UK Agricultural Policy Post-Brexit

Sustainable Farming and the Environmental Land Management Scheme

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ABSTRACT

The UK is in the process of developing its post-Brexit agriculture policy. The government's objectives are to increase the productivity of the farming sector and make it more sustainable – through paying farmers subsidies to promote 'public goods'. The paper analyses this second aim. A number public goods are selected (reducing green house gas emissions, improving soil quality, improving water quality, improving air quality, promoting biodiversity and improving public health) and, for each good, recommendations are made to the UK government. The recommendations are focused mostly on sustainable farming practices that should receive government subsidy through the Environmental Land Management Scheme, being piloted in 2021. Aside from the public goods, regulation is considered and how it can best serve a role alongside subsidy in promoting the public goods, drawing on challenges similar schemes faced in the past.

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We hope that our work will enrich public discourse on the topic of agricultural policy not only in the United Kingdom, but also internationally.

Will Melling,
Editor, 2020-21
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EXECUTIVE SUMMARY

Purpose of the paper

The UK's new post-Brexit agricultural policy is aiming to fix the productivity problem and create a more sustainable farming sector. The paper assesses the second of these two aims.

The subsidy framework that will promote sustainable farming will be set out in the Environmental Land Management Scheme which will pay farmers to produce 'public goods'. The paper has selected a number of the public goods included in the Environmental Land Management Scheme, and some that were omitted, and analyses which policies will best promote the good.

For each good, set out below, a number of policy recommendations are made that could be incorporated into the Environmental Land Management Scheme as it is trialled and developed over the next few years.

Policy Recommendations

The paper is divided into sections targeting one of the public goods. Some areas are interrelated (for example, soil quality and water quality) but cross references are made where necessary.

(a) Green House Gases

This section of the paper looks at reducing Green House Gas (GHG) emissions in the UK agricultural sector, the 5th largest source of GHG in the UK. It focuses on methane production first (which contributes 56% of GHG in animal agriculture) and nitrous oxide second (the second largest emitter following methane, accounting or 31% of CO2 equivalent GHG production in farming). The two main activities that produce methane in UK agriculture are enteric fermentation (75%) and manure management (22%), and soil emissions account for 90% of nitrous oxide emissions in UK agriculture. There are a number of proposals for these activities.

The recommendations for enteric fermentation:

- Introduce feed supplement subsidies under Tier 1 of the ELMS which could reduce methane production in adult cattle by 8.5% in females and as much as 18.5% in males.
- Introduce funding for further research into artificial feed additives as initial studies show they could reduce methane production from enteric fermentation by 22-35%. Further research should be followed by approval and subsidy via the ELMS to encourage wide use.
- Selective breeding, increasing milk and beef yields, could facilitate a reduction in numbers of livestock necessary. This provides economic benefits and environmental benefits. Under a subsidy scheme in Tier 1 ELMS breeding data should be collected

for use by breeding associations, a sire reference subsidy scheme should be set up and selective breeding practices encouraged via subsidy.
- ELMS should subsidise strategic rotational grazing practices under Tier 1 ELMS and also subsidise mixed cropping to also reduce the use of synthetic N fertilizers. Rotation grazing is a low cost, high return form of reducing GHG through carbon sequestration and producing better quality and lower fibre forages, which could reduce GHG in cattle through enteric fermentation by 22%.

The recommendations for manure management:

- Subsidised and low interest loans should be investigated under Tier 2 of ELMS for the implementation of anaerobic digestion plants. 95% of manure emissions come from anaerobic digestion in the break down of animal and food waste. Anaerobic digestion provides an opportunity to capture biogas for fuel.

The recommendations for soil emissions:

- 43% of farms in England currently have no nutrient management plan in 2020. Under Tier 1 of the ELMS subsidy for the implementation of proper nutrient plans, along current government guidelines, should be adopted.
- However, reduction in the use of N-fertilisation is recognised as the most effective measure to reduce nitrous oxide. Under a 'public money for public goods' approach to fertilisation, the government guidelines should move from economic optimum to environmental optimum and research into this optimum rate should be conducted and implemented as part of the ELMS.

(b) Soil Quality

Managing soil quality provides several benefits: reducing carbon emissions, increasing productivity, biodiversity, long-term viability of farming practices, water quality in adjacent rivers and reducing flood risk. Under Tier 1 of the ELMS, which Defra has suggested should offer farmers a 'menu' of different sustainable farming options that are accessible to all farmers and with minimum proof of compliance procedures needed, encouraging high levels of participation.

There are a number of suggested measures that should be included into the 'menu' of options:

- An organic 'menu' option that would expand organic conversion and maintenance payments, currently covered by the Countryside Stewardship for England, and make organic farming more profitable and providing multiple environmental outcomes.
- An agroforestry 'menu' option, incentivising farmers to convert to agroforestry methods. This will aid mitigating soil erosion, nitrogen leaching and biodiversity loss while increasing carbon sequestration.

In the longer term it is recommended that the aim for government intervention in the agriculture sector to move away from subsidies to business relationships:

- The focus should move from subsidy to natural capital market-based solutions which provide environmental improvements at minimal cost to the taxpayer. This approach

would see farmers paid for outcomes such as sequestering carbon and enhancing natural capital, rather than improving things like soil quality. Placing the environment at the heart of the agriculture sector.

(c) Water Quality

Water companies spend million cleaning water from rivers polluted with agricultural chemicals in slurry, paid through higher water bills for consumers. The Environment Agency is spending £5.6 billion on flood defences over the next 6 years. Farmers lose value through topsoil degradation. Our proposals for improving water quality are:

- Water management needs to be provided at the catchment level with a system operator approach allowing higher stakeholder engagement with better outcomes.
- Farmers should be incentivised to embed soil improving cropping systems (SICs) per Tier 1 of the ELMS, explained further in the soil quality section of the paper, as water quality is tied to management of soil quality under intensive agricultural methods.
- The 'Pay to Pollute' principle should be applied to fertilisers and pesticides which would reduce chemical use and therefore spill into rivers. Research should be undergone to investigate mechanisms where water companies could pay farmers for improvements to water quality.
- A national database of water quality, as put forward by the Soil Association for soil, should be created. This data would enable evidence-based policy in rewarding farmers for outcomes and allow for accurate cost-benefit analysis for future policy developments.
- Farmers should be incentivised to find solutions to flood risks through reverse auctioning processes. Working at the catchment level, in partnership with key stakeholders such as the Environment Agency, would be beneficial such as the schemes trialled in the Somerset Levels or by Wessex Water in Poole.

(d) Air Quality

Farmers should not be paid to provide 'air quality' as a public good, it is non-excludable and difficult to measure the extent farmers have provided for it. Our suggestion is that:

- Regulation on existing practices that cause significant air pollution should be considered, these activities include burning waste.
- The cost of using ammonia should also fall under the 'Pay to Pollute' principle to account for its negative impact on air quality.

(e) Regulation

Alongside the subsidy regime captured in the 'public money for public goods' principle at the heart of the ELMS, there is a role for regulatory action. Our proposals include:

- Regulation should not be the main focus of the ELMS, which would benefit from focusing on incentivising good practice, and other assistance such as education or advisory resources, and capital grants to aid continual improvement.
- Participation in the ELMS should be voluntary, farmers will be encouraged to join due the strength of the business case and financial incentives. Higher rates of participation lead to success and this is achieved through working with farmers – and was the reason for some previous regulatory interventions.
- However, there should be outright bans on certain practices. Where regulation exists it should be well-enforced to ensure compliance, and charged in the same was as anti-competitive behaviour (10% of turnover).
- New regulation will require a new regulatory body to manage the ELMS and handle enforcement. Effective use of technology for monitoring outcomes will be required to ensure compliance.

(f) Biodiversity

Previous failures in biodiversity under the CAP (for instance in European farm bird population) are tied to food production, another objective that agricultural policy promotes, which can adversely damage essential habitats. Current proposals offer greater flexibility to pursue biodiversity goals by 'delinking' Direct Payments from the requirement to farm the land under the ELMS. However, these are in conflict with an emphasis in the Agriculture Act on prioritising food security and food production.

Our proposals:

- Brexit creates an opportunity to ensure biodiversity remains an essential aim of domestic agriculture policy under the ELMS, and is not usurped by greater food production levels with negative impacts, as seen under the CAP.
- Lessons can be learned from the United States Conservation Reserve Programme – rewilding previously farmed land – and Australia's Environmental Stewardship Programme pilot programme targeting specific endangered species; for instance targeting the European water vole the population of which has declined by over 90% since the 1960s, and to restore flower meadows, hedgerows and trees essential for bees and other species that form part of the ecosystem.

(g) Public Health

Public health is a benefit from other 'public goods' considered under the ELMS, such as air quality, but is not considered a public good in its own right. Neglecting to classify 'public health' as a 'public good' under the ELMS is a missed opportunity, as the farming sector and public health are interconnected, particularly when it comes to diet. Currently the UK population do not eat enough fruit and vegetables (F&V) and the ELMS could mitigate this through providing that F&V are affordable, the main barrier to consumption. Farmers should be incentivised to shift from cereals to F&V in crop production, which would also provide economic benefits due to cereal productions overreliance on subsidy to remain being economic viable.

Our proposals are:

- Award zero-interest or low-interest loans for investment, alongside lump-sum subsidies for smaller projects, to cereal producing farms intending to shift their production towards horticulture under Tier 2 of the ELMS.
- Loans would be tied to the conditions that the recipient approves a portion of their land under the 'use less, rewild the rest' principle. Tied with precision farming technology subsidies to increase production.
- Subsidies given under Tier 1 to fruit and vegetable farmers who supply public institutions to offer F&V at below market prices.

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1. Introduction

1.1 Background - The CAP and its Problems

Making up 37.4% of the European Union's budget, the Common Agricultural Policy constitutes the EU's largest single program.[1] It provides direct income support for farmers, engages in market measures to mitigate volatility, and funds rural development measures. Consequently, the CAP has a profound influence in shaping the economic conditions of the agricultural sector in member countries.

The Common Agricultural Policy has two main pillars. Pillar I is responsible for the payments to farmers – this manifests itself in two ways. The first is via direct income support, which is a subsidy paid based on the amount of land a farmer owns. This is contingent on meeting certain minimal cross-compliance standards of environmental management, animal welfare and traceability. These include greening measures such as crop diversification or setting up Ecological Focus Areas to plant nitrogen-fixing crops. The second is via market support, which is funding used for minimising the effects of market volatility on farmers. Pillar II is about rural development, whether that be for environmental purposes of combating climate change, to help achieve a balanced development of local rural communities or as a way of improving agricultural productivity by ensuring sustainable resource management and competitiveness.

Within the UK, agriculture takes up 72% of all land and 1.45% of all employment - for that, it received €4.2 billion in payments from the CAP.[2] The UK's CAP payments were dominated by direct aid, which took up 75%, with less than 1% going to support stable market prices. The remaining 24% came from Pillar II programs under the European Agricultural Fund for Rural Development as well as domestically co-financed schemes, like the UK's Rural Development Programs. The United Kingdom's withdrawal from the European Union meant that it needed a new set of agricultural policies following Brexit in order to replace the funding its agriculture sector previously received from the CAP.

The government proposed and passed the Agriculture Act 2020 in order to do so.[3] This replaces the framework of agricultural payments set up in CAP for a few reasons. Firstly, the direct payments under the CAP have been criticised because they are given based on farm size. This means that these payments are helping the rich get richer, with around 20% of farmers receiving 80% of the money.[4] Not only is this inequitable, it is inefficient, because it is the larger farmers who face fewer risks of income volatility affecting their livelihoods and are more able to take advantage of economies of scale. Indeed, the fact that the direct

[1] European Commission, 'CAP expenditure in the total EU expenditure' (2020) <https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/cap-expenditure-graph1_en.pdf>, accessed 5 January 2021
[2] Department for Environment, Food and Rural Affairs, 'Agriculture in the United Kingdom 2019' (2020) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904024/AUK_2019_27July2020.pdf>, accessed 5 January 2021
[3] Agriculture Act 2020
[4] European Commission, 'European Union Statistical Factsheet' (2020) <https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/agri-statistical-factsheet-eu_en.pdf>, accessed 3 January 2021

payments reduce the competitive pressures on the largest farmers means that those best placed to engage in innovation due to their larger profits have the least incentive to do so. Furthermore, the subsidies provided allow larger farmers to bid up land rental prices, squeezing out smaller farmers[5] - in fact, we have seen land prices more than double since payments on the basis of land size were introduced.[6] In this way, the payments act as a government subsidy to reduce competition.

Secondly, the direct payments have in many cases resulted in agricultural and environmental degradation[7] – the clearest indicator of this deterioration is the fact that the population of farmland birds have fallen by over a third in the last 30 years.[8] Bird populations are highly responsive to ecological conditions, due both to their mobility and their sensitivity to the populations of insects they eat, meaning that they are a good proxy for the condition of the environment. This decline has been attributed to the CAP incentivising farmers to expand their agricultural land to land which is ill-suited for agricultural produce and to produce using more ecologically intensive methods. The former has resulted in landscape elements like hedges being destroyed, as well as wetlands being drained and fallow land being reduced, resulting in fewer nesting habitats for insects and birds. The latter has caused farmers to switch away from mixed farming, as well as to use pesticides and herbicides more, giving birds fewer food sources to forage from. The combination of the two has therefore caused reduced biodiversity.[9] Furthermore, the greening initiatives required by the CAP are so minimal that they border on having no practical impact[10] because they only affect 5% of CAP land[11] - consequently, the overall effect is environmental damage.[12]

Thirdly, insofar as the main result of the CAP is to subsidise farmers and increase the price of agricultural produce by nearly 20%[13], it may not be the most efficient or deserving use of money. This is especially true because it is funded by taxpayers, meaning that low-income families are forced to foot the bill twice for food – once in higher taxes, and once in higher food prices.

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[5] Department for Environment, Food and Rural Affairs, 'Moving Away From Direct Payments' (2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740669/agri-bill-evidence-slide-pack-direct-payments.pdf>, accessed 2 January 2021

[6] Alex Lawson, 'Outlook and historical context' (2018) <https://www.savills.co.uk/research_articles/229130/228020-0>, accessed 5 January 2021

[7] Ariel Brunner and Harry Huyton, 'The environmental impact of EU green box subsidies' (2009) <https://doi.org/10.1017/CBO9780511674587.017<, accessed 7 January 2021

[8] International Renewable Energy Agency, 'IRENA 28 – Population trends of farmland birds in EU-15' (2005) <https://ec.europa.eu/eurostat/documents/2393397/2518916/IRENA+IFS+28+-+Population+trends+of+farmland+birds+in+EU.pdf/99c16567-e3ff-4f2b-851a-019f3d85f15a>, accessed 5 January 2021

[9] Juan Traba and Manuel Morales, 'The decline of farmland birds in spain' (2019) <https://www.nature.com/articles/s41598-019-45854-0>, accessed 29 December 2020

[10] Jonas Josefsson et al., 'Sensitivity of the farmland bird community to crop diversification in Sweden' (2016) <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.12779>, accessed 10 January 2021

[11] Samo Jereb, 'Greening: a more complex income support scheme' (2017) <https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=44179>, accessed 18 December 2020

[12] Viorel Stefan, 'Biodiversity on farmland' (2020) <https://www.eca.europa.eu/Lists/ECADocuments/SR20_13/SR_Biodiversity_on_farmland_EN.pdf>, accessed 23 December 2020

[13] Kristian Niemitz, 'Abolish the CAP, let food prices tumble' (2013) <https://iea.org.uk/blog/abolish-the-cap-let-food-prices-tumble>, accessed 20 December 2020

1.2 The Agriculture Act 2020

The government's Agriculture Act gets rid of many of these issues by simplifying to a framework of "public payments for public goods", ensuring that goods which "would otherwise be undersupplied by the market" are produced.[14]

This received a generally positive reception from various stakeholders. The National Farmers Union is broadly supportive although raised issues at consultation about whether the production of food itself could be considered a public good, because of the strategic value in the United Kingdom having a degree of self-sufficiency and greater food security.[15] Environmental groups welcomed the emphasis on rewarding farmers for securing the longer term future of the environment, and the cultural and ecological benefits that land can provide.[16] For example, the National Trust has advocated for looking at the resilience of the natural environment as an important goal, whether this is for developing wildlife diversity or rebuilding soil health. Indeed, the Soil Association was successful in lobbying for the Act to acknowledge soil as "an essential natural asset".[17] This is because soil is a form of natural capital that has the ability to provide various public goods,[18] such as the effective capture of carbon from the atmosphere at a rate twice that of vegetation,[19] the buttressing of a wildlife habitat[20] and the capacity to absorb water as to reduce flood risks.[21]

The details of the 'public payments for public goods', in the form of the Environmental Land Management Scheme (ELMS), will be discussed further under 'Scope of the Paper', but first it is worth considering the definition of a 'public good'.

[14] Department for Environment, Food and Rural Affairs, 'Health and Harmony' (2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/684003/future-farming-environment-consult-document.pdf>, accessed 17 December 2020
[15] Public Bill Committee, 'Written evidence submitted by the NFU (AB20)' (2018) <https://publications.parliament.uk/pa/cm201719/cmpublic/Agriculture/memo/AB20.htm>, accessed 27 December 2020
[16] Tom Lancaster, 'Agriculture Bill 2020: Do good things come to those who wait?' (2020) <https://www.wcl.org.uk/agriculture-bill-2020-do-good-things-come-to-those-who-wait.asp>, accessed 18 December 2020
[17] Gareth Morgan, 'Commitment to soil in Agriculture Bill' (2020) <https://www.soilassociation.org/news/2020/january/16/commitment-to-soil-in-agriculture-bill/>, accessed 29 December 2020
[18] Katarina Hedlund, 'Soil as Natural Capital' (2013) <https://www.reading.ac.uk/caer/documents/pb_soil.pdf>, accessed 4 January 2021
[19] European Environment Agency, 'Soil — The forgotten resource' (2010) <https://www.eea.europa.eu/signals/signals-2010/soil>, accessed 12 January 2021
[20] Soil Association, 'The future of British farming outside the EU' (2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf>, accessed 6 January 2020
[21] Environment Agency, 'The state of the environment: soil' (2019) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805926/State_of_the_environment_soil_report.pdf>, accessed 18 December 2020

1.2.1 Definition of Public Goods

What are public goods? These are defined in economics based on two criteria. The first is excludability and the second is rivalry. Excludability refers to the extent to which people can be prevented from using the good or service if they have not paid for it. Rivalry refers to the extent to which people using the good or service prevents its simultaneous consumption by others.

These criteria produce four types of goods. Firstly, there are private goods like foodstuffs which are excludable and rival. An apple is excludable in that if you do not pay for an apple, you will not get an apple. It is also rival, because if you eat an apple, someone else cannot eat the same apple. Secondly, there are common goods like fish stocks which are non-excludable and rival. They are non-excludable because it is difficult to demarcate which fishes belong to which person – as such, one cannot stop fishermen from fishing from the general stock of fish. However, this is still a rivalrous good, because one person fishing will result in fewer fish for other people. Thirdly, there are club goods like cable television which are excludable and non-rival. For example, if you do not pay for HBO, you will not be able to watch it – you can be excluded from this good. However, it is non-rival since you watching HBO does not stop other people from sitting next to you and watching it too. Fourthly, there are public goods like the air which are non-excludable and non-rival. It is impossible to stop other people from breathing the air, and their breathing does not diminish - your ability to breathe the air.

