OPTIMISING CARBON SEQUESTRATION OPPORTUNITIES IN ARGYLL & BUTE

Economic Impact
Final Report
for
Highlands and Islands Enterprise

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Contents

1 INTRODUCTION

OVERVIEW

1.1 With climate emergency very high on the political agenda in Scotland, the UK and internationally, there is a great deal of interest in opportunities around carbon sequestration. In response, carbon markets have already been developing.

1.2 ekosgen was commissioned by Highlands and Islands Enterprise to undertake an assessment of the socio-economic potential of carbon sequestration activities in Argyll & Bute. This work forms part of a wider project considering the carbon sequestration potential of Argyll & Bute. This project is being delivered by Highlands and Islands Enterprise on behalf of Argyll & Bute Council as part of wider work examining carbon sequestration in Argyll & Bute, supported by funding from the Community Renewal Fund.

1.3 There are seven work packages in total within the project, and whilst these are discrete, they are integrated. This study forms part of Work Package 4, and has been informed by findings from Work Packages 1 and 3. Its findings will be used to inform the development of business models as part of Work Package 5.

REPORT PURPOSE AND STRUCTURE

1.4 This report focuses on the economic impacts that can be achieved under different carbon sequestration approaches in Argyll & Bute. The report is structured as follows:

- Chapter 2 summarises the socio-economic context in Argyll & Bute;
- Chapter 3 provides an overview of trends in carbon sequestration and carbon markets;
- Chapter 4 sets out a high-level baseline for land use and carbon sequestration potential (in land use terms) in Argyll & Bute;
- Chapter 5 discusses potential economic impacts; and
- Chapter 6 sets out a range of scenarios to illustrate the potential impacts that may arise from different modes of carbon sequestration activity in the area.

2 CONTEXT

Summary

- As of 2021, Argyll & Bute has a population of around 86,200, accounting for 1.6% of Scotland's total population. Since 2000, the population of Argyll & Bute has declined by 5%.
- Argyll & Bute has a significantly older population than that of Scotland as a whole: more than 26% of the population is aged 65+, versus only 19% nationally.
- The ageing population can partly be attributed to the issue of outmigration, with Argyll and Bute having a negative net migration trend. The Council has found tackling the issue of youth retention to be challenging.
- The population of Argyll & Bute are sparsely located across 7,000km^2, with no single dominant employment and service centre and a population density of 12.1 inhabitants per km^2. This is further evidenced by 57% of all business sites in Argyll & Bute being located in Remote Rural locations.
- Employment in Argyll & Bute has a higher concentration of employees in small business (56%) and those self-employed (10%) than the national averages (49.6% and 7.8%, respectively).
- With the above factors in mind, Argyll & Bute requires an economic opportunity to act as a catalyst to reverse the trends of a declining, ageing and sparsely located population.
- 30% of the land (2,000km^2) in Argyll and Bute is dedicated to woodland, with the vast majority (85%) of this being commercial conifer. Forestry is a key sector in Argyll & Bute's economy and therefore HIE and public sector partners are well-placed to consider sequestration activity in forestry.
- Further, there is a strong dependence on agriculture in Argyll & Bute – with over 9% of the total workforce working in agriculture, forestry and fishing. This has implications for silvopasture opportunities, where agricultural land could yield better carbon results by combining trees and forage while maintaining livestock yields.

INTRODUCTION

2.1 This chapter sets out the context for carbon sequestration activities in Argyll & Bute. It considers the Argyll & Bute context in terms of geography and the socio-economic characteristics of the area.

THE ARGYLL & BUTE CONTEXT

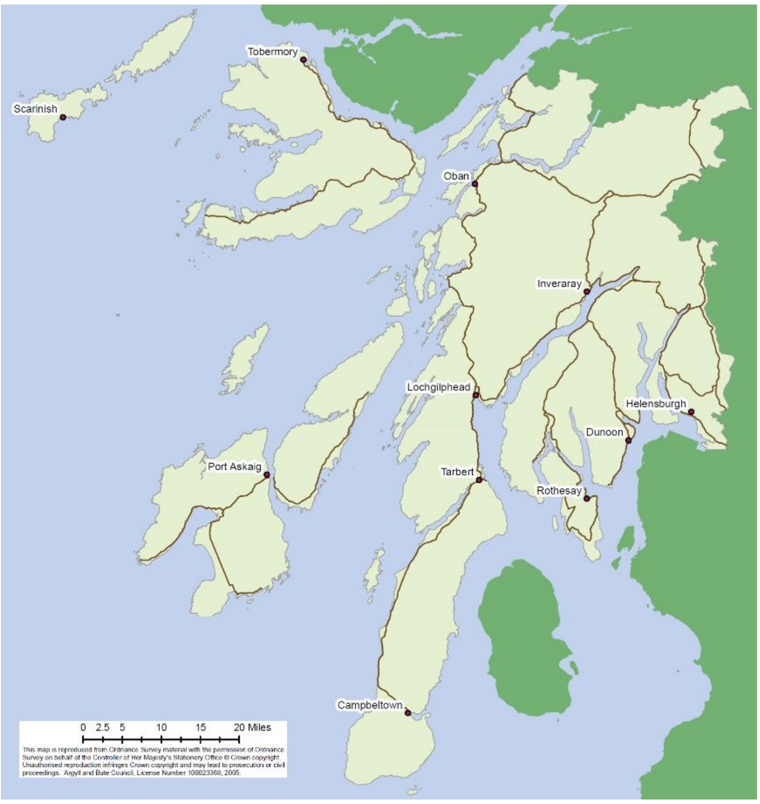
Geographical characteristics

2.2 Argyll & Bute is a sparsely populated local authority area in the West of Scotland. It lacks a single dominant employment and service centre and rather incorporates six main towns. These are: Lochgilphead (the administrative centre) located in mid-Argyll; Oban to the north west of the area and part of Oban, Lorn and the Isles; Campbeltown in south Kintyre; Rothesay on the Isle of Bute; Dunoon on the Cowal peninsula; and Helensburgh which is the largest town and sits at the intersection of the Firth of Clyde, East Clyde and the Gareloch.

2.3 Argyll & Bute covers a large geographic area of just under 7,000km^2, which makes it the second largest local authority by area in Scotland. As shown in Figure 1.1, parts of east Argyll & Bute are in relatively close proximity to Glasgow and are thus well-connected to the Central Belt (specifically Helensburgh and Lomond). However, many parts are comparatively distant in terms of transport connectivity, and as such much of Argyll & Bute is geographically remote – particularly its island communities.

2.4 The total population of Argyll is Bute was just over 85,000 in 2020. The area has a very low population density of approximately 12.1 inhabitants per km^2, which in itself presents a number of infrastructure, socio-economic and connectivity challenges.

Figure 2.1. Map of Argyll & Bute



Source: Argyll & Bute Council, 2022

Land Coverage type

2.5 Argyll & Bute is closely bound with woods and forests, many of which have considerable social, cultural, and environmental significance. There are significant sections of semi-natural woodland in Argyll & Bute, many of which contribute significantly to the area's natural and cultural history. However, much of the woods were planted in the years after the foundation of the Forestry Commission in 1919. The area was instrumental in quadrupling Scotland's forest cover throughout the twentieth century.[1]

2.6 Woodlands and forests cover 30% of Argyll & Bute, totalling 2,00km^2. These woodlands and forests represent 15% of Scotland's total forest resource. Around 85% comprises productive and commercial coniferous forests, with the remainder comprising seminatural and native woodland with birch and Atlantic oakwood dominating.

2.7 Argyll & Bute has around 37,500ha of ancient woodland (an area of land where there has been a continuous cover of trees since 1600). 27,000ha are semi-natural in origin.

Socio-economic characteristics

Population and migration

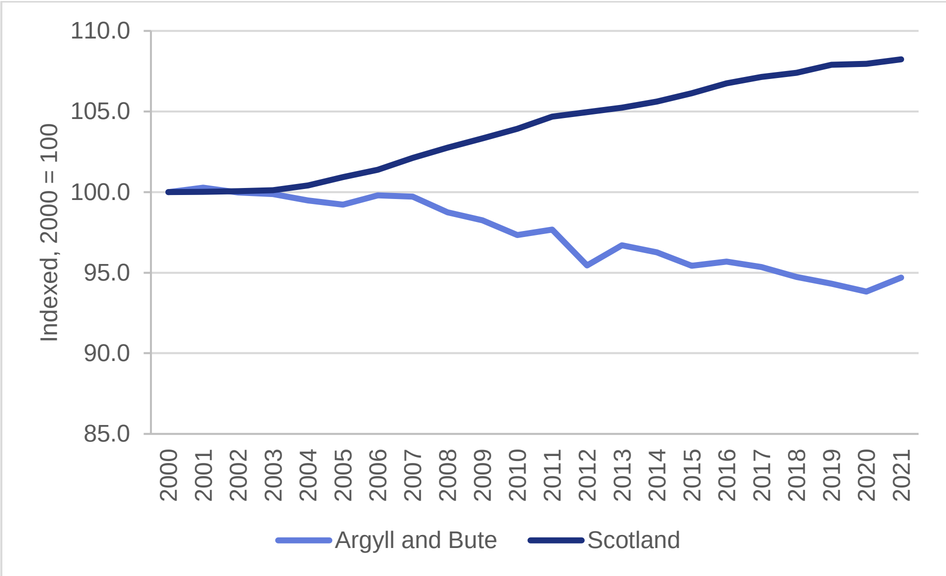
2.8 As of 2021, Argyll & Bute has a population of around 86,200, accounting for 1.6% of Scotland's total population.[2] The overall trend in Argyll & Bute's population is that of significant decrease. Since

[1] https://www.argyll-bute.gov.uk/sites/default/files/planning-and-environment/Woodland%20and%20Forestry%20Strategy%20Consultation%20Draft.pdf

[2] NRS Population Estimates (2022)

2000, the population in Argyll & Bute has decreased by over 5% (Figure 2.2); this was the third lowest proportional decrease in Scotland after Inverclyde and West Dunbartonshire. However, between 2020 and 2021, Argyll & Bute's population saw an increase of around 1%.

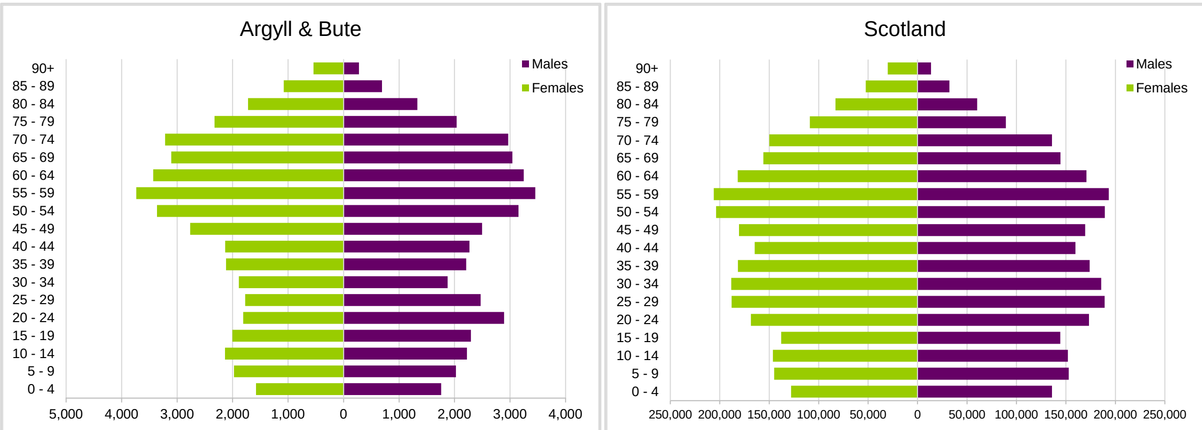
Figure 2.2. Population growth, 2000-2021



Source: NRS Population Estimates, 2022

2.9 Figure 2.3 shows the population structure of Argyll & Bute, with the gender split detailing an increasingly balanced proportion split of males and females living within the area. Argyll & Bute has a significantly older population than that of Scotland as a whole: more than 26% of the population is aged 65+, versus only 19% nationally. This is indicative of out-migration, particularly of younger people. Previous research has identified the population retention and attraction challenge that the area faces with regards to young people.[3]

Figure 2.3: Age composition of population, 2020



Source: ONS Population Estimates, 2022

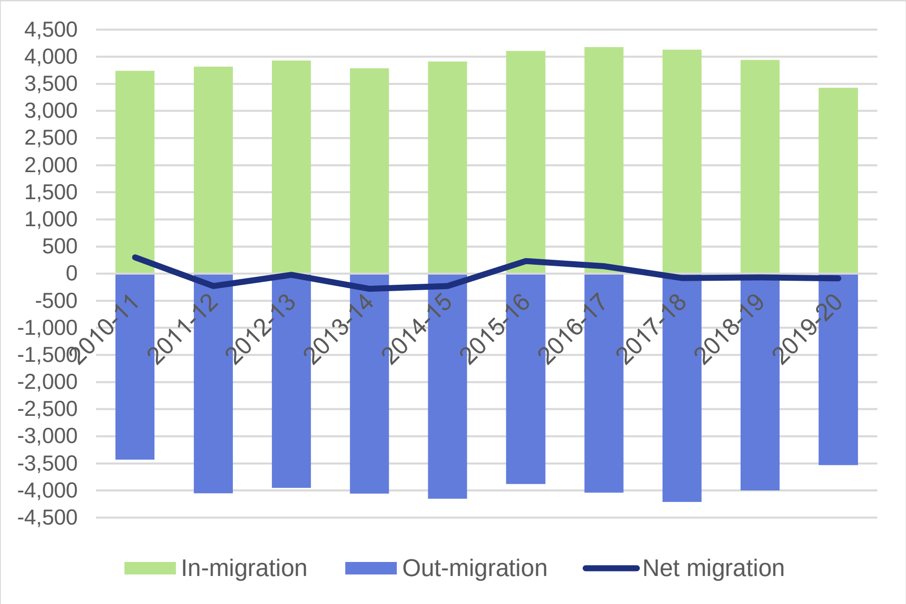
Migration

2.10 Figure 2.4 shows that across each yearly output between 2010-11 and 2019-20, there has been a negative net migration trend within over half of the recorded periods. The lowest net migration rate recorded is between 2013-14, with a net migration of -280 people, followed by -230 people in 2014-15. Despite a brief spell of positive net migration, this returns to a negative trend from 2017-18 onwards.

[3] See for example: ekosgen for HIE (2018) Young People in the Highlands and Islands – Maximising Opportunities

2.11 The most significant out-migration occurs between 2017-18, with 4,210 people migrating elsewhere. This is further worsened by a continual decline of in-migration levels since 2016-17. The recorded in-migration of 3,430 people in 2019-20 is a -17.9% decrease from 2016-17 in which 4,180 people migrated to Argyll & Bute.

Figure 2.4. Migration trends of Argyll & Bute, 2010-2020

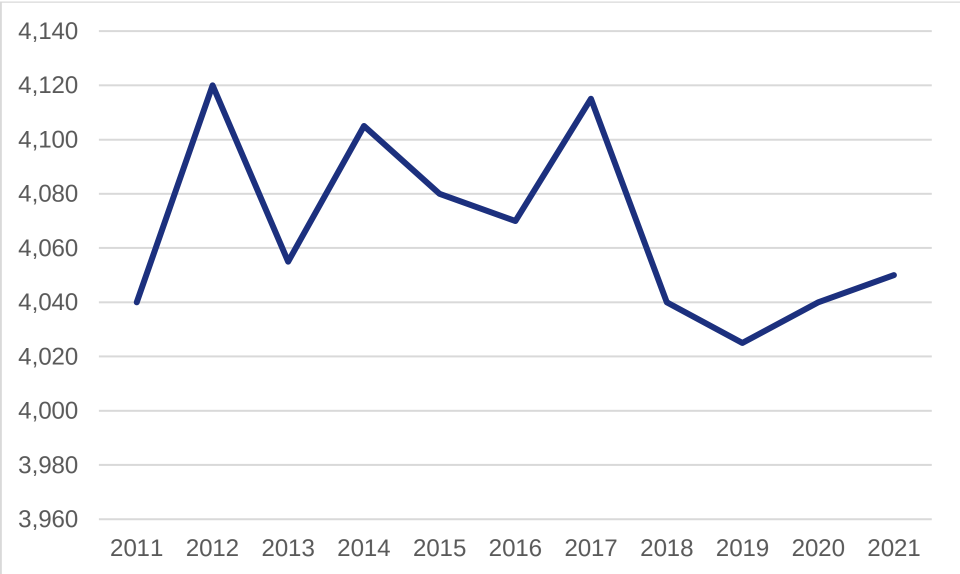


Source: National Records of Scotland, 2021

Business base and employment

2.12 As of 2021, there were 4,050 businesses operating in Argyll & Bute, accounting for only 1.2% of the national business base. Between 2011 and 2021, there was an uplift of 10 (0.2%) businesses.

Figure 2.5: Number of businesses in Argyll & Bute, 2011-2021

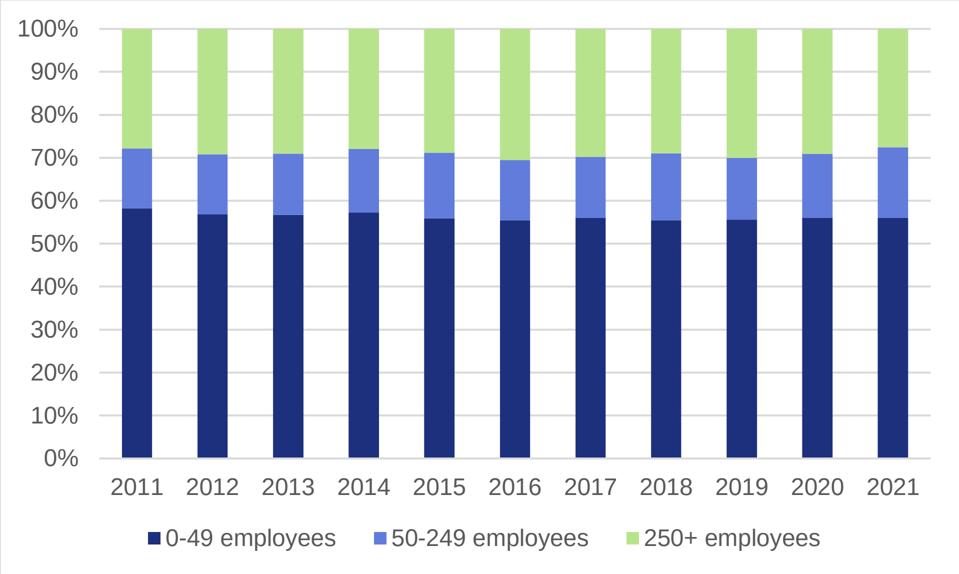


Source: Scot Gov, Businesses in Scotland 2021, 2022

2.13 In 2021, 15,630 of employees at businesses in Argyll & Bute were working at small companies (0-49 employees), accounting for 56.0% of the total number of employees in the area. Employees at medium sized businesses (50-249 employees) accounted for 16.5% (4,610 employees) of the total employees in the area, with employees at large businesses (250+ employees) accounting for 27.5%

(7,700 employees) of the total employment in Argyll & Bute. This compares to Scottish averages of 36.5% employment in small companies, 13.9% employment in medium companies and 49.6% of employment in large companies.

Figure 2.6. Share of Argyll & Bute employment by employment size band, 2011-2021



Source: Inter Departmental Business Register (ONS)

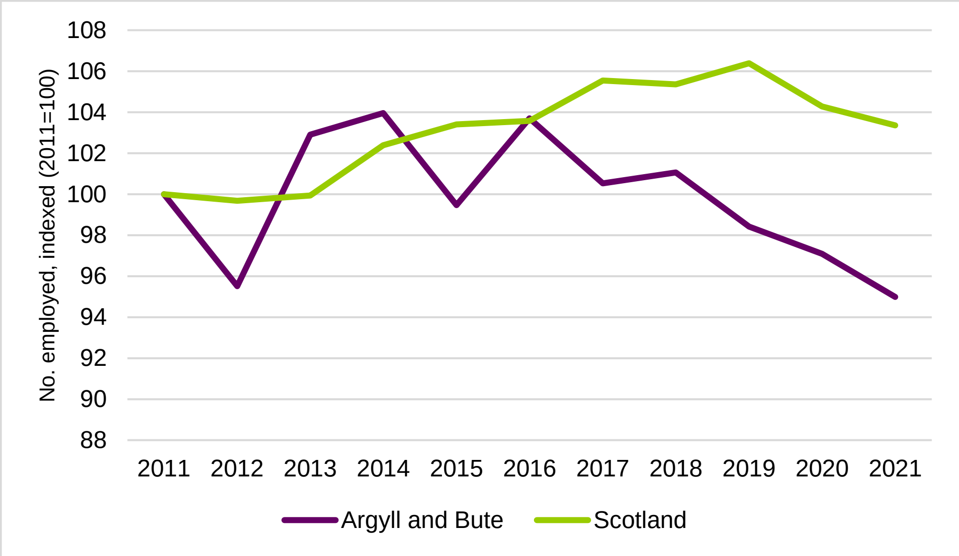
2.14 When comparing the urban/rural classifications, it can be seen that in 2021, 535 (12%) of business sites registered are classified as Other Urban Areas, 55 sites (1%) in Accessible Small Towns, 1,175 sites (26%) in Remote Small Towns, 165 (4%) in Accessible Rural locations and 2,545 (57%) in Remote Rural locations.

2.15 It should be noted that ONS' Inter Departmental Business Register listed 89.3% of businesses within Argyll & Bute as micro businesses (0-9 employees) in 2021. These trends are similar to those at a national level, with micro sized businesses accounting for 88% of the total business base. Due to much of Argyll & Bute's rural geography, the area is at a disadvantage, with larger businesses more likely to be situated within highly populated and centralised regions.

2.16 In 2021, 36,000 people worked in Argyll & Bute, accounting for 1.4% of total employment in Scotland.

2.17 Since 2011, there has been a drop of 1,900 people in employment in Argyll & Bute, a decrease of 5%. In contrast, there has been a growth rate in employment of 3.4% nationally. As shown in Figure 1.5, the national trend of employment growth is steady, whereas Argyll & Bute's is very inconsistent, and is currently as its lowest point as of 2021.

