Consultation Response

Call for Evidence - Environmental Change and Food Security

The CLA welcomes the foresight and long-term thinking underpinning this EAC call for evidence. Our members are passionate about delivering reliable primary produce for domestic and export markets. Climate change and biodiversity loss are already having profound effects on the security of the world's food system and will increasingly shape the UK's future food security.
Despite increasingly extreme weather events, the UK is likely to continue to have one of the more stable environments for agriculture in the future. Nonetheless, we will need to adapt our land use and how we produce food to reduce our greenhouse gas emissions and ensure food security. Crucially, we need planned investment at farm and national level to avoid the impacts of acute and chronic water shortages that can damage farming output and result in environmental harms.

Key points from the CLA on environmental change and food security:

1. Climate change will increasingly disrupt agricultural production, especially overseas. Given that the UK currently imports 50% of its food, enhancing domestic food security means increasing the UK's self-sufficiency in commodities which we can grow but for which our self-sufficiency is low, particularly fruit and vegetables.

2. To ensure domestic food security, government policy must prioritise water for food production, particularly during droughts. The government must also urgently help farmers overcome the current barriers to on-farm reservoir construction.

3. The CLA believes that it is possible for UK farmers to maintain and grow national food security in the face of climate change with appropriate investment in new crops and production methods and the revival of older practices. This will require public and private investment in R&D, support for new supply chains, knowledge-exchange and advice.

4. The CLA supports the National Food Strategy approach of the three-compartment model, which recognises the need for increased agroecological approaches to land management, sustainable, high-yield farming, and land specifically managed for nature and carbon. However, CLA members are clear that a Land Use Framework is not necessary, given there are already sufficient institutional processes in place to support decision-making on land. It is the CLA view that a Land Use Framework may add bureaucracy and stifle innovation in farming and environmental management just when it is most needed.

5. Alongside food production, farmers and land-managers have critical roles to play in delivering biodiversity and carbon sequestration; this must also be properly supported. The new agricultural grant schemes must enable farmers to transition to sustainable, low-carbon, nature-positive agriculture. The CLA supports the current plans for ELMs, but there needs to be greater clarity on (i) the total budget to be allocated to ELMs; (ii) the proportion of that budget allocated to each scheme; and (iii) more explicit information on the government's goals for food security.

6. Private-sector environmental markets will become increasingly important in meeting net-zero and biodiversity net-gain targets. The government should ensure that these emerging markets are robust – for example, by establishing standards for measurement, reporting and verification – and that they do not lead to perverse and/or irreversible changes in land use which damage future food security.

Responses to specific questions posed in the Call for Evidence:

What are the main risks posed to future UK food security from projected climate change and biodiversity loss pathways?

Climate change is increasing the frequency and severity of extreme weather events, both worldwide[1] and in the UK[2]. Agricultural production is vulnerable to drought and heat extremes[3]. Impacts on world markets are particularly relevant given 50% of the UK's food is imported and 70% of the cropland used to produce UK food is located overseas[4]. Any assessment of the UK's food security needs to be grounded in the recognition that we are part of a global food system made more fragile by climate change and biodiversity loss.

Increasing global temperatures, heat extremes, and uncertain precipitation are likely to limit agricultural production in many tropical and subtropical areas[5]. More frequent extreme weather events are predicted to increase yield losses and the volatility of agricultural commodity markets[6], which could increase imported food and animal-feed prices in the UK.

It is unclear exactly how yield patterns will change under climate change[7]. However, it is likely that yields of key cereal and oilseed crops will decrease[8]. A 2019 study shows that climate change is already shrinking the number of consumable calories produced each year across the top ten global crops, particularly in already food-insecure countries[9]. Climate change has slowed down

[1] Seneviratne, S.I., et al., 2021. Weather and Climate Extreme Events in a Changing Climate. In, *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter11.pdf

[2] Zachariah, M., et al. 2022. Without human-caused climate change temperatures of 40ºC in the UK would have been extremely unlikely. World Weather Attribution. https://www.worldweatherattribution.org/without-human-caused-climate-change-temperatures-of-40c-in-the-uk-would-have-been-extremely-unlikely/

[3] Lesk, C., et al. 2016. Influence of extreme weather disasters on global crop production. *Nature*, 529(7584), pp.84-87.

