Closing the information gap: using space-based EO for wetland mapping and monitoring

Whitepaper from UK Space Agency National Space Innovation Programme project: Space-based Mapping & Monitoring of Wetlands Carbon Sequestration

LE London Economics

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About Argans

ARGANS, is a UK-registered company with headquarters based in Plymouth UK, offices in Sophia-Antipolis and Brest, and staff located in London and Southampton.

ARGANS has over a decade of experience within remotely sensed Earth Observation, working with the European Space Agency as technical experts Mission Performance Centre quality control for Sentinel 2 and 3; exploiting EO missions to deliver Environmental monitoring products and services. We provide expertise to assess the relationship between healthy wetlands and their carbon capture potential, the feasibility for EO to monitor these habitats with respect to carbon capture.

About London Economics

London Economics (LE) is a leading economic consultancy with a dedicated team of professional economists focussing on the space sector. Across more than 100 projects in the last decade we have advised national governments, international organisations, and private companies on the economics of space.

For this project, our relevant expertise includes knowledge of the applications of space, specialist expertise on the environment and environmental applications of Earth Observation (EO), the value EO generates for users, user requirements research, market identification and sizing, business case development and commercial feasibility analysis.

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1 About this whitepaper

Climate change is an increasingly pressing threat for mankind, and the UK Government clearly recognises that. Environmental and emission reduction policies are being put in place and financial incentives are being introduced across the country as part of efforts to tackle the problem head on.

In this whitepaper we discuss the potential of wetlands, both in the UK and worldwide, to contribute to these efforts. Unfortunately, this potential is currently being vastly under-utilised, with wetlands across the UK being used in environmentally destructive ways or otherwise allowed to degrade. Despite government, general public, and scientific support, a lack of cost-effective information-gathering techniques are to blame.

Funders of environmental projects need robust, transparent, independent, and credible information about the ongoing effects of their investment. Furthermore, proposed projects require detailed information to identify the most suitable areas and opportunities. Current methods of gathering this information are costly, slow, and have high marginal costs when extending coverage areas. Space-based Earth Observation (EO) methods can bring the costs of measurement down while providing high-frequency, scalable information that is substitutable with in-situ activities.

London Economics and ARGANS, with matched funding from the UK Space Agency, are developing a tool to provide precisely this EO data for wetlands. Such a tool can provide significant cost savings to a range of market participants, while simultaneously providing the transparency, independence, robustness, and ultimately credibility that those funding wetlands projects require to invest.

2 Climate change: searching for solutions

Climate change

The research is clear: the release of greenhouse gases (GHG) into the atmosphere, contributes to the greenhouse effect, and threatens ecosystems and our way of life. Scientists estimate that to limit the rise in the global average temperature to 1.5 degrees Celsius, humanity must restrict the atmospheric concentration of CO_2 to approximately 350 parts per million[1] (ppm).

There is already too much CO_2 in the atmosphere - CO_2 concentration is currently at 417 ppm[2] - so we must act to reduce ongoing emissions alongside removing some from the air if we are to hit the recommended target. Many proposed solutions to remove CO_2 from the atmosphere, such as directly capturing carbon from the air and burying it, are "complex, untested, and expensive"[3] according to the IMF, though promising efforts to develop this technology are ongoing.[4] This places greater emphasis on reducing emissions until carbon capture becomes technologically feasible and cost-effective. It is imperative to find ways to reduce emissions that are both environmentally and cost effective if climate change and its catastrophic consequences are to be mitigated.

[1] Hansen et al. (2008). Target Atmospheric CO_2: Where Should Humanity Aim? Available at https://arxiv.org/abs/0804.1126. [Accessed 29/03/2021].
[2] Carbon Brief. (2021). Met Office: Atmospheric CO_2 now hitting 50% higher than pre-industrial levels. Available at https://www.carbonbrief.org/met-office-atmospheric-co2-now-hitting-50-higher-than-pre-industrial-levels. [Accessed 29/03/2021].
[3] International Monetary Fund (2019). Nature's Solution to Climate Change. Available at https://www.imf.org/external/pubs/ft/fandd/2019/12/pdf/natures-solution-to-climate-change-chami.pdf. [Accessed 29/03/2021].
[4] Report of the Parliamentary Advisory Group on CCS (2016). Lowest cost decarbonisation for the UK: the critical role of CCS. Available at https://www.sccs.org.uk/images/expertise/reports/oxford/oxburgh_report_the_critical_role_of_CCS.pdf. [Accessed 29/03/2021]

The UK's role in mitigating climate change

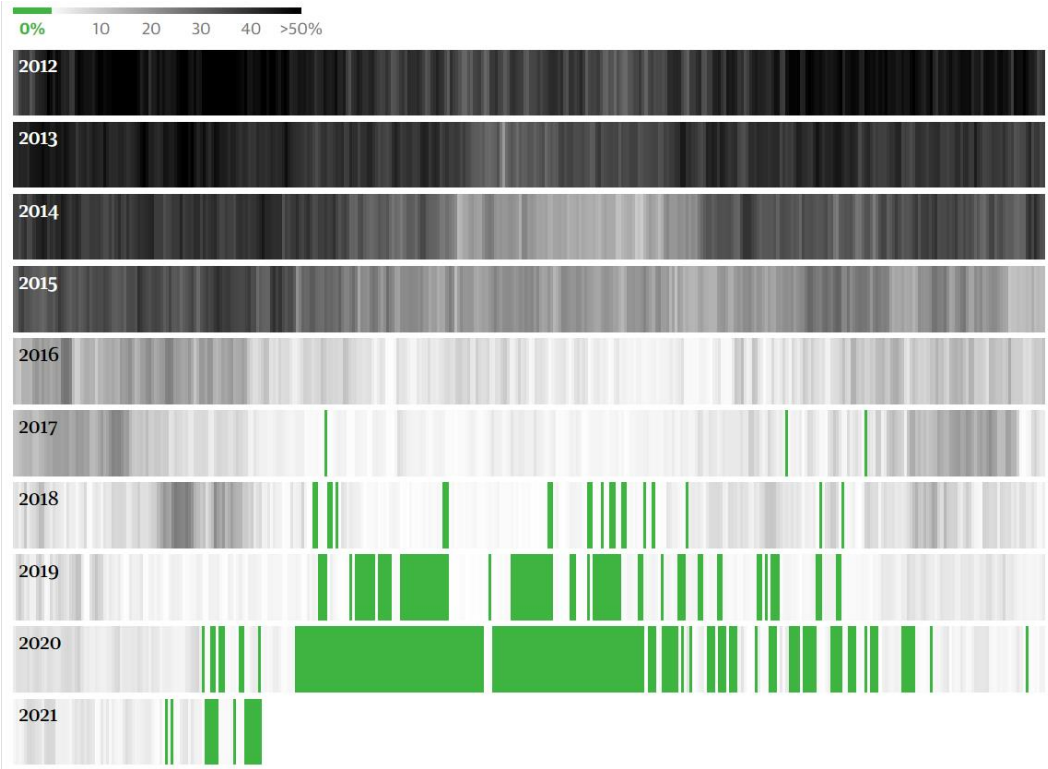
The UK was an early adopter of ambitious climate change targets. In 2008 the pioneering UK Climate Change Act committed the country to reduce 2050 GHG levels by 80% compared to 1990 levels. In 2019, this ambition was updated to net zero by 2050 – a first for a major economy.[5] This includes an early ambitious milestone of a reduction of at least 68% by 2030.[6]