Figure 2.7. Employment, 2011-2021

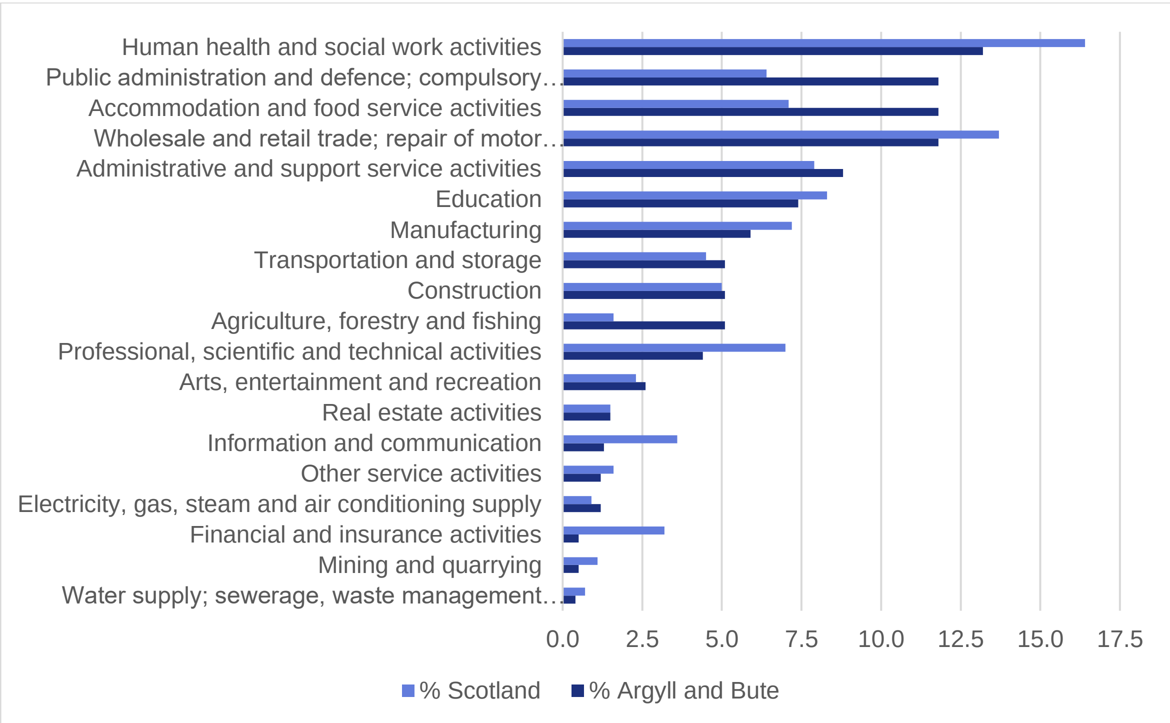


Source: ONS annual population survey

2.18 Data from BRES show that of the 34,000 employees in Argyll & Bute, 22,000 (66.7%) are full-time employees, with 12,000 (33.4%) working part-time. Further, 10.0% of people are self-employed in Argyll & Bute. These trends are comparable with those on a national scale, with 66.8% of total employees working full time and 33.2% working part- time, and 7.8% of workers being self-employed in Scotland.

2.19 Figure 2.8 shows that employment in Argyll & Bute is concentrated in human health and social work; public administration and defence; accommodation and food services; and wholesale and retail trade, which together account for 48% of employment in Argyll & Bute. In total, 3,500 people are in employment in Agriculture, forestry and fishing, accounting for over nine per cent of the Argyll & Bute workforce – more than three times the national rate.

Figure 2.8. Top employment sectors, 2020



Source: Business Register and Employment Survey, 2022

Economic performance

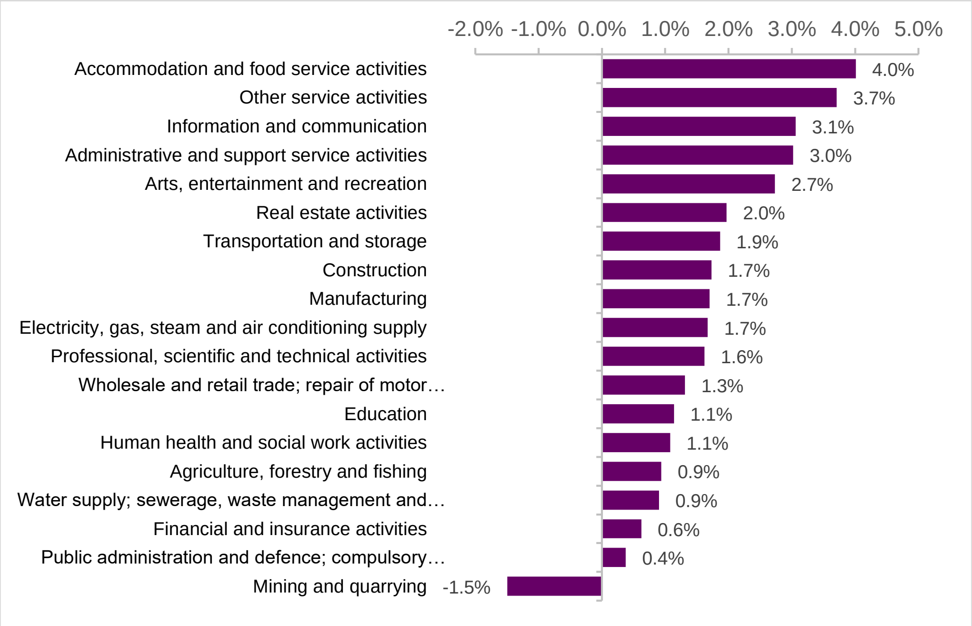
2.20 In 2021, GVA was forecast to be £4.71 billion in Argyll & Bute, 3.2 per cent of Scotland's output (£146.9 billion). The highest value sectors in the regional economy were forecast to be Public Administration and Defence (£298m), Real Estate Activities (£279m),and Human Health and Social Work Activities (£202m).

2.21 Prior to the pandemic, the area's economic growth rate was lower than Scotland's. On average the Argyll & Bute economy grew by 0.5 per cent each year (2009-2019). From 2019 to 2020, the region's economy contracted sharply as measures were taken across the country to limit the spread of COVID-19. The contraction of economic output in Argyll & Bute was estimated to be 9.3 per cent between 2019 and 2020, which was lower than what occurred across Scotland.

2.22 In the mid-term it is forecast that Scottish GVA will return to pre-pandemic levels in 2022, with growth of 8.2 per cent in 2021 and 5.4 per cent in 2022. Overall, GVA growth in Scotland is forecast to average 1.8 per cent per year between 2021 and 2031

2.23 As shown in Figure 2.9, Accommodation and food services is forecast to have the largest annual GVA growth in Argyll & Bute from 2021-2031, at 4.0 per cent. It is followed by Other Service Activities (3.7 per cent) and Information and Communication (3.1 per cent). Agriculture, forestry and fishing is anticipated to grow at just under 1% over the period.

Figure 2.9. Forecast average annual GVA change by Industry (%) (2021-2031), Argyll & Bute



Source: Oxford Economics, 2021

Connectivity

2.24 According to the 2020 edition of "Scottish Transport Statistics",[4] Argyll & Bute has 2,583km of public roads within its boundaries, accounting for 4.6% of Scotland's total road network. This includes three trunk roads (A82, A83, A85 and A828), which account for 12% (301km) of the area's road network for which Transport Scotland are responsible. The remainder are the responsibility of Argyll & Bute Council, and are a mix of class of roads.

[4] https://www.transport.gov.scot/publication/scottish-transport-statistics-no-39-2020-edition/

2.25 Due to the geography of Argyll & Bute, and the nature of many of its roads, journey times are typically longer than for other parts of the country over routes of comparable length.

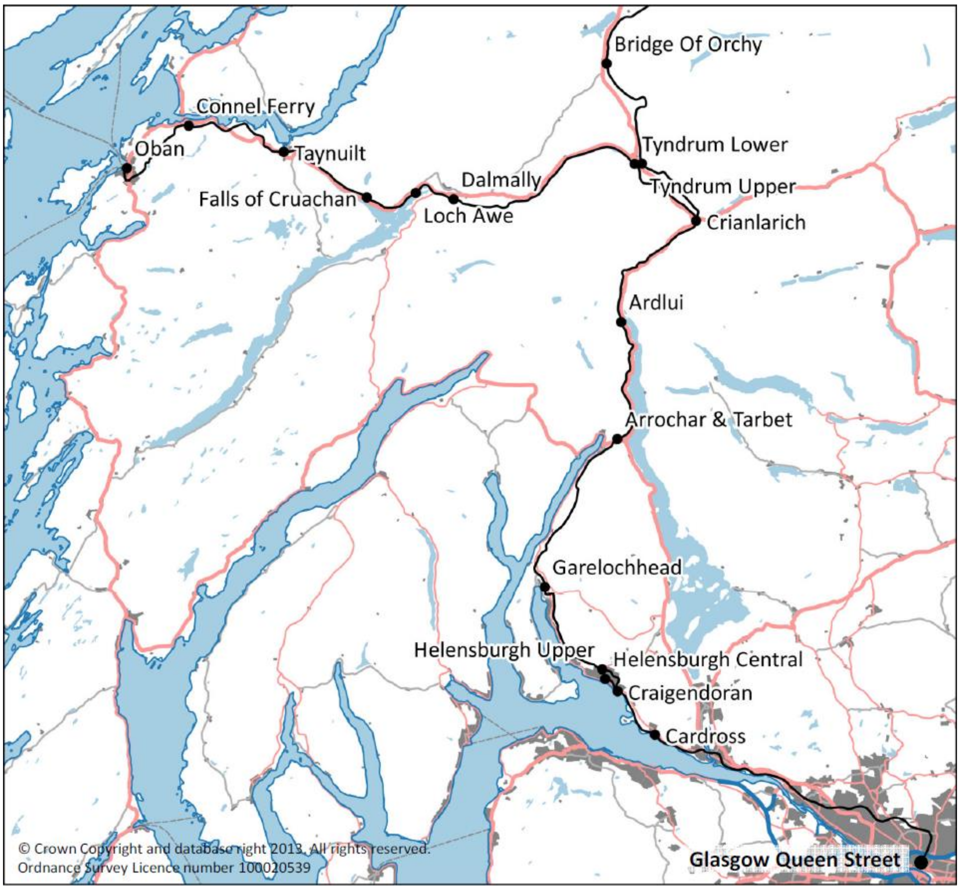
2.26 For example, an average journey time between Lochgilphead and Oban is almost one hour to cover a distance of just 37 miles. Some journeys also involve the use of at least one ferry service (which also increases the trip cost by having to pay ferry fares).

2.27 Argyll & Bute is poorly served by the rail network. Rail within Argyll & Bute consists of:

- A line from Glasgow that ends at Helensburgh Central; and
- The West Highland Line from Glasgow that travels through the east of the area and onto Fort William, with a spur at Crianlarich to Oban.

2.28 As shown in the map below, Argyll & Bute has 14 rail stations, covering the majority of the north-west. Two train stations are in Helensburgh. The other 11 stations in Argyll & Bute lie between the Oban and Glasgow line, apart from Bridge of Orchy which is further north on the line to Fort William.

Figure 2.10. Rail Network in Argyll & Bute



Source: HIE, 2016

2.29 Argyll & Bute has a very large number of ferry services. The vast majority of them carry vehicles as well as passengers. Reflecting the geography of the area, some ferries connect two parts of the mainland rather than serving an island. Some islands also have more than one ferry service. For example, Mull has three services, each offering access to/from different parts of the mainland. Islay has services to both Colonsay and Oban in addition to its main link to Kennacraig, while Bute has one ferry service to Inverclyde and another to Cowal. Even the small island of Lismore has two services – one passenger only, the other a vehicular operation.

2.30 Some of Argyll & Bute's services connect to other local authorities. For example to:

- Highland – e.g. Fishnish-Lochaline
- North Ayrshire – e.g. Ardrossan-Campbeltown
- Inverclyde – e.g. the Western Ferries service from Cowal
- Outer Hebrides – i.e. Oban-Castlebay/Lochboisdale

2.31 Island ferry services largely provide links to the mainland. However, there are also some limited inter-island sailings, for example between Coll and Tiree, and between Islay and Colonsay, which are often a by-product of services to/from the mainland. In addition, travelling between some islands (e.g. Iona, Jura) and the mainland requires the use of two ferry services to complete the journey.

2.32 Oban Airport is located approximately 6 miles from Oban; the airport offers local services to the Isle of Coll, island of Colonsay and Isle of Tiree in the Hebrides. The closest international airport is Glasgow Airport, located approximately 90 miles by road, with a journey time of approximately 2 hours 10 minutes by car from Oban.

3 TRENDS IN CARBON SEQUESTRATION AND CARBON MARKETS

Summary

- There are various carbon sequestration activities that are currently being practiced or in development, ranging from biological, to geological, to technological.
- The most feasible methods to be employed in Argyll & Bute are likely to be biological, in particular aiming to utilise the high level of land coverage with regards to woodland and peatland.
- Carbon codes are voluntary carbon standards for biological carbon sequestration projects. Business can "buy" credits through investing in carbon sequestration schemes to compensate for unavoidable carbon emissions, resulting in a reduction in their net emissions.
- The carbon codes of particular interest for Argyll & Bute are the Woodland Carbon Code and the Peatland Code. Carbon units in both schemes can be either be used against the buyer's own emissions, or can be sold to a third party to compensate for their emissions. These carbon codes thereby represent an additional revenue stream for landowners in peatland or woodland areas.
- In addition to the above voluntary regulations for carbon sequestration, the UK and Scottish Governments and Argyll and Bute Council have all implemented policies that either explicitly or indirectly influence carbon sequestration activity.
- The UK Government launched their Net Zero Strategy in October 2021, with the ambition is to capture and store 20-30 Mt of carbon emissions per year by 2030, with a further binding target to reach net zero carbon emissions by 2050.
- The Scottish Government has pledged to go further, committing to achieving net zero emissions of all greenhouse gasses by 2045 in the Climate Change Act 2019.
- In response to this, Argyll and Bute Council launched their Decarbonisation Plan in November 2020, which has a focus on delivering a 75% reduction in carbon emissions by 2030 and net zero by 2045, as well as supporting the development of the local low carbon economy.

INTRODUCTION

3.1 This chapter provides an overview of the trends in carbon sequestration and carbon markets on a global basis. First it presents an overview of the three main types of carbon sequestration processes (biological, geological, and technological), and the associated costs. Then it discusses carbon codes, in particular the two codes of interest for Argyll and Bute, the Woodland Carbon Code and the Peatland Code, as well as the Australian Carbon Industry Code of Conduct. Finally, it provides a policy context for carbon sequestration and carbon markets, at both UK and Scottish level.

CARBON SEQUESTRATION PROCESSES

3.2 Carbon sequestration is the process of capturing, securing and storing carbon dioxide from the atmosphere. The idea is to stabilize carbon in solid and dissolved forms so that it doesn't cause the atmosphere to warm. The process shows tremendous promise for reducing the human "carbon footprint." There are three main types of carbon sequestration: biological, geological and technological.

Biological Carbon Sequestration

3.3 Biological carbon sequestration is the storage of carbon dioxide in vegetation such as grasslands or forests, as well as in soils and oceans. It is stored naturally, and these areas that sequester carbon are known as carbon sinks.

Oceanic carbon sequestration

3.4 Oceans absorb roughly 25 percent of carbon dioxide emitted from human activities annually.

3.5 Carbon flux goes in both directions in the ocean. When carbon dioxide releases into the atmosphere from the ocean, it creates what is called a positive atmospheric flux. A negative flux refers to the ocean absorbing carbon dioxide.

3.6 Colder and more nutrient rich zones of the ocean can absorb more carbon dioxide than warmer zones. Therefore, the polar regions typically serve as net carbon sinks. By 2100, most of the global ocean is expected to be a large carbon sink for atmospheric carbon, which could alter the oceans' chemistry and lowering the pH of the water, making it more acidic.[5]

3.7 The cost of various ocean alkalinity carbon storage technologies is largely speculative at this stage. Renforth et al. (2013) indicated a range of 72–159 US$ per tonne CO_2 taken up. This range reflects the extraction, calcination, hydration, and surface ocean dispersion costs at a global scale (including transportation). In the case of direct addition of alkaline minerals to the ocean (i.e., without calcination), the cost is estimated to be 20–50 US$ per tonne CO_2 (Harvey, 2008; Köhler et al., 2013; Renforth and Henderson, 2017). Overall, at 10–190 US$ per tonne CO_2, the cost effectiveness is moderate.[6]

3.8 Oceanic restoration can be an expensive method of sequestering carbon. As an example of coastal and oceanic restoration costs per hectare, it is estimated that the cost of restoring saltmarshes along the UK coastline as a means of sequestering carbon, is between £100,000 and £500,000 per hectare.[7]

Soil carbon sequestration

3.9 Carbon is sequestered in soil by decomposing plant material (which originally captured the carbon through photosynthesis) and can be stored as soil organic carbon (SOC). Typically, agricultural activities can degrade and deplete the SOC levels but this carbon deficit opens up the opportunity to reduce carbon emissions and store carbon through new land management practices. Soil can also store carbon as carbonates. Such carbonates are created over thousands of years when carbon dioxide dissolves in water and percolates the soil, combining with calcium and magnesium minerals, forming "caliche" in desert and arid soil.

3.10 Carbonates are inorganic and have the ability to store carbon for more than 70,000 years, while soil organic matter typically stores carbon for several decades. Scientists are working on ways to accelerate the carbonate forming process by adding finely crushed silicates to the soil in order to store carbon for longer periods of time. However, current science indicates that carbonate may release more carbon as CO_2 in the calcination process than it actually stores.[8]

3.11 Land management techniques for soil carbon sequestration can not only store CO_2 in the soil but also enhance agricultural yields. It is estimated that the CO_2 utilised in the form of that increased output might be as much as 0.9 to 1.9Gt CO_2 per year in 2050, at costs of -$90 to -$20 per tonne CO_2.[9]

3.12 Actions have been taken in the UK to improve soil health quality. These include the launching of the Sustainable Farming Incentive by the UK Government, which pays farmers to provide the public goods of improved water quality, animal health and welfare, biodiversity and climate change mitigation.

[5] https://sos.noaa.gov/catalog/datasets/ocean-atmosphere-co2-exchange/

[6] https://www.frontiersin.org/articles/10.3389/fclim.2020.575716/full

[7] https://researchbriefings.files.parliament.uk/documents/POST-PN-0651/POST-PN-0651.pdf

[8] e.g. see Hanein, T. et al. (2021) Decarbonisation of calcium carbonate at atmospheric temperatures and pressures, with simultaneous CO_2 capture, through production of sodium carbonate, Energy and Environmental Science, 14(12), pp.6595-6604. At: https://pubs.rsc.org/en/content/articlelanding/2021/ee/d1ee02637b

[9] https://energypost.eu/10-carbon-capture-methods-compared-costs-scalability-permanence-cleanness/

The UK Government has committed to paying £22 per hectare for arable and horticultural soils at the "introductory" level and £40 per hectare for "intermediate" level interventions.[10]

Forestry carbon sequestration

1.13 Roughly 25 percent of global carbon emissions are captured by plant-rich landscapes such as forests, grasslands, peatlands and moorlands, and stored as biomass or living material such as leaves, branches and tree trunks. When plants die or when their leaves and branches fall off, the carbon stored is either released back into the atmosphere or is transferred into the soil (as discussed above). Wildfires and human activities that involve harvesting and deforestation can contribute to the diminishment of forests as a carbon sink.

3.13 Timber from both new and existing forests is an economically valuable product that could potentially store CO_2 in buildings and, by doing so, displace cement use. It is estimated that up to 1.5Gt CO_2 could be utilised in 2050 in this way, at costs of between -$40 and $10 per tonne CO_2. [11]

3.14 In terms of reforestation costs, the Woodland Trust in 2019 estimated that it costs roughly £6,000 per hectare (or £3.80 per tree) to plant a new woodland from scratch.[12] Actual costs will depend on many variables, including the previous ownership and usage of land.

3.15 Savills estimated in 2021 that the value of land in Scotland used for forestry varied between £8,513 in North Scotland, to £16,555 in Central Scotland. In the South of Scotland, the value per productive hectare was £15,100.[13]

3.16 Savills also report on the value of potential income streams and carbon yields from various forestry types, noting that a mixed conifer and broadleaf forest in Scotland can see a carbon price of £25/tonne from broadleaf trees, yielding 500 tonnes per hectare of felled conifer or 40 tonnes per hectare for thinned conifers. This timber equates to £80/tonne for felled timber and £30/tonne for thinned timber.[14]

Grassland carbon sequestration

3.17 Grasslands are a reliable carbon sink in areas that are hit hard by droughts and wildfires, which in turn cause forest fires that produce elevated carbon fluxes. Unlike trees, grasslands sequester most of their carbon in the soil. When grasslands are burned, most of the carbon stays fixed in the roots and soil. Intact forests have the ability to store more carbon, but in unstable conditions due to climate change, grasslands may be arguably more resilient.

3.18 It has been estimated in a study relating to the economic costs of carbon sequestration that the cost for repurposing grassland as a carbon sink is between US$ −6.52 and US$3.78 per tonne of CO_2. Market costs were estimated at between 12.70 and US$ 30.90, depending on the scale of implementation and the level of destocking required to restore grasslands and sequester carbon.[15]

3.19 From a costings table completed for Coventry, Warwick and Solihull, it was determined that the average costings for maintenance of grassland habitat is £227 per hectare per year, while it costs £1,686 per hectare to create new grassland habitat. It is estimated that the combined costs of 30 years of maintenance is on average £8,496 per hectare.[16]

[10] https://www.gov.uk/government/publications/sustainable-farming-incentive-full-guidance/sustainable-farming-incentive-full-guidance

[11] https://energypost.eu/10-carbon-capture-methods-compared-costs-scalability-permanence-cleanness/

[12] https://www.theguardian.com/society/2019/dec/28/replanting-britain-its-about-the-right-tree-in-the-right-place

[13] https://pdf.euro.savills.co.uk/uk/rural---other/spotlight---the-forestry-market-2021.pdf

[14] Ibid.