The reason why public goods are special relates to the economic concept of efficiency – this is where the mathematical condition of $\frac{MU1}{MC1} = \frac{MU2}{MC2}$ holds. What this means is that, supposing there are only two goods, the ratio of marginal utility to marginal cost for both goods should be equal. In effect, efficiency is when every good provides the same bang per buck – if this were not the case, it would make sense to spend more on the good with a higher ratio until the ratio decrease. Individual consumers are usually assumed to buy goods to fulfil the condition of $\frac{MU1}{P1} = \frac{MU2}{P2}$ – that is, they want the ratio of marginal utility to price to be equalised across goods for a similar reason as above. Meanwhile, producers will produce up till $P = MC$, where the price of the good is equal the marginal cost of producing that good. Any more than that would result in them losing money, while the opposite would result in there being profitable opportunities they are not using. We can see that these two combinations of conditions mean that an efficient outcome ought to arise naturally via the market mechanism.

However, public goods change this dynamic – because they provide benefits to a third party not involved in the transaction due to their non-excludability and non-rivalry, we cannot rely on the market to produce the correct amount. We can think about these external benefits by recognising that for public goods, $MSU1 > MU1$ holds. That is, the marginal social utility is greater than the marginal utility to the person involved in the transaction. If we assume the other good is a private good where $MSU2 = MU2$, we can substitute these back into the original condition of $\frac{MU1}{MC1} = \frac{MU2}{MC2}$ to see that we will get an outcome of $\frac{MSU1}{MC1} > \frac{MSU2}{MC2}$. In the same vein as how we defined efficiency, we can define social efficiency as where $\frac{MSU1}{MC1} = \frac{MSU2}{MC2}$ – it is clear that the market provision of public goods will not fit this criterion, since people will effectively be freeriding off the public goods others have paid for, resulting in an

underproduction of this public good. This is the case for why public goods should be provisioned in another way, such as by government subsidies. An additional advantage of subsidising public goods is that it provides an alternative and diversified channel of income stream for smaller farms, which enables them to compete even though they may not be able to achieve the same level of agricultural productivity as the most mechanised and capital-intensive ones[22].

This definition holds for the majority of the goods discussed in this paper, except that of 'public health' which, perhaps for this reason, has not been included in the governments understanding of 'public good' in the Agriculture Act 2020. However, we have included it in our considerations due to the opportunity that might be being missed to greater integrate the approach to tackling both the public policy problem of sustainable agriculture, and the dietary problems persistent in the UK, particularly relating to fruit and vegetable consumption. This is why the Royal Society for Public Health has argued for health to be one such public good. For example, providing sufficient financial incentives to increase the amount of agricultural land deployed for producing fruits and vegetables could result in nearly 2,000 lives being saved every year from cardiovascular deaths due to the consequent abundance of fresh and healthy produce changing its price relative to other foods.[23]

1.3 Scope of the Paper

1.3.1 The Government's Aims

When it was clear the UK was leaving the CAP, the Department for Environment, Farming, and Rural Affairs (DEFRA), investigated the problems that Direct Payments under the CAP had caused in the UK farming sector to inform future policy decisions.[24] There are generally two problems that the department is hoping to solve with current domestic farming proposals: (i) the persistent productivity problem in UK agriculture, and (ii) promoting 'public goods' through subsidy and regulation.

As for productivity, the CAP, it was itself an impediment to productivity improvements, due to its direct payments reducing the competitive pressures on farmers.[25] The Brexit process has not helped increase productivity in the short term because farming is a sector that requires uniquely significant levels of foresight and planning, twice as many farmers have been decreasing their investments than increasing investments as a result.[26] Overall

[22] Bazyli Czyżewski and Agnieszka Brelik, 'Providing Environmental Public Goods under the Common Agricultural Policy as a Cure for Market Failure' [2019] European Research Studies Journal 22 (3)
[23] Paraskevi Seferidi, 'Potential impacts of post-Brexit agricultural policy on fruit and vegetable intake and cardiovascular disease in England' (2019) <https://nutrition.bmj.com/content/3/1/3>, accessed 2 January 2021
[24] DEFRA, 'Moving Away From Direct Payments' (2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740669/agri-bill-evidence-slide-pack-direct-payments.pdf>, accessed 2 January 2021
[25] Environment, Food and Rural Affairs, 'The future for food, farming and the environment' (2018) <https://publications.parliament.uk/pa/cm201719/cmselect/cmenvfru/870/87005.htm>, accessed 12 January 2021
[26] Farming UK, 'Mid-term farmer confidence hits all-time low as more certainty urged' (2017) <https://www.farminguk.com/news/mid-term-farmer-confidence-hits-all-time-low-as-more-certainty-urged_48225.html>, accessed 10 December 2020

productivity has been low in the UK, and agricultural output has increased by 0.8% a year compared to the average of 2% per annum in developed countries, productivity growth has been almost at a plateau since the 1990s.[27]

The government has introduced a number of measures aimed to tackle this productivity problem. In the past, they were organised under the Countryside Productivity schemes, which ranged from providing small grants of £3,000 to £12,000 for buying new equipment to farm productivity grants that began at a minimum of £35,000.[28] Similar programmes have been announced in the Agriculture Act such as the Farming Investment Fund.[29]

However, the productivity measures are not the focus of our paper. The paper focuses on the second of the two government aims, promoting 'public goods' through regulation and subsidy. It may be the case that some of the proposed measures, for instance our proposals for increased selective breeding to increase milk and beef yields, may have the knock on effect of increasing productivity however this is a side-effect as the aims are focused on sustainability.

1.3.2 The Environmental Land Management Scheme (ELMS)

The scheme that will put the 'public money for public goods' principle to practice is the Environmental Land Management Scheme (ELMS). This will be the focus of our paper all discussions below will be related to the ELMS proposed scheme and areas that there could be room for improvement.

The ELMS functions by administering subsidies for public goods, ranging from environmentally friendly land and water management or cultural and natural heritage preservation to soil quality and genetic diversity or agricultural productivity. For all of these goals, the program splits them into three tiers, "providing standards all farmers must meet, whilst also providing options for them to deliver additional benefits".[30]

- Tier 1 is given for environmentally sustainable agriculture and forestry practices, relating to smaller changes that all farms can achieve and be rewarded for.
- Tier 2 aims at locally targeted environmental outcomes, which will likely involve cooperation between different land managers at important locations.
- Tier 3 is to help support land use change at a landscape scale, often targeted at environmental commitments like nature recovery and net zero target – in this way,

[27] Rohit Kaushish, 'UK agricultural productivity fails to keep pace with global trends' (2015) <https://www.nfuonline.com/cross-sector/farm-business/economic-intelligence/economic-intelligence-news/uk-agricultural-productivity-fails-to-keep-pace-with-global-trends/>, accessed 21 December 2020
[28] Department for Environment, Food and Rural Affairs, 'Rural Development Programme for England Countryside Productivity Scheme' (2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761059/Improving_Farm_Productivity_handbook_v2.pdf>, accessed 3 January 2021
[29] DEFRA, 'Government unveils path to sustainable farming from 2021' (2021) https://www.gov.uk/government/news/government-unveils-path-to-sustainable-farming-from-2021
[30] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021

> farmland management will be inextricably linked to the broader 25 Year Environment Plan goals set by the government.[31]

Unfortunately, after this paper was researched and written the government announced changes to the Tier system, opting for 'three components' that do not map directly onto the previous tiered approach. However, as acknowledged in the 'Path to Sustainable Farming' roadmap, DEFRA "refer to components when previously [they] have said tiers". Therefore, where Tier 1 is discussed, it should be taken to refer to the Sustainable Farming Incentive 'component' which covers the majority of recommendations in this paper. Where proposals are related to Tier 2 and 3, they should too fit within the new Local Nature Recovery and Landscape Recovery 'components'.

1.3.3 Current government proposals under the ELMS

Following a series of consultations running over several years, DEFRA published 'The Path to Sustainable Farming: An Agricultural Transition Plan 2021 to 2024' in November 2020.[32] This was the most detailed plan setting out the course for the transition from Direct Payments to the ELMS. The plan outlines that Direct Payments will be tapered off from 2021, the launching of a Farming Investment Fund targeting productivity, improving payments through existing schemes throughout the transitional period, such as the Country Stewardship scheme.

As for the ELMS, the announcement set out that the EMLS will be piloted from 2021-2024, and that the government is looking for 5,500 farms to participate in the first stage of implementing the new policy.[33] The Sustainable Farming Incentive, a core component of the ELMS, will be rolled out from 2022. This core element of ELMS covers the payments made by DEFRA to farmers for carrying out environmentally sustainable practices including cropland management, livestock management, tree and woodland management, boundary and hedgerow management, soil management, nutrient management, biodiversity and more. Alongside the Sustainable Farming Initiative, there are two further components to ELMS. Firstly, the Local Nature Recovery which will pay for actions to support local nature recovery and deliver local environmental priorities such as restoring habitats, woodland, wetlands, freshwater, peatland, heathland and more. Secondly, the Landscape Recovery will support the delivery of landscape and ecosystem recovery in the long-term, land use change projects including the restoration of wilder landscapes where appropriate, large-scale tree planting and peatland restoration.[34]

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[31] Department for Environment, Food and Rural Affairs, 'At a glance: summary of targets in our 25 year environment plan' (2019) <https://www.gov.uk/government/publications/25-year-environment-plan/25-year-environment-plan-our-targets-at-a-glance>, accessed 10 December 2020

[32] DEFRA, 'The Path to Sustainable Farming: An Agricultural Transition Plan 2021 to 2024', (2020) accessible at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/954283/agricultural-transition-plan.pdf.

[33] GOV.UK, 'Government unveils path to sustainable farming from 2021' (2020) accessible at https://www.gov.uk/government/news/government-unveils-path-to-sustainable-farming-from-2021

[34] *Ibid*, p 32-3.

These were announced after the paper was researched and written, and therefore our 'Tier' approach is slightly outdated. However, as acknowledged in the 'Path to Sustainable Farming' roadmap, DEFRA "refer to components when previously [they] have said tiers". Therefore, where Tier 1 is discussed, it should be taken to refer to the Sustainable Farming Incentive 'component' which covers the majority of recommendations in this paper. Where proposals are related to Tier 2, the policy recommendation should be taken at face value and applied to the new component system to fit in where necessary.

Because the scheme is still at the point of commencing pilots within the next two years, it is the right time to analyse the policies proposals that should be incorporated into the ELMS to tackle the public goods that are analysed in the paper.

1.3.4 The Public Goods analysed in our paper

There is a selection of 'public goods' that shall form the basis of our analysis of ELMS, each covered by a section in the paper, and the recommendations submitted to the government:

- Reducing greenhouse gas emissions
- Improving soil quality
- Improving water quality
- Improving air quality
- Improving biodiversity
- Improving public health
- In addition, the paper will also consider how regulation can be introduced effectively alongside the ELMS tiered system of subsidy payments to ensure that the positive environmental outcomes are achieved in the most efficient manner. The correct regulatory framework is currently not contained in the proposals set out in the ELMS so there is scope here for some suggestions.

The public goods that the government has said the ELMS will pay for include:[35]

- Clean and plentiful water
- Clean air
- Protection from and mitigation of environmental hazards
- Mitigation of and adaptation to climate change
- Thriving plants and wildlife
- Beauty, heritage and engagement

The paper's selected 'goods' reflect a range of the goods that DEFRA are intending to include under the scheme, but also include some that DEFRA chose not to include but could be beneficial to consider (public health) given the opportunity re-writing agricultural policy presents.

In each section, the problems faced in promoting each good will be set out first, and then our analysis of how best to solve the problems. This will then be followed with direct

[35] DEFRA, 'Farming for the Future- Policy and Progress update' (DEFRA, 1 February 2020) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/868041/future-farming-policy-update1.pdf> accessed 4th January 2021

recommendations to the UK government about policy measures that should be adopted under the Tier systems in the ELMS that will best promote the good, bearing in mind the cost effectiveness of each proposal.

There is an element of cross-referencing between the measures. For instance, improving soil quality can help mitigate river pollution, increasing water quality. Similarly, improved air quality can improve public health.[36] Improved soil quality can reduce greenhouse gas emission, and so on. Where there is overlap the sections refer the reader to other sections of the paper where those issues are handled in greater detail.

Some of our recommendations are currently being considered by the government, for instance manure management was set out in the Policy Discussion Document dated February 2020 as a Tier 1 measure under the ELMS. In which case our proposals aim to give detail about how they could be best adopted. In most cases, our recommendations are currently not publicly being considered by DEFRA, which is where the paper will make most of its contributions.

1.3.5 The 'Public Goods' outside the scope of this paper

The paper is limited in the scope so choices were made about the goods that would be best to analyse; those that have the most impact or could see greater improvement. Two main areas of concern left out from our considerations and the body of our proposals are: (i) animal welfare, and (ii) food production and national food security.

The reason that animal welfare has not formed the body of our proposals is because twofold. Firstly, under current proposals it is separated out from the initial launch of ELMS, as the roadmap set out in 'The Path to Sustainable Farming: An Agricultural Transition Plan 2021 to 2024' noted that the Animal Health and Welfare Pathway is being established aside from, for instance, the Sustainable Farming Incentive that handles many of the environmental policy changes that made the core of our focus. Secondly, one of the key elements for animal welfare in the UK raised during the Agriculture Bills readings in the Commons, and from stakeholder responses to consultation, were that imports from abroad would undercut higher UK animal welfare standards. However, this is viewed as a matter not related to domestic reform, subsidy and regulation and so it will not form the basis of our reasons. The UK currently has a high standard of animal welfare and this is maintained under the Agriculture Act, so it was an area that could present less scope for change.

As for food security and production, the NFU lobbied that food production be considered a public good itself, although the government has not included it as such. The NFU argued the UK should be "maintaining a robust and resilient domestic food production sector" – in fact, they go so far as to say that the government should provide new rules such that "schools, hospitals, hotels and restaurants, and all procurement under the government buying standards are … sourcing British assured ingredients".[37] As a compromise, the government

[36] CA Pope III, 'Epidemiological basis for particulate air pollution health standards' (2000) (32(1) Aerosol Science & Technology <https://www.tandfonline.com/doi/abs/10.1080/027868200303885> accessed 4 January 2021

[37] Gail Soutar, 'The future for food, farming and the environment' (2018) <https://www.nfuonline.com/efra-report-june-2016-nfu-summary-and-position-brief/>, accessed 3 December 2020

has included a 5 year report on the state of food security in the UK. The NFU's concern has a reasonable grounding; the UK currently imports half of its food and 84% of its fresh fruit. Just-in-time logistics and the free movement of goods the EU provided means that the UK's food supply chains are very susceptible to exogenous shocks, with only around a week's worth of groceries in the country as a buffer.[38] For example, the ease at which food can be delivered from the EU means 70% of the UK's vegetable imports come from just two European countries.[39] If there were sudden and localised climate shocks in those areas, this could prove to be an issue for access to these key foodstuffs. Indeed, the volatility of the global market was seen in 2008, where fruits and vegetable prices rose by nearly 33%, wheat prices by 130% and rice prices by 74%[40]. These sorts of price shifts asymmetrically affect less affluent households, because they spend a higher proportion of their expenditure on food and spend it on staples which are often hardest hit by price changes. However, some have found these concerns over food security to be hyperbolic, because the chance of having agricultural supplies cut off is incredibly low.[41]

The main reason food security and production are not considered a 'good' within the scope of this paper is that, again, our core focus was how regulation and subsidy can create a more environmentally sustainable agriculture sector. Although food security is an important strategic concern, it is not one that fits into the core research question of this paper, and is one that the government will continue to periodically review (given the new 5 year reporting requirement under the Agriculture Act) so is similarly an area that does not have immediate impact in the discussions around domestic agriculture policy.

[38] Tim Benton et al, 'Food Politics and Policies in Post-Brexit Britain' (2019) <https://www.chathamhouse.org/2019/01/food-politics-and-policies-post-brexit-britain>, accessed 23 December 2020
[39] Ruth Barnes, 'Security of UK Food Supply' (2017) <http://researchbriefings.files.parliament.uk/documents/POST-PN-0556/POST-PN-0556.pdf>, accessed 11 January 2020
[40] Global Food Security, 'UK Threat' (2015) <https://www.foodsecurity.ac.uk/challenge/uk-threat/>, accessed 14 December 2020
[41] Dieter Helm, 'British Agricultural Policy after Brexit' (2016) <http://www.dieterhelm.co.uk/natural-capital/environment/agricultural-policy-after-brexit/>, accessed 12 January 2021

2. Greenhouse Gas

2.1 Overview

According to the current proposals by the Department for Environment, Food & Rural Affairs, the mitigation of climate change is a major goal for the emerging Environmental Land Management scheme.[42] Greenhouse gas (GHG) emissions clearly need to be a salient priority for the scheme, since they are the most important contributors to global warming and hold great potentials for improvement. Legislation passed by Parliament in June 2019 requires the government to reduce the UK's net GHG emissions by 100% relative to 1990 levels by 2050.[43] Although the UK lowered overall emissions to 57 per cent of 1990 figures by 2018,[44] we are not even on track to meet our previous, less ambitious target of 80% emissions reduction by 2050 committed to in 2008.[45] The UK's Committee on Climate Change has highlighted the agricultural sector as a critical priority where progress has been too slow, has not matched the success of other sectors, and "will need stronger and more effective policies."[46] The enactment of the Environmental Land Management scheme offers a golden opportunity to implement those long-awaited, robust changes in policy, which can render British agriculture adaptable to 21st century expectations. The following section analyses agricultural GHG emissions in the context of the national cohort, addressing the most important practices driving those emissions and makes policy suggestions on mitigating emissions from those sources in reflection to the Agriculture Act 2020. The solutions put forward aim to introduce the most up-to-date and inventive practices in agriculture, such as the passages on altering ruminants' feed composition, the application of artificial feed additives, or the promotion of anaerobic digestion. Other proposals intend to impose long-standing governmental professional principles in fuller effect with the help of the ELM scheme, as it is in the case of breeding and genetic selection, grazing management and N fertilizers.

In the past two decades we could observe a steady, although meagre decline in total GHG emission deriving from agricultural activities, amounting to a 16 per cent reduction of 1990 emission levels.[47] Despite this decrease there is still a sizable problem. Overall, the British agricultural sector was responsible for 45 megatons of CO2-equivalent greenhouse gasses in 2019, which makes up for roughly 10 per cent of total UK emissions[48]. Agricultural activity is the 5th largest source of GHG-s in the UK economy, with more than double the emissions of the mining sector and four times that of national construction business,[49] while contributing only 0.6 per cent to the annual Gross Domestic Product and employing merely 1.5 per cent of

[42] Agriculture Act 2020
[43] The Climate Change Act 2008 (2050 Target Amendment) Order 2019
[44] Institute for Government, 'UK net zero target' <https://www.instituteforgovernment.org.uk/explainers/net-zero-target> accessed 12 January 2021
[45] Committee on Climate Change, *Net Zero: The UK's contribution to stopping global warming [*May 2019]
[46] IBID
[47]Department for Business, Energy & Industrial Strategy, *2018 UK Greenhouse Gas Emissions, Final figures* [February 2020] National Statistics https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862887/2018_Final_greenhouse_gas_emissions_statistical_release.pdf
[48]IBID
[49] Office for National Statistics, *Greenhouse gas emissions in the United Kingdom, 1990 to 2018* [2019]

the British workforce.[50] This asymmetry becomes a more pressing issue as the greenhouse effect and the ensuing climate change emerges as an outstanding priority for public policy. What further distinguishes agriculture from other fields in the UK is that its effective emissions primarily comprise of methane (CH_4) at 56 per cent, and nitrous-oxide (NO_2) at 31 per cent, leaving the remaining 13 per cent for carbon-dioxide (CO_2). The proportion of agricultural CO_2 emissions relative to the national cohort is rather marginal, less than 1 per cent. In contrast, methane emissions from agriculture make up 50 per cent of the total UK output, while nitrous-oxide emissions stand at 70 per cent. [51] Due to the strategic importance of these two gasses in the agricultural sector for the formation of climate policy, they will also be the primary concern of the following section.

