming without talking about the messy issues of power, transparency and justice.

Agroecology answers questions on climate, nature and healthy food, but implicit in it are also principles of fairness and equity – to the businesses, growers and workers in the supply chain; to animals and nature; to rural communities with close connection to the farmed landscape; to citizens and to the generations to come.

It is why we use the UN FAO definition in *10 Elements of Agroecology*, an internationally agreed definition, developed to support progress towards the seventeen Sustainable Development Goals.

> ***"Agroecology is based on applying ecological principles to optimise the relationships between plants, animals, humans and the environment. Through building these relationships, agroecology supports food production, food security and nutrition, while restoring the ecosystems and biodiversity that are essential for sustainable agriculture. Agroecology can play an important role in mitigating and adapting to climate change.***
>
> ***Agroecology is grounded in place-specific designs and organisation, of crops, livestock, farms and landscapes, conserving community, cultural and knowledge diversity. To harness all the benefits from adopting agroecological approaches, the right enabling conditions are required, adapting and aligning policies, public investments, institutions, and research priorities.***
>
> ***Agroecology is the basis for growing food systems that are equally strong in environmental, economic, social and agronomic dimensions."***
>
> Adapted from The 10 Elements of Agroecology: Guiding the transition to sustainable food and agriculture systems (FAO, 2016).[23]

We know fairness matters to citizens too.[24] Thus, in considering policy options now, for the future of farming systems across the UK and thinking of the choices we need to make for a healthy, resilient and sustainable food system, we also ask the question: which choices are more likely to lead towards a fair and just food system, for communities right across the UK, for now and for future generations?

Choosing our Path

There are, of course, other potential routes advocated for a more sustainable future. The most widely talked about is the land-sparing scenario, where much more land is returned to nature, and food production intensifies in other parts of the country. Further scenarios point to the growth of technical solutions, such as lab-based food production, which removes land from the food system all together.

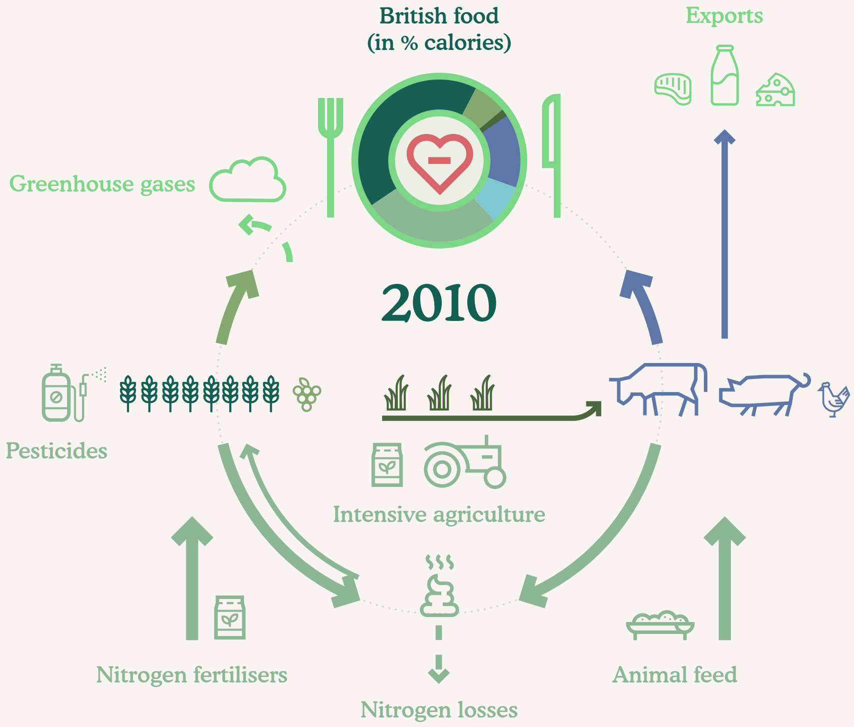
The safest, fairest, most resilient and sustainable path is likely to be a broad one, incorporating a continuum of approaches, one which acts on the climate emergency and makes space for nature on the one hand, and deploys appropriate new technologies on the other. However, we think this modelling helps demonstrate that a transition to agroecology can address more of the critical and interconnected challenges.

Now vs future: the overall picture

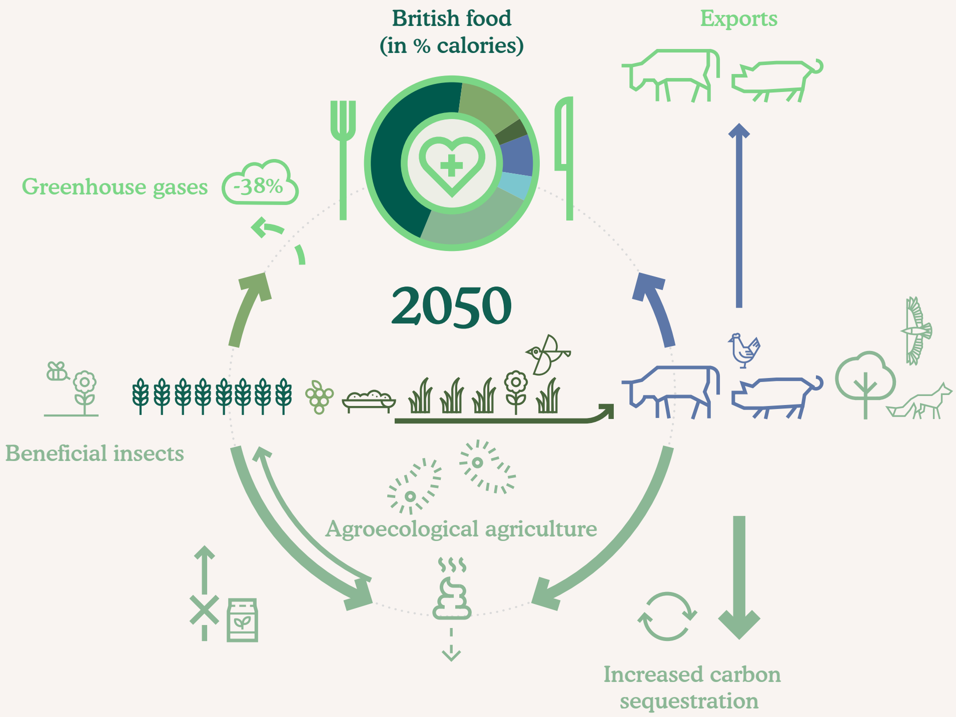
THE CURRENT UK FOOD SYSTEM

- Cereals and starchy foods
- Fruit and vegetables
- Protein crops (peas, lentils, etc.)
- Meat, eggs and fish
- Dairy products
- Others

For full breakdown of diet figures please see page 19



AN AGROECOLOGICAL UK



A Just Transition

In our report *Farming Smarter*,[25] we set out the economic case for agroecology, and the resources needed to facilitate that transition. Further research will delve deeper into some of the social and economic questions. For example, the Soil Association is now commissioning research, funded by Esmée Fairbairn Foundation, to understand the practical implications for farmers, citizens and supply chains of a transition to new and mixed farming patterns; the impact on farm level economics and activity.

Modelling the reorganisation of the UK food and farming system is seriously complex, throwing open many different dependencies and trade-offs.

The scale of the ecological and economic challenges in front of us requires society to face into some big questions. Can we continue to produce, consume – and waste – so much in wealthy countries, while countries in the Global South struggle to meet their basic needs? What limits could or should we place on food and farming businesses to operate within just social and ecological boundaries? What practical or technological fixes help provide fair and transparent solutions – and which simply mask the underlying problems? Where are the potential stranded assets in the sector – and how could we 'hospice' those to a respectful end? And how and where should we invest in a fair and resilient food and farming system that also acts on the interconnected challenge for climate, nature, health and wellbeing?

All modelling is based on a set of assumptions (which we make explicit in the next section) and can only ever provide data for discussion on possible ways forward. Modelling the reorganisation of the UK food and farming system is seriously complex, throwing open many different dependencies and trade-offs. And there are some immediate and practical implications to consider – for policy makers and for farm and food businesses trying to make the right choices right now.

There is much to consider in the technical working paper that accompanies this report, and we will be exploring the model's implications through further inquiry with government, industry and communities as we work towards publishing the full study and analysis in spring 2021. We describe how we will take this forward at the end of the paper.

3. The Modelling Approach

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The modelling we draw on in *Farming for Change* is developed from IDDRI's Ten Years for Agroecology in Europe[26] model and regionalised for the UK. The modelling sets out to optimise farming outcomes for climate, nature and health, and has been developed by a team of scientists and agronomists. It tests the feasibility in land use and in yield terms of phasing out synthetic nitrogen fertiliser and pesticides. It also develops an account of the climate impact reduction and sequestration potential of land use changes associated with agroecological farming. Building on the findings at a European level, this UK modelling gives us more data and information about what a change to agroecology could mean for the UK in terms of food balance, land use changes and GHG emissions from agriculture by 2050.

