Food, Farming & Countryside Commission

NOVEMBER 2020

Farming Smarter

The case for agroecological enterprise

About the authors

TONY GREENHAM

Tony is a Senior Fellow of the Finance Innovation Lab and was previously Director of Economics at the RSA and Head of Finance and Economics at the New Economics Foundation. His publications include 'People Powered Prosperity: Ultra-local approaches to making poorer places wealthier', 'Where Does Money Come From? A guide to the UK monetary and banking system' and 'The British Business Bank: Creating good sustainable jobs'. Tony's early career was in the City as a chartered accountant and investment banker with Barclays and Credit Suisse. He is currently the Executive Director of South West Mutual, a regional mutual challenger bank serving the south west of England, and part time Company Secretary for the Food, Farming and Countryside Commission. Tony has a MSc in Environmental Assessment and Evaluation from the London School of Economics and a BA in Philosophy, Politics and Economics from the University of Oxford.

MARCUS LINK

Marcus is co-founder and CEO of New Foundation Farms, a disruptor enterprise in the agricultural sector with the mission of establishing a scaled regenerative food and farming enterprise in the UK. As an entrepreneur he has been involved with successfully delivering complex innovation projects in education, agriculture and digital business. He is a co-founder and co-curator of the Holos Earth Project. Marcus holds a degree in Philosophy and Religious Studies and a business qualification focusing on start-up management. He is a fellow of the RSA.

Acknowledgements

The authors would like to thank Duncan McCann who was part of the larger study on the role of an Agroecology Development Bank in the transition to agroecology in the UK in which this piece has its origin. The nature of such an Agroecology Development Bank will be the subject of a separate piece.

We have undertaken desktop research augmented by a number of stakeholder interviews and are grateful to Andrew Voysey (Soil Capital), Alice Hu Wagner (British Business Bank), Mark Suthern (Barclays Bank) and Oli Rodker (Landworkers Alliance, Ecological Land Cooperative) who gave up their time to give us the benefits of their insights and experience. Our thanks to Walter Jehne (Regenerate Earth) and Ethan Soloviev (HowGood) who shared their extensive insights into the potential for regenerative agricultural approaches. We are also indebted to Sue Pritchard and David Fursdon from the FFCC for their comments and suggestions.

Furthermore, we acknowledge the significant role of Paul McMahon's white paper 'The case for investing in ecological farming',[1] which has provided the basis for our global perspective on macroeconomic trends in agriculture. It provides an excellent summary from an economic perspective and we have allowed ourselves to quote liberally from his work so as not to reinvent the wheel.

The views in this report are solely the authors and we do not claim that this report is a comprehensive survey.

Food, Farming & Countryside Commission

Contents

1	**Executive Summary**	**6**
2	**A note on terminology and frameworks**	**11**
3	**Home farm truths: an ecological and financial audit**	**13**
3.1	The true cost of industrial agriculture	**13**
3.2	The financial state of UK farms	**19**
3.3	Implications for policy	**26**
4	**Agroecology: the real green revolution**	**31**
4.1	Agroecological principles	**32**
4.2	History, levels, and lineages of regenerative agriculture	**35**
4.3	The potential to produce more from less	**40**
5	**Agroeconomy: farming smarter not harder**	**43**
5.1	Theoretical framework: from gross yield to value added	**44**
5.2	Evidence: from incremental productivity improvement to systems-level shift	**45**
5.3	Evidence: a study of small agroecology farms in the UK	**37**
5.4	The implicit strategy of agroecology	**50**
5.5	Agritech and agroecology	**51**
6	**Barriers and levers for change**	**54**
6.1	System inertia: Eight lock-ins preventing progress	**54**
6.2	Barriers to and drivers of adoption of regenerative agriculture in the UK	**57**
6.3	Research and knowledge dissemination	**59**
6.4	Investing in agroecology at pace and scale	**61**
6.5	Supporting the agroecological entrepreneur	**64**
7	**Conclusions and recommendations**	**67**
8	**Case studies**	**74**
9	**Endnotes**	**80**

We have used the following acronyms frequently throughout the document:

AE = Agroecology/-ical
BPS = Basic Payment Scheme
CAP = Common Agricultural Policy
ELMS = Environmental Land Management Scheme
GHG = Greenhouse gas
GVP = Gross Value of Production
IPES-Food = The International Panel of Experts on Sustainable Food Systems
NAO = National Audit Office
UN FAO = United Nations Food and Agriculture Organization
VA = Value Added.

1. Executive summary

1. Executive summary

There is a transformation underway in UK farming towards approaches that enhance environmental services, restore natural capital, contribute to low carbon transition and produce healthy food while supporting rural livelihoods.

The UN labels the broad range of approaches to agriculture which integrate positive ecological and social outcomes as agroecology. In other contexts, such approaches are being referred to as *ecological farming* or *regenerative agriculture*. We use all three terms throughout the report and have provided a brief history of the concepts. We acknowledge the lack of a settled consensus around terminology and conceptual frameworks in these fields, but suggest that common ground can be found in the proposition that approaches based in sound ecological understanding, and adapted to local conditions by skilled farming entrepreneurs, can both improve ecological and health outcomes and drive superior profitability in farming.

In other words, the opportunity in UK agriculture is 'farming smarter, not harder'.[2]

Common ground can be found in the proposition that approaches based in sound ecological understanding, and adapted to local conditions by skilled farming entrepreneurs, can both improve ecological and health outcomes and drive superior profitability in farming.

While this report focuses on the UK, the transition to agroecological approaches is happening elsewhere in the world. Major brands are adopting *regenerative agriculture* at significant scale as we write. In 2019, US-based General Mills announced that 1 million acres of their supply chain will be transitioned to regenerative practice by 2030.[3] In September 2020, Walmart and Cargill both announced their commitments to transitioning 50 million acres[4] and 10 million acres,[5] respectively, to regenerative practice. In 2009, SLM Partners invested in 480,000 hectares of grazing land in Australia for beef cattle production using regenerative approaches[6].

To put this into perspective, the total land area of 62+ million acres affected by these three corporations alone exceeds the total land area under agricultural management in the UK (23.7 million acres) by a factor in excess of 2.5. The regenerative beef cattle initiative referred to above is equivalent to 5% of the UK's agricultural land. There is no effort in the UK we are aware of which matches the scale of this ambition. Here, we are still wrestling at the levels of practice, policy, finance, education and research, and how to bring this together in a framework once we leave the EU and its Common Agricultural Policy-based Basic Payment Scheme (BPS).

This review, therefore, is intended as an introduction to the thinking and principles behind such smarter approaches to agriculture and land management. We consider how we might transition to such approaches at pace and scale, what hinders them from being adopted more quickly, and map out the landscape and frameworks for assessing the effectiveness of agricultural approaches. It is beyond the scope of this review to provide answers to questions regarding consumer habits, affordability, demand and supply issues, the structure of dominant retailers and other important considerations. Nonetheless, we have made several conclusions about the direction of necessary further research.

WHERE ARE WE NOW? THE FINANCIAL AND ECOLOGICAL STATE OF UK FARMING

Drawing on the well-established economic theory of externalities, we identify six major hidden costs of dominant forms of industrialised agriculture: climate change, water pollution, poor nutrition, toxic chemicals, antibiotic resistance and destruction of biodiversity.

We set out four major threats to business as usual that establishes a strong case for a rapid and large-scale transformation in farming methods:

1. degrading natural assets
2. high and volatile input costs
3. vulnerability to a changing climate
4. shifting consumer trends

These threats are posed to an already financially precarious industry. The apparent financial strength of the UK farming sector as measured by asset values, which are fundamentally driven by increasing land prices, in fact masks considerable fragility of farming businesses. Based on the latest data, the average farm business income was £50,400 but only 12% of this was from agricultural activity, with 62% coming from subsidies and 26% from diversification. (In 2018, 42% of farms in England were profitable only with subsidy, and a further 16% were not profitable even with subsidy.) Combined with the uncertainty of future farm incomes from the changing and reducing level of government subsidy, the conditions are not conducive to encouraging innovation in farming methods – yet urgent change is required.

WHERE SHOULD WE BE GOING? THE POTENTIAL OF AGROECOLOGY

The FFCC follows the United Nations Food and Agriculture Organization's (UN FAO) definition of agroecology (AE) as

> ***an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. It seeks to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system.***[7]

It is about understanding ecosystems better and using this knowledge to farm smarter, not harder, working with nature rather than against it.

We find that despite the success of some agroecological entrepreneurs there are significant barriers that impede the adoption of AE approaches.

There is sound theoretical and empirical support for the proposition that AE can grow more nutrient-dense food on less land while delivering a range of ecological and social benefits including biodiversity regeneration, water conservation, carbon sequestration, improved soil health and more employment in higher quality work. Crucially, it can do this while improving profitability of farming enterprises by focusing on a number of approaches including substituting external inputs for internal resources and focusing on profitability rather than gross yields.

We find that despite the success of some agroecological entrepreneurs there are significant barriers that impede the adoption of AE approaches. The International Panel of Experts on Sustainable Food Systems (IPES-Food) identifies eight mutually reinforcing 'lock-ins' that reinforce business as usual and prevent farming businesses from migrating to new methods and business models.

Furthermore, it is of great concern that even those publicly funded UN organisations which set the tone of food security policies and projects at the international level, and which support engagement with agroecology – i.e. the UN FAO, the International Fund for Agricultural Development (IFAD), the World Food Programme (WFP) and the Green Climate Fund (GCF) – channel either none or only a small fraction of their (EU including UK) funds towards projects which support transformative agroecology. This is a trend that is mirrored at the national level of the contributor countries, most of which do not even report separately on their agroecology-related spending.

While recognising this challenging backdrop, we identify three specific actions in the UK that would help it grasp the potential of agroecology:

1. Research and knowledge dissemination.

There is an urgent need for relevant research; in particular, more robust methods are needed to measure and quantify ecologically meaningful outcomes, and further research is needed into the most efficient approaches and combinations of approaches in different ecoregions of the UK.

2. Investing in agroecology at pace and scale.

There is a shortage of appropriate finance for some viable business propositions. Even where external finance is available, or transition to agroecology can be financed from internal business cash flows, to achieve change at necessary pace and scale requires a significant mobilisation of a range of forms of capital including equity and debt.

3. Supporting the agroecological entrepreneur.

The nature of agroecology is knowledge intensive and requires an appetite for innovation and risk that would be greater enhanced by robust business support including training, mentoring and effective diffusion of knowledge. The challenge posed by the large cohort of farmers at retirement age should be grasped as an opportunity to back a new generation of agroecological farmers.

WHAT NEXT? MULTI-DIMENSIONAL INTERVENTION TO ACCELERATE TRANSITION

We conclude that there is a strong case for co-ordinated mission-driven interventions to accelerate the transition to agroecology.

We recommend that further research be undertaken into the most effective national level intervention to meet the research, finance and enterprise support needs identified in this report, and that as part of this research a number of pilot funds be established in different geographic contexts across the UK that operate not as a passive supplier of finance to businesses but as a proactive AE development institution that brings together in a one-stop shop the range of knowledge, skills, training, mentoring and innovative finance required to stimulate and support a new wave of agroecological entrepreneurs.

2. A note on terminology and frameworks

2. A note on terminology and frameworks

We acknowledge that some of the key terms used by us in this report are used differently in different contexts around the world. For example, *agroecology* has been used to denote a science, a movement, or an agricultural practice.[8] A good starting point to appreciate the wide range of meanings is the Agroecology Info Pool, created by the Swiss foundation BioVision, which brings together definitions from over 20 sources including the UN FAO, USDA and Nature.[9] The OECD offers yet another one[10] which it in turn traces back to the UN's Glossary of Environment Statistics dated 1997.[11]

This report is for a UK audience and was written in the UK, where the term agroecology has found its way via the House of Lords into the proposed Agriculture Bill 2020 – which, at the time of writing, was due for debate in the House of Commons on 4th November 2020.[12]

Our starting point for the use of the term *agroecology* is the UN FAO's definition, which labels the broad range of approaches to agriculture that integrate positive ecological and social outcomes as agroecology.

Our starting point for the use of the term *agroecology* is the UN FAO's definition, which labels the broad range of approaches to agriculture that integrate positive ecological and social outcomes as agroecology. The reason for this choice is also grounded in a commitment to the UN's inclusive global vision of the Sustainable Development Goals (SDGs) and the prominent place agricultural activity has in achieving these goals.

These goals have little meaning if we are not committed to actual positive outcomes, and we discuss the relevance of outcomes in section 4. The importance for us lies not in a final definition but rather in a framework of thought and action and the different levels of impact on ecology, society, and economy.

We endeavour to bring to bear an approach which is characterised by an openness to patterns of thought and action on the same continuum.

Gliessman has articulated a framework of five levels entitled *Transforming food systems with agroecology*[13] which is compatible and complimentary with Levels 1 to 3 of the four levels of regenerative agriculture articulated in this report (section 4).

It is for this reason that we also refer to *ecological farming or regenerative agriculture* and other combinations of these terms throughout the report as subsets of an agroecological vision about human impact on nature. Section 4.2, 'History, levels and lineages of regenerative agriculture' provides a brief history of the concepts which lead to the possibilities inherent in our different levels of understanding of the possibilities of the relationship between humans and nature, from functional to evolutionary.

3. Home farm truths: an ecological and financial audit

3. Home farm truths: an ecological and financial audit

We may be approaching a threshold beyond which the agriculture that we've always known cannot support human civilization as we know it.

Al Gore, Former US Vice President and author of 'An Inconvenient Truth'[14]

It no longer seems controversial to suggest that farming needs to change if we are to reduce environmental harms such as greenhouse gas (GHG) emissions and loss of biodiversity. Although perhaps less in the public eye, it is also of pressing concern to policymakers and farmers alike that the profitability of agriculture in the UK is under sustained pressure.

But how fundamental are these issues? Can we tweak the system and rely on continuous marginal improvements to advance environmental, social and economic outcomes from food and farming? Or is the system more deeply flawed?

In this section we review the true ecological and human costs of today's dominant methods of agriculture before assessing the financial health of farming business in the UK. The two issues must be tackled together, as loading more costs onto barely viable businesses will not end well.

The good news is that improving ecological performance does not need to be a barrier to profitability. Rather, it is the route map to improved business performance.

3.1 The true cost of industrial agriculture

This [conventional agriculture] is mining. This is extractive nutrient harvesting. It's not sustainable. Through history we've had civilisation after civilisation collapse once they have completely extracted and exploited their soil resources.

Walter Jehne, climate scientist and soil microbiologist, Director of Healthy Soils Australia[15]

NEGATIVE EXTERNALITIES

The term *externality* describes the impact of economic activity on nature and society. When such impacts are harmful, they are referred to as *negative externalities*. The literature on externalities is extensive and well established in economics and their existence in theory is non-controversial. Their calculation in practice is more contested, particularly by polluters in view of the implications for their balance sheets of the 'polluter pays' principle.

Industrialised food and farming systems generate significant negative externalities that are not accounted for in their own costs. The justification is that this allows for cheap food but, in reality, humanity and the environment pay a high price. The true cost of food, if all these externalities were priced, would look very different. For example, one study found that on an average UK farm the environmental cost to produce $100 of food was an extra $26.[16]

Another study from 2014 estimated the cost of environmental externalities from agriculture in the UK in the region of £5.7–7.2 billion per year: 6.3–7.9% of the £90.8 billion total market cost of food to UK households. This was likely to be a considerable underestimate at the time of the report since several substantial impacts such as biodiversity loss, soil erosion and water pollutants from industry had not been factored in:[17] Soil degradation was calculated in 2010 to cost £1.2 billion every year.[18]

If we add up environmental externalities, the cost of obesity and subsidies, the total external cost of the UK food system has been estimated to be between £11 billion and £26 billion. This would mean that the effective food bill is at least 12–28% greater than the price paid at the till.[19]

We briefly describe six key externalities below:

1. Climate change

Agriculture is a major culprit when it comes to GHG emissions. In total, about 24% of human-made emissions comes from the agriculture and forestry sectors, which is more than from industry or transport.

Of this 24%, half comes directly from agricultural production (i.e. 12% of all human-caused GHG emissions).

The other 12% come from deforestation and peatland degradation, a significant proportion of which is driven by expansion of intensive agriculture in developing countries.[20]

2. Water pollution

Over-use of fertilisers can lead to run-off and leaching of nutrients, polluting watersheds. Farm-source pollution therefore forces water companies and governments to spend millions of pounds on water purification.

Only 17% of the nitrogen used in agriculture ends up being consumed by humans in crops, dairy or meat products. The rest leaks to soils, freshwaters and the atmosphere, where it affects human health, climate and biodiversity. It leaks especially quickly from soils made lifeless by chemicals, as healthy soil biology is needed to convert nitrogen into a plant-palatable form.[21]

3. Poor nutrition

Over the past 100 years, farmers in advanced economies have focused on yield, volume and standardised production of commodities that are easily traded and stored, but which have steadily declined in quality and value. An increasing share of the value has been taken by food manufacturers or restaurant chains that use cheap staples combined with artificial flavours to 'trick' the taste buds of consumers. The easy availability of unhealthy, processed foods has had dire consequences for human health.[22]

4. Toxic chemicals

Toxic pesticides are a direct risk to the farmers and farmworkers who apply them. Occupational exposure to pesticides in the USA poisons as many as 20,000 farmworkers every year. Rural and agricultural communities have been found to experience higher rates of leukaemia, non-Hodgkin lymphoma, multiple myeloma and soft tissue sarcoma, as well as cancers of the skin, lip, stomach, brain and prostate. Farmworkers also bring home toxic chemicals on their clothes and body. As a result, pesticide exposure is attributed to higher rates of birth defects, developmental delays, leukaemia and brain cancer among farmworker children.[23]

5. Antibiotic resistance

Intensive industrial practices in agriculture are often unhealthy for animals. Large doses of antibiotics are used to keep pigs, chickens and cattle alive and to promote growth. For example, some 70% of all the antibiotics used in the USA are given to animals. The majority of these are also medically important to humans. When bacteria evolve resistance to antibiotics, much of which is linked to factory farming of animals, we are on the cusp of a 'post-antibiotic era' that 'could plunge medicine back into the dark ages'. Projections of deaths from drug-resistant infections by 2050 estimate 390,000 deaths for Europe alone.[24]

6. Destruction of biodiversity

Monocultures and the liberal use of pesticides also destroy biodiversity. In our human-dominated age – the Anthropocene – species are becoming extinct at an unprecedented rate. The expansion of agriculture, and in particular simplified, chemicalised agriculture, wipes out natural habitats and creates sterile farm habitats in their place. Biodiversity is essential to the healthy functioning of ecosystems. The loss of species can have unforeseen consequence and push systems off balance. It also erodes a genetic bank that scientists draw on for medicines and all kinds of innovations – including new crops – to the detriment of future generations.[25]

"We may be approaching a threshold beyond which the agriculture that we've always known cannot support human civilization as we know it."

AL GORE
FORMER US VICE PRESIDENT
AND AUTHOR OF 'AN INCONVENIENT TRUTH'[14]

EXTERNALITIES COME HOME TO ROOST

Externalities may be external to individual businesses or even to entire industries, but business and industries operate within an economy that is part of and depends on the natural world. It is reasonable to expect that one day the bills will have to be paid. We consider there to be four risks posed to agriculture which are reaching significant or critical levels that threaten to undermine business viability in the immediate to medium terms.

1. Degrading natural assets

Land degradation through agriculture has been a factor in the decline of many civilisations in the past and is a worldwide problem today.[26] A major study in 2015 by the Intergovernmental Technical Panel on Soils (ITPS) found that 33% of land globally is moderately or highly degraded.[27] This leads to an estimated economic loss of $40 billion per year.[28] Each year about 12 million more hectares are degraded.[29] Recent research indicates that, under business as usual, the current soils in agricultural production will yield about 30% less than they would otherwise by 2050.[30]

Agriculture erodes soil and changes its structure through:

- physical degradation (compaction or waterlogging)
- chemical degradation (leaching, salinisation, acidification, nutrient imbalances and fertility depletion)
- biological degradation (loss of vegetation on rangelands, deforestation, and loss of biodiversity, which includes the loss of soil organic matter and soil microbes).

Over-tilling and poor livestock management can destroy soil structure, strip the soil of vegetative cover and lead to water and wind erosion. Irrigation is a major cause of salinisation: salts are left behind as irrigation water evaporates. Use of chemical fertilisers and pesticides can kill the microorganisms that hold soil together, keep it aerated and make nutrients available to plants.

A UK Environment Agency report, published in 2019, was unambiguous in its finding that 'intensive agriculture has caused arable soils to lose 40 to 60% of their organic carbon, and the impacts of climate change pose further risks' and they went on to argue that 'Soil carbon loss is an act of economic and environmental self-harm. Farmers manage 70% of the land. Poor soil quality affects their income and way of life.'[31]

Agriculture is also the main driver of deforestation in tropical countries and places a massive strain on scarce water resources. It is responsible for 70% of total water use now. Under business as usual, agriculture's demands are expected to almost double between now and 2030.[32]

Agriculture is also the main driver of deforestation in tropical countries and places a massive strain on scarce water resources.