2.2 Methane

This section focuses most extensively on methane, not only because it represents the bulk (56 per cent) of agricultural emissions, but also because the practices which produce methane lag behind other fields in reducing their emissions-intensity. Although the methane emissions originating from agriculture have declined from 33 megatons to about 27 megatons since 1990,[52] this 16 per cent reduction throughout the past twenty years boils down to the contraction of the British livestock industry. The number of cattle on UK farms has dropped from 12 million to 10million between 1990 and 2015. Sheep numbers have decreased from a historical peak of 45 million in the late 1990s to 34 million two decades later. Pig farming has plummeted in a similar manner in the examined timeframe, plunging from 8 to 5 million.[53] Bearing these figures in mind, the aforementioned decline in emissions seems rather bleak, and the reduction of agricultural methane emissions emerges as a long-neglected, urging necessity.

The upcoming paragraphs are concerned with the two most important drivers of agricultural methane emissions, enteric fermentation and manure management. Enteric fermentation is a digestive process whereby feed constituents are broken down by micro-organisms into simple molecules. Both ruminant animals (e. g. cattle and sheep), and non-ruminant animals (e.g. pigs and horses) produce methane, although ruminants are the largest source per unit

[50] H. Plecher, 'United Kingdom: Distribution of gross domestic product (GDP) across economic sectors from 2009 to 2019' (Statista, Nov 18, 2020) <https://www.statista.com/statistics/270372/distribution-of-gdp-across-economic-sectors-in-the-united-kingdom/#:~:text=In%202019%2C%20agriculture%20contributed%20around,percent%20from%20the%20services%20sector.&text=The%20vast%20majority%20of%20the,particular%20keeps%20the%20economy%20going> accessed 10 January 2021

[51] Department for Food, Environment & Rural Affairs, *Agricultural Statistics and Climate Change* [6th Edition, July 2015] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/476879/agriclimate-6edition-13nov15.pdf

[52] Department for Food, Environment & Rural Affairs, *Agricultural Statistics and Climate Change* [9th Edition, September 2019] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835762/agriclimate-9edition-02oct19.pdf

[53] Yago Zayed, Philip Loft, *Agriculture: Historical Statistics* (Briefing Paper Number 3339, House of Commons Library, June 2019,)

of feed intake.[54] The proposed measures for tackling enteric fermentation include altering ruminants' feed composition, applying artificial feed additives, improving breeding practices and encouraging appropriate grazing management practices. The discharge of GHG-s from manure occurs as follows: Methane is naturally released from the anaerobic decomposition of organic material. In addition, substantial amounts of nitrous oxide (N2O) are produced during the storage and treatment of the animal waste. Nitrous oxide is produced from the combined nitrification-denitrification process that occurs on the nitrogen in manure. The majority of nitrogen in manure is in ammonia (NH3) form. Nitrification occurs aerobically and converts this ammonia into nitrate, while denitrification occurs anaerobically, and converts the nitrate to N2O.[55]

2.2.1 Enteric Fermentation

The enteric fermentation of cattle and sheep is the single gravest threat to UK agricultural climate sustainability. Enteric methane excretion accounts for roughly 75 per cent of such emissions in British agriculture,[56] with ruminants such as cattle and sheep in the forefront. Gas production from cattle farming makes up about 60 per cent of total methane emissions on the countryside, with sheep taking an additional 14 per cent, leaving a mere 1 per cent share for pigs, poultry and others.

Feed Composition

Altering the feed composition of cattle and sheep aims to reduce the emissions intensity of livestock while also enhancing feed efficiency at the same time. About 10% of a cow's energy intake is typically lost through the enteric fermentation process,[57] which means that farmers are also economically incentivized in the long-run to increase animal productivity by minimizing this digestive deficiency in utilizing feed intake. Besides being a no-regret measure with no trade-offs but only benefits from both environmental and economic perspective, the optimisation of digestibility delivers positive results instantaneously and does not require great financial investment. According to the findings of the UN Food and Agriculture Organisation in Argentina, the strategic supplementation of adult female cows for a period of 90 days with cottonseed and sunflower meal reduced enteric methane kg CH4

[54]Department for Food, Environment & Rural Affairs, *Agricultural Statistics and Climate Change* [6th Edition, July 2015] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/476879/agriclimate-6edition-13nov15.pdf

[55] Paul Jun, Michael Gibbs, Kathryn Gaffney, 'CH4 and N2O Emissions from Livestock Manure' [1996] https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_2_CH4_and_N2O_Livestock_Manure.pdf

[56] National Atmospheric Emissions Inventory, *Pollutant Information: Methane* https://naei.beis.gov.uk/overview/pollutants?pollutant_id=3

[57] Food and Agriculture Organization of the United Nations (FAO), *Reducing Enteric Methane for Improving Food Security and Livelihoods* [2016] https://www.ccacoalition.org/en/activity/enteric-fermentation#:~:text=Available%20measures%20to%20reduce%20methane,and%3B%20improving%20performance%20through%20breeding

/kg LW by 8.5%. On the other hand, strategic supplementation of adult males for 90 days resulted in a 17.3% to 18.5% reduction in enteric methane kg CH4 /kg LW. [58]

Suggestions:

- Issuing a comprehensive list of feed supplements which mitigate the emissions intensity of ruminants' digestive processes, such as tallow, sunflower oil, whole sunflower seeds, linseeds and cottonseeds[59]
- Prescribing protocols for the proper application of such supplements, determining: optimal rationing of supplements specific thresholds for the quantity of supplements per livestock to qualify for subsidies.
- Providing regular subsidies under Tier 1 of the Environmental Land Management scheme for the application of the aforementioned supplements in the prescribed manner

Artificial Feed Additives

Artificial feed additives designed specifically for the mitigation of methanogenesis promise even greater advancements in livestock sustainability. This inventive technological field is unfolding currently, which offers the UK the chance to take full advantage of it via its new agricultural subsidy-system. The most potential resides at the moment in products featuring the chemical 3-NOP as an active compound. It is the most extensively studied and scientifically proven solution to the challenge of enteric methane to date. Studies show that the lowest proposed commercial dose of 3-NOP (60 mg/kg dry material of the total daily ration) when applied to total mixed rations can reduce methane emissions from dairy cows by 22–35% without affecting feed intake and milk yield.[60] Concerns of application are alleviated by research conducted on rumen fluid samples, where 3-NOP demonstrated to inhibit growth of methanogenic archaea at concentrations that do not affect the growth of nonmethanogenic bacteria in the rumen. Hence, the bacterial flora of the rumen remains intact, minimizing the risk of negative side effects.[61] Dutch nutritional corporation Royal DSM has already commenced filing for its new 3-NOP based additive at European and US authorities, and expected to gain approval by 2021.[62] A similar product's capability called

[58] Food and Agriculture Organization of the United Nations, *Low-Emissions Development of the Beef Cattle Sector in Argentina* [2017] http://www.fao.org/3/a-i7671e.pdf
[59] Karen A. Beauchemin, Sean M. McGinn, Hélène V. Petit, 'Methane abatement strategies for cattle: Lipid supplementation of diets' [May 2007] https://cdnsciencepub.com/doi/pdf/10.4141/CJAS07011
[60] Royal DSM, 'Taking action on climate change, together' [August 2019] https://www.dsm.com/content/dam/dsm/corporate/en_US/documents/summary-scientific-papers-3nop-booklet.pdf
[61] Evert C. Duin, Tristan Wagner, Seigo Shima, Divya Prakash, Bryan Cronin, David R. Yáñez-Ruiz, Stephane Duval, Robert Rümbeli, René T. Stemmler, Rudolf Kurt Thauer, Maik Kindermann, 'Mode of action uncovered for the specific reduction of methane emissions from ruminants by the small molecule 3-nitrooxypropanol' [May, 2016
[62] Alex Scott, 'DSM seeks approval of additive that minimizes methane from cattle' (Chemical and Engineering News, 23 July 2019 Volume 97, Issue 30) <https://cen.acs.org/business/food-ingredients/DSM-seeks-approval-additive-minimizing/97/i30> accessed 12 January 2021

Mootral Ruminant was also certified by the UK's Carbon Trust to reduce dairy cattle enteric methane production by up to 38% following successful use.[63]

Suggestions:

- Commissioning further research into the prospective utilisation of artificial feed additives which mitigate the enteric fermentation of ruminants
- Completing a precursory subsidy framework for the application of artificial feed additives, to be implemented as soon as such products gain governmental approval

Breeding and Genetic Selection

Although under current scientific consensus emissions intensity remains largely unaffected by selective breeding, improving the efficiency with which feed is converted into live weight gain or milk, i.e. the feed conversion ratio is still achievable and desirable. The range of parameters which can be influenced by genetic selection also include milk yield and calf growth rates, which should serve as the primary focus of the upcoming paragraph. The identification and traceability of animals for breeding and animal welfare purposes is already considered as a priority in Part 4, Article 34 of the Agriculture Act 2020.[64]

Bolstering milk yields can facilitate lowering emissions on dairy farms by reducing the number of animals required to produce a fixed level of output. The UK dairy industry is already a showcase example for this phenomenon alongside the US and Canada, which managed to maintain milk production while reducing the number of dairy cows.[65] Long-term trends imply that there is scope to significantly increase milk yield in the future. The average British Milk yield was 6000 kg/cow/year in 1996, which elevated to 8000 kg/cow/ within a decade.[66] Furthermore, experimental herds in the UK have achieved yields of over 13,000 kg milk/cow/year.[67] DEFRA estimated in 2008 that "the high rates of annual reduction in emissions achieved to date would still be expected to be sustained over the next 15 years if current selection practices were to continue," which were indeed realized. [68]

The prospects of selective breeding are just promising for beef as for dairy. Studies found that genetic progress in growth rates lagged considerably behind that of the US and Canada, where beef cattle generally have higher growth rates and are finished significantly younger,

[63] Jane Byrne, 'DSM submits methane inhibitor to EU feed additive approval process' (Feed Navigator 19 Jul. 2019) <https://www.feednavigator.com/Article/2019/07/19/DSM-submits-methane-inhibitor-to-EU-feed-additive-approval-process> accessed 12 January 2021
[64] Agriculture Act 2020
[65] J. L. Capper, R. A. Cady, D. E. Bauman, 'The environmental impact of dairy production: 1944 compared with 2007' (Journal of Animal Science, June 2009 -,Volume 87, Issue 6) <https://academic.oup.com/jas/article/87/6/2160/4731307> accessed 12 January 2021
[66] European Commission JRC Technical Reports, *Impact of animal breeding on GHG emissions and farm economics* [2019] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC117897/jrc_report_29844.pdf
[67] R. Dewhurst, G. Miller, 'How do different livestock types, sizes and breeds differ in their greenhouse gas emissions?'
[68] Department for Food, Environment & Rural Affairs, *A study of the scope for the application of research in animal genomics and breeding to reduce nitrogen and methane emissions from livestock based food chains*. [2008] Research Project Final Report.

suggesting that major reductions in emissions could be achieved by using breeding to increase growth rate and reduce age at slaughter.[69] DEFRA reckoned that reductions in emissions intensity of around 2 per cent to 5 per cent could be achieved for the beef industry within 15 years via genetic improvement, which can translate into 10 per cent more carcass weight per day of age.[70] Projected annual economic benefits from genetic improvement amount up to £10.7 million for sheep and £4.9 million for the beef industry besides significant reductions in total emissions.[71] The realised returns from genetic improvement are substantially below their potential in the UK.[72]

A 2019 survey, conducted as part of the H2020 GenTORE project found that the greatest barriers for genetic and genomic breeding was the lack of adequate economic incentive, only long term returns on investment and high cost of investment. As a result of these challenges, the current level of recording uptake is low and the optimisation of genetic improvement not realised in the majority of beef breeds. Currently it is estimated that less than 15% of UK beef are involved in performance recording. This compares with the dairy-farming sector where the comparable figure is nearer to 50%."[73]

Suggestions:

- Setting up a subsidy-scheme under Tier 1 of the Environmental Land Management scheme rewarding systematic phenotyping practices, and the regular provision of animal performance data to breeding associations in as part of the Cattle Tracing System (CTS) of the British Cattle Movement Service (BCMS).
- Creating a sire reference subsidy-scheme, which incentivises herds to use selected high-performance index sires and to collect and analyse progeny and potentially carcass data of progeny.
- Subsidizing selective breeding practices, which take account of external benefits such as the mitigation of methanogenesis.

<u>Grazing and Management</u>

[69] Peter Amer, Tim Byrne, Peter Fennessy, Gemma Jenkins, Daniel Martin-Collado, Donagh Berry, (AbacusBio Limited), 'Review of the Genetic Improvement of Beef Cattle and Sheep in the UK with Special Reference to the Potential for Genomics' [May 2015] https://www.signetdata.com/media/2553/review-of-the-genetic-improvement-of-beef-cattle-and-sheep-in-the-uk-final-report-140515.pdf
[70] M.G. Keane Teagasc, 'Ranking of Sire Breeds and Beef: Cross-Breeding of Dairy and Beef Cows' [March, 2011]
[71] Peter Amer, Tim Byrne, Peter Fennessy, Gemma Jenkins, Daniel Martin-Collado, Donagh Berry, (AbacusBio Limited), 'Review of the Genetic Improvement of Beef Cattle and Sheep in the UK with Special Reference to the Potential for Genomics' [May 2015] https://www.signetdata.com/media/2553/review-of-the-genetic-improvement-of-beef-cattle-and-sheep-in-the-uk-final-report-140515.pdf
[72] *Ibid.*
[73] Department for Food, Environment & Rural Affairs, *Report on how beef genetics can help increase the profitability of UK beef farmers* [August 2015] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/459192/fangr-beef-genetics-report.pdf

Pasture grazing is considered to be the most environmentally sound form of beef cattle rearing due to the carbon sequestration of green vegetation. In addition, around 65% of farmland in the UK is best-suited to growing grass rather than any other crop.[74] Nevertheless, pasture management also requires considerable know-how, and properly applied best practices in cattle and sheep grazing can dramatically influence the total effective emissions of a farm alongside its economic productivity. An easily implementable, low-cost, high-return practice in pasture management is rotational strategic grazing. Under rotational grazing, only one portion of pasture is grazed, while the remainder of the pasture rests. To accomplish this, pastures are subdivided into smaller areas called paddocks and livestock are moved from one paddock to another. Resting grazed paddocks allows forage plants to renew energy-reserves, rebuild vigour, deepen their root system and give long-term maximum production.75 The growth of pasture may be divided into three phases:

> Phase I: Pasture is very short (<3 cm) and root reserves are usually low. The small leaf area limits the amount of energy that plants can obtain from the sun, so growth is slow.
>
> Phase II: there is enough leaf for plants to grow rapidly.
>
> Phase III: growth slows down and quality falls as the plants mature and set seed

Under continuous grazing, vegetation often cannot complete Phase II, the most productive part of its life-cycle due to being grazed prematurely. This is undesirable from the perspective of carbon sequestration, the mitigation of enteric fermentation and pasture productivity. Studies attribute up to 22% increase in soil organic carbon sequestration rates to rotational grazing schemes. In addition, rotational grazing maintains the utilized forage at a relatively young and even growth stage, allowing cattle to utilize better-quality, lower-fibre-content forages. This lowers methane emissions from grazing animals—per unit of beef gain—by up to 22% when compared with continuous grazing.[76] Finally, rotational grazing enables pastures to produce the most biomass on a given land area, elevating dry matter production by up to 2 tons/acre. Both start-up and maintenance costs are minor for rotational grazing, which merely comprise of capital spending for electrical fencing and water systems.[77] A further advantage of such practices is that manure is dispersed more evenly throughout the pastures, and farmers can even strategically direct manure distribution to a specific part of the field.

A further example of best practices in agricultural field-management is mixing cropping and grazing enterprises for the benefit of both activities. Continuous cropping of the same area is detrimental to soil structure, reduces soil organic matter and biodiversity, and is likely to be unsustainable unless there are extensive fertiliser inputs.[78] Seeding patches of crop-land with

[74] National Farmers' Union, 'The facts about British red meat and milk' [February 2020] https://www.nfuonline.com/nfu-online/sectors/dairy/mythbuster-final/
[75] Dan Undersander, Beth Albert, Dennis Cosgrove, Dennis Johnson, Paul Peterson, 'Pastures for Profit: A Guide to Rotational Grazing' [2002] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1097378.pdf
[76] Terry C. Clement, Dean D. Giampola, Peter C. Dickison, 'Methane Emissions of Beef Cattle on Forages' (Journal of Environmental Quality, January 2003, 32,1) https://www.researchgate.net/publication/240784364_Methane_Emissions_of_Beef_Cattle_on_Forages
[77]Dan Undersander, Beth Albert, Dennis Cosgrove, Dennis Johnson, Paul Peterson, 'Pastures for Profit: A Guide to Rotational Grazing' [2002] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1097378.pdf
[78]Government of New South Wales, Department of Primary Industries, 'Responsible, sustainable beef production' <https://www.dpi.nsw.gov.au/animals-and-livestock/beef-cattle/husbandry/general-management/production> accessed 12 January 2021

annual or perennial legumes instead, and using those areas as pastures for cattle is a sustainable solution for restoring soil fertility and supplementing cattle's dietary needs at the same time. As for cropping purposes, conclusive evidence shows that using legumes and the manure of grazing cattle instead of synthetic N fertilizers has a considerably lower global warming potential, milder N2O flux rates and more restrained nitrate leaching potential.[79] In an experiment where N-fertility of several perennial pastures was supplied by N fertilizer for 5 years and then by alfalfa that was inter-seeded into the grasses, it was found that nitrate leaching was reduced by between 48 and 76 per cent when the N source changed from ammonium nitrate to alfalfa.[80] Regarding benefits for grazing, legumes are an integral part of high-quality cattle forage. According to the Australian Department of Primary Industries, at least 30 per cent of a cattle's diet should consist of legumes.[81] These types of plants are very low-growing and tolerate close grazing. Legumes continue to branch and enlarge and eventually flower. Unlike grasses, legumes flower in the seeding year and several times annually every year thereafter.[82]

Suggestions:

- Subsidizing strategic rotational grazing practices on sheep and cattle farms under Tier 1 of the Environmental Land Management scheme under the following conditions: ruminant farmers submit a comprehensive all-year grazing strategy, detailing the subdivision of pastures into paddocks, and the forage layout. Applicants need to provide photographic evidence for the presence of necessary infrastructure to their grazing strategy and document their compliance with the grazing strategy in the same manner.
- Subsidizing mixed cropping and grazing enterprises under Tier 1 of the Environmental Land Management scheme under the following conditions: a set minimum area of cropping land is used as a pasture paddock in the grazing-strategy submitted by the farmer. The concerned land area is planted with annual or perennial legumes such as alfalfa, red and white clovers, alsino etc. Subsidies are proportional to the area of land planted with legumes and grazed by cattle instead of being handled with synthetic N fertilizers.