The UK model builds on a first stage of modelling in 2018 that looked at macro-level food system inputs and outputs (considering average yields and aggregated land use patterns using a mass-flow model named TYFA*m*). Aware of the limitations of a European-wide model, the diversity of agricultural systems and landscapes across the EU and the UK, and the need to close the nitrogen cycle at a regional level, IDDRI further developed the model to allow testing of the assumption at a regional level (TYFA*regio*). The UK model breaks the UK into three agronomic regions. Clearly these do not reflect the real diversity of land use and farming systems in each of these areas, but even so they provide a level of detail not achieved by similar exercises elsewhere. The model builds in some differences in farming across these regions, reflecting that an agroecological mixed farming system in terms of crops and livestock will be different in, say, Northern Ireland, compared to East Anglia and that some areas will adopt more specialist extensive livestock grazing systems, rather than the mixed farming approach that characterises the model. TYFA*regio* is designed to test the agronomic reasoning supporting the model's assumptions at a regional level and acts as an intermediary level of analysis, connecting local/landscape issues (e.g., land use changes at a regional level, nitrogen balancing) with macro issues (e.g., food balance, export capacity, and carbon emissions and sequestration).

As with all foresight modelling, the IDDRI model is based on a number of assumptions outlined below.

Diets are changed substantially with a reduction in meat, dairy and sugar and increase in fruit, vegetables and nuts. Waste in the food system is reduced by 10%

Land is prioritised for food production first, then animal feed then non-food uses

Mixed farming approach #1: farming systems are broadly categorised into specialist extensive livestock systems in the north of the UK, mixed cropping and livestock systems in the south, west and east and vegetable systems focused on the fertile lowland areas of each region

Mixed farming approach #2: specialised cropping & grassland areas become more mixed with permanent grassland always having a 30% share of legume crops to support soil fertility, biodiversity and carbon sequestration. Grain fed livestock are only deployed when needed for nitrogen balance in cropping areas

Mixed farming approach #3: nitrogen is managed at a landscape level integrating livestock and arable systems to match nitrogen supply and need at a balance of 110-118%, driving local fertility transfer, and removing synthetic nitrogen inputs entirely

Extensive practices are prioritised with permanent grassland always extensively managed and intensively managed grassland redeployed

A precautionary approach is taken to the use of crop protection products with ecologically driven integrated pest management prioritised, and removing chemical sprays entirely

Yields are assessed against a future climate change scenario and derived from organic baseline data are assumed to be 17% lower in the west and 25% lower in the north and the east

Good research raises questions, as well as providing answers, and the IDDRI model is no different. At the end of each chapter, we outline questions for supplementary inquiry which will be further developed for the full IDDRI technical paper, as well as broader questions for policy makers, industry and citizens about the implications and trade-offs implied by the research findings.

4. The Diet Question

WHAT DIETARY SHIFT WILL BE NEEDED FOR AN AGROECOLOGICAL UK FOOD SYSTEM?

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A core assumption of the IDDRI model is that diets across the UK need to change significantly. With major dietary change, an agroecological future for the UK is possible. The same dietary changes that will make agroecology viable in the UK will also improve public health – making the case for change doubly important. Improving climate, nature and health through dietary change and agroecology is one of the most important changes we can make towards a more fair and just food system.

Widespread dietary change is of course not easy to achieve and will require urgent policy and practice change by government, actors within the food system and citizens. This is imperative to enabling an agroecological transition, as well as improving public health and all the associated benefits that come from a healthier, more sustainable diet. While this is a daunting challenge, and many decisions remain about how to achieve this change, the diet proposed by the IDDRI model is possible with smart, fast and sustained effort.

Dietary Changes Needed

The diet incorporated into the IDDRI model is based on dietary recommendations from the European Food Safety Authority, current eating habits in the UK and changes necessary to address environmental challenges (biodiversity and climate change).[26] The model also incorporates a 10% reduction in waste.[i] In this UK model, IDDRI applied dietary change assumptions for the EU in 2050 to the UK, as diets across the UK are broadly aligned to those in the EU.[ii] Data on current diets in the UK was taken from the FAO diet database (2017).[iii] The model assumes the UK population will increase from 65.8 million inhabitants in 2010 to 77.5 million in 2050, according to the medium projections from the Office for National Statistics.

The basics of this diet will not come as a surprise to anyone familiar with healthier and more sustainable diets: more vegetables, less sugar, less meat. Specifically, the diet per person per day is comprised of:

- **an average of 2300 calories**
- **carbohydrates making up 40–65% of daily calories, with sugars capped at 100g**
- **fat making up 30–40% of calories**
- **50g of protein, with a maximum of 35g of that protein coming from animal sources**
- **30g of fibre**

Relative to the current average diet in the UK, this diet is slightly lower in calories, animal products and sugar, and is higher in plant-based proteins, fruit and vegetables (Figure 1).

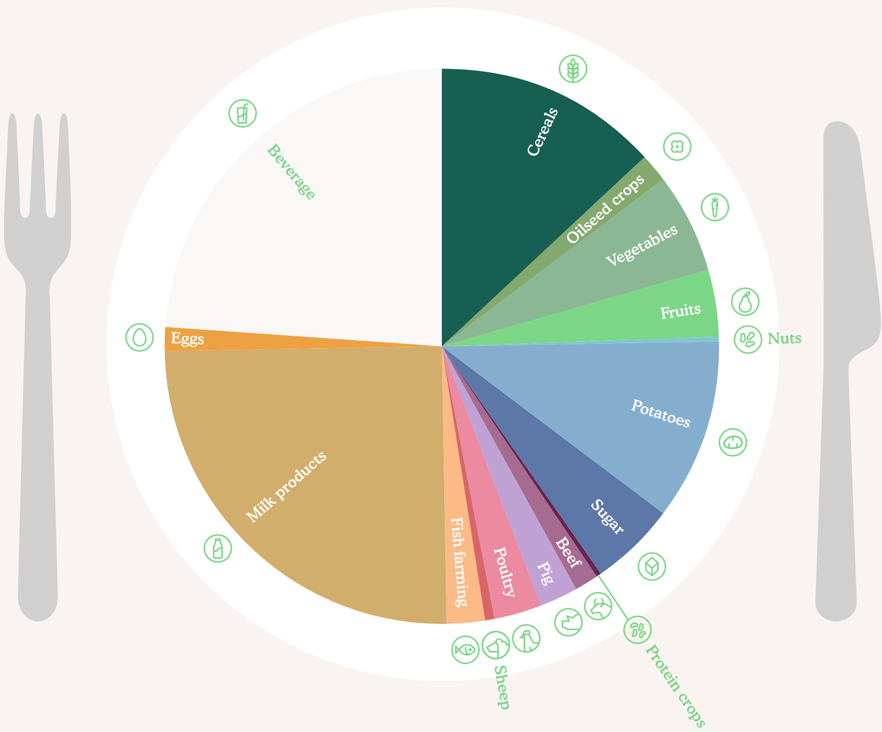
i The waste improvement coefficient in the model is, in comparison to other models, voluntarily modest to enable this work to focus on the contribution of agricultural solutions. Reducing waste by 20% (as in the Courtauld Commitment) or by 50% (as in in the Committee on Climate Change report on Land Use Policy for Net Zero UK[47]) would have better aligned with broader waste reduction objectives, but would have made it more difficult to assess the impact of agroecology versus waste reductions.

ii On average, the UK diet is close to the EU28 one, except that consumption of potatoes, beverages and sugar is higher in the UK. Animal product consumption in the UK is also slightly above the EU average.

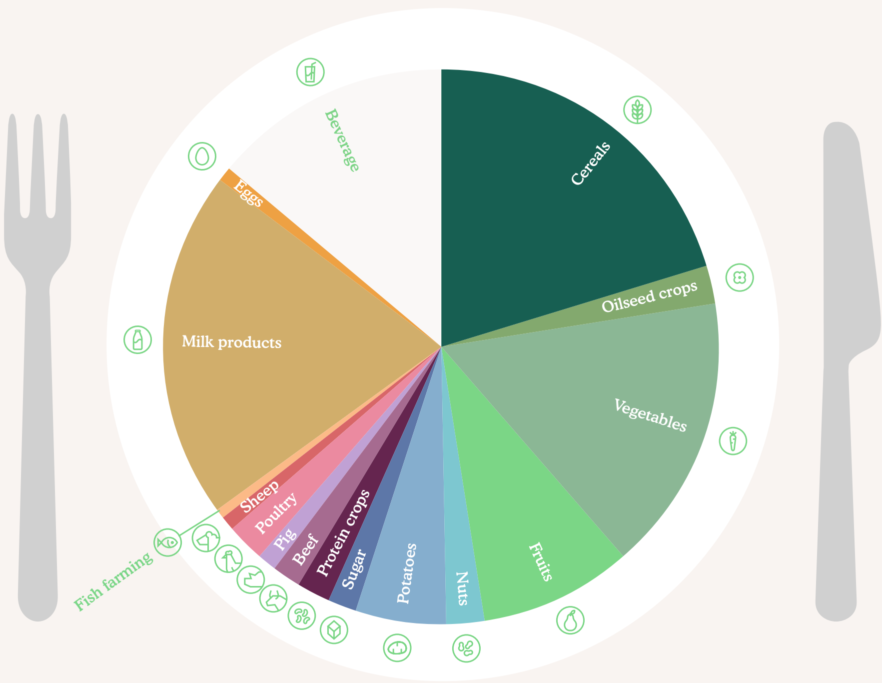
iii This is the database commonly used for international comparison, and the one mobilised for TYFA*m*. The FAO methodology differs from other UK data sources, including the National Diet and Nutrition Survey; therefore, comparison between the databases is not possible.