On the global stage, the UK is also a signatory to the 2015 Paris Agreement, the result of the 2015 United Nations Climate Change Conference of the Parties (COP21) where 196 participating Parties, such as the UK, EU Member States, and China, agreed to act to limit global warming to below 2 degrees Celsius (°C), and preferably to the 1.5°C already referenced.[7] In climate ambitions submitted to the UN in 2020, the UK further committed to reducing emissions at the fastest rate of any major economy, and to doubling the number of green jobs[8] with the creation of 250,000 extra roles.

Despite the announcement in March 2021[9] that the UK has cut CO_2 emissions at the second fastest rate in the world since the Paris Agreement, largely thanks to a reduction in the use of coal to generate power (see Figure 1), UK Government projections show the country will miss its legally binding carbon targets later this decade.[10] The UK's ability to achieve its climate ambitions and continue to excel relative to its peers has obvious implications for its credibility as host of the 2021 United Nations COP26 conference in Glasgow, Scotland, adding yet more pressure to act on climate change.

[5] UK Government (2008; revised 2019). Climate Change Act 2008. Available at https://www.legislation.gov.uk/ukpga/2008/27/section/1. [Accessed 29/01/2021].
[6] UK Government (2020). The UK's Nationally Determined Contribution under the Paris Agreement https://www.gov.uk/government/publications/the-uks-nationally-determined-contribution-communication-to-the-unfccc. [Accessed 29/01/2021].
[7] UNCC (undated). The Paris Agreement. Available at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement. [Accessed 29/01/2021]
[8] ONS (2020). Low carbon and renewable energy economy, UK: 2018. Available at https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/finalestimates/2018. [Accessed 29/03/2021]
[9]The Times (2021). Britain is second best in the world at cutting carbon emissions. Available at https://www.thetimes.co.uk/article/britain-is-second-best-in-the-world-at-cutting-carbon-emissions-3cc0rmrw6. [Accessed 25/03/2021]
[10] UK Government (2019). Updated energy and emissions projections: 2018. Available at www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018. [Accessed 25/03/2021]

Figure 1 Daily share of Britain's power generated by burning coal



Source: Drax Electric Insights, available at https://www.theguardian.com/business/2020/apr/28/britain-breaks-record-for-coal-free-power-generation

Options for mitigating climate change

There is, of course, a need for rapid and large cuts from all sources of GHG, including CO_2 emissions, to meet net zero and Paris Agreement temperature targets. However, eliminating emissions is more difficult for some sectors such as cement, steel and chemical production, and heavy-duty transport.

Methods to capture greenhouse gases and trap emissions during industrial processes are under development.[11] However, to achieve net zero by 2050 it is very likely that residual emissions from these "harder-to-abate sectors"[12] will need to be balanced, or 'offset', by the removal of greenhouse gases from the atmosphere.

A combination of public pressure, binding policy commitments, and increasing engagement from the business community motivates companies in these sectors, governments, and consumers to commit substantial investments to offset carbon emissions. Alongside technology-based carbon capture methods still under development, greenhouse gases can be removed from the atmosphere **using nature-based solutions** that develop and protect carbon sinks, including afforestation and wetlands restoration and conservation.

[11]Grantham Research Institute on Climate Change and the Environment (2018). What is carbon capture and storage and what role can it play in tackling climate change? Available at https://www.lse.ac.uk/granthaminstitute/explainers/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/. [Accessed 29/03/2021].

[12] Energy Transitions Commission (2018). Mission Possible: reaching net-zero carbon emissions from harder to abate sectors by mid-century Available at https://www.energy-transitions.org/wp-content/uploads/2020/08/ETC_MissionPossible_FullReport.pdf. [Accessed 29/01/2021].

Wetlands as a carbon sink

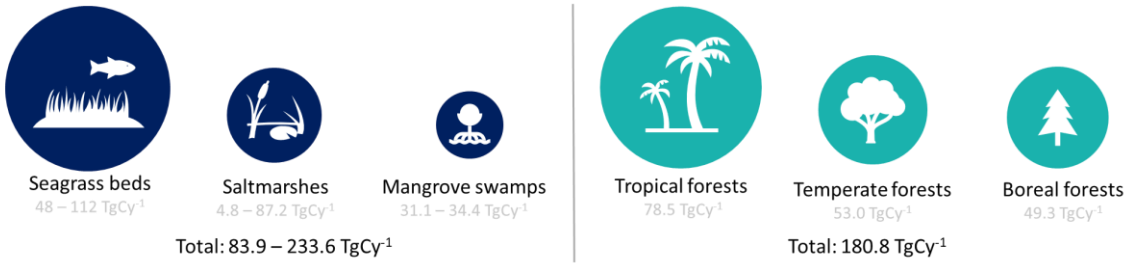
Atmospheric CO_2 is naturally captured and stored in wetlands, but this process can be enhanced through human-led activities that both improve the extent and quality of biomass and reduce the degradation of existing ecosystems. Martha Urrego, Secretary General of the Ramsar Convention on Wetlands goes as far as stating that "Wetlands are the most effective carbon sinks on our planet"[13].

