CLIMATE VULNERABILITY INDEX ASSESSMENT FOR THE ST KILDA WORLD HERITAGE PROPERTY

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Cover Village Bay, St Kilda
(Jim Richardson, used with permission)

EXECUTIVE SUMMARY

Main St, Village Bay
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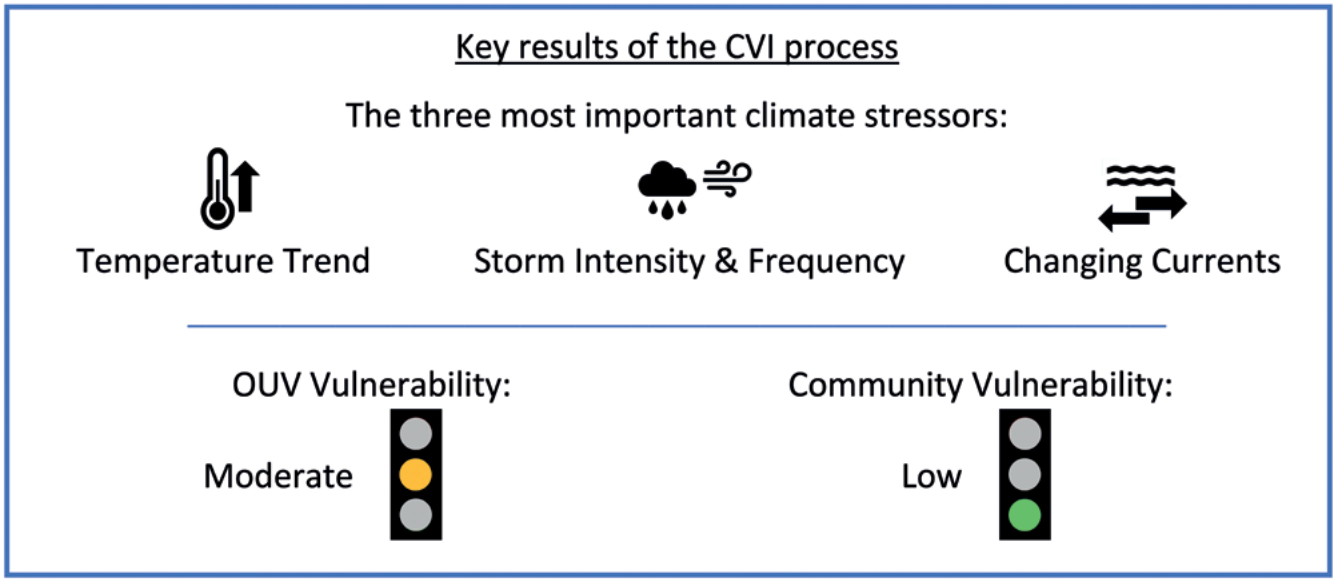
Climate change has been identified as the fastest-growing threat to World Heritage (WH) and many WH properties are already experiencing negative impacts. This has resulted in the degradation of the values for which many WH properties were listed, which in turn has impacts upon the communities associated with these properties. As the climate crisis intensifies, the urgent need to understand the climate vulnerability of the world's natural and cultural heritage remains.

This report describes the outcomes from an application of the Climate Vulnerability Index (CVI) for the St Kilda WH property, the first application undertaken anywhere in the world for a mixed heritage property (i.e., recognised for both natural and cultural values). The CVI is a methodology to rapidly assess the vulnerability of natural and cultural WH properties. It systematically evaluates the realised and potential impacts upon the values that collectively comprise the Outstanding Universal Value (OUV) of the property, as well as the consequent impacts upon the economic, social and cultural (ESC) elements of the associated community.

The CVI workshop for St Kilda:

- involved property managers, researchers and representatives from various relevant agencies, municipalities, non-governmental organisations (NGOs) and the community
- selected ca. 2050 as the future time scale and consideration of a high-emissions scenario (RCP8.5) for the vulnerability assessment
- identified the three key climate stressors presenting the greatest threat: **Temperature Trend, Storm Intensity & Frequency** and **Changing Currents**, noting likely interactions with each other and other stressors
- determined that the **OUV Vulnerability** for the property was **Moderate** (on a three-point scale, Low/Moderate/High), indicating the potential for some decline or alteration of many of the values and attributes that comprise the OUV
- assessed the **Community Vulnerability** to be in the lowest category **(Low)**, indicating minimal effects upon the economic, social and/or cultural (ESC) connections
- noted the adaptive capacity in regard to WH values and their management, and of the wider community associated with the property.