[15] https://www.frontiersin.org/articles/10.3389/fenvs.2021.657608/full

[16] https://www.rugby.gov.uk/download/downloads/id/168/habitat_target_costings_to_2026.pdf

Peatland carbon sequestration

3.20 Peatlands are wetlands which occupy 3% of the global land surface and 12% of UK land area. In the UK these peatlands take the form of blanket bogs, raised bogs, fens and bog woodland. Healthy peatlands capture carbon dioxide from the atmosphere through photosynthesis. Because the plants that grow on peatlands do not fully decompose under wet conditions, they do not release carbon which would otherwise be returned to the atmosphere as CO_2.

3.21 However, it is estimated that 78% of UK peatland no longer remains in near-natural condition, having been degraded as a result of drainage in order to make the land more suitable for crops and tree growth.[17] Drainage releases carbon stored within the peatlands into the air and is thereby a source of carbon dioxide emissions into the atmosphere.

3.22 Restoration of these peatlands is therefore required in order to return the habitats to carbon sinks. This can be achieved through a variety of methods, including: covering bare peat areas with vegetation; blocking drains to raise the water table and return the peatlands to waterlogged conditions; and re-introducing Sphagnum mosses into areas they have been lost.

3.23 Peatland ACTION is a national programme to restore peatlands across Scotland, led by the Scottish Government, who pledged in 2020 to deliver £250 million in investment towards peatland restoration up to 2030.[18] The programme funds on-the-ground restoration activities, including the installation of peat dams to raise water levels or revegetating peat hag to stabilise eroding peat. Since 2012, Peatland ACTION has helped to restore over 25,000 hectares of previously damaged peatland.[19]

3.24 In a 2021 study undertaken to analyse and update typical peatland restoration costs using data from the Scottish Peatland ACTION restoration projects, when considering the final reporting forms used for each project, it was discovered that the mean estimate of restoration costs is £1,878 per hectare to restore peatland in Scotland, while the median value of all 111 projects' final reporting forms was found to be £1,000 per hectare.[20]

Geological carbon sequestration

3.25 Geological carbon sequestration is the process of storing carbon dioxide in underground geologic formations, or rocks. Typically, carbon dioxide is captured from an industrial source, such as steel or cement production, or an energy-related source, such as a power plant or natural gas processing facility and injected into porous rocks for long-term storage.

3.26 Research shows that the cost of geologic sequestration without by-product credits (such as additional oil produced with enhanced oil recovery) ranges from $2.84 to $28.12 per tonne of CO_2, depending on characteristics specific to the type of geologic formation.[21] However, it should be noted that sequestration of this type can only be achieved under certain geological conditions.

3.27 There is work currently taking place with regards to geological carbon sequestration in Scotland, with respect to the Acorn Project. Based at the St Fergus gas-processing plant on the north-east coast of Scotland, where one-third of the UK's gas supply comes ashore, the Acorn Project aims to repurpose existing gas pipelines to take carbon dioxide directly to the Acorn CO2 Storage Site via the existing Goldeneye Pipeline for storage.

[17] https://www.ceh.ac.uk/sites/default/files/Peatland%20factsheet.pdf

[18] https://blogs.gov.scot/rural-environment/2020/07/20/peatland-action-fund-open-for-new-applications/

[19] https://www.nature.scot/professional-advice/land-and-sea-management/carbon-management/restoring-scotlands-peatlands

[20] https://sefari.scot/sites/default/files/documents/The%20costs%20of%20peatland%20restoration%20March%202021.pdf

[21] https://pdf.sciencedirectassets.com/277910/1-s2.0-S1876610209X00020/1-s2.0-S1876610209008832/main.pdf

3.28 The Acorn Project's first phase will cost £276 million, and will transfer at least 300,000 tonnes of carbon dioxide per year, with the aim to reach a capacity that can store up to 2 million tonnes of carbon dioxide per year.[22]

Technological carbon sequestration

3.29 Scientists are exploring new ways to remove and store carbon from the atmosphere using innovative technologies. Researchers are also starting to look beyond removal of carbon dioxide and are now looking at more ways it can be used as a resource.

Graphene production

3.30 Carbon dioxide can be used as a raw material to produce graphene, which is a technological material commonly used to create screens for smart phones and other technological devices. Graphene production is limited to specific industries but is an example of how carbon dioxide can be used as a resource and a solution in reducing emissions from the atmosphere.

3.31 A pilot plant demonstrator capturing 10 kg carbon dioxide per day is being developed in a project funded by the Swiss government and Swiss industry. The team estimates that the technology will drop the cost of carbon capture close to $30 per ton of carbon dioxide, in contrast to commercial processes where the cost is two-to-four times higher.[23]

Direct Air Capture (DAC)

3.32 A means by which to capture carbon directly from the air using advanced technology plants. However, this process is energy intensive and expensive. While techniques such as direct air capture can be effective, they are still costly to implement on a mass scale.

3.33 In 2015, Carbon Engineering launched its first pilot plant for capturing CO_2 in British Columbia in Canada. After capturing the CO_2 in solution, the plant transfers it into a solid, which when heated releases it in a pure gas stream. The crucial CO_2-capturing chemical is recycled. From a 3-year pilot evaluation, Carbon Engineering had collected enough data to calculate the plant's efficiency—and project the costs of building a commercial scale plant with the same technology. They found that their technology can capture CO_2 for between $94 and $232 per ton, as they reported in June 2018.[24]

Engineered molecules

3.34 Scientists are engineering molecules that can change shape by creating new kinds of compounds capable of singling out and capturing carbon dioxide from the air. The engineered molecules act as a filter, only attracting the element it was engineered to seek.

3.35 Researchers at the Massachusetts Institute of Technology project capital plus operating costs at $50 to $100 per ton of CO_2 captured in a study that study of electro-swing cells (when negatively charged, these cells absorb CO_2 and when positively charged, the CO_2 is released) that was supported as part of the MIT Energy Initiative Seed Fund. That range is in line with costs using other, less-flexible carbon capture systems.[25]

Costs of carbon sequestration

3.36 From the above information, it can be seen that there are various methods of carbon sequestration available and currently in development. Each has their own variation with regards to

[22] https://www.reutersevents.com/sustainability/can-uk-acorn-carbon-capture-project-grow-solution-industry-emissions

[23] https://phys.org/news/2021-02-graphene-filter-carbon-capture-efficient.html

[24] https://www.science.org/content/article/cost-plunges-capturing-carbon-dioxide-air

[25] https://news.mit.edu/2020/new-approach-to-carbon-capture-0709

effectiveness (in terms of cost per tonne of Carbon sequestered) and price. The effectiveness and price of each method of sequestration, where available, is displayed below.

Table 3.1: Cost of carbon sequestration by method

Method	Description	Cost/tCO_2 ($)	Cost/hectare
Biological			
Oceans	Adding alkaline materials to the sea in order to balance the acidity of CO2 absorbed	$10 to $190	Restoring Saltmarshes: £100,000 - £500,000 (2021)
Soil	Improving land management techniques to improve soil quality through the addition of minerals that absorb carbon- as a by-product, improving crop yields	-$90 to -$20	Policy Initiative: £22-40 (2022)
Forests	Timber from forests being used in place of cement, thereby absorbing carbon beyond the tree's life in the forest	-$40 to $10	UK: £6,000 (2019)
Grasslands	Destocking agricultural / degraded land in order to restore grassland which sequesters carbon underground	$12.70 to $30.90	Creation: £1,686 (2022)
Peatlands	Restoration of wetlands that have been previously drained by restoring water levels and reintroducing peat-producing mosses (Sphagnum) to act as a carbon sink		Scotland: £1,878 (2021)
Geological			
Carbon Capture and Storage	Storing carbon under within porous rocks for long-term storage	$2.84 to $28.12	Unit costs for CCS: $400-$500 million (2021)
Technological			
Graphene Production	Using a graphene filter with CO2 sized holes to filter it out from other molecules	$30	
Direct Air Capture	Using advanced technology plants to capture CO2 from the air, then recycling it for other purposes (captured as a solution, then heated to become steam)	$94 to $232	
Engineered Molecules	Using compounds as a filter that attracts carbon only and releases everything else	$50 to $100	

3.37 As can be seen above in Table 3.1, there are various methods of carbon sequestration practice that can be expensive (in particular, the technological methods). However, adopting biological methods such as adopting land management practices for organic soil carbon sequestration or reforestation practices are much more affordable and can result in more productive land, increasing the yields received, and therefore may be a more economical use of land than current practice demonstrates.

CARBON CODES

3.38 Carbon codes are voluntary carbon standard for biological carbon sequestration projects. Carbon buyers (i.e. businesses) can invest in carbon sequestration schemes to compensate for their unavoidable carbon emissions. These schemes guarantee transparency and accountability in the carbon sequestration process, while providing benefits for water, biodiversity, communities and the economy. The carbon codes of interest for the Argyll & Bute region are: the Woodland Carbon Code and the Peatland Code.

Woodland Carbon Code

3.39 The Woodland Carbon Code (WCC) is a government-led scheme that regulates, verifies, and validates how landowners can participate in projects that use part of their woodland for carbon sequestration and credit trading. The carbon sequestration from these projects is translated into carbon units which can be used only once. The carbon units can be either be used against the buyer's own emissions, or can be sold to a third party to compensate for their emissions.[26]

3.40 WCC projects produce verified[27] and validated[28] units. Verified carbon units can be used against current year's emissions, while validated ones are available for sale for future vintages and can be used for future Net Zero plans. In both cases 1 unit corresponds to 1 tonne of carbon dioxide sequestered, either currently or in the future.

3.41 Project developers with verified units in Scotland:

- Muck Water Plantation in East Ayrshire, by project developer Fountains Forestry Ltd (1.5 hectares);[29]
- Acktron Mixed Woodland in Highland, by project developer Michael Stuart (46.98 hectares).[30]

3.42 The list of project developers with validated units in Scotland is longer. The following is an indicative list of projects in Argyll & Bute:

- Homeston[31] by Tilhill Forest near Campbeltown: 32.7 ha area and predicted claimable 8,809 tCO_2e.
- Talatoll New Woodland Creation[32] by RDS Forestry Limited near Clachan: 366.2 ha area and predicted claimable 96,018 tCO_2e.
- Dunlossit Planting Phase 1[33] by Crosscut Forestry Ltd on Islay: 114.9 ha area and predicted claimable 27,013 tCO_2e.
- Ruantallain Estate - Rozga's Wood New Woodland Creation[34] by RDS Forestry Limited on Islay: 43.6 ha area and predicted claimable 12.112 tCO_2e.
- Luing Woodland Creation[35] by Cadzow Brothers on Slate Islands: 90.2 ha area and predicted claimable 43,674 tCO_2e.
- Accurrach[36] by Tilhill Forest near Invereray: 32.2 ha area and predicted claimable 10,365 tCO2e.
- Glenorchy Farm Native Woodland[37] by Diverse Ecology near Arichastlich: 27.3 ha area and predicted claimable 12,261 tCO_2e.
- Stronafian House[38] by Forest Carbon Ltd near Kames: 17.8 ha area and predicted claimable 1,764 tCO_2e.
- Otter Woodland Creation[39] by TreeStory Limited near Kames: 129.7 ha area and predicted claimable 52,267 tCO_2e.

3.43 These projects give Argyll & Bute a total area of 854.6 hectares dedicated to carbon sequestration for future carbon units, for a collective predictable claimable 264,283 tCO_2e. This equates to around 0.5% of the total forested area in Argyll & Bute.

[26] https://www.woodlandcarboncode.org.uk
[27] Referred to as Woodland Carbon Units (WCU)
[28] Referred to as Pending Issuance Units (PIU)
[29] https://www.woodlandcarboncode.org.uk/buy-carbon/woodland-carbon-projects/craigengillan-groups-1-and-2
[30] https://mer.markit.com/br-reg/public/project.jsp?project_id=103000000004596
[31] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000027113
[32] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000027275
[33] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000026679
[34] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000027060
[35] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000026943
[36] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000026964
[37] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000016117
[38] https://mer.markit.com/br-reg/public/master-project.jsp?project_id=103000000017181
[39] https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000026963

Peatland Code

3.44 The Peatland Code was set-up to help facilitate restoration of the UK's extensive peatlands, 80% of which are estimated to be in a degraded state.[40] Degraded peatlands are a significant source of GHG emissions, and in the UK alone are contributing 23 million tonnes of CO_2e emissions each year,[41] almost 3.5% of the country's total carbon footprint.[42]

3.45 The Peatland Code[43] is the certification standard for peatland restoration in the UK, offering the assurance that greenhouse gas mitigation claims are validated and verified by an independent body. The code safeguards the integrity of its project's carbon credits and, through the generation and sale of these units, provides land managers undertaking peatland restoration with a source of revenue.

International examples: Australia

3.46 The Australian Carbon Industry Code of Conduct provides guidance for project developers, agents, aggregators and advisers undertaking carbon projects.[44] This climate-related consumer protection code of conduct aims to increase the quality of carbon abatement that is occurring in Australia, ensuring that projects ranging from traditional fire management to native ecosystem regeneration projects all contribute positive outcomes to local employment and the environment, as well as the stakeholders involved.[45]

POLICY CONTEXT

3.47 Carbon Sequestration is part of the UK Government's Clean Growth Strategy,[46] which is designed to enable the UK to become a global technology leader for Carbon Capture, Usage and Storage (CCUS) and facilitating the deployment of CCUS at scale during the 2030s, subject to costs coming down sufficiently. While CCUS has the potential to decarbonise the economy and maximise economic opportunities for the UK, it is currently expensive. The government's action plan for the sector, the UK CCUS Deployment Pathway,[47] was published in 2018 and highlights the importance of ensuring a supportive business environment that delivers a cost reduction trajectory so that the domestic deployment of CCUS can continue growing.

3.48 The Energy Act 2008 provides for a licensing regime that governs the offshore storage of carbon dioxide. It forms part of the transposition into UK law of EU Directive 2009/31/EC on the geological storage of carbon dioxide. In England, Wales and Northern Ireland the Energy and Industrial Strategy to the Oil and Gas Authority (OGA) is now the licensing authority for offshore storage; in Scotland the territorial sea is authorised by Scottish ministers.[48]

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[40] IUCN, UK Peatlands: Peatland Programme. Available at: https://www.iucn-uk-peatlandprogramme.org/about-peatlands/uk-peatlands

[41] S myth, Mary-Ann & Artz, Rebekka & Taylor, Emily & Evans, Chris & Moxley, Janet & Archer, Nicole & Burden, Annette & Williamson, Jennifer & Donnelly, David & Thomson, Amanda & Buys, Gwen & Malcolm, Heath & Wilson, David & Renou-Wilson, Florence. (2017). Implementation of an Emissions Inventory for UK Peatlands. Available at: https://www.researchgate.net/publication/333056609_Implementation_of_an_Emissions_Inventory_for_UK_Peatlands

[42] IUCN (2021), Peatland addition to the UK GHG inventory adds 3.5% to national emissions. Available at: https://www.iucn-uk-peatlandprogramme.org/news/peatland-addition-uk-ghg-inventory-adds-35-national-emissions

[43] https://www.forestcarbon.co.uk/certification/the-peatland-code

[44] https://carbonmarketinstitute.org/code/

[45] https://www.sustainabilitymatters.net.au/content/sustainability/news/code-of-conduct-will-hold-carbon-industry-accountable-1550446611

[46] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

[47] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759637/beis-ccus-action-plan.pdf

[48] https://www.gov.uk/guidance/uk-carbon-capture-and-storage-government-funding-and-support

UK

3.49 In November 2020, the Prime Minister set out his ambition that the UK will become a world leader in technology to capture and store harmful emissions away from the atmosphere, with an ambition to remove 10 million tonnes (Mt) of carbon dioxide (CO_2) by 2030 in the UK Government's **Ten Point Plan**[49]**.**

3.50 In October 2021, the government's **Net Zero Strategy** expanded on this ambition. The UK's ambition is to capture and store 20-30 Mt of carbon emissions per year by 2030, with a further binding target to reach net zero carbon emissions by 2050.[50] Carbon emissions will be captured from across the economy, including 6 million tonnes per annum (Mtpa) of industrial CO_2 emissions by 2030, increasing to 9 Mtpa by 2035.

3.51 **The Transport and Storage (T&S) Regulatory Investment Model**[51] is intended to be the primary driver of private investment into the Carbon Capture, Usage and Storage (CCUS) sector, with regards to Transport and Storage. There is a need to raise around £15 billion in private investment to construct and deliver the early phases of the CCUS T&S assets. Key objectives for model include:

- Attracting investment in T&S networks to establish a new Carbon Capture, Usage, and Storage (CCUS) sector;
- Enabling low-cost decarbonisation in multiple sectors; and
- Developing a market for carbon capture – a long-term vision.

3.52 The **Carbon Capture and Storage Infrastructure Fund (CIF)** was first announced at Budget in March 2020, and its allocation of £1bn was confirmed at the Spending Review in November 2020.[52] The government has committed to deploy carbon capture, usage and storage (CCUS) in 4 industrial clusters (Transport and Storage, Industrial Carbon Capture, Power Carbon Capture Utilisation and Storage, and Hydrogen), aiming to capture 10MtCO_2 a year by 2030.

3.53 The **Woodland Carbon Guarantee (WCaG)** is a £50 million scheme that aims to help accelerate woodland planting rates and develop the domestic market for woodland carbon for the permanent removal of carbon dioxide from the atmosphere.[53] It is an objective in the 25 Year Environment Plan and was announced in the autumn 2018 Budget.

3.54 The International Union for Conservation of Nature **(IUCN) UK Peatland Strategy 2018-2040**[54] was developed to:

- Support co-ordinated large-scale action to conserve and restore the UK's peatlands;
- Bring about more widespread sustainable management;
- Help prioritise and ensure sufficient resources are available for delivery;
- Continue to promote partnership working and knowledge sharing across different sectors and countries;
- To co-ordinate monitoring and reporting of peatland condition and functionality to allow the UK to report to EU and International obligations including National Green House Gas (GHG) accounting and Biodiversity conventions amongst others;
- Implement international recommendations for peatlands including those from the Food and Agriculture Organisation of the United Nations (UNFAO) and Wetlands International;

[49] https://www.gov.uk/government/news/pm-outlines-his-ten-point-plan-for-a-green-industrial-revolution-for-250000-jobs

[50] https://www.gov.uk/government/publications/net-zero-strategy

[51] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1045066/ccus-transport-storage-business-model-jan-2022.pdf

[52] https://www.gov.uk/government/publications/design-of-the-carbon-capture-and-storage-ccs-infrastructure-fund/the-carbon-capture-and-storage-infrastructure-fund-an-update-on-its-design-accessible-webpage.

[53] https://www.gov.uk/guidance/woodland-carbon-guarantee

[54] https://www.iucn-uk-peatlandprogramme.org/uk-strategy

- Deliver a strong, unified and cohesive message to funders and policy makers that peatland conservation, restoration and sustainable management should remain high on the agenda.

Scotland

3.55 The **Scottish National Strategy for Economic Transformation**[55] focuses on the priorities for Scotland's economy as well as the actions needed to be able to achieve the ambition of a wellbeing economy in the next decade. Within this strategy, there is a recognition that decarbonisation is a crucial new and developing market opportunity, "one where Scotland will become world leading and secure first-mover advantage." Decarbonisation, low carbon and carbon sequestration are highlighted as areas of significant opportunity, citing the North East as an area where there are opportunities in the circular economy, as well as carbon capture and storage. The Forth Valley Region is highlighted as an area with focus relating to transport, tourism, business support and low carbon activities. Projects in the Highlands and Islands region include those relating to offshore wind, hydrogen, heat decarbonisation and energy systems.

3.56 Scotland has committed to achieving **Net Zero** emissions of all greenhouse gasses by 2045 in the Climate Change Act 2019. This is tougher than a net-zero carbon target, which commits only to balancing carbon dioxide emissions: it means that no greenhouse gasses are at all.[56] To meet this targets, a rapid transformation across all sectors of the Scottish economy and society is required. These increased ambitions are reflected in the 2020 update of the Climate Change Plan 2018-2032.[57]

3.57 The **Climate Change Plan 2018-32 (2020 Update)**[58] considers a range of different outcomes across a range of different areas of the economy (electricity, buildings, transport, industry, wastage, land use and forestry, agriculture and negative emissions technologies) that that will occur provided the respective policies are established, maintained or boosted in order to maximise both Scotland's climate change mitigation and adaptation potentials. Of these, forestry and land use are acknowledge to be a main way of sequestering carbon from the atmosphere and there are policies being maintained and established to "enhance the contribution that trees make to reducing emissions through sequestering carbon." A further outcome established in this is the desire to "enhance the contribution of peatland to carbon storage" by supporting an increase in the annual rate of peatland restoration. Within agriculture, it is acknowledged that "carbon sequestration and existing carbon stores on agricultural land have helped to increase and maintain our carbon sink" and as such the role of agroforestry and planting trees and hedgerows can be of benefit to both farmers and the carbon sink in Scotland. The role of Negative Emissions Technologies (NETs) is to be explored further as a way of sequestering carbon in Scotland through feasibility studies, while carbon capture usage and storage technologies have been prioritised for development in order to ensure commercial scale products are launched by the late 2020s.

3.58 **Scotland's Forestry Strategy 2019 to 2029,**[59] updated in 2021,[60] presents a 50-year vision and 10-year framework to action, expand, protect and enhance Scotland's forests and woodlands. In turn, it is hoped that these forests will deliver greater economic, social and environmental benefits to Scotland's people. It relays the Climate Change Plan target to incrementally increase the annual woodland creation target from 12,000 to 18,000 ha per year by 2024/25.