[4] de Ruiter, H et al. 2016. Global cropland and greenhouse gas impacts of UK food supply are increasingly located overseas. *Journal of The Royal Society Interface*, 13(114), p.20151001.

[5] Kummu, M., et al. 2021. Climate change risks pushing one-third of global food production outside the safe climatic space. One Earth, 4(5), pp.720-729.

[6] Lesk, C., et al. 2022. Compound heat and moisture extreme impacts on global crop yields under climate change. *Nature Reviews Earth & Environment*, 3(12), pp.872-889.

[7] Sloat, L.L, et al. 2020. Climate adaptation by crop migration. *Nature communications*, 11(1), pp.1-9.

[8] Zhao, C., et al. 2017. Temperature increase reduces global yields of major crops in four independent estimates. *Proceedings of the National Academy of Sciences*, 114(35), pp.9326-9331.

[9] Ray, D.K., et al. 2019. Climate change has likely already affected global food production. *PloS one*, 14(5), p.e0217148.

agricultural-productivity growth since the 1960s by around 21%[10]. Crops also appear less nutritious when grown under higher CO_2 concentrations and warmer temperatures[11].
Furthermore, whilst global food production is currently buffered by increased meltwater rates from mountain glaciers[12], meltwater-production rates will decline by the mid-to-late 21st Century, which will cause water deficits and reduced crop yields in many of the world's irrigated breadbasket regions[13]. One modelling study suggests that 10% of the UK's total surface-water-irrigated agricultural supply may be subject to snowmelt risks under 2°C of global warming[14].
Globally, agriculture is the largest contributor to biodiversity loss[15], yet agriculture also depends on the high abundance and species richness of invertebrates to deliver pollination services and biological pest control[16]. 35% of global crop production by volume depends on animal pollinators[17]. Although the UK is among the countries least reliant on animal pollination[18], the widespread loss of pollinating insects in Britain since 1980 is concerning for farmers.

How can the UK ensure that enough water is available for crop growing while preventing unsustainable levels of abstraction that can impact the ecology and resilience of our rivers, wetlands and aquifers?

- **Water for food production should be considered in legislation as an essential use in drought situations.** Water security is essential for food security, and the CLA believes it must not be considered separately. Water for farm production is currently not included as an essential use during droughts in the Water Resources Act 1991.

- **Increased support for on-farm storage reservoirs:** To ensure enough water is available for crop growing whilst preventing unsustainable abstraction, farmers want to construct on-farm reservoirs. These will allow them to abstract water in high-flow periods to irrigate crops during low-flow periods. However, increasing costs and poor alignment between grant funding, planning-permission approval, and abstraction licencing are limiting reservoir construction. In the current inflationary environment, a hold-up on any one of these prerequisites means that the quoted cost of reservoir construction increases and may make the overall project cost prohibitive, given that the grant value does not proportionally increase. To overcome these roadblocks:

[10] Ortiz-Bobea, A et al. 2021. Anthropogenic climate change has slowed global agricultural productivity growth. *Nature Climate Change*, 11(4), pp.306-312.
[11] Myers, S.S., et al. 2014. Increasing CO2 threatens human nutrition. *Nature*, 510(7503), pp.139-142.
[12] Pritchard, H.D., 2019. Asia's shrinking glaciers protect large populations from drought stress. *Nature*, 569(7758), pp.649-654.
[13] Qin, Y., et al. 2020. Agricultural risks from changing snowmelt. *Nature Climate Change*, 10(5), pp.459-465.
[14] Qin, Y., et al. 2022. Snowmelt risk telecouplings for irrigated agriculture. *Nature Climate Change*, 12(11), pp.1007-1015.
[15] Dudley, N. and Alexander, S., 2017. Agriculture and biodiversity: a review. *Biodiversity*, 18(2-3), pp.45-49.
[16] Dainese, M., et al. 2019. A global synthesis reveals biodiversity-mediated benefits for crop production. *Science advances*, 5(10), p.eaax0121.
[17] Klein, A.M., et al. 2007. Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B*: biological sciences, 274(1608), pp.303-313.
[18] Potts, S.G., et al. 2016. Safeguarding pollinators and their values to human well-being. *Nature*, 540(7632), pp.220-229.