Figure 1: TYFA UK Model of dietary change

2017



2050



There has been extensive debate about the level and type of meat that forms part of a healthy and sustainable diet, with meat reduction recommendations included in the recent EAT-Lancet report and the Committee on Climate Change.

Legumes and pulses play an important role in the IDDRI diet both for their protein content and for their ability to fix nitrogen in the soil, and as result we see a tripling in consumption and seven-fold increase in farmed area.

There has been extensive debate about the level and type of meat that forms part of a healthy and sustainable diet, with meat reduction recommendations included in the recent EAT-Lancet report and the Committee on Climate Change.[22,28] The IDDRI model recognises the role of pasture-fed livestock in agroecological food systems, and that cereal-based animal feed for pigs and chickens competes directly with human consumption of those crops. Therefore, the IDDRI diet significantly reduces pork and chicken meat, and considerably decreases dairy as well due to the associated relatively intensive grassland management and fodder crops. Beef sees a relatively smaller reduction and sheep is held constant as a result of their role in nutrient cycling and fertility building in mixed farming systems.

To put the IDDRI meat recommendations into real life terms, 35g of animal protein is equivalent to around 100g of beef, which is roughly one portion. On average across the UK, men eat 88g of animal protein per day and women eat 64g per day, well above protein levels (50g) necessary for health and the 35g of animal protein recommended in the IDDRI diet. Protein requirements vary per person, but on average people are advised to have two to three protein sources per day.[29] Reducing meat in the diet so that it makes up only one of those daily portions is realistic. Not only would doing so help to enable an agroecological transition, but as meat is one of the largest budget items on a household's shopping bill,[30] reducing the quantity would mean that higher quality, agroecologically produced meat becomes relatively more affordable. In sum, "less but better" meat.[31]

What Next?

The IDDRI model supports other research which affirms how important widespread dietary change is in any future scenario for the UK. We know what the core barriers are to achieving the dietary change outlined in the model. Our food system and food environment are dominated by unhealthy and unsustainable foods, and a shocking number of people and families in the UK struggle to afford enough food – let alone healthy and sustainable food.[32]

How we achieve this change is a subject for serious debate and action – it is not a question of if, but how and when. How can we ensure agroecologically produced food is affordable and accessible for all citizens? How can the dominance of unhealthy products in the food environment be shifted so healthier options are more widely available?

With the National Food Strategy in preparation in England, the Good Food Nation Bill on the table in Scotland, and similar multi-stakeholder initiatives in development in Wales and Northern Ireland, there are enormous policy opportunities right now to reshape our diets and food systems – and to do so in a way that enables a wider transition to agroecology. Internationally, this should be top of the agenda at the United Nations Food Systems Summit in autumn 2021 and an integral part of COP26 discussions – food system and dietary change is absolutely part of the climate equation.

To help make dietary change a reality, FFCC has previously outlined several policy options – some that we can just get on and do, some that we need to test and evaluate, and some that we need to debate. Our future work programme will focus in on affordability, ultra-processed food and diversified food systems.

Bill and Cath Grayson, Morecambe Bay Conservation Grazing Company

Bill and Cath are organic livestock farmers and conservation graziers, rearing native-breed cattle on 1,100 hectares of high nature value land scattered across Cumbria, North Lancashire and North Yorkshire.

"There is an underpinning link between our health, the nutritional content of the food we eat and the environment in which that food was produced.

Our system of grazing is primarily geared towards delivering optimal wildlife habitat on some of the region's most important nature reserves. We use cattle that we have selected over several generations to be able to cope with the more challenging conditions that have made these sites of marginal value for modern agriculture. Much of the terrain is either steep and rough or low-lying and waterlogged, conditions that are problematic for efficient production, but which favour natural regeneration by trees and shrubs. Over time, a complex mosaic of woody and open habitats can develop, which are ideal for wildlife.

Our beef is therefore produced from cattle that are free to choose their diet from an extraordinarily rich array of plant species growing on soils that have never been ploughed or treated with chemical inputs. Livestock diets based on this level of diversity supply the grazing animal with many more of the secondary compounds that have been shown to provide health benefits for both the animals themselves and the people who eat them. Analyses of meat samples from cattle reared in our system have demonstrated much higher concentrations of omega-3 fatty acids compared with samples from animals reared on a more conventional diet with much less plant variety.

When we started farming 30 years ago, our focus was primarily on delivering specific ecological objectives for wildlife, rather than providing much broader aims for environmental sustainability. But just as society has become increasingly aware of the dangers posed by the climate and biodiversity emergencies, so we have come to appreciate the special role that conservation grazing and agroecological practices generally can play in tackling most of these vital issues. Meat produced from livestock that graze on pastures rich in different plant species while also browsing trees and shrubs has an additional and crucially important part to play in helping to restore our nutritional health. If society is going to resolve all the threats to the food system, we feel it needs to focus on agroecological principles to ensure that farming remains within the limits that nature sets."

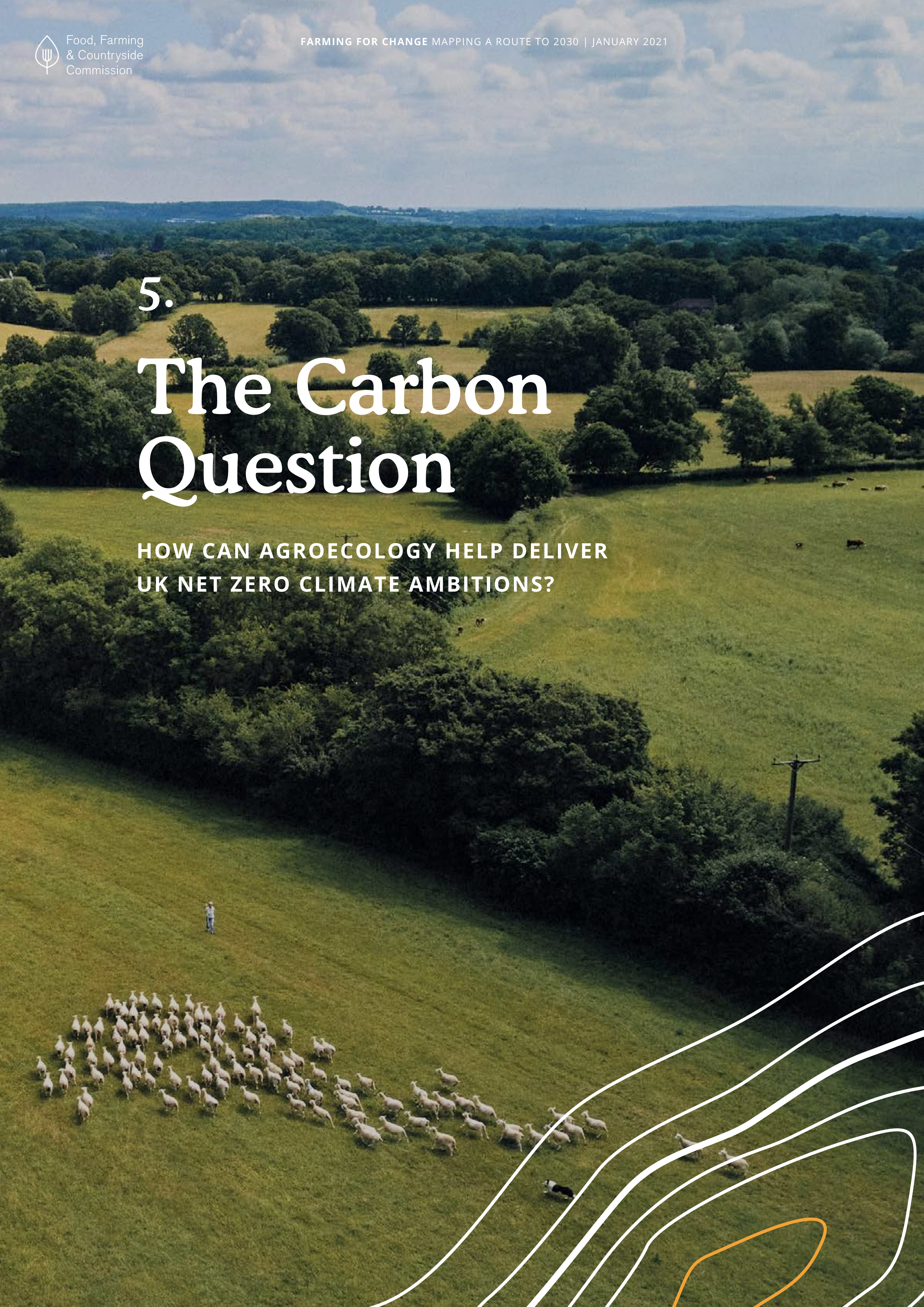
Rosy Rose, Meadowsweet Organics, Fife

Meadowsweet Organics is an organic market garden of about 2.5 hectares, growing mostly organic vegetables but also cut flowers and medicinal herbs.