3.59 Within the **Scottish 2020/21 budget**, it was announced that the Scottish Government would allocate £250 million over 10 years to support peatland restoration, with a target of restoring 250,000 hectares of degraded peatland by 2030.[61] In June 2021, the first projects were announced in this

[55] https://www.gov.scot/publications/scotlands-national-strategy-economic-transformation/documents/

[56] https://www.gov.scot/news/reaching-net-zero-1/

[57] https://www.gov.scot/policies/climate-change/

[58] https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/

[59] https://www.gov.scot/publications/scotlands-forestry-strategy-20192029/

[60] https://forestry.gov.scot/news-releases/scotland-showing-leadership-on-climate-forests

[61] https://www.gov.scot/news/scottish-budget-2020-21/

allocation, with £22m allocated to five partners including NatureScot and Scottish Water to deliver a range of new and existing restoration projects across Scotland.[62]

3.60 In a **statement to the Scottish Parliament** in October 2021, the Cabinet Secretary for Net Zero, Energy and Transport provided an update regarding the development and deployment of Carbon Capture, Utilisation and Storage in Scotland, in particular the Acorn Scottish Cluster project in North East Scotland. Within it, the Secretary estimates that the projects can support an average of 15,100 jobs between 2022-2050, with a peak of 20,600 jobs in 2031 and an anticipated carbon storage of 6 million tonnes per year by 2030. It is for this reason that the Secretary further explained that "the Scottish Government will continue to press for Track-1 status for the Scottish Cluster, and to support the development and deployment of CCUS in Scotland that is compatible with our climate change targets."[63]

3.61 **Scotland's National Peatland Plan** (2015) identifies the wide range of benefits provided by healthy peatlands, including a rich biodiversity, good water quality and carbon storage. It sets out a vision for how to manage and restore Scotland's peatlands through a joint approach involving land owners and managers, scientific and technical expertise and appropriate levels of funding, together with the necessary policies and guidance to steer activities in the desired direction.[64] In 2020 the Scottish Government announced a £250 million ten-year funding package to support peatland restoration, with a target of restoring 250,000 hectares of degraded peatland by 2030. In 2021-22, five partners including NatureScot and Scottish Water will get a share of £22 million to deliver a range of new and existing restoration projects across Scotland.[65]

Argyll and Bute

3.62 The **Argyll and Bute Economic Strategy 2019-2023**[66] focuses on the Council's key priorities for the region of developing and maintaining critical economic infrastructure to connect with national and international markets, making Argyll and Bute attractive with regards to skills, residents, visitors and businesses, and achieving "smart growth" by applying learning from best practice activity. As part of the Strategy's smart growth aim, there is a key outcome outlined to lower the carbon footprint in Argyll and Bute. This will be done through collaboration with Argyll and Bute Renewables Alliance (ABRA) to tackle strategic issues that currently limit their potential to generate, distribute, allow local people to take up employment opportunities and makes best use of clean energy. There is also an emphasis on the forestry sector in Argyll and Bute as a priority sector, and as such there is a need to maintain and improve the skill base in the forestry sector to facilitate this sector's continued growth. As such, carbon sequestration activity through forestation is likely to be of importance within any supporting priority sector actions taken featuring the forestry sector.

3.63 In November 2020, Argyll and Bute Council launched their **Decarbonisation Plan 2021**[67] to make a commitment that as businesses, communities and services recover from the pandemic in Argyll and Bute, they will be doing it in a low carbon and environmentally responsible manner. Actions taken as a result of this decarbonisation plan will result in higher carbon sequestration activity- in particular citing the Peatland Restoration project Argyll and the Isles Coast and Countryside Trust (ACT) are undergoing on Islay[68] as an example of good practice in carbon sequestration. This Decarbonisation Plan features four broad aims, namely:

- In line with national requirements, to achieve 75% carbon reduction by 2030 and net zero before 2045;
- Supporting the low carbon economy through recovery;

[62] https://www.gov.scot/news/funding-to-restore-scotlands-iconic-peatlands/
[63] https://www.gov.scot/publications/development-deployment-carbon-capture-utilisation-storage-scotland/
[64] https://www.nature.scot/doc/scotlands-national-peatland-plan-working-our-future
[65] https://www.gov.scot/news/funding-to-restore-scotlands-iconic-peatlands/
[66] https://www.argyll-bute.gov.uk/sites/default/files/economic_strategy_0.pdf
[67] https://www.argyll-bute.gov.uk/moderngov/documents/s168183/Decarbonisation%20Plan%20Appendix%20A.pdf
[68] https://www.act-now.org.uk/cann

- Leading by example and develop practices and partnerships that inspire low carbon behaviours; and
- Making "Climate Friendly Argyll and Bute" a recognised brand and underpin behaviours of our staff and customers.

3.64 Argyll and Bute Council are currently developing a second **Local Development Plan**[69] that has been drafted and is currently being reviewed by Scottish Government. Within it, the Council has an explicit vision of "an economically diverse and successful area based on sustainable and low carbon development." In order to facilitate this, land use planning is to follow principles that include avoiding the loss of tress and woodland, avoiding the disturbance of peatlands and carbon rich soil, as well as encouraging the development and use of renewable energy generation technologies and/or low carbon sources of heat and power such as bio mass.

3.65 Within the **Highland and Argyll Local Plan District's Flood Management Plan 2016-2022**[70], there is two stated aims- to avoid an overall increase in flood risk, and to reduce overall flood risk in the region. To both ends, an increase in the soil health quality of peatland would aid in reducing flood risk and therefore decrease the overall flood risk in the region, in an environmentally conscious manner.

[69] https://www.argyll-bute.gov.uk/sites/default/files/finalpldp2writtenstatementdepositv2_ac1.pdf

[70] https://www.argyll-bute.gov.uk/sites/default/files/highland_argyll_local_flood_risk_management_plan_june_2016.pdf

4 THE EXISTING POSITION IN ARGYLL & BUTE: A BASELINE

Key points

- The total agricultural area in Argyll & Bute is over 509,000ha, of which 441,600ha is utilised.
- Of the 1,944 farm holdings in the area, cattle and sheep farms in Less Favourable areas (LFAs) are the most highly represented, accounting for 48%.
- Farm holdings in the area are typically larger than the Scottish average, but Standard Output per farm is considerably lower than that of Scotland as a whole.
- Agricultural employment in Argyll & Bute totalled 2,780 in 2021. It is a workforce in need of rejuvenation: Around 90% of the workforce is over 41, and around two-thirds of the workforce is over the age of 55. This has implications for any potential carbon sequestration activity.
- There is around 165,000ha of identified existing forest in Argyll & Bute. Around 76,000ha is identified as preferred land for future forestation, and 146,700ha has potential to accommodate woodland, but contains at least one significant sensitivity.
- Forestry and logging supported 4,500 workers in the area in 2020.
- An estimated 50% of Argyll & Bute's land area is heather moorland, peatland, rough grassland and bracken scrub. In total, there is almost 49,500ha of degraded peatland in the area.
- There is a high sequestration capacity within the Argyll & Bute marine planning region. However, the capacity of natural marine habitats to sequester and store carbon in Argyll & Bute is largely unsupported, and this is a major barrier to market development.

INTRODUCTION

4.1 This chapter sets out the existing position in Argyll & Bute with regard to agriculture, forestry and peatland. It summarises the current hectarage, employment and economic output/value for agriculture, forestry and peatland.

AGRICULTURE

Farm production and holding type, and hectarage

4.2 According to the 2021 Scottish Agricultural Census, there were 1,958 farm holdings across the total agricultural area in Argyll & Bute, with 1,934 farm holdings across Argyll & Bute's utilised agricultural area. The total utilised agricultural area in Argyll & Bute is almost 441,600ha, out of a total agricultural area of over 509,100ha. The total agricultural area in Argyll & Bute includes almost 53,000ha of woodland.

Table 4.1: Farms by production type in Argyll & Bute, 2021[71]

Farm type	No. holdings	Area (ha)
Wheat	*	*
Barley: Total	86	1,576
Spring	*85*	*1,469*
Winter	*7*	*107*
Oats, triticale and mixed grain	12	55
Rape for oilseed and linseed	0	0
Potatoes	27	7
Peas and beans for combining	0	0
Stockfeeding crops(1)	45	336
Vegetables for human consumption	43	6
Orchard and soft fruit	*	*
Bulbs, flowers and nursery stock	18	7
All other crops	29	40
Fallow land: Total	65	502
More than 5 years	*40*	*373*
5 years or less	*25*	*129*
Total crops and fallow	***253***	***2,575***
Grass: 5 years old and over	1,397	63,501
Grass: Under 5 years old	231	3,247
Sole right grazing	1,290	363,307
Common grazing	59	8,953
Total grass and rough grazing	***1,934***	***439,008***
Utilised Agricultural Area (UAA)(2)	**1,934**	**441,583**
Woodland	726	52,970
Other land	1,175	14,588
Total agricultural area(3)	**1,958**	**509,141**

(1) Includes lupins and maize.
(2) Utilised agricultural area excludes woodland and other land such as yards and derelict land, etc.
(3) Inclusion of common grazing land brings total agricultural area in Scotland to a higher level than that published in the June agricultural census.
* Data suppressed to prevent disclosure of individual holdings.

Source: Scottish Government/RESAS, 2021

4.3 The average farm holding size in Argyll & Bute is 250.6ha. However, the average (mean) farm size by size class ranges from 1.1ha to 1,122.4ha.

Table 4.2: number of farms in Argyll & Bute by size, 2019[72]

Size	No.	%	Average (ha)
0<2 ha	263	14%	1.1
2<5 ha	261	13%	3.4
5<10 ha	206	11%	7.2
10<20 ha	191	10%	14.5
20<50 ha	238	12%	32.6
50<100 ha	219	11%	72.2
100<200 ha	181	9%	144.4
200+ ha	385	20%	1122.4
Total	**1,944**	**100%**	**250.6**

Source: Scottish Government/RESAS, 2020

4.4 Cattle and sheep farms in Less Favourable areas (LFAs) are the most highly represented farm type in Argyll & Bute. Farms of this type account for almost half (48%) of farm holdings in the area. This

[71] https://www.gov.scot/publications/results-scottish-agricultural-census-june-2021/documents/
[72] https://www.gov.scot/publications/economic-report-on-scottish-agriculture-tables-2020-edition/

is a much higher rate than nationally (29%). LFA cattle & sheep farms in Argyll & Bute account for c.6% of the national total.

Table 4.3: Number of farm holdings in Argyll & Bute by type, 2019[73,74]

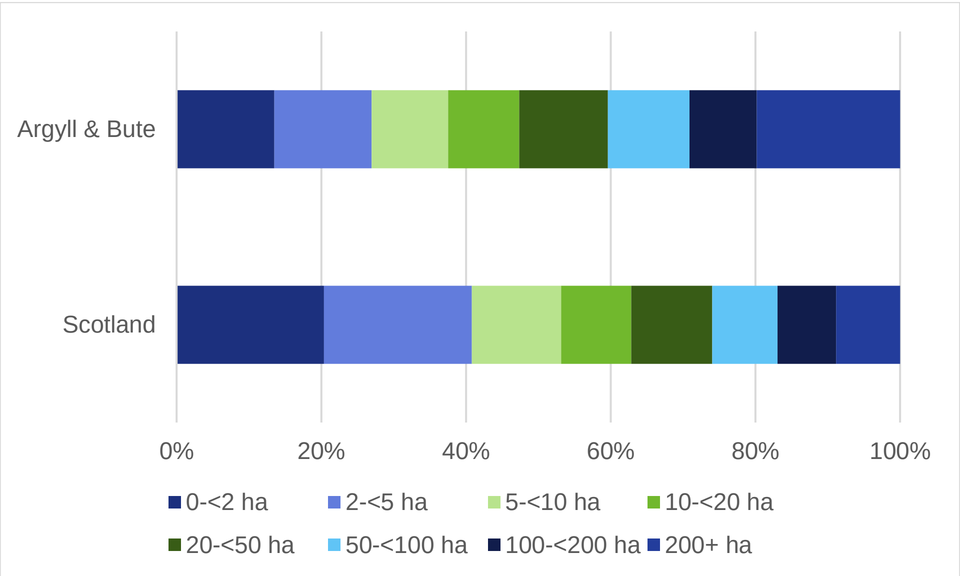
Farm type	No. holdings	%
LFA cattle & sheep	929	48%
General cropping: forage	753	39%
Mixed holdings	79	4%
Unclassified	72	4%
Specialist dairy	29	1%
Specialist poultry	32	2%
Specialist horticulture & permanent crops	28	1%
Specialist pigs	10	1%
Non LFA cattle & sheep	5	<1%
Specialist cereals	*	<1%
General cropping	*	<1%
Total	**1,944**	**100%**

***** Data suppressed to prevent disclosure

Source: Scottish Government/RESAS, 2020

4.5 Farm holdings in the area are typically larger than the Scottish average. As figure 4.1 indicates, Argyll & Bute has a lower proportion of smaller holdings (<10ha), and a higher proportion of holdings of 50 or more – particularly of holdings over 200ha. This is likely due to the proportion of LFA cattle & sheep holdings as set out in Table 4.2 above.

Figure 4.1: Share of farms by size, 2019[75]



Source: Scottish Government/RESAS, 2020

[73] https://www.gov.scot/publications/economic-report-on-scottish-agriculture-tables-2020-edition/

[74] Data differs from that presented in Table 4.1 due to differences in data collection and categorisation between the Economic Report on Scottish Agriculture, and the Scottish Agricultural Census

[75] https://www.gov.scot/publications/economic-report-on-scottish-agriculture-tables-2020-edition/

Standard output from agriculture

4.6 The Standard Output (SO)[76] per farm holding in Argyll & Bute was £30,541 in 2019, and c.£59.4 million in total.[77] This is around 59% of the Scotland SO average (£51,729 per farm holding), but above the Highlands and Islands SO average of £13,568.

Agricultural employment

4.7 Agricultural employment in Argyll & Bute totalled 2,780 according to the 2021 Scottish Agricultural Census, which equates to around 4% of the total Scottish agricultural workforce. This includes 1,659 working occupiers, 474 full-time employees, 368 part-time employees, and 208 casual and seasonal employees.[78] This equates to approximately 1.4 workers per holding.

4.8 Taking into consideration the hours worked by part-time and seasonal workers (i.e. whether those working part-time are working more or less than half-time, or the full time equivalent of seasonal workers), then the total Standard Labour Requirement (SLR) for farm holdings in Argyll & Bute is approximately 2,106, or an SLR of 1.086 per holding.[79]

4.9 Whilst the total number of occupiers and employees has remained largely consistent over the last decade or so, the SLR has increased over the period – particularly from 2015 onwards. This suggests an increase in the amount of labour required by farm holdings in Argyll & Bute to carry out all of their agricultural activity.

4.10 However, wider information from the Scottish Agricultural Census indicates a number of issues with the workforce. The principal challenge facing the agricultural workforce in all parts of Scotland is that it is an ageing workforce. Around 90% of the workforce is over 41, and around two-thirds of the workforce is over the age of 55. Male workers are typically older, and constitute around 60% of the Scottish agricultural workforce. It is anticipated that the older demographic in Argyll & Bute may exacerbate this issue further. Additionally, there is evidence to suggest that the migrant agricultural workforce in Scotland has decreased in the period following Brexit.[80]

4.11 As such, it can be argued that Argyll & Bute's agricultural workforce is in need of rejuvenation, and carbon sequestration activity may offer a means through which to achieve this – though the issue of succession planning may have implications for the implementation of carbon sequestration activity.

[76] Standard Outputs (SO) represent the estimated farm-gate worth (£s) of crops and animals without taking account of the costs incurred in production.

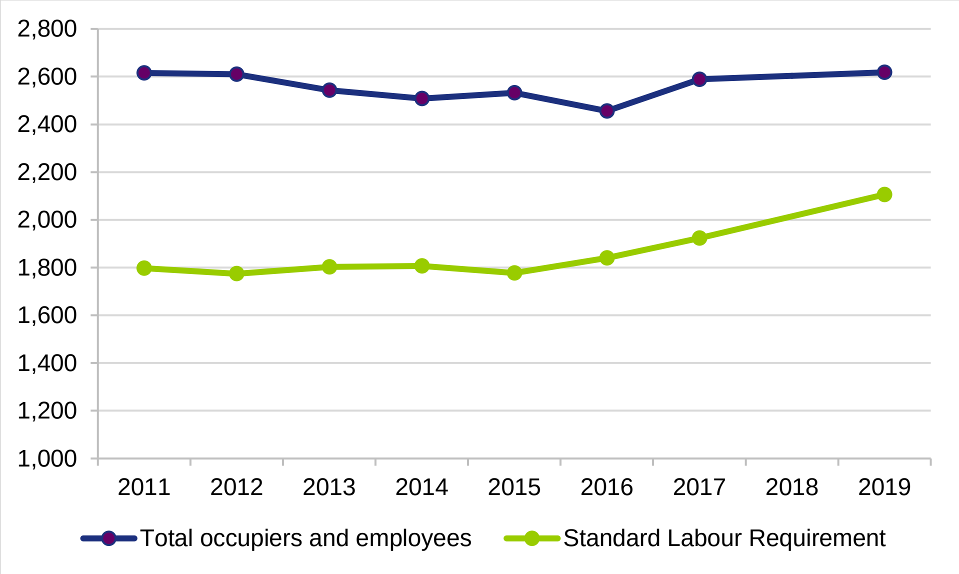
[77] https://www.gov.scot/publications/economic-report-on-scottish-agriculture-tables-2020-edition/

[78] https://www.gov.scot/publications/results-scottish-agricultural-census-june-2021/documents/

[79] https://www.gov.scot/publications/economic-report-on-scottish-agriculture-tables-2020-edition/

[80] https://www.gov.scot/publications/results-scottish-agricultural-census-june-2021/

Figure 4.2: Total occupiers and employees v. Standard Labour Requirement, Argyll & Bute, 2011-19[81]



Source: Scottish Government, Economic Report on Scottish Agriculture (ERSA), 2012-20

FORESTRY

Forestry hectarage

4.12 Argyll & Bute Council's Woodland and Forestry Strategy 2011 identified around 165,500ha of forestation in Argyll & Bute (see Table 4.4). It is worth noting that a considerable proportion of Argyll & Bute is considered to have limited or very limited flexibility for growth of tree crops, or is considered unsuitable. These areas include natural heritage and historic environment designations, as well as existing agricultural land.

Table 4.4: Land capability for forestry, 2011[82]

Land Capability for Forestry (flexibility for the growth and management of tree crops)	Total (ha)	Proportion of Argyll & Bute	Existing afforestation (ha)	Proportion of afforested area	Area Remaining (ha)	Proportion of remaining area
Excellent	260	<1%	34	<1%	227	<1%
Very good	8,043	1%	776	<1%	7,267	2%
Good	23,115	4%	2,415	2%	20,699	4%
Moderate	77,031	12%	17,721	11%	59,309	13%
Limited	211,128	33%	82,840	52%	128,288	27%
Very limited	187,260	29%	50,830	32%	136,431	29%
Unsuitable	116,265	18%	5,441	3%	110,824	23%
Other (built-up areas, water)	15,613	2%	5,441	3%	10,172	2%
Total area	623,102	100%	165,498	100%	473,217	100%

Source: Argyll & Bute Council, 2011

4.13 Current forestry open data from Argyll & Bute Council[83] shows that there is approximately 160,500ha of existing planted woodland, with a further 76,600ha identified as preferred (that is, land that offers the greatest scope to accommodate future expansion of a range of woodland types), and

[81] No data reported for 2018

[82] https://argyll-bute.gov.uk/moderngov/mgConvert2PDF.aspx?ID=55380

[83] https://argyll-bute.maps.arcgis.com/apps/webappviewer/index.html?id=a4ef5fe5bae1479b85f4c2d8fbc63b4a

146,700ha as having potential to accommodate a range of woodland types, but where at least one significant sensitivity exists.

Forestry employment

4.14 According to BRES data, current forestry employment in Argyll & Bute is 300 workers, as at 2020. This is out of a total Scottish workforce of c.4,500 workers (Table 4.5).

Table 4.5: Employment in forestry and logging, 2020

	Employment	
	Argyll & Bute	Scotland
2015	225	4,000
2016	250	4,500
2017	225	4,000
2018	225	4,500
2019	250	5,000
2020	300	4,500

Source: BRES, 2022

Forestry economic value

4.15 Latest available data from the Scottish Annual Business Statistics (2019) indicate that Forestry and logging generates around £218 million of GVA at basic prices in Scotland. A conservative estimate for Argyll & Bute, based on the proportion of Scotland's woodland resource in Argyll & Bute (c.15% of Scotland's total woodland resource) is £33 million.[84] Based on the hectarage of forestry, this would equate to around £205 of GVA per hectare.

PEATLAND

4.16 Peatlands are by far the world's most efficient terrestrial carbon store. Scotland has 13% of the world's blanket bog, with the Flow Country the largest of expanse in Europe (4000km^2) and holding about one quarter of the UK's soil carbon (understood to be twice the amount of the UK's woodlands). The huge reserves of peatlands in the Highlands and Islands, in their natural state, are a carbon store. For example, the Flow Country in Caithness and Sutherland is Europe's largest area of blanket bog peatland, extending to 494,210 acres (200,000 hectares). These reserves are Scotland's largest terrestrial carbon store, holding around 1.6 billion tonnes of carbon.

4.17 Over time, land use practices have caused them to degrade and coupled with climate change, there is a risk that many areas in Scotland may not be able to support peatlands in the near future. The potential losses of carbon have been calculated and show that more than half of the carbon currently stored in Scottish blanket bogs will be at risk of loss as emissions arising from peatland degradation. It is therefore vital that the carbon they currently hold is secure and that steps are taken to avoid their degradation, and thus prevent emissions (typically due to their drying out). There is an opportunity to restore the peatlands to enhance their capacity to maintain carbon stocks and the Scottish Government's Climate Change Plan has set a target to restore 250,000 ha of degraded peatlands by 2030. Scottish Natural Heritage (SNH) has kick-started the restoration challenge with the 'Peatland ACTION' project.

4.18 There currently are multiple peatland projects in Scotland, with a number located in Argyll & Bute. There are currently several Peatland ACTION projects completed or underway in Argyll and Bute. While the public repository of project includes geographical coordinates, it doesn't include project area for any given project, or detailed project maps. A total of 10 feasibility studies are included in the public

[84] Scottish Government (2021) Scottish Annual Business Statistics, 2019

repository, two in 2015-16, six in 2017-18 and two in 2018-19. Nine projects involve restoration, one in 2012-13, two in 2013-14, one in 2014-15, two in 2018-19 and three in 2019-2020. By contrast, only one project involved monitoring (carbon flux) in 2014-15 and two projects included other eligible activity, namely *Rhododendron ponticum* control (2015-16) and volunteer engagement through the "Bog Squad" with Butterfly Conservation (2017-18 and 2018-19).[85]

4.19 Other projects of note include two projects on Islay as part of the Collaborative Action for the Natura Network (CANN) Project, a cross-border environment project which aims to improve the condition of protected habitats and to support priority species found within Northern Ireland, the Border Region of Ireland and Scotland.[86] These are at Eilean na Muice Duibhe (Duich Moss) and Rinns of Islay.[87]

4.20 A consortium[88] of soil scientists and international carbon protocol experts, farming community, and Defra's Soils and Green Finance teams are developing a UK Farm Soil Carbon Code (UKFSCC). This will consist of a set of formal protocols that allow farmers to quantify and verify reduced greenhouse gas emissions and/or soil carbon capture as a result of adopting regenerative farming practices.[89]

4.21 An estimated 50% of Argyll & Bute's land area is heather moorland, peatland, rough grassland and bracken scrub.[90] However, much of the peatland in Argyll & Bute is Class 1 or Class 2 (nationally important carbon-rich soils, deep peat and priority peatland habitat, with areas likely to be of high conservation value, or potentially high conservation value and restoration potential).[91]

4.22 Nevertheless, there is a considerable area of peatland in Argyll & Bute identified as being degraded and eligible for Peatland Code, providing significant opportunities for an increase in supply of projects delivering carbon emission reduction in Argyll and Bute. In total, there is almost 49,500 hectares of degraded peatland in Argyll & Bute (Table 4.6).[92] These areas have the potential to bring emission reduction through avoided losses.