By eroding the natural resource base on which agriculture depends (soils, water reserves and ecosystems), farmers increase their cost base: more fertilisers are needed to compensate for lifeless soils, more diesel or electricity is needed to pump groundwater from increasing depths, more pesticides or high-tech seeds are needed to keep nature in check. The input treadmill speeds up. In addition, the assets that farmers – or investors – have worked so hard to acquire are depreciating in value.

About 40–50% of food comes from crops that rely on wild pollinators or domestic honeybees. It is hardly news that their populations are in steep decline because of pesticide use and habitat change.[33] Technological alternatives to natural pollinators are proposed which are either expensive or unproven.

Globally, some 220 weed species have evolved herbicide resistance, and 600 cases of insecticide resistance have been recorded.[34]

A loss of ecosystem functionality and species diversity creates risks for farmers. But instead of focusing on these, farmers are being told to use more powerful pesticides or to buy more expensive new GM seeds.[35]

2. High and volatile input costs

Profitability in farming is driven not by high prices but good margins. Modern, industrial agriculture is heavily dependent on a range of inputs that can erode margins. These inputs include:

- non-organic fertilisers (nitrogen in the form of urea and ammonia, phosphate, potassium)
- pesticides (herbicides, insecticides, fungicides)
- seeds (including expensive biotech seeds in some regions)
- diesel fuel and electricity for machinery
- animal feed, primarily cereals and soybeans.

The problem is that although the price of commodities has risen over the past decade, the cost of inputs has risen even quicker.

Globally, the average price of urea, phosphate and diesel in real terms was around 80% higher between 2005 and 2014 compared to the two decades between 1984 and 2004. The UN FAO Food Price Index was 43% higher in 2005–2014 compared to the previous two decades. Farmers' margins were squeezed even in a time of high prices for their produce.[36]

3. Vulnerability to a changing climate

Agriculture has always been at the mercy of the weather and no technology has made a difference to this. Volatile weather, including droughts, floods, heavy downpours and heatwaves, has been one of the most obvious causes of supply shortfalls over the past decade.

The insurance group Munich RE's natural catastrophe database indicates that the frequency and intensity of extreme weather events are on the increase, having tripled since 1980.[37]

There is an obvious reason for this: climate change. The 2014 update by the Intergovernmental Panel on Climate Change (IPCC) made the strongest link yet between current weather extremes and long-term global warming. A Swiss-led study in 2015 found that global warming was to blame for most extremely hot days and almost a fifth of heavy downpours recorded globally.[38] And the intensity and frequency of these events is set to increase as the slow pace of action on reducing GHG emissions means it is almost certain that temperatures will rise by 2.6–2.9°C by 2100.[39]

This poses a massive threat to food production in coming decades. Farms that lack resilience – because of bare soils, degraded soils, poor water cycles and lack of diversity – will suffer the most.

4. Shifting consumer trends

Mainstream consumers are increasingly concerned about issues such as the nutritional value of food, pesticide residues, the use of antibiotics and hormones in animal products, genetic modification, and animal welfare. Whether grounded in evidence or not, the perception exists that modern, industrial agriculture is bad for people and the environment. And perception drives behaviour. This has led to increased demand for foods that are clean, green and healthy.

The risk for investors who back industrial farming systems that are perceived as polluting and unhealthy is that their products will be relegated to lower value commodity markets. They will be locked out of some of the fastest growing markets where price premiums are available for clean, green and healthy food.

3.2 The financial state of UK farms

So, against these global trends and financial risks, how is agriculture currently faring in the UK?

UK agricultural businesses vary hugely in size, type, tenure, region, approach and performance. This makes generalisations about the economic performance and financial state of farms difficult. However, we can draw out some general trends using published data from Defra.[40]

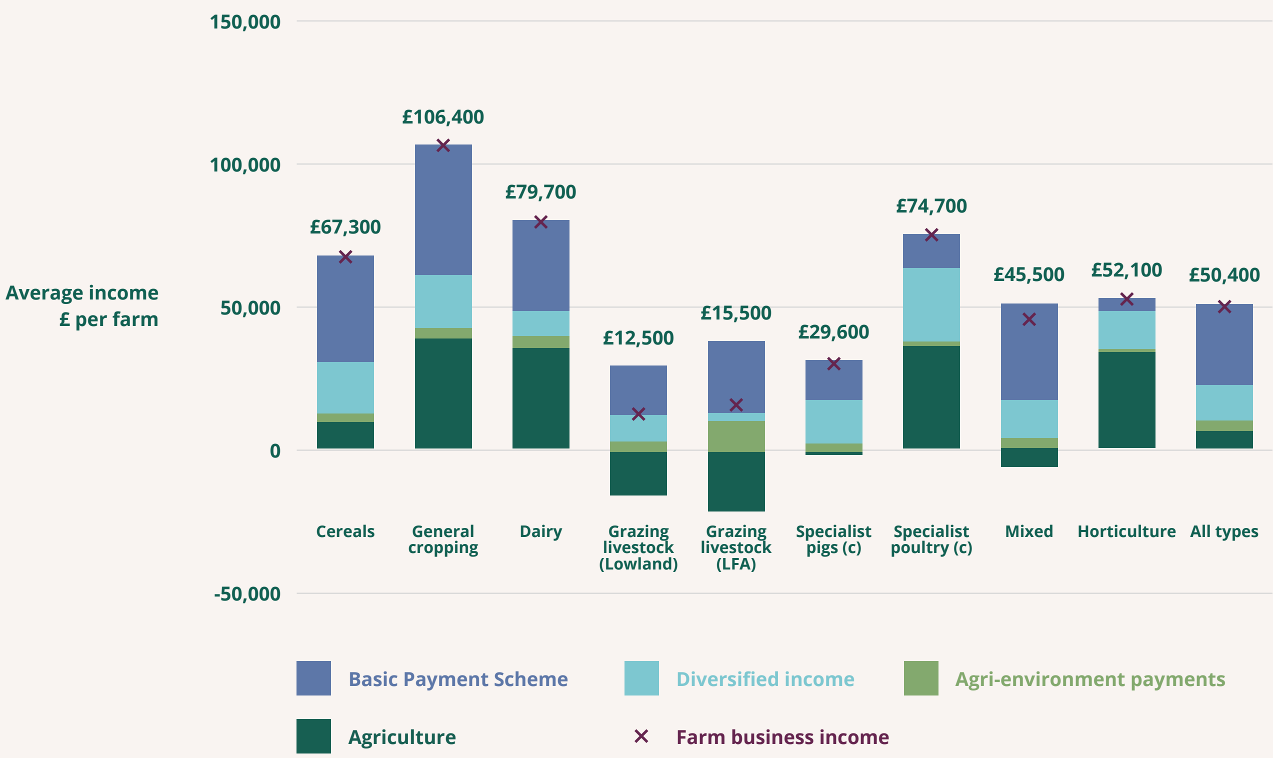
FARM BUSINESS INCOME

The Defra publication 'Farm Business Income by type of farm in England, 2018/19',[41] provides a picture of UK farming which is altogether less robust, with significant dependency on subsidies and non-farming income. Some farm types lose money on their core agricultural production and only survive through subsidies and non-farming income.

- The average farm business income for all farms was £50,400 but only 12% of this was from agricultural activity, with 62% coming from subsidies and 26% from diversification.
- Horticulture showed the highest income from production at 66%, with only 7% from subsidies and a further 26% from diversification.
- Across all farm types, the average Basic Payment received was approximately £27,300 – over 54% of the average farm income and a significant proportion of average farm business income for all farm types apart from horticulture and poultry farms.
- On average, cereal, general cropping, dairy, specialist poultry and horticulture farms generated a positive return from farming activities.
- In contrast, grazing livestock (Less Favoured Areas (LFA) and lowland), specialist pigs and mixed farming produced a negative return from farming and were thus entirely dependent on subsidies.

Figure 1: Farm business income by cost centre, 2018/19.

(Adapted according to the Open Government Licence v.3 from: Defra (2019) Farm Business Income by type of farm in England, 2018/19.)



Financial resilience is important in the face of uncertainties such as unfavourable weather

Defra links farmers' financial resilience to net worth, which is one of the reasons why a low gearing ratio is, generally speaking, considered better. Financial resilience is important in the face of uncertainties such as unfavourable weather – for example, in 2018/19, a very cold, late spring and extremely hot, dry summer impacted incomes negatively.

ASSETS AND LIABILITIES

The average net worth (the value of assets less financial liabilities) across all farms in England was £1.9 million in 2017/18, with approximately 40% of farms exceeding £1.5 million. Within this, fortunes vary widely with three main factors:

- land tenure
- farm size
- full/part/spare-time working.

As shown in Figure 2, land values play a significant part in average net worth, accounting for 76% of average total assets of £2.1 million. Tenure is therefore a significant factor for net worth, illustrated by the extent to which tenant farmers have fallen behind other forms of tenure since 2009/10. Farms that are of mixed tenure but mainly owner occupied had the greatest average net worth of £2.77 million, while wholly tenanted farms had an average net worth of £289,000.

Figure 2: Net worth calculation across all farms in England, 2017/18.

(Adapted according to the Open Government Licence v.3 from: Defra (2019) Balance sheet analysis and farming performance, England 2017/2018.)

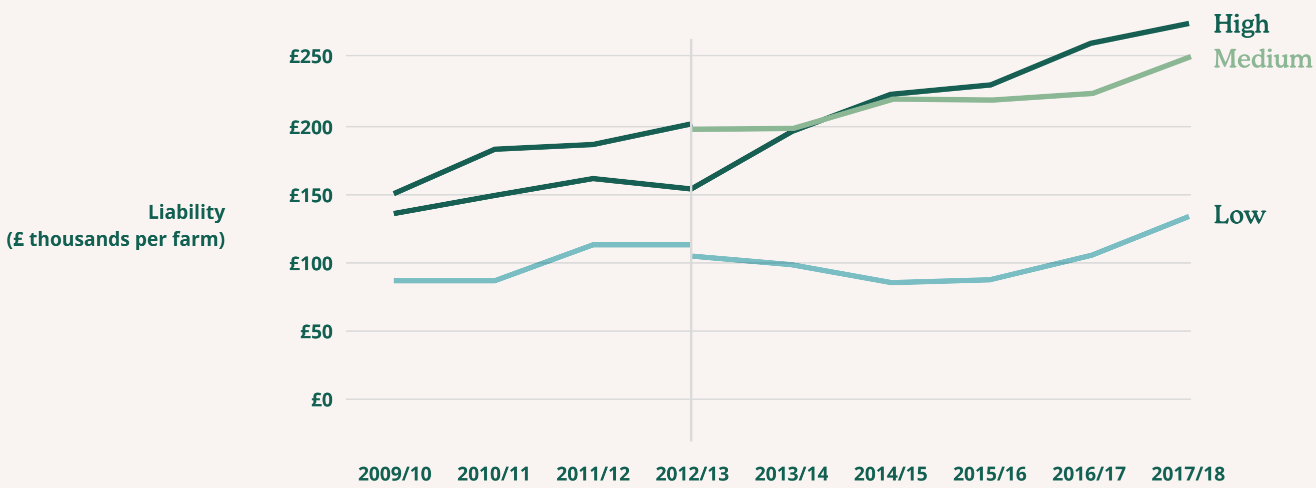
Farm size is positively correlated with average net worth, increasing with farm size from £1.13 million for smaller farms, which were more likely to be worked on a part-time or spare-time basis, to £4.24 million for very large farms. Smaller farms are worth more per hectare, ranging from £18,300 per ha for spare/part-time farms to £11,100 per ha for very large farms. While this may appear reassuring in terms of net worth for existing small farm operations, it also indicates that smaller farmers face relatively higher costs for access to land.

According to Defra, those farms with lower net worth (less than £0.5 million) were more likely to be small and spare/part-time; to be pigs/poultry or horticulture, and to be tenanted farms. Those farms with greater net worth (at least £1.5 million) were more likely to be large / very large farms, to be cereal or general cropping farms, to be in the south east of England, to be mainly owner occupied rather than tenanted, or to be economically high performance.

The gearing ratio (liabilities/assets) provides a measure of the long-term financial viability of a farm. A lower ratio is generally seen as more acceptable because this suggests that the farm business is more likely to be able to meet its investment needs from earnings. A higher ratio may be seen as a greater risk as interest costs will be higher and the farm will have less collateral to borrow against. However, being highly geared does not necessarily imply an unsuccessful business. Investment can increase profitability, so increasing the gearing ratio can lead to better performance.

This appears to be borne out by the different trends in average level of debt for farms in each economic performance band. [42] For those farms in the top performance group, the average level of debt has increased considerably since 2012/13. For the lowest performing farms, the average level of debt has changed little in the same time frame (see Figure 3).

Figure 3: Average liabilities per farm, by farm economic band



Note: Standard output coefficients were updated in 2012/13 from a 5 year average centred on 2007 to a 5 year average centred on 2010. Results for 2012/13 have been calculated using both for comparability.

The Defra publication shows the average gearing ratio of farm businesses in England at 11% in 2017/18, only a marginal change from the previous year; in fact, there has been little change in the average gearing ratio across all farms since 2009/10.

Half of farms in England had a gearing ratio of less than 5%, while 7% had a gearing ratio of at least 40%, with the ratio varying with farm size, tenure and economic performance as follows:

- larger farms have higher gearing than part/spare-time and smaller farms (see Figure 4)
- tenanted farms have higher gearing than owner occupied (see Figure 5)
- farms with lower liabilities have lower gearing ratios.

Looking through the lens of assets and liabilities, Defra concludes that UK farms are in a favourable financial situation because where debt and gearing are high, this is driving investment in increased profitability. Where debt and gearing are low, this is also considered favourable as these farms have a lower risk of default.

Figure 4: Distribution of gearing ratio by farm size, 2017/18.

(Adapted according to the Open Government Licence v.3 from: Defra (2019) Balance sheet analysis and farming performance, England 2017/2018.)

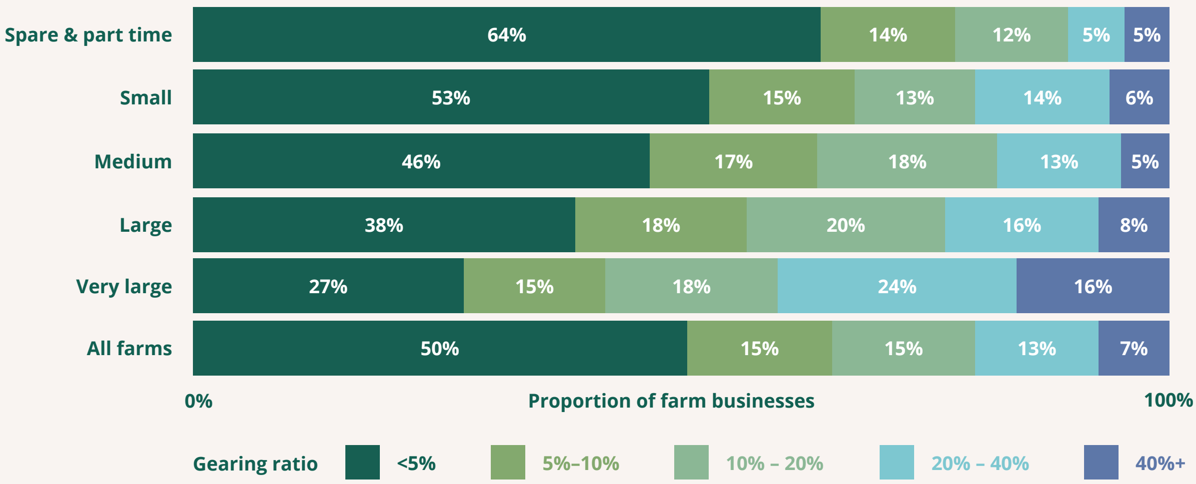
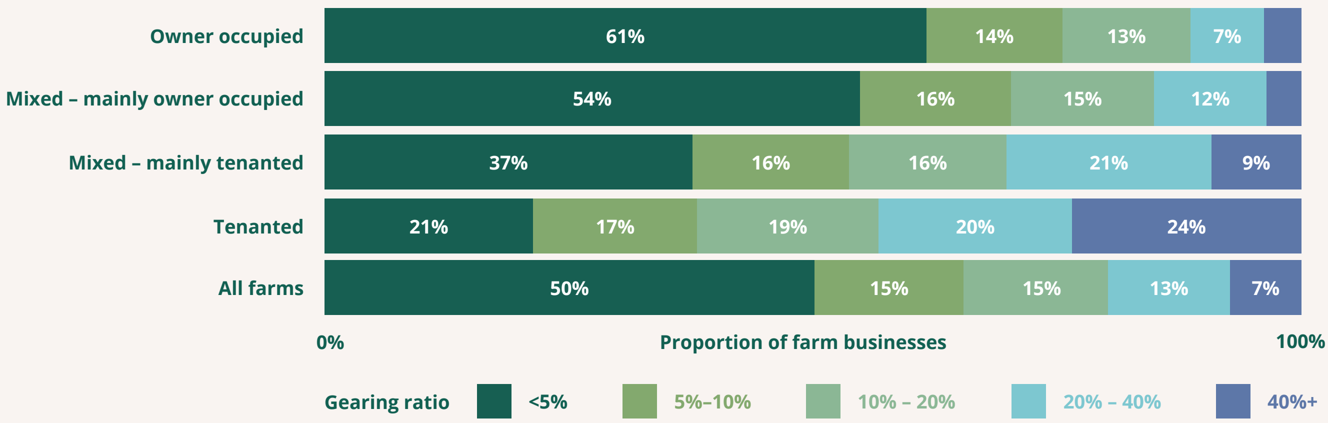


Figure 5: Distribution of gearing ratio by farm tenure.

(Adapted according to the Open Government Licence v.3 from: Defra (2019) Balance sheet analysis and farming performance, England 2017/2018.)



However, balance sheet assessments should be treated with caution because of the impact of inflated land values being driven by factors unrelated to farming. Land values can be driven up by investment in land for speculative purposes, or by nearby development of infrastructure increasing the location value of farmland regardless of the agricultural value. We expand on this further below.

THE GLOBAL EMERGENCE OF FARMLAND AS A NEW ASSET CLASS

Prior to 2005, there was little money to be made in farming. Beginning in the mid-2000s, however, the prices of food commodities began to rise sharply based on a number of macro trends underpinning the increase in food prices.

On the demand side:

- The world's population reached 7.1 billion in 2013 (forecasts see it surpassing 9.5 billion by 2050 and the UN FAO estimates that food production will need to increase by 70% by 2050 to meet increasing demand).
- Rising incomes in the fast-growing Asian economies, especially China, have led to greater demand for meat, dairy and protein.
- Bioenergy has created a whole new market for agricultural commodities, e.g. more than 30% of the current US corn harvest is turned into ethanol.

Prior to 2005, there was little money to be made in farming. Beginning in the mid-2000s, however, the prices of food commodities began to rise sharply based on a number of macro trends underpinning the increase in food prices.

On the supply side:

- Land and water resources are under pressure.
- The best, most accessible land is already being used, especially in the most heavily populated regions.
- Climate change, rising input costs and land degradation are all putting breaks on production.
- Yield growth has slowed since a burst of innovation in the 1960s and 1970s.

These macro trends lead to the increase in the price of food. Between 2005 and 2014, the Food Price Index of the UN FAO was on average 41% higher in real terms than the previous decade (and 71% higher in nominal terms).[43] This translated into higher farm incomes and higher returns to farmland ownership in most parts of the world.

If we consider the other financial reasons why farmland is attractive to long-term investors, we begin to see why farmland got the attention of institutional and other investors:

- Land is a 'real asset'. It cannot be trucked away or broken down and sold; it will always retain some value and therefore offers downside protection.
- It can generate income, either in the form of rents or profits from farm operations, thereby satisfying investors' hunger for yield – any yield – in the current environment.

Compared with locations such as the USA, Australia and Ireland, the UK is not considered an attractive investment destination.

- The returns from farmland are historically uncorrelated or negatively correlated with equity and bond markets, providing diversification.
- And these investments offer a natural hedge against inflation, as food prices and farmland prices go up during inflationary periods.
- Last but not least, farmland can boast some impressive historical performance data. The NCREIF Farmland Index in the USA (annualised return 10.7%, standard deviation 6.5%) has outperformed stocks and bonds (S&P 500 annualised return 6.3%, standard deviation 17%) over the past forty years, with lower volatility.[44]

Clearly, farmland offers compelling financial returns at apparently low risk. It is not surprising, then, to find that a flurry of institutional investors deployed real money into farmland: more than 100 funds were closed between 2006 and 2015, raising in excess of $21 billion that has been deployed into land purchases globally. Outside of funds, billions more have been invested through managed accounts or direct investments.[45]

THE UK IS A SPECIAL CASE, BUT NOT IN A GOOD WAY

Compared with locations such as the USA, Australia and Ireland, the UK is not considered an attractive investment destination. This is because the price of farmland is already over inflated in the UK meaning the agricultural investment will struggle to deliver financial returns comparable to other countries.