2.2.2 Manure

Manure management is beyond doubt the second greatest source of methane emissions in the UK agricultural sector behind enteric fermentation, accounting for roughly 22% of

[79]T.E Crews, M.B Peoples, 'Legume versus fertilizer sources of nitrogen: ecological trade-offs and human needs' (Agriculture, Ecosystems & Environment, May 2004, Volume 102, Issue 3) https://reader.elsevier.com/reader/sd/pii/S0167880903003402?token=2A45FE223E1B84A4C9F9960FB6AEE95E06723255D2E4EBA2F175E2CA89C174257E3B74C848C740D1943FDCC6E7613949
[80] L.B Owens, W.M Edwards, R.W Van Keuren, 'Groundwater nitrate levels under fertilized grass and grass-legume pastures' [1994]
[81] Government of New South Wales, Department of Primary Industries, 'Responsible, sustainable beef production' <https://www.dpi.nsw.gov.au/animals-and-livestock/beef-cattle/husbandry/general-management/production> accessed 12 January 2021
[82] Dan Undersander, Beth Albert, Dennis Cosgrove, Dennis Johnson, Paul Peterson, 'Pastures for Profit: A Guide to Rotational Grazing' [2002] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1097378.pdf

methane emissions.[83] In addition, 6 per cent British agricultural nitrous oxide emissions derive from manure management.[84] Although the role of animal dung and urine in UK agricultural GHG emissions is already substantial, what places manure management into the forefront of discussions about agricultural reform are its huge GHG reduction potentials. According to government estimates, 1.5 megatons of annual GHG reductions are achievable by pursuing environmentally sound manure management practices, and by 2018 only 0.04 megatons, about 2.5 per cent of this potential was actually realized.[85]

Anaerobic Digestion

Anaerobic digestion is the process by which organic matter such as animal or food waste is broken down to produce biogas and biofertilizer. About 95 per cent of the aforementioned 1.5 megaton GHG reduction potential from manure management is attributed to anaerobic digestion. By 2020, only highly marginal results were achieved in this field, with 4 per cent of concerned farms using anaerobic digestion to process livestock manures and slurries in the UK.[86]

Biogas production is best suited for farms that collect manure as a liquid, slurry or semi-solid; at a single point (a lagoon, pit, pond, tank or other similar structure), every day or every other day, which means that it is mostly applicable at confinement diary farms, and concentrated animal feeding operations (CAFO-s) for swine and poultry.[87] Manure and slurry alongside other organic wastes first go through a waste handling system, then enter the anaerobic digester, where biogas is separated from other co-products. After leaving the Biogas Handling System, methane can be utilized to produce electricity via reciprocating engines or microturbines, heat via burning directly in boilers or heaters, and biofuel, transported in pipelines in compressed form.[88] Anaerobic digestion is a highly efficient form of energy production from wastes, endorsed and supported by governmental policy with feed-in tariffs.[89] Co-products such as digested solids can be applied as livestock bedding, or

[83]Department for Food, Environment & Rural Affairs, *Agricultural Statistics and Climate Change* [9th Edition, September 2019] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835762/agriclimate-9edition-02oct19.pdf
[84] U. Skiba, S. K. Jones, U. Dragosits, J. Drewer, D. Fowler, R. M. Rees, V. A. Pappa, L. Cardenas, D. Chadwick, S. Yamulki, A. J. Manning, 'UK emissions of the greenhouse gas nitrous oxide' [5 May 2012] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3306628/
[85]Department for Environment, Food & Rural Affairs, *Greenhouse gas emissions from agriculture indicators: Slurry and manure* [December 2020] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945474/ghgindicator-9slurry-18dec20.pdf
[86]IBID: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945474/ghgindicator-9slurry-18dec20.pdf
[87] United States Environmental Protection Agency, AgSTAR, 'How does anaerobic digestion work?' <https://www.epa.gov/agstar/how-does-anaerobic-digestion-work> accessed 12 January 2021
[88] IBID
[89] Office of Gas and Electricity Markets, *Feed-In Tariff (FIT) rates* [March 2020] https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-rates

sold for use in landscape products, such as soil amendments or biodegradable planting pots. Liquid effluents called liquor are a valuable, easily applicable and nutrient-rich fertilizer.[90]

Anaerobic digestion plants can easily cover the total electricity and heat consumption of diary and livestock farms alongside concentrated animal feeding operations, while large-sized biogas plants often sell off excess production to grid, ensuring further profits for the operator.[91] Hence, biogas recovery systems can neutralise methane and nitrous oxide emissions from manure, supply the energy-needs of farms and provide high-quality biofertilizer at the same time, making factory farms possibly carbon neutral, or even carbon negative. Nevertheless, anaerobic digestion plants entail especially high start-up costs. Investment for the implementation of necessary infrastructure ranges from £210,000 for small plant producing 25 kWh to £14 million systems pumping out 13,500m3 of gas and 23,000 kWh of electricity every day.[92] The payback on investment tends to be between 4-6 years, considerably lower than in the case of solar or windpower. In summary, anaerobic digestion is one of the most environmentally sound and economically viable alternative energy sources, offering high returns in public goods for taxpayers' money, requiring subsidies due to the high costs of implementation and late returns on investment.

Suggestion:

- Providing subsidised, zero-interest and low-interest loans under Tier 2 of the Environmental and Land Management scheme for the implementation of anaerobic digestion plants to mitigate high start-up costs

2.3 Nitrous Oxide (N2O)

Nitrous Oxide is the second-most emitted gas in the British agriculture sector, representing 31 per cent of CO2 equivalent GHG production.[93] The agricultural sector is responsible for 68 per cent of UK nitrous oxide emissions, therefore it is the primary field of improvement to achieve reduction goals with regard to N2O.[94] Nitrous oxide emissions have declined from 19 megatons to 14 megatons since 1990, adding up to a roughly 26 per cent contraction overall.

2.3.1 Soil Emissions

[90] Gabriel Adebayo Malomo, Aliyu Shuaibu Madugu, Stephen Abiodun Bolu, 'Sustainable Animal Manure Management Strategies and Practices' [August, 2018] https://www.intechopen.com/books/agricultural-waste-and-residues/sustainable-animal-manure-management-strategies-and-practices
[91] National Farmers' Union, 'Delivering Britain's clean energy from the land' [November 2016] https://www.nfuonline.com/assets/69296
[92] IBID
[93]Department for Business, Energy & Industrial Strategy, *2018 UK Greenhouse Gas Emissions, Final figures* [February 2020 National Statistics] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862887/2018_Final_greenhouse_gas_emissions_statistical_release.pdf
[94]National Atmospheric Emissions Inventory, *Pollutant Information: Nitrous Oxide* https://naei.beis.gov.uk/overview/pollutants?pollutant_id=5

The single most important, nearly exclusive (90 per cent)[95] driver of nitrous-oxide emissions in British agriculture are soil emissions. Direct soil emissions refer to two natural processes, when nitrous oxide is lost to the atmosphere from the soil. First, autotrophic bacteria convert ammonium (NH_4) into nitrate (NO_3) through a biological oxidation process called nitrification, making N available for uptake by plants and discharging nitrous oxide as a side-product. Secondly, denitrification occurs under anaerobic soil conditions such as water-clogging and soil saturation, when NO_3 and NO_2 is converted into nitrous oxide. Indirect soil emissions refer to processes which produce different N-compounds that later convert into nitrous oxide. These include ammonia volatilization, the conversion of ammonium into gaseous ammonia and its subsequent emission into the atmosphere; and leaching, the process when percolating rainfall washes residual and mineralised nitrates below the root zone, making nutrient inaccessible for plants and possibly contaminating ground-water. Although the above-mentioned phenomena occur naturally as part of the nitrogen cycle, the scale and intensity of such processes is exacerbated by anthropogenic environmental factors, such as the use of synthetic fertilizers and manure as an organic fertilizer, atmospheric deposition, improved grassland soils, crop residues, the cultivation of organic soils, N-fix crops and deposited manure on pasture.

Reduction N-Fertilisation

Reduction in the application rates of fertilizer N is widely recognized as the most effective measure of reducing N_2O emissions. The non-linear correlation between fertilizer use and nitrous oxide emissions lend further importance to applying the right amount of N-fertilizers, as nitrous oxide production starts rising sharply when rates of fertilizer addition exceed the quantity of N required by the crop. Key findings of a meta-analysis on yield-scaled N_2O emissions by non-leguminous annual crops revealed that yield-scaled N_2O emissions were smallest (8.4 g N_2O-N kg−1N uptake) at application rates of approximately 180–190 kg N ha−1 and increased sharply after that (26.8 g N_2O-N kg−1 N uptake at 301 kg N ha−1). At an N surplus of 90 kg N ha−1 yield-scaled emissions increased threefold.[96] Hence, the primary objective of government intervention should be the prevention of N-fertilizer application exceeding crop nutritional needs for best yields. This rate of fertilizer use is currently addressed by governmental fertilization guidelines as the economic optimum rate, which is the quantity of N above which further additions do not result in economic benefit. DEFRA surveys reveal that there is serious room for improvement in this regard, as 43 per cent of farms accounting for 25% of the farmed area in England have no nutrient management plan in 2020.[97]

[95]UK Parliamentary Research Briefings, Post Note Number 486, *Emissions from Crops* [January 2015] http://webcache.googleusercontent.com/search?q=cache:PyWMFHRfYHoJ:researchbriefings.files.parliament.uk/documents/POST-PN-486/POST-PN-486.pdf+&cd=17&hl=en&ct=clnk&gl=hu

[96]J. W. Van Groenigen, G. L. Velthof, O. Oenema, K. J. Van Groenigen, C. Van Kessel, 'Towards an agronomic assessment of N_2O emissions: a case study for arable crops' [November 2010] (https://onlinelibrary.wiley.com/doi/10.1111/j.1365-2389.2009.01217.x

[97]Department for Environment, Food & Rural Affairs, *Greenhouse gas mitigation practices - Farm Practices Survey England 2020* [11 June 2020] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/891354/fps-ghg2020-statsnotice-11jun20.pdf

The currently preferred economic optimum rate featured in governmental fertilisation guidelines prioritizes the achievement of highest crop yields. Nevertheless, in sentiment of the new agricultural subsidisation-principle "Public money for public goods", governmental attitudes towards fertilization could be reconfigured for the best environmental outcomes. An environmental optimum fertilizer rate should be based upon the quantity of N2O emitted and nitrate (NO 3) leached per unit of grain produced.[98] Such an optimum rate may well differ from the economic optimum. "Making uniform reductions in fertilizer applications (which this measure would require) is distinct from reducing excess applications of fertilizer, since the latter would only affect farmers using more than the recommended fertilizer application. For this reason, an overall fertilizer reduction could achieve significant reductions in emissions."[99] It was estimated that the annual UK abatement potential by 2022 would be 0.46 kt N2O assuming a 5% reduction in the application of fertilizer N.[100]

Suggestions:

- Subsidizing the submission and subsequent abiding of nutrient management plans under Tier 1 of the Environmental Land Management scheme, which adopt the economic optimum rate for fertilization practices.
- Commissioning research for the determination of an environmental optimum rate for fertilization.
- Subsidizing the submission and subsequent abiding of nutrient management plans which adopt the environmental optimum rate on a substantially higher rate, to make up for ensuing losses in productivity and reward positive environmental contributions

[98] Hoben JP, Gehl RJ, Millar N, Grace PR, Robertson GP, 'Nonlinear nitrous oxide (N2O) response to nitrogen fertilizer in on-farm corn crops of the US Midwest' (Global Change Biol., 2011, 17, 1140–1152)
[99] Robert M. Rees, John A. Baddeley, Anne Bhogal, Bruce C. Ball, David R. Chadwick, Michael Macleod, Allan Lilly, Valentini A. Pappa, Rachel E. Thorman, Christine A. Watson & John R. Williams 'Nitrous oxide mitigation in UK agriculture' (Soil Science and Plant Nutrition, 2013, 59:1, 3-15) https://www.tandfonline.com/doi/pdf/10.1080/00380768.2012.733869
[100] Moran D, MacLeod M, Wall E, 'Developing carbon budgets for UK agriculture, land-use, land-use change and forestry out to 2022.' (Clim. Change, 2011, 105, 529–553.)

3. Soil quality

3.1 Overview

The fundamental importance of soil health to farm productivity, food security, climate change and public health has been neglected by governments for far too long[101]. Modern intensive agriculture, practiced in the UK since the Second World War and further incentivised by the CAP, has decimated soil quality[102]. This is a global issue; almost a third of the world's arable soils have been lost to erosion and pollution over the last 40 years, and it will take hundreds or thousands of years for these degraded soils to recover naturally[103]. In the UK, we lose an estimated 2.2 million tonnes of topsoil each year, costing around £45 million per year, of which £9 million is in lost production[104]. The depletion of soil nutrients results in lower yields for farmers, sometimes driving higher fertiliser use, which in turn encourages further soil degradation and exacerbates the problem[105]. This form of intensive agriculture is not sustainable in the long term.

Recent statements from UK ministers have not been matched by action[106]. Soil, perhaps farmers' most valuable asset continues to be degraded by modern agricultural methods. However, the government's existing soil commitments provide a starting point for a new UK policy framework. The global 4 per 1000 soil carbon initiative aims to increase soil organic carbon by 0.4% each year and the overall aim is for all English soils to be managed sustainably, with degradation threats tackled successfully, by 2030[107].

Effective soil management improves soil quality over the long term and would provide multiple benefits or 'public goods'. These include: reducing carbon emissions and meeting government climate change targets, increasing the productivity of the soil and long-term viability of farming practices, increasing biodiversity, improving water quality in river catchments, and reducing flood risk. All of these benefits make economic sense; they would save taxpayer money in regeneration or mitigation expenses, increase natural capital, and provide sustainable economic growth.

[101] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[102] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp224
[103] Grantham Centre for Sustainable Futures, 'A sustainable model for intensive agriculture' (2015) p2 <http://grantham.sheffield.ac.uk/wp-content/uploads/A4-sustainable-model-intensive-agriculture-spread.pdf> accessed 4 January 2021
[104] DEFRA, 'Safeguarding Our Soils: A strategy for England' (DEFRA, 2009) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69261/pb13297-soil-strategy-090910.pdf> accessed 4 January 2021
[105] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[106] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[107] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021

3.2 Incentivising farmers to improve soil quality

In terms of policy, Tier 1 should initially reward farmers to improve **soil quality**, a desired **outcome,** by establishing sustainable farming **practices**. This would be alongside the implementation of a **pay-to-pollute principle**, where farmers would **increasingly** pay for the carbon emissions and pollution caused by their existing practices, discouraging the use of diesel fuel, inorganic fertilisers, and artificial pesticides *(see the pay-to-pollute section)*. Over the next decade, farmers should be increasingly rewarded through Tier 1 for **'outcomes'**, which can be understood broadly as **ecosystem services.** Ecosystem services can be understood as benefits human societies derive from the natural environment and healthy ecosystems[108]. By 2030, this shift should culminate in natural capital markets being established, with soil quality, and ecosystem services like the resulting carbon sequestration, as **valuable natural capital assets** which the market pays for. This allows for a decade of continuous improvement, but at an acceptable pace to farmers and with a guaranteed income. However, it represents a long-term shift from government subsidy to market solutions, providing maximum positive environmental outcomes at minimum cost to the taxpayer. By 2030, the establishment of good practices should provide farmers with sustainable, profitable yields from increasingly productive soil whilst achieving the government's long-term commitment to tackling degradation threats.

Given the market does not currently adequately reward the delivery of environmental public goods, the ELMS will be an effective way for the government to intervene and utilise public funding to deliver them until they can be provided by natural capital markets[109]. This should happen until 2030, **whilst** the mechanisms, platforms and markets needed to value and exchange natural capital properly are developed.

3.3 Soil Improvements in Tier 1

Current DEFRA thinking on Tier 1 is that the Tier should focus on encouraging environmentally sustainable farming, including actions to create environmental benefits that the majority of the farmers could take. This would comprise activities such as planting cover crops and wildflower margins, or other practices which could generate valuable outcomes at scale[110].

[108] GC Daly, *'Nature's services: societal dependence on natural ecosystems'* (Yale University Press 1997) pp. 454-464
[109] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp218
[110] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021

However, whilst some practices which might be rewarded have been mentioned[111], there has been no more detail on the specifics of the scheme, payment mechanisms or what the finalised scheme would look like. We therefore propose a suggestion of how Tier 1 of the ELMS could be developed, using the government's criteria and best practice from agricultural research at Lancrop[112]. Improving soil quality can create multiple valuable environmental benefits and outcomes and should therefore be a principal aim of Tier 1.

Soil improving cropping systems (SICs) are specific combinations of (1) crop types, (2) crop rotations and (3) management techniques aimed at halting soil degradation and/or improving soil quality whilst having positive impacts on profitability and sustainability[113]. Tier 1 of the ELMS could incentivise application of these universally, building on existing soil stewardship payments and assurance schemes which incentivise farmers to increase the organic matter of the soil, such as organic and LEAF[114].

This is the practice of SICs as outlined by Lancrop:

SIC Component	**Basic Principle**
Crop rotations	Long and diverse crop rotations Cover crops Intercropping
Nutrient management	Applying manure and other organic fertilisers rather than artificial ones Effective incorporation of slurry Cover crops, especially nitrogen-fixing legumes Arable crop rotations
Irrigation management	Optimal irrigation
Drainage management	Maintaining water levels in peat soils Contour ploughing

[111] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[112] Lancrop Laboratories, 'Soil Organic Matter' (Lancrop Laboratories, May 2019) <https://www.lancrop.com/#/analysisSoil> accessed 4 January 2021
[113] SoilCare, 'SICS' (SoilCare, April 2020) <https://soilcareproject.eu/images/_SoilCare_biodiversity_factsheet_final.pdf>
[114] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021

Tillage management	Minimum or no tillage cultivation (like direct drilling)
Pest management	Integrated pest management, reduced use of pesticides
Weed management	Mechanical weeding
Residue management	Residue return
Mechanisation management	Controlled trafficking (especially on wet soils) Smaller machinery Low pressure tyres
Landscape management	Treelines, hedges, fringes

Proof of compliance requirements for Tier 1 could be minimal to reduce the administrative burden on farmers and encourage high rates of participation. Proof of compliance could be minimised using technology, as desired by government[115]. For example, remote satellite observation could be used to assess crop rotations, cover crops, and landscape management; electronic proof of purchase receipts and digital accounting could demonstrate purchase of inputs. Meanwhile, data should be collected, submitted, and verified periodically, such as with regular soil organic matter reporting to a national database[116].

3.3.1 Different menu options

The Government plan details how there might be a need for 'menu options' for different farm types and how these might include 'arable, pastoral, mixed and upland' options[117]. This makes sense for incentivising improvements to soil and water quality, where different farming practices vary in their management of the soil. Detailed above is an example of how SICS could be applied to a Tier-1 arable context, rewarding farmers for transitioning to

[115] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[116] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[117] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021

sustainable farming practices. However, with several 'menu options' for SICs relevant to farm-type, Tier 1 should accommodate all farmers in transitioning to more sustainable methods and improving soil quality. All options would include many of the practices detailed above. However, a pastoral menu plan, for example, would include things like limiting or controlling grazing to avoid compaction and exposing bare soils[118]. Meanwhile, in uplands or soils containing high amounts of peat, farmers should be rewarded for maintaining the water levels of, and protecting, peat soils[119] (*see 'Water quality' section*). Having menu options of SICs for different farm types would ensure that incentivised practices are appropriate to their specific farming contexts.

A higher option for farmers in Tier 1 should reward organic farmers. The public benefits delivered by organic farming have been well documented by independent research over the last 30 years. They include more wildlife and biodiversity, healthier soils and carbon storage, flood protection, clean water, lower pesticide and antibiotic use, more jobs and healthier food[120]. Tier 1 of the ELMS could have a higher 'menu option' which would improve and expand the organic conversion and maintenance payments, as currently operating under Countryside Stewardship for England.