"For me, health is really, really important – it's why I got into organic farming. I think one of the best things you can do is grow good quality food for people.

We grow over 50 different varieties of vegetables and when we're selling the produce, we emphasise the health qualities. I think leafy greens are a huge missing part of our diet – plants like spinach, chard and kale are so important because they've got huge amounts of vitamins and minerals in them. We all need to grow and eat more of them.

For fertility, we use green-waste compost, a liquid fertilised from comfrey that I grow and Scottish volcanic rock dust. We've seen a big improvement in the crops we're growing, and in the quality of the land."



5.

The Carbon Question

HOW CAN AGROECOLOGY HELP DELIVER UK NET ZERO CLIMATE AMBITIONS?

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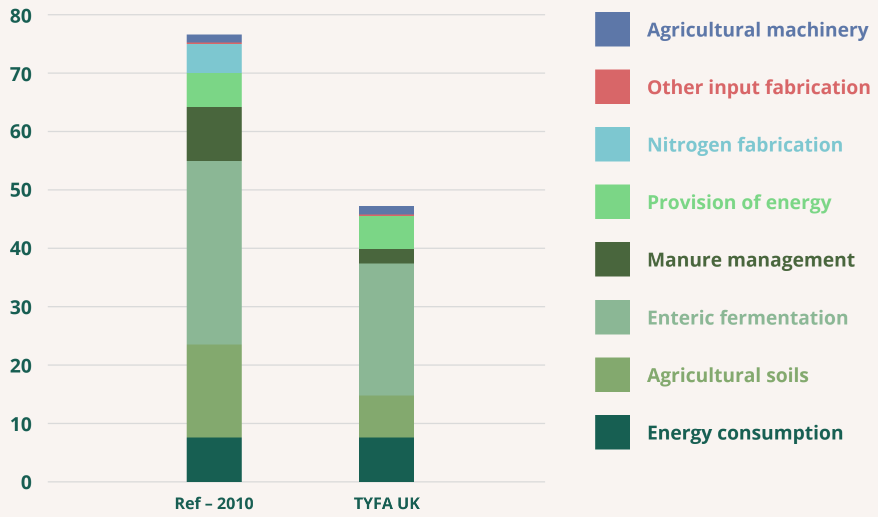
This research assessed the impact of the IDDRI model in terms of GHG emissions and carbon sequestration potential using the ClimAgri® calculator. ClimAgri® measures all agricultural GHG emissions related to the functioning of the sector, from upstream to downstream.[33] Direct emissions include 'classical' non-CO_2 emissions – methane (CH_4) and nitrous oxide (N_2O) coming from soil management, manure management and enteric fermentation – and CO_2 emissions associated with energy consumption at the farm level. Indirect emissions include CO_2 and non-CO_2 emissions from fabricating inputs as well as energy provision to upstream activities.

The model predicts that direct and indirect GHG emissions originating from agriculture would decrease by 38% in 2050 in an agroecological system (Fig 2). In addition, since vegetable protein imports are brought down to zero, and a significant share of those proteins currently come from deforested areas in South America, the total emissions reduction could even be higher.

Figure 2: Emissions reduction of TYFA UK – compared to 2010 (Mt CO_2eq/yr)



One of the most important sources of GHG emission reduction (N_2O and CO_2 in particular) results from the phase-out of chemical fertilisers, particularly nitrogen. In the UK, in 2010, emissions from agricultural soils represented almost 25% of total direct agricultural emissions.[34] By eliminating the use of synthetic nitrogen and significantly improving the efficiency of nitrogen use, reducing excess nitrogen by up to 90% through use of organic manures, the model predicts that N_2O emissions linked to the application of nitrogen to soils would significantly decrease (−53%), while emissions linked to the fabrication of nitrogen are brought down to zero.

Emissions from manure management would also significantly diminish (−72%) as a result of a reduced number of livestock and more extensive systems altering manure management practices, particularly for the bovine herd. Notably this means the reduction of liquid forms of manure (slurry) that result from more intensive systems.

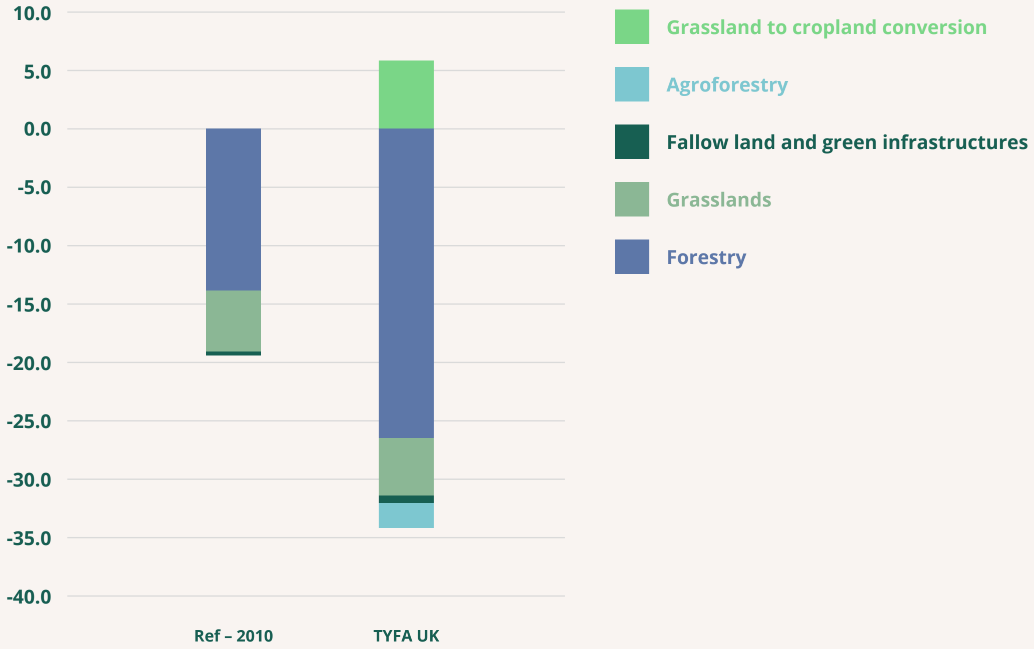
Emissions linked to ruminant livestock, namely methane from enteric fermentation, would reduce by around 28%. Ruminant livestock are an essential component of the IDDRI model due to the key role of natural grassland in biodiversity conservation, with enough animals to graze those grasslands. However, to reduce enteric emissions, the model hypothesises that half of the bovine herd is given a feed additive. These additives are already available and can bring down the level of enteric emissions by 14% per cow– according to the existing literature.[35–37] Yet, they can only be used in semi-intensified bovine herds, i.e., given to animals which spend enough time in housed systems to allow their feed to be managed. In the IDDRI model, 80% of cattle under a mixed system could allow such a feed management practice. However, the model assumes that only 60% of them would utilise a feed additive.

Direct emissions linked to the consumption of energy would remain almost constant (−2%). The model maintains that vegetable production should be seasonal as much as possible, and the area of heated greenhouses remains unchanged.

Based on coefficients taken from literature (see accompanying technical paper for more details), this research measured a carbon sequestration potential for the IDDRI model. Due to great uncertainties regarding carbon sequestration rates, and the evolution of forest land and its management practices, all sequestration data provided in the model must be interpreted as an order of magnitude. The potential for carbon sequestration in the model is determined by land use choices, particularly with regard to the 1.2m hectares of land made available for other purposes (see The Nature Question chapter for this discussion). To explore the carbon sequestration potential of a shift to agroecology, IDDRI modelled largely afforesting the land made available for other uses; however, there are alternative land uses and other trade-offs to consider, such as for more grazing livestock to support exports, which will be explored in the full technical report.

The afforestation scenario of the model suggests that agroecology across the UK could increase net annual carbon sequestration by around 47% relatively to 2010 (Figure 3) with 28Mt CO_2 sequestrated, representing 60% of the carbon emissions of the agricultural sector in 2050.