One key factor behind this in the UK are the rules on inheritance tax which allow investment in farmland to yield very large tax savings, pushing up its value. Another factor for farmland near to expanding settlements or on major transport routes is the potential windfall gains from planning permission for change of use to commercial or residential. Creating gains of multiples of the original investment, this creates a premium for some land which exceeds its agricultural value.

Michael Fiddes, then Head of Estates and Farm Agency at Strutt & Parker, commented in October 2019 that 'the range in prices paid [for agricultural land] remains wide, with the value being driven by location, rather than the productive capacity of the land itself'.[46] He continues: 'The long-term trend of farmers buying fewer of the farms for sale continues, particularly if they have to borrow money to fund their purchase. In the last two years, farmers have bought just over half of the farms sold but have spent well below half of the total value paid.' This gives rise to a paradox that the finances of existing farms look healthy because of rising land values at the same time that unaffordable farmland is choking off new entrants to farming and threatening the long-term viability of the sector.

3.3 Implications for policy

Based on an assessment of assets and liabilities, Defra concludes that UK farms are in a favourable financial situation. Farm businesses, the argument goes, need to focus on increasing productivity in order to drive up revenues, and they have capacity to borrow more for investment in productivity improvements.

However, it is possible that a farm with degraded soils in an artificially simplified landscape which is locked into liabilities related to agrochemical inputs and heavy machinery with a loss-making agricultural operation dependent on subsidies, is regarded by Defra as being in a favourable financial position. This is a system in which, in the words of one researcher, 'taxpayers' money is being used to top-up the incomes of large and unsustainable farms'.[47]

The National Audit Office (NAO) challenges Defra's benign outlook in its criticism of the transition to the Environmental Land Management Scheme (see Box A below). The NAO criticises the lack of guidance to farmers to allow them to plan, pointing out that direct payments account for an average of 61% of farms' net profit, and around 4 in 10 farms would be loss-making without them. Crucially, the NAO questions Defra's expectation that productivity gains will offset the withdrawal of direct payments stating that 'there is limited evidence that many farms are equipped to increase their productivity.'[48]

THE WRONG KIND OF PRODUCTIVITY: SOIL IS THE MOST IMPORTANT ASSET

Omission of any assessment of soil in the Defra financial data stands in contrast with the conclusion of the Environment Agency that poor soil quality affects farmers' income and way of life. We would argue that without taking account of the depreciation or dilapidation of the core asset of farms – the soil – we cannot gain a complete understanding of their economic and financial health.

Similarly, the negative impact of industrial agriculture on ecosystems and biodiversity is ignored in conventional assessment of farm business models. Commenting on AE prototypes in the US, D'Souza and Ikerd argued that 'as long as the natural resource base is viewed as costless in the market place, the short-term benefits from using industrial methods are likely to continue to exceed the short-run costs, thereby encouraging their continued adoption.'[49]

Furthermore, the UK Environment Agency argue that agriculture and land management are critical to meeting the Committee on Climate Change's target of net zero by 2050.[50]

Mark Carney, the former Bank of England governor, drives the point home about the congruence, in the end, of climate and economics when he says that the 'transition to net zero carbon emissions would change the value of every asset, raising the risk of shocks to the financial system'.[51]

The eight lock-ins referred to in section 6 of this report might explain why depleting ecological systems are not factored into the economic assessment of the sector and Defra, looking perhaps through different lenses, sees the majority of farms as being in a favourable position. This benign assessment underpins the expectation that farms will adapt readily to the Environmental Land Management Scheme (ELMS) through productivity gains. If the productivity gains continue to ignore measures such as soil health, then not only will business as usual potentially further weaken farm finances but will also further undermine the environmental outcomes which the ELMS aspires to.

It will not be possible to have it both ways. The stark reality of the climate emergency makes the strategic case for initiatives that take agriculture into a direction that pursues economic, ecological and social dimensions at the same time.

Box A – The Environmental Land Management Scheme (ELMS)

Under the EU's Common Agricultural Policy (CAP), 85,000 farmers in England received a total of £2.2 billion in subsidy between October 2017 and October 2018. Most of these subsidy payments to farmers were based on the amount of land they farm.

Following exit from the EU, the UK will no longer be part of CAP and the government is designing and implementing a new domestic agricultural policy and regulatory arrangements. Defra is developing the Future Farming and Countryside Programme to carry out the government's proposals in England for which a budget of £38.2m budget was set aside in 2018–19.

As we have seen, Defra's position is that the loss of CAP subsidies can be offset by productivity improvements from farmers improving their business approaches or by new entrants taking over farm businesses that cease to be viable – although this assessment is contested by the NAO.

The policy statement released on 25th February 2020 set out a three-component approach to ELM that would pay for:

1. environmental benefits from interventions such as using cover crops and planting wildflower margins
2. locally targeted environmental outcomes designed to address specific local environmental needs
3. land use change such as wetlands, peatland and forest restoration that generate environmental benefits such as biodiversity, flood mitigation and carbon sequestration.

The NAO has pointed out a number of risks including complexity, lack of preparation and fraud. They also highlight the risk we alluded to earlier – that the withdrawal of direct payment income may force farmers to adopt more intensive farming methods that appear more productive on narrow conventional measures but also damage the environment and undermine the delivery of the very same public goods – such as biodiversity, flood management and lower carbon farming – that ELMS aims to generate.

MAKE THE POLLUTER PAY – ARE ENVIRONMENTAL TAXES THE ANSWER?

In the face of climate change and ecosystem degradation, there has been a trend of regulating and/or taxing pollution more as governments around the world stepped up forceful regulatory efforts and began penalising dirty production systems. In Europe, for example, the 2015 reform of the CAP introduced 'greening' measures which require arable farmers to rotate crops, designate land as ecological focus areas and retain more permanent grassland.[52]

Some say putting a price on carbon would change the equation of food production overnight.

Already in 1993, Ikerd saw 'the role of public policies in moving agriculture toward a sustainable path as being either to (a) impose environmental constraints on producers, or (b) *provide incentive payments or targeted subsidies to encourage adoption of sustainable practices*'.[53] However, policy has not yet allowed or encouraged any significant change in practices. An empirical study on the economic potential of agroecology across Europe in 2018 still found the CAP structurally biased in favour of conventional agriculture and large farms, with the lion's share of the budget going to the largest 20% of farms.[54]

Some say putting a price on carbon would change the equation of food production overnight.

But the threats extend far beyond carbon to food security and farm incomes, with intensive agricultural methods also causing declines in biodiversity and environmental quality.[55] These issues are all interconnected, with the latest soil science linking health and ecological impacts to farming methods and the biological processes at the centre of the way in which food is grown in the soil.[56]

Leading soil scientist and director of the Carbon Management and Sequestration Center at the Ohio State University, Professor Rattan Lal, argues for making agriculture a solution to environmental issues through regulatory and market incentives that reward innovation in farming methods through payments for ecosystem services such as sequestering of carbon in soil and vegetation (terrestrial biosphere), improving quality and renewability of water resources, strengthening biodiversity, and making agriculture nutrition-sensitive.[57]

The danger from over-reliance on a single policy instrument such as carbon taxes is not just the unintended negative consequences for other key environmental indicators such as soil health, water and biodiversity. If insufficient attention is given to the capacity of the whole system – from field to fork – to evolve and adapt, and we do not consider how to support farming enterprises though such a significant transformation in food and farming systems, we risk a collapse in UK farming as a viable industry.

Perhaps some rewilding enthusiasts, lab-protein entrepreneurs or proponents of relying on international trade to feed the UK would find such a prospect of little concern. We take the opposite stance, not just for the sake of preventing loss of livelihoods and damage to social and cultural fabric of town and country, but because farming is part of the solution to fixing the externalities – the social and environmental harm – it has previously been responsible for.

Therefore, for policy innovation to succeed in its objectives of substantial improvements in economic, environmental and health outcomes, we argue it should be grounded in a thorough appraisal of:

- **which agricultural practices are most likely to yield these benefits**
- **the barriers to system change**
- **the necessary levers or conditions to catalyse transformation.**

The remainder of this report explores these three issues.

4. Agroecology: the real green revolution

4. Agroecology: the real green revolution

Agroecology (AE) is a heterogeneous term denoting a large body of different approaches, also covering approaches known as regenerative and ecological agriculture.

The FFCC follows the UN FAO's definition of agroecology as

> ***an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. It seeks to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system.***[58]

In practice, AE approaches can be seen as having three common qualities:

1. reduction in the use of external inputs and a simultaneous improvement in the quality and use-efficiency of internal inputs
2. dynamic improvement often supported by farmers sharing their experiences, on-farm experimentation and, sometimes, applied research
3. improved farming incomes, higher employment and more resilient farms and rural areas.

The potential of AE and its precursors as a driver of more sustainable, resilient food systems has been identified internationally in an academic context for three decades or so. As an academic discipline, it studies 'agroecosystems that are both productive and natural resource conserving, and that are also culturally sensitive, socially just and economically viable'.[59]

The underlying principles were identified as a significant strategic option in the 1990s in a nationwide survey of Dutch farmers.[60] The transition potential of AE in the US and global context was discussed at least as far back as 1993,[61] and in 2010 the UN identified the strong potential of agroecology to support human rights, access to food and broader economic development.[62]

In France, the government now views AE as a key pillar for such a transition,[63] stating in its CAP 2020 negotiations outline paper that:

> ***The CAP must support farmers' agroecological transition to production systems using fewer inputs (energy, pesticides, fertilisers, water) and which are more resilient. [...] The CAP must give farmers the means to generate sufficient income to achieve their transition. In terms of the environment, the non-market services rendered by agriculture and forestry must attract more remuneration, while support must be conditional on compliance with a minimum of rules.***[64]

A broad multinational research effort focused on the economics of agroecological approaches in Europe found that they produced healthier food at the same time as improving farm incomes and employment at regional and national level.[65] These views are also supported by a study in the UK which suggested that small-scale farms and market gardens display positive productivity, financial viability and multifunctional benefits.[66]

4.1 Agroecological principles

First of all, it is important to emphasise that there is no one-size-fits-all practice for diverse soils and ecoregions. As Professor Rattan Lal states with reference to regenerative agriculture, it 'is all inclusive, and its site-specific package(s) must be fine-tuned in the context of biophysical factors and the human dimensions'.[67]

However, secondly, what all these approaches do have in common is that they are soil-centric rather than seed-centric and that they are based on the premise that the 'health of soil, plants, animals, and humans is one and indivisible'. Lal suggests expanding the latter concept, based on the realisation of the living soil[68] in the context of the climate emergency and the era of Covid-19, by stating that the 'health of soil, plants, animals, people, and the environment is one and indivisible'.[69]

The bold insight is that 'humans can reclaim the role of a beneficial keystone species in the larger global ecosystem'.

Thus, the question is not whether agroecology can produce an adequate amount of nutritious food for the growing and increasingly affluent world population while also reducing and offsetting some anthropogenic emissions. Rather, the question is: how can agroecology be adapted to produce enough food, be a negative emission technology and advance the SDGs of the United Nations?

The bold insight is that 'humans can reclaim the role of a beneficial keystone species in the larger global ecosystem'. Beyond being able to do good with agriculture through a set of practices and design strategies, agroecology can also be a way of thinking at the systemic level where we can see ourselves and our agency 'as nature itself, understanding that if we seek to develop the landscape we must also develop ourselves'.[70]

The capacity to see and manage the complexity of interdependent living systems requires pattern recognition. Our interaction with nature is itself pattern generating, thus leading to interdependent ecological and cultural evolution. Agroecological approaches thus can and do 'seek not only to reverse the degeneration of the earth's natural systems, but also to design human systems that can co-evolve with natural systems'.[71]

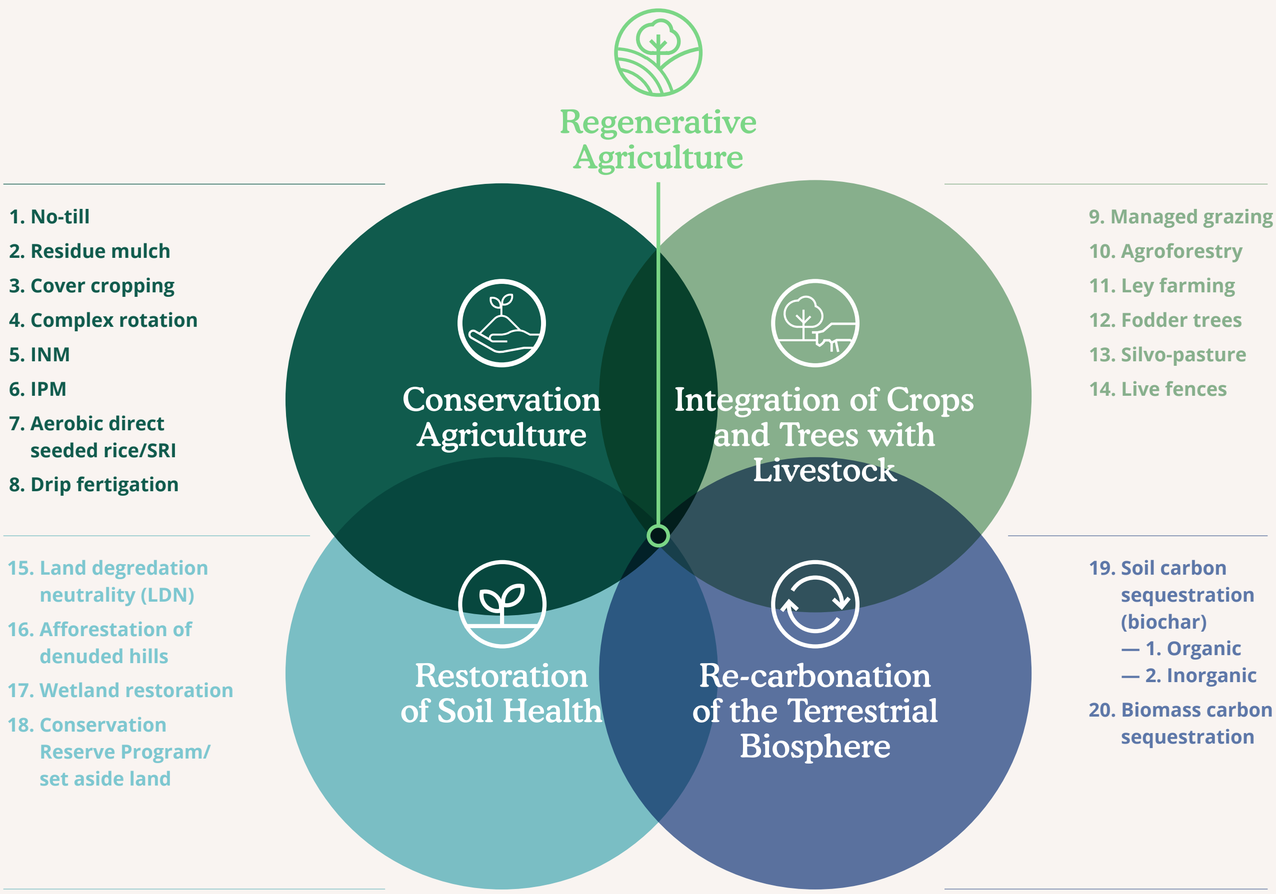
This is why it is not possible to give a global one-size-fits-all definition of agroecological approaches (whether we describe them as regenerative, ecological or agroecological). It does not stem from semantic pedantry but is the consequence of realising that defining the discipline puts ‘a wall around our agricultural landscapes, separating them from the natural world’.[72]

As we shall later see, this open-ended nature of agroecological approaches is one reason why it is knowledge intensive, why it appeals to an action-research based entrepreneurial attitude, and why a different perspective on education and research in this field is fundamental to supporting such entrepreneurship.

Figure 6: Professor Rattan Lal’s understanding of regenerative agriculture for food and climate.

Basic tenets of regenerative agriculture designed to draw carbon dioxide from the atmosphere. Specific packages of practices depend on site-specific biophysical environments and the human dimensions.

Adapted with permission from: Lal, R. 2020. Regenerative agriculture for food and climate. *Journal of Soil and Water Conservation* 75(5):123A-124A. https://doi.org/10.2489/jswc.2020.0620A.



INM = integrated nutrient management
IPM =integrated pest management
SRI = system of rice intensification

THE CONTINUUM PERSPECTIVE OF AGROECOLOGY: FROM DEGENERATIVE TO REGENERATIVE

Instead of seeking a single definition, it is possible to view agriculture as an activity in nature on a continuum which is degenerative at one end and regenerative at the other:

Figure 7: The agricultural continuum.

(Adapted from: Soloviev, E (2018) Regenerative agriculture continuum.)

Degenerative are all 'those processes, practices and protocols that decrease the health and wellbeing of a place, person or entity. Ecological and social degradation results from fragmentation, over-simplification, homogeneity, and destructive reactivity. There is a loss of possibility, opportunity, and individual agency.' Regenerative is that which continuously develops and enhances 'the vitality of a farm, a community, or a watershed. The capacity and capability of the place or entity evolves, growing its complexity, interconnectedness, and ability to express its uniqueness into the world. New potential emerges that has never been seen before.'[73]

We do not generally yet understand what it means to have seen, felt, and tasted the regenerative potential: if we understand it in the light of the continuum approach, we can ask an exciting question: 'How far can we take it?'

The utility of the continuum perspective is that it can be used to explore any system from an individual farm to an international industry. When applied to the way in which we grow food and fibre, we can expand the simple idea of the continuum to focus on our inputs and practices. Instead of a binary distinction between conventional/industrial and agroecological/regenerative, we then get to appreciate 'the living whole process in order to discern aspects of how it works and its effects on the world'.[74]

These are early days for agroecological approaches.

OUTCOMES-FOCUS VERSUS SETS OF PRACTICES

More and more organisations, individuals and businesses make claims about their practices, describing them as agroecological, ecological or regenerative. However, some uses oversimplify, banalise or fragment, instead of engaging with these terms as a whole and viable discipline. 'Global consumer product goods companies including Patagonia, Organic India, Nutiva and Lush Cosmetics and

The key to making sense of any regenerative claims is as simple as it is effective. All we need is to understand whether the effect of the practice is regenerative.

non-profits such as Project Drawdown, Kiss the Ground, Carbon Underground, Regeneration International, Via Campesina, and the Apios Institute all refer to regenerative agriculture, although the meaning may differ with each use.'[75] So, how do we know what they all mean when they use these terms? Have they actually changed how they are thinking or even what they are doing?

The key to making sense of any regenerative claims is as simple as it is effective. All we need is to understand whether the effect of the practice is regenerative, i.e. whether it has a regenerative outcome: 'only systemic outcomes can confirm that a regeneration is taking place'. Therefore, there can be no such thing as a 'regenerative agriculture practice', i.e. a set of practices that will under all circumstances deliver the same result. Essentially, this is the functional mindset behind conventional/industrial approaches to agriculture, a mindset which works by superimposing a set of one-size fits all practices which may well be successful in one context onto another. This is opposed to an approach which pursues outcomes.[76]

Such outcomes-focused frameworks capture a quality of ecological awareness that, for example, led the Cambridge educated founder and pioneer of the organic movement, Sir Albert Howard (1873–1947), in 1943 to articulate the Law of Return; a teaching principle that Howard used to encourage the adoption of farming practices that would follow nature's example of recycling all natural and organic waste products back into the soil.[77] Lal describes it as follows: 'replace what is removed, respond wisely to what is altered, predict what alterations may occur through anthropogenic/natural perturbations, and adopt practices that restore and enhance soil health'.[78]

4.2 History, levels and lineages of regenerative agriculture

Above, we touched upon how the continuum perspective allows us to understand the relationship of land and people, of natural systems and human systems, as interdependent, complex, coevolving living systems. What really brings home the importance of the evolutionary perspective is a look at the epistemology and history[79] of the use of the terms *ecology* and *regeneration* and how they became agricultural concerns. For example, the first use of the term *regenerative agriculture* has been traced back to 1985 in the context of the work of Robert Rodale and the Rodale Institute[80] which focused on developing organic agricultural practices to enable the regeneration of agricultural resources and which he later extended to regenerative economic thinking.

This use emerged out of a history of thinking regarding the relationship between human settlements and nature, the origins of which have been traced back to the

1880s. The introduction of the concept of, if not the term, ecological design itself is dated to 1915.

Beginning in 1935, organismic biologists were the first to formulate a systems view of life, seeking a more accurate depiction of how life ordered and organised itself within a particular landscape or geographic location. It is at this point that the human/nature dichotomy begins to give way to a growing understanding that all species are ecologically integrated with each other and with the abiotic constituents of their habitat.

Beginning in 1935, organismic biologists were the first to formulate a systems view of life, seeking a more accurate depiction of how life ordered and organised itself within a particular landscape or geographic location.

In the 1950s and 1960s, Eugene and Howard Odum brought to attention the importance of understanding how the earth's ecological systems interact with one another and laid the foundation for the development of ecology into a modern science based on the core concept of the ecosystem as the fundamental ordering structure of nature.