Table 4.6: Area of degraded peatland in Argyll & Bute with peatland restoration carbon supply opportunities

Pre-restoration condition category (emission, $tCO_2e\ ha^{-1}\ yr^{-1}$)	Post-restoration category condition (emission, $tCO_2e\ ha^{-1}\ yr^{-1}$)	Emission reduction $tCO_2e\ ha^{-1}\ yr^{-1}$	Area in Argyll & Bute	Maximum annual potential supply opportunity $ktCO_2e\ yr^{-1}$
Actively Eroding, drained (23.84)	Drained, revegetated (4.54)	19.3	3,784	73.03
Drained modified grass/heather dominated or undrained actively eroding (4.54)	Modified (2.54)	2.00	45,706	91.41

Source: SAMS Enterprise, 2022

MARINE RESOURCE

4.23 The ocean plays a vital role in the removal of atmospheric CO_2. The Highlands and Islands has extremely valuable but currently underused marine environmental resources, particularly in relation to natural resources like seaweed and microalgae. With almost two thirds of the UK's coastline, the Highland and Islands is at the forefront in relation to the health of Scotland's marine environment and

[85] SAMS Enterprise (2022) Optimising carbon sequestration opportunities in Argyll and Bute
[86] https://thecannproject.org/about/the-cann-project/
[87] https://thecannproject.org/explore/
[88] For all consortium partners see https://www.sustainablesoils.org/soil-carbon-code/the-consortium
[89] https://www.sustainablesoils.org/soil-carbon-code/about-the-code
[90] https://www.argyll-bute.gov.uk/planning-and-environment/biodiversity
[91] https://soils.environment.gov.scot/resources/peatland-restoration/
[92] SAMS Enterprise (2022) Optimising carbon sequestration opportunities in Argyll and Bute

the sustainability of marine planning. The region is a valuable innovation and test area for developing marine environmental services and associated technologies.

4.24 Carbon storage and sequestration has also gained prominence in Scotland in recent years. Scotland has not only the storage capacity but also the geographical context and know-how to become a major hub for CO_2 transport and storage in Europe.[93] With its access to the largest portion of Scottish waters, it also has the opportunity of becoming a leader in marine biotechnology applications of carbon sequestration through seaweed, seagrass, or shellfish.

4.25 Whilst there is ongoing research to identify the extent of carbon stores in the marine environment in Argyll & Bute, it is accepted that there is a high sequestration capacity within the Argyll and Bute marine planning region. This is through macroalgae, kelp and intertidal fucoid species, saltmarshes, seagrass, phytoplankton and calcifying marine plant species such as maerl, as well as through the areas seabed sediments – sediments in sealochs in particular are the largest store of marine organic carbon in the region.[94]

4.26 However, the capacity of natural marine habitats to sequester and store carbon in Argyll and Bute is largely unsupported. That is, it currently does not have management and ownership models equivalent to those of the terrestrial environment, due to the nascent nature of the marine biotechnology and marine environmental services sectors. The lack of supporting management and ownership structures is a major barrier to market development.

[93] https://www.sccs.org.uk/images/expertise/reports/opportunities-for-co2/CO2-JointStudy-Full.pdf

[94] SAMS Enterprise (2022) Optimising carbon sequestration opportunities in Argyll and Bute

5 ECONOMIC IMPACTS

Key points

- Based on available data and research, a range of economic impacts can be supported by carbon sequestration activity:
  - Forestation can support up to 1.0 FTE per hectare for site preparation and planting and up to 0.08 FTE per hectare for management, depending on site area and tree type
  - Silvopasture can support c. 0.07 FTE and 0.16 FTE per hectare for preparation/planting and management respectively
  - Peatland restoration can support 1.1-1.2 FTE per hectare on typical restoration projects.
- Carbon credit prices vary by sequestration type, but unit prices have typically increased in recent years, and this trend is set to continue.
- Considerable carbon revenue generation is possible in Argyll & Bute, dependent on sequestration mode and the rate of carbon units per hectare that can be achieved – though there are opportunity costs in terms of loss of agricultural output and cost of establishment, which can be considerable in some instances.
- A number of wider benefits can also be realised, including: improved biodiversity and habitat creation; flood mitigation; improved water and air quality; better soil and nutrient management and reduced erosion; shelter for livestock; sustainable timber production; creation of skilled jobs; physical and mental health improvements; social well-being; and increased community engagement and community wealth building.

INTRODUCTION

5.1 This chapter provides an overview of estimations of the economic impact for each terrestrial carbon sequestration option. Marine carbon sequestration is not considered at this stage due to lack of market development. The analysis draws on a range of available data regarding employment, revenue generation, carbon units, etc. to present potential impacts for Argyll & Bute. The chapter then models typical impacts and costs for an assumed area of 10% of Argyll & Bute's agricultural land. These impacts are provided for illustrative purposes at this stage.

METRICS

Employment

Carbon farming forestry

5.2 Supported direct employment for forestry management of a plantation of mainly conifers with a small proportion of broadleaf, without thinning, could range from 0.003 FTE per hectare for larger plantations to just under 0.03 FTE per hectare for smaller plantations (c.50-100ha). With a slightly larger proportion of broadleaf in the mix and with periodic thinning, supported direct employment could increase to just over 0.03 FTE per hectare.

5.3 Supported direct employment for site preparation and planting could be in the region of 0.07-0.1 FTE per hectare, dependent on tree and forestry use type.

5.4 Supported direct employment for forestry management of broadleaf is understood to be higher, and could be in the region of 0.08 FTE per hectare.

Table 5.1: Employment (FTE) per hectare by tree planting type[95]

Plantation type	**FTE/ha**
Management	
Forestry plantation (c.20,000ha), Eskdalemuir, Borders	0.003
Forestry plantation (c.3,000ha), Tweedsmuir, Borders	0.009
Average employment requirement across UK forestry	0.006
Predominantly conifer plantation, without thinning (c.50ha)	0.029
Mainly conifer with 20% broadleaf, periodic thinning (c.50ha)	0.031
Broadleaf (mixed) (c.20ha)	0.080
Site preparation and planting	
Predominantly conifer plantation, without thinning	0.074
Mainly conifer with 20% broadleaf, periodic thinning	0.067
Broadleaf (mixed)	0.095

Source: Steve Westbrook/Forestry Commission, 2022; Forest Research, 2021; SAC Consulting, 2014

Silvopasture and agroforestry

5.5 Agroforestry (the growing of both trees and agricultural/horticultural crops, or livestock cultivation) differs from silvopasture (explicitly the integration of tree growing, foraging and grazing of domesticated livestock on the same unit of land)[96], and thus has different employment requirements. However, there is a lack of clarity in available literature regarding employment requirement for silvopasture. Based on review of employment impacts for agroforestry as discussed above, supported direct and indirect employment for silvopasture could be approximately 0.16 FTE per hectare for management, and 0.07 FTE per hectare for site preparation and management.

Table 5.2: Employment (FTE) per hectare, agroforestry

	FTE/ha	
	Direct	**Direct and indirect**
Agroforestry (c.10ha) – management	0.16	0.29
Agroforestry (c.10ha) – site preparation and planting	0.07	0.11

Source: Steve Westbrook/Forestry Commission, 2022

Peatland restoration

5.6 Based on research and analysis conducted by Glenk et al. (2021) for SEFARI[97] and Okumah et al. (2019) for SRUC, it is estimated that peatland restoration activity could support up to 0.021 FTE per hectare. This is based on identified costs from Peatland Action project application forms and final project forms. Employment estimates have been derived using turnover:employment ratios from the latest Scottish Annual Business Statistics, with an assumed pattern of spend by sector for restoration services (e.g. plant hire, environmental services, etc.).

5.7 Using a mean restored peatland area of 62.44ha identified by Glenk et al. (2021) in Peatland Action projects, a typical project could expect to support between 0.7 and 1.3 FTE. It is worth noting that peatland restoration projects typically rely on a considerable amount of volunteer resource time,

[95] Based on data from review of available literature, including: Steve Westbrook/Forestry Commission, Scottish Forestry and the Welsh Government (2022) Impact of investment in forestry on employment in England, Scotland and Wales; Forestry Commission/Forest Research (2021) Forestry Statistics and Forestry Facts & Figures; SAC Consulting (2014) Eskdalemuir: A comparison of forestry and hill farming; productivity and economic impact; SAC Consulting (2019) Tweedsmuir and Moffat Hills Area – Appraisal of Economic Opportunities – Economic baseline and projections

[96] A useful discussion of Agroforestry, silvopasture and silvoarable is set out in: B. Raskin, & S. Osborn (Eds.) (2019), The Agroforestry Handbook: Agroforestry for the UK

[97] Glenk, K. Sposato, M., Novo, P., Martin-Ortega, J., Shirkhorshidi. (2021). The costs of peatland restoration – March 2021 update on database based on the Peatland Action Programme in Scotland. SEFARI report.

and are majority-funded by Government support schemes (around 87%). Alternative costs from Natural England suggest a cost of £2,000 per hectare of rewetting, and £12,000 per hectare of revegetation.[98]

Table 5.3: Employment (FTE) per hectare, peatland restoration

	Stated application form costs		Stated final project form costs	
	£/ha	FTE/ha	£/ha	FTE/ha
Mean peatland restoration cost per hectare	£2,028	0.021	£1,878	0.020
Median peatland restoration cost per hectare	£1,222	0.013	£1,000	0.010
Mean peatland restoration cost per hectare, excl. outliers	£1,766	0.018	£1,253	0.013
Median peatland restoration cost per hectare, excl. outliers	£1,217	0.013	£1,000	0.010
Employment supported per typical restoration project (c.62ha)		1.2		1.1

Source: Consultant estimates, from Glenk et al. (2021), Okumah et al. (2019), SABS (2021)

5.8 Additionally, it is worth noting that recent work undertaken by Scottish Government and NatureScot has examined the local economic impacts of natural capital investments, with a view to improving the understanding of local multipliers (i.e. indirect and induced impacts) through more bespoke input-output models for natural capital investments.[99]

Economic value

5.9 The following sections summarise the economic value that can be obtained from carbon credit revenue across the three sequestration types under consideration. This focuses on current market rates, which are typically between £10-£30 depending on sequestration approach, PIU or verified WCU/PCU, etc. A range of future estimates and forecasts, and values relating to the realisation of net zero ambitions are also available, and some of these are considered with regard to potential scenarios in Chapter 6.

Carbon farming forestation

5.10 Woodland carbon credits can be purchased as a Pending Issuance Unit (PIU), or as a Woodland Carbon Unit (WCU). A WCU is a tonne of CO_2e which has been sequestered in a WCC-verified woodland, whilst a PIU is effectively a promise to deliver a WCU in future.[100]

5.11 It is worth noting that the price of carbon units (both PIU and WCU) have increased considerably in recent years. For example, a native planting scheme in Argyll secured £13.50 per PIU in June 2021, but as at January 2022 was seeking £16-£17. Similarly, a native planting scheme in Northumberland, originally seeking offers above £15 per PIU, realised £18 per unit.[101] An additional factor is the vintage of PIUs, i.e. The date at which when PIUs mature and are validated as WCUs. Longer-term PIU vintages cost less than those that have an imminent maturation/validation date.[102] Since WCUs have necessarily been validated, they typically cost more than PIUs, but are readily available as carbon credits.

5.12 Based on a review of prices for woodland carbon credits, the following prices per unit for both PIU and WCU can typically be expected in Scotland at present (Table 5.4).

[98] http://publications.naturalengland.org.uk/publication/5101422143340544

[99] https://www.gov.scot/binaries/content/documents/govscot/publications/research-and-analysis/2022/08/understanding-local-economic-impacts-natural-capital-investment/documents/understanding-local-economic-impacts-natural-capital-investment/understanding-local-economic-impacts-natural-capital-investment/govscot%3Adocument/understanding-local-economic-impacts-natural-capital-investment.pdf

[100] https://woodlandcarboncode.org.uk/buy-carbon/what-are-woodland-carbon-units

[101] https://carbonstoreuk.com/publications/woodland-carbon-update-jan-2022/

[102] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1084680/FC_Fact_Sheet_Carbon_FINAL_14062022.pdf

Table 5.4: Price per carbon unit for different plantation types

Scheme type	£/unit
PIU[103]	
Productive conifer woodland	£15
Native woodland planting scheme	£17
Mixed woodland (conifer and broadleaf)	£12.50
New planted broadleaf	£22
Woodland Carbon Guarantee scheme, fourth round	£18.62
Forestry commission PIU estimates	£10-£30
WCU[104]	
WCU price range estimates	£17.31-£24.41

Source: Forestry Commission, 2022; UK Government, 2022; Carbon Store UK, 2021-22

5.13 It should be noted here that whilst productive conifer woodland is able to attract carbon credits, conifer planting for carbon sequestration has to undergo a separate level of additionality testing. In practice, productive conifer woodland is being discouraged for the time being. It also attracts higher levels of grant funding through the Forestry Grant Scheme (FGS)[105] than other woodland types, which would undoubtedly prove problematic in terms of securing support through the Woodland Code. FGS support is available to support woodland improvement, management, forest infrastructure and co-operation between landowners and forestry projects. The SAMS Enterprise report into carbon sequestration opportunities in Argyll & Bute[106] provides a fuller discussion of FGS support.

5.14 Productive conifer woodland is included here and below in terms of an option for carbon sequestration for illustrative purposes only.

5.15 As shown in Figure 5.1, the number of carbon units per hectare that can be achieved varies by woodland type, and by age of woodland. Understandably, the more mature a woodland is, the more carbon it will have sequestered: more mature woodland has sequestered more carbon historically than new woodland. Based on available data and ranges of carbon units per hectare, a reasonable average is **350 CO_2e units per hectare** over a period of c.30 years.

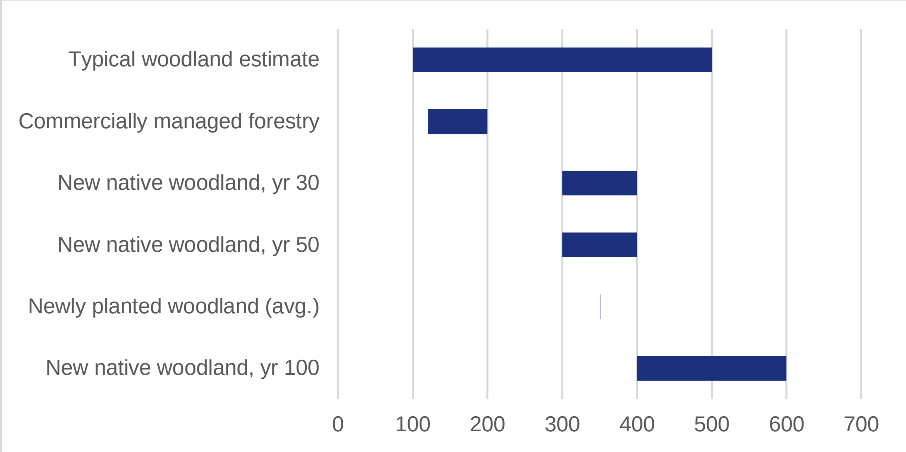
[103] Based on evidence from Forestry Commission, 2022: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1084680/FC_Fact_Sheet_Carbon_FINAL_14062022.pdf; Forestry Commission/DEFRA, 2022: https://www.gov.uk/government/news/10-million-to-provide-long-term-income-for-woodland-creation-with-fifth-auction-of-woodland-carbon-guarantee; Carbon Store UK, 2021: https://carbonstoreuk.com/publications/woodland-carbon-update-july-2021/; Carbon Store UK, 2022: https://carbonstoreuk.com/publications/woodland-carbon-update-jan-2022/.

[104] Based on evidence from CLA, 2021: https://www.cla.org.uk/news/value-carbon/; Savills, 2021: https://www.savills.co.uk/research_articles/229130/313520-0 ; Townsend Chartered Surveyors, 2021: https://townsendcharteredsurveyors.co.uk/environmental-services/woodland-carbon-code/.

[105] https://forestry.gov.scot/publications/108-the-forestry-grant-scheme-a-guide-to-grant-options-for-woodland-creation/viewdocument/108

[106] SAMS Enterprise (2022) Optimising carbon sequestration opportunities in Argyll and Bute

Figure 5.1: Carbon units per hectare



Source: Forestry Commission, 2021; Woodland Carbon Code, 2021; Carbon Store UK, 2021; Townsend Chartered Surveyors, 2021

5.16 Based on the above analysis, the following income values per hectare are assumed for carbon credits over a 30-year period, as set out in Table 5.5.

Table 5.5: Estimated income values per hectare for carbon credits, forestation

	£ per unit	Carbon units per hectare	£ per hectare
Mixed woodland	£12.50	100-500	£1,250-£6,250
New native woodland	£17	300-400	£5,100-£6,800
Commercially managed forestry	£15	120-200	£1,800-£3,000

Source: Consultant estimates

The potential for Argyll & Bute

5.17 Based on data in the Argyll & Bute Woodland and Forestry Strategy[107] and analysis by SAMS Enterprise[108] regarding preferred land area for forestation expansion, a reasonable assumption of land that could theoretically be set aside for carbon farming forestation, is 10% of Argyll & Bute's current total agricultural area[109], i.e. c.50,914ha. This equates to around two-thirds of the total area identified as preferred, and just under one quarter of the total area as either preferred or having potential to accommodate woodland. This assumes that there is a degree of overlap between total agricultural area and land that is preferred or has potential for woodland, and that there would be modest interest in setting aside agricultural land – particularly given that all of Argyll & Bute is considered *Severely Disadvantaged* in terms of Less Favoured Area status.[110]

5.18 Table 5.6 sets out the estimated income values from carbon credits under each carbon woodland type. Between £63.6 million and £346.2 million could be expected to be generated if 10% of Argyll & Bute's total agricultural area is set aside for carbon farming, dependent on woodland type and carbon units per hectare achieved over a 30-year period. Equivalent values for illustrative purposed only are also provided for the preferred area for woodland expansion, as well as the preferred and potential area combined.

[107] https://argyll-bute.gov.uk/moderngov/mgConvert2PDF.aspx?ID=55380

[108] SAMS Enterprise (2022) Optimising carbon sequestration opportunities in Argyll and Bute

[109] Total agricultural area rather than utilised agricultural area: it is assumed that some currently unutilised agricultural area is (more) suitable for (re)forestation.

[110] https://www.gov.scot/binaries/content/documents/govscot/publications/map/2017/06/agriculture-maps/documents/less-favoured-areas-in-scotland/less-favoured-areas-in-scotland/govscot%3Adocument/Map%2B-%2BLess%2BFavoured%2BAreas%2Bin%2BScotland%2B.pdf

Table 5.6: Estimated income values from carbon credits, forestation, Argyll & Bute

	£ per unit	Lower range		Upper range	
		Carbon units per hectare	Carbon credit revenue	Carbon units per hectare	Carbon credit revenue
Based on 10% of total agricultural area (c.50,914ha)					
Mixed woodland	£12.50	100	£63,642,600	500	£318,213,100
New native woodland	£17	300	£259,661,900	400	£346,215,900
Commercially managed forestry	£15	120	£91,645,400	200	£152,742,300
Based on preferred area for future woodland expansion (c.76,600ha)					
Mixed woodland	£12.50	100	£95,750,000	500	£478,750,000
New native woodland	£17	300	£390,660,000	400	£520,880,000
Commercially managed forestry	£15	120	£137,880,000	200	£229,800,000
Based on preferred and potential area for future woodland expansion (c.223,000ha)					
Mixed woodland	£12.50	100	£279,125,000	500	£1,395,625,000
New native woodland	£17	300	£1,138,830,000	400	£1,518,440,000
Commercially managed forestry	£15	120	£401,940,000	200	£669,900,000

Source: Consultant estimates

5.19 It is worth noting at this point that this does not take into consideration the timeframes for different woodland types in realising carbon sequestration, or the point at which landowners may sell their carbon units. However, following validation, units are typically verified every five years, and may be sold then, or retained for selling at a later point, and potentially at a higher price.

5.20 Based on the typical employment per hectare discussed above and taking an average value from the range presented in Table 5.1, a conservative estimate of the employment impact (management) would be in the region of **1,000 FTE** per annum, dependent on forestry type.

Silvopasture

5.21 Dependent on the density and configuration of planting in silvopasture approaches, the number of stems (trees) per hectare in silvopasture can be anywhere from 5% to 25% of the density of conifer plantation, and between 6% and 38% of broadleaf forest.[111] It should be acknowledged that the carbon credit rate will be dependent on the tree density per hectare. However, a minimum density of 400 trees per hectare is required to qualify for carbon credits through the Woodland Code. This is 16% of typical conifer plantation density (2,500 per hectare) and 25% of mixed woodland or broadleaf (1,600 per hectare). A density of 400 trees per hectare can also attract FGS agroforestry support.

5.22 Assuming the upper values of the carbon credit ranges presented in Tables 5.5 and 5.6 above, and a minimum planting density of 400 trees per hectare, the following values per hectare can be expected (Table 5.7). It is clear that on this basis, mixed woodland or broadleaf would be more advantageous.