Figure 3: Carbon sequestration originated from land use change in 2050 (Mt Co_2/year)



The main source of carbon sequestration is forestry. In the IDDRI model, CO_2 sequestrated from forestry doubles from 13.7Mt CO_2/yr to 26.5Mt CO_2/yr (+93%). The model also assigns 10% of utilised agricultural area (UAA) to silvoarable and silvopastoral agroforestry (1.4m hectares of agricultural land with a planting density of 188 trees/ha). This provides important functions including carbon sequestration and other ecosystems services, such as providing shelter for livestock, habitat for pollinators, and improving water retention and nutrient cycling. As a result, the model makes the simplifying assumption that agroforestry does not affect crop yields and does not divert land from agriculture. The carbon sequestration provided by agroforestry systems represents 2.2Mt CO_2/yr or around 6% of total carbon storage of the IDDRI model. In addition, an associated doubling of the area for green infrastructures (hedges, copses, ponds) to 603,000ha adds a further 0.5Mt CO_2/yr.

The model does not account for carbon sequestered in soils at this stage due to the uncertainty surrounding this scientific area, though there is potential for further carbon sequestration through certain agroecological practices, particularly those that build soil organic matter. The Farm Carbon Cutting Toolkit shows the potential in this area with a 0.1% increase in soil organic matter over 1 hectare of land potentially sequestering up to 8.9t CO_2/yr.[38] If this is factored across the landscape then the impact on this model is evidently substantial, providing further flexibility on land use.

The model does see some carbon losses through the conversion of grassland into cropland in existing grassland areas to diversify land use and enable nutrient cycling. This might reduce carbon stocks by around 6Mt CO_2, which represents 17% of the total carbon sequestrated through forestry, agroforestry, grasslands and green infrastructures.

The model achieves an overall GHG emissions reduction of nearly 30Mt CO_2/yr. It brings emissions from agriculture and land use down by 38% to 47.5Mt CO_2/yr by 2050, with 28.3Mt CO_2/yr of this (60%) offset by carbon sequestration from forestry, agroforestry and green infrastructures. This leaves 19.2Mt CO_2/yr emissions remaining from agriculture. To put this in context, the *Sixth Carbon Budget* from the Committee on Climate Change provided a range of potential scenarios for 2050 emissions from agriculture ranging from pessimistic (26Mt CO_2/yr) to optimistic (−14Mt CO_2/yr).[28]

What Next?

The IDDRI model shows the potential for carbon sequestration through agroecological systems is considerable. But there are areas of uncertainty and different plausible pathways for realising carbon sequestration through food system and land use change in the UK and globally. Other modelling studies like the FABLE Consortium employ different assumptions to those made in the IDDRI model, resulting in different pathways to carbon reduction.[39] Further work will compare the assumptions made here with those in other models.

Key questions remain around the IDDRI model's assumptions which require further discussion, dialogue and research. What trade-offs do carbon focused outcomes require of land use? Do we focus on optimising for carbon outcomes or do we need to strike more of a balance between biodiversity, food production and future trade possibilities? What carbon mitigation options could be further applied to this model? And particularly, what is the potential carbon sequestration of soils from different agroecological farming practices?

With COP26 in Glasgow this year, there are big policy opportunities to make the case for agroecology as a nature-based solution to climate change, as a way of realising a just rural transition, and to integrate food and land use systems into the climate change discourse. There is already a huge amount of work being done in government through the Climate Change Committee, in business and industry through the Global Resources Initiative, and by farming bodies like the NFU and their commitment to net zero by 2040. It will be important to compare the implications of the IDDRI modelling alongside all this other work.

At FFCC, we will be working with our Farming Leadership Group, our network of county and country inquiries and other partners, to explore opportunities during governments' transition periods out of CAP, to test and trial agroecological policy approaches and farm practices. We will also continue to make the case for a more strategic approach to land use in England through a land use framework.

Ian Boyd, Whittington Lodge Farm, Gloucestershire

Whittington Lodge Farm produces carbon neutral beef near Cheltenham. The farm prioritises soil health, fertility and wildlife.

"How we farm now meets the definition of agroecology which, to me, means food production that makes the best uses of nature's goods and services while not damaging those resources.

Regular bird surveys show us that wildlife on the farm is increasing dramatically since our transition to agroecological practices. Greenhouse gas emissions have reduced and, through using the Carbon Cutting Toolkit, we now know the farm is a net sequestrator of carbon.

The organic and Pasture for Life certifications have allowed us to build a strong brand that enables direct-to-consumer sales of beef, allowing the farm full benefit of the value of the finished cattle.

With the anticipated loss of the Basic Payment Scheme and proposed Environmental Land Management Scheme, farmers are increasingly realising that they will need to change. Importantly, it is entirely possible for the farming system at Whittington to be scaled up to much larger farms."

6. The Livestock Question

WHAT ROLE SHOULD RUMINANT LIVESTOCK PLAY IN THE FUTURE UK FOOD SYSTEM?

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WHAT ROLE SHOULD RUMINANT LIVESTOCK PLAY IN THE FUTURE UK FOOD SYSTEM?

A substantial reduction in meat and dairy, as assumed in the model's dietary shift, presents quite a challenging picture for the UK livestock industry. However, we need to dig a little deeper to properly understand the consequences of this on the land and what farmers produce.

The model seeks to deliver both climate and biodiversity outcomes, without compromising food security or offshoring production. It tackles the issue that ruminant livestock have morphed into the climate villain of global agriculture and explores what happens when you view ruminant livestock from an ecological perspective in the context of UK ecosystems, without conflating the arguments with production systems in other countries.

This model puts ruminant livestock right at the heart of a functioning, balanced agroecological system.

In recent research, Rowntree et al explore the opportunities to capitalise on livestock's ecological role as biological up-cyclers and their role in integrating crop and livestock systems as well as wider ecosystem services.[40] The research demonstrates livestock can play an essential ecological function in nutrient cycling, soil health, biodiversity and building resilience to climate change while also reducing emissions. With this research, the latest in a series of publications demonstrating the vital ecological function of grazing livestock, the model puts ruminant livestock right at the heart of a functioning, balanced agroecological system. This is rooted in an appreciation of the UK agrarian climate and the natural productive potential in UK grasslands to support grass-fed livestock. Without them, farmers would not be able to harness the potential of our grasslands to produce nutrient-dense protein, resulting in offshoring of food production. Ruminant livestock's capacity to improve soil fertility through transferring organic fertilisers between grasslands and crops would also be missed.

We talk about ruminant livestock here because to provide for the diet, land use change and ecological function needed in a UK landscape, extensively grazed cattle are the primary actors. While livestock production as a whole declines by 36% in a 2050 IDDRI scenario, beef production remains relatively stable compared to all other sectors (fig 4). As a result of the reduced beef consumption of 25% associated with the dietary shift in the model, but retaining pasture-based beef output, the UK ends up with a surplus of high welfare UK beef (+24%) for export, whereas the UK is a net importer today.

Figure 4: Change of physical production and domestic coverage for livestock between 2017 and 2050

	2017 (DEFRA 2017)	2050 (model)	2017	2050
MILK	14,964,373 t	8,450,595 t	106%	100%
BEEF	904,344 t	878,559 t	81%	124%
SHEEP	308,785 t	204,622 t	101%	80%
PIG	867,278 t	484,671 t	61%	114%
POULTRY	1,839,741 t	978,539 t	90%	99%
EGGS	748,314 t	398,020 t	86%	107%

Meat production units are tonnes of carcase deadweight

DOMESTIC COVERAGE

High deficit → Balance

Potential for export

The model acknowledges ruminants as a GHG contributor, with enteric fermentation and associated methane emissions from ruminant livestock contributing 28% of remaining agricultural emissions in 2050. However, through this process they are also able to transform nitrogen from UK grasslands into an organic fertiliser that is far less volatile than nitrogen in its synthetic mineral form. Instead of only considering their climate impact, we can account for the underutilised benefits ruminant livestock can provide in nutrient cycling in the absence of synthetic fertilisers, in managing biodiversity rich pasture, and as a strategic farm business asset generating value from UK's naturally rich grassland base.

Viewed in this way, it is relatively climate efficient to tolerate a reasonable amount of enteric fermentation in order to supply organic nitrogen fertiliser and to eliminate synthetic nitrogen and associated carbon costs. This model demonstrates a more sophisticated appreciation of the role of ruminant livestock in a future UK food system, beyond current generalised views at a global level on their climate impact. Despite the reduction in overall numbers, their central role in the functioning of an agroecological food system must be taken into account.

What Next?

The IDDRI model highlights the integral function of ruminant livestock in a UK agroecological system by taking a holistic view. Though ruminants are recognised as significant GHG contributors to total agricultural emissions in 2050, their benefits as nutrient cyclers, managers of biodiverse grasslands and providers of nutrient-dense protein, while enabling a reduction in the offshoring of food production and an elimination of synthetic nitrogen use, must also be accounted for.