Peatland is a prevalent type of wetland in the UK, with soil formed from carbon-rich dead and decaying plant material under waterlogged and low oxygen conditions. Deep peat in good condition is a natural carbon sink which stores carbon for hundreds or even thousands of years.[14] However, research in 2018 estimated that 80% of UK peatlands are in a degraded state.[15] In this damaged state the peat-forming vegetation is stripped away, exposing and drying peat that then releases carbon dioxide back into the atmosphere.

Damaged peatlands are therefore a net emitter of greenhouse gases at present. By one estimate[16] they emit over 20 million tonnes of carbon dioxide equivalent annually, generating **4% of the UK's total emissions**. Protecting peatlands from further damage and restoring them back to their natural state therefore also directly decreases existing carbon emissions.

To contextualise the size of the opportunity wetlands represent, an examination of the global potential for carbon storage by types of wetlands versus types of forest by the Wildfowl and Wetlands Trust, shown in Figure 2, finds that that the total annual capacity of wetlands to store carbon is very likely equal to or greater than forests[17].

Figure 2 Global potential for carbon storage, wetlands and forests



Note: $TgCy^{-1}$ = Teregrams of carbon per year, where 1 Teregram = 10^6 tonnes. Wetlands represent comparable global potential for carbon storage to forests, despite having an areal extent an order of magnitude smaller.

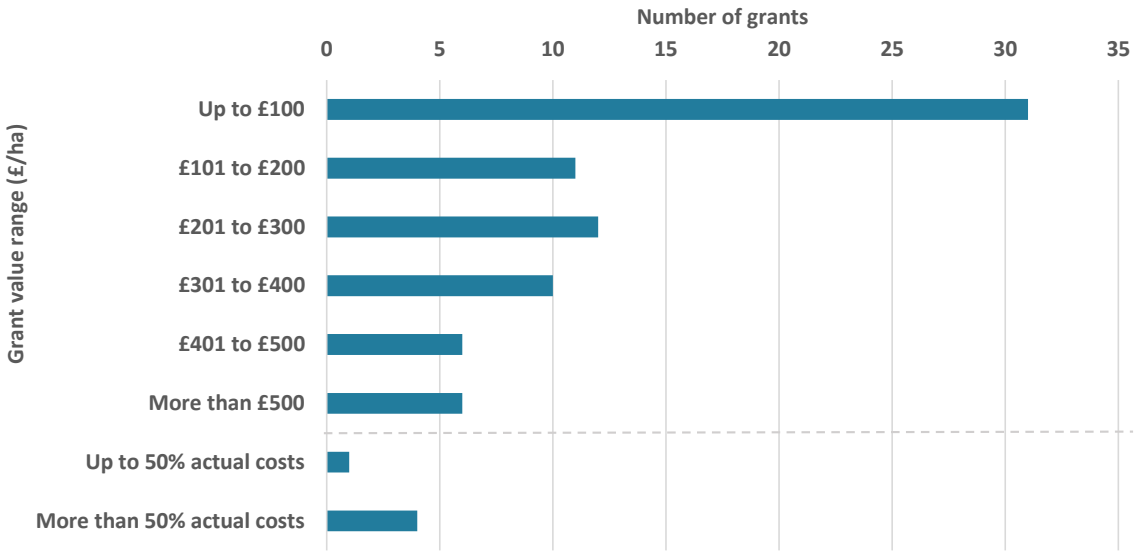
Source: McLeod et al. (2011). 'A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2'

[13] WWT (undated). Blue Carbon. Available at https://features.wwt.org.uk/blue-carbon/index.html. [Accessed 29/03/2021].
[14] ONS (2019). UK natural capital: peatlands. Available at https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalforpeatlands/naturalcapitalaccounts. [Accessed 27/01/2021].
[15] IUCN Peatland Programme. (2018). UK Peatland Strategy. Available at: https://portals.iucn.org/library/sites/library/files/documents/2018-015-En.pdf. [Accessed 27/01/2021].
[16] CEH. (2017). Implementation of an Emission Inventory for UK Peatlands. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1904111135_UK_peatland_GHG_emissions.pdf. [Accessed 27/01/2021].
[17] WWT (undated). Blue Carbon. Available at https://features.wwt.org.uk/blue-carbon/index.html. [Accessed 29/03/2021].

Wetland policy in the UK

Efforts are already underway to improve the management of the UK's wetlands. Brexit means that the European Common Agricultural Policy is being phased out in the UK. As part of this, the UK government is leading a strategy to incentivise farmers to improve their local environment (e.g., restoring wildlife habitats and creating woodlands to manage flood risks). Of the 200-plus individual grants that are available for land stewardship under the UK Government's Countryside Stewardship scheme, around 80 refer to wetland management practices[18]. The chart below summarises the value of these grants.

Figure 3 Wetland management grant values



Note: The chart shows the number of grants by grant value range that include incentives on the management of wetlands.
Source: London Economics analysis of UK Government Countryside Stewardship grants

From 2024, the government will introduce several new schemes such as the flagship Environmental Land Management (ELM) scheme to reward farmers for contributing to the production of public goods[19]. It was founded on the principle of 'public money for public goods' and is intended to provide a mechanism for achieving the goals set by the 25 Year Environment Plan[20] and achieving the commitments to net-zero emissions by 2050, while simultaneously supporting the rural economy. In addition, the ELM will also play a role in supporting the "30by30" target which plans to protect 30% of England's land for biodiversity by 2030, through habitat creation and restoration, and securing long-term management and protection for wildlife-rich habitats[21].

In addition to land management grants, DEFRA launched a £640m Nature for Climate Fund in 2020. This fund targets restoration of 35,000 ha of degraded peat in the UK and accompanies the new UK

[18] UK Government (undated). Countryside Stewardship grants. Available at: https://www.gov.uk/countryside-stewardship-grants. [Accessed 27/03/2021].
[19] Of course, farmland does not contain 100% of wetland area in the UK, and other schemes apply to other categories of landowners.
[20] The 25 Year Environment Plan aims to improve the UK's air and water quality and protect threatened plants, trees, and wildlife species. Published by HM Government in 2018, it is available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf. [Accessed 08/02/2021].
[21] Defra. (2020). The path to sustainable farming. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/954283/agricultural-transition-plan.pdf. [Accessed 08/03/2021].