In 1968, biologist and systems theoretician Ludwig von Bertalanffy published his General System Theory (GST). This introduced the concept of open systems, emphasised the difference between physical and biological systems, and introduced evolutionary thinking – thinking focused on change, growth and development that in turn opened the door to a new science of complexity.

In the 1960s and 1970s, Charles Krone, who was one of the pioneers of Procter and Gamble's revolutionary work design 'Levels of Work', developed living systems thinking as a developmental technology for consciously improving systems thinking capacity. His work drew on and greatly extended GST and Systematics, a discipline that uses systemic frameworks to understand complex wholes within which people are participants rather than observers. Of particular importance for regenerative development was Krone's framework depicting orders or levels of work that living systems of all scales need to carry out. Ranging over four levels from basic operations up through regenerative work, it enables practitioners to see wholes at work and design for the integrated evolution of all levels in support of a regenerative change process:

1. **Level 1: 'operating'** – which he defined as getting things done and doing them well (this teases apart the difference between efficiency and effectiveness);

2. **Level 2: 'maintaining or sustaining'** – keeping something at its highest level of function within a constantly changing system (this is where concepts like resilience and antifragility come in);

3. **Level 3: 'evolving systems'** – work that increases the capability of a complex system to evolve over time; and

4. **Level 4: 'regenerating'** – work that builds the capacity of a unique, whole system to make contributions that bring forth new value in an ongoing way.

At P&G Soap, it helped employees 'to see markets, customers, and even soap making as living structured wholes'.[81]

In 1978, the word *permaculture* was first used – from a contraction of permanent agriculture or permanent culture – to describe an ecological design system to promote design of human habitats and food production systems based on the relationships and processes found in natural ecological communities. By creating 'human-made ecosystems', permaculture demonstrated how to provide for a host of human needs while reducing dependence on environmentally destructive industrial practices. While earlier iterations of ecological design promoted integration of human and natural systems for more sustainable development, permaculture was the first ecological design system to introduce the concept of a regenerative effect as a new standard of ecological performance for the built environment – the generation of a surplus or overabundance of energy and resources that could be reinvested to evolve natural and human living systems as an integrated whole.

In the 1980s, this then led to Robert Rodale's use of the term *regenerative agriculture* as described above.

Working with an adaptation of Krone's matrix of four levels originally developed for Procter and Gamble, Soloviev and Landua have suggested a corresponding framework for design and decision-making but now applied to the way the concept of regeneration is being used in agriculture, informed by their exposure to regenerative agriculture projects in South America, North America, Asia and Europe:[82]

1	2	3	4
Level 1: Functional	**Level 2: Integrative**	**Level 3: Systemic**	**Level 4: Evolutionary**

Each level has characteristic foundations, goals, processes, and guiding directions to organise work. They build on each successively in complexity. Levels 1 and 2 will generally focus on the landscape in an outer ecological sense. Levels 3 and 4 will also require engagement with the inner landscape of human consciousness and social fabric.

1

Level 1, the functional level, is a practice-based approach to farming and focuses (in the main) on growing the same vegetables and arable crops of industrial/conventional agriculture but doing so in such a way that carbon is sequestered in the soil, organic soil matter is increased, underground microbiology is improved, and a diverse soil and food web is nurtured. The key recognition here is that humans can do good. The focus is to regenerate soil. Farmers can expect to lower input costs and increase yields and resilience over time, which together lead to increased economic profits. The carbon sequestration, biological resilience and profitability of this level means that regenerative agriculture is a strategy for climate change mitigation and adaptation as well as economic improvement. The motivation behind this approach is found in the fear of the consequences of climate change while at the same time wanting to maintain life as we know it.

2

Level 2, the integrative level, is a design approach to farming which pursues outcomes. It is much bolder in attitude, limited only by human creativity and design ingenuity, and motivated by the joy of improving places and landscapes. This transcends the focus on soil and is about multi-factor regeneration of the health and vitality of whole living ecosystems. Single best practices are combined into integrative whole systems, as are the principles and tools of carbon farming, permaculture and Holistic Management. Agricultural enterprises, crops and breeds are selected for optimal fit to the farm's ecology, expanding into tree-based agroforestry. Instead of focusing only on mitigating climate change, the goal here is a low energy, high yield agriculture as a possible aim for the whole world.

3

Level 3, the systemic level, transcends practices and design strategies; it is a way of thinking in which humans understand themselves as a part of nature and one which works with our capacity to see and manage the complexity of interdependent living systems. Living systems are non-linear but have causal webs. Where Level 1 and 2 work towards robustness and resilience, the systemic level offers the possibility of antifragility, which actually benefits from disorder and disturbance.[83] At the systemic level, farms are woven into an ecosystem of groups of regenerative enterprises operating in and beyond their ecoregions. Thinking and landscape co-evolve. No farming season is ever the same; no landscape ever identical to what it was; humans see and generate the shifting patterns of the place.

4

Level 4, the evolutionary level, emerges from a pattern understanding of place and ecological context within which particular agricultural systems exist. It requires a deep understanding of the characteristics of the locality including geology, hydrology, ecology, flora and fauna as well as human history. Such deep pattern-understanding usually requires three or four generations to develop although more rapid methods of stimulating this level of insight have been developed.[84] Farms cease to exist as standalone entities; they are understood as embedded in context – ecological, social, economic. Farms, businesses and social systems come together and go beyond matching crops to the current landscape as they align with the common longer-term vision and potential of place rooted in a mutual understanding of multi-layered history. Such agri-ecological-economic systems evolve our understanding of industrial supply chains[85] into a diversity of global and local regenerative producer supply webs.

Alongside the four levels of regenerative agriculture, Soloviev has described five primary intellectual and practical lineages of the use of the term *regenerative agriculture*. Each lineage has a different definition, farming philosophy and approach to growing their community. The labels and references to organisations here are not exclusive and apply widely. We have, additionally, proposed how the lineages may sit within the framework of levels outlined above:

1. Rodale Organic

The Rodale Organic lineage holds that 'regeneration' is a combination of 40-year-tested conservation farming practices with a focus on soil – cover cropping, crop rotation, compost, low- or no-till. The concept is based on basic organic agriculture practices promoted by Rodale since the 1970s, re-dubbed 'Regenerative Organic' since 1985 and requiring the tenets of organic agriculture as a baseline. Consumer packaged goods brands have been strongly promoting this lineage, most notably through Regenerative Organic Certification.

This lineage impacts the functional Level 1 and beyond.

Permaculture as a global movement loves the idea of regenerative agriculture but for the most part fails to achieve significant levels of agricultural production.

2. Permaculture/Regrarians[86]

The Permaculture/Regrarian group generally includes small CICs and individual projects as opposed to larger commercial ventures.

Permaculture as a global movement loves the idea of regenerative agriculture but for the most part fails to achieve significant levels of agricultural production. Along with a strong focus on small-scale design and unproven beliefs about reversing climate change, this lineage tends towards ideals from the human potential movement, focusing on how to create 'thriving' and 'abundance' for all.

Despite its idealism, by way of outcome permaculture is at home in Level 1.

Regrarians, emerging from but transcending the scale and idealism of permaculture, have for decades integrated Holistic Management with keyline (maximising beneficial use of water) and ecological design processes at farm-scale around the world. Some impressive regenerative agriculture farm design comes from this lineage as it effectively integrates agroforestry, comprehensive water-planning, soil-building and holistic livestock management while building farmer capacity and economic viability.

This lineage is therefore associated with Levels 2 and 3.

3. Holistic Management

Holistic Management is promoted by both the Savory Institute and Holistic Management International as well as the national/regional Savory Hubs around the world, focusing on a comprehensive decision-making framework designed for animal-centric ecosystem regeneration.

In 2018 Savory released their Land to Market Ecological Outcome Verification system, with backing of some significant food and fashion brands. This is a market-leading, outcomes-based (instead of practice-based) standard. It requires a positive trend-line for ecosystem improvements and encourages positive landscape development along the regenerative continuum. However, the land-to-market programme in practice generally connects into the supply chain of the old industrial paradigm.

This lineage impacts at Levels 2 and 3.

4. Regenerative Paradigm

Organisations which work with an understanding of Krone's 'Levels of Work' aspire to working with the regenerative paradigm at all levels and at the frontier of the regenerative continuum. Organisations in this space include the Carol Sanford Institute,[87] Regenesis,[88] Terra Genesis International,[89] Regen.Network[90] and others that have applied the paradigm to business, design, planning, education and agriculture.

Many people who begin their journey in the permaculture lineage mentioned above find their way to here.

This approach takes its regenerative impact into Level 4.

5. Soil Profits

Character-led – especially in the USA, by Ray Archuleta, Gabe Brown and others – the soil profits lineage draws on practices and inspiration from other lineages but appeals strongly to conventional farmers by eschewing the dogmas of organic agriculture and focusing on bottom-line profits through increased soil health.

It bypasses prejudices against organic by allowing farmers to still use (limited) synthetic inputs and focusing on the economic arguments for decreasing inputs and improving soil through good crop rotation, no-till and grazing practices. In this way it can significantly broaden the appeal of experimenting with new farming approaches.

It is being adopted by significant numbers of mainstream conventional farmers.

This approach integrates several lineages but also straddles Levels 1 to 3 of the matrix with different degrees of impact, though most are at home in Levels 1 and 2.

4.3 The potential to produce more from less

We suggest that there are two significant conclusions to be drawn from this survey of principles and lineages of AE:

When we face the fact that global agriculture already produces enough food to feed 10 billion people but about 30% of all food produced is wasted, it is clear that it is important to break the vicious circle of produce, waste, degrade and pollute.

1. Outcomes are the key: the actual effects of any activity on the land and people, its outcomes, beyond any philosophy or particular practice.
2. There is a long way to go yet before we are anywhere close to realising the full potential of regenerative approaches to agriculture.

When we face the fact that global agriculture already produces enough food to feed 10 billion people but about 30% of all food produced is wasted, it is clear that it is important to break the vicious circle of produce, waste, degrade and pollute. Instead we need to produce more from less: less land, chemicals, water, GHGs, soil degradation and energy.[91] This would allow us to transcend the continuum perspective, grow more nutrient-dense food on less land, and be able to spare land and resources for nature.

How AE production at scale meets the 'more from less' principle is demonstrated in the case of Balbo Group, a 30,000+ hectare operation in Brazil run on agroecological principles, which produces 34% of the world's organic sugar (see Case study 1). Balbo Group makes good use of technology to operate at scale and achieve 20% higher productivity than conventional sugarcane production with a level of biodiversity over 50% of that found in Sao Paulo's national parks. Its latest technological innovation project seeks to construct a prototype of a 100% autonomous weed control robot which can avoid the use of pesticides not just in organic agriculture.

Another perspective on the potential for AE approaches comes from Australian climate scientist and soil microbiologist Walter Jehne, who was involved in the IPCC's adoption of its soil focus. For him it is clear that 'soil carbon sequestration is the key to achieving negative net carbon emissions'. Via the climate action group Regenerate Earth, he has outlined how 'we can do this globally, using photosynthesis to draw down 20 billion tC / an (twice our current net "acknowledged" annual deficit) back into our soils'.[92]

Counter to the current consensus based on 'oxidative agricultural practices',[93] Jehne is convinced that 'there is no question that lead innovators working with natural systems can consistently bio-sequester 10 tonnes of Carbon (37 t CO2) per hectare per annum: well above the 3–5 t CO2 deemed by some to be the maximum'.[94]

In our interview with him, Jehne pauses when asked what the basis of his claims might be. He responds: 'Even Darwin confirmed rates in his garden in Surrey in 1871 of some 11 t C (40 t CO2) per ha per year.'[95]

The evidence in favour of agroecology is compelling but for it to be embraced by business across the farming and food system it needs to be at least commercially viable and preferably more profitable than the industrial agricultural system it is replacing. In the next section we set out why agroecology is good business.

5.

Agroeconomy: farming smarter not harder

5. Agroeconomy: farming smarter not harder

But how can you improve farm performance? If you attend one of the agriculture investing conferences that have sprung up in recent years, you will hear a typical narrative from fund managers and agribusiness executives. Their business plan is to take 'under-utilised' land and to introduce 'modern' technology and inputs – in the form of seeds, fertilisers, agro-chemicals, machines or irrigation – to produce a small number of commodities. Scale, specialisation, simplification and standardisation are the mantras. Mechanisation and chemicalisation the tools. Or, they talk excitedly about 'AgTech'. [...] Many of these new technologies support or intensify the high-input, industrial model of farming. For example, precision agriculture and 'Big Data' tools make the application of chemicals and fertilisers more efficient, but they lock farmers into the use of these inputs. Other companies seek to take food production off the land altogether, putting it in a warehouse under artificial lighting or keeping it in the laboratory (as in the case of lab-grown meat). The ideal state is farm-as-factory, an industrial, linear process where inputs and outputs can be tightly controlled and the variability of nature tamed. Financial investors tend to 'get' these sorts of systems, as they look like the industrial businesses they more usually invest in. The irony is that this approach to agriculture is being challenged as never before. [...] It can be expensive, risky, unsustainable and produce food of doubtful quality. Instead, farmers around the world are devising innovative alternatives that are more diverse, make better use of natural process, have less impact on the environment and are more profitable – all backed by a deeper understanding of biological and ecological science.

Paul McMahon, co-founding Partner of SLM Partners, formerly McKinsey and Climate Change Capital[96]

In section 3 we argued that conventional farm finances are more fragile than the headline data might suggest. In addition, the value of key assets such as soil health tends to be overstated and the costs of intensive agriculture for ecosystem and human health are understated.

How is agroecology different?

5.1 Theoretical framework: from gross yield to value added

The key to understanding the difference between conventional/industrial and AE approaches is the difference between Value Added (VA) and Gross Value of Production (GVP).

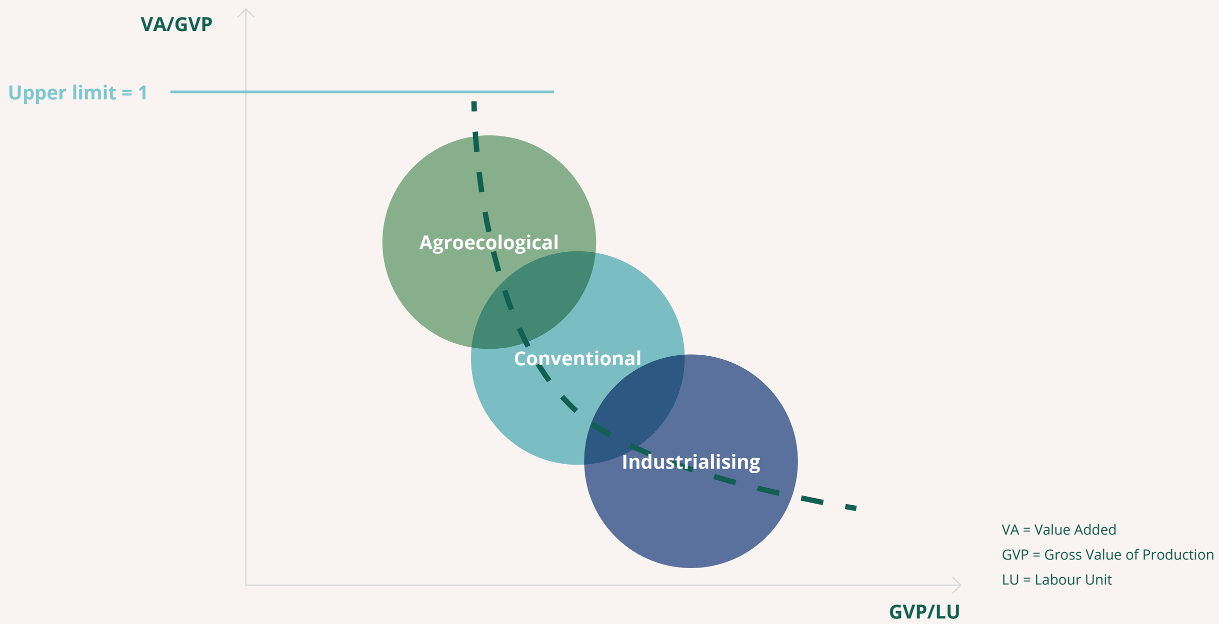
- GVP is the monetary value of the production from a given land area. This is analogous to sales or turnover in a non-agricultural business.
- VA is the difference between GVP and the costs of production after input costs are taken into account. This is analogous to profit in a non-agricultural business.

Conventional agriculture seeks to maximise GVP. Agroecology focuses on VA.

The difference arises because mainstream agricultural businesses and the institutions that surround them (banks, ministries, etc.) consider input costs to be more or less given. Indeed, input costs are difficult to alter without significant change to the methods of production as these methods determine the need for fertiliser, pesticides and herbicides, and the agricultural equipment required to operate large-scale industrial farms. All these factors are outside the control of the farmer. The cost that is considered manageable is the amount of labour input and so in conventional/industrial agriculture, farmers seek to maximise total production (GVP) realised per unit of labour (GVP/LU).

Figure 8: The interrelations between VA/GVP and GVP/LU (for different agricultural organizational models).

(Adapted from: van der Ploeg, J, et al. (2019) The economic potential of agroecology: empirical evidence from Europe. Journal of Rural Studies 71.)



This hidden potential of AE has gone unnoticed because, by focusing on the returns to land area and to labour, we have missed entirely the returns relative to ecological resources.

As a result, conventional thinking leads to a focus on levels of GVP per hectare, per animal and/or per unit of labour, which are often lower in AE than in conventional agriculture. This 'yield gap' feeds the misplaced assumption that AE is not capable of rendering comparable incomes. Yet, such conventional analyses miss the point that by achieving dramatic reductions in input costs, AE businesses can achieve higher levels of VA and hence profitability for the farmer.

This hidden potential of AE has gone unnoticed because, by focusing on the returns to land area and to labour, we have missed entirely the returns relative to ecological resources.

Of course, conventional and industrial agriculture can also increase their technical efficiency, which is often held up as one of the strengths of these types of farming. The basic difference, though, is that these increases in technical efficiency are usually acquired on the market and thus by increasing input costs only make a small contribution (if any at all) to increasing the VA/GVP ratio. Apparent efficiency improvements in such systems are accompanied by increased costs and lead to a stagnation, or even a deterioration, in the VA/GVP ratio.

In conventional/industrial practice this translates into ongoing scale-enlargement and/or reducing labour input. While at one time (notably during the 1950s and 1960s) this may have seemed socially, politically and economically desirable to release labour resources for expanding manufacturing, retail and service sectors of the economy, many commentators nowadays would agree that it is counter-productive in terms of maintaining an urban/rural balance or preserving the integrity (social, economic or ecological) of the countryside.[97]

5.2 Evidence: from incremental productivity improvement to systems-level shift

> ***If you want to make small changes, change the way you do things.***
> ***If you want to make major changes, change the way you see things.***
> Don Campbell, Canadian Holistic Management rancher[98]

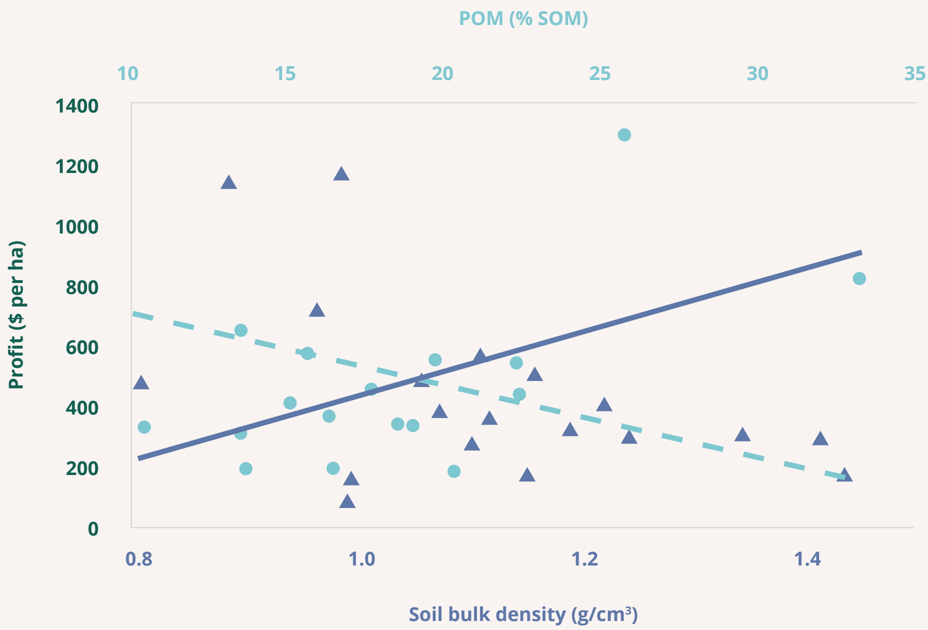
LaCanne and Lundgren's US-based comparative study of regenerative versus conventional farming operations makes the case that, under certain conditions, 'the regenerative system was nearly twice as profitable as the conventional'.[99]

Profit was positively correlated not with yield, but with the particulate organic matter of the soil, one of the symptoms of abundant soil biology.

In other words, regenerative farms are more profitable because of their superior soil health as represented by particulate organic matter. This contrasts sharply with simplified, conventional/industrial food production systems which pit soil health against profitability.