Key questions arise on how best to measure the cost–benefit of ruminant livestock in a UK food system, not only accounting for their climate and environmental costs, but also their ecological function and economic potential. There are also questions to be answered on where barriers and opportunities lie in the integration into arable farming systems of ruminant livestock managed under agroecological practices. This includes the need for further research on methane mitigation through livestock health, genetics, feeds and the tackling of epidemic disease such as bovine TB, and the ramifications of these on opportunities for mixed farming landscapes. Further research is also required from a dietary perspective on the impacts of agroecologically produced red meats on human health.

At FFCC, we are working with a network of partners across the UK, to research, explore, reframe, and facilitate discussion around the role of ruminant livestock in a UK food system. Part of this work will include exploring the potential of agroecological practices organised at the landscape level within England's Environmental Land Management Scheme.

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Rob Havard, Havard & Co Organic Farms, Worcestershire

Rob farms over 1,000 acres which have been in Environmental Stewardship Schemes for over 10 years. The main operation is pedigree grass-fed, organic Aberdeen Angus breeding cattle which are fattened on grass and herbs alone.

"Our cattle are fed on grazed grass and hay using a system of 'deferred mob grazing', which means leaving grass later and grazing at higher covers. The pastures are then rested for an average of 60 days to grow. This Holistic Planned Grazing aims to avoid re-grazing the growing plant and to maximise regrowth and rest periods. The method also contributes to soil health with the cows lifting soil organic matter to 12–15% on some parts of the farm.

As such, part of the work is also land regeneration, creating and restoring native species-rich grassland and making the most of the natural biodiverse pastures the farm is situated on, proving simultaneously that they can be productive and valuable for fattening stock. Populations of wild birds have been increasing annually, as well as wildflower species, which have increased butterfly counts as well as other beneficial insects and pollinators.

Meadow foxtail gives early and late grazing while herbs and legumes like ribwort plantain and birdsfoot trefoil create a wider mineral profile in the forage for the grazing animals, along with good protein levels to help provide a balanced, healthy diet. The livestock thrive on the pasture diversity that provides all their needs, allowing them to be fattened on grass and natural herbs alone.

Importantly, these methods of grazing shorten the housing period, cutting costs while also cutting costly inputs such as fuel, contracting and machinery by using a low-input system, based around mimicking nature. Variable costs have also been reduced – no hard feed or mineral supplementations and no routine use of vaccinations or wormers.

Holistic Planned Grazing has made the most of diverse native pastures and has restored many acres of native species-rich pastures. Using grazing techniques that are based on recreating natural processes allows us to grow fitter cattle for less money while leaving the land in a better state than when we found it."

7.

The Productivity Question

WHAT IS THE YIELD POTENTIAL FOR AGROECOLOGY AND HOW ELSE MIGHT IT DRIVE PRODUCTIVITY?

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WHAT IS THE YIELD POTENTIAL FOR AGROECOLOGY AND HOW ELSE MIGHT IT DRIVE PRODUCTIVITY?

Are agroecological farming practices less productive? Taken at face value the answer to this question is nearly always yes; but examining that presumption in more detail reveals big questions in two critically important areas: yield and natural capital.

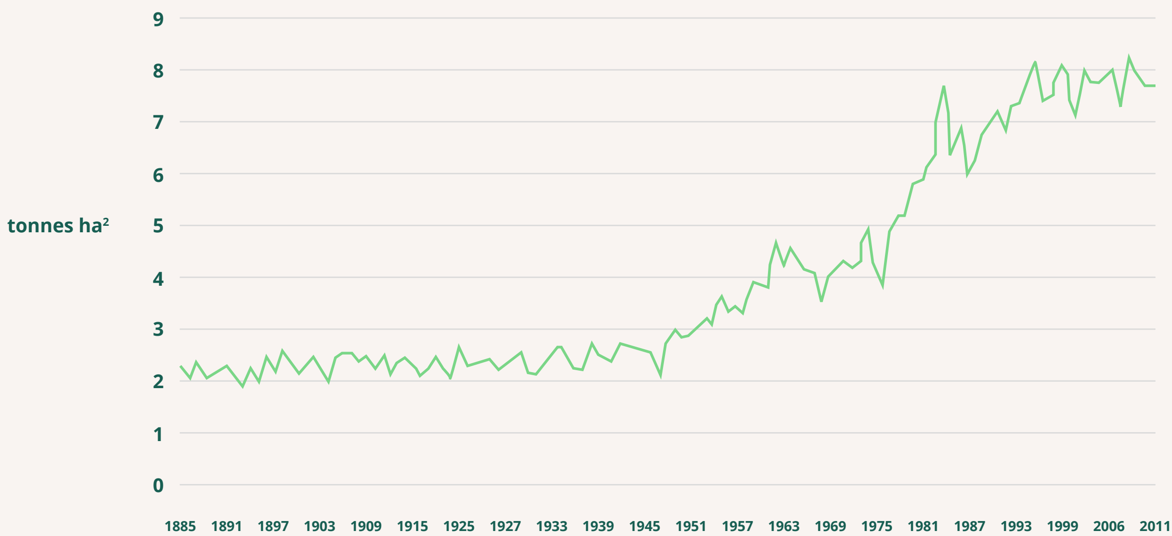
Yield

Yield has always been thought to be the Achilles heel of an agroecological future, but considering some of the agronomic dead-ends some conventional practices are coming up against and the potential disruption of climate change, a food system built on a lower but more robust and less volatile yield base could become more desirable.

Taking wheat yields as a worked example, Figure 5 shows the development of yields in the UK over the past century, with both a plateau and increased variability in the past decade. In 2019, NFU Harvest Survey data reported the smallest UK harvest since 1981 with yields down 15–18% across key commodity crops.[41]

Figure 5: UK wheat yields 1885 – 2011

(Source: Defra.)



There is now a clear production risk associated with business-as-usual agricultural intensification.

Climate change with the increased extremes in weather is one key explaining factor, but dysfunctional agro-ecosystems, the health of soils and the associated impact on the ability of existing farming systems to cope with these extremes, must also be considered. Is it the case that technology and efficiency is the limiting factor in yield potential or is it that crops are now in an agronomic cul de sac caused by the perfect storm of resistant pests, poor soil health and extreme climate events?

Regardless of cause, banking on continual productivity gains through incremental technical efficiency and future potential yield gains deserves scrutiny, even if it appears to be the most palatable pathway at the moment. Its attractiveness in the context of current metrics is a key feature – but this is offset by its relatively poor performance on biodiversity. The questions remain: can yields return to an upward trajectory and how far can technical efficiency take us towards delivering climate goals and nature recovery? What are the risks associated with this pathway and how robust is it in the face of future climate change?

There is now a clear production risk associated with business-as-usual agricultural intensification. While it promises more efficient, low carbon farming, generating economies of scale, delivering high output at low prices for the agri-food chain, what if the production output is not reached and the chain of socio-economic advantages is put at risk? There are potential retrofit solutions to address these impacts if they occur, either through insurance or calling for public funds to support food production, but none would be particularly economically palatable within the context of current capital-intensive business models or in the present government's policy intentions.

Taken in comparison, an agroecological scenario that builds a 'no regrets' foundation – one with considerable room for manoeuvre to develop more climate resilient landscapes, to build soil health and ecological diversity, with the flexibility to explore alternative land uses, and able to support diverse types and scales of businesses – feels no less promising in terms of a future pathway. It is perhaps more robust considering future ecological and climatic uncertainty. And whereas the food production output is not as attractive in the short and medium term, this could be tackled by interconnected – and necessary – policy interventions, on diet, consumption and waste.

The model's assumptions are based on the meta-analysis of organic yields carried out by Ponisio in 2015.[42] These project a positive scenario for organic systems in northern Europe with organic yields increasing 15% by 2050 as a result of a more favourable climate. In southern Europe, due to a relatively harsher climate, yields decline by 20%. At a UK level IDDRI has broadly assumed in the model no climate impact on yields for the croplands of the east and north-east and a slightly positive impact in the grasslands of the west and north-west. However, we need to account for generalised organic baseline yields being lower than conventional due to absence of synthetic fertilisers and so assume a yield reduction of −25% in the north and east of the UK and −17% in the west. In the IDDRI model this results in an average yield of 5.7t/ha for cereals in TYFA UK 2050 against conventional yields of 7.8t/ha today. This is a relatively positive situation for the UK with a low risk of climate impact on future 2050 yields, and a yield penalty in the west of the UK that is relatively advantageous compared to other regions in Europe.

Our enhanced understanding of soil life opens up potential to support increased agroecological production without the use of synthetic inputs.