Peatland Strategy, which aims to restore, reduce (damages), and protect peatlands. The Peatland Strategy targets two million hectares of peatland in good condition, under restoration, or being sustainably managed by 2040.

Barriers to wetlands as a solution

Wetlands thus have the potential to help achieve the UK's climate change ambitions. They constitute a meaningful portion of emissions, are currently in poor condition, and have significant upside potential for long-term carbon capture and sequestration, if properly maintained. Government subsidies to ensure adequate provision of the public good that is wetland maintenance are a good start, but barriers to widespread efforts remain. Mapping and surveying costs range from £20.70 to £57 per hectare and verifying ranges from £17 to £51.80 per hectare[22], representing prohibitive amounts when considering the millions of hectares of UK peatland[23]. Without innovation in how wetlands are utilised as part of the UK's environmental strategy, the opportunity they represent will continue to be underexploited.

3 Why are wetlands under-utilised as a solution?

Information underpins markets for carbon sequestration

Developing a good understanding the natural resources available is an important first step in any nature-based climate change solution. Natural capital accounting records the stocks of natural capital, e.g. the hectares of woodland and peatland, and the flows of services provided by this natural capital, such as amount of carbon sequestered and flood prevention benefits. These stocks and flows are recorded in both physical and financial terms.

To encourage specific uses of natural capital, such as wetlands, financial incentives are generally required. Wetland management activities have traditionally focused on providing services that generate financial revenues, such as cultivation and grazing – activities that led to the degradation of a substantial share of UK peatland. Estimates show that in the UK, 80% of peatland is degraded[24].

Box 1 Examples of peat use for agriculture and horticulture

In England, **38%** of peat is currently managed for intensive agriculture in the lowlands, which are highly profitable arable lands. One such area, the East Anglian Fens, has **90%** of its farmland classified at Grade 1 or 2 land. This means that much of the originally marshy wetlands is now high quality agricultural land which is subject to little or no limitations on its exploitation.[25]. It covers less than **4%** of England's farmed area but produces more than **7%** of the country's total agricultural

[22] London Economics analysis based on [1] Office for National Statistics (2019). UK natural capital: peatlands https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalforpeatlands/naturalcapitalaccounts. [Accessed 27/01/2021]. [2] Moxey, A and Morling, P. (2018) Funding for peatland restoration and management. Available at: https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-11/CoI%20Funding.pdf. [Accessed 29/03/2021]. [3] London Economics' stakeholder engagement.

[23] Office for National Statistics (2019). UK natural capital: peatlands, Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalforpeatlands/naturalcapitalaccounts. [Accessed 23/03/21].

[24] IUCN Peatland Programme. (2018). UK Peatland Strategy. Available at: https://portals.iucn.org/library/sites/library/files/documents/2018-015-En.pdf. [Accessed 27/01/2021].

[25] Land Research Associates (undated). Agricultural Land Grades and Maps. Available at http://www.lra.co.uk/services/soil-survey-soil-mapping/agricultural-land-grades. [Accessed 09/03/2021].

output and is worth **£1.23 billion** to the UK economy. Restoration may therefore not be economically viable in all settings.[26]

Furthermore, peat extracted from wetlands remains the main ingredient in sold growing media for horticulture. In 2019, peat represented **41.5%** (down from 58.2% in 2011) of growing media for retail[27].The UK 25 Years Environmental plan[28] aims to remove peat from horticulture by 2030 and focus on alternative growing media.

In an attempt to reduce destructive uses of wetland area, the Government introduced many of the subsidies and grants identified earlier, some of which are classed as Payments for Ecosystem Services (PES), with the goal of incentivising public and private landowners to regenerate and protect peatland. In economics, public goods are those that benefit everyone without being used up. Governments often intervene in the market to encourage their production as there is a tendency for undersupply as individuals wait for others to produce the goods and hence enjoy the benefits without having to pay the costs to produce them. The environmental benefit of improving peatlands management, which costs those carrying it out but benefits everyone as carbon remains sequestered rather than being released, is a clear example of a public good.

Box 2 Market mechanisms for conservation

Several well-established approaches to conservation utilise markets to provide benefits. These approaches aim to correct ecosystem-related market failures[29]. These can include[30] **public payment schemes**, where government pays land or resource managers to improve ecosystem services for the benefit of the wider public; **private payment schemes**, in which private beneficiaries of ecosystem services directly pay service providers; and **public-private payment schemes**, whereby government in partnership with private funds pay land managers or others to deliver ecosystems services.

Another important mechanism is payments for ecosystem services (PES). The distinguishing characteristic of PES is that there is a focus on the 'beneficiary pays' principle. This means that the beneficiaries of the ecosystem services cover the cost of their provision[31]. For example, a water utility may pay landowners upstream the rewet their peatland, which provides water filtration and thereby improves water quality. The key to a successful PES scheme is that both providers and beneficiaries always need to be better off under the contract than otherwise. This ensures continued provision of the ecosystem service.

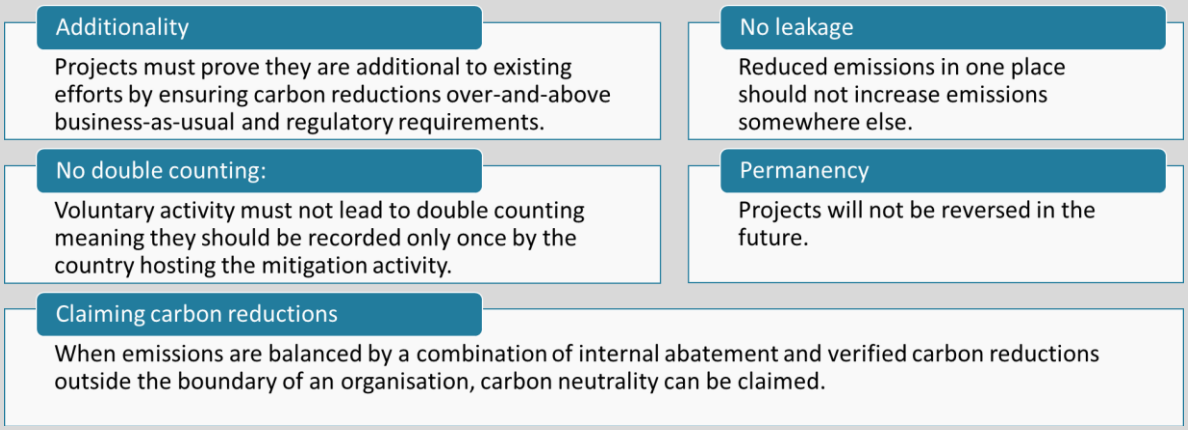
Offsetting is another popular market-based mechanism used to ensure the provision of ecosystem services, including for carbon. Offsetting is based on the 'polluter pays' principle. The market mechanism here is that the organisation or individual pays for the services that compensate for its/their negative impact on the environment, such as CO_2 emissions. This payment is generally facilitated by the creation of 'carbon credits' which polluters can purchase. The standard practice is