Table 5.7: Estimated income values per hectare for carbon credits, silvopasture

	£ per unit	Carbon units per hectare	£ per hectare
Mixed woodland	£12.50	125	£1,562.50
New native woodland	£17	100	£1,700.00
Commercially managed forestry	£15	32	£480.00

Source: Consultant estimates

[111] DEFRA, 2022; Galbraith Group, 2022; Nadia El-Hage Scialabba (Ed.) (2022) Managing Health Livestock Production and Consumption; Campanhola, C. and Pandey, S. (Eds.) (2019) Sustainable Food and Agriculture: An Integrated Approach

The potential for Argyll & Bute

5.23 Based on analysis by SAMS Enterprise[112] regarding current areas of grassland/pasture in Argyll & Bute, there is 173,950ha of grassland and pasture on either organic soils or organo-mineral soils. Table 5.8 presents two options – the first assumes 10% of existing grassland and pasture is set aside for silvopasture; the second assumes 50% is set aside. These options reflect different potential levels of appetite for silvopasture amongst existing pastoral/livestock farmers, and recognise that silvopasture has to be conducted in conjunction with open grazing on rotation, to allow sufficient time for the recovery of grass, shrub and or trees. There is also evidence to support that silvopasture planting up to a tree density of 400 trees per hectare has little or no impact on grazing/livestock capacity, and therefore allows existing livestock capacity/herd size to be maintained.[113]

Table 5.8: Estimated income values from carbon credits, silvopasture, Argyll & Bute

	£ per unit	Carbon units per hectare	Carbon credit revenue
Based on 10% of existing grassland/pasture			
Mixed woodland	£12.50	125	£27,179,688
New native woodland	£17	100	£29,571,500
Commercially managed forestry	£15	32	£8,349,600
Based on 50% of existing grassland/pasture			
Mixed woodland	£12.50	125	£135,898,438
New native woodland	£17	100	£147,857,500
Commercially managed forestry	£15	32	£41,748,000

Source: Consultant estimates

5.24 Based on the typical employment per hectare discussed above in relation to Table 5.2, a conservative estimate of the employment impact for silvopasture (management) on 10% of Argyll & Bute's existing grassland/pasture land would be in the region of **1,700 FTE**, dependent on planted tree type. At 50% of existing grassland/pasture, this would be more than **8,000 FTE**.

Peatland restoration

5.25 Recent evidence indicates that the price per unit for a tonne of upland peat carbon is £12 (as PIU), assuming 75% public subsidy to address cashflow challenges for landowners and help finance peatland restoration.[114] This suggests a subsidy-free PIU price of c.£48 per unit. This is in line with evidence from a recent Interreg NW Europe-funded project, *Care Peat*, which identified a target price of €70 per tonne of peatland carbon.[115]

5.26 Assuming a potential c.200 carbon units per hectare of upland peat[116], this equates to a carbon credit income of: £2,400 per hectare alongside a further £7,200 grant funding.

OPPORTUNITY COSTS

5.27 As discussed above, the adoption of carbon sequestration techniques in Argyll & Bute would help to secure a considerable amount of sequestered carbon, as well as employment and revenue

[112] SAMS Enterprise (2022) Optimising carbon sequestration opportunities in Argyll and Bute

[113] https://www.agroforestry.ac.uk/agroforestry-systems/pastoral

[114] http://publications.naturalengland.org.uk/publication/5101422143340544

[115] https://www.nweurope.eu/projects/project-search/care-peat-carbon-loss-reduction-from-peatlands-an-integrated-approach/news/netherlands-first-carbon-credit-sale-from-peatland-rewetting/

[116] Conservative estimates based on: http://publications.naturalengland.org.uk/publication/5101422143340544; and https://www.gov.scot/publications/national-development-plan-crofting/pages/11/

generation impacts. However, there would necessarily be an opportunity cost to setting aside a portion of Argyll & Bute's agricultural land for forestation. These are summarised below.

Carbon farming

5.28 The cost of forestation can vary widely, with some estimates ranging from c.£1,000 per hectare[117] to in excess of £7,500 per hectare[118], dependent on tree type and planting requirements. Evidence from the UK[119],[120] and Ireland[121] suggests that average reforestation costs in Scotland may be as follows:

- £3,500 per hectare for forestry plantation; and
- £6,700 per hectare for new woodland.

5.29 Based on these prices per hectare, and assuming no public subsidy, this equates to between £178-341 million to reforest 10% of Argyll & Bute's agricultural land, dependent on tree/forest type and not taking into consideration any additional costs for difficult terrain.

5.30 Loss of agricultural employment and output are also additional opportunity costs. Assuming the same 10% rate of conversion of agricultural land to forest in Argyll & Bute, this may equate to:

- Approximately **275 workers** (an SLR[122] of c.210); and
- **£5.15 million** in standard agricultural output per annum.

Silvopasture

5.31 Cost per hectare silvopasture forestry establishment are somewhat lower than for forestry plantation. Whilst there will be a price differential due to the lower density of tree planting, these costs include necessary protection from livestock for planted trees. Planting costs may range from £1,000 or £2,000 per hectare[123,124,125] to around £3,800 per hectare,[126] again dependent on tree selection and livestock requirement.

5.32 Assuming a **cost per hectare of £1,500**, this would equate to a cost of **c.£26 million** to convert c.10% of Argyll & Bute's existing grassland and pasture to silvopasture. Converting 50% would likely cost in the region of £130 million. At a cost of £3,000 per hectare, this would rise to c.£52 million and £260 million respectively. In terms of an impact on agricultural output, as discussed a similar intensity of farming (i.e. no negative impact on agricultural output) can be achieved with planting of up to 400 trees per hectare.

5.33 However, it is worth noting that under some silvocultural/silvopastural systems, a lower intensity of farming may be realised.[127] In such instances, this may equate to a reduction in agricultural output of **c.£1.34 million per annum** at 10% of total grassland/pasture, or **c.£6.73 million** per annum for 50% of total grassland, assuming a 25% reduction in farming intensity in Argyll & Bute for example. This is

117 https://www.frontiersin.org/articles/10.3389/ffgc.2021.629198/full

118 https://www.sciencedirect.com/science/article/abs/pii/S0264837714002737

119 Steve Westbrook/Forestry Commission, Scottish Forestry and the Welsh Government (2022) Impact of investment in forestry on employment in England, Scotland and Wales

120 Woodland Trust, cited in: https://www.theguardian.com/society/2019/dec/28/replanting-britain-its-about-the-right-tree-in-the-right-place

121 https://www.teagasc.ie/crops/forestry/advice/establishment/reforestation/

122 SLR is broadly equivalent to FTE.

123 https://drawdown.org/solutions/silvopasture

124 https://www.fwi.co.uk/business/silvopasture-what-it-is-and-how-it-benefits-livestock-farming

125 https://macaulay.webarchive.hutton.ac.uk/agfor_toolbox/try_it.html

126 Steve Westbrook/Forestry Commission, Scottish Forestry and the Welsh Government (2022) Impact of investment in forestry on employment in England, Scotland and Wales

127 https://www.fwi.co.uk/business/silvopasture-what-it-is-and-how-it-benefits-livestock-farming

illustrative, and elsewhere in this report, it is assumed that no negative impact arises from the adoption of silvopasture, based on the chosen density of planting.

Peatland restoration

5.34 Upland re-wetting can cost in the region of **£1-2,000 per hectare**, and approximately **£12,000 per hectare** for re-vegetation.[128] For the purposes of this report, re-wetting costs are assumed to be £1,000 per hectare. Assuming a 100-hectare upland peat project comprised of 90 hectares rewetting and 10 hectares revegetation, this would equate to a restoration cost of £210,000.

WIDER BENEFITS OF CARBON FARMING AND SILVOPASTURE

5.35 Carbon farming through the creation of new woodlands has wider social, economic, ecological, and environmental benefits, besides sequestering carbon.[129] EFTEC, in an assessment project commissioned by the Woodland Carbon Code, estimated that, on average, each carbon unit (tCO_2e) purchased from a Woodland Carbon Code project also delivers at least a further £100/tCO_2e of value through its estimation of outputs and outcomes that are arrived at through co-benefits realised in wildlife, water quality, climate change mitigation and adaptation, and benefits to the local community.[130]

5.36 This compares to a World Bank estimate of the "shadow price of carbon" of between \$42-\$92/tCO_2e (2022 value) that acknowledges that many projects funded by World Bank generate global social benefits from reduced GHG emissions (or costs from increased emissions).[131]

Ecological and environmental benefits

5.37 A first benefit is to **improve biodiversity and habitat creation**: woodlands provide essential habitats to a wealth of wildlife, including nesting birds, shade-loving plants, and fungi. Appropriate native tree planting plays a central role in the efforts to tackle the biodiversity crisis.[132]

5.38 Enhancing biodiversity is most effective in areas that are planted with native woodland species as opposed to non-native conifer plantations. This is due to the natural evolution of the food chain associated with these trees- as trees native to the region developed, other plants and animals native to the region developed close relationships with these tree species, becoming reliant on them for food, breeding sites and shelter.

5.39 In a 2019 study conducted by Woodland Trust, it was discovered that there were 2,300 species of flora and fauna found to be supported by native Oaks in the UK, while 326 of these species specifically depended on oak for survival.[133]

5.40 It should be noted that non-native conifer plantations can still improve the surrounding wildlife's biodiversity through increasing the amount of deadwood available in the habitat and protecting and covering old growth features like standing dead trees.[134]

5.41 Woodland creation also provides an alternative source of food for pollinators.[135] Pollinators need flowers that produce lots of nectar for energy, and pollen for protein. It is advised that native trees are

[128] http://publications.naturalengland.org.uk/publication/5101422143340544

[129] https://woodlandcarboncode.org.uk/buy-carbon/why-buy-wcc-verified-carbon-units

[130] https://forestry.gov.scot/publications/sustainable-forestry/economic-research/588-assessing-the-wider-benefits-of-the-woodland-carbon-code

[131] https://thedocs.worldbank.org/en/doc/911381516303509498-0020022018/original/2017ShadowPriceofCarbonGuidanceNoteFINALCLEARED.pdf

[132] https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/

[133] https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/oak-tree-wildlife/

[134] https://www.woodlandtrust.org.uk/blog/2020/07/biodiversity-and-native-woods/

[135] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1078625/The_Case_for_Trees_WEB_May_2022.pdf

best for pollination, and overall for native wildlife as risks relating to planting of non-native trees that carry pests and diseases are minimised, while native trees support native wildlife to a higher degree.[136]

Water management and flood risk mitigation

5.42 Another benefit of woodland creation is **flood mitigation**. A mature tree captures over 700 gallons of water per year. Carefully planted patches of woodland across a river basin can reduce the flow velocity in the neighbouring river, when rainfall is high, by almost 50%.[137] Upland woodland can reduce water run-off by intercepting, using and recycling more rainwater than grassland, and woodland on a river's floodplain can slow the flow of floodwater – and reduce the risk of floods in communities.[138]

5.43 Woodlands reduce the risk of flooding through a greater need for water at the source (where the trees are planted), having a higher infiltration rate in woodland soils to reduce rapid runoff, and exerting higher levels of hydraulic roughness through foliage and woody debris acting as a drag on flood waters to disrupt flow of water.[139]

5.44 In particular, there is evidence to suggest that conifer woodland has a better potential with regards to water retention and storage, due to a higher degree of water use compared to native species and the typically drier soils beneath productive conifer woodland, meaning they are better able to receive and store rainfall.[140] However, this may also negatively impact on stream flow supporting hydro-electric generation schemes.

5.45 It should be noted, however, that planting trees on silvopasture for the purposes of grazing can have an impact on the total tree coverage and as a result, would have diminishing returns with regards to mitigating flood risk. Further, upper soil layers that are compacted as a result of intensive sheep grazing can lead to increased local flood risk and as a result, clumped tree configurations as opposed to even spaced tree configuration and fencing off tree areas in local silvopastural systems would help alleviate flood risk more effectively.[141]

5.46 Woodlands can have a positive effect on **water quality**, by acting as a water filter.[142] Flood water often contains high levels of phosphorus pollutants and nitrogen. Without trees, that flood water would flow directly into rivers and lakes without being filtered. Trees break the rainfall allowing soil microbes to transform the pollutants.[143]

5.47 Planting a new woodland across slopes or beside a river can help to intercept run-off and greatly reduce pollution from entering nearby waterways. The trees provide a buffer to waterways by reducing, and in most cases, preventing pollutants from adjacent fields from entering nearby watercourses.[144] This, therefore, provides an ecosystem service by removing the cost of maintaining the quality of water supplied in the absence of woodland's role in pollution removal. Otherwise, water may need to be treated (i.e. purified) via more expensive means.[145]

136 https://pollinators.ie/planting-native-trees-for-pollinators/

137 https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/

138 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1078625/The_Case_for_Trees_WEB_May_2022.pdf

139 https://www.unda.co.uk/news/well-designed-productive-woodland-reduces-flood-risk/

140 Ibid.

141 https://research.bangor.ac.uk/portal/files/8561742/33072.pdf

142 e.g. see https://acsess.onlinelibrary.wiley.com/doi/10.2134/jeq2019.01.0020

143 https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/

144 https://forestrycommission.blog.gov.uk/2022/03/01/making-space-for-nature-to-benefit-water/

145 https://forestry.gov.scot/publications/592-the-feasibility-of-valuing-woodland-s-contribution-to-regulating-water-quality-and-quantity-summary/viewdocument/592

Air quality

5.48 Woodlands can also affect **air quality** by absorbing harmful gases such as carbon dioxide, nitrogen oxide, ammonia, and sulphur dioxide. Trees also remove particulate pollution from the air by catching particulate matter on their leaf surfaces.[146]

5.49 Furthermore, woodlands lower windspeed and can reduce spray drift (the movement by wind of any pesticides beyond their targeted area) up to 90%, as well as helping to capture pesticide run-off and ammonia released from livestock units, which can help cut pollution.[147]

Soil

5.50 Woodlands can be used to **manage soil and nutrient losses**. Planting woodland between the field edge and a river can reduce sediment run-off by 90-100%, nutrient losses by 20-80%, and reduce pesticide loss in run-off by 60-100%.[148]

5.51 Creating woodlands can help **reduce soil erosion**. Wind and rain are the two largest natural forces eroding the soil: wind can do significant damage to a dry land, and raindrops have the power and momentum to dislodge soil when they hit the ground. Trees break up droplets of rain and weaken their strength while roots hold the soil together and protect it from the effects of wind. Creating woodlands can therefore limit the erosive damage from wind and rain.[149]

Timber

5.52 Woodlands can improve **sustainability** through the creation of **timber**, a highly sustainable material. In fact, timber has the lowest embodied energy (i.e. energy used in its processing, production, and transport, from tree to consumer use) of any mainstream building material, and significantly less than for steel, concrete, or aluminium.[150]

5.53 It should be noted, however, that the economic benefits of timber farming may counteract the benefits of carbon financing. In May 2022, Scottish Forestry strengthened the Woodland Carbon Code with revised “additionality” tests.[151] This makes forestry projects that are economically viable (such as timber production) without receipt of carbon credits not eligible for carbon financing.

Livestock benefits

5.54 Another benefit of woodland creation is providing **livestock shelter**[152] by increasing woodland cover on silvopasture land also has an impact on the temperature of the habitat, acting as a natural coolant given the ability to shade the land the trees are planted on. If an animal has to expend less energy maintaining their core body temperature, that energy goes into weight gain, ensuring better welfare of the animal and ultimately resulting in higher profits. It has been estimated that sheep with adequate shelter and shade demonstrate a 10 – 15% greater weight gain than those without.[153]

5.55 In addition to shelter, woodland creation on silvopasture land can provide an additional food source for livestock. Tree forage tends to have higher micronutrients and tannins than grasses, which

[146] https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/tackling-air-pollution-with-trees/

[147] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1078625/The_Case_for_Trees_WEB_May_2022.pdf

[148] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1078625/The_Case_for_Trees_WEB_May_2022.pdf

[149] https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/

[150] https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/

[151] https://forestry.gov.scot/news-releases/rules-strengthened-around-woodland-carbon-schemes

[152] https://woodlandcarboncode.org.uk/buy-carbon/why-buy-wcc-verified-carbon-units

[153] https://www.farmingfornature.ie/resources/groundtips/agroforestry-silvopasture/

can in turn benefit livestock health[154] as well as reducing parasite burdens within livestock, allowing animals to engage in self-medication against these parasites.[155]

Socio-economic benefits

5.56 Carbon farming and silvopasture also provide communities with wider socio-economic benefits. In the first instance, the creation and maintenance of woodlands generates the need for **skilled jobs**,[156] for example specialist skills required when managing ancient and veteran trees.[157] Successful woodland creation, then, is necessarily paired with the growing and upskilling of the forestry sector workforce.

5.57 Woodland projects also encourage **community engagement** with and access to trees and forests and have a positive impact on environmental education and development of these communities, for example through staff volunteering or school projects.

5.58 Woodlands can be used for leisure outdoor activities, thus further diversifying land usage whilst bringing benefits for individuals' **physical and mental health, and** their **social well-being**. It is reported that typically, when compared with urban environments, natural environments such as forests and woodlands improve human mood states, concentration and performance.[158] In addition to this, access to leisure and recreational green space can improve physiological issues by lowering blood pressure, pulse rates and reduce stress levels.[159]

5.59 Woodland creation can also contribute to **community wealth building,** the concept of redirecting wealth back into the local economy through placing control and benefits of assets and resources into the hands of local people.[160] If forestry and woodland cover is owned by the local community, its assets are also community owned and thus any wealth generated from the forest would then belong to the community. The various types of capital that can be gained from community forestry include new financial capital (from timber revenues), social capital (co-operation, new capacity, and associations), individual capital (jobs), natural capital (generating ecosystem services) and built capital (if designing trails, recreational facilities or campsites).[161]

[154] https://www.resilience.org/stories/2019-11-08/silvopasture-the-benefits-of-integrating-livestock-and-trees/

[155] https://research.bangor.ac.uk/portal/files/24881132/Agroforestry_handbook_6_6_19_full_pdf.pdf

[156] https://woodlandcarboncode.org.uk/buy-carbon/why-buy-wcc-verified-carbon-units

[157] https://www.gov.uk/government/news/woodland-projects-across-england-to-receive-funding-for-jobs-training-and-increasing-tree-cover

[158] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2793342/

[159] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1078625/The_Case_for_Trees_WEB_May_2022.pdf

[160] https://www.landcommission.gov.scot/our-work/good-practice/community-wealth-building

[161] Lyman, M, Grimm, C & Evans, J, 2014. *Community forests as a wealth creation strategy for rural communities* in Community Development Vol. 45.

6 SCENARIO MODELLING

Key points

- A range of scenarios have been developed to demonstrate the potential impacts arising from carbon sequestration activity.
- These scenarios are designed to be illustrative only, and are presented under optimal conditions, with a number of underpinning assumptions.
- These scenarios include:
    - Peatland restoration;
    - Conifer forestation;
    - Native woodland forestation;
    - Silvopasture;
    - Forestation with higher-value carbon units;
    - Combination of forestation and silvopasture, with a higher value of carbon unit for each; and
    - Integrated carbon sequestration approach (peatland restoration, forestation and silvopasture) with a very high carbon unit price for each.
- However, there are a number of dependencies and considerations, both strategic and operational, that will impact on the extent to which each scenario can be realised.

INTRODUCTION

6.1 Building on the information presented in the preceding chapters, this chapter sets out a number of carbon sequestration scenarios for consideration, along with the main assumptions and limitations underpinning these scenarios. It also presents some high-level dependencies and considerations for all scenarios.

PURPOSE OF SCENARIOS

6.2 The scenarios presented below are intended to be illustrative only – that is, to demonstrate the maximum possible theoretical gains under each scenario. Differing scenarios are included to illustrate the requirements and theoretical potential of each. A range of take-up rates and carbon credit prices have been considered, and are included across each of the scenarios.

6.3 Importantly, the scenarios have been presented under 'optimal' conditions

ASSUMPTIONS AND LIMITATIONS OF SCENARIOS

6.4 Table 6.1 sets out the assumptions underpinning the scenarios, as well as the limitations of and caveats for the scenarios.

Table 6.1: Assumptions, caveats and scenario limitations

Consideration	Summary of assumptions and caveats
Land allocation	The land allocated over to sequestration activities is based on possible total land available for a particular mode of carbon sequestration. For peatland restoration, this necessarily means sequestering carbon through restoration of currently degraded peatland. For forestation, it is assumed that this will occur on agricultural land, on the basis that sequestration through the Woodland Carbon Code currently has to be achieved through woodland creation. No assumptions have been made regarding on where land for sequestration will be allocated, nor have assumptions been made on the configuration of land allocation – i.e. whether the total allocation will be comprised of parcels of land from each land holding, or will be comprised of a particular number of holdings.
Impact of soil type on net sequestered carbon	No assumptions have been made on the impact of soil type on the net amount of carbon that may be sequestered through forestation. For example, whilst forestation on mineral soils with minimal planting intervention may have a negligible effective on net sequestration, planting on more organic soils with e.g. mounding will result in some carbon emissions. Whilst it is recognised that it is likely that not all forestation planting will occur on mineral soils, no adjustment has been made to sequestration rates at this time.
Sale of carbon credits	For the purposes of simplifying the scenarios, it is assumed that carbon credits are sold by landowners rather than being retained by landowners to meet their own carbon offsetting/insetting requirements. It is also assumed that they are sold at the earliest opportunity (e.g. as PIUs), rather than trying to factor in any likely price rises for carbon units for sale at a later point in time.
Employment creation	It is assumed that created employment opportunities for set-up/establishment are time-limited, i.e. not permanent employment. As such, these are expressed in FTE job years and on an FTE basis. A discounting factor has been applied to operational employment creation, to account for any potential economies of scale on larger or clustered sequestration schemes.
Peatland restoration	It is assumed that all peatland restoration undertaken is largely re-wetting. In the scenarios presented, re-wetting constitutes 90% of activity, and revegetation accounting for the remaining 10%.
Silvopasture	It is assumed that any silvopasture approach can be done in such a way as to not negatively impact existing livestock farming approaches re herding, animal husbandry and other movements of animals. Further, it is assumed that the specified density of planting does not require any reduction in the intensity of current livestock farming.
Timeframe	Whilst it is acknowledged that verification of carbon is undertaken at regular intervals (c.5 years), for the purposes of these scenarios, a 30-year timeframe for sequestration of carbon is assumed. However, it is noted that for woodland schemes, it is likely that these will be contractually required to be maintained at the developer's cost for a longer period.
Buffers, risk and permanence	Existing requirements on mandatory buffers and risk-related discounting for Woodland/Peatland codes have been incorporated in the scenarios. As such, the total carbon units presented are the amounts able to be sequestered less the discounted amounts – so 30% in the case of the PCC, and 40% in the case of WCC.
Public sector support	The scenarios assume a neutral position on public sector support. That is, beyond available support through either the Peatland Carbon Code or Woodland Carbon Code, no additional support is assumed – either through other mechanisms such as the Woodland Grant Scheme, or other support such as grant funding income to support ongoing operational costs (e.g. maintenance and management), validation, verification and monitoring.
Validation, verification and monitoring	Similar to the situation discussed above in relation to public sector support, no assumptions are made on the available support for ongoing validation, verification and monitoring of sequestered carbon. Further, no assumptions are made on the costs associated with required ongoing validation, verification and monitoring.
Multiplier effects	The scenarios do not consider multiplier effects. As such, estimates are conservative. Job creation is derived from research conducted by Steve Westbrook/Forestry Commission (2022), Forest Research (2021) and SAC Consulting (2014), and presents direct employment only. However, the potential for supply chain development is acknowledged in consideration of other revenue potential.