This may still be a conservative assumption due to the scope of potential yields being demonstrated by the broad range of agroecological systems. A recent meta-analysis by Tamburini et al looked at the impact of diversity in agricultural systems and found no negative impact on yields, but great enhancement in the regulatory ecosystem services that govern yield, with greater potential for increased yields in the long term compared to conventional farming practice.[43] However, this is based on what we know now, and we are only just starting to grapple with some of the potential of biological systems, particularly in soils. It would be just as reasonable to assume a higher organic yield baseline by 2050 due to advances in knowledge and technology in agroecological systems. Our enhanced understanding of soil life – with the rising domain of micro-life and nutrient flows in underground networks, and of biological controls that utilise landscape ecology perspectives – opens up potential to support increased agroecological production without the use of synthetic inputs. In this field, further research on nitrogen fixation and improvement of legumes of all kinds is a crucial sector to investigate to enhance agroecological production. Nitrogen fixation is, in the end, the critical variable of the overall productivity of agro-ecosystems freed from synthetic nitrogen.

So, from a yield perspective, the UK acts as a strong candidate for the consideration of agroecology. The other outcomes of the model are only possible in the UK because of these potential yields in a future 2050 scenario. Without such yields, we would need to revise the outcomes in terms of overall land use which currently provide an encouraging amount of flexibility for alternative uses. Crucially the model faces up to the impact of future climate change, while also unlocking the potential mitigation options in land use change.

Natural Capital and Ecosystem Services

Synthetic inputs have underpinned productivity gains in agriculture for a long time and farming has become progressively more efficient in their use, but the question remains as to where a farming system that remains dependent on synthetic inputs (even at incrementally reduced levels) ends up, when taken to a logical conclusion. Arguably it remains dependent on technical interventions largely in conflict with nature, and following farming processes that often stem from generalised approaches, or multinational interests that do not fit a farms' true productive potential. These often prioritise short-term yield gains, compromising wider ecosystem services that could support yields and productivity in the longer term.

It's time to rethink productivity separate from the influence of synthetic inputs and generalised policy, and consider more multifunctional land uses, built on natural processes and local competitive advantages, that work together to maximise synergies in the wider landscape. What is the true potential of land when considered from the point of view of working in harmony with nature, rather than against it?

That potential may be about working with a farm's natural capital. This may be the climatic opportunity to produce nutrient-dense meat and dairy off grass in a maritime climate, or it may be a landscape opportunity for habitat protection and woodland creation, or a geographic opportunity for public access, energy generation or local food chains. Farmers are finding more opportunities to produce multiple outcomes of these types, off the same land. And crucially farmers are finding more and more ways to farm with nature in the middle of fields, rather than compartmentalised around the edges. These are ecological food production systems, which build diversity and optimise the natural synergies between soils, trees, crops and livestock to deliver more enterprise and output off the same land, utilizing space in both the vertical and horizontal dimensions.

What Next?

The IDDRI model shows some of the challenges and complexities with defining productivity in agroecological systems. From an output potential based on today's conditions they are less productive, but take a long-term, whole-systems perspective that factors in future climate risk and the view is somewhat different. There are many questions that still need answering. How does yield potential change across different types of agroecological farming practices in different farming systems across different areas of the UK? What are the productivity pros and cons of different pathways for agriculture in the UK in the context of future climate change? What further research is needed to better understand the interaction of nitrogen and carbon in soils, and potential ways to reduce losses to the environment from biological nitrogen fixation and in the application of manures? What policy interventions would deliver more multifunctional land use to deliver against food security, public health, climate and nature outcomes?

In England, Scotland, Wales and Northern Ireland, post-CAP agricultural transition and environment plans provide policy opportunities to explore the contribution agroecology can make to the food system. Farmer-led research networks such as Innovative Farmers, LEAF (Linking Environment and Farming), FWAG (The Farming and Wildlife Advisory Group), PFLA (Pasture for Life Association) and the Nature Friendly Farming Network are already making great strides in examining these questions at the farm level, but to provide confidence in the potential of these approaches, funding is required from research councils to test initial findings and initiate larger scale field trials.

Stephen and Lynn Briggs, Whitehall Farm, Cambridgeshire

Stephen and Lynn are tenant farmers who have integrated trees into their wheat, barley, clover and vegetable-producing business, establishing the largest agroforestry system in the UK.

"Wind erosion affects the fine, grade one soils on the farm, so we planted apple trees in rows as windbreaks, but also to produce fruit. It's efficient, multifunctional use of land. It's getting more for the same area – through three-dimensional farming – while helping manage the risk of climate change by having a mix of perennials and annuals.

It has delivered everything we wanted. It's making us more income, delivering soil protection and biodiversity benefits. We've increased soil organic matter and improved soil structure, which is boosting our overall farm productivity. Productivity increases also result from making the farm bigger, with the agroforestry trees expanding land use in three dimensions, being deeper rooting and using more space above ground than annual crops.

Our 52 hectare silvoarable agroforestry scheme cost an initial £65,000 to establish in 2009. In total, 8% of the land is planted with trees and the remaining 92% is cropped under the existing cereal rotation. It took five years for the trees to mature into full production. The fruit yield per hectare is now similar to the surrounding arable crop, with gross margins typically around £1,000/ha. The young fruit trees will continue to grow and increase to peak yield in year 15.

A key part of profitability is the ability to add value to farm outputs. Adding value to commodities like cereals is difficult, whereas there is greater potential to increase the value of the fruit through processing into juice or direct sales. We have built and opened a farm shop to benefit from the direct retail. Because of the agroforestry, we've also been able to employ someone full-time on the farm as there is an even amount of labour throughout the year – there's plenty of pruning and management of the trees to do over winter."

8.

The Nature Question

HOW COULD AGROECOLOGY HELP RECOVER BIODIVERSITY AND MAKE MORE SPACE FOR NATURE?

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HOW COULD AGROECOLOGY HELP RECOVER BIODIVERSITY AND MAKE MORE SPACE FOR NATURE?

Loss of biodiversity is just as catastrophic as climate change.

The IDDRI model focuses on the potential of an agroecological food system, built off a foundational layer of biodiversity in all aspects of the landscape. It does not seek to confine biodiversity to set parts of the landscape or indeed set parts of the field, but rather to embed ecological richness throughout the whole system. And it is important to see this as a whole system, because it is only through being able to utilise natural synergies between farming and nature that the model is able to function without chemical sprays or synthetic nitrogen. As a result, the model is built off a more mixed farming system, characterised by low levels of synthetic inputs and low stocking.

At the landscape level this means breaking down the agricultural specialisation between grasslands and arable production in the west and east of the UK. In the western grassland areas this means reversing the current trend away from arable cropping (declined by 1.6m hectares since the 1950s) and increasing, for example, the area allocated to cereals by more than 500,000ha or 67%. This is achieved largely through a substantial reduction in the area of intensively managed grassland and fodder crops. In the eastern arable areas this means halving the area allocated to cereals and increasing the area of permanent grassland by 730,000ha or 64%.

The model also doubles the area for green infrastructures from 300,000ha to 603,000ha or from 2% to 4% of total agricultural area, and a seven-fold increase from 177,000ha to 1.2m hectares in agricultural land area for alternative uses, such as afforestation. All of these macro-landscape-level changes provide a more diverse foundation from which to approach the challenge of building soil fertility and managing pests and weeds in the absence of synthetic inputs and controls. It means there is more opportunity to balance nutrient sources (livestock) and nutrient sinks (crops) due to geographic proximity and there are longer more diverse crop rotations combining legumes, oilseeds, root crops and cereals. These practices, combined with more green infrastructures to host predators and associated ecological controls, will support genuine improvement in practices like integrated pest management on which food production will depend.

An agroecological system works best when practices are designed in synergy, and at fine grain in the landscape. For example, in contrast to approaches to afforestation which section off large tracts of land for tree planting, the model places these throughout the farmed landscape, either through silvopastoral and agroforestry systems (which also assist climate resilience), or through establishing farm woodlands at scales of around 10ha, instead of in monocultural blocks of hundreds or even thousands of hectares. An important design feature in the model is mosaic landscapes, where crops, livestock and green infrastructures are all mutually reinforcing, so that the wildlife in an orchard is supported, for example, by the surrounding crops and habitat corridors.

Without addressing foundational layers of biodiversity and all of its hierarchical interdependencies from the soil ecosystem to the field to the landscape scale, we will not achieve the ecological richness needed to progress agricultural practice without synthetic inputs.

What this looks like in practice is a patchwork of landscapes that include smaller field parcels; more hedgerows, more copses, more wetlands; and functional habitat corridors that sustain a range of biodiversity and wildlife. This matters, for without addressing foundational layers of biodiversity and all of its hierarchical interdependencies from the soil ecosystem to the field to the landscape scale, we will not achieve the ecological richness needed to progress agricultural practice without synthetic inputs.