[26] Defra. (2020). England Peat Strategy. Available at: https://consult.defra.gov.uk/natural-environment-policy/b005767e/supporting_documents/England%20Peat%20Strategy_policy%20discussion%20document.pdf [Accessed 09/03/2021].
[27] Defra. (2019). Growing media monitor. Available at: https://hta.org.uk/uploads/assets/baa50362-3876-4a46-9690c7fb711446a9/Report-vf.pdf [Accessed 09/03/2021].
[28] HM Government (2018). A Green Future: Our 25 Year Plan to Improve the Environment. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf [Accessed 08/02/2021].
[29] Market failures are instances of inefficient distribution of resources or when market forces lead to a net social welfare loss. See https://www.iied.org/markets-payments-for-environmental-services. [Accessed 27/01/2021].
[30] Please see DEFRA (2013). *Payments for Ecosystem Services: A Best Practice Guide*, for more details.

for one of these credits to be equivalent to a one tonne reduction of CO_2 emissions, meaning purchasers can fully offset their emissions by purchasing an equal number of carbon credits.

Carbon credits are issued by verifying agencies, which independently audit the capacity of a particular method to reduce or capture emissions. The auditing and verification process is particularly important, as purchasers need to know that some key requirements are being fulfilled. Some of the requirements[32] are presented in the figure below.

Figure 4 Carbon credit purchaser requirements



Source: ICROA. (2020). Position paper. Voluntary actions post 2020.

Offsets play a key role in many corporate climate strategies. Given this, companies could be concerned about staking their reputations on projects that are far away and difficult to monitor. The NGO Carbon Market Watch notes[33] that 'problematic additionality testing and difficult monitoring, reporting, and verification' are inherent risks in the offset market. Unfortunately, these concerns are too often well-founded: Bloomberg reports that just 10% of the offsetting credits currently on the market are delivering the verifiable action they promise, harming the long-term future of the market[34] [35].

Purchasers need robust, transparent, independent, and credible information about the ongoing effects of their investment to have enough confidence to invest public or private money in nature-based solutions that are not readily observable. Furthermore, proposed projects require detailed information to identify the most suitable areas and opportunities for offsetting. Despite government, public, and scientific support, a lack of cost-effective information-gathering techniques are to blame for hampering the market for UK (and global) wetlands as a carbon sequestration option. Indeed, researchers are still finding large new wetlands, such as the 150,000 square kilometres peatlands discovered in Congo in 2017. These previously unidentified peatlands hold an

[32] ICROA (2020). ICROA's position on scaling private sector voluntary action post-2020. Available at https://www.icroa.org/resources/Documents/ICROA_Voluntary_Action_Post_2020_Position_Paper_March_2020.pdf [Accessed 27/01/2021].
[33] Carbon Market Watch (2013). REDD. Available at https://carbonmarketwatch.org/2013/04/09/redd/ [Accessed 29/03/2021].
[34] Bloomberg (2020). Carbon Offsets Risk Libor Moment Without Tougher Rules. Available at https://www.bloomberg.com/news/articles/2020-09-02/carbon-offsets-risk-libor-moment-without-tougher-rules [Accessed 27/01/2021].
[35] Instances of outright fraudulent claims have occasionally become known, though these often come from the much larger and more closely monitored compliance market. For example, a study by the Stockholm Environment Institute showed outright fraught in a number of joint development mechanism projects: https://www.sei.org/featured/joint-implementation-undermined-global-climate-ambition-study-finds/. [Accessed 27/01/2021].

estimated 30 billion tons of carbon, equivalent to a full 20 years of CO_2 emissions from the USA[36]. This case highlights the potential for discovery of new and under-utilised wetlands across the globe.

Current methods for assessing wetlands' potential

Direct measurement of carbon emissions before, during, and after wetlands conservation projects is possible, though these are sensitive to several factors including the water table, temperature, and vegetation growth. Direct measurements are done via in-situ stations that measure continuous fluxes. These methods require labour-intensive, complex, and expensive equipment. For instance, assessing the effect of 'rewetting' wetlands using a technique called direct flux measurement costs in the order of €10,000 per hectare per year[37].

Other, cheaper, methods are based on indirect estimations of the carbon flux through direct measurements of indirect variables. Peatland carbon flux is currently estimated by classifying the state of the peat blanket and mapping the level of ground erosion in the surroundings of the site[38]. These indirect methods save on costs but also produce far less accurate information on the opportunity and impact of areas of wetlands for carbon sequestration.