Shadow carbon value	Given that additional wider benefits are qualitatively assessed, the World Bank's shadow price of carbon[162] is included in an effort to monetise the wider benefits of carbon sequestration activity. This is currently estimated to be around $60 per carbon unit.[163] At this point, no adjustment has been made to reflect any relative differences between modes of carbon sequestration and the social/community/environmental benefits that they can secure.

[162] https://thedocs.worldbank.org/en/doc/911381516303509498-0020022018/original/2017ShadowPriceofCarbonGuidanceNoteFINALCLEARED.pdf

[163] It is worth noting that recent Bank of England estimates place a shadow carbon price at $150 per unit by the end of the decade – around double the World Bank forecasts for shadow carbon price for 2030. See: https://www.bankofengland.co.uk/speech/2021/may/sarah-breeden-managing-the-impact-of-climate-change

BASE SCENARIOS

Scenario 1: Peatland restoration

6.5 This scenario comprises the restoration of over 4,900 hectares of degraded peatland in Argyll & Bute. Assuming a carbon unit price of c.$15 (£12.50) for upland peatland carbon, it is estimated that this could generate c.£8.7 million in carbon revenue.

Main advantages

6.6 The main advantage in this scenario is the reversal of carbon emissions from an important but degraded carbon store in the area. In addition to the carbon sequestered, peatland restoration can bring additional benefits through reduced flood potential and improved water management, and increased biodiversity.

Main disadvantages

6.7 Beyond the demand for labour, plant hire, etc. for restoration activity, it is anticipated that the scope for ongoing employment is minimal, save for some ongoing monitoring of recovery and occasional livestock management. Also, the estimated carbon revenue from peatland restoration falls short of estimated restoration costs. However, this is arguably offset by the additional social benefits secured.

Table 6.2: Scenario 1: Peatland restoration[164]

Scenario description	Peatland carbon unit price of c.$15 (£12.50) assumed. 10% of the total area of degraded peatland in Argyll & Bute assumed to be restored, through a combination of 90% rewetting and 10% revegetation.
Notes	15% discount applied to total carbon units to account for margin of error in measurement, plus further 15% discount applied to total carbon units for allocation to buffer as per Peatland Carbon Code
Total hectares	4,949.0
Hectares, forestation	-
Hectares, silvopasture	-
Hectares, peatland	*4,949.0*
Carbon units per hectare	200
Units/hectare, forestation	-
Units/hectare, silvopasture	-
Units/hectare, peatland	200
Total carbon units	692,860
Carbon units, forestation	-
Carbon units, silvopasture	-
Carbon units, peatland	*692,860*
£ per unit, forestation	-
£ per unit, silvopasture	-
£ per unit, peatland	£12.50
Carbon credit revenue (£)	£8,660,800
Average revenue per holding (£)	*£4,455*
Set-up costs	£10,392,900
Operational costs (per annum)	£371,200
Estimated loss of agricultural output (SO per annum)	£500,500
Other revenue potential	
Supply chain development	Some potential to develop peatland management supply chain through increased plant hire, land management expertise, demand for skilled workers
Timber	-
Manufacturing and construction	-
Tourism and leisure	Potential for botanical and/or wildlife tours, e.g. birdwatching, insects, etc. Possibility of creating boardwalks through peatland to maintain hill-walking access

[164] Figures rounded here and throughout to avoid any potential spurious accuracy

Miscellaneous	Potential to integrate community benefit funding as part of carbon unit price (to donate to community trust or similar)
Job creation, set-up/planting/restoration (FTE job years/FTEs)	100 (10 FTE)
Job creation, operational (FTEs)	-
Wider benefits	
Biodiversity	Improved peatlands can see increase in biodiversity, given role they play in species conservation
Flood/water management	Increased water interception and storage can slow water loss/run-off from hills can reduce flood peaks Water storage capacity can maintain flows in drought periods Improved water quality through filtration of pollutants in soil
Soil	Reduction in soil erosion; improved soil management
Other environmental	Reduction in nutrient losses Net climate cooling effect through carbon absorption and increased surface water, at the local level
Livestock benefits	-
Health and wellbeing	Peatland restoration volunteering opportunities, contributing to physical and mental health and social well-being
Other community and cultural	Peatland projects can contribute to increased community engagement Positive impact on environmental education Increased demand for skilled jobs (peatland management) Important component of upland landscape Contribution to community wealth building
Social value (£ equivalent), carbon shadow price	£41,571,600

Scenario 2: Forestation (conifer)

6.8 This scenario illustrates the impact of carbon forestation through the planting of conifers on almost 51,000 hectares, equivalent to around 10% of Argyll & Bute's total agricultural land. At a carbon price of c.$18 (£15), carbon credit revenue of c.£91.6 million is generated.

Main advantages

6.9 This is a relatively straightforward approach to sequestering carbon through forestation. A considerable number of carbon units can be achieved through sequestration in conifer forestation, as well as the realisation of wider environmental benefits through water and soil/nutrient management.

Main disadvantages

6.10 In practice, this scenario is unlikely given the extra additionality tests that conifer forestation needs to pass under the Woodland Carbon Code, which are arguably more stringent under v2.2 of the Woodland Carbon Code.[165] In essence, conifer plantations are typically considered economically viable though future income from timber – though this may be overcome through careful creation of productive and non-productive zones or elements.

6.11 Additionally, it is expected that biodiversity impacts under this scenario would be more limited in scope than for other forestation scenarios. As such, it is a sub-optimal option for sequestration, but may be considered the most economically advantageous for landowners where there is no incentive to consider wider societal and environmental benefits. This may be where sequestration activities may be necessary, but limited public sector support exists – e.g. whether in meeting establishment costs, or in ongoing validation, verification and monitoring.

Table 6.3: Scenario 2: Forestation (conifer)

Scenario description	Forestation carbon unit price of c.$18 (£15) assumed. Modest take-up: 10% of agricultural land set aside for forestation, with productive conifer planted at 2,500 trees per hectare.
Notes	20% discount applied to total carbon units to account for margin of error in measurement, plus further 20% discount applied to total carbon units for allocation to buffer as per Woodland Carbon Code 2.0
Total hectares	50,914.1
Hectares, forestation	*50,914.1*
Hectares, silvopasture	-
Hectares, peatland	-
Carbon units per hectare	200
Units/hectare, forestation	*200*
Units/hectare, silvopasture	-
Units/hectare, peatland	-
Total carbon units	6,109,692
Carbon units, forestation	*6,109,692*
Carbon units, silvopasture	-
Carbon units, peatland	-
£ per unit, forestation	£15
£ per unit, silvopasture	-
£ per unit, peatland	-
Carbon credit revenue (£)	£91,645,400
Average revenue per holding (£)	*£47,143*
Set-up costs	£178,199,350
Operational costs (per annum)	£1,782,00
Estimated loss of agricultural output (SO per annum)	£5,149,300
Other revenue potential	
Supply chain development	Some potential to develop forest management supply chain through increased plant hire, demand for woodland management expertise, demand for skilled workers

[165] https://woodlandcarboncode.org.uk/standard-and-guidance

Timber	Potential for revenue from thinning during growing rotation, or felling at end of rotation. However, passing more stringent additionality testing would be required in order to secure carbon financing
Manufacturing and construction	Potential to supply construction companies, furniture makers, etc. with timber
Tourism and leisure	Some potential for creation of ecotourism offers, e.g. forest walks (including forest canopy walkways), forest lodges
Miscellaneous	Potential to integrate community benefit funding as part of carbon unit price (to donate to community trust or similar)
Job creation, set-up/planting/restoration (FTE job years/FTEs)	3,700 (370)
Job creation, operational (FTEs)	1,000
Wider benefits	
Biodiversity	Modest increase in biodiversity, and some new habitat creation
Flood/water management	Increased water interception and storage compared to grassland and native woodland Reduced sediment run-off Improved water quality through filtration of pollutants in soil
Soil	Reduction in soil erosion; improved soil management
Other environmental	Reduction in nutrient losses Cooling effect of forests on (local) climates through biophysical processes of forest Improved air quality through absorption of harmful gases by trees
Livestock benefits	Some shelter opportunity for livestock on boundary of forested areas
Health and wellbeing	Increased outdoor leisure potential, contributing to physical and mental health and social well-being opportunities
Other community and cultural	Woodland projects contribute to increased community engagement Positive impact on environmental education Increased demand for skilled jobs (woodland management) – attraction and retention of skilled workers Contribution to community wealth building
Social value (£ equivalent), carbon shadow price	£366,581,500

Scenario 3: Forestation (native)

6.12 This scenario presents the impacts anticipated from carbon capture forestation with native woodland. Through a carbon unit price of c.$20 (£17) and land equivalent to around 15% of Argyll & Bute's total agricultural land set aside for sequestration activities, it is estimated that a total of £311.6 million in carbon credit revenue could be generated.

Main advantages

6.13 This establishes a considerable proportion of native woodland in Argyll & Bute, and helps to secure a number of biodiversity and other environmental outcomes, such as improved soil management and reduction in flood risk. It would also increase demand for woodland management services and/or workers.

Main disadvantages

6.14 Under this scenario, there would still be a gap between set-up and establishment costs, and the anticipated carbon credit revenue – though this would be offset by the wider benefits associated with the scheme. It would also contribute to the loss of agricultural output, and associated spend in the local economy.

Table 6.4: Scenario 3: Forestation (native)

Scenario description	Forestation carbon unit price of c.$20 (£17) assumed. Modest take-up, with slight uplift over scenario 2 to reflect increased attractiveness of biodiversity gains: 15% of agricultural land set aside for forestation, with native woodland planted at 1,600 trees per hectare.
Notes	20% discount applied to total carbon units to account for margin of error in measurement, plus further 20% discount applied to total carbon units for allocation to buffer as per Woodland Carbon Code 2.0
Total hectares	76,371.2
Hectares, forestation	*76,371.2*
Hectares, silvopasture	-
Hectares, peatland	-
Carbon units per hectare	400
Units/hectare, forestation	*400*
Units/hectare, silvopasture	-
Units/hectare, peatland	-
Total carbon units	18,329,076
Carbon units, forestation	*18,329,076*
Carbon units, silvopasture	-
Carbon units, peatland	-
£ per unit, forestation	£17
£ per unit, silvopasture	-
£ per unit, peatland	-
Carbon credit revenue (£)	£311,594,300
Average revenue per holding (£)	*£160,285*
Set-up costs	£511,686,700
Operational costs (per annum)	£5,346,000
Estimated loss of agricultural output (SO per annum)	£7,724,000
Other revenue potential	
Supply chain development	Increased potential to develop forest management supply chain through increased plant hire, demand for woodland management expertise, demand for skilled workers
Timber	Potential for some revenue from thinning during growing rotation, or felling at end of rotation, dependent on tree species planted. However, passing more stringent additionality testing would be required in order to secure carbon financing.
Manufacturing and construction	Potential to supply construction companies, furniture makers, etc. with timber

Tourism and leisure	Potential for creation of ecotourism offers, e.g. forest walks (including forest canopy walkways), forest lodges, wildlife and botanical walking tours, etc.
Miscellaneous	Potential to integrate community benefit funding as part of carbon unit price (to donate to community trust or similar)
Job creation, set-up/planting/restoration (FTE job years/FTEs)	7,200 (720)
Job creation, operational (FTEs)	1,600
Wider benefits	
Biodiversity	Improved biodiversity and habitat creation
Flood/water management	Increased water interception and storage compared to grassland/pasture Reduced sediment run-off Improved water quality through filtration of pollutants in soil
Soil	Reduction in soil erosion; improved soil management
Other environmental	Reduction in nutrient losses Cooling effect of forests on (local) climates through biophysical processes of forest Improved air quality through absorption of harmful gases by trees
Livestock benefits	Some shelter opportunity for livestock on boundary of forested areas
Health and wellbeing	Increased outdoor leisure potential, contributing to physical and mental health and social well-being opportunities
Other community and cultural	Woodland projects contribute to increased community engagement Positive impact on environmental education Increased demand for skilled jobs (woodland management) – attraction and retention of skilled workers Contribution to community wealth building
Social value (£ equivalent), carbon shadow price	£1,099,744,500

Scenario 4: Silvopasture

6.15 This scenario sets out the potential for adoption of silvopasture approaches on c.10% of the grassland and pasture in Argyll & Bute. Assuming a carbon unit price of c.$15 (£12.50) and planting on almost 17,400 hectares to create silvopasture woodland, it is estimated that 1.3 million carbon credits and £16.3 million in carbon credit revenue could be achieved.

Main advantages

6.16 Assuming that the silvopasture approach could be implemented in a configuration that did not impact on the effectiveness of herding, animal husbandry, etc., this scenario would deliver carbon and wider environmental and societal benefits without the loss of agricultural output. Further, as well as biodiversity and environmental benefits, silvopasture brings with it benefits for the livestock themselves, such as increased foraging opportunity, the potential to self-medicate through foraging, and increased shelter (known as *Zoopharmacognosy*).

Main disadvantages

6.17 The main disadvantage with this approach is that the intensity of carbon sequestration is necessarily of an order lower than forestation approaches, though they can be delivered alongside other sequestration activity, e.g. hedgerow planting, conservation tillage and the leaving of crop residues, and other regenerative agricultural practices. However, it is anticipated that increased livestock management will be required alongside woodland management, to prevent animal damage to trees in the period immediately after planting.

Table 6.5: Scenario 4: Silvopasture

Scenario description	Silvopasture carbon unit price of c.$15 (£12.50) assumed. Modest take-up: 10% of grassland/pasture converted to silvopasture, with mixed woodland planting at 400 trees per hectare.
Notes	20% discount applied to total carbon units to account for margin of error in measurement, plus further 20% discount applied to total carbon units for allocation to buffer as per Woodland Carbon Code 2.0
Total hectares	17,395.0
Hectares, forestation	-
Hectares, silvopasture	*17,395.0*
Hectares, peatland	-
Carbon units per hectare	125
Units/hectare, forestation	-
Units/hectare, silvopasture	*125*
Units/hectare, peatland	-
Total carbon units	1,304,625
Carbon units, forestation	-
Carbon units, silvopasture	*1,304,625*
Carbon units, peatland	-
£ per unit, forestation	-
£ per unit, silvopasture	£12.50
£ per unit, peatland	-
Carbon credit revenue (£)	£16,307,800
Average revenue per holding (£)	*£8,670*
Set-up costs	£26,092,500
Operational costs (per annum)	£1,217,650
Estimated loss of agricultural output (SO per annum)	£0
Other revenue potential	
Supply chain development	Some potential to develop silvopasture supply chain through demand for (combined) woodland and livestock management expertise, possible agroforestry services, demand for skilled workers and additional farm labourers
Timber	Assumed no thinning or felling of trees planted in silvopasture system, thus no timber produced
Manufacturing and construction	-
Tourism and leisure	-

Miscellaneous	Potential to integrate community benefit funding as part of carbon unit price (to donate to community trust or similar)
Job creation, set-up/planting/restoration (FTE job years/FTEs)	1,200 (120)
Job creation, operational (FTEs)	1,700
Wider benefits	
Biodiversity	Improved biodiversity and habitat creation
Flood/water management	Increased water interception and storage compared to grassland/pasture Reduced sediment run-off Improved water quality through filtration of pollutants in soil
Soil	Reduction in soil erosion; improved soil management
Other environmental	Reduction in nutrient losses Silvopasture contributes to local climate cooling through biophysical processes of trees Improved air quality through absorption of harmful gases by trees
Livestock benefits	Livestock shelter Foraging opportunities, including potential for livestock to self-medicate Silvopasture can lead to increased yields through increased soil health and biodiversity, contributing to increased productivity in land usage
Health and wellbeing	
Other community and cultural	Woodland projects contribute to increased community engagement Positive impact on environmental education Increased demand for skilled jobs (woodland management) - attraction and retention of skilled workers Contribution to community wealth building
Social value (£ equivalent), carbon shadow price	£78,277,500

ENHANCED SCENARIOS

Scenario 5: Higher value forestation (native)

6.18 This scenario presents the impacts anticipated from carbon capture forestation with native woodland, but with a higher value ascribed to carbon units. Consequently, it is assumed that a higher carbon price will necessarily stimulate higher interest from landowners, and so a greater proportion of land is given over to sequestration activities.

6.19 Through a carbon unit price of c.$40 (£34)[166] and land equivalent to around 20% of Argyll & Bute's total agricultural land set aside for sequestration activities, it is estimated that a total of just under £831 million in carbon credit revenue could be generated.

Main advantages

6.20 This scenario will secure the biodiversity and other environmental/societal outcomes as set out in Scenario 3. However, due to the higher carbon unit price, the anticipated carbon revenue will exceed the set-up costs. This scenario also offers the potential to secure higher community value through allocating a sizeable proportion of the carbon unit price to a community fund or similar – though this would require the 'stacking of benefits' rather than the 'bundling' of wider benefits that currently takes place.

Main disadvantages

6.21 The higher value of carbon unit price is anticipated to drive increased appetite amongst landowners. This would result in a significant proportion of agricultural land being diverted to carbon sequestration activities, of which it is expected that at least some can be categorised as high-quality agricultural land. This in turn would have a knock-on effect in terms of a negative impact on standard agricultural output and thus agricultural employment. Further, it would reduce the critical mass of agricultural activity in Argyll & Bute, and potentially negatively affect the economic viability of other agricultural operations.

Table 6.6: Scenario 5: Higher value forestation (native)

Scenario description	Higher forestation carbon unit price of c.$40 (£34) assumed. Increased take-up: 20% of agricultural land set aside for forestation, with native woodland planted at 1,600 trees per hectare.
Notes	20% discount applied to total carbon units to account for margin of error in measurement, plus further 20% discount applied to total carbon units for allocation to buffer as per Woodland Carbon Code 2.0
Total hectares	101,828.2
Hectares, forestation	*101,828.2*
Hectares, silvopasture	-
Hectares, peatland	-
Carbon units per hectare	400
Units/hectare, forestation	*400*
Units/hectare, silvopasture	-
Units/hectare, peatland	-
Total carbon units	24,438,768
Carbon units, forestation	*24,438,768*
Carbon units, silvopasture	-
Carbon units, peatland	-
£ per unit, forestation	£34
£ per unit, silvopasture	-
£ per unit, peatland	-
Carbon credit revenue (£)	£830,918,100
Average revenue per holding (£)	*£427,427*
Set-up costs	£682,248,900

[166] A carbon price of $40 has previously been identified as necessary to meet greenhouse gas emissions targets: https://www.bloomberg.com/graphics/2018-carbon-pricing/

Operational costs (per annum)	£7,128,00
Estimated loss of agricultural output (SO per annum)	£10,298,700
Other revenue potential	
Supply chain development	Increased potential to develop forest management supply chain through increased plant hire, demand for woodland management expertise, demand for skilled workers
Timber	Potential for some revenue from thinning during growing rotation, or felling at end of rotation, dependent on tree species planted. However, more stringent additionality testing would be required in order to secure carbon financing
Manufacturing and construction	Potential to supply construction companies, furniture makers, etc. with timber
Tourism and leisure	Potential for creation of ecotourism offers, e.g. forest walks (including forest canopy walkways), forest lodges, wildlife and botanical walking tours, etc.
Miscellaneous	Greater potential to integrate community benefit funding as part of carbon unit price (to donate to community trust or similar) through higher carbon price.
Job creation, set-up/planting/restoration (FTE job years/FTEs)	9,600 (960)
Job creation, operational (FTEs)	2,100
Wider benefits	
Biodiversity	Considerably improved biodiversity and habitat creation
Flood/water management	Increased water interception and storage compared to grassland/pasture Reduced sediment run-off Improved water quality through filtration of pollutants in soil
Soil	Reduction in soil erosion; improved soil management
Other environmental	Reduction in nutrient losses Cooling effect of forests on (local) climates through biophysical processes of forest Improved air quality through absorption of harmful gases by trees
Livestock benefits	Some shelter opportunity for livestock on boundary of forested areas
Health and wellbeing	Increased outdoor leisure potential, contributing to physical and mental health and social well-being opportunities
Other community and cultural	Woodland projects contribute to increased community engagement Positive impact on environmental education Increased demand for skilled jobs (woodland management) – attraction and retention of skilled workers Contribution to community wealth building
Social value (£ equivalent), carbon shadow price	£1,466,326,000

Scenario 6: High carbon value combined forestation and silvopasture

6.22 This scenario presents the impacts that could be achieved through the combination of forestation and silvopasture. It also demonstrates the impact of a significantly higher carbon price – c.$60 (£50) per unit. Under this scenario, carbon credit revenue of c.£1.58 billion can be potentially be realised.

Main advantages

6.23 As well as securing the biodiversity and other environmental/societal outcomes as set out in earlier scenarios, the combination of silvopasture and forestation would result in a lower impact on agricultural activity versus the total proportion of land given over to sequestration activities. Further, due to the higher carbon unit price, the anticipated carbon revenue will exceed the set-up costs. As with Scenario 5, this scenario also offers the potential to secure higher community value through allocating a sizeable proportion of the carbon unit price to a community fund or similar – though this would require the 'stacking of benefits' rather than the 'bundling' of wider benefits that currently takes place.