This is the fundamental issue that land-sparing approaches alone fail to resolve. All land matters and can support food, nature and climate outcomes together, under one system, better than it can if artificially segregated in siloed, monocultural landscapes. Without a fundamental layer of micro-life – bacteria, fungi, insects, earthworms – there is much diminished capacity for a flourishing food system. A tree in a monoculture landscape may offer a good refuge for a bird of prey, but what if there is no small animal to catch? Here we come back to the intrinsic need to have low-input farming not as a niche proposition fragmented across the countryside but at a landscape level so its full potential can be reached.

Land-sparing approaches in which large areas are devoted to nature-based solutions, to reverse climate change and for restoring biodiversity – such as tree planting or rewilding – can appear attractive propositions. While the ambition certainly matches the urgency of the climate and nature challenges, the trade-offs require intensification of farming elsewhere, that potentially reduce diversity and resilience in the farmed landscape. To mitigate this risk, the notion of 'sustainable intensification' has been proposed, defined by Pretty et al "as a process or system where agricultural yields are increased, without adverse environmental impact and without the conversion of additional non-agricultural land".[44] Latterly, however, the notion of sustainable intensification has started to include more controversial practices, focused largely on the first clause of that definition, such as genetic modification and gene editing, and intensive poultry and pork production systems, as well as the less contentious practices originally envisaged in the definition, such as aquaponics and 'stacking' methods like agroforestry, silvopasture, and vertical and indoor farming.

Discussions on intensification can leave unresolved the costs and trade-offs associated with high-input, high-output agriculture including the impact of high nitrogen excesses on our air and water quality, dependency on crop protection products and the associated impacts on biodiversity and the cost of ever greater stocking densities on animal welfare. Intensification from a purely agronomic level comes with its trade-offs; but in socio-economic terms too, it raises questions of power, control and fairness in the food system, and about which type of food and farming system contributes to other co-benefits, such as increasing and sustaining jobs and protecting diverse farming communities, in a living, working countryside.

What Next?

An agroecological system points to a smarter, more knowledge-intensive approach to designing our farming systems at the landscape scale beyond the apparently simple and blunt combination of grassland, crops and forestry blocks towards which the intensification pathway is leading. For a truly resilient food system which supports nutrient cycling, nature and food production without using synthetic inputs, we need to unlock the right combination of these elements at the right scale.

But what policy levers and incentives would support diversification of the farmed landscapes with more mixed farming practices and systems? What opportunities are there to progress tree planting objectives at a smaller level, integrating trees across our landscape rather than large, confined areas?

Important policy questions arise from the research, such as what policy levers and incentives could support diversification of UK farmed landscapes and what opportunities are there to accelerate current rewilding objectives from concentrated locations to ones integrated across UK landscapes? There are also questions surrounding the impact of transition: Do the benefits attributed to removing synthetic inputs justify the cost and complexity of organising a mixed farming landscape? And what would a transition to this kind of landscape entail from a specialised arable area and a specialised grassland area? Some questions require further research such as on the optimisation of integrated pest management approaches and the suitability of certain mixed farming agronomic practices to specific UK locations.

Mark and Liz Lea, Green Acres Farm, Shropshire

The Leas farm 450 acres of organic land in Shropshire. A system built on the belief that sustainability requires diversity.

"The farm works on a five-year arable rotation, which is mixed with clover leys grazed by cattle and sheep, as well as producing red clover seed. Cropping includes milling oats, peas for human consumption and fourteen different milling wheats.

Our use of companion cropping – growing crops together to provide mutual benefits such as pest control, higher yields or improved pollination – as well as diverse cover crops and agroforestry all contribute to the resilience of the farm. We also run a composting enterprise on the farm and the product from this has contributed to the substantial increase in soil health here over the last twenty years.

We're proud to farm in a way that contributes positively to biodiversity and soil, air and water quality while producing healthy food that is in genuine demand."

9. Looking Ahead

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"In any probable future, we will have to adapt to temperature increases and climate changes in the UK."

Chris Stark, Climate Change Committee

"We cannot tackle the climate crisis without similar ambition to meet the nature crisis head on – the two are inseparable. The climate crisis is driving nature's decline while the loss of wildlife and habitats leaves us ill-equipped to reduce our emissions and adapt to change."

Craig Bennett, The Wildlife Trusts

"A business that pins all their hopes on the R&D department is a risky investment ... if we don't take significant action to both reduce emissions and adapt right now, we're on a hiding to nothing."

Emma Howard Boyd, Environment Agency

"But the task is large, the window of opportunity is short, and the risks are existential."

Mark Carney

"... to move forward, we need nothing short of a paradigm shift, one that inspires action at revolutionary levels and pace."

HRH Prince of Wales

During the spring and summer of 2020, in the early stages of the Covid-19 pandemic, several things became quickly apparent. In times of crisis, we rely on fundamental – foundational – things: having somewhere safe to live and enough nourishing food to eat; care and companionship of family and friends; space in the outdoors and nature.

Instead of being the 'super-year', in which countries redoubled their efforts to tackle the climate and nature emergencies, 2020 has shown up, in sharp relief, the fragilities and fault-lines in a functioning society the mature economies tend to take for granted. For farmers in the UK, the year started with floods, followed quickly by droughts, followed by reduction in yields. In other parts of the world – Australia, California – fires ravaged the countryside. In eastern Africa plagues of locusts decimated staple crops. In countries around the world, the global food system is being disrupted by increasingly frequent 'unprecedented events'. Covid-19 dislocated life on an unparalleled global scale within months, transforming whole sectors of the economy.

Now, people are turning their attention to the recovery, tackling the interconnected challenge of climate, nature, health and economic crises, while setting a path for a fairer, more resilient and sustainable society. The UK food and farming system is right at the heart of this urgent task.

FFCC commissioned the IDDRI research to examine whether it is possible to feed a UK population through a shift to agroecology. And if it is, what are the implications, for governments, businesses and society? The IDDRI model shows that it is plausible, and that a transition to agroecology also points to many potential co-benefits. It confirms that any potential solutions which focus on single issues alone are likely to be only partially successful at best, and at worst set up further risk and fragility elsewhere in the system. The five 'sentinel' questions we have explored in this report reiterate the profound relationships between climate and nature, business productivity and farming systems, diet and health, as well as signalling further questions to be explored, for a fair and sustainable transition – fair to farmers and growers, businesses, citizens and communities.

The Global Movement

2021 is now the Super Year for action on sustainability, from net zero to the SDGs.

In advance of the Food Systems Summit, COP15 on biodiversity and COP26 on climate change, among others, many countries are now incorporating agroecological actions into their agriculture sectors to support their Nationally Determined Contributions (NDCs). Our partners, the Food and Land Use Coalition, a global network committed to transforming the food system for the health of people, nature and climate, describe 'Ten Critical Transitions', incorporating agroecological principles[45] and laying out practical actions for farmers everywhere. And many countries are already developing food system strategies for resilience and adaptation, rooted in agroecological principles.

> **"In Andra Pradesh, in India, 6 million farmers have committed to encouraging what they call zero budget natural farming, based around closed-loop approaches, utilising cows and their manure; no synthetic fertilisers or other chemicals; using local seed and minimum tillage. Sikkim has made the commitment to convert all agriculture to organic. The UAE is proving a world leader in using hydroponics and vertical farming to produce crops on otherwise arid terrain, developing drought-resistant crop strains. In Columbia, 1 million food producers are receiving 'agro-climatic' information via specialised technology to help them make 'climate-smart' farming decisions. Cameroonian agroforestry is a long-established way of growing crops – often cacao – in forest land without devastating natural habitats and of building social resilience by diversifying rural farmers' income. In sub-Saharan Africa, intercropping different produce in proximity, including pollinator plants, is widely used. Ecuador campaigns for responsible consumption of agricultural produce resilient to the effects of climate change."**[46]

The shift to agroecological principles and practices is now a global movement and has the backing of countries, businesses and landworkers' movements around the world. These are radical shifts but are fundamentally practical and action orientated, both plausible and fair, for now and future generations.

Fertile Ground for Further Inquiry

Good research throws up fresh questions. Following the publication of this report we will be testing the modelling in the diverse realities of people's lives, livelihoods and landscapes. We will seek views from businesses, organisations, individuals and communities in different parts of the UK to explore the questions and trade-offs around land use, food production, carbon sequestration, the applicability of the model for devolved nations, dietary change and on-farm management practices.

In navigating a safe and sustainable route to 2030, a resilient pathway will more likely be a broad and inclusive one. Working with partners, on the difficult questions and the practical steps, we are finding common ground towards a more sustainable future, in which agroecology signposts a promising path.

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The Food, Farming and Countryside Commission focusses on food and farming, climate, nature and the public's health, for a just transition to a greener, fairer world. With partners in governments, businesses and communities, we generate radical ideas and practical actions to transform our countryside and our economy. We help convene collective leadership on the difficult questions and resource communities to become more resilient and adaptable for the challenges ahead.