- Defra could increase the Farming Transformation Fund Water Management Grants to 60% of reservoir cost and further financial support could be provided through capital allowances on reservoir materials.
- Clear communication on future funding rounds of the Farming Transformation Fund Water Management Grants will allow farm-businesses to plan.
- The CLA is calling for a working group comprising DLUHC, the EA and Natural England to fast-track planning permission and abstraction licencing for grant applicants.
- Winter refill abstraction licences should be reformulated in terms of flow not winter season, to enable members to recharge their reservoirs out-of-season when flows are high – especially in light of more extreme, non-winter precipitation patterns linked to climate change[19].
- The incoming Environmental Permitting Regime further disincentivizes reservoir construction. Reservoirs are expensive to construct[20] and therefore must have water security guaranteed across the full investment-return period. From 2023, abstraction licences will be reviewed every six years, which is unlikely to cover most reservoir investment-return periods. This disincentive could be alleviated by reducing the frequency of abstraction licence review, e.g., to once every 12 years.

- **Enforcing Temporary Use Bans (TUBs) on public water supplies during future drought conditions would reduce the severity of agricultural droughts, provide water to secure harvests, and protect the environment from unsustainable abstraction.** It seems increasingly unreasonable that the public water supply should be unrestricted whilst spray irrigation bans are imposed on agriculture under Section 57 of the Water Resources Act 1991 – as occurred between 29th August and 1st November 2022 in Norfolk, Sussex and Essex, where spray irrigators' abstraction licences were reduced by 50% without a corresponding TUB.

- **Funding to model future water availability is largely unavailable to non-public water supply abstractors**. This makes it difficult for farmers to demonstrate their need for funding for reservoirs and long-term water security via regional planning frameworks, such as Water Resources Plans. The government could allocate research funding to support modelling the impact of climate change on water availability at catchment and other farm-relevant scales.

[19] E.g., Cotterill, D., et al. 2021. Increase in the frequency of extreme daily precipitation in the United Kingdom in autumn. *Weather and Climate Extremes*, *33*, p.100340.
[20] Capital costs for agricultural reservoirs range from £100,000 to more than £400,000, according to 2014 Cranfield University research. Annual operating and maintenance costs are c.10% of capital costs. There are also additional archaeological survey costs plus planning and abstraction-licence application fees. Given current inflation, these costs will now be significantly higher. Data: Weatherhead, K., et al. 2014. *Water for Agriculture (FFG1112) March 2014* https://www.greensuffolk.org/app/uploads/2021/05/2016-02-08-Cranfield-Rsr-costs-table.pdf:

- **Without long-term water security for irrigated crops in the UK, including fruit, salad crops and field vegetables, production will become more volatile and decline due to high risk**. This will further reduce the UK's already poor self-sufficiency in horticulture[21]. The CLA is already hearing that horticulturalists in the East of England are shifting to cereal production due to the lower risks posed by less water-demanding crops.

What practices could the UK adopt to become more self-sufficient while reducing emissions associated with agriculture?
The CLA supports the need to reduce emissions from agriculture to net zero by 2050, via a just transition. UK farmers will require enhanced government support to deliver these objectives. Possible steps towards greater self-sufficiency and reduced emissions are detailed below.

Meat:
The CLA acknowledges the pressure to reduce meat consumption to meet net-zero targets[22], given the carbon intensity of red meat[23]. However, this must be driven by consumer demand to avoid simply offshoring carbon emissions. UK beef production is about half as carbon-intensive as the global average (48 $kgCO_2eq./kg$ beef vs. 99 $kgCO_2eq./kg$ beef), 14% less intensive than the EU average[24], and significantly more carbon-efficient than South American beef[25].
UK farmers can reduce emissions from livestock further through:

- investments in slurry management across all livestock species, such as installing anaerobic digestion facilities, solid-liquid separation, and decreased slurry storage time[26]. Many of these technologies will require government investment;
- genetic testing to identify animal lineages that produce less methane during enteric fermentation, and selectively breeding these[27];
- research and deployment of methane-suppressing feed additives for cattle[28], provided these do not negatively impact on livestock or human health and are cost-effective[29];