Earth Observation as an economical solution

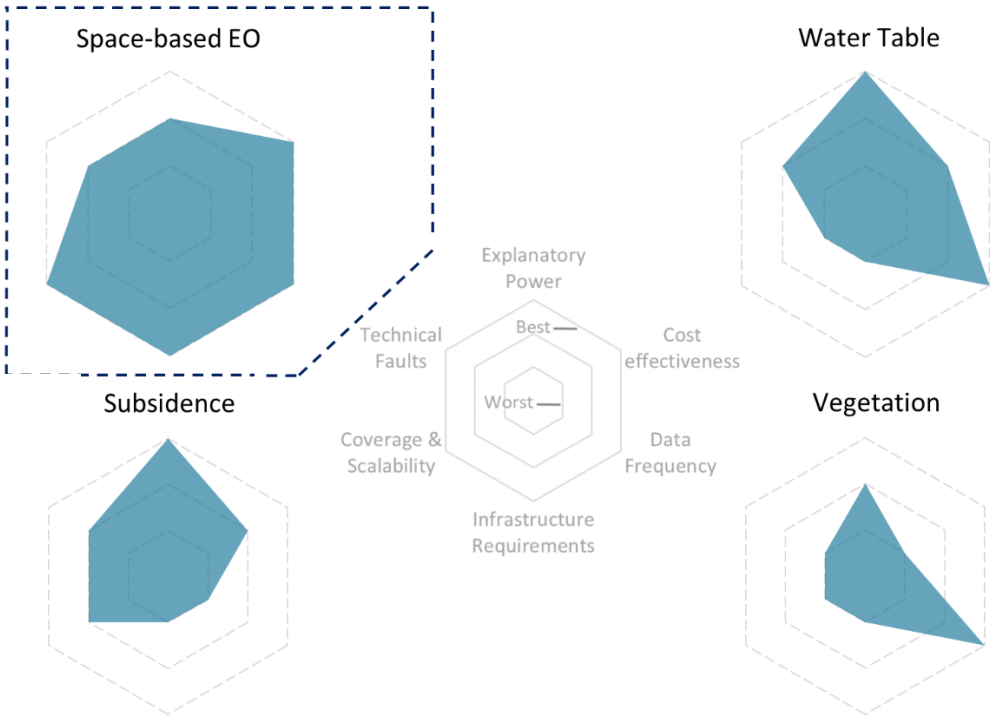
The costs associated with direct measurements of indirect variables impede scalability. The proxies currently measured (peat blanket status, ground erosion) are measured in-situ and necessitate humans physically visiting and working in locations that are often vast, remote, and difficult to navigate. These measurement costs are necessary to verify that projects actually meet the requirements summarised earlier. Naturally, even the cheaper methods of gathering information suffer serious drawbacks due to financial constraints, which, in turn, limit time and staff that can be committed. These constraints result in precisely the lack of information that hamper the market for UK wetlands as a carbon sequestration option.

Space-based solutions can provide proxy estimation that is heavily correlated with in-situ activities. One key advantage of remote sensing, using measurement devices on satellites orbiting the earth, is the **scalability** of activities. The ease of extending the geographical coverage of a satellite to a new area can **drastically reduce costs.** Space-based Earth Observation (EO) solutions support consistent, wide-area, scalable, repeatable monitoring, change detection, and hot-spotting over hard-to-reach areas and have consistently been shown to be more cost-effective than conventional terrestrial methods (e.g. aerial surveys, in-situ surveys) for environmental monitoring[39]. For example, space-enabled solutions are up to **seven and twelve times more cost-effective** than non-space-based solutions for agriculture and forestry applications, respectively[40].

[36] Yale Environment 360. (2017). Can We Find the World's Remaining Peatlands in Time to Save Them? Available at https://e360.yale.edu/features/can-we-discover-worlds-remaining-peatlands-in-time-to-save-them [Accessed 29/03/2021]
[37] Joosten and Couwenberg. (2009). Are emissions from peatland MRV-able? Available at: http://www.imcg.net/media/download_gallery/climate/joosten_couwenberg_2009.pdf [Accessed 27/01/2021]
[38] IUCN UK. (2017). Peatland Code. Field Protocol. Available at: http://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/PC_Field_Protocol_v1.1.pdf [Accessed 29/01/2021]
[39] London Economics. (2019). Value of satellite-derived Earth Observation capabilities to the UK Government today and by 2020. Available at https://londoneconomics.co.uk/wp-content/uploads/2018/07/LE-IUK-Value-of-EO-to-UK-Government-FINAL-forWeb.pdf [Accessed 29/03/2021]
[40] London Economics (2019). Economic evaluation of the International Partnership Programme (IPP): Cost-effectiveness Analysis. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833420/UKSA_IPP_Cost_Effectiveness_Analysis_-_FINAL_for_web.pdf [Accessed 29/03/2021]

Space-based solutions compare favourably to each of the currently utilised methodologies. Figure 5 indicates the relative performance of a satellite-based EO methodology relative to three common methodologies: water table, subsidence, and vegetation analyses, all of which are performed using data collected during physical site visits. Water table analysis involves drawing many samples from wells, which provides high-quality but high-cost information. Subsidence analysis entails monitoring the change in peat height (also known as subsidence) due to shrinkages or oxidation, providing low frequency and poor scalability data, which is, however, of high quality. Finally, vegetation analysis, which requires high-cost and high-tech 'Multiple Eddy Covariance Towers' comes with very high initial and marginal costs when extending coverage, and generates information that is highly correlated with that of space-based solutions.

Figure 5 Relative performance of wetland monitoring methodologies



Note: Key characteristics of each method for proxying CO_2 in wetlands, with a rating summarising the relative 'success' in each of the performance areas.

Note: Explanatory power: capacity to explain the outcome variable; Cost effectiveness: providing good value for the amount spent; Data frequency: how often data is collected; Infrastructure requirements: expenditure needs for equipment; Coverage & scalability: proportionality of infrastructure costs with area covered; Technical faults: susceptibility to equipment failures.

Source: London Economics literature review

4 Unlocking the potential of UK wetlands: the EO solution

Space-based Earth Observation (EO) methods can bring the costs of measurement down while providing high-frequency, scalable information such that many constraints on the market for UK wetlands as a carbon sequestration option are much reduced, if not entirely removed.