Agroforestry can dramatically help mitigate soil erosion, nitrogen leaching, and biodiversity loss while increasing carbon sequestration[121]. To British agriculture agroforestry therefore offers opportunity to increase yields and farm profitability, boost resilience through diversity, and deliver big environmental benefits at the same time[122]. Another higher option of the ELMS Tier 1 system should incentivise greater practice of agroforestry in the UK. Tier 2 could also be applicable to incentivising agroforestry here.

3.3.2 The Business Case

There is a strong business case for farmers applying SICS and transitioning to Tier 1 of the ELMS in terms of reduced input costs, increased long-term yields and improved productivity. The SICS practices detailed above significantly reduce input costs for farmers. For example, practicing minimum tillage, such as direct drilling, saves labour, fuel, and machinery costs[123]. Meanwhile, cover crops and crop rotations reduce the need for artificial fertilisers and pesticides. Costs saved are only likely to increase as the 'Pay to Pollute' principle is applied to input chemicals (*see 'Pay to Pollute' section*). In terms of assets, poor

[118] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp62
[119] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp118
[120] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[121] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[122] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[123] Louise Impey, 'Why no-till is profitable despite having a yield penalty' (Farmers Weekly, 01 July 2019) <https://www.fwi.co.uk/arable/land-preparation/ploughing-cultivation/why-no-till-is-profitable-despite-having-a-yield-penalty> accessed 4 July 2021

soil management or loss of topsoil constitutes a loss of natural capital and a valuable asset[124], whilst SICS and Tier 1 reverses this, providing opportunity for long-term improvements to crop yields, and therefore profits.

3.4 Payment mechanism

Tier 1 should reward farmers for transitioning to the basic principles of SICS. Transition to these practices should halt soil degradation and improve soil quality whilst having positive impacts on profitability and sustainability. Paying farmers to embed practices should achieve the government goal of giving farmers clear guidance on what they need to do in order to deliver environmental outcomes while keeping their financial and delivery risks low[125]. Education and advisory support will be crucial to getting farmers to apply these SICS principles, but many farmers are already making the transition. Incentivising full participation should be achievable, with opportunity here for a rare and genuine win-win-win: positive environmental outcomes, leaner and more profitable farm business operations, and the increased long-term viability and productivity of UK agriculture.

The DEFRA 'Farming for the Future- Policy and Progress update' details how they are "considering a range of ways to calculate payments for ELM." Current thinking is that "for tier 1, it may be most appropriate to base payment rates on the income foregone and costs incurred"[126]. However, they now understand that "to secure sufficient participation to deliver the desired environmental benefits, we may need to take a more flexible approach than under existing schemes, for example through adjusting prices over time in response to supply and demand to achieve the desired level of uptake"[127].

The base payment rates would cover the income foregone, without adequate financial incentives farmers are unlikely to make the switch. However, framing Tier 1 or the ELMS as 'income forgone' is wrong. Not only does it conceptualise sustainable farming methods in a problematic way, income may be foregone in lower yields, but evidence shows this can be offset in an equivalent reduction in input costs, with a zero or positive effect on profitability overall[128]. Meanwhile, yields and productivity are likely to increase over the long-term as

[124] R. C. Palmer and R. P. Smith, 'Soil structural degradation in SW England and its impact on surface-water runoff' (2013) Soil Use and Management <https://doi.org/10.1111/sum.12068> accessed 4 January 2021
[125] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[126] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[127] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[128] Louise Impey, 'Why no-till is profitable despite having a yield penalty' (Farmers Weekly, 01 July 2019) <https://www.fwi.co.uk/arable/land-preparation/ploughing-cultivation/why-no-till-is-profitable-despite-having-a-yield-penalty> accessed 4 July 2021

soils improve. Payment will therefore more than cover the costs of the transition and foregone income. This is especially true if the agricultural budget is maintained. As the National Farmers Union detailed in their post-Brexit consultation paper, "Eliminating direct support does not necessarily imply ending all policies which benefit farmers and growers. If the same total budget could be preserved, there would be considerable sums available for, to take one example, encouraging investment and improving competitiveness"[129]. Overall, the business case for applying SICs should result in realised financial gains and improved livelihoods for farmers, and with the size of payments staying the same, there would be no aggregate loss to the agricultural sector on the whole. Instead, farmers will be rewarded with public money for improving soil quality, natural capital, and the long-term viability of agriculture, instead of for owning land.

3.4.1 Shifting to outcomes

Initially, measured positive environmental outcomes could take the form of a reward 'bonus' for participation in the Tier 1 scheme. This would pay for demonstrated and measured improvements to soil organic matter, carbon emissions / sequestration, water quality and soil biodiversity. Meanwhile, improvements which mitigate flood risk would be paid by the river catchment system operator (*see 'Reducing flood risk' section*). Shifting to a pay for outcomes could build on existing government aims. For example, a bonus could be paid to farmers who achieve the governments '4 per 1000' idea, of improving organic matter content by 0.4% per year[130]. Grants and bonus payments could also be paid to farms for becoming certified as fully organic. Over the decade the bonus payment would still be non-competitive, guaranteeing farm income, and could increase as a proportion of the Tier 1 payment at a pre-specified rate, rewarding continuous improvement. With the simultaneous reduction in basic participation payments, outcomes would make up an increasing proportion of the payment. Positive environmental outcomes would therefore be directly incentivised and financially rewarded, loosely as 'ecosystem services'. This makes the most economic logic in the medium-to-long term and gives farms adequate incentive and information with which to plan long-term business strategy and the transition to sustainable farming methods.

Possible outcomes which could be financially rewarded:

Outcome	**Proof**	**Payment**
Increased soil organic matter content	Adherence to the global 4 per 1000 soil carbon initiative, aiming to increase soil organic carbon by 0.4% each year. Regular soil organic matter monitoring and reporting by farmers to a national database.	Yes

[129] National Farmers' Union, 'Arrangements for English Agriculture and Horticulture outside the European Union. Policy options, circulated to members' (National Farmers' Union, 2016) pp15
[130] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021

Reduced carbon footprint	Carbon footprint assessment	Yes
Improved water quality	For the Environment Agency and water companies to monitor throughout the catchment.	Yes- water companies to possibly contribute
Increased biodiversity	Soil assessment General biodiversity assessment	Yes

A shift to 'paying for outcomes' reflects the government recognition that as Tier 1 helps farmers embed environmentally sustainable practices into their business and the actions paid for become the norm, they "may have to amend what we pay for through this tier"[131]. Payments and their impacts should be monitored closely so as to best inform changes to the system over the next decade.

Amending the payments should not be done through ratcheting up requirements, modelled on the GAEC, as the paper suggests[132]. This would likely increase the administrative burden on farmers, be over-prescriptive and regulation heavy, and is not a long-term market solution beneficial to the taxpayer. Instead, over the next decade farmers should be increasingly paid for soil quality **'outcomes'**, as detailed above**.** By 2030, this shift should culminate in natural capital markets and auctions, paying for public goods and activities like carbon sequestration once the importance, practice, and financial benefits of improving soil quality are realised.

As detailed, this would allow for a decade of continuous improvement at a pace palatable to farmers but with a long-term shift from government subsidy to market solutions, providing maximum positive environmental outcomes at minimum cost to the taxpayer. By 2030, the productivity of the soil should have also started to increase, providing increased and **sustainable yields** for farmers and meeting government commitments to tackling degradation threats.

This long-term shift to natural capital markets would work well with Tiers 2 and 3 proposed in the ELMS. Though tiers 2 and 3 are beyond the scope of this section of the paper, as they aim for local and landscape level improvements, they will also substantially benefit soil outcomes. Their associated payment mechanisms, detailed in the government paper as:

[131] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[132] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021

shifting from actions to 'results-based payments', reverse auctions for farmers offering environmental improvements, enhanced 'competitive' land management contracts, blended green finance and natural capital markets[133], would all align well with the long-term proposals to improve soil quality detailed above. This shift away from government subsidy to markets incorporating and setting the price for natural capital makes economic sense, providing, public goods, prosperous livelihoods for farmers, and positive environmental outcomes at minimal cost to the taxpayer[134]. At this point public money can then be solely focused on public goods which cannot be provided by private markets. Through the ELMS, over time public money can therefore be used to provide the best positive environmental outcomes, enhancing natural capital, and achieving net zero, in the most economically efficient way possible.

3.5 Recommendations

- Farmers should be incentivised for good management and improvement of their soil. The benefits of effective soil management are multiple and include: increased carbon sequestration, reduced flood risk, reduced fertiliser and pesticide use, increased long-term yields and productivity, and increased biodiversity[135].
- Building on the 'Tiered' approach suggested in DEFRA's 'Farming for the Future- Policy and Progress update'[136], farmers should be offered a 'menu' of different sustainable farming options in the ELMS. The basic option would pay for embedding sustainable farming practices which improve soil quality, accessible to all farmers and with minimum proof of compliance procedures needed. This would encourage high rates of participation. More ambitious options should then reward for measurable positive outcomes.
- There should be the inclusion of an organic 'menu option' in Tier 1. This would expand the organic conversion and maintenance payments currently managed by Countryside Stewardship for England and make organic farming more profitable, providing multiple positive environmental outcomes[137].
- There should be an agroforestry 'menu option' in Tier 1, incentivising farmers to convert to agroforestry methods. Agroforestry helps mitigate soil erosion, nitrogen leaching, and biodiversity loss while increasing carbon sequestration[138].
- In the long-term, the aspiration should be for the agricultural sector to transition from government subsidies to business relationships, in the form of natural capital market-based solutions which can provide significant environmental improvements

[133] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[134] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp218
[135] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[136] DEFRA, 'Farming for the Future- Policy and Progress update' (DEFRA, 1 February 2020) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/868041/future-farming-policy-update1.pdf> accessed 4th January 2021
[137] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[138] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021

at minimal cost to the taxpayer. This would see farmers paid for outcomes like sequestering carbon and enhancing natural capital, rather than improving things like soil quality. Putting the environment firmly into the heart of the economy and financial system is an effective long-term market solution to providing sustainable economic growth.

4. Water

4.1 Overview

'Clean and plentiful water' and 'protection from and mitigation of environmental hazards', such as flooding, are laid out as public goods in the 2020 Agricultural Act[139]. Mainstream farming in the UK currently prevents, rather than facilitates, the provision of these public goods. Polluted water and heightened flood risk result from the poor management of soils and land associated with modern intensive agricultural methods. Clean water can therefore be provided by improving soils through SICS (*as detailed in the 'Soil quality' section*) and embedding the 'Pay to Pollute principle' (*see the 'Pay-to-Pollute' section*), which would reduce chemical use and, therefore, river pollution. Flood risk can also be reduced by maintaining soil quality. In short, both clean water and reduced flood risk can be provided by transitioning to sustainable farming techniques. This would benefit the economy on a whole: saving money spent by water companies on cleaning water for drinking, and by the Environment Agency on building hard engineered flood defences, whilst enhancing natural capital.

Since the middle of the twentieth century, intensive and agrichemical agriculture has done immense damage to UK river systems[140]. Currently, partly due to poor management practices, agrochemicals, such as fertilisers, pesticides and slurries run off farmland to pollute streams and rivers[141]. Of the 24 megatons of phosphorus fertilisers applied each year, less than 15% is actually absorbed by crops and these chemicals create hypoxic dead zones in oceans and rivers[142]. Failure of slurry holding pits and the spreading of slurry in winter also releases slurry into river systems and destroys biodiversity[143]. Meanwhile, other pastoral practices like sheep dipping add further residual chemicals into the river system[144]. In terms of drainage, run-off is a big problem for many rivers, and has been exaggerated by farming practices. Degraded soils are unable to retain water effectively, leading to an increased risk of flooding. Moorlands drainage and over-grazing in the uplands have exposed fragile soils and increased surface runoff[145]. At lower elevations, river catchments are sometimes ploughed up for crops, also increasing soil exposure and runoff[146]. The impacts of these practices are likely

[139] UK Parliament, The Agriculture Act 2020 (UK Parliament, 3 December 2020) <https://commonslibrary.parliament.uk/research-briefings/cbp-8702/> accessed 3rd January 2021
[140] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp20
[141] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp19
[142] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[143] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp64
[144] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp64
[145] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp62
[146] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp62

to be further exacerbated over the next decade by an increase in extreme weather events, which may result in larger amounts of rainfall in shorter periods[147].

These agricultural externalities come at a huge cost[148]. Numerous stakeholders spend money on water management. Water companies spend millions on cleaning water from rivers polluted with agricultural chemicals and slurry, paid for by consumers with higher water bills[149]. The Environment Agency is spending £5.6 billion on flood defences over the next 6 years[150], as well as significant amounts of money on enforcements and on dredging silt run-off from fields[151]. Meanwhile, farmers lose the value of valuable topsoil to silt in rivers, often outweighing profits from crops[152]. Despite the costs and spending, public goods like clean water and reduced flood risk are not still provided. This represents very poor value for taxpayer money.

Current government proposed policy for the ELMS lacks sufficient detail on how to provide clean water[153] and an ambitious systemic solution to river catchment management.

4.2 Shifting to a 'catchment approach'

Farmers have an integral role to play in providing clean and plentiful water. Stopping the environmental damage in river catchments starts with reducing the chemical inputs into rivers and the silting from erosion[154]. Both of these can be addressed by applying SICS and the 'Pay-to-Pollute' principle for agricultural inputs such as pesticides, herbicides, and artificial pesticides. The SICS financially rewarded in Tier 1 of the ELMS (*as detailed in the 'Soil quality' section*) would incentivise much of the changes needed to provide clean water and reduce flood risk. The ELMS and regulation should not apply Helm's principle of 'paying-to-pollute' to river pollution directly. This would only be over-punitive on farmers, but also difficult to measure and implement. The same results can be achieved by working with them to apply SICS. Meanwhile, reduced chemical usage would be incentivised enough

[147] Wilby, R.L., Beven, K.J. and Reynard, N.S., 'Climate change and fluvial flood risk in the UK: More of the same?.' (2008) Hydrological Processes: An International Journal, 22(14), pp.2511-2523 <https://doi.org/10.1002/hyp.6847> accessed 4 January 2021

[149] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp63

[150] GOV.UK, 'Building flood defences fit for the future' (GOV.UK, 17 April 2020) <https://www.gov.uk/government/news/building-flood-defences-fit-for-the-future#:~:text=From%202015%20onwards%2C%20the%20government,protect%20the%20country%20from%20flooding.&text=That%20is%20why%20in%20the,over%20the%20next%20six%20years.> accessed 4 January 2021

[151] Dieter Helm, Green and Prosperous Land: A Blueprint for Rescuing the British Countryside (Harper Collins 2019) pp63

[152] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp63

[153] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021

[154] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp21

anyway through the higher prices reflected in the 'Pay-to-Pollute' principle on purchased agricultural inputs (*see the 'Pay-to-Pollute' section*).

Treating river catchments as 'systems' and taking a 'whole-system' approach is crucial to providing public goods like clean water and reduced flood risk. System operators should start with the river catchment as a whole, as an integrated system, and not a series of marginal discrete projects. The relevant knowledge and expertise of stakeholders could then be incorporated and the subsidies and other spends taken in totality. In consultation with DEFRA and in accordance with environmental law protections, system operators could come up with required high-level outputs. They could then auction out the functions out where possible to those who can add the greatest environmental and economic benefits, which would be highly cost-effective[155].

4.3 Tier 1 of the ELMS

The 'Uplands or 'Pastoral' version of Tier 1 could ensure that heather moorland is managed properly, as important carbon stores and reservoirs of biodiversity. Ploughing of the uplands would be limited, digging peat stopped and peat bogs restored. Farmers should be incentivised to rewet them and to maintain light sheep grazing, which should encourage their regeneration with sphagnum moss[156]. Sheep-dip and other pollutants should be prevented from entering rivers, with sheep not treated with chemicals near rivers upstream. Meanwhile, proper slurry storage would prevent slurry from ending up in rivers[157]. The bogs and the uplands would retain water and hence manage the catchments more effectively, both improving water quality downstream and limiting flooding.

In the lowlands, Tier 1 SICS methods would limit the use of fertilisers, especially near rivers, put an end to maize and cereal crops close to rivers to stop silting, and seriously control the application of herbicides and pesticides[158]. Minimum tracking and other SICS methods would also minimise compaction, soil erosion and surface run-off. Water companies could pay farmers for demonstrated improvements to water quality (*as seen in 'Outcomes' of the 'Soil quality' section of this policy paper*).

4.4 Tier 2 of the ELMS- reducing flood risk

Public money should be used to achieve the best outcome, in terms of public goods, for the least cost. For Tier 2 of the ELMS, the government proposed that it could include

[155] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp76
[156] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp223
[157] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp64
[158] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp21

"instream/river and overland flow attenuation and diversion (natural flood management)"[159]. Tier 2 could cover afforestation and soft engineering methods such new woodlands on lower slopes which could act as natural flood defences. This may be a good solution in the short-term and worth paying for. However, the most effective long-term solution would be to have a catchment system operator, with a catchment budget, asking the relevant parties to bid the public goods they can offer and the associated costs[160]. Some water companies are already paying farmers not to pollute through this reverse auctioning mechanism, such as through offering to pay farmers not to put certain chemicals on specific bits of land and to retain ground cover over the winter. For example, Wessex Water has set up EnTrade, an online platform providing an auction to farmers to keep the land covered around Poole Harbour[161]. In trials where water companies have paid for water quality improvements, benefits have exceeded costs by 8 times[162].

The same is true for flood-risk, with many rivers suited to this approach. This solution could see the Environment Agency bid for flood defence monies against bids from natural capital flood defence providers, from the Wildlife Trusts to farmers offering to hold flood waters. In this context, reverse auctioning of natural solutions to flooding can offer major enhancements to the natural environment at lower cost and with less emphasis on the alternative hard solutions[163]. The Environment Agency or an alternative catchment system operator could provide reduced flood risk at minimum cost, possibly in co-ordination with house insurance companies. Hard engineering methods, such as the new concrete canal being built around Oxford, might not be needed, or could be constructed at a reduced scale, were money instead spent on trees, meadows, and better land management[164]. Farmers too could save money in the value of the lost soil, increasing long term yields and productivity.

With SICS, the 'Pay to Pollute' principle and river catchment management systems, the ELMS can provide clean and plentiful water in perpetuity. This would benefit consumers in the form of reduced water bills[165]. With the Tiers proposed in the ELMS, the 'Pay to Pollute' policy and reverse auctioning, rivers could be in a much better state, providing key public goods like clean and plentiful water, and protection from environmental hazards like flooding[166].

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[159] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021

[160] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp191

[161] Wessex Water, 'Poole Harbour catchment initiative' (Wessex Water, June 2015) <https://www.wessexwater.co.uk/environment/catchment-partnerships/poole-harbour-catchment-partnership> accessed 4 January 2021

[162] G Bright, E Connors, and J Grice, 'Measuring natural capital: towards accounts for the UK and a basis for improved decision-making.' (2019) Oxford Review of Economic Policy, 35(1), pp.88-108.

[163] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp31

[164] Dieter Helm, Green and Prosperous Land: A Blueprint for Rescuing the British Countryside (Harper Collins 2019) pp31

[165] Dieter Helm, Green and Prosperous Land: A Blueprint for Rescuing the British Countryside (Harper Collins 2019) pp388

[166] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp66

4.5 The role of regulation

Regulation is important (*see 'Regulation' section*). For water, regulation should include: catchment plans, pollution control and monitoring, and the protection of peat bogs and moorland[167]. Special protection of peat bogs is especially needed- due to their importance to clean water, reducing flooding and sequestering carbon. There also need to be credible mechanisms for checking delivery, with associated penalties[168].