[21] https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2021/united-kingdom-food-security-report-2021-theme-2-uk-food-supply-sources#united-kingdom-food-security-report-2021-theme2-indicator-2-1-9
[22] National Food Strategy 2021. *The Plan.* https://www.nationalfoodstrategy.org/wp-content/uploads/2021/10/25585_1669_NFS_The_Plan_July21_S12_New-1.pdf
[23] Poore, J. and Nemecek, T., 2018. Reducing food's environmental impacts through producers and consumers. *Science*, 360(6392), pp.987-992.
[24] Committee on Climate Change, 2020. *Land use: Policies for a Net Zero UK.* https://www.theccc.org.uk/wp-content/uploads/2020/01/Land-use-Policies-for-a-Net-Zero-UK.pdf
[25] Kim, B.F., et al. 2020. Country-specific dietary shifts to mitigate climate and water crises. *Global Environmental Change*, 62, p.101926.
[26] Grossi, G., et al. 2019. Livestock and climate change: impact of livestock on climate and mitigation strategies. *Animal Frontiers*, 9(1), pp.69-76.
[27] González-Recio, O., et al. 2020. Mitigation of greenhouse gases in dairy cattle via genetic selection: 2. Incorporating methane emissions into the breeding goal. *Journal of Dairy Science*, 103(8), pp.7210-7221.
[28] Roque, B.M., et al. 2021. Red seaweed (Asparagopsis taxiformis) supplementation reduces enteric methane by over 80 percent in beef steers. *PLoS One*, 16(3), p.e0247820.;
[29] https://www.cla.org.uk/documents/590/Call_for_Evidence_on_Methane_Suppressing_Feed_Products.pdf

- prioritizing the production of high-quality beef and dairy through agroecological grazing systems, which may assist some soil carbon sequestration[30];
- rearing breeds of cattle for multiple uses (milk, meat, leather), rather than beef-only;
- improving livestock productivity, health, and their housing systems[31].

Pulses and legumes:
From both climate and health perspectives, pulses and legumes should play larger roles in the UK diet[32]. A warming climate and advances in plant breeding make domestic pulse production an increasing opportunity. For instance, newly bred soybean varietals could mature as far north as southern Scotland in a warmer climate[33]. Soybeans could become a commercially valuable break crop in cereal crop rotations, which would protect against pests and diseases, fix nitrogen in the soil, and reduce fertilizer usage, which is a significant source of greenhouse gas emissions. The UK currently imports around 3.2 million tonnes of soybeans each year, the majority from South America[34], implicated in deforestation[35].
Traditional British pulses varietals, such as fava (field) beans, marrowfat peas, and large blue peas, which have either fallen from favour or are now bred as livestock feed, could form a much large component of the UK diet. They present similar benefits to soybean cultivation. Currently, the UK exports the majority of its fava beans to the Middle East and Japan[36]. Awareness campaigns could increase domestic consumption of fava beans, which would improve our protein security.
The government could support farmers to explore these opportunities by breaking the lock-in within agri-food systems which incentivizes the production of crops with more upstream technical funding and downstream storage and processing capacity[37]. More funding for research, development, and cultivation of higher-yielding domestic pulse varieties could help increase the UK's future self-sufficiency in low-carbon protein sources.

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[30] Garnett, T., et al. (2017). *Grazed and Confused? Ruminating on cattle, grazing systems, methane, nitrous oxide, the soil carbon sequestration question – and what it all means for greenhouse gas emissions*. FCRN, University of Oxford.
[31] Grossi, G., et al. 2019. Livestock and climate change: impact of livestock on climate and mitigation strategies. *Animal Frontiers*, 9(1), pp.69-76.
[32] Willett, W., et al. 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, 393(10170), pp.447-492.
[33] Coleman, K., et al. 2021. The potential for soybean to diversify the production of plant-based protein in the UK. *Science of the Total Environment*, 767, p.144903.
[34] Efeca, 2019. *UK Roundtable on Sustainable Soya*. https://www.efeca.com/wp-content/uploads/2019/12/UK-RT-on-Sustainable-Soya-APR-2019-final.pdf
[35] https://www.theguardian.com/environment/2019/oct/05/tesco-m-and-s-supermarkets-likely-to-have-soya-linked-to-deforestation-supply-chains
[36] https://sustainablefoodtrust.org/news-views/rediscovering-british-pulses/#:~:text=Britain%20grows%20about%20400%2C000%20tonnes,peas%20and%20large%20blue%20peas
[37] Magrini, M.B., et al. 2018. Pulses for sustainability: breaking agriculture and food sectors out of lock-in. *Frontiers in Sustainable Food Systems*, 2, p.64.