With matched funding by the UK Space Agency's National Space Innovation Programme (NSIP), London Economics and ARGANS have investigated the commercial and technical viability of an EO solution. The proposed tool that was investigated has two key features:

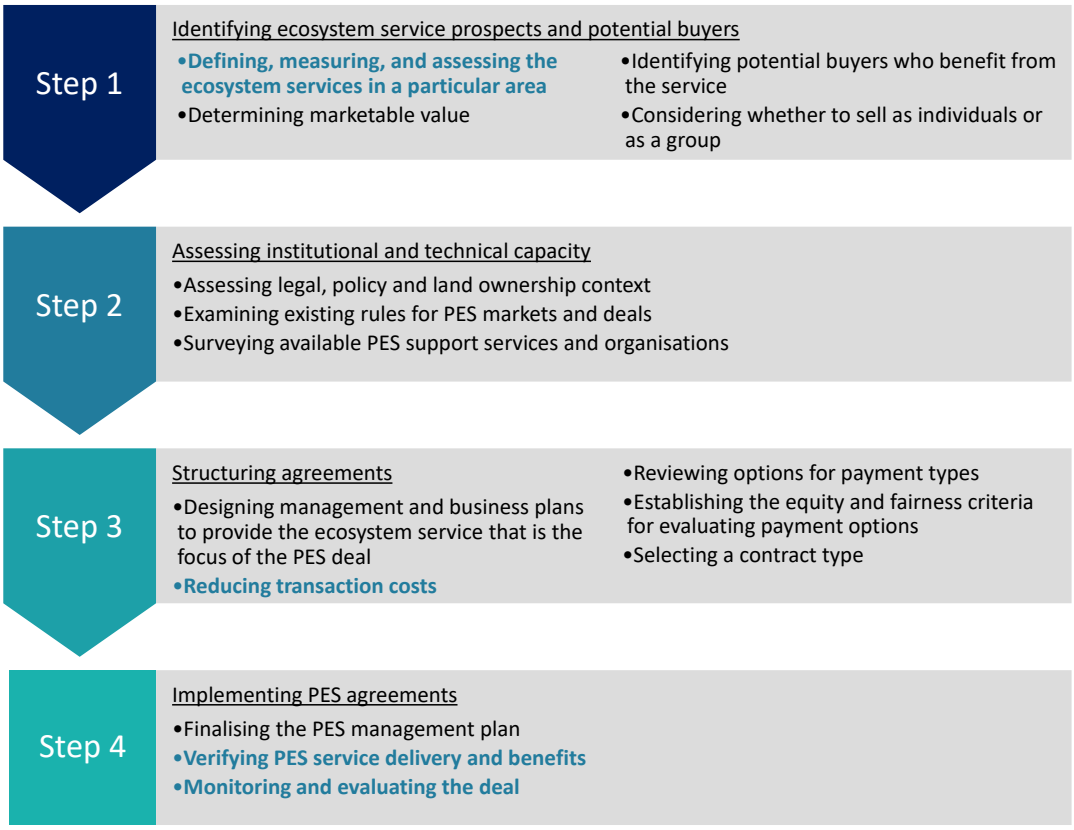
- **Feature 1:** A **mapping feature** to identify the extent of wetlands and those with greatest needs for preservation as well as degraded wetlands and areas best suited for restoration.
- **Feature 2:** A **monitoring feature** to provide data that indicate the conditions of the wetlands over time. By using land change methods, the tool can track the restoration progress over time and provide accurate measures of sequestered carbon at a given point in time and space.

The first feature will enable governments and other funders of carbon sequestration initiatives to identify more land ripe for restoration than currently known owing to the scalability of space-borne technologies coupled with artificial intelligence. This method is more cost-effective than traditional surveying (on-site or aerial photography).

The data provided by the second feature can support several objectives, including verification for the voluntary carbon offset market, and monitoring and verification of Government grants and subsidies in agriculture. Monitoring from space not only provides a cost-effective solution, but also allows for repeated accurate measurements of land change, is less prone to error, and provides a more transparent and scalable solution.

To implement any PES or sell credible carbon credits successfully, several steps need to be considered, as outlined by the UNEP[41]. Based on our initial assessment, space based EO can support several of these steps. We highlight them **in blue**.