Figure 9: Corn fields with high particulate organic matter and low bulk density in the soil have greater profits.

(Adapted from: LaCanne, C, and Lundgren, J (2018) Regenerative agriculture: merging farming and natural resource conservation profitably. PeerJ 6:e4428. DOI: 10.7717/peerj.4428.)



POM = particulate soil organic matter
SOM = soil organic matter

But AE is inherently much more than 'farming without chemical inputs': it partly overlaps with organic agriculture yet simultaneously goes far beyond it. AE involves processes of production and reproduction that are radically different from those contained in conventional agriculture by emphasising:

- the centrality of living nature
- the importance of developing and maintaining an autonomous resource base
- the ongoing improvement of resources within the farm itself
- structuring the labour process as a learning process
- diversified production
- establishing interacting cycles that produce synergies.

Against this context, IPES-Food comments that, 'while industrial systems often improve one outcome (e.g. productivity) at the expense of others (e.g. environmental degradation, nutrient availability), diversified agroecological systems are showing major potential to reconcile the various priorities'.[100]

This mirrors a central aspect of AE that appears repeatedly across the available literature: it is not just a matter of small adjustments or course corrections to industrial and conventional agriculture that make the difference. LaCanne and

Lundgren conclude: 'To attain this requires a systems-level shift on the farm; simply applying individual regenerative practices within the current production model will not likely produce the documented results.'[101]

The shift is systemic beyond the farm in the sense of the multiple and interconnected benefits of agroecology for society and the environment more broadly. Care of the soil, water and biodiversity, reduction of GHG emissions, provision of public education about farming, and the building of community have been cited by one study as multifunctional benefits generated by such farms in the wider sense.[102]

However, the current system exhibits barriers to change (which we examine in section 6). For example, in the case of technology:

> ***UK investment in agricultural research and development has focussed on technologies for industrial farming to the exclusion of small and medium scale technology. Hence, growers are forced to rely on old, and sometimes unreliable, machinery, or import equipment [...] from mainland Europe or the United States, where the market has driven on-going development of modern equipment that is of an appropriate scale and price for small farmers.***[103]

Some AE farms have found themselves in the same situation for some key inputs such as seeds appropriate for AE producers: 'Similarly, the development of commercial plant varieties that accentuate the qualities desired by direct marketing, organic growers, [sic] such as flavour and disease resistance, is hampered by cost, regulation and lack of investment.'[104]

Yet, despite the relative absence of subsidies, the following have made it possible for AE enterprises to thrive on the fringes of the system: the focus on profit through synergies and layering of economic activity as opposed to yield; the better understanding of the biological niche as opposed to superimposing a technology-friendly simplified landscape; and attracting and maximising the return on investment from 'knowledge workers'.

5.3 Evidence: a study of small agroecology farms in the UK

Laughton's 2017 study of small AE farms, A Matter of Scale (AMOS),[105] set out to challenge the assumption that bigger automatically means 'more productive' and 'more viable', by collecting and analysing data about the yields, financial performance and multifunctional benefits of AE farms of 20ha and less.[106]

The study showed 'a diverse and vibrant sector, which attracts new entrants and incubates entrepreneurs'. Many of the holdings were five hectares or less and while some were focused on horticulture, others were operating several different enterprises including eggs, meat and micro-dairy. This approach to layering enterprises on the same land is a key component of AE approaches.

In discussing the AMOS study, Laughton describes how, in September 2017, 'a delegation of Defra officers from the Organic Team took part in a two-day study tour of small, agroecological farms in the Midlands, including three visits to holdings which took part in the study. Being able to show efficient and viable small farms in action, backed up by a detailed report about their productivity, was powerful in challenging *the preconceptions held by some of the delegates*.'[107]

She writes that 'a culture of disbelief exists that such farms can be economically viable in an age when family farms of 50–200 hectares are being amalgamated into ever larger units' and describes how such 'farms are often viewed as an old fashioned, romantic anachronism – unprofitable, inefficient and not to be considered as serious contributors to food security or rural economic growth' which are 'at best considered to be niche – producing "high end" products for an elite market – and at worst to be simply "hobby farms".'

Perhaps this preconception arises because it is fairly typical for farming households to have income from 'off-farm' employment: the distribution of income sources showed that for farms of less than 50ha, 44% would come on average from agriculture on that farm, 15.5% from non-agricultural activities on the farm, 13% from off-farm employment and 20% from pensions, savings and investments.[108]

Yet, Laughton's study found that these farms appear to have greater economic resilience, higher proportion of income derived from food production and less reliance on subsidies, when compared with Defra farm income data for UK agriculture and horticulture. She further notes that this superior performance is achieved against considerable headwinds including low farm gate prices within the food supply chain and high labour demands of small farms, and is particularly impressive given the fact that '78% were receiving no farm subsidies, and subsidies made up less than 20% of the income for 19% of those who were receiving subsidies'.[109]

While many holdings in the study were not able to live off the returns from farming alone and supplemented income with off-farm employment, or had diversified by running courses, campsites or holiday lets, the study nonetheless demonstrates the capacity of AE to realise levels of VA/GVP that are substantially higher than those of conventional and, especially, industrialised agriculture.

A further positive feature of these farms is their ability to attract increasing numbers of new entrants who bring youth and innovation to the agricultural sector.

So why are smaller agricultural enterprises not treated more seriously from a policy point of view?

It is generally assumed that bigger is better because economies of scale are observed in other sectors of the economy, and thus subsidies and financial institutions favour agricultural approaches that pursue size, yield and efficiency. Yet this is based on a misconception: 'Greater performance in a mechanical system is obtained by scaling up. Greater power means greater output: bigger is better.' However, the 'bigger is better' maxim does 'not hold for biological systems. There, size follows function'.[110]

D'Souza and Ikerd have applied this thinking to the nature of work and the difference between 'production line' work in industrial agriculture and 'knowledge work' in agroecology. Other things being equal, the smallest effective size is best for enterprises based on information and knowledge work. '"Bigger" will be "better" only if the task cannot be done otherwise.'[111]

As we move into a post-Brexit environment, the agricultural sector could be significantly hit by difficulties ensuring enough labour.

In biological systems, individual elements must conform to their ecological niche. From this perspective, industrial/conventional farms will be sustainable only if their niche is proportionate. It is readily apparent that many of today's farms are degrading both the natural and human resource base as they have expanded beyond their ecological and societal niches. It will take knowledge work, not physical or economic muscle, for farmers to find a niche where they carry out their function by means that are ecologically sound, economically viable and socially responsible.

This knowledge work makes AE management intensive and, inherently, information and knowledge intensive, which in turn gives rise to VA/GVP as the strategic differentiator. It might also provide a better route to high quality work and improvements in wellbeing and productivity than chasing technical efficiencies aimed at replacing or down-skilling labour inputs.

As we move into a post-Brexit environment, the agricultural sector could be significantly hit by difficulties ensuring enough labour. Whereas the seasonal nature of much of the labour will not change – fruit and veg will still need to be harvested on mass within short windows – the nature of the work done year-round will. There will be a greater focus on the quantity and quality of labour to build internal know-how and develop efficient approaches, working through experimentation, fine-tuning and learning processes, to increase the technical efficiency of the production process.

5.4 The implicit strategy of agroecology

The available literature suggests that the strong performance of agroecology businesses arises from six strategic differences in the AE productive process:

1. Substitution of internal for external resources

This leads to an optimisation of the use of locally available resources and their contribution to maintaining ecosystem services with minimum external inputs. Costs associated with external input are low; the use-efficiency of internal resources is high.

2. Diversified, 'multi-product' operations

Such operations optimise economies of scope through synergistic loops based on different, interlinked crops and animal breeding activities.

3. The search for and realisation of synergies

AE operations constantly fine-tune the whole by searching for and realising resource-use efficiency and synergies.

4. Labour: operatives become knowledge workers

In AE, workers are not 'operatives' but 'knowledge workers', building internal know-how and developing efficient approaches through the quantity and quality of labour build. They increase the technical efficiency of the production process with experimentation, fine-tuning and learning processes.

With regard to labour, the AMOS study found that workers are attracted by the meaningful nature and variety of agroecological farm tasks in statistically significant numbers: 'an average of 2.3 full time equivalents work on each holding, with the average per ha being 3.2'. This is much higher than the mean for the UK of 0.026 annual work units (AWU) per hectare.[112] However, 'labour issues were frequently mentioned as a limiting factor in increasing productivity' in the AMOS study, which leads to the next item.

5. Knowledge work supported by technology enables scale and efficiencies

The Balbo Group in Brazil (Case study 1) is an impressive example of how comparatively simple technological innovation can support AE practices by way of reducing external inputs, increasing synergies, enabling diversified operations and deliver scale through synergies with knowledge work.

6. The creation of new routes to market improves off-farm prices

AE is also a movement that creates new alliances among farmers and between consumers and producers that result in new markets which can result in improved off-farm prices.

For the AMOS study, Laughton comments: 'Most of the farms were adding value either by direct marketing or processing their produce into cheese, juices or preserves. Vegetable box schemes, farmers' markets and community supported agriculture schemes enable better incomes, while building customer trust through provision of fresh and sustainably produced food.'[113]

5.5 Agritech and agroecology

Agricultural technology, or agritech, is a growing sector estimated to contribute £14.3 billion to UK economy, employing 500,000 people.[114] Broadly defined, it simply refers to the application of science and technological innovation to agriculture. A detailed consideration of the opportunities afforded by the interaction of agroecology and agritech is beyond the scope of this report, but we offer four observations for further debate and research:

1. AE farming is not 'anti-science'. In fact, it is deeply science based and knowledge intensive. The cutting-edge science in agriculture today is not in chemistry: it is in biology. We are only beginning to understand soil microbiology, species interactions, and ecosystem functioning. Professor Gordon Conway of Imperial College London, a former president of the Rockefeller Foundation, calls the emergence of ecology as a sophisticated discipline 'the second great revolution in modern biology' alongside genetics.[115]

2. AE is therefore agritech – but of a different kind. It is a revisiting of the original definition of *technology* and its Greek origins: *techne* means art, skill, craft or the way something is gained, and *logos* means word, the utterance by which inward thought is expressed, a saying or an expression. *Technology*, thus, does not just refer to physical objects such as new machines or seeds. It refers also to knowledge or mental objects. Literally, technology means words or discourse about the way things are gained. Knowledge-intensive agroecological farming systems, therefore, are advanced forms of human technology.

3. The application of technology within AE seeks to enhance labour productivity rather than replace labour, and in this way can be seen as an approach to technology that augments human capabilities and improves the quality of work.[116]

4. AE focuses on technology that is widely accessible either because it is open source rather than proprietary, or lower cost and thereby affordable to smaller scale producers.[117]

In view of this, and as highlighted earlier in this section, there has been underinvestment in research and development for smaller scale agroecology. It would be advisable to review government support through UK Research and Innovation, the Transforming Food Production Challenge, Knowledge Transfer Network and agritech catalyst rounds to ensure that they do not exclude or disadvantage technological innovation within AE.

6. Barriers and levers for change

6. Barriers and levers for change

> *I practiced the conventional production model of farming for many years. I chased higher yield when growing crops and more pounds when raising beef. Everywhere I turned, the message of increasing production was pounded into me. Magazines, newspapers, radio, universities, extension service, agricultural agencies, everywhere and everyone was telling me that I had to produce more 'to feed the world'. Stacked GMO traits, hybrid grain varieties, foliar fertilizer, seed treatment, larger equipment.*
>
> Gabe Brown, US American regenerative rancher[118]

If agroecology delivers environmental and social benefits at the same time as improving business performance, why isn't everybody doing it yet? We consider this question in the next section by identifying factors that may prevent change in agricultural systems, before exploring three conditions or levers for change (sections 6.3–6.5).

6.1 System inertia: Eight lock-ins preventing progress

A transition to something must also be a transition away from something else. IPES-Food examined what might be keeping industrial agriculture in place[119] and concluded that industrial food systems have taken shape around industrial agriculture, creating a set of negative feedback loops ('lock-ins') that serve to reinforce this mode of farming. The report identifies eight such lock-ins:

1. **Path dependency**, by which industrial agriculture becomes self-reinforcing through the investments it requires, and the need to see a return on those investments;
2. **Export orientation**, which is a major driver of highly-specialised and industrial modes of production of exportable bulk agricultural commodities, kept in place by policies and incentives;
3. **The expectation of cheap food**, which industrial agriculture is uniquely positioned to provide, encouraging farmers to further specialise and industrialise their production in order to supply large volumes of specific commodities at low costs;
4. **Compartmentalised thinking** that governs the setting of priorities in politics, research and business but is ill-equipped to respond to the cross-cutting challenges facing food systems;

5. **Short-term thinking** dominating political and business cycles, thereby pushing short-term solutions to the forefront and keeping these actors firmly wedded to existing systems – even as they generate increasing problems;
6. **'Feed the world' narratives** that claim that the same systems and same actors driving the Green Revolution-style productivity increases of the past must remain at centre stage, while deflecting attention away from the failings of industrial agriculture;
7. **Measures of success** that undervalue the benefits of agroecology; and
8. **Concentration of power** that reinforces all the lock-ins.

The impact of path dependencies, the first factor, was identified by a study in the UK and France that found that calls for transformation in the agri-food systems became diluted and co-opted to fit within existing food policy initiatives, thereby defending existing investments from disruptive change in the industry.[120]

Measures such as nutritional quality, resource efficiency, impact on biodiversity, provision of ecosystem services, food security, resilience to climate shocks and impact on livelihoods and equity, are clearly relevant to a complete picture of social, economic and environmental value.

Factor 7, measures of success, contributes to another effective lock-in, which is availability (or not) of appropriate finance. The benefits of diversified agroecological farming are systematically undervalued by conventional measures of agricultural productivity, which adversely affects businesses' access to finance. Measures such as nutritional quality, resource efficiency, impact on biodiversity, provision of ecosystem services, food security, resilience to climate shocks and impact on livelihoods and equity, are clearly relevant to a complete picture of social, economic and environmental value. Failure to incorporate a more holistic set of indicators risks privileging industrial agriculture at the expense of agroecology.

In this context, CIDSE commissioned a policy brief[121] which asks a pertinent question: 'Does public finance support the food system transformation required by the crises we are facing?' It chose to look at two sets of publicly funded organisations with agroecology-related missions:

1. The UN FAO, the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP), which are all UN agencies of great importance 'in setting the tone of food security policies and projects at the international level and because of their recent engagement in favour of agroecology'.
2. The Green Climate Fund (GCF), which describes itself as 'the world's largest dedicated fund helping developing countries reduce their GHG emissions and enhance their ability to respond to climate change'. As over 90% of countries' Nationally Determined Contributions (NDCs) include agriculture targets, and as 12.5% of NDCs specifically refer to agroecology, the authors of the report expected 'money flows to reflect this increased focus on agroecology'.

However, using data for the period 2016–2018, the research led by the Centre for Agroecology, Water and Resilience (CAWR) of Coventry University in the UK found that:

The financial support for transformative agroecology is either minimal or non-existent.

- None of the UN's food and finance agencies' EU-funded projects are supportive of a transformative agroecology (targeting food system change or the redesign of the agroecosystem as a whole).
- 2.7% goes to projects partially supportive of agroecology.
- 17.5% goes to projects with an uncertain potential to support agroecology.
- The remaining '79.8% of the money flows are supporting business as usual approaches'.

Furthermore, with regard to the GCF, the authors found that

- 79.3% of the money flows are going towards business as usual approaches (enabling of conventional agriculture and efficiency improvements).
- 10.6% of the money is invested in agricultural projects are supportive of a transformative agroecology.
- 10.1% of the money is channelled towards projects partially supporting agroecology.

This, according to the authors, warranted a closer look at the national level within (some) EU countries contributing to EU and UN food and agriculture funds, asking: 'Are the trends that were identified above also reflected at the national level?'

The findings reflected the above results: the financial support for transformative agroecology is either minimal (Belgium, Germany) or non-existent (UK). Furthermore, in most countries, agroecology is not even a category used to report agricultural spending, including in the UK – a point which shows the work needed on measures of success.

Another lock-in that deserves deeper scrutiny is that of the concentration of power, which can be viewed as the 'mother of all lock-ins', reinforcing all the others. Food and agriculture sectors are notable for a high degree of corporate concentration. In 2013:

- The world's top three commercial seed corporations (Monsanto, DuPont and Syngenta) controlled over half (53%) of the world's commercial seed market, and the top 10 controlled over three-quarters (76%).
- Just six firms held 76% of the global agrochemical market.
- The top 10 pesticide companies controlled almost 95% of the global market.
- The top 10 fertiliser firms controlled 41% of the global market.[122]

There are millions of farmers selling their products into increasingly globalised commodity markets. They are price takers. But when inputs are controlled by a small number of large firms as detailed above, this gives these firms more power to set prices. Farmers complain that the costs of inputs are 'sticky', rising quickly alongside food prices but then taking much longer to come down after food prices peak. Corporations do their best to make sure that much of the economic surplus from rising food prices goes to them (see next section).[123]

Any approach aimed at stimulating an agricultural transition should therefore consider lock-ins and identify opportunities for overcoming system inertia though, for example, changing financial incentives, addressing market imbalances, or providing research and data required for more holistic and accurate measurement of the social, environmental and economic impacts of different farming methods.

We must shift the centre of gravity in food systems, allowing harmful dependencies to be cut, the agents of change to be empowered, and alliances to be forged in favour of change.

But is policy innovation enough to drive rapid systems change? Probably not, if we take the example of Denmark as a guide. Denmark's public policy choices in favour of organic farming since the mid-1980s have led to 10% of farmland now being under organic agriculture compared to 3–4% in the UK. Evidently, public policy can drive the direction of agriculture but, on the other hand, decades of state support in favour of organic farming, including heavy taxes on pesticides and fertilisers, might have been expected to drive faster and further.

In the words of the IPES-Food, we 'must shift the centre of gravity in food systems, allowing harmful dependencies to be cut, the agents of change to be empowered, and alliances to be forged in favour of change'.[124]

We discuss in sections 6.3–6.5 below three potential areas of focus to drive systemic change at a faster pace and at a scale that matches both the extent of the social, environmental and economic challenges the UK faces and, importantly, the rich potential of agroecology to help address them. These are:

- significant investment in AE research and knowledge dissemination
- turning access to finance from a barrier to a catalyst for change
- supporting agroecological entrepreneurs.

Before this, we briefly survey the barriers and drivers within the current adoption of AE practices in the UK.

6.2 Barriers to and drivers of adoption of regenerative agriculture in the UK

The validity of systemic lock-ins in the UK context has recently been evidenced through interviews with a range of professionals from the British agricultural industry by an MSc student at the Royal Agricultural University.[125] His research identified barriers to adoption of regenerative agriculture in the UK which are set out in the tables below. We have categorised the findings according to whether they are long-term or systemic drivers, short-term and policy-driven considerations or focused on the farmers themselves.[126]

BARRIERS TO ADOPTION OF AGROECOLOGY

Long term / systemic

- a dichotomy in the UK agricultural system between food becoming cheaper while margins are narrowing due to increasing levels of inputs required to maintain the food production system as it is
- a 'race to the bottom': taking margins out of food production while manufacturers, retailers and consumers demand cheaper food
- large industry suppliers and their advisors pressurise farmers to invest in equipment, apply more inputs and drive for increased yields, thus creating a distorted image of the true cost and the ease of change
- over-specialisation of farms
- innovation and change inhibited by making entry to agriculture hard for younger generations.

Current / policy driven

- current subsidies reward 'land sparing' for short-term, unfocused environmental schemes and do not adequately fund transition to environmentally minded regenerative farming
- BPS payments have propped up tenancy and land rental agreements
- uncertainty of UK's import and export position, making forecasting and long-term vision impossible for some.

Farmer focused

- average age of farmers (60) and their limited environmental education causes resistance and a lack of desire to adopt new practises
- a culture of risk aversion and 'doing what works' has made change seem difficult and far-off for some.

DRIVERS OF ADOPTION OF AGROECOLOGY

Long term / systemic

- Some see the parallel cliff edge and the possibility of market premiums and (subsidy/environmental) support approaching.

Current / policy driven

- land ownership and low borrowing allow farmers to try new systems and implement new practises
- farmers motivated by environmental concerns recognise that healthy soils and increased biodiversity will safeguard their farms for future generations
- access to new information and opportunities through social platforms and peer-to-peer learning has opened the door to the younger generation of farmers, who are making 'on farm' decisions that aim to regenerate the land
- thought leaders – who are driven by new economic possibilities in the form of lower inputs, diversification, carbon markets, new environmental subsidies and artisan products – are making funding transition easier
- personal experiences of crisis and trauma, coupled with a desire to escape the drudgery of conventional farming and to feel 'like you are working with nature', is promoting a wave of early adopters and evangelists
- the sudden appearance of agriculture in the mainstream press, alongside issues of climate change and biodiversity loss, has started some consumers and producers on a 'journey of discovery back to where their food is from'.