Main disadvantages

6.24 The higher value of carbon unit price is anticipated to drive increased appetite amongst landowners. This would result in a significant proportion of agricultural land being diverted to carbon sequestration activities, of which it is expected that at least some can be categorised as high-quality agricultural land – though the silvopasture approach would see at least some agricultural activity retained. However, the potential for a reduction in the critical mass of agricultural activity in Argyll & Bute remains, and thus potential negatively effects on the economic viability of other agricultural operations.

Table 6.7: Scenario 6: High carbon value combined forestation and silvopasture

Scenario description	Very high forestation carbon unit of c.$60 (£50) assumed. Higher silvopasture carbon unit of c.$30 (£25) assumed. Increased forestation take-up: 25% of agricultural land set aside for forestation with native woodland planted at 1,600 trees per hectare Increased silvopasture take-up: 20% of grassland/pasture converted to silvopasture, with moderately higher value native woodland planting at 400 trees per hectare
Notes	20% discount applied to total carbon units to account for margin of error in measurement, plus further 20% discount applied to total carbon units for allocation to buffer as per Woodland Carbon Code 2.0
Total hectares	162,075.3
Hectares, forestation	*127,285.3*
Hectares, silvopasture	*34,790.0*
Hectares, peatland	-
Carbon units per hectare	335.6
Units/hectare, forestation	*400*
Units/hectare, silvopasture	*100*
Units/hectare, peatland	-
Total carbon units	32,635,860
Carbon units, forestation	*30,548,460*
Carbon units, silvopasture	*2,087,400*
Carbon units, peatland	*0*
£ per unit, forestation	£50
£ per unit, silvopasture	£25
£ per unit, peatland	-
Carbon credit revenue (£)	£1,579,608,000
Average revenue per holding (£)	*£813,455*
Set-up costs	£904,996,200
Operational costs (per annum)	£11,345,300
Estimated loss of agricultural output (SO per annum)	£23,172,000
Other revenue potential	

Supply chain development	Increased potential to develop silvopasture supply chain through demand for (combined) woodland and livestock management expertise, possible agroforestry services, demand for skilled workers and additional farm labourers
Timber	Potential under forestation for some revenue from thinning during growing rotation, or felling at end of rotation, dependent on tree species planted. However, more stringent additionality testing would be required in order to secure carbon financing
Manufacturing and construction	Potential to supply construction companies, furniture makers, etc. with timber from forestation
Tourism and leisure	Potential for creation of ecotourism offers, e.g. forest walks (including forest canopy walkways), forest lodges, wildlife and botanical walking tours, etc. in forested area
Miscellaneous	Potential to integrate community benefit funding as part of carbon unit price (to donate to community trust or similar)
Job creation, set-up/planting/restoration (FTE job years/FTEs)	14,500 (1,450)
Job creation, operational (FTEs)	6,100
Wider benefits	
Biodiversity	Greatly improved biodiversity and habitat creation
Flood/water management	Increased water interception and storage compared to grassland/pasture Reduced sediment run-off Improved water quality through filtration of pollutants in soil
Soil	Reduction in soil erosion; improved soil management
Other environmental	Reduction in nutrient losses Cooling effect of forests on (local) climates through biophysical processes of forest Silvopasture contributes to local climate cooling through biophysical processes of trees Improved air quality through absorption of harmful gases by trees
Livestock benefits	Livestock shelter Foraging opportunities, including potential for livestock to self-medicate Silvopasture can lead to increased yields through increased soil health and biodiversity, contributing to increased productivity in land usage
Health and wellbeing	Increased outdoor leisure potential, contributing to physical and mental health and social well-being opportunities
Other community and cultural	Woodland projects contribute to increased community engagement Positive impact on environmental education Increased demand for skilled jobs (woodland management) - attraction and retention of skilled workers Contribution to community wealth building
Social value (£ equivalent), carbon shadow price	£1,958,151,600

Scenario 7: Very high carbon value integrated carbon sequestration

6.25 This scenario illustrates the potential effect of a significantly higher carbon price. This is based on previous estimates of carbon pricing set out by the Bank of England in early 2021.[167]

Main advantages

6.26 This scenario has the potential to secure a very high degree of wider societal and environmental benefits alongside significant carbon credit revenue – currently estimated to be in the region of £3.2 billion, and almost three times that of estimated set-up costs.

Main disadvantages

6.27 As with the previous scenario, the much higher value of carbon unit price is anticipated to drive significantly increased appetite amongst landowners. This would result in a large proportion of agricultural land being diverted to carbon sequestration activities, of which it is expected that at least some can be categorised as high-quality agricultural land – though the silvopasture approach would see at least some agricultural activity retained. However, the potential for a reduction in the critical mass of agricultural activity in Argyll & Bute remains (and is anticipated to be greater than that under Scenario 6). This will likely negatively affect the economic viability of other agricultural operations.

Table 6.8: Scenario 7: Very high carbon value integrated carbon sequestration

Scenario description	Significantly higher forestation carbon unit of c.$100 (£85) assumed, in line with Bank of England forecasts. Much higher silvopasture carbon unit of c.$40 (£35) assumed. Higher peatland carbon price of $30 (£25) assumed. Increased forestation take-up: 30% of agricultural land set aside for forestation with native woodland planted at 1,600 trees per hectare Increased silvopasture take-up: 25% of grassland/pasture converted to silvopasture, with moderately higher value native woodland planting at 400 trees per hectare. 20% of degraded peatland in Argyll & Bute assumed to be restored, through a combination of 90% rewetting and 10% revegetation.
Notes	Woodland: 20% discount applied to total carbon units to account for margin of error in measurement, plus further 20% discount applied to total carbon units for allocation to buffer as per Woodland Carbon Code 2.0: Peatland: 15% discount applied to total carbon units to account for margin of error in measurement, plus further 15% discount applied to total carbon units for allocation to buffer as per Peatland Carbon Code
Total hectares	206,127.8
Hectares, forestation	*152,742.3*
Hectares, silvopasture	*43,487.5*
Hectares, peatland	*9,898.0*
Carbon units per hectare	327.1
Units/hectare, forestation	*400*
Units/hectare, silvopasture	*100*
Units/hectare, peatland	*200*
Total carbon units	40,653,122
Carbon units, forestation	*36,658,152*
Carbon units, silvopasture	*2,609,250*
Carbon units, peatland	*1,385,720*
£ per unit, forestation	£85
£ per unit, silvopasture	£35
£ per unit, peatland	£25
Carbon credit revenue (£)	£3,241,909,700
Average revenue per holding (£)	*£1,669,222*
Set-up costs	£1,109,390,400
Operational costs (per annum)	£14,478,400

[167] See https://www.bankofengland.co.uk/-/media/boe/files/events/2021/january/climate%20action%20slides.pdf

Estimated loss of agricultural output (SO per annum)	£25,746,700
Other revenue potential	
Supply chain development	Increased potential to develop silvopasture supply chain through demand for (combined) woodland and livestock management expertise, possible agroforestry services, demand for skilled workers and additional farm labourers
Timber	Potential under forestation for some revenue from thinning during growing rotation, or felling at end of rotation, dependent on tree species planted. However, more stringent additionality testing would be required in order to secure carbon financing
Manufacturing and construction	Potential to supply construction companies, furniture makers, etc. with timber from forestation
Tourism and leisure	Potential for creation of ecotourism offers, e.g. forest walks (including forest canopy walkways), forest lodges, wildlife and botanical walking tours, etc. in forested area
Miscellaneous	Potential to integrate community benefit funding as part of carbon unit price (to donate to community trust or similar)
Job creation, set-up/planting/restoration (FTEs)	17,700 (1,770)
Job creation, operational (FTEs)	7,500
Wider benefits	
Biodiversity	Significant gains in biodiversity and habitat creation made
Flood/water management	Increased water interception and storage compared to grassland/pasture Reduced sediment run-off Improved water quality through filtration of pollutants in soil
Soil	Reduction in soil erosion; improved soil management
Other environmental	Reduction in nutrient losses Cooling effect of forests on (local) climates through biophysical processes of forest Silvopasture contributes to local climate cooling through biophysical processes of trees Improved air quality through absorption of harmful gases by trees
Livestock benefits	Livestock shelter Foraging opportunities, including potential for livestock to self-medicate Silvopasture can lead to increased yields through increased soil health and biodiversity, contributing to increased productivity in land usage
Health and wellbeing	Increased outdoor leisure potential, contributing to physical and mental health and social well-being opportunities
Other community and cultural	Woodland projects contribute to increased community engagement Positive impact on environmental education Increased demand for skilled jobs (woodland management) - attraction and retention of skilled workers Contribution to community wealth building
Social value (£ equivalent), carbon shadow price	£2,439,187,300

7 CONCLUSIONS, CONSIDERATIONS AND RECOMMENDATIONS

INTRODUCTION

7.1 Following the presentation of the scenarios in the preceding chapter, this chapter sets out the conclusions from the report's findings. It also presents a series of considerations and dependencies for carbon sequestration activity. Following this, it outlines a number of priorities for future carbon sequestration.

CONCLUSIONS

7.2 The scale of Argyll & Bute's natural carbon assets presents an opportunity for the area with regard to carbon sequestration activity. Carbon sequestration represents not only an economic opportunity to stimulate the economy, but also an opportunity to secure wider community wealth building and environmental benefits. Achieving these could transform the region's economy and help to reverse the trends of a declining, ageing and sparsely located population.

7.3 A significant proportion of Argyll & Bute is covered by existing farmland, forestation and peatland. Around 76,000ha of Argyll & Bute is identified as preferred land for future forestation, and almost 49,500ha of peatland is considered degraded and in need of restoration.

7.4 The most feasible approaches to carbon sequestration in Argyll & Bute in the immediate future are terrestrial biological – that is, through forestation (including silvopasture) and peatland restoration. However, it is worth noting that the extent of Argyll & Bute's marine carbon assets mean that marine-based sequestration opportunities may be realised in future, as market mechanisms and regulatory frameworks for this develop.

7.5 As the scenarios presented in this report demonstrate, considerable carbon revenue generation is possible in Argyll & Bute. However, this is dependent on sequestration mode and the rate of carbon units per hectare that can be achieved. Market rates for carbon credits are predicted to continue increasing in price, which can in theory lead to significant revenue generation.

7.6 A number of wider benefits can also be realised, including: improved biodiversity and habitat creation; flood mitigation; improved water and air quality; better soil and nutrient management and reduced erosion; shelter for livestock; sustainable timber production; creation of skilled jobs; physical and mental health improvements; social well-being; and increased community engagement and community wealth building.

7.7 However, the scenarios as presented are intended to be purely illustrative – to demonstrate maximum theoretical impacts of each approach, and degree of adoption within Argyll & Bute. Whilst set-up and operational costs are presented alongside possible carbon credit revenue, these opportunities do not take into consideration other costs, such as salaries/wages for jobs created, nor do they consider other revenue generation possibilities, e.g. Woodland Grant Scheme for set-up, additional income from stacked benefits (where this becomes possible).

7.8 The scenarios must therefore be read in this way – as illustrative, and not advocating one or other approach. Whilst the enhanced scenarios demonstrate the scale of economic opportunity, the opportunities afforded by the base peatland or woodland scenarios may ultimately be more achievable, and may complement existing agricultural and forestry activity.

7.9 Nevertheless, the scenarios demonstrate that carbon sequestration can be considered a strategic opportunity for Argyll & Bute. The potential impact in terms of value of economic activity and employment creation is of a magnitude higher than current economic activity and employment levels. This offers

7.10 However, the economic impacts presented above have arguably been considered in isolation. To begin realising the potential impacts that each scenario may present, there are a number of dependencies and factors that must be considered. These are set out in the next section.

DEPENDENCIES AND OTHER CONSIDERATIONS

7.11 In order to pursue carbon sequestration as a strategic opportunity for economic development and community wealth building in Argyll & Bute, the following issues and dependencies must be taken into consideration.

Local economic conditions: The capacity of the local economy, and the constraining effect of the structural inequalities and associated challenges, to support the uptake and expansion of carbon sequestration activities is a critical factor in realising any potential economic impact. This includes the impact of the area's geography, and longstanding barriers to economic growth such as a lack of supporting infrastructure, e.g. housing, services, physical infrastructure. The impacts outlined above are intended to demonstrate what may be possible under optimum conditions; therefore they would be reliant on the local economy's ability to support a nascent industry to develop.

Public sector support and intervention: The extent of public sector support, and how this influences behaviour, is a significant consideration. Whilst there may be a recognition of the value of sequestration in response to the climate emergency, without additional public sector support, either for set-up costs or to support ongoing verification and monitoring, local landowners will potentially choose sub-optimal sequestration options, or sell to outside parties. This brings with it the risk of investors looking to acquire land to achieve their own carbon offsetting ambitions, but potentially without any consideration of or appetite for achieving local environmental and societal/community benefits. Ultimately, this will determine the extent to which Argyll & Bute (and also other areas in Scotland) can navigate between free market conditions or an interventionist approach to influence the degree of local benefits (economic, social and environmental) that can be secured.

Influencing behaviour: Behaviour change amongst landowners, and farmers in particular, will need to be influenced to encourage non-traditional modes of land management. There is at least some anecdotal evidence to suggest that there is a 'moral obligation' amongst landowners to maintain current modes of farming and land management, and not to be 'seen as the one' that shifts away from current practices. Further, the (negative) experience of some landowners of other support programmes e.g. the Agri-Environment Climate Scheme (AECS), where there is a perception of onerousness in administration and risk of not receiving payments, will also need to be overcome.

Availability of information on carbon sequestration: there is a degree of information asymmetry, with many landowners and farmers being unsighted on the principles, requirements or benefits of carbon sequestration activity. Overcoming this and influencing decision-making of landowners will be important to implementation of any carbon sequestration activity.

Balancing existing farming activity and sequestration through forestation and peatland: Finding a common ground for farmers and the ambition for forest sequestration will be important to avoid the sale of large portions of land to outside interests (e.g. large corporations) looking to quickly secure their own carbon credit needs without necessarily considering the local impacts that they could achieve. Further, additional consideration must be given to the existing carbon sequestration and biodiversity impacts already achieved through existing good agricultural practice in grazing and livestock management, for example. Any new scheme or approach should consider the impact in terms of not only potential amount of carbon sequestered, but of long-term impact on agricultural output and, ultimately, food security.

Configuration of sequestration activity: The ability to minimise (or even negate) any potential impact on existing land use activities will be important, particularly for farms. There may be a significant difference between valley, ravine or gully planting (or planting on other marginal, peripheral land), or planting of shelter strips, and open planting, and even the configuration of silvopasture planting, in the ability to minimise the impact of sequestration approaches on existing agricultural and land management practices.

Requirements of future agricultural payment support: There is currently a lack of clarity concerning future agricultural payment support following Brexit. Current advice being given to farmers from NFU Scotland and other industry bodies is for farmers to hold onto any carbon credits they may have, since these might be needed to qualify for future agricultural payment support. This may therefore impact on the sale of credits through carbon trading where landowners do adopt sequestration activity. This is important to consider given the requirements of the net zero emissions targets for 2045, and the contribution that agriculture and land management must make to these targets.

Science supporting the Woodland and Peatland Codes: There is currently a sizeable discounting rate to account for a potential margin of error in measurement of carbon units. This is 20% under the Woodland Carbon Code, and 15% under the Peatland Carbon Code. Improvements to the science and methodology underpinning measurement, validation and verification may allow for a smaller degree of discounting – which in turn may make sequestration under either Code more attractive to landowners.

Buffers and risk: Currently, landowners seeking to sequester carbon under the Woodland and Peatland Codes are required to contribute to a buffer as part of the approach to the management of risks and permanence, and to cover any unanticipated losses from individual project failures. However, the impact of climate change and extreme weather events may influence the perceived risk associated with carbon farming, and forestation in particular, given recent high-profile storm damage on woodland and forest plantations in Scotland.

Stacking of benefits: The ability to stack benefits, rather than the current approach to bundling wider benefits with the carbon units when they are sold, may increase the attractiveness of carbon sequestration – and also the price of such units, where wider benefits can be adequately quantified and evidenced. The World Bank shadow carbon price goes some way to providing a proxy measure for such benefits; however, other approaches, such as DEFRA's Biodiversity metric 3.0 (v3.1) could be applied. Research has also been undertaken by Scottish Forestry in relation to the application of the Natural Capital Protocol to a forest creation project at Larriston in the Scottish Borders, which demonstrated values for natural hazard regulation, recreation, aesthetics and biodiversity alongside carbon benefits.[168] Developing a standardised approach in line with this may help to unbundle and stack wider benefits with carbon sequestration projects.

Philanthropy and securing local content and impacts: There is understood to be a growing market for philanthropic ambitions over and above the Carbon Codes, and there is merit in recognising the value of the Scottish 'premium' or 'kudos' attached to securing carbon credits in Scotland. This is particularly important to bear in mind where and when stacking benefits becomes possible.

Carbon values: Consideration should be given to the exact carbon values that should be applied to projects. There is significant variation between existing market rates, estimates from the Bank of England and the World Bank (as included in scenarios above) and BEIS valuations. Current guidance for Scottish City and Regional Growth Deals includes carbon value estimates to inform managing carbon emissions associated with City Region and Growth Deal projects. The central estimate for carbon units in 2022 is £248 (low £124; high £373).

[168] https://forestry.gov.scot/publications/988-forest-sector-final-report/download

Land holding size and tenure: Land holdings in Argyll are typically small, and most Argyll tenures don't incorporate woodland, so there is a risk to land tenancy in pursuing carbon sequestration activity without any subsequent change in tenure agreements or legislation.

Critical mass of agricultural activity: Anecdotal evidence suggests that current agricultural output in Argyll & Bute is decreasing such that it is approaching a tipping point in terms of critical mass. For example, there may be potential for situation where if one farm in a cluster (e.g. dairy) switches to carbon farming forestation, it may make it economically unviable for the remaining number to be served by a tanker, and so they lose their access to markets. Alternatively, a reduction in livestock in one area may impact on the viability of livestock markets in the area (currently Dalmally, Oban, Tiree, and Islay).

PRIORITIES GOING FORWARD

Proactive public sector intervention

7.12 It is clear from discussion of both opportunities and dependencies above that a proactive, interventionist approach to developing the carbon market in Argyll & Bute should be taken to nurture and grow a nascent sector with considerable potential for the area. There is a clear role for Argyll & Bute and HIE at the local and regional level respectively to ensure that an adequate business support environment is in place. There is also a role at the national level for Scottish Government and its agencies to provide the necessary policy and regulatory environment to encourage pursuit of carbon sequestration opportunities.

7.13 Public sector intervention can also help to shape the nature of the carbon sequestration market, to maximise local economic development and secure greater community wealth building, e.g. through building in requirements for 'local content; in wider benefits. This may help to mitigate against situations of large-scale land purchase for carbon sequestration by outside interests, with minimum return for local landowners and communities. Argyll & Bute's economy is arguably already characterised by low-value commodities – carbon sequestration offers the opportunity to secure higher-value products.

Facilitating the carbon sequestration market

7.14 As part of the proactive approach by public sector actors to stimulate the carbon sequestration market, there is a need to explore in detail approaches to facilitation of the carbon market in Argyll & Bute. This is necessary to shape the way in which the local sector develops, to articulate standards and expectations of trade in carbon credits, and to engage local businesses. This must be done with a view to exploring ways in which local benefits can be stimulated, whilst at the same time fulfilling corporate social responsibility needs and securing ongoing social licence to operate for local businesses (rather than, for example, selling off carbon credits to international businesses). A carbon market facilitator can also ensure pricing structures and local content requirement for carbon credits to suit local needs. It is recognised that the outputs of both WP6 and WP7.2 will play an important role in beginning to articulate how a facilitating body or organisation may be structured.

Securing landowner engagement

7.15 The evident information asymmetry regarding carbon sequestration means that securing landowner and farmer engagement in discussions regarding carbon sequestration (not only in Argyll & Bute but Scotland more widely) is an important step. All strategic actors have a role to play in this. Part of this will include the clarification of terminology, concepts, etc. (e.g. what is meant by community benefits is often misunderstood). This will also help to determine the appetite for adopting carbon sequestration, and to better understand the way in which existing land uses and carbon sequestration approaches can complement each other.

Understanding the dynamics of landowner-tenant farmer relationships

7.16 As noted above, farm holding tenures don't typically include woodland. Landowner-famer/tenant farmer contractual arrangements and relationships need to be better understood, to inform discussions on carbon sequestration, and see what scope there is for innovating within existing tenures to deliver carbon sequestration activities. HIE and strategic partners including Scottish Forestry, NFU Scotland and NatureScot are well-placed to lead on this.

Building a critical mass of activity

7.17 Given the nature of land holdings and tenures in Argyll & Bute, there is a need to explore ways in which projects can be organised to create critical mass of activity. Clusters of projects, drawing on learning from elsewhere in Scotland, is one means of achieving this. Other approaches may include landscape-scale projects or programmes of activity.

Exploring the role of carbon sequestration in sustainability of agriculture

7.18 Carbon sequestration has potential to revitalise the land-based workforce in Argyll & Bute. However, it remains unclear whether adoption of carbon sequestration techniques can increase the sustainability of agricultural livelihoods in the area. Further research is therefore required to fully understand the impact that carbon sequestration may have on farming income streams, building on the work to prepare a business model as part of WP5.

Stacking benefits and articulating wider impacts

7.19 HIE, in partnership with Scottish Forestry and other partners, should explore ways in which social, community, environmental benefits can be unbundled from carbon credits, to secure maximum benefits for landowners, farmers and communities. Stacking benefits can potentially see increased revenue – enhanced further by the added value of Argyll & Bute (or Scottish) carbon credits – building on the kudos element, which plays to the burgeoning philanthropic market. Stacking benefits is the mechanism through which other environmental services can be built in, to secure increased benefits alongside increased revenue.

7.20 Alongside this, HIE and partners should also explore ways to better articulate the community, social, and environmental value that can be obtained through carbon credit trading, so that there is no ambiguity around what sequestration activity can bring, and carbon credits are not traded on the basis of carbon alone.

Anticipating higher-level, strategic benefits

7.21 Whilst carbon sequestration offers opportunities to contribute to the achievement of net zero ambitions through carbon sequestration, additional more strategic benefits can also be achieved. Following conclusion of the wider project, there is a need to explore ways in which longer-term strategic ambitions can be achieved through carbon sequestration activities, and through the design of a facilitation/market scheme. This may include transformational ambitions around re-wilding, for example.

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