4.6 Recommendations

- Water needs to be provided at the catchment level, with a system operator approach. Rivers operate as systems, managing them at the catchment level allows stakeholders to work together to provide improved outcomes.
- Farmers should be incentivised to embed SICS, as per Tier 1 of the ELMS (*see 'Soil quality' section*). This would remove water pollution, through reducing chemical use and leaching into rivers. It would also reduce flood risk by improving soil carrying capacity and reducing run-off.
- The 'Pay to Pollute' principle should be applied to fertilisers and pesticides (*See 'Pay-to-Pollute' section*). This would reduce chemical use and the amount of chemicals that could leach into river systems, improving water quality. Mechanisms should be looked into where water companies could pay farmers for measured proven improvements to water quality (*see 'Outcomes' of 'Soil quality' section*).
- Build a national database of water quality, similar to what the Soil Association propose for soil quality. This data would enable evidence-based policy development and the rewarding of farmers for outcomes. In the long-term, money needs to be spent on the activities that offer the most effective environmental outcomes to provide best value for money to the taxpayer.
- Farmers should be incentivised to offer solutions for reducing flood risk through a reverse auctioning process. They could offer soft management methods in catchment areas with a risk of flooding. The management strategies should be designed in partnership with the Environment Agency and take the form of multi-stakeholder, catchment-based solutions like the scheme trialled in the Somerset Levels or by Wessex Water in Poole.

[167] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp118
[168] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp191

5. Air

5.1 Overview

Air quality is a public good of crucial importance to human health[169]. However, its provision in the ELMS has been barely mentioned by government publications so far (*see DEFRA's paper*[170]). Detailed analysis of recommendations for reducing greenhouse gas emissions and achieving net-zero by 2050 can be seen in the *'Greenhouse Gas'* section of the paper.

Ammonia from farms is a major contributor to air pollution, and air pollution affects people's health and wellbeing. Ammonia is a by-product of pigs, poultry, cattle, and livestock, with ammonia emissions produced by farm manures, slurry, and other wastes[171].

It is therefore important that animal waste is properly managed under the ELMS. This should be part of the Tier 1 payment for pastoral farms. Grants might also be provided for conversions to less-polluting farming methods, such as covering slurry pits to limit ammonia emissions, and measures to reduce the risk of spillages[172]. As detailed in the *'Soil quality'* section of this paper, there should be a long-term shift to pricing ecosystem services, and more broadly natural capital, by 2030. Part of this could reward farmers for the improvements to air quality that woodland, and activities such as afforestation and agroforestry, provide.

5.2 Paying to pollute

The new ELMS should apply a 'Pay to Pollute' principle to certain agricultural inputs. Making polluters pay and focusing subsidies on the public rather than private goods, would greatly improve economic efficiency and transform the agricultural landscape. Applying a 'Pay to Pollute' policy to agricultural inputs would be the most effective method of providing soil, water and air quality, and other positive environmental outcomes like reduced carbon emissions.

An efficient economy is one that internalises all the costs and benefits of economic activities into prices and decision-making. In an efficient economy pollution is charged: it is inefficient not to charge for pollution, resulting in a lower level of economic prosperity[173]. In many other

[169] CA Pope III, 'Epidemiological basis for particulate air pollution health standards' (2000) (32(1) Aerosol Science & Technology <https://www.tandfonline.com/doi/abs/10.1080/027868200303885> accessed 4 January 2021
[170] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[171] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp179
[172] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp179
[173] Dieter Helm, Green and Prosperous Land: A Blueprint for Rescuing the British Countryside (Harper Collins 2019) pp10

industries, damage is already subject to regulatory restraints and pollution taxes[174]. Very little of intensive chemical farming is actually economic in its current form- reliant on subsidies, tariffs, and the avoidance of paying for the pollution it causes[175]. The externalities of fuel, fertiliser, antibiotics and pesticides in terms of pollution and environmental impact have been outlined in various other sections of this paper (*see the 'Soil quality, 'Water quality', and 'Air quality' sections*). Meanwhile, the 2011 'The Natural Choice' paper[176] establishes that citizens have the right to clean air, water, and the enjoyment of the countryside, broadly conceived as 'public goods' which the ELMS should provide.

Products that farmers are currently using are therefore creating large economic damage, not internalised, and reflected in their costs but externalised in their impacts and the costs of repairing the environmental damage. The most efficient way to reduce this damage and is therefore to charge the producers of the pollution. This makes economic sense; common carbon price and pricing of emissions has been shown to correct otherwise distorted prices and lead to best climate outcomes[177]. In the case of agriculture, if farmers paid for the pollution they caused, they would use chemicals in smaller quantities and target them more accurately[178].

This would be more effective than other proposals. The Soil Association propose a Nitrogen Budget, similar to that already being trialled in Scotland[179]. This would provide certainty about the quantity of artificial nitrogen usage, it would remain capped at a fixed level with firms that use it likely given permits. However, this likely be difficult to implement and less effective in actually reducing use of artificial nitrogen than using the market through the 'Pay-to-Pollute' principle. It would make more sense for the environmental costs of nitrogen fertilisers to be internalised in the market and reflect their externalities, or environmental damage. This would then provide a strong economic incentive for farmers to reduce their use of artificial nitrogen.

A pragmatic approach would start with cases where polluters can be identified, and where the impacts are expected to be considerable[180]. Here the aim is not to provide government revenue, a good environmental charge is one that abolishes itself, but to use market incentives to provide the best possible positive environmental outcomes. The 'Pay-to-Pollute' principle should cover carbon, fertilisers, pesticides, herbicides, and antibiotics. A carbon

[174] Dieter Helm, 'British Agricultural Policy after BREXIT, Natural Capital Network – Paper 5' (2016) pp13 <http://www.dieterhelm.co.uk/natural-capital/ environment/agricultural-policy-after-brexit/> accessed 4 January 2021
[175] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp85
[176] HM Government, 'The Natural Choice: securing the value of nature' (*HM Government*, June 2011) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228842/8082.pdf> accessed 4 January 2021
[177] Dieter Helm, Green and Prosperous Land: A Blueprint for Rescuing the British Countryside (Harper Collins 2019) pp230
[178] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp65
[179] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021
[180] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp200

price already exists in the UK for example[181] and it should also be levied on imports at the border to reflect fair competition and high environmental standards.

Helm suggests charging for other forms of pollution, such as that in rivers. However, as detailed in the *'Water quality'* section of this paper, this would be over-punitive on farmers, as well as difficult to measure and implement. Through applying the SICS proposed in this paper for Tier 1, reducing river pollution in the form of chemicals, silt and slurry could be incentivised, whilst working constructively with farmers as the government desire.

This proposal balances pragmatism in what to charge and how, without being over punitive on farmers or negatively affecting farmer livelihoods. The cost of inputs like fertilisers should be levied on producers, as the charged by the manufacturer plus the environmental cost of energy-intensive production and the impacts of applying it[182]. The charge would be put back into the ELMS budget, so there would be no aggregate loss to the agricultural sector on the whole, farmers would receive the money when rewarded for practicing sustainable methods and providing public goods[183].

It would be best to start with a low charge in the short run, but credibly commit to raising the tax in the medium to long-term, to give time and incentives to polluters to change their behaviours[184]. Unlike the government idea of adjusting payments to farmers for Tier 1, the increasing pay-to-pollute charge over the next decade needs to be fixed, to provide clear market signals to business planners and allow them to plan over the long-term. However, adding pollution charges to fertilisers, pesticides and herbicides could have an immediate effect: decisions to buy and apply these, and the quantity applied, are made on a continuous basis[185].

5.2.1 Regulation

Not all pollution lends itself to charges, and in some cases identifying the polluter is so difficult that it is better to just regulate. All pollution charges should work in a broader regulatory context[186].

[181] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp201
[182] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp196
[183] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp10
[184] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp245
[185] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp244
[186] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp200

5.2.3 Impact

There would be immediate and dramatic improvements from applying a 'Pay-to-Pollute' principle to the ELMS. The economics of agriculture would be transformed and the use of fertilisers, pesticides, herbicides, and antibiotics in agriculture significantly reduced over the long-term. Farmers would use substitutes- working with nature and halting the decline of carbon in the soils. Crop rotation, mixed-farming approaches, which produce manure for fields, and greater efforts to prevent the loss of the now more valuable soils would all feature more strongly[187]. These changes, along with the financial rewards for transitioning to sustainable farming methods, both with Tier 1 payments and reduced input costs, would remove the externalised advantage over intensive agriculture over organic and less intensive methods. The livelihoods of farmers would be improved, not harmed. As the NFU detailed, if the total budget could be preserved, there would be considerable sums available for encouraging investment and improving competitiveness[188]. The 'Pay to Pollute' principle would therefore not cost anything to economy in aggregate, revenue would go to rewarding farmers for good practice, some of which, in the form of Tier 2 and 3 payments, could go to repairing past damage and enhancing natural environment. Beneficiaries would be the less chemical-intensive farmers and more marginal farmers- such as the small family mixed farms of lowlands and uplands. They would have more to offer to the public good because they have retained a better environment and would be rewarded accordingly[189].

There would be direct beneficiaries from making polluters pay. The gainers would include water and sewage treatment companies and hence water customers since water quality in the rivers and the aquifers would be less polluted and less costly to treat[190]. Improvements to soil, water, and air quality, with all the benefits and public goods these provide, would be incentivised and provided at minimum cost to the taxpayer and with no harm to livelihoods. Again, this is a case for a genuine win-win-win: positive environmental outcomes, leaner and more profitable farm business operations, and the increased long-term viability and productivity of UK agriculture.

5.3 Recommendations

- Farmers should not be paid to provide 'air quality' as a public good. This is because as a non-excludable and difficult to measure good, it would be very difficult to demonstrate farmers provision of it.

[187] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp216
[188] National Farmers' Union, 'Arrangements for English Agriculture and Horticulture outside the European Union. Policy options, circulated to members' (National Farmers' Union, 2016) pp15
[189] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp90
[190] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp198

- However, there should be tough regulation on any existing practices which cause significant air pollution. These include activities like burning waste (*see 'Regulation' section of the paper*').
- The cost of using ammonia should also reflect the air pollution caused by its use, following the 'Pay to Pollute Principle'.

6. Regulation

6.1 Overview

Given the market does not adequately reward the delivery of environmental public goods, the ELMS will be an effective way for government to intervene and utilise public funding to deliver them[191]. The ELMS will be a form of 'market-based' regulation, a genuinely original piece of legislation with which to tackle environmental issues in the UK agricultural sector. Nonetheless, the ELMS will need to sit alongside legal regulation, as part of a wider agricultural system as the government propose[192]. However, details of this regulation are lacking from current government proposals, with farmers unsure as to what the regulatory side of the ELMS is going to look like. All the government has detailed, so far, is that they are keen to learn from the regulatory downfalls of the Countryside Stewardship Scheme and to lessen any future regulatory burden on the farming community[193]. This section will outline what form regulation should take in terms of participation, legislation, enforcement, and the Tier system.

It is worth noting that regulation on UK food standards is crucial to the ELMS. If UK farmers are regulated to high environmental standards, but imported food is not, UK farmers will not be able to compete fairly. Food imports should, therefore, also have their social and environmental externalities internalised into their costs. There needs to be a renewed focus on food supply chains to improve resilience, farmer incomes, and environmental sustainability[194].

6.2 Participation

Participation in the ELMs and basic standards should not be legally required. Farmers should sign up to the ELMS due to the business case and financial incentives for doing so, rather than being forced to participate in the scheme. Higher rates of participation and success can be achieved by working with farmers than by forcing them to comply with a difficult set of regulations.

[191] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[192] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[193] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[194] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021

6.3 New Agencies, Public Bodies and Legislation

New public bodies, agencies and legislation are needed to ensure that the ELMS is effectively implemented and successful. At a high-level, there should be a Nature Act, enshrining in law the principles of the 2011 white paper 'A Natural Choice'. This would hold governments to account in achieving long-term environmental targets beyond the 5-year limit of a government term. An Office for Environmental Protection (OEP) could ensure that standards do not slip, or regulations become weakened[195], perhaps providing reviews and updates every 5 years. Meanwhile, a new body should be created to manage the ELMS. It is practical for a single body to craft a high-level plan detailing how to achieve the greatest environmental asset benefits from taxpayer money, rather than to have multiple bodies, like the Environment Agency, DEFRA, or Natural England, managing inter-linked environmental issues. This new body should also be responsible for regulating and enforcing the ELMS. The most effective solution would be to create a proper Environment Protection Agency, charged with regulating, licensing, prosecuting, and enforcing across both the public and private sectors, and with a broader domain and more legal power than the OEP[196].

6.4 Tougher Enforcement and Penalties

In some cases, identifying the polluter is difficult and it is better to regulate. There are also cases where the impacts are so bad that outright bans are appropriate[197]. Breaches of regulation should be better enforced and with tougher penalties. For example, currently fines for things like spills and slurry pollution are not sufficient in serving their purpose as a deterrent. Properly resourced policing and significant fines could all but eliminate these sources of river pollution[198]. Changing business law so that gross acts of pollution were treated more seriously, perhaps charged at 10% of turnover like anti-competitive behaviour[199], would significantly reduce the risk of environmental pollution.

6.5 Regulations Role in the Tier System

The aims of the ELMS are, broadly, to use 'public money for public goods'. There are several conditions on the actions the scheme should pay for. The ELMS should not reward actions

[195] GOV.UK, 'New Office for Environmental Protection will ensure governments maintain green credentials' (DEFRA, 16 October 2019) <https://deframedia.blog.gov.uk/2019/10/16/new-office-for-environmental-protection-will-ensure-governments-maintain-green-credentials/> accessed 4 January 2021
[196] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp238
[197] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp200
[198] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp65
[199] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp204

which are 'required by domestic regulations' or 'already paid for through public funds'[200]. It should 'drive the implementation of the 'polluter pays' principles over time' and 'provide good value for money to the taxpayer'[201]. As detailed in the 'Soil quality' section of this paper, the most effective long-term way to provide public goods at minimum cost the taxpayer is to transition from government subsidy to natural capital markets and a market-based solution. The proposals in the 'Soil, Water and Air quality sections of this paper satisfy these requirements- offering increasingly outcome-dependent market-based solutions, and the 'polluter pays' principle, as methods with which to provide positive environmental outcomes at minimum cost the taxpayer. It also established that lessons should be learnt from the Countryside Stewardship Scheme, which was "burdensome, inflexible and too focused on punitive actions rather than improvement"[202]. Currently CSS claims have to be evidenced every year providing fresh evidence of compliance. Penalties are applied for non-compliance with sometimes stringent requirements in respect to documentation[203]. Regulation of the ELMS therefore has the risk of being over-punitive and over-prescriptive, possibly alienating the farming community and key stakeholders like the NFU. In terms of practicality this could harm participation rates and the success of the ELMS.

The ELMS should therefore not be accompanied with overly stringent or heavy regulation. Participation in the scheme should not be mandatory. Participation should be incentivised by the strong business case (*as detailed in the 'Soil quality' section of this* paper) and financial incentives. Farmers should be able to offer positive environmental outcomes in the ways they see fit, allowing flexibility. This could take the form of reverse-auctioning processes and natural capital markets[204] (*as detailed in the 'Soil quality' section of this* paper). Regulatory requirements should therefore be minimal. Government proposals to perhaps use self-assessment or a risk-based approach, taking into account historic delivery of environmental outcomes or membership of assurance schemes[205], are promising and worth exploring. Technology should be used to ensure that evidence needed to prove compliance with any of the Tier payments of the ELMS is rigorous but not burdensome. This would involve proving the application of practices to start with and then in demonstrating measured improvements (*as detailed in 'Soil quality' section of this* paper). For example, new innovative technologies using remote sensing, AI and geospatial data can be used for

[200] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[201] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[202] DEFRA, 'Farming for the Future- Policy and Progress update' (DEFRA, 1 February 2020) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/868041/future-farming-policy-update1.pdf> accessed 4th January 2021
[203] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[204] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp218
[205] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021

monitoring, providing and analysing data[206]. Compliance is likely to improve massively with this level of scrutiny[207].

The DEFRA paper suggests continuously tightening regulation and requirements for the ELMS as improvements are made, similar to the model of cross-compliance used in the Good Agricultural and Environmental Condition (GAEC)[208]. However, this model had its limitations, with few inspections and few subsidy withdrawals[209]. Shifting to an outcome and natural capital-based market solution (*as detailed in the 'Soil quality' section of this paper*), could provide better results with far less administrative and regulatory burden. Again, this could be more palatable to the NFU and the farming community, with a higher likelihood of success. The ELMS should achieve the aims of the 25 Year Environmental Plan by working innovatively with the farming community, rather than through heavy regulation and penalisation. This is best achieved by a proportionate approach which focuses on assisting, guiding, and directing future plans so that there is continuous improvement, with penalisation a last resort.

6.6 Recommendations:

- The ELMS should work with farmers, using market solutions to provide public goods and positive environmental outcomes. Emphasis should be on rewarding farmers for good practice and providing assistance in the form of educational or advisory resources and capital grants to ensure continuous improvement. Regulation should be an integral part of the ELMS, but not the main mechanism through which progress is made.
- Regulation for the proposed Tier system to the ELMS should not be too stringent and penalisation for failures in compliance should be a last course of action. Technology can be used to monitor compliance with the Tier system of the ELMS, often remotely and at minimum cost. Effective use of technology for monitoring would also ensure high rates of compliance.
- There should be outright bans on certain practices. Regulation should be well-enforced and there should tough penalties for significant breaches. For example, gross acts of pollution should be charged in the same way as anti-competitive behaviour, at 10% of turnover. This would provide adequate incentive with which to seriously reduce risk of environmental pollution.
- A new regulation body should be created with which to manage the ELMS and enforce regulation.

[206] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp231
[207] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp238
[208] DEFRA, 'Environmental Land Management Policy discussion document' (DEFRA, 1 February, 2020) <https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf> accessed 4th January 2021
[209] Dieter Helm, *Green and Prosperous Land: A Blueprint for Rescuing the British Countryside* (Harper Collins 2019) pp89

- Regulation on UK food standards is crucial to the ELMS. If UK farmers are regulated to high environmental standards, but imported food is not, UK farmers will not be able to compete fairly. Food imports should also have their social and environmental externalities internalised into their costs. There needs to be a renewed focus on supply chains to improve resilience, farmer incomes, and environmental sustainability[210].
- Participation in the ELMs and basic standards should not be legally required. Farmers should want to sign up to the ELMS due to the business case and financial incentives, rather than being forced to sign up to a scheme. Higher rates of participation and success can be achieved by working with farmers than by forcing them to comply with a difficult set of regulations.

[210] The Soil Association, 'The future of British farming outside the EU' (The Soil Association, 20 March 2017) <https://www.soilassociation.org/media/10560/soil-association-report.pdf> accessed 4th January 2021

7. Biodiversity

7.1 Overview

Biodiversity in this paper refers to the collection of all forms of living organisms and their interactions. As a highly complex variety of life, biodiversity encompasses genes, species, communities, habitats and ecosystems. Therefore, it is unsurprising that biodiversity is crucial to human well-being since well-preserved ecosystems could ensure the quality of air, water, food, etc. Otherwise, loss of biodiversity could lead to extinction of animals and plants which could be potential sources of new medicine and huge monetary loss.