Our analysis is that positive change is being driven primarily by farmers and their responses to environmental concerns and business opportunities, but that the barriers are largely systemic and policy driven. Therein lies a huge opportunity for smart policy-making that takes a system-wide approach to unleash the entrepreneurial potential of the UK agricultural sector to shift towards a regenerative system.

The author of the study, Harry Farnsworth, comments that, while this is not an extensive list, 'it wouldn't take much of a shift within the industry for regenerative to become more widely adopted and for more farms and communities to see and feel the benefits on natural capital and the farmed environment'.[127]

6.3 Research and knowledge dissemination

We believe that the economic case for agroecology is compelling on the basis of available theory and evidence, but that there is a need to significantly scale up research, data and insight into agroecology and, in particular, to improve the knowledge base in four areas:

1. key performance indicators for agroecology

2. natural systems, biology, soil science

3. how to scale and employ technology

4. turning natural systems into profitable businesses.

Despite an 'inverse relationship' between farm size and productivity being proven in the Global South, insufficient data exists about the productivity of small farms in the UK. Paul McMahon concurs that 'much of the academic research on AE has focused on development projects in Africa, Latin America and Asia'. However, he sees 'no reason why ecological farming cannot work on a large scale within a commercial environment. [...] The scale of operation is really a question of levels of social and economic development.' He points to a raft of impressive case studies (see the case studies section of this paper).

Farming agroecologically, or smarter, is knowledge intensive. Machinery and technology will play an important role, alongside a deep biological and ecological understanding, and a management framework which allows for the transformation of 'all agricultural systems to a symbiotic relationship between ecology and economy'.

In other words, the knowledge gap we need to address is about how to shift agriculture from an 'input-intensive, unprofitable ecological problem to a knowledge-intensive, profitable ecological solution'.

However, at the level of the individual farm, the problem so often is that a complete shift in thinking and approach is necessary: only a commitment to total change allows the real benefits to flow. When there is no external pressure or incentive, a voluntary change of practice will likely appear as a significant risk. Yet it is precisely at the level of the individual farmer that a transition to AE approaches must take place. From there, systems-level change will follow, given sufficient numbers.

Relevant education and training can de-risk the transition for individual farmers when it allows them to identify relevant outcomes, to work with the prevailing conditions of the ecological context they find themselves in, and to build a profitable business around a suitable natural systems approach. A management framework that is both outcomes focused and able to work with the conditions of any particular ecological context needs to be anchored in three knowledge bases:

1. the latest soil science, which understands soil as a complex living system
2. the complete suite of agroecological tools and techniques for farming and land management
3. a comprehensive, systematic, complexity-aware design, management and measurement system which can optimise economic and ecological outcomes simultaneously, and measure performance in both.

The latter system is usually the missing link yet crucially determines the ability to combine economic and ecological results across different agricultural contexts and optimise for both (see Box B below for an example of poor measurement driving poor performance).

These three dimensions of the knowledge base being in place gives 'the potential for a fast, viable and productive transition from resource intensive chemical-based soil mining to a knowledge-intensive industry which profitably harnesses natural processes and provides a rich habitat for a thriving biologically-diverse web of life'.[128]

Box B – How partial soil tests can lead to resource misallocation

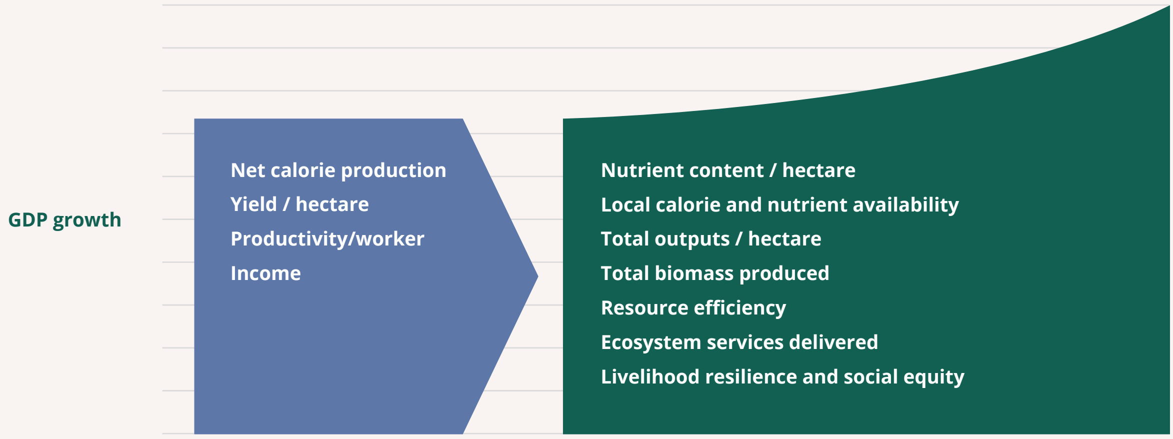
Conventional soil tests evaluate only the chemical and physical properties of the soil and use caustic, reactive acids (nitric and sulfuric acid). These tests ignore the fact that 90% of the nutrient cycle is biological and therefore does not mimic the interaction of soil nutrients and root systems. Conventional soil tests, therefore, do not work well for estimating nutrient levels and give an incomplete picture of soil health that favours the fertiliser industry. This can result in farmers being recommended to apply significant additional inputs that can affect ecosystem health negatively – and unnecessarily. By comparison, the Haney soil test biomimics the three most common acids (oxalic, malic and citric acid) emitted by plant roots and uses water as an extract based on the fact that it rains water(!). This test then measures seven parameters related to soil biology much more accurately, arriving at a final soil-health score and estimating any necessary nutrient input based on a more holistic assessment of the soil.[129]

The potential for the transition is to move away from an approach to agriculture which the Director of Healthy Soils Australia, climate scientist and microbiologist Walter Jehne, describes as 'mining' and 'extractive nutrient harvesting'[130] towards one which recognises that, in Allan Savory's words, 'ultimately, the only wealth that can sustain any community, economy or nation is derived from the photosynthetic process – green plants growing on regenerating soil.'[131] 'Extractive nutrient harvesting' is not sustainable and, in Jehne's view, has repeatedly led to the collapse of civilisations 'once they have completely extracted and exploited their soil resources'[132]

More broadly, the IPES-Food makes a number of suggestions for more adequate measurement of the economic performance of agriculture, summarised in Figure 10, which provides an illustration of the data sets that an Agroecology Development Bank[133] might play a leading role in developing for the benefit of both the farming and financial sectors.[134]

Figure 10: Measuring what matters for sustainable food systems.

(Adapted with permission from: IPES-Food (2016) From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems.)



Long the preserve of individual farmers working on the fringes, ecological farming is now going mainstream. The idea that ecology should be at the centre of agriculture has been endorsed by the two Rome-based UN food agencies (the UN FAO and the International Fund for Agricultural Development), the oldest scientific fellowship in the world (the Royal Society), an international study involving 900 experts from 110 countries (the International Assessment of Agricultural Knowledge, Science and Technology for Development, or IAASTD) and the French Agricultural Research Centre for International Development (CIRAD).

However, not enough is known about the leading edges of agroecological practice as it could be applied in the UK.

6.4 Investing in agroecology at pace and scale

In section 5, we concluded that the economic fundamentals of agroecology are sound and over the long term are more favourable than conventional agriculture. Does this mean that there is no need for any intervention in the supply of finance as theoretically all viable projects would receive appropriate commercial finance?

Our research has indicated that in many cases farming businesses can access the bank finance they need, including to transform production methods, but there are also circumstances in which banks may find it difficult to lend.

Furthermore, if input costs can be reduced through transition from industrial methods towards agroecology, could the transition be financed entirely from internal cash flows with no need for external finance?

Our research has indicated that in many cases farming businesses can access the bank finance they need, including to transform production methods, but there are also circumstances in which banks may find it difficult to lend, including:

- tenant farmers and/or farm contractors, who are unable to offer adequate security for loans. Farm tenants have been able to offer livestock and capital equipment as security, but with falling and uncertain livestock values and in the context of less capital and more knowledge-intensive methods of AE, this may become more of a barrier to loan finance.
- smaller farms, for which transaction costs of lending are proportionately larger relative to loan size
- new entrants to farming, or succession within an established farm enterprise, where there is insufficient financial track record
- application of new farming methods that, although potentially well evidenced in general, lack a track record in a particular setting and so appear more risky.

Laughton's study of small farms found that lack of working capital was a limiting factor on business efficiency.

The AMOS study found that AE farmers encountered significant barriers to productivity that included:

- lack of capital to invest in equipment and infrastructure, meaning the efficiency of some holdings was less than optimal
- affordability of land and accommodation
- lack of technology suitable for small-scale farmers.

In many cases, the bulk of any start-up capital was spent on land, with insufficient funds being left over to invest in buildings, fencing and machinery. 'Although people manage and innovate with what is available, inefficiencies resulting from animals escaping due to poor fencing, machinery breaking down when needed and forage being ruined when stored under tarpaulins rather than in a barn were seen as a drain on the business.'[135]

Many of these circumstances are familiar to the financing of infrastructure projects and of SMEs (small and medium-sized enterprises). In the case of the former, there can be significant positive externalities that cannot be captured, in particular the lack of sufficient collateral, start-up finance being too risky for deposit funded banks, and smaller loan sizes being commercially less viable relative to the costs of transacting and servicing them.

In the UK the British Business Bank (BBB) addresses this need through a combination of provision of financial products, initiatives to expand the diversity of SME finance providers, publication of market intelligence and data, and improving the matching of demand and supply of finance through signposting and engagement. The existence of gaps in finance provides a case for intervention even if many businesses are currently able to access external finance.

Furthermore, the scale of transformation required suggests that there is a significant funding need if faster progress is to be achieved, and an opportunity for finance to act as a catalyst for the transformation to new business models. An example of such a finance intervention is the role of the Green Investment Bank in stimulating the supply of finance to the offshore wind sector in the UK (see Box C below).

Box C – The Green Investment Bank

In the UK context, the role of the Green Investment Bank (GIB) in stimulating the supply of finance to the offshore wind sector is instructive. Offshore wind was economically viable, but when it was an early stage technology in its commercial application with minimal financial track record, the level of skill, experience and institutional capability that commercial banks had in financing oil and gas sectors was not mirrored in the offshore wind sector. The GIB acted as a centre of expertise, crowding in private sector finance to robustly profitable but as-yet-unproven projects. The barriers were as much institutional (skilling up banking staff, developing technical expertise and data, and evolving risk appetites and risk management frameworks for a new technology) as purely about availability of capital at the right price. There could be a parallel with finance for agroecology in that the role of the GIB was temporary in facilitating a transition in finance from an obsolete technology (fossil fuel) to a new technology (large-scale renewables).

As BBB products and CAP subsidies are both classified as state-aid there has been a general exclusion for the agriculture sector. This is set to change with the UK's departure from the EU, providing an opportunity to review whether specific financial products could be designed to stimulate the shift to agroecology.

However, any supply side finance interventions are most likely to succeed when measures are also in place to develop the demand side – a flow of bankable business propositions that can make productive use of external finance.

6.5 Supporting the agroecological entrepreneur

An observation that sheds light on the potential conflict between central policy frameworks and farming realities is that ecological farming systems are both intensely local and knowledge-intensive (the opposite of 'farming by numbers') in at least two ways: the ecological context of the particular local combination of soils, climate, terrain and biodiversity; and the specific social context which must be understood to build harmonious working teams and external relationships. The business environment often varies too, such that only people with local knowledge will get the best value when selling crops or animals or buying inputs or services.[136]

This elevates the importance of the role of farmers and growers. The most successful will be able to apply knowledge, insight and skill in a dynamic process of experimentation where plans are adjusted to feedback and new data in real time – in other words, entrepreneurialism.

A second reason for focusing on the role of the agroecological entrepreneur is the significant challenge and opportunity of farm succession that is posed by the imminent generational transition in UK agriculture.

As Table 1 shows, in the UK a third of all 'holders'[137] are over the typical age of retirement (65) and the median age of holders is 60. This is contrasted with the proportion of under-35s, which is just 3%. Whereas the proportion of holders between 45–64 has remained flat since 2003 the big shift has been from those under 44 (decreased by 6%) to those over 65 (increased by 7%). This clearly shows that the average age of the UK farmer is increasing.

Table 1: Proportion of holders in each age group.

(Source: Agriculture in the UK 2018, Defra.)

	% OF HOLDERS IN EACH YEAR					
HOLDERS' AGE	2003	2005	2007	2010	2013	2016
UNDER 35 YEARS	3	3	3	3	3	3
35–44 YEARS	15	14	12	11	10	9
45–54 YEARS	24	23	23	25	25	23
55–64 YEARS	29	29	29	29	28	29
65 YEARS AND OVER	29	31	33	32	34	36
MEDIAN AGE (YEARS)	58	58	59	59	59	60

There is no simple or single intervention to encourage and support entrepreneurship but we conclude that regulatory and market incentives, institutions and other interventions should always be designed with the entrepreneur at the centre and to explicitly allow for a multitude of diverse approaches and experimentation.

The issue is further compounded by the fact, highlighted recently by the president of NFU Scotland when he stated that 'a huge number [of farmers] are approaching retirement, with no clear successor to run the operational side of their business'.[138] Farm holders need urgent support to help them manage the transition like the Land Matching Service operated by NFU Scotland, which wants to match those with land, including those wanting to retire with young people who want to enter farming. Their goal is 'to help restructure our industry by encouraging young people into farming and bringing new skills, new thinking and the next generation into agriculture'.

Initiatives such as the land matching service are very important but a large influx of young farmers without a track record, or operating as tenant farmers, and potentially using different methods of farming on the land will be a challenge for the conventional finance sector to fund at scale.

How can we support agroecological entrepreneurs?

BizFizz, a multi-year programme of enterprise support in economically disadvantaged areas, demonstrated that lasting change within local economies can be brought about by supporting business initiatives that are driven by people with a passion for them to succeed.[139] The project found that local structural problems often prevent the 'passion and the resourcefulness, creativity and entrepreneurial flair of the people who live in these places' to flourish and thus require carefully honed policy frameworks and agencies to uncover and release the hidden potential.

Crucially, the project spent four years developing social capital **through building supportive networks around entrepreneurs** and mobilising under-utilised resources: knowledge, contacts, premises, finance. The approach highlighted how support agencies and their resources can achieve local regeneration through entrepreneurship when 'official targets and jaded institutional bias are put aside; when support agencies [...] build up the necessary trust and credibility to enable people to follow their passion'.

There is no simple or single intervention to encourage and support entrepreneurship but we conclude that regulatory and market incentives, institutions and other interventions should always be designed with the entrepreneur at the centre and to explicitly allow for a multitude of diverse approaches and experimentation. This flows from the nature of AE as a knowledge-based business that requires localised knowledge and innovation to drive intended outcomes, rather than a process-driven and standardised system that can be micro-managed from the centre.

7. Conclusions and recommendations

7. Conclusions and recommendations

> ***We have encouraged a type of farming which has damaged the earth… If you have heavy machines churning the soil and impacting it, if you drench it in chemicals that improve yields but in the long term undercut the future fertility of that soil… ultimately you really are cutting the ground away from beneath your own feet.***
>
> Michael Gove, Secretary of State for the Environment (October 2017)[140]

The policy context for agriculture has travelled a long way since 2007, when environment secretary David Miliband dismissed organic food as a 'lifestyle choice that people can make' and criticism of conventional farming methods on environmental or health grounds were robustly dismissed by the industry.[141]

Ten years on from David Miliband, Michael Gove, then environment secretary, announced that parts of the country 'were 30 to 40 years away from […] the fundamental eradication of soil fertility',[142] with one scientific study suggesting no more than 100 harvests remaining.[143]

The analysis and evidence presented in this paper strongly support a policy framework that encourages a shift towards agroecology at pace and scale. There is an opportunity to reverse the decades of self-defeating environmental damage highlighted by Michael Gove at the same time as growing a more profitable, innovative and knowledge-intensive UK farming industry.

AGROECOLOGY AS A WIN-WIN SOLUTION

For years, debates about the future of food have had one underpinning assumption – a trade-off between the ecology and society on the one hand and the economy on the other. We have been told we can either have abundant cheap food, or we can have food grown in a nature-friendly way, but in smaller quantities and it will cost more.

Our first conclusion is that the need for this trade-off no longer exists.

Our report argues, based on the available evidence, that agroecological methods can be both profitable, therefore ensuring farmer's livelihoods, and deliver improvements in soil, water and biodiversity as well as, critically, reductions in GHG emissions.

Furthermore, there are social benefits from AE, including the transformation of land workers from semi-skilled 'production line' operatives to skilled knowledge workers, improving the quality of jobs. The quantity of jobs would also be likely to increase significantly, especially with a shift towards agroecological horticulture.

These positive environmental and social benefits do not have to come at the expense of profits or economic performance. On the contrary, AE is good business. Our positive assessment of the economics of agroecology draws on three key components:

1. The benefits of diversified agroecological farming are systematically undervalued by conventional measures of agricultural productivity.
2. The financial position of existing farm businesses is overly reliant on inflated land values and direct farm payments through CAP.
3. Despite the lack of subsidies given to AE businesses, their focus on profit through synergies, layering of different outputs and reducing non-labour inputs, as opposed to focus on gross yield, has made it possible for AE enterprises to thrive.

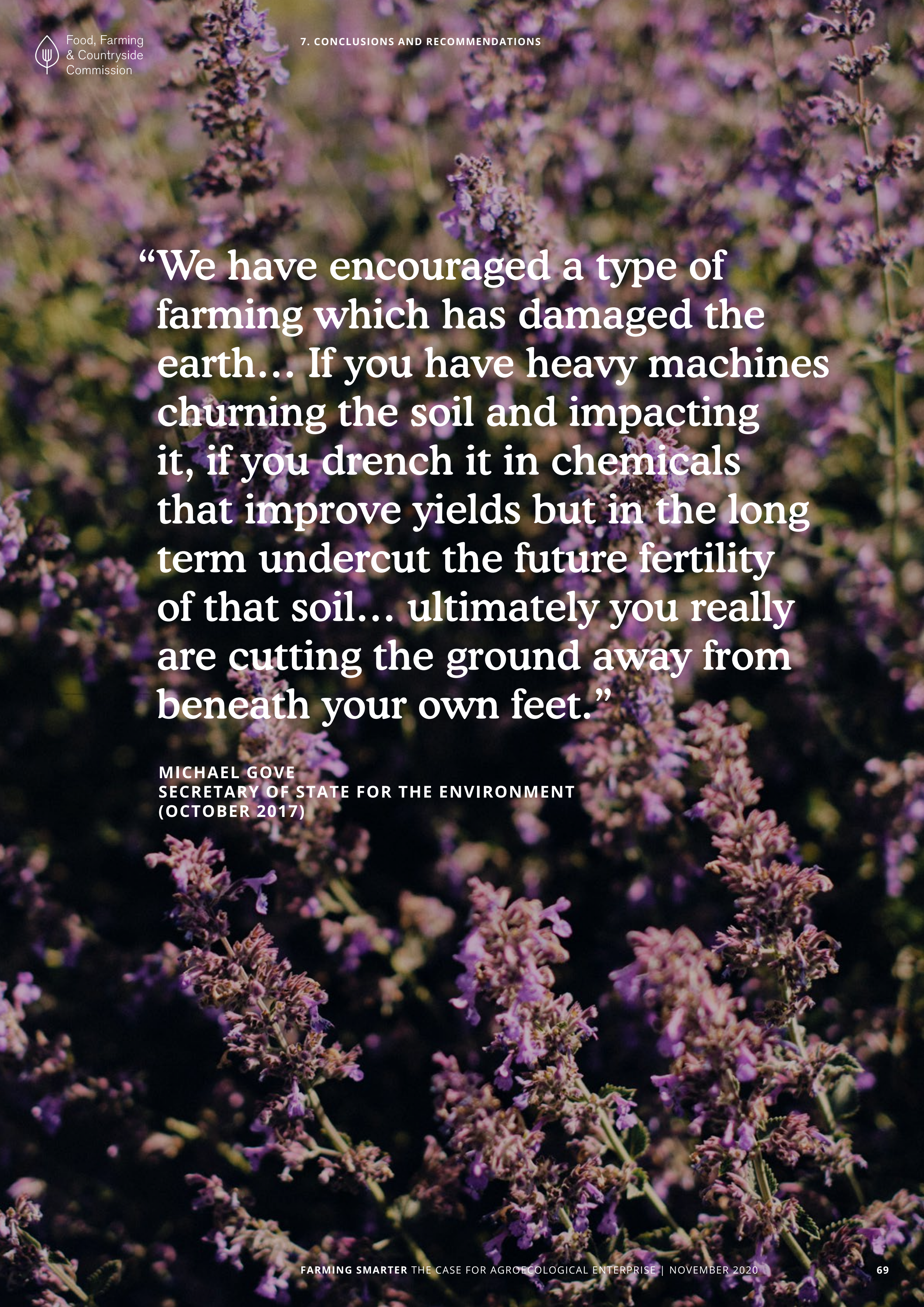
We have followed the broad definition of agroecology as represented by the UN FAO,[144] within which are included organic and other approaches that demonstrate environmental and social benefits, which result in lower aggregate production and higher costs to consumers. However, balancing such whole system trade-offs is an important issue for policy, and so it is significant that our research also indicated that some agroecological approaches do not lead to lower overall gross production – because of the layering of different produce on the same land – or to higher consumer prices.