Orchard crops:
The UK currently imports 84% of its fruit[38]. Orchards present an opportunity to increase UK carbon stocks[39] and biodiversity whilst improving self-sufficiency in fruit. Orchards are a key part of the UK's food heritage yet, as recently as 1991, the government paid for the removal ('grubbing up') of apple trees. The government could now pay for their re-establishment, using traditional varieties. Orchards can also be successfully integrated into agroforestry schemes in terms of overall farm income, with only small arable yield declines[40]. Grant schemes would help support the high, upfront cost of establishing agroforestry.

Regenerative farming:
Agroecological and regenerative farming practices can reduce the amount of fertilizer which needs to be applied to land, reducing nitrous oxide and carbon dioxide emissions without decreasing crop yields on cropping years[41].

Wastage:
The charity WRAP estimates that wasted food in the UK generates 25 million tonnes (Mt) of CO_2e each year, equivalent to roughly 5% of UK territorial emissions. Only 15% of this is on-farm wastage[42]. The UK government should tackle food wastage to improve food security and reduce greenhouse gas emissions.

Could the UK's land be better used to secure our domestic food supply?
The three-compartment model will help resilience:
Food production, renewable energy, carbon sequestration, and conservation all place competing demands on land use. The CLA recognises that the balance of UK land use will need to change to meet net-zero and biodiversity net-gain targets. However, food security and environmental goals are not zero-sum games: they can be delivered together. The CLA supports the approach taken by Henry Dimbleby and colleagues in the National Food Strategy[43], which proposes a three compartment model: high-yield farmland managed alongside lower-yield, regenerative agriculture and land set aside specifically for nature. Regenerative and high-yield agriculture may also blur together in some cases.
From the perspective of food security, the least productive areas of UK land are fortunately those with the greatest potential for carbon sequestration[44]. As the Basic Payment Scheme is withdrawn, market forces are expected to shift lower-grade agricultural land away from extensive livestock

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[38] https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2021/united-kingdom-food-security-report-2021-theme-2-uk-food-supply-sources#united-kingdom-food-security-report-2021-theme2-indicator-2-1-9
[39] Gregg, R., et al. 2021. *Carbon storage and sequestration by habitat: a review of the evidence (second edition).* Natural England Research Report NERR094. Natural England, York.
[40] Staton, T., et al. 2022. Productivity, biodiversity trade-offs, and farm income in an agroforestry versus an arable system. *Ecological Economics*, 191, p.107214.1
[41] Jordon, M.W., et al. 2022. Temperate Regenerative Agriculture practices increase soil carbon but not crop yield—a meta-analysis. *Environmental Research Letters*, 17(9), p.093001.
[42] https://wrap.org.uk/taking-action/food-drink/actions/action-on-food-waste
[43] National Food Strategy 2021. *The Plan.*
[44] Ibid.

rearing towards multiple environmental land-management schemes. Livestock can still play an important role in these schemes as they may improve grassland biodiversity[45] and help ecosystem regeneration when stocked at lower densities. Subject to consumer demand, more land-use-efficient protein sources like legumes[46] could then fulfil food security within the three-compartment model.

The UK Climate Change Committee estimates that achieving net-zero will place an additional £1.4 billion cost per year on UK farmers and land-managers[47]. The CLA urges the government to provide sufficient funding to support new livelihoods for rural landowners and land-managers in delivering public goods. Their knowledge of the local land will be invaluable in ensuring carbon sequestration is maintained long-term.

Additionally, robust, government-led standards for measurement, reporting and verification of carbon stocks will give land-managers the confidence to invest in private carbon and natural capital markets.

A Land Use Framework would be unhelpful:
The National Food Strategy proposed a Land Use Framework as a decision-making tool to determine the best way to balance net-zero and other objectives on rural land, which the Government Food Strategy has adopted. However, CLA members are clear that a Land Use Framework is not necessary. There are already sufficient institutional processes in place to support decision-making on land, particularly with the introduction of Local Nature Recovery Strategies. A Land Use Framework may add bureaucracy and stifle innovation in farming and environmental management, just when it is most needed. For example, a Land Use Framework which zoned land into separate energy and food production areas could stifle innovation in the emerging practice of agrivoltaics – producing food beneath solar panels. Agrivoltaics addresses the problem that solar farms remove land from food production. Research indicates that agrivoltaic systems are highly land-efficient[48], they shade crops and livestock, and therefore reduce production losses from extreme heat and drought[49]. They also increase soil moisture, which potentially makes agrivoltaics several times more water-efficient than conventional agriculture, producing greater late-season biomass[50]. Agrivoltaics requires relatively little change to production methods[51] and may even improve agricultural profits on shade-tolerant plants like cabbages and broccoli by producing greener brassicas which consumers prefer[52].