Climate change is expected to threaten some areas in the archipelago more than others and to increasingly impact upon at least some of the values that collectively contribute to the OUV. Potential impacts discussed included effects on seabird food resources; and the damage to the landscape due to the interaction between increased visitor numbers and storm-related climate impacts. The biological values of the cultural landscape were considered more vulnerable to impacts from climate change than the cultural/archaeological values, principally due to the relative spatial scales affected and available options for adaptive capacity.

The workshop provided an opportunity to exchange knowledge and experience relevant to cultural and natural heritage management and to increase the awareness about climate change in the community. Management actions must apply a precautionary approach to avoid any negative effects on the OUV. These may include minimising non-climate stressors on the ecosystem (and thereby enhancing natural resilience); improving collaboration between WH managers and researchers; and enhancing research and monitoring efforts to better predict and understand changes in the marine system. The workshop also highlighted the value of a transparent and repeatable framework for rapid assessment of climate impacts on heritage properties.

In addition to local management, immediate global action to substantially reduce greenhouse gas emissions is critical. To reduce climate change impacts in the near term, the combination of actions to mitigate climate change and support climate adaptation is essential to maintain the OUV of St Kilda.

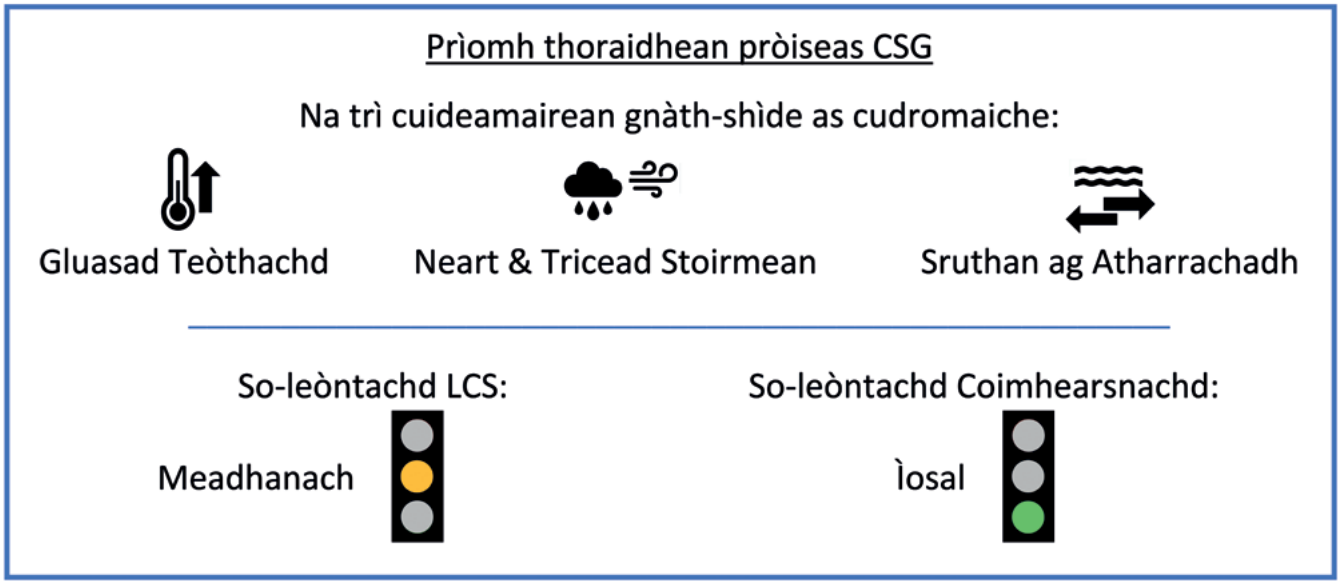
GEÀRR-CHUNNTAS GNÌOMHACH

Chaidh atharrachadh gnàth-shìde a chomharrachadh mar an cunnart as luaithe a tha a' fàs do Dhualchas na Cruinne (DC) agus tha mòran sheilbhean DC air droch bhuaidh fhulang mar-thà. Tha seo air ciallachadh gu bheil crìonadh anns na luachan a thug clàradh do mhòran sheilbhean DC sa chiad àite, agus tha sin an uair sin a' toirt buaidh air na coimhearsnachdan co-cheangailte ris na seilbhean sin. Fhad 's a tha èiginn na gnàth-shìde a' fàs nas miosa, tha cruaidh-fheum ann fhathast a bhith a' tuigsinn so-leòntachd gnàth-shìde dualchas nàdarra is cultarach an t-saoghail.