Figure 6 Space-based EO's contribution to environmental project implementation

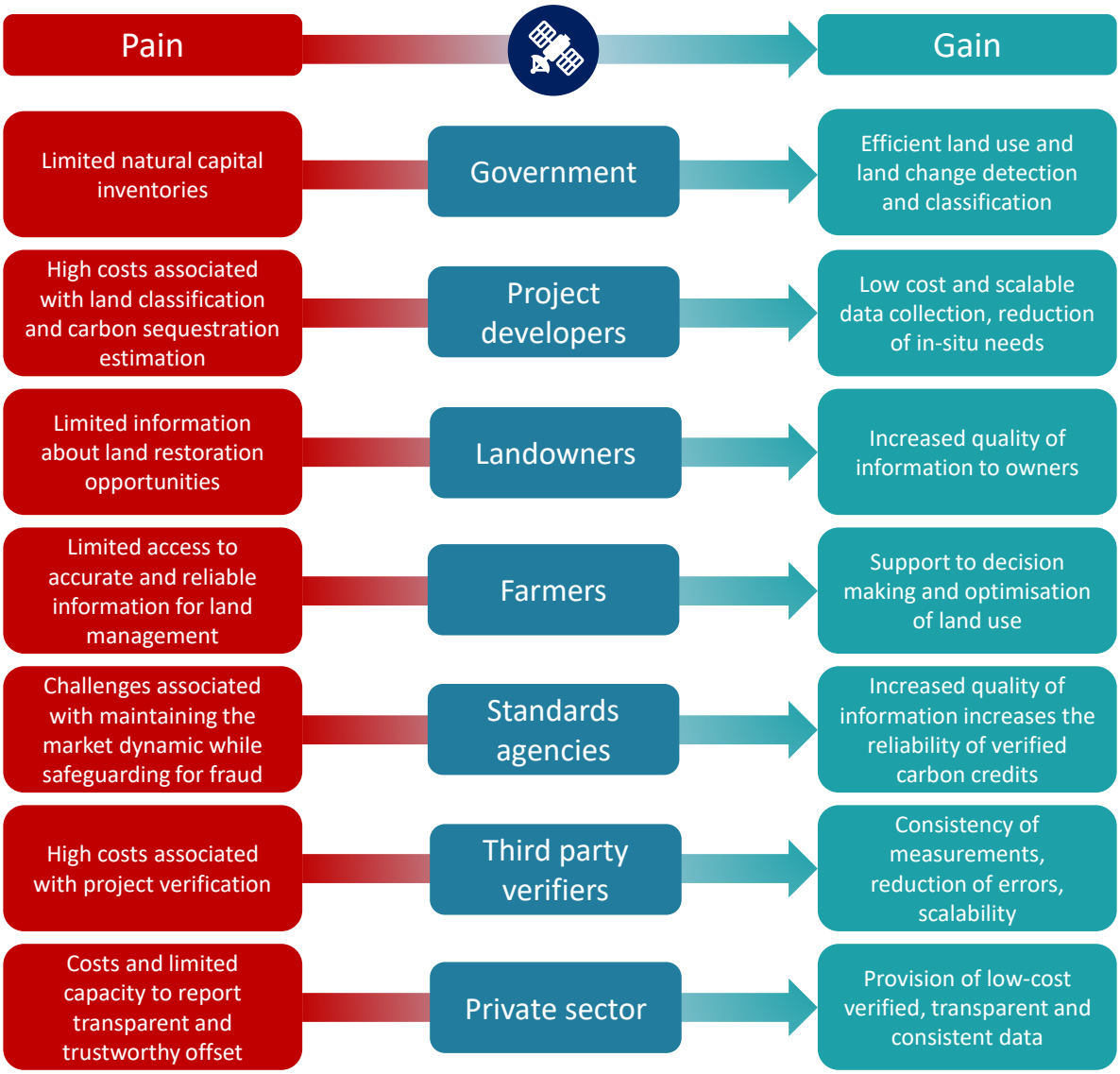


Source: London Economics analysis of UNEP report on PES.

[41] UNEP. (2008). Payments for Ecosystem Services: Getting Started - A Primer (unep.org). Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/9150/payment_ecosystem.pdf?sequence=1&isAllowed=y. [Accessed 27/01/2021].

EO methods can ease the collection of data about wetland carbon sequestration and reduce the information constraints currently in place for many stakeholders Seven different groups of stakeholders are identifiable, ranging from commercial companies seeking to communicate transparent and trustworthy offset efforts to the public to improve brand reputation and meet CSR goals to farmers and landowners who can make better informed land-use decisions. The breakdown of use cases and gains is detailed in the figure below.

Figure 7 Space-based wetland mapping and monitoring use cases



Source: London Economics

5 Market opportunities

A commercial mapping and monitoring application has the potential to fill a key niche in several markets. The market for wetlands regeneration appears to offer notable commercial potential since the **need for mapping and monitoring services is shared by all areas of the market** – including the supply-side (landowners, developers of wetland restoration projects, and those that supply certification of carbon credits), and demand-side (companies, consumers, and governments that finance restoration projects and obtain certified carbon credits). As already discussed, non-EO based

methods for mapping and monitoring of wetlands regeneration and carbon sequestration exist, but these are often costly, slow to update, and difficult to scale. By offering low-cost solutions to each of these drawbacks, EO solutions pose a **highly commercially viable alternative** that can drive the market for wetlands as a carbon sequestration option to new heights.

Multiple needs have emerged from national pilots of land stewardship policy updates and an EO tool could support both landowners and public bodies responsible for subsidy systems. Landowners and farmers have repeatedly stated that there is a need for land management tools. These tools need to include many data layers to be able to provide the most detailed and accurate information, and hence support decision making at the farm level, support policy making at the national level, and underpin natural capital accounts. Such a tool could also be used by policymakers to monitor individual reporting and ensure there is no deviation or abuse of the subsidy regime. The Rural Payment Agency has already used satellite data to maintain compliance with the EU Common Agricultural Policy.

Further, with market demand for environmental services projected to increase due to increasing climate change consciousness and mitigating actions of governments, businesses, and consumers, we expect significant public and private capital to be devoted to carbon mitigation efforts, with wetlands regeneration being one beneficiary. As presented earlier, the UK Government committed to become carbon neutral by 2050, but increasing **private investments** in offsets may be driven by the following factors:

- **Brand reputation**: For some consumer groups, brand reputation has become closely tied to impacts on the planet[42], leading to traditional brands seeking to recapture their demand. For example, Arla UK now produces the first carbon neutral milk by using offsets[43].
- **Green finance and ESG rankings**: Investors increasingly scrutinize companies' ESG scores - offsets help companies to boost scores by allowing them to reach net neutral or reach this sooner. To improve their score, private companies can invest in abatement methods (including carbon offsets) to reduce/compensate for their emissions.
- **Climate risk disclosure:** The UK government is increasing its efforts to push large companies to disclose their dependencies and impacts on nature[44].

The result is a trend towards companies making sustainability commitments and undertaking action plans to meet these commitments. For example, a 2019 survey by YouGov with 502 UK businesses found that **46%** of respondents said their organisation planned to become carbon-neutral by 2030[45] (e.g. Aldi UK, Marks & Spencer). According to EcoAct, **45%** of FTSE companies have committed to be net-zero by 2050, however, only 16% have a credible strategy to meet these requirements[46].

British businesses have often been at the forefront of these developments. Aviva, for example, became the first carbon neutral life insurer in the world in 2006 – with the help of offsets[47]. Likewise,

[42] For example, a recent poll by Censuswide for Aviva shows 9% of 16–24-year-olds have become vegan, or across the population reduction in met consumption sits at 32%: https://www.aviva.co.uk/aviva-edit/in-the-news-articles/generation-woke-over-55s/
[43] Arla (2020). Carbon Neutral milk launch – Here's how it works. Available at: https://www.arla.com/company/news-and-press/2020/news/carbon-neutral-milk-launch/. [Accessed 27/01/2021].
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EasyJet is to become the world's first major carbon neutral airline[48]. The London School of Economics is hoping to do the same, as the first university[49].

According to the same report: "Alignment to the Taskforce on Climate-related Financial Disclosures has increased rapidly from only 15% of FTSE 100 companies in 2018 to 56% in 2020 as companies respond to investor demands for business climate risk assessments."

Our assessment of the restoration market value shows that over the next 30 years, if national efforts achieve the set goal of restoring up to 55% of the degraded wetland[50], the UK market for mapping, surveying, and verification could be worth **tens of millions of pounds until 2050**. There are also significant international opportunities to utilise a tool that assists in the same tasks, resulting in a healthy potential export market.

6 Concluding thoughts

Wetlands, both in the UK and overseas, have huge potential to play a role in climate change and emission reduction ambitions. This potential is currently being under-utilised due, in part, to the prohibitive cost of acquiring information to identify, monitor, and verify the progress of environmental projects. We have outlined the benefits of a Space-based Earth Observation tool and highlighted the healthy size of the potential market for such a product.

Contact

If you have any questions or wish to register your interest in our work, we welcome you to get in touch.

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