However, given its non-excludable and non-rivalrous nature, biodiversity is essentially a public good which, despite its immense benefits to society and individuals, could not effectively rule out free riders and hence necessitates state legislation and government intervention. For example, the UK government has passed laws requiring official approval for the use of herbicides in near water and has established a range of national parks and wildlife sanctuaries to protect biodiversity.[211]

7.2 Impact of Agricultural Policy

Secondly, after elaborating upon the value of biodiversity as an essential public good, we need to analyse the impacts of agricultural policies on this public good and why the new 2020 Agriculture Act attaches great importance to biodiversity. Agricultural land use covers 42% of Western Europe's total surface area and impacts 20% of the British, French and German vegetation.[212] It also involves 50% of their bird species.[213] Husbandry, use of fertilisers and herbicides, and rearing livestock requires much land and natural resources, and invariably changes the local landscape and affects other species living in the same habitat.

Given Europe's more than 5000 years' history of cultivation and grazing livestock, it is rare to find any landscape in Europe unaffected by agricultural activities. Furthermore, European lowlands, wetlands and woodlands have also been intensively managed since the adoption of chemical pesticides, fertilisers, tractors and specialisation of farm systems in the twentieth century which has rendered European rural landscape an integral part of traditional culture and European identity.[214] Hence, given the close relationship between agriculture and biodiversity, the importance of carefully designed agricultural policy in maintaining both

[211] UK Government, 'Biodiversity and ecosystems', (2020). https://www.gov.uk/environment/biodiversity-and-ecosystems. accessed 31 December 2020.

[212] E.J.P. Marshall, V.K. Brown, N.D. Boatman, P.J.W. Lutman, G.R. Squire, L.K. Ward. 'The Role of Weeds in Supporting Biological Diversity Within Crop Fields.' Weed Research, 43 (2003).
[213] D.J. Pain, M.W. Pienkowski. 'Farming and Birds in Europe: the Common Agricultural Policy and Its Implications for Bird Conservation. Academic Press, San Diego. (1997)
[214] Péter Batáry, Lynn V. Dicks, David Kleijn, William J. Sutherland, 'The Role of Agri-environment Schemes in Conservation and Environmental Management.' Conservation Biology. vol. 29, 4. (2015)

biodiversity and cultural heritage could hardly be overestimated. Moreover, due to Europe's rather long history of agricultural activities and its emphasis on rural culture, it is also imperative to ensure a delicate balance between biodiversity and traditional rural landscape. This is explicitly stated in Part 1. Chapter 1 of the 2020 Agriculture Act, which stipulates financial assistance to be given to 'manage land or water in a way that maintains, restores or enhances cultural or natural heritage'.[215] Therefore, a well-considered agricultural policy would be best to promote synergistic efforts in integrating the mission of creating natural habitats for local flora and fauna and the goal of preserving traditional landscape.

7.3 Relative Success of CAP

The UK has been a member of the European Union since 1973 and as the UK was required to comply with the general Common Agricultural Policy, biodiversity in the UK has long been influenced by EU legislation. The Common Agricultural Policy requires European countries to adopt agri-environment schemes which cost €23 billion from 2007 until 2013 and effectively covers around 25% of the EU's utilised agricultural area.[216] The schemes contain specific environmental objectives including the protection or enhancement of biodiversity, soil, water, landscape, and air quality and stipulate financial assistance to farmers for adopting such specific environmental management practices on their farms. Those schemes are multi-functional, encompassing a range of agricultural activities deemed conducive to the environment, which aims to encourage farmers to adopt a balanced and integrated approach to environmental issues. For example, increasing wildlife habitats is promoted alongside limiting the impacts of stock farming on grassland, and preserving genetic biodiversity in local species and animal breeds. Since the reforms of the Common Agricultural Policy in 1992 which placed greater emphasis on the environment, these agri-environment schemes have been considerably effective in protecting biodiversity in multiple member states. For example, in Germany, these schemes have also protected natural habitats for rare insects and flowers. A study of wildflower patches created between 2010 and 2013 in Hesse, central Germany shows that those patches have created habitats for as many as 76 flowering plant species and 322 insect species in total. Hungary has similarly initiated an agri-environmental scheme to protect the great bustard, which is the only member of the genus Otis, and one of the heaviest living flying animals in the world.[217]

In particular, the Common Agricultural Policy has made significant contributions to the protection of biodiversity in the UK. The UK implemented agri-environment schemes such as Countryside Stewardship in England as part of Pillar II requirements. British farmers are required to follow the 'greening' requirements on Ecological Focus Areas. For example, under agri-environment schemes the British government has provided substantial funding to farmers and land managers to farm in a way that supports biodiversity, enhances the landscape, and improves the quality of water, air and soil, including the Northern Ireland Rural Development Programme 2007-13. The budget available for the agri-environment programme is £180 million, part-financed by the European Agricultural Fund for Rural

[215] Agriculture Act 2020, Part 1 Ch1 (1c)
[216] European Commission, 'Agri-environment Schemes: Impacts on the Agricultural Environment', Science for Environment Policy, 57. (2017)
[217] European Commission, 'Agri-environment Schemes: Impacts on the Agricultural Environment', Science for Environment Policy, 57. (2017)

Development (EAFRD), and the target is to maintain 42 per cent of agricultural land under environmental enhancement agreement by 2013.[218]

This policy has been relatively successful in protecting biodiversity in the UK. England's five most threatened bumblebees including the shrill carder bee returned to England after twenty-five years, now spreading across Kent and into East Sussex.[219]

Nevertheless, the Common Agricultural Policy has also been accused of adversely affecting the European farmland bird population which has diminished from 600 million to 300 million, Between 1980 and 2009. The UK has been particularly victimised by this policy. The population of grey partridges has decreased by 82% in Europe whilst this figure has reached 91% in Britain.[220]

Despite the contributions of the agri-environmental policies, this loss is partly attributed to other schemes under the Common Agricultural Policy to promote food production, which has consequently led to removals of important habitats for farmland birds such as hedgerows, wetlands and meadows has robbed farmland birds of their homes and food.

7.4 Government Proposals in Agriculture Act

As the UK is set to leave the European Union, it is preparing new legislation and regulatory frameworks to replace the Common Agricultural Policy. Hence, it is crucial that the new Agriculture Act would be able to preserve the existing mechanism conducive to biodiversity whilst making necessary modifications to make it more efficient and balanced. The new Agriculture Act elevates biodiversity to the status of public good and stipulates power to provide financial assistance for this purpose. Clause 1 enshrines biodiversity on three levels. Firstly, it emphasises the need to protect the health and wellbeing of individual plants and animals by giving financial assistance. Secondly, it reinforces protection of genetic diversity of native livestock, native equines and plants and their wild relatives. Lastly, it integrates the protection of biodiversity and cultural heritage by 'supporting public access to and enjoyment of the countryside, farmland or woodland and better understanding of the environment'.[221] Therefore, it is evident that the new Agriculture Act aims to adopt a new integrative approach to replace the direct payment mechanism under the Common Agricultural Policy which specified 'greening' requirements including Ecological Focus Area. Convinced that the Direct Payments under the Common Agricultural Policy may not be the most efficient use of taxpayers' money to protect biodiversity, the UK is about to 'delink'

[218] Department of Agriculture, Environment and Rural Affairs, 'Agri-environment Schemes', UK Government, (2020). https://www.daera-ni.gov.uk/articles/agri-environment-schemes#:~:text=Agri%2Denvironment%20schemes%20provide%20funding,of%20water%2C%20air%20and%20soil. accessed 31 December 2020
[219] Nik Shelton, 'Country's Rarest Bumblebees Make a Comeback', Royal Society for the Protection of Birds. (5 October 2010). http://ww2.rspb.org.uk/about-the-rspb/about-us/media-centre/releases/261841-countrys-rarest-bumblebees-make-a-comeback. Accessed 31 December 2020
[220] Robin McKie. 'How EU Farming Policies Led to a Collapse in Europe's Bird Population'. The Guardian. (London.26 May 2012). https://www.theguardian.com/environment/2012/may/26/eu-farming-policies-bird-population. Accessed 31 December 2020.
[221] Agriculture Act 2020, Part 1 Ch1 (1c)

Direct Payments from the requirement to farm the land under the future Environment Land Management scheme. [222] This new mechanism is believed to be able to offer farmers extra flexibility for environmental work. Within the new framework of the Environment Land Management scheme, the Department for Environment, Food and Rural Affairs would be assigned a greater role in implementing and regulating measures to protect biodiversity, such as by encouraging sustainable agriculture and forestry, by supporting the delivery of locally targeted environmental outcomes, and helping land use change for environmental objectives. Since the new framework emphasises flexibility, it could involve greater collaboration between land managers and the Department for Environment, Food and Rural Affairs.[223]

In short, it is encouraging to see that under the EU Common Agricultural Policy and Britain's early emphasis on protection of natural habitats and promotion of biodiversity, there is a solid legislative foundation for agricultural policies targeting biodiversity and British administrators and farmers have been well familiarised with environmentally friendly practices and highly cooperative in the implementation process. Hence, given its previous achievements in promoting biodiversity as part of the European Union, Brexit could be interpreted as a rare opportunity which gives Britain additional autonomy to rebalance agricultural development and biodiversity as well as target Britain's rare native breeds or species. Additionally, the new Agriculture Act aims for greater efficiency and flexibility for both British administrators and farmers in customising agri-environment policies without overhauling the entire system. Given the relative success in protecting biodiversity under the Common Agricultural Policy, the new legislation could wisely target its bureaucratic inefficiencies in the implementation process, at least theoretically. The new mechanism relies on a sound rationale to increase efficiency by promoting an integrated partnership between the government and farmers which could potentially maximise flexibility. This is commonly achieved through state subsidies given out to private landowners to promote agricultural activities favourable to local wildlife and preservation of rural landscape. In a highly liberal market economy, state subsidies could act as crucial financial incentives in the decision-making process and effectively influence each individual farmer to adopt more environmentally friendly means of production.

Hence, the key to its success is a clear framework that guides individual farmers to adopt particular practices deemed conducive to biodiversity and cultural access and provides sufficient monetary compensation for any cost incurred.[224] Unlike the specific 'greening' requirements and rules under the Common Agricultural Policy, this new mechanism could theoretically simplify the bureaucratic process by replacing Direct Payments with funds targeting particular environmental objectives. For example, it is essential to differentiate

[222] UK Government, 'Agriculture Bill to Boost Environment and Food Production', UK Government', 2020. https://www.gov.uk/government/news/agriculture-bill-to-boost-environment-and-food-production accessed 15 Janurary 2020.
[223] Tom Lancaster, 'Agriculture Bill 2020: Do Good Things Come to Those Who Wait?', Wildlife and Countryside, January 2020. https://www.wcl.org.uk/agriculture-bill-2020-do-good-things-come-to-those-who-wait.asp accessed 15 January 2021.

[224] F. Barraquand and V. Martinet, 'Biological Conservation in Dynamic Agricultural Landscapes: Effectiveness of Public Policies and Trade-offs With Agricultural Production', Ecological Economics, vol 70. 5 (2011)

between different rural landscapes and various agricultural uses of land. Intensive farming on cropland may be widely adopted to cultivate cash crops to generate income whereas extensive grassland farming may require a relatively lower input and be used as more appropriate habitats for wildlife.[225] In the decision-making process, individual farmers have to consistently take into account the financial gains from selling crops cultivated on cropland and sold at fluctuating market price and the constant revenue from grassland derived from government subsidies. Hence, financial assistance could maximise its outcome and efficiency by preserving the economic equilibrium between gains and costs in order to incentive farmers to rationally pursue a more stable and more profitable source of income by adjusting land use to agricultural activities more favourable to wildlife and local heritage.[226]

7.5 Concerns and recommendations

Nevertheless, despite its emphasis on greater flexibility and efficiency, the new Agriculture Act has raised concerns about government commitment to biodiversity conservation in comparison to other agricultural aims. The greatest concern is whether the new clauses included on food security will prioritise food production over biodiversity. Some environmental groups have argued that the most important conditions to biodiversity conservation are vast land reserved for wildlife, ample funding and minimal human disturbance. Hence, they are worried that these new clauses might sacrifice wildlife for food production by adopting not so productive farming methods and greater agricultural land use just like some old Common Agricultural Policy measures did. In spite of the government's assurance that an integrated approach to environmentally sustainable food production would require a synergy of soil health, biodiversity and food production, it can be alarming if major changes happen to agricultural production given that as much as 70 per cent of UK land has already been managed for agriculture.[227] The World Wide Fund for Nature has cautioned that increased food production would necessitate agricultural intensification in the UK and constitute a major threat to wildlife. Additionally, over-abstraction and pollution from fertilisers and pesticides also pose serious threats to fish and birds as less than a fifth of England's rivers are healthy.[228]

An exemplar is the United States Conservation Reserve Programme. It has maintained a delicate balance between food production and biodiversity since inception. As one of the largest private-lands conservation programmes in the United States, it was first initiated by President Ronald Reagan in 1985, and has recently experienced several changes in 1990,

[225] P.F. Donald, R. E. Green and M. F. Heath. 'Agricultural Intensification and the Collapse of Europe's Farmland Bird Populations.' Proceedings of the Royal Society B: Biological Sciences, 268 (2001), 25, 29. https://royalsocietypublishing.org/doi/abs/10.1098/rspb.2000.1325. accessed 31 December, 2020

[226] F. Barraquand and V. Martinet, 'Biological Conservation in Dynamic Agricultural Landscapes: Effectiveness of Public Policies and Trade-offs With Agricultural Production', Ecological Economics, vol 70. 5 (2011)

[227] Land Institute, 'How Will the New Agriculture Bill Affect the Environment?', Land Institute, 20 January 2020, https://www.landscapeinstitute.org/news/new-agriculture-bill-jan-2020-environmental-impacts/ accessed 15 January 2021.

[228] World Wide Fund for Nature, 'Five Threats to UK Wildlife', World Wide Fund for Nature, (2020). https://www.wwf.org.uk/updates/5-threats-uk-wildlife accessed 6 Janurary 2021

1996, 2002, and 2008. It involves direct payments to agricultural producers to encourage them to change land currently used for agricultural production to resource conserving practices generally for ten to fifteen years. Cropland can be converted to grasslands, wildlife habitats and grassed waterways.[229] This programme is chiefly supervised by the U.S. Department of Agriculture's (USDA's) Farm Service Agency (FSA) which covers a range of substitute schemes including the Grassland Reserve Program, the Farmable Wetlands Program and the Conservation Reserve Enhancement Program. In general, the Conservation Reserve Programme has involved 318,944 farms under 563,298 contracts and has covered 20,770,138 acres in total by November 2020.[230] In particular, the Conservation Reserve Enhancement Programme pays as much as $180 per acre to farmers to target environmental issues on farmland in specific regions.[231] As a result, the Conservation Reserve Programme has successfully managed to protect wildlife, leading to significant increase in population of the redhead duck and sage grouse. The land converted to wildlife habitats has contributed to a population increase by 13.5 million per annum for pheasants. In particular, the population of ducks in the Prairie Pothole Region has increased by approximately thirty per cent since 1992.[232]

However, Britain's reinforced commitment to food security and production and the removal of Direct Payments to increase efficiency could significantly distort the incentive mechanism in favour of food production over biodiversity. Although in theory, environmentally sustainable production methods could complement biodiversity conservation, it is highly worrying that greater financial incentive for intensified agricultural activities would seriously disturb wildlife. Therefore, it is advisable for the UK to strengthen protection of targeted animal and plant species in order to maximise damages. Australia's Environmental Stewardship Programme can be a good exemplar for such kind of government-led pilot projects targeting particular species. It was first introduced in 2007 to encourage farmers in New South Wales, Queensland, and South Australia to sign contracts up to fifteen years for protection of vital ecosystems. Targeting specific nationally threatened species and ecological communities, the Environmental Stewardship Programme aims to enhance habitat quality, improve conditions of ecological communities and promote long-term protection of endangered species.[233] This programme consists of two important pilot projects, the Box Gum Grassy Woodland Project and the Multiple Ecological Communities Project. Both projects, which comprised the entire program, employed a reverse auction tender process involving $152 million government investment in grants for farmers.

[229] Megan Stubbs, 'Conservation Reserve Program (CRP): Status and Issues' Congressional Research Service, (29 August, 2014). http://www.nationalaglawcenter.org/wp-content/uploads/assets/crs/R42783.pdf accessed 31 December 2020
[230] Farm Service Agency, 'Conservation Reserve Program Statistics', U.S. Department of Agriculture, (2020). https://www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index. Accessed 31 December 2020.
[231] Farm Service Agency, 'Conservation Reserve Program Statistics', U.S. Department of Agriculture, (2020). https://www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index. Accessed 31 December 2020.
[232] National Wildlife Federation, 'Maintaining Benefits of Expiring CRP', National Wildlife Federation. (2020) http://www.nwf.org/Wildlife/Policy/Farm-Bill/Farm-Bill-Success-Stories/Success-Expiring-CRP.aspx. Accessed 31 December 2020.
[233] Department of Agriculture, water and the Environment, 'Agriculture Stewardship Package', Australian Government, (2020). https://www.agriculture.gov.au/ag-farm-food/natural-resources/landcare/sustaining-future-australian-farming accessed 31 December 2020

In particular, the Box Gum Grassy Woodland Project can be a good reference. It was first introduced in 2007 to improve the conditions of woodland ecological communities of box gum grassy south east Australia through the Box Gum Grassy Woodland Project, involving 26,470 hectares by 210 land managers for an approximate cost of $71 million over 15 years.[234] The Project has successfully established close cooperation with Landcare New South Wales, Grassy Box Woodland Conservation Management Network, National Parks and Wildlife Service, and Birds Australia.[235]

For example, the UK government could create a similar pilot project to target the European water voles, which live along grassy banks of rivers, ditches, ponds, and streams. Due to predation by American minks and pollution of their riparian habitats, the water vole population in the UK has decreased by more than 90 per cent since the 1960s and is around only 220,000 in 2004.[236] Hence as the most threatened mammals in the UK, water voles need further legal protection and financial assistance in addition to Schedule 5 of the Wildlife and Countryside Act 1981 that stipulates protection of water voles.[237] In addition to current measures of categorising it as a priority conservation species, licensing and mandating avoidance and mitigation methods, it would be conducive to the restoration of the water vole population if the government adopt a more proactive role by provide funding and strengthening its cooperation with the Wildlife Trusts, the People's Trust for Endangered Species and other organisations dedicated to the protection of water voles. Similar pilot projects could also be included in the agri-environmental policy to target other endangered species that require urgent assistance, including the farmland birds like the grey partridge, tree sparrow, skylark, linnet and yellowhammer, animals including the hazel dormice, red squirrel and Scottish wildcat, and insects such as the bearded false darkling beetle, and small tortoiseshell butterfly.[238] Finally, to mitigate the possible negative impacts of reinforced food production on biodiversity, it would be highly beneficial if additional pilot projects could be set up to mitigate the environmental damages by providing financial assistance to the restoration of flower meadows and hedgerows and trees, which are essential

[234] Emma Burns, Charlie Zammit, Simon Attwood and David Lindenmayer, The Environmental Stewardship Program: Lessons on Creating Long-term Agri-environment Schemes', in Dean Ansell, Fiona Gibson, David Salt, 'Learning from agri-environment schemes in Australia. Investing in biodiversity and other ecosystem services on farmsnull' ANU Press, (2016)
[235] Emma Burns, Charlie Zammit, Simon Attwood and David Lindenmayer, The Environmental Stewardship Program: Lessons on Creating Long-term Agri-environment Schemes', in Dean Ansell, Fiona Gibson, David Salt, 'Learning from agri-environment schemes in Australia. Investing in biodiversity and other ecosystem services on farmsnull' ANU Press, (2016)
[236] Jane Dalton, 'UK's Favourite Wildlife Species at Risk of Extinction 'Without Revolution in Disastrous Modern Food Farming' the Independent, (03 March 2018). https://www.independent.co.uk/news/uk/home-news/wildlife-extinct-revolutionise-food-farming-species-declines-wiped-out-a8233511.html accessed 6 January 2021
[237] UK Government, 'Water Voles: Surveys and Mitigation for Development Projects', UK Government, 2020. https://www.gov.uk/guidance/water-voles-protection-surveys-and-licences#:~:text=The%20water%20vole%20is%20fully,breaking%20the%20law%20if%20you%3A&text=possess%2C%20sell%2C%20control%20or%20transport,water%20voles%20bred%20in%20captivity) accessed 15 January 2021.
[238] Countrylife, 'Britain's most endangered animal species', countrylife, (29 August, 2019). https://www.countryfile.com/wildlife/10-of-the-most-endangered-animal-species-in-britain/ accessed 6 January 2021

for bees and other species further up the food chain and have suffered significant loss over the past decades.