[45] Fraser, M.D., et al. 2014. Mixed grazing systems benefit both upland biodiversity and livestock production. *PLoS One*, 9(2), p.e89054.
[46] https://ourworldindata.org/grapher/land-use-protein-poore
[47] Committee on Climate Change, 2020. *Land use: Policies for a Net Zero UK.* https://www.theccc.org.uk/wp-content/uploads/2020/01/Land-use-Policies-for-a-Net-Zero-UK.pdf
[48] ibid
[49] Barron-Gafford, G.A., et al. 2019. Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands. *Nature Sustainability*, 2(9), pp.848-855.
[50] Hassanpour Adeh, E., et al. 2018. Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency. *PloS one*, 13(11), p.e0203256.
[51] Marrou, H., et al. 2013. Microclimate under agrivoltaic systems: Is crop growth rate affected in the partial shade of solar panels?. *Agricultural and Forest Meteorology*, *177*, pp.117-132.
[52] Chae, S.H., et al. 2022. Agrivoltaic Systems Enhance Farmers' Profits through Broccoli Visual Quality and Electricity Production without Dramatic Changes in Yield, Antioxidant Capacity, and Glucosinolates. *Agronomy*, 12(6), p.1415.

The CLA is totally opposed to the proposed ban on solar on grade 3b agricultural land, and indeed suggests greater flexibility in planning regulations to permit trialling agrivoltaics on higher-grade land.

When considering how to adapt to climate change and improve domestic food security, risks for sea-level rise and flooding must be considered:
A large proportion of the UK's most productive agricultural land, used for growing vegetables and salad crops, is located in low-lying, flood-prone areas reclaimed from marshlands and fens[53]. The CLA notes that this agricultural land is poorly protected by existing sea defences. The financial losses from seawater inundation and soil salinization following storm surges are likely to be high and could take land out of production for up to 7 years (as modelled in Lincolnshire)[54]. Under a drier future climate, there will be even less freshwater to flush out salts deposited by seawater inundation, exacerbating this risk[55].
Therefore, the government must remember the need to improve food security when deciding whether to protect best-and-most-versatile farmland from sea-level rise and fluvial flooding. Cost-benefit analysis for flood defences should incorporate the (future) value of agricultural land and food security within financial decision-making. Whilst targeted marsh migration into agricultural land may buffer landward farms from reduced crop yields and saltwater incursion into groundwater, robust compensation will be required[56] and other areas of UK land will need to become more efficient at producing food to compensate. Creative compromises exist, nevertheless: livestock farmers can graze cattle on flooded marshland areas, for example, without altering their efflux of carbon[57].
Collectively, these strategies indicate the innovation and creativity that will enable us to better use our land to secure domestic food supply and meet climate objectives.

[53] https://magic.defra.gov.uk/StaticMaps/Agricultural%20Land%20Classification%20-%20Provisional%20(England).pdf and https://www.cpre.org.uk/wp-content/uploads/2022/07/Building-on-our-food-security.pdf
[54] Gould, I.J., Wright, I., Collison, M., Ruto, E., Bosworth, G. and Pearson, S., 2020. The impact of coastal flooding on agriculture: A case-study of Lincolnshire, United Kingdom. *Land Degradation & Development*, 31(12), pp.1545-1559.
[55] Gould, I., et al. 2021. Salinization threats to agriculture across the North Sea region. In, Negacz, K. et al., *Future of Sustainable Agriculture in Saline Environments*, Taylor &Francis Group. pp.71-92.
[56] Guimond, J.A. and Michael, H.A., 2021. Effects of marsh migration on flooding, saltwater intrusion, and crop yield in coastal agricultural land subject to storm surge inundation. *Water Resources Research*, 57(2), p.e2020WR028326.
[57] Harvey, R.J., et al. 2019. No detectable broad-scale effect of livestock grazing on soil blue-carbon stock in salt marshes. *Frontiers in Ecology and Evolution*, *7*, p.151.

For further information please contact:

Matthew Doran
Land Use Policy Adviser
CLA, 16 Belgrave Square
London SW1X 8PQ

Tel: 020 7235 0511
Email: matthew.doran@cla.org.uk
www.cla.org.uk