If it can be demonstrated that best practice AE methods can indeed maintain production volumes and low consumer prices comparable with industrial intensive agriculture, while simultaneously delivering better ecological and social outcomes and more financially viable farm businesses, clearly the implications for policy would be significant as existence of such policy trade-offs could be eliminated or materially reduced. This is one of many questions where further research is needed.

ACHIEVING PACE AND SCALE: THE CASE FOR MULTI-FACETED INTERVENTION

Our initial research suggests that it may be possible for individual farm businesses to transition to AE within existing market conditions, either without external finance or by accessing the required finance from the market on commercial terms, where the following conditions hold true:

- an agricultural enterprise has the **vision and will** to transition
- the management team are well established with a good **track record**
- the nature of the farm business provides **opportunities** for early, no or low regret reductions in inputs or, if not,
- the **transition is from a position of financial strength**, including the ability to offer security for debt finance.



> “We have encouraged a type of farming which has damaged the earth… If you have heavy machines churning the soil and impacting it, if you drench it in chemicals that improve yields but in the long term undercut the future fertility of that soil… ultimately you really are cutting the ground away from beneath your own feet.”

MICHAEL GOVE
SECRETARY OF STATE FOR THE ENVIRONMENT
(OCTOBER 2017)

Despite Defra's conclusions that most farms are in a favourable financial position, our assessment of the financial state of agriculture in the UK in section 3.2 suggests there are a significant number of farms in a weak financial position.

Yet, it is questionable whether the vision and will is readily available in sufficient quantity. In this regard, Gabe Brown recounts this anecdote: 'Once, when I was speaking to a large crowd of corn and soybean producers in Nebraska, I asked how many of them made a profit on their corn the previous year. One person raised his hand. […] I asked how many planned on planting corn the following year. *Every* hand went up.'[145] The multi-headed hydra of the lock-ins rears her heads again in relation to how to transition to AE, even when it makes so much sense, ecologically and economically.

Then, there is the case of an abundance of will and vision but a deficit of money. Our research suggests there are distinct gaps in provision of finance for agroecology:

- tenant farmers and/or farm contractors
- smaller farms
- new entrants, or succession within an established farm enterprise
- application of new farming methods within a business introducing greater uncertainty than business as usual approaches.

Despite Defra's conclusions that most farms are in a favourable financial position, our assessment of the financial state of agriculture in the UK in section 3.2 suggests there are a significant number of farms in a weak financial position. This is in the context the gathering threats to profitability set out in section 3.1, and the uncertainty posed by the transition to ELMS. These circumstances undermine the ability of farmers to embrace the uncertainty of radical changes in their business model at precisely the point where enterprise and innovation is called for.

Furthermore, even if determined agricultural entrepreneurs can flourish within, or despite, the current system, this will not achieve broad and rapid transformation of farming businesses, in the face of barriers to change set out above in section 6, to the adoption and scaling of new farming approaches that have sound economic and businesses characteristics.

INITIAL RECOMMENDATIONS: OPTIONS TO BE EXPLORED

Our analysis suggests that if we are to grasp the opportunity of a transition to agriculture that delivers more profitable farming businesses as well as better environmental, social and health outcomes, action is required across three areas.

1. Research and knowledge dissemination

There is a need to significantly scale up research, data and insight into agroecology and in particular to improve the knowledge base in four areas:

- key performance indicators for agroecology
- natural systems, biology, soil science
- how to scale and employ technology
- turning natural systems into profitable businesses.

This could be achieved through a new agroecology research institute that is given responsibility for undertaking these four areas of research or acting as a co-ordinating and/or commissioning body to draw together existing knowledge and ensure effective dissemination in the form of applicable know-how and training for agricultural businesses.

2. Appropriate finance

There is a need to not just plug gaps in existing market provision for bank finance, but also expand provision of a broader range of finance including risk-bearing (equity) funding and long-term patient capital. Furthermore, the current precarious nature of farm incomes needs to be addressed if famers are to be supported to take risks, innovate, and transform business methods and performance. This could mean forms of insurance or income guarantees that provide sufficient economic security to encourage farming enterprises to accelerate transformation towards agroecology.

We recommend that pilot funds be considered at a local or regional level to test financial products, services and distribution models for accelerating the shift to agroecology.

This could be achieved at national level through the creation of a National Agroecology Development Bank, as recommended in the FFCC report 'Our Future in the Land',[146] or through the extension of mandates of existing institutions such as the British Business Bank.

In parallel, we recommend that pilot funds be considered at a local or regional level to test financial products, services and distribution models for accelerating the shift to agroecology.

3. Enterprise support

Although there is substantial evidence and practice behind agroecology approaches, there is likely to be significant need for innovation in developing new methods, technology and knowledge application, adapting proven methods to new regions, and adapting to already occurring climate impacts. This requires that the agroecological entrepreneur is placed at the centre and that a range of support is accessible through mentoring, skills development, and training in applied knowledge, tools and techniques.

This could be achieved through creating AE-specific business support agencies similar to existing 'growth hubs' and other forms of SME business support. Our initial view is that such a support agency is most likely to succeed when it is place based, with deep knowledge of the specific business (farming) conditions where it operates, and fully integrated with the research and finance institutions called for above.

In summary, we recommend that further research be undertaken into the **most effective national level intervention** to meet the research, finance and enterprise support needs identified in this report, and that as part of this research **a number of pilot development projects be established** in different geographic contexts across the UK that operate not as a passive supplier of finance to AE businesses but as a proactive AE development institution that brings together in a one-stop shop the range of knowledge, skills, training, mentoring and innovative finance required to stimulate and support a new wave of agroecological entrepreneurs.

8.

Case studies

8. Case studies

Case study 1: Balbo Group, Brazil[147]

WORLD LEADERS IN ORGANIC SUGAR PRODUCTION

> ***We don't worry too much about the crop itself – we take care of the whole ecosystem [...] our production system now achieves 20% higher productivity than conventional sugarcane production, with genuine concern for environmental, social, and economic factors. It is the first time that an organic, large-scale initiative has produced a higher yield than conventional agriculture!***
>
> Leontino Balbo Junior

Started in 1903 in the state of Sao Paulo, Brazil, the Balbo Group (also known by their consumer-facing brand 'Native') has continuously developed and become the world leader in organic sugar production.

The group's three plantations cover 37,800 hectares and produce approximately 3.2 million tonnes of sugarcane. A further 3.3 million tonnes of sugarcane are grown by 300 self-employed farmers local to the plantations.

From 1986 onwards, Leontino Balbo Jr. developed a comprehensive and viable new production and harvesting system that he named Ecosystem Revitalization Agriculture (ERA). This initiative applies the principles of regenerative agriculture in conjunction with technical innovation to replicate the resilient, regenerative ecosystem of uncultivated land.

34% of the global organic sugar market

From this crop, Native today produces 75,000 tonnes of organic sugar annually – 34% of the global market – which is sold on five continents and used in over 100 high profile products, plus an annual production of 55,000m3 of organic ethanol.

Fertilisation and pest-control powered by leveraging internal synergies

To reduce dependency on expensive and potentially harmful artificial inputs, chemical fertilisers were replaced by a unique Integrated Organic Fertilisation Programme:

The group developed the first Brazilian cane harvester in partnership with a local manufacturer. The machine cuts cane into pieces and feeds them into a hopper where opposing currents of air strip off the leaves and spray them onto the ground, thereby returning 20 tonnes of previously unused organic material per hectare to the soil each year. This restores nutrients and forms a mulch that helps keep weeds down and prevents water evaporation.

Pesticides were exchanged for a natural pest and disease management system, which leverages naturally resistant crop varieties, a biological control programme, and cultural control methods to inhibit pests and weeds.

Keen to valorise all material flows, a system to recycle organic by-products was put in place. The solid residue from juice filtration, the ash from the boilers, and the liquid residue left over after ethanol distillation are all collected and applied back to the fields.

Pesticides were exchanged for a natural pest and disease management system, which leverages naturally resistant crop varieties, a biological control programme, and cultural control methods to inhibit pests and weeds.

Thermoelectric power from sugarcane bagasse

Additionally, sugarcane bagasse (the dry, pulpy residue left after the juice of the sugarcane has been extracted) is fed directly into the furnaces powering its thermoelectric power plants, producing 200 tonnes of steam per hour, and thus enabling the Balbo Group to produce 100% of its own energy needs to process around 6 million tonnes of sugarcane per year. Beyond that, thanks to its investment in cutting-edge technology, the business generates enough extra power to supply a city of 476,000 inhabitants.

Soil compression is another potential threat for soil vitality as conventional farming equipment compacts earth and hampers aeration, water penetration and microbial health. Balbo Group devised a low-tech yet effective solution for this, using high flotation tyres which are partially deflated before vehicles are driven into the fields.

Ecological success

The economic success is paralleled by an ecological abundance: the farm has a level of biodiversity that's over 50% of that found in Sao Paulo's national parks, proving that a thriving ecosystem can coexist with what at first sight appears to look like crop monoculture.

Social impact & public education

Beyond agricultural practices and technologies, the workers were trained and earned qualifications to take more highly skilled positions in the new production programme. Away from the farm, consumer awareness was raised through demos in supermarkets with animations showing customers the benefits of ERA.

Case study 2: Bagber Farm, Dorset, UK[148]

A BRITISH TENANT FARMER BATTLES WITH BUREAUCRACY, STRANDED ASSETS AND LITTLE ROOM FOR MANOEUVRE TO MAKE A MOVE IN THE DIRECTION OF REGENERATIVE FARMING

John Hawkins is a tenant farmer and runs 239ha of marginal land at Bagber Farm, Blandford Forum, Dorset.

In the past, he achieved average yields of 9t/ha of wheat but relied on 7t/ha of chicken manure, maximum nitrogen doses and a lot of chemical input to achieve this level. The connected high costs challenged profitability. At the same time, he had an ageing machinery fleet, poor grain storage and no money to invest.

John carries out biennial hedge-cutting and established 6ha of wildflower meadows, 8ha of wild bird food mix and 6ha of cherry trees but this attempt at diversification failed to pay its way.

Casting about for ways to develop the farm under his financial circumstances, he took part in various environmental trials. It was a water quality project that led to some funding to cover crop trials and arable reversion, both of which were less expensive to implement than the previous arable crops and yielded better returns. On that basis, he then decided to trial a regenerative agriculture scheme across the whole farm, based on a low-input rotation that builds natural fertility and reduces his reliance on artificial fertilisers.

This way, after years of struggling to make his conventional arable rotation pay, he has found a way to be rewarded for environmental gains rather than bumper yields. The self-designed and implemented trial is funded through a whole-farm Mid-Tier Countryside Stewardship scheme and an arable reversion project sponsored by Wessex Water.

Hardship of Defra bureaucracy

John self-designed the scheme but found the process of combining the Mid-Tier prescriptions, complying with BPS/EFA rules and satisfying the contract with Wessex Water hard. Yet, in his experience, the biggest hardship was the bureaucracy he encountered while dealing with Defra.

John comments, 'This was intolerable at times and it was made far more complicated than necessary. Sadly, it's the biggest barrier to setting up a system like this. We got there in the end, but if it wasn't for the help of our catchment sensitive farming specialist, we would have likely failed.'

Economic upside

John has put 10ha of reed canary grass on his main run-off areas, which is a Wessex Water-sponsored four-year experiment.

By dropping his input costs so significantly, each tonne of crop he has sold cost him significantly less to produce then when he was chasing maximum yield. His first harvest under the new regime saw spring barley yields drop from about 7t/ha to 5t/ha, but he met the required quality standard. Overall, his gross margin was much higher.

Consequentially, John has significantly reduced risk by securing a steady income and lowering his input costs.

Ecological improvement

Butterflies and summer pollinators have increased and, interestingly, John has not had any evidence of flea beetle on his brassica cover crops which may be linked to a more balanced ecosystem and the presence of relevant predators.

John reports a significant rise in the number of ground-nesting birds and rare raptors which he puts down to the bigger population of ground-dwelling mice and voles.

Increased worm activity points to soil health improvements.

However, John's new regime still depends on spraying off the fertility- and carbon-building leys with glyphosate after two years before he plants either spring barley or canary seed – he does not allow livestock in his rotation, most likely because it is thought that this will be damaging, because the scheme prevents it or because it is currently not feasible, economically.

Social benefits

In total, John needs to cover an area of approximately 200ha with his drilling operation per year. He can travel at a rate of 2ha/hour which amounts to 100 hours of work each year with no further operations to consider. This compares very favourably at roughly one-third of what he was doing previously.

Overall, John experiences his new regime as a far less stressful way of doing things. 'It's nice to not be burning the midnight oil every night in the summer and autumn', he comments.

Uncertainty and future plans

The collaboration with Wessex Water means that he can continuously monitor the scheme to measure its effect. Improvements can be made on a six-monthly rolling basis to deliver better results.

However, John has not heard back from Defra with any follow up requests and he does not see any room to improve the existing scheme during its life.

Also, at this point, he has not considered other routes to market and diversifying his production accordingly. Thus, he is dependent on above-mentioned funding streams and hopes that they will keep him going until the ELMS is rolled out to all farms and that he will be in a good position to transfer into the scheme, easily.

If this turns out not to be the case, John still has the option of reverting back to a more conventional system. 'Hopefully with healthier soils', he says.

Case study 3: SLM Partners[148]

GLOBAL, LARGE-SCALE INVESTMENTS IN REGENERATIVE AGRICULTURE AND ECOLOGICAL LAND MANAGEMENT PROJECTS

Founded in 2009, with offices in New York, London, Dublin and Gold Coast, Australia, SLM Partners is an asset manager that acquires and manages rural land on behalf of institutional investors. This way it channels capital investments from pension funds, insurance companies and family offices towards regenerative and ecological land management systems that are profitable and deliver environmental benefits.

The business is co-founded by Paul McMahon who was previously Vice President at Carbon Change Capital and engagement manager at McKinsey&Co, and there is evidence of his deep professional exposure in these roles to the possibility of agriculture and land management in the reduction of carbon emissions.

SLM Partners selects its projects on the following criteria:

- applicable at commercial scale
- economic returns that are as good or better than industrial production models
- proven environmental benefits, especially the ability to reduce GHG emissions
- sufficient evidence in published studies to back up these claims.

This informs its interest in the following arenas:

- holistic planned grazing for beef cattle and sheep
- no-till cropping with diverse cover crops and mob grazing
- agroforestry
- low-input pasture-based dairy
- certified organic agriculture.

On the ground, SLM partners with experienced operational teams who know how to work with nature to deliver profitable and sustainable outcomes.

Unusually in the large-scale land management world, SLM Partners take a long-term perspective, adopting land management approaches that minimise synthetic inputs, increase resilience to climatic volatility and enhance soil fertility, while producing food and other commodities at a competitive cost.

The location of its offices supports its claims to be focused on opportunities in countries with stable regulatory environments, competitive agricultural or forestry sectors, and good access to international markets. Some of these aspects currently exclude the UK and McMahon expressly makes the case against investments in the UK as, in his view, it does not possess an attractive land market because farmland prices are 'distorted by factors that have nothing to do with agricultural potential, such as lifestyle buyers, ecotourism or residential development'. Additionally, in the UK, 'prices are inflated because of inheritance tax rules which allow people to pass land to their heirs without being subject to inheritance taxes. This drives down the potential yield of all farming systems.'

On the ground, SLM partners with experienced operational teams who know how to work with nature to deliver profitable and sustainable outcomes.

SLM's first project was the SLM Australia Livestock Fund which acquired 480,000 hectares of grazing land in Australia for beef cattle production using Holistic Management. SLM also manages the SLM Silva Fund, a sustainable Irish forestry fund. Currently, SLM Partners is developing new organic farmland investment strategies in North America and an investment strategy in Chile focused on sheep production using a grazing system based on Holistic Management.

9. Endnotes

1 McMahon, P (2016) The investment case for ecological farming. *SLM Partners*. Accessed 06.09.2020: https://slmpartners.com/wp-content/uploads/2016/01/SLM-Partners-Investment-case-for-ecological-farming.pdf.

2 Eadie, L and Stone, C (2012) Farming smarter, not harder: securing our agricultural economy. *CPD*. Accessed 05.09.2020: https://cpd.org.au/wp-content/uploads/2012/10/cpd_land_report_EMBARGOED_UNTIL_1_NOV.pdf.

3 General Mills (2019, 4th Mar) General Mills to advance regenerative agriculture practices on one million acres of farmland by 2030. Accessed 13.10.2020: https://www.generalmills.com/en/News/NewsReleases/Library/2019/March/Regen-Ag.

4 Walmart (2020, 21st Sept) Walmart sets goal to become a regenerative company. Accessed 13.10.2020: https://corporate.walmart.com/newsroom/2020/09/21/walmart-sets-goal-to-become-a-regenerative-company.

5 Christenson, B (2020, 16th Sept) Cargill to advance regenerative agriculture practices across 10 million acres of North American farmland by 2030. *Cargill*. Accessed 13.10.2020: https://www.cargill.com/2020/cargill-to-advance-regenerative-agriculture-practices-across-10.

6 McMahon (2016) The investment case for ecological farming.

7 UN FAO (2018) The 10 elements of agroecology: guiding the transition to sustainable food and agricultural systems. Accessed 12.11.2020: http://www.fao.org/3/I9037EN/i9037en.pdf.

8 Wezel, A et al. (2009) Agroecology as a science, a movement and a practice. A review. *Agron. Sustain. Dev*. 29, 503–515. https://doi.org/10.1051/agro/2009004.

9 Biovision (n.d.) Agroecology info pool: definitions. Accessed 03.11.2020: https://www.agroecology-pool.org/agroecology/definitions/.

10 OECD (2003) Glossary of statistical terms: agro-ecology. Accessed 03.11.2020: https://stats.oecd.org/glossary/detail.asp?ID=81.

11 UN (1997) Glossary of Environment Statistics, Studies in Methods, Series F, No. 67. Accessed 12.11.2020: https://unstats.un.org/unsd/publication/seriesf/seriesf_67e.pdf.

12 UK Parliament (2020) Agriculture Bill 2019-21. Accessed 03.11.2020: https://services.parliament.uk/Bills/2019-21/agriculture.html.

13 Gliessman, S (2016) Transforming food systems with agroecology. *Agroecology and Sustainable Food Systems* 40:3, 187-189. Accessed 03.11.2020: https://doi.org/10.1080/21683565.2015.1130765.

14 Gore, A (2019) 'We really need to wake up quickly': Al Gore warns of a looming food crisis caused by climate change. *The Washington Post*. Accessed 28.10.2020: https://www.washingtonpost.com/lifestyle/food/this-is-really-dangerous-al-gore-warns-of-a-looming-food-crisis-caused-by-climate-change/2019/10/21/bd3eec7e-f1cf-11e9-89eb-ec56cd414732_story.html.

15 Jehne, W, and LifeWorks Foundation (2020) Regeneration – An earth saving evolution [Film]. *YouTube*. Accessed 07.02.2020: https://www.youtube.com/watch?v=o7FsP3qw2so, at 32 seconds.

16 The Prince's Charities, International Sustainability Unit (2011) What price resilience? Towards sustainable and secure food systems [online]. Accessed 28.10.2020: https://issuu.com/getresilient/docs/tpc0632_resilience_report_web11_07_smaller.

17 New Economics Foundation (2014) Urgent recall: our food system under review. Accessed 27.10.2020: https://neweconomics.org/uploads/files/c07a6485ca717dfdf1_e8m6ibzkh.pdf.

18 UK Environment Agency (2019) The state of the environment: soil. Accessed 28.10.2020: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805926/State_of_the_environment_soil_report.pdf.

19 New Economics Foundation (2014) Urgent recall.

20 Smith, P, et al. (2014) Agriculture, Forestry and Other Land Use (AFOLU). In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Accessed 28.10.2020: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter11.pdf.

21 Fowler, D, et al. (2013) The global nitrogen cycle in the twenty-first century. *Phil. Trans. R. Soc. B.* Accessed 28.10.2020: http://doi.org/10.1098/rstb.2013.0164.

22 McMahon (2016) The investment case for ecological farming.

23 Farmworker Justice (2013) Exposed and ignored: how pesticides are endangering our nation's farmworkers. Accessed 29.10.2020: http://kresge.org/sites/default/files/Exposed-and-ignored-Farmworker-Justice-KF.pdf.

24 Gallagher, J (2015) Antibiotic resistance: world on cusp of 'post-antibiotic era'. *BBC News*. Accessed 29.10.2020: https://www.bbc.co.uk/news/health-34857015.

25 Millennium Ecosystem Assessment (2005). Ecosystems and human well-being: biodiversity synthesis. *World Resources Institute,* Washington, DC. Accessed 29.10.2020: https://www.millenniumassessment.org/documents/document.354.aspx.pdf.