8. Public Health

According to current proposals, public health benefits are not considered among the "public goods" subsidised by the Environmental Land Management scheme.[239] There are 'knock-on' public health benefits contained in other public goods currently considered by the ELMS, for instance see the '*Air Quality'* section of this paper.

Nevertheless, neglecting public health in its own right might prove to be a missed opportunity. The agricultural sector and public health are interrelated on multiple points, most saliently on dietary issues. The upcoming section sets out a model for incorporating people's dietary needs into the ELM subsidy scheme by encouraging the production of affordable and easily available fruits and vegetables (F&V) to the UK population. Realising this goal necessitates considerable, yet realistically attainable structural reconfiguration in the UK crop production sector. The paper considers the proposed changes in crop production priorities a long-needed step forward with growing urgency, and the implementation of the ELM provides a unique chance to initiate major steps towards a 21st century British agriculture.

8.1 Insufficient F&V intake and poor nutrition

According to recommendations of the National Health Service's Eatwell Guide, a healthy diet should include 5 portions of a variety of fruit or vegetable every day. They can be fresh, frozen, canned, dried or juiced.[240] The findings of NHS surveys reveal that the UK population lags far behind the advised proportions. "In 2018, only 28 per cent of adults were eating the recommended five portions of fruit and vegetables per day – and the average (mean) was 3.7 portions per day. Fewer men than women meet the five-a-day guideline, and young people aged 16 to 24 are also less likely than other adults to get their five-a-day. In 2018, 18% of children aged 5 to 15 ate five standard portions of fruit and vegetables per day."[241] Such figures are even more disheartening in the light of long-term tendencies, which show a slight decline of vegetable consumption from 2006 in all examined age groups. The consequences of poor British diets are self-evident: 63 per cent of adults in England were overweight or obese. In the 2017 OECD Obesity report, the UK ranked as the 6th most obese economically developed country with a 27% adult obesity rate, more than double of that in Italy, Norway or the Netherlands.[242] Compared to eating less than one portion of fruit and vegetables, the risk of death by any cause is reduced by 14% by eating one to three portions, 29% for three to five portions, 36% for five to seven portions and 42% for seven or more. Each daily portion of

[239] Department for Environment Food & Rural Affairs, *The Environmental Land Management scheme: public money for public goods* [October 2020] https://www.gov.uk/government/publications/the-environmental-land-management-scheme-an-overview/the-environmental-land-management-scheme-public-money-for-public-goods
[240] National Health Service, 'The Eatwell Guide' <https://www.nhs.uk/live-well/eat-well/the-eatwell-guide/> accessed 13 January 2021
[241] Organization for Economic Co-operation and Development 'Obesity Update' [2017] http://healthsurvey.hscic.gov.uk/data-visualisation/data-visualisation/explore-the-trends/fruit-vegetables.aspx
[242] IBID

vegetables reduces overall risk of death by 16%.[243] In summary, there is great room for improvement in British F&V consumption, which offers considerable potentials for preventing cardiovascular decease and other mortality factors.

After having established our case for the major benefits associated with increased fruit and vegetable consumption, we need to assess to what extent do prices act as a hindrance for this goal. Is unaffordability a significant cause for low F&V consumption in the UK? Multiple studies have linked prices and consumption of F&V in England, which allow us to presume a causative relation between reductions in prices and increases in consumption. The 2016 survey of the Food Futures Panel reported that 79% of their respondents selected price and value for money as a major aspect of their dietary decisions, constituting the 2nd most important factor.[244] The effect of price changes on intake of F&V products is often estimated using UK-specific price elasticities. Price elasticities measure the change in demand of a good as a response to a change in its own price (own-price elasticity) or the price of another good (cross-price elasticity). Studies have attributed considerably high price elasticity rates for fruits and vegetables, especially in the long run.[245] It has been estimated, that price increases in the F&V sector in case of Brexit with a free trading agreement with the EU would reduce vegetable intake by 2.7% (2.2% to 3.3%), whereas intake of fruits would reduce by 7.0% (5.9% to 8.4%), which would convert into approximately 5740 (2860 to 11 910) extra CVD deaths or a 0.8% increase in CVD mortality over the 10-year period[246] In addition, the Food Foundation reported that "26.9% of households would need to spend more than a quarter of their disposable income after housing costs to meet the Eatwell Guide costs"[247] In parallel, price reductions of fruits and vegetables are usually reflected with proportional consumer demand in the UK.[248] According to EU statistics, on average, the frequency of a daily intake of at least five portions of fruit and vegetables increased with increasing income. While only 11 per cent of participants belonging to the lowest income quintile consumed at least 5 portions of F&V as part of their daily diet, this figure elevated to 17 per cent in the upper

[243] Oyinlola Oyebode, Vanessa Gordon-Dseagu, Alice Walker, Jennifer S Mindell, 'Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data' [March 2014] https://jech.bmj.com/content/68/9/856.short?g=w_jech_ahead_tab
[244] Food Futures Panel, *Trade-offs in future food systems – consumer perspectives* [March 2016]
[245]Richard Tiffin, Kelvin Balcombe, Matthew Salois, Ariane Kehlbacher, 'Estimating Food and Drink Elasticities' [November 2011) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/137726/defra-stats-foodfarm-food-price-elasticities-120208.pdf
[246] Paraskevi Seferidi, Anthony A Laverty, Jonathan Pearson-Stuttard, Piotr Bandosz, Brendan Collins, Maria Guzman-Castillo, Simon Capewell, Martin O'Flaherty, Christopher Millett, 'Impacts of Brexit on fruit and vegetable intake and cardiovascular disease in England: a modelling study' https://bmjopen.bmj.com/content/bmjopen/9/1/e026966.full.pdf
[247] Courtney Scott, Jennifer Sutherland, Anna Taylor, 'Affordability of the UK's Eatwell Guide' [September 2018] https://foodfoundation.org.uk/wp-content/uploads/2018/09/Affordability-of-the-Eatwell-Guide_Final_Web-Version.pdf
[248]Richard Tiffin, Kelvin Balcombe, Matthew Salois, Ariane Kehlbacher, 'Estimating Food and Drink Elasticities' [November 2011) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/137726/defra-stats-foodfarm-food-price-elasticities-120208.pdf

income quintile group.[249] British family food datasets unveil similarly concerning societal F&V consumption patterns in the UK.[250]

8.2 Providing affordable F&V by domestic farmers

Having emphasised the potential public health benefits related to price reductions in the Fruit & Vegetable sector, we need to evaluate how the Environmental Land Management scheme can contribute to this goal. The upcoming paragraphs propose the expansion of fruit and vegetable production in the domestic crop farming sector via the ELM subsidy-scheme, which could drive down prices, boost farmer's profits and mitigate the UK's food dependency at the same time. According to parliamentary publications from the Environment, Food & Rural Affairs Committee, legislators have been conducting intensive talks with various stakeholders about including public health among subsidized public provisions, and especially about a horticultural shift in British agriculture. Vicki Hird from Sustain reckoned: "We can repair that harm that the CAP did by investing and helping farmers to convert to top fruits, to other types of field vegetables, etc. That would diversify production and provide what I think is the 30 million new portions of fruit and veg that we need to deliver the seven a day that we actually need to be eating." [251]

In 2016, the UK produced just 49 percent of its food while 30 percent came from countries within the EU. The same year, the UK imported 10.3 billion euros of fruits and vegetables, the country's largest food import category by value. UK exports of fruit and vegetables sat at just 1.1 billion euros, creating a 9.2 billion euro trade deficit in 2016.[252] In 2017, approximately 76 percent of the UK's vegetable imports and 41 percent of the country's fruit and nuts imports originated from the EU. Thus, changes to the UK trade regime are likely to affect prices of F&V by increasing costs of trade. With price being one of the main determinants of consumer behaviour in the UK, this is a golden opportunity for domestic F&V producers to make use of their comparative advantage and alleviate the country's foreign dependency for its F&V supplies by expanding their market share. Although domestic F&V famers can cut costs at shipping, packaging, and - as a novelty after Brexit - with the absence of international import administration, competing with the labour costs of large-scale farmers in Spain, Morocco or Egypt is a major challenge.

The Netherlands goes forward as a textbook example for the UK to follow in order to revitalize its agricultural sector. Despite its miniscule land-area, mediocre soil quality, low yearly average temperatures and scarce sunny hours, the Netherlands is the world's second

[249]EuroStat, *Fruit and vegetable consumption statistics* [March 2018] https://ec.europa.eu/eurostat/statistics-explained/pdfscache/68501.pdf
[250] Department for Environment Food & Rural Affairs, *Family food datasets* [2018] https://www.gov.uk/government/ statistical-data-sets/family-food-datasets
[251] Commons Select Committee for Environment Food & Rural Affairs, 'Public money for public goods' (Parliament Home Page, June 2018) <https://publications.parliament.uk/pa/cm201719/cmselect/cmenvfru/870/87006.htm> accessed 14 January 2021
[252]Gro-Intelligence, 'Brexit Reveals UK's Dependence on EU Fruit' [May 2018] <https://gro-intelligence.com/insights/articles/brexit-reveals-uk-dependence-on-eu-fruit#:~:text=UK%20exports%20of%20fruit%20and,imports%20originated%20from%20the%20EU> accessed 14 January 2021

greatest agricultural exporter behind the United States, with $111 billion worth of agricultural exports.[253] Besides similarities in climate, the tenure-systems in the UK and the Netherlands also share similarities, as both agricultural sectors are based on small-farm holdings, and most farms are owner occupied. In fact, the average cultivable area of British farms is 54 hectares, while the Dutch is less than half of that, at 25 hectares.[254] Larger farm size favours heightened profitability, as it allows to exploit the benefits of economies of scale. Overall, the geographic and structural givens of the United Kingdom are favourable over the Netherlands, while also being akin in their determining features. What distinguishes the Netherlands from other economically developed countries on the same geographical latitude is their embracement of horticulture, sustainable intensification, mechanisation and innovation.

The Dutch agricultural sector managed to counterbalance high labour costs and soil scarcity by intensifying its agricultural production and prioritizing horticulture over extensive cereal production due to its higher yields per acreage and consequent profitability. Intensive mechanised F&V farming requires more added value, and less physical labour, mitigating labour costs. Instead of engaging in a race-to-the-bottom on workers wages, deploying state-of-the-arc technology can increase competitiveness more effectively. The potential gains in efficacy are hard to overestimate: According to data from FaoStat, the yield per square meter of tomatoes in the Netherlands is six times greater than Spain's.[255] Nevertheless, the acquisition of the necessary infrastructure such as glass houses, and technologies such as aquapoincs, automated precisional irrigation, LED lighting and solar panels requires major investment from farmers.

According to data on Agricultural Land Classification (ALC), almost 20 per cent of total agricultural land in England is suitable to grow fruit and vegetables as grade 1 and 2 lands. However, only 1.4% of land is used for fruit and vegetable production at the moment.[256] Currently, the overwhelming majority of UK croppable land is used for the cultivation of cereals, followed by temporary grass, oilseeds and uncropped arable land.[257] A study conducted by the Public Health Policy Evaluation unit of Imperial College London modelled two scenarios where agricultural land allocated to fruit and vegetables would gradually increase over seven years until it reaches 10% or 20% of suitable land (or 1.9% and 3.9% of

[253] Kate Whiting, 'These Dutch tomatoes can teach the world about sustainable agriculture' (World Economic Forum, November 2019) <https://www.weforum.org/agenda/2019/11/netherlands-dutch-farming-agriculture-sustainable/#:~:text=The%20Netherlands%20might%20be%20a,and%20%247.4%20billion%20of%20vegetables> accessed 14 January 2021

[254] EuroStat, *Farm structure in the Netherlands* [July 2008] https://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Farm_structure_in_the_Netherlands_-_2007_results#:~:text=These%20farms%20made%20use%20of,with%2024%20ha%20in%202005).

[255] Annemarie Breukers, Olaf Hietbrink, Marc Ruijs, 'The power of Dutch greenhouse vegetable horticulture: An analysis of the private sector and its institutional framework' [August 2008] https://webcache.googleusercontent.com/search?q=cache:dZ-Qx1DmF5YJ:https://edepot.wur.nl/27928+&cd=9&hl=en&ct=clnk&gl=hu

[256] Paraskevi Seferidi, 'Agriculture Bill: Public health must be a public good' (Royal Society for Public Health, February 2020) <https://www.rsph.org.uk/about-us/news/guest-blog-agriculture-bill-public-health-must-be-a-public-good.html> last accessed 14 January 2021

[257]Department for Environment, Food & Rural Affairs, *Agriculture in the United Kingdom* [2019] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904024/AUK_2019_27July2020.pdf

total agricultural land respectively).[258] Historical data can illustrate the feasibility of these scenarios; the average use of land for fruit and vegetables between 1983 and 1990 in England was 1.9%, similar to the least ambitious modelled scenario.[259] The project concluded that "increasing F&V land until it reaches 10% of Grade 1–2 land would contribute approximately 1.1 million tonnes of extra fruit and 4.0 million tonnes of extra vegetable production between 2021 to 2030. Under the more ambitious scenario of F&V land reaching 20% of Grade 1-2 soils, the study estimated that F&V production would increase by approximately 5.2 million and 19.2 million tonnes, respectively, between 2021 to 2030."[260] The aforementioned research estimated a potential increase in F&V intake by approximately 3.7% and 7.8% respectively until 2030 based on the more lowkey scenario. According to more audacious calculations, F&V intake would be approximately 17.4% and 37% higher by 2030. Nevertheless, the research was predicated on the assumption that all extra production would be mirrored by increased consumer demand. Such presumptions can only be made if we make sure that domestically produced F&V is competitive enough on the British market.

8.3 Policy Outline

Encouraging a profile change in British agriculture in pursuit of higher F&V production with subsidies in a holistic policy-framework could drive down F&V prices, dramatically increasing F&V intake with all the subsequent health benefits. The policy suggestion put forward in the upcoming paragraphs aims to circumvent the contentious topic subsidizing mere F&V production by focusing in helping farmers transit from cereals to F&V instead, and intertwining such measures with afforestation and rewilding, a public provision beyond doubt.

Farmers should be incentivised to shift from cereals to F&V in crop production on suitable lands under the "Use less, and rewild the rest!" principle. This subsidy-strategy would financially reward the conversion from cereal to F&V production, which requires substantially more limited land use, and offers long term profitability for farmers. According to the research of DEFRA, the average farm business income in the UK from cereals is £62. 800, while horticulture offers average incomes of £42400[261] In return, farmers should be obligated to designate a given portion of previously cropped land for rewilding projects. Such a framework could offer farmers considerably higher profit margins than they would make with cereal production, ensure affordable F&V for the UK population, and contribute to the government's goal of planting 30,000 hectares of trees every year, as part of nature conservation efforts. The above-described profile-change in British agriculture is not just an

[258] Paraskevi Seferidi, Anthony A Laverty, Jonathan Pearson-Stuttard, Piotr Bandosz, Brendan Collins, Maria Guzman-Castillo, Simon Capewell, Martin O'Flaherty, Christopher Millett, 'Impacts of Brexit on fruit and vegetable intake and cardiovascular disease in England: a modelling study' https://bmjopen.bmj.com/content/bmjopen/9/1/e026966.full.pdf

[259] Paraskevi Seferidi, 'Agriculture Bill: Public health must be a public good' (Royal Society for Public Health, February 2020) <https://www.rsph.org.uk/about-us/news/guest-blog-agriculture-bill-public-health-must-be-a-public-good.html> last accessed 14 January 2021

[260] IBID

[261] Department for Environment, Food & Rural Affairs, *Farm Business Income by type of farm, England, 2019/20* [December 2020] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/944352/fbs-businessincome-statsnotice-16dec20.pdf

instrument to achieve public health and environmental goals, but an unavoidable economic necessity. The cereal-heavy British agricultural sector has long been chronically reliant on CAP subsidies to turn a profit. It has been estimated that EU subsidies made up between 50 and 60 per cent of farm income in the UK as a whole.[262]

In order to provide affordable F&V, assisting already existing horticultural farms in acquiring new equipment and machinery is essential. Nevertheless, subsidies for such modernisation efforts should follow the principles of sustainable intensification, making UK horticulture more competitive and environmentally sound at the same time.

One might rightfully argue that consumer behaviour is not exclusively influenced by prices, despite high price elasticity of F&V evidenced above. Shifting away the centre of gravity of British crop production from cereals more towards F&V can only provide increased profits and economic viability for farmers if consumer demand matches the elevated levels of supply. Although the bulk of such an increase is expected from greater consumer engagement due to enhanced affordability, and market gains on the expense of foreign competitors, the government can also help to kick-start this process in a socially responsible way. The collaboration between the domestic agricultural sector and public procurement offers a practical solution to many of the debates around the inclusion of F&V in the ELM scheme. Subsidization on the simple merit of healthy food provision is not just controversial because such products should be economically viable on the markets on their own, but also because these produces still end up at the highest bidder costumer. Consequently, the most deprived and heavily effected by insufficient F&V intake still might not end up enjoying those products labelled as 'public goods.' Nevertheless, it is hardly the case with public procurement in schools, higher-education institutions, NHS hospitals and care homes or prisons, where people receive identical meals for an identical price. Financially supporting the long-term, contractual co-operation between public institutions offering procurement and local F&V farmers could help to supplement the diets for all equally, with special regard to the least affluent, who qualify for free school meals or other forms of free public procurement.

8.4 Recommendations

Awarding zero-interest or low-interest loans for great investments alongside lump-sum subsidies for smaller projects to cereal producing farms intending to shift their production focus towards horticulture under Tier 2 of the Environmental Land Management scheme with the following provisions:

- the recipient of such subsidies approves of the designation of a portion of his/her land for rewilding purposes
- the size of the land-portion designated for rewilding purposes is proportional with the assigned sum of subsidies
- the recipient of such subsidies submits a detailed rewilding plan

[262] Lords Select Committee for the European Union, 'Withdrawing from CAP financial support' (Parliament Home Page, 2017) <https://publications.parliament.uk/pa/ld201617/ldselect/ldeucom/169/16908.htm> accessed 14 January 2021

- the subsidy scheme only covers the start-up costs of conversion from crop production to horticulture

Subsidizing the acquisition and implementation of precision farming technologies in horticulture such as aquaponics, automated precision irrigation, LED lighting and solar panels under Tier 1 of the Environmental Land Management scheme.

Providing subsidies under Tier 1 of the Environmental Land Management scheme for fruit and vegetable farmers who are the contractual suppliers of public institutions under the following provisions:

- the contract is valid for at least a year
- the supplied produces only include healthy fruits and vegetables
- the supplier is capable of offering F&V below market price due to those subsidies

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