26 See: Diamond, J. (2005) Collapse: how societies choose to fail or succeed. Allen Lane; Montgomery, D. (2007) Dirt: the erosion of civilizations. University of California Press.

27 UN FAO and ITPS (2015) Status of the world's soil resources: technical summary. Accessed 13.09.2020: https://www.researchgate.net/publication/286465123_The_Status_of_the_World's_Soil_Resources_Technical_Summary.

28 ELD Initiative (2013) A global initiative to raise awareness of the economic losses arising from land degradation. *UNU-INWEH*. Accessed 13.09.2020: https://www.eld-initiative.org/fileadmin/pdf/ELD_Interim_Report_Summary_2013_2_1.pdf.

29 UNCCD (n.d.) The United Nations Decade for Deserts (2010-2020) and the fight against Desertification. Accessed 13.09.2020: https://www.unccd.int/actions/united-nations-decade-deserts-2010-2020-and-fight-against-desertification.

30 Hunt, N, and McFarlane, S (2014, 14th July) 'Peak soil' threatens future global food security. *Reuters*. Accessed 13.09.2020: https://www.reuters.com/article/peaksoil-agriculture-idUSL6N0PP3HZ20140717.

31 UK Environment Agency (2019) The state of the environment: soil.

32 Brown, L (2011) World on the edge: how to prevent environmental and economic collapse. Earthscan.

33 Lampkin, N, et al. (2015). The role of agroecology in sustainable intensification. Report for the Land Use Policy Group. Organic Research Centre, Elm Farm and Game & Wildlife Conservation Trust. Accessed 29.10.2020: https://www.researchgate.net/publication/279206784_The_Role_of_Agroecology_in_Sustainable_Intensification.

34 Pretty, J (2014) Sustainable intensification in agricultural systems. *Annals of Botany* 114:8, 1571–1596. https://doi.org/10.1093/aob/mcu205.

35 Wines, M (2014) Invader batters rural America, shrugging off herbicides. *New York Times*. Accessed 29.10.2020: https://www.nytimes.com/2014/08/12/us/invader-storms-rural-america-shrugging-off-herbicides.html.

36 McMahon (2016) The investment case for ecological farming.

37 Munich RE (2014) Topics Geo: after the floods. Natural catastrophes 2013: Analyses, assessments, positions – 2014 issue. Accessed 29.10.2020: https://issuu.com/emilioiannarelli/docs/302-08121_en.

38 Doyle, A (2015) Torrential rains increasing in warming world: study. *Reuters*. Accessed 16.07.2020: https://www.reuters.com/article/us-climatechange-rainfall-idUSKCN0PI1DR20150708.

39 Bruckner, T (2014) Energy systems. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Accessed 29.10.2020: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter7.pdf.

40 Defra (2019) Balance sheet analysis and farming performance, England 2017/2018. Accessed 12.11.2020: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/861825/fbs-balancesheetanalysis-22jan19.pdf.

41 Defra (2019) Farm Business Income by type of farm in England, 2018/19. Accessed 17.02.2020: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/847722/fbs-businessincome-statsnotice-21nov19.pdf.

42 '*Economic performance* for each farm is measured as the ratio between economic output (mainly sales revenue) and inputs (costs). The inputs for this calculation include an adjustment for unpaid manual labour. The higher the ratio, the higher the economic efficiency and performance. The farms are then ranked and allocated to performance bands based on economic performance percentiles:

- Low performance band – farms that were in the bottom 25% of economic performers
- Medium performance band – farms that were in the middle 50% of performers
- High performance band – farms that were in the top 25% of performers.'

See Defra (2020) Balance sheet analysis and farming performance, England 2018/2019. Accessed 17.02.2020: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/861828/fbs-balancesheetanalysis-30jan20.pdf. (Italics in original.)

43 UN FAO (n.d.) FAO food price index. Accessed 06.09.2020: http://www.fao.org/worldfoodsituation/foodpricesindex/en/.

44 TIAA-CREF Center for Farmland Research (2013) Farmland markets: valuation, investment performance and issues for the future. Accessed 18.11.2020: https://farmland.illinois.edu/wp-content/uploads/2019/09/Farmland-Markets-Performance-and-Issues-Center-Draft-public.pdf.

45 Preqin (2015) Preqin special report: natural resources. Accessed 06.09.2020: https://docs.preqin.com/reports/Preqin-Special-Report-Natural-Resources-November-2015.pdf.

46 Fiddes, M (2019, 25th Oct) English estates & farmland market review: autumn 2019. *Strutt & Parker*. Accessed 12.11.2020: https://rural.struttandparker.com/article/english-estates-farmland-market-review-autumn-2019/.

47 van der Ploeg, J, et al. (2019) The economic potential of agroecology: empirical evidence from Europe. *Journal of Rural Studies* 71. Accessed 10.09.2019: https://doi.org/10.1016/j.jrurstud.2019.09.003.

48 National Audit Office (2019) Early review of the new farming programme. Accessed 10.02.2020: https://www.nao.org.uk/press-release/early-review-of-the-new-farming-programme/.

49 D'Souza, G, and Ikerd, J (1996) Small Farms and Sustainable Development: Is Small More Sustainable? *Journal of Agricultural and Applied Economics* 28:1. https://doi.org/10.1017/S1074070800009470.

50 UK Environment Agency (2019) The state of the environment: soil.

51 Carrington, D (2019, 13th Oct) Firms ignoring climate crisis will go bankrupt, says Mark Carney. The Guardian. Accessed 06.02.2020: https://www.theguardian.com/environment/2019/oct/13/firms-ignoring-climate-crisis-bankrupt-mark-carney-bank-england-governor.

52 UK Government (2014, 10th June) Press release: CAP greening criteria announced. Accessed 12.11.2020: https://www.gov.uk/government/news/cap-greening-criteria-announced.

53 Ikerd (1993), cited in: D'Souza, G, and Ikerd, J (1996) Small Farms and Sustainable Development. (Our italics.)

54 van der Ploeg, et al. (2019) The economic potential of agroecology.

55 Speight, B (2019) Chief Executive of the RSPB, on *Today*, Radio 4, 4th October 2019, 8.46am.

56 For an easy to read summary by Dr Christine Jones, see: Jones, C (2018) Light farming: restoring carbon, organic nitrogen and biodiversity to agricultural soils. Accessed 07.02.2020: http://amazingcarbon.com/JONES-LightFarmingFINAL(2018).pdf.

57 Lal, R (2020) Regenerative agriculture for food and climate. *Journal of Soil and Water Conservation* 75:5. Accessed 06.09.2020: https://www.jswconline.org/content/jswc/early/2020/07/31/jswc.2020.0620A.full.pdf.

58 UN FAO (2018) The 10 elements of agroecology.

59 Altieri et al. (2008), cited in: van der Ploeg, et al. (2019) The economic potential of agroecology.

60 Misset (1992), cited in: van der Ploeg, et al. (2019) The economic potential of agroecology.

61 D'Souza, G, et al. (1993) Factors affecting the adoption of sustainable agricultural practices. *Agr. and Resour. Econ. Rev.* 22, cited in: D'Souza, Gerard & Ikerd, John (1996) D'Souza, G, and Ikerd, J (1996) Small Farms and Sustainable Development.

62 De Schutter, O (2010) Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter. UN Human Rights Council. Accessed 07.02.2020: https://www2.ohchr.org/english/issues/food/docs/a-hrc-16-49.pdf.

63 Bellon and Ollivier (2018), cited in: van der Ploeg et al. (2019) The economic potential of agroecology.

64 Government of France (2018) French position in the CAP 2020 negotiations. Accessed 07.02.2020: https://www.arc2020.eu/wp-content/uploads/2019/02/181214_cap-2020_french-position_en.pdf.

65 van der Ploeg, et al. (2019) The economic potential of agroecology.

66 Laughton, R (2017) A matter of scale: a study of the productivity, financial viability and multifunctional benefits of small farms (20 ha and less). Landworkers' Alliance and Centre for Agroecology, Coventry University. Accessed 12.11.2020: https://www.scholacampesina.org/wp-content/uploads/2018/10/A-Matter-of-Scale-Report-LWA-2017.pdf.

67 Lal (2020) Regenerative agriculture for food and climate.

68 Balfour (1943), cited in: Lal (2020) Regenerative agriculture for food and climate.

69 Lal (2020) Regenerative agriculture for food and climate. (Italics in original.)

70 Soloviev, E, and Landua, G (2016) Levels of regenerative agriculture. *Terra Genesis International*. Accessed 29.10.2020: http://ethansoloviev.com/wp-content/uploads/2019/02/Levels-of-Regenerative-Agriculture.pdf.

71 Mang, P, and Reed, B (2012) Regenerative development and design. Accessed 29.10.2020: https://www.researchgate.net/publication/273379786_Regenerative_Development_and_Design.

72 Soloviev, E (2018) Regenerative agriculture continuum. *Medium*. Accessed 06.09.2020: https://medium.com/@ethansoloviev/regenerative-agriculture-continuum-4346f78dde3e.

73 Ibid.

74 Ibid.

75 Soloviev and Landua (2016) Levels of regenerative agriculture.

76 Soloviev, E (2016) Lineages of regenerative agriculture (short version). Re-source. Accessed 29.10.2020: http://www.ethansoloviev.com/lineages-of-regenerative-agriculture-short-version/.

77 Heckman, J (2007, 21st July) A history of organic farming: transitions from Sir Albert Howard's War in the Soil to the USDA National Organic Program. *The Weston A. Price Foundation.* Accessed 06.09.2020: https://www.westonaprice.org/health-topics/farm-ranch/a-history-of-organic-farming-transitions-from-sir-albert-howards-war-in-the-soil-to-the-usda-national-organic-program/.

78 Lal (2020) Regenerative agriculture for food and climate.

79 For a fuller rendition of the necessarily brief and incomplete history provided in this section see: Mang & Reed (2012) Regenerative development and design.

80 Francis, C, and Harwood, R (1985) Enough Food: Achieving Food Security through Regenerative Agriculture. Kutztown, PA: Rodale Institute, cited in: Soloviev and Landua (2016) Levels of regenerative agriculture.

81 For the four levels of Krone's 'Levels of work' and its impact at Proctor & Gamble, see: Sanford, S (2016) What is regeneration? Part 2 – Living structured wholes. *Carol Sanford Institute*. Accessed 01.11.2020: https://carolsanfordinstitute.com/what-is-regeneration-part-2/.

82 For a complete description of the matrix of living systems frameworks, see: Soloviev and Landua (2016) Levels of regenerative agriculture.

83 Taleb, N (2012) Antifragile: things that gain from disorder. New York: Random House, cited in: Soloviev and Landua (2016) Levels of regenerative agriculture.

84 The 'Regenesis Story of Place' process, see: Regenesis Group (2016) Story of Place. Accessed 31.10.2020: http://www.regenesisgroup.com/services/story-of-place. See also: Soloviev and Landua (2016) Levels of regenerative agriculture.

85 Incidentally, the term *supply chain* does have colonial undertones and as a metaphor is embedded in a mechanistic understanding of the universe.

86 For Regrarians, see: http://www.regrarians.org/ (accessed 01.11.2020).

87 For the Carol Sanford Institute, see: https://carolsanfordinstitute.com/ (accessed 01.11.2020).

88 For Regenesis, see: https://regenesisgroup.com/ (accessed 01.11.2020).

89 For Terra Genesis International, see: http://www.terra-genesis.com/ (accessed 01.11.2020).

90 For the Regen.Network, see: https://www.regen.network/ (accessed 01.11.2020).

91 McAfee (2019), cited in: Lal (2020) Regenerative agriculture for food and climate. Lal (2013), cited in: Lal (2020) Regenerative agriculture for food and climate.

92 Jehne, W (2020) Regenerate earth: the practical drawdown of 20 billion tonnes of carbon back into soils annually, to rehydrate bio-systems and safely cool climates. *Healthy Soils Australia*. Accessed 30.10.2020: http://nzbiocharltd.co.nz/resources/Regenerate-Earth-Paper-Walter-Jehne%20%281%29.pdf.

93 Oxidative agriculture is any kind of soil management which oxidises more carbon back into CO2 than it fixes through bioconversion into stable soil carbon. See Jehne (2020) Regenerate earth.

94 Personal correspondence with Walter Jehne, 05.08.2020.

95 Ibid.

96 McMahon (2016) The investment case for ecological farming.

97 van der Ploeg et al. (2019) The economic potential of agroecology.

98 Quoted in: Brown, G (2018) Dirt to soil. Chelsea Green Publishing.

99 LaCanne, C, and Lundgren, J (2018) Regenerative agriculture: merging farming and natural resource conservation profitably. *PeerJ* 6:e4428. https://doi.org/10.7717/peerj.4428.

100 IPES-Food (2016) From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems. *International Panel of Experts on Sustainable Food systems.* http://www.ipes-food.org/_img/upload/files/UniformityToDiversity_ExecSummary.pdf.

101 LaCanne and Lundgren (2018) Regenerative agriculture.

102 Laughton (2017) A matter of scale.

103 Ibid.

104 Ibid.

105 Ibid.

106 Laughton, R, and Kiss, C (2017, 25th Oct) A matter of scale. The A Team Foundation. Accessed 07.02.2020: https://www.ateamfoundation.org/blog-1/2017/10/25/a-matter-of-scale-amos.

107 Ibid. (Our italics.)

108 Winter, M, and Lobley, M (2016) Is there a future for the small family farm in the UK? Report to The Prince's Countryside Fund, London. *Prince's Countryside Fund.* Accessed 07.02.2020: https://www.princescountrysidefund.org.uk/downloads/research/is-there-a-future-for-the-small-family-farm-in-the-uk-report.pdf.

109 Laughton (2017) A matter of scale.

110 Drucker (1989), cited in: D'Souza, G, and Ikerd, J (1996) Small Farms and Sustainable Development.

111 D'Souza, G, and Ikerd, J (1996) Small Farms and Sustainable Development.

112 Martins, C, and Tosstorff, G (2011) Eurostat: statistics in focus 18/2011, cited in: Laughton (2017) A matter of scale. (More recent data is available but compares similarly.)

113 Laughton (2017) A matter of scale.

114 UK Government (2018) Business Secretary calls for new tech revolution in agriculture. Accessed 12.11.2020: https://www.gov.uk/government/news/business-secretary-calls-for-new-tech-revolution-in-agriculture.

115 Conway, G (1999). The doubly green revolution. *Cornell University Press*. Accessed 31.10.2020: https://doi.org/10.7591/9781501722660.

116 This is consistent with the RSA's research into the future of work. See for example Dellot, B (2015) Ours to master: how makerspaces can help us master technology for a more human end. RSA. https://www.thersa.org/globalassets/pdfs/reports/rsaj3881_ours_to_master_report_11.15_web.pdf; and the RSA Future Work Centre: https://www.thersa.org/action-and-research/rsa-projects/economy-enterprise-manufacturing-folder/the-future-of-work.

117 For example, see Farm Hack (https://farmhack.org/tools) and Gkisakis, V, et al. (2018) Digital revolution in agriculture: fitting for agroecology? ARC2020. Accessed 17.02.2020: https://www.arc2020.eu/digital-revolution-agriculture-agroecological-approach/.

118 Brown (2018) Dirt to soil.

119 IPES-Food. 2016. From uniformity to diversity.

120 Ajates Gonzalez, R, et al. (2018) Translating agroecology into policy: the case of France and the United Kingdom. *Sustainability* 10:8, 2930. Accessed 07.02.2020: https://www.mdpi.com/2071-1050/10/8/2930.

121 CIDSE (2020) Finance for agroecology: more than just a dream? An assessment of European and international institutions' contributions to food system transformation. Accessed 02.11.2020: https://www.cidse.org/wp-content/uploads/2020/09/CIDSE-Agroecology-and-Finance-Briefing-Sept-2020-1.pdf.

122 Gura, S, and Meienberg, F (2013) Agropoly: A handful of corporations control world food production, translated by Christine Wittstock. *Berne Declaration (DB) & EcoNexus*. Accessed 06.02.2020: https://www.econexus.info/sites/econexus/files/Agropoly_Econexus_BerneDeclaration.pdf.

123 DTN The Progressive Farmer (2014, 10th Oct), cited in McMahon (2016) The investment case for ecological farming.

124 IPES-Food. 2016. From uniformity to diversity.

125 Farnsworth, H (2020) What are the main barriers to entry and drivers for adoption of regenerative agriculture for the British agricultural industry. Royal Agricultural University, Cirencester. Unpublished Thesis: MSc Sustainable Agriculture and Food Security.

126 Authors' categorisation of Farnsworth's research findings.

127 Farnsworth, H (2020) What are the main barriers.

128 Drewell, M (2020) Regenerative insight #1: why would a sane society support ecologically destructive food production when it isn't necessary? *New Foundation Farms.* Accessed 31.10.2020: https://www.newfoundationfarms.com/regenerative-agriculture/why-would-a-sane-society-support-ecologically-destructive-food-production-when-it-isnt-necessary/. (As clarified in 'About the authors', co-author of this report Marcus Link is CEO of New Foundation Farms.)

129 Ward Laboratories Inc. (n.d.) Haney test. Accessed 06.02.2020: https://www.wardlab.com/haney-test/ (although this is a commercial resource it is also the most comprehensive, and includes links to USDA hosted information by Dr Haney); the soil test is also referenced in: Brown (2018) Dirt to soil.

130 Jehne, W, and LifeWorks Foundation (2020) Regeneration – An earth saving evolution [Film]. *YouTube*. Accessed 07.02.2020: https://www.youtube.com/watch?v=o7FsP3qw2so, at 32 seconds.

131 Lykins, A (2017, 17th Feb) The business case for 'Holistic Management'. *GreenBiz*. Accessed 06.02.2020: https://www.greenbiz.com/article/business-case-holistic-management.

132 Jehne, W, and LifeWorks Foundation (2020) Regeneration – An earth saving evolution [Film].

133 For the proposal for an Agroecology Development Bank, see Food, Farming and Countryside Commission (2019) Our future in the land. *RSA*. Accessed 19.11.2020: https://www.thersa.org/globalassets/reports/rsa-ffcc-our-future-in-the-land.pdf.

134 IPES-Food. 2016. From uniformity to diversity.

135 Laughton (2017) A matter of scale.

136 McMahon (2016) The investment case for ecological farming.

137 Defined as the person in whose name the holding is operated.

138 Savills (2018, 21st Nov) Connecting enterprising young entrants with retiring farmers. Accessed 17.02.2020: https://www.savills.co.uk/insight-and-opinion/savills-news/271199-0.

139 NEF (2010) Who's the entrepreneur? The BizFizz Story: unleashing the passion, transforming communities. Accessed 06.09.2020: https://neweconomics.org/uploads/files/55400eb98c812d391d_ycm6vgefa.pdf.

140 van der Zee, B (2017, 24th Oct) UK is 30-40 years away from 'eradication of soil fertility', warns Gove. *The Guardian*. Accessed 06.02.2020: https://www.theguardian.com/environment/2017/oct/24/uk-30-40-years-away-eradication-soil-fertility-warns-michael-gove.

141 BBC News (2007, 7th Jan) 'No proof' organic food is better. Accessed 04.02.2020: http://news.bbc.co.uk/1/hi/uk/6238227.stm.

142 Harvey, F (2018, 13th Mar) UK farmers to be given first ever targets on soil health. *The Guardian*. Accessed 06.02.2020: https://www.theguardian.com/environment/2018/mar/13/uk-farmers-to-be-given-first-ever-targets-on-soil-health.

143 Case, P (2014, 21st Oct) Only 100 harvests left in UK farm soils, scientists warn. *Farmers Weekly*. Accessed 16.02.2020: https://www.fwi.co.uk/news/only-100-harvests-left-in-uk-farm-soils-scientists-warn.

144 UN FAO, see: http://www.fao.org/agroecology/overview/en/; UN FAO (2018) The 10 elements of agroecology.

145 Brown (2018) Dirt to soil.

146 Food, Farming and Countryside Commission (2019) Our future in the land.

147 Ellen MacArthur Foundation (n.d. [updated July 2020]) Balbo Group: regenerative agriculture at scale. Accessed 29.01.2020: https://www.ellenmacarthurfoundation.org/case-studies/regenerative-agriculture-at-scale.

Native Alimentos (n.d.) Balbo Economic Group: tradition in always producing more. Accessed 05.02.2020: https://www.nativealimentos.com.br/en/native/balbo-economic-group.

148 Andrews, J (2020, 22nd Jan) Low-input cropping plan slashes costs and risk for tenant farmer. Farmers Weekly. Accessed 04.02.2020: https://www.fwi.co.uk/machinery/cultivation-drilling/cereal-drills/low-input-cropping-plan-slashes-costs-and-risk-for-tenant-farmer.

149 McMahon (2016) The investment case for ecological farming; See also: SLM Partners, https://slmpartners.com/ (accessed 01.11.2020).

Food, Farming
& Countryside
Commission

**Food, Farming &
Countryside Commission**
Kemp House
160 City Road
London EC1V 2NX

t: +44 (0) 20 7118 1870
w: ffcc.co.uk

Registered in
England and Wales

Company no. 12562770

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.