Tha an aithisg seo a' toirt cunntas air na builean bho bhith a' cur Clàr So-leòntachd Gnàth-shìde (CSG) an gnìomh airson seilbh DC Hiort, a' chiad chur an gnìomh airson seilbh dualchais mheasgaichte (i.e., aithnichte an dà chuid airson luachan nàdarra agus cultarach). 'S e dòigh-obrach a th' anns an CSG gus measadh luath a dhèanamh air so-leòntachd sheilbhean nàdarra agus cultarach DC. Bidh e a' dèanamh measadh eagarach air na buaidhean a bh' air na luachan mar-thà agus na buaidhean a dh'fhaodadh a bhith air na luachan, a tha còmhla a' dèanamh suas Luach Coitcheann Sònraichte (LCS) na seilbhe, a bharrachd air na buaidhean a thig às a sin air eileamaidean eaconamach, sòisealta agus cultarach (ESC) na coimhearsnachd co-cheangailte.

Bha bùth-obrach CSG Hiort:

- a' gabhail a-steach manaidsearan sheilbhean, luchd-rannsachaidh agus riochdairean bho ghrunn bhuidhnean buntainneach, cathrachdan, Buidhnean Neo-Riaghaltasach (BNR) agus a' choimhearsnachd
- air ca. 2050 a thaghadh mar sgèile-ama airson an ama ri teachd agus airson beachdachadh air suidheachadh sgaoilidhean àrda (RCP8.5) airson a' mheasaidh sho-leòntachd
- air na trì prìomh chuideamairean gnàth-shìde san robh a' bhagairt as motha a chomharrachadh: **Gluasad Teòthachd, Neart & Tricead Stoirmean** agus **Sruthan ag Atharrachadh,** a' toirt fa-near gum biodh eadar-obrachadh buailteach eatarra agus le cuideamairean eile



- air dearbhadh gun robh an **t-So-leòntachd LCS** airson na seilbhe aig **Meadhanach** (air sgèile trì puingean, Ìosal/Meadhanach/Àrd), a' sealltainn gum faodadh lùghdachadh no atharrachadh a bhith ann an cuid de na luachan is na feartan a tha san LCS
- air measadh gun robh an **t-So-Leòntachd Coimhearsnachd** san earrainn as ìsle **(Ìosal)**, a' comharrachadh gum biodh buaidh aig a' char as lugha air ceanglaichean eaconamach, sòisealta agus/no cultarach (ESC)
- air toirt fa-near dhan chomas cho-fhreagrach a thaobh luachan DC agus an stiùireadh, agus a thaobh na coimhearsnachd fharsaing a bha co-cheangailte ris an t-seilbh.

Thathar an dùil gum bi atharrachadh gnàth-shìde a' bagairt cuid de sgìrean anns na h-eileanan nas motha na sgìrean eile agus gum bi barrachd buaidh aige air co-dhiù cuid de na luachan a tha còmhla a' cur ris an LCS. Am measg nam buaidhean a chaidh a dheasbad, bha buaidh air stòrasan-bìdh eòin-mhara; agus am milleadh air a' chruth-thìre mar thoradh air an eadar-obrachadh eadar barrachd luchd-turais agus buaidhean gnàth-shìde co-cheangailte ri stoirmean. Bhathar dhen bheachd gun robh luachan bith-eòlasach na cruth-tìre cultarach nas so-leònte a thaobh buaidhean atharrachadh gnàth-shìde na bha na luachan cultarach/àrc-eòlais, gu h-àraid air sgàth nan sgèilean spàsail air an robh buaidh agus na roghainnean a bha rim faotainn a thaobh comas atharrachail.

Thug a' bhùth-obrach cothrom eòlas agus fiosrachadh a tha buntainneach do stiùireadh dualchais chultarach is nàdarra a thoirt seachad agus gus mothachadh a thogail mu atharrachadh gnàth-shìde sa choimhearsnachd. Feumaidh gnìomhan stiùiridh dòigh-obrach fhaiceallach a chleachdadh gus droch bhuaidh sam bith air an LCS a sheachnadh. Dh'fhaodadh iad seo a bhith a' gabhail a-steach a bhith a' lùghdachadh chuideaman neo-ghnàth-shìde air an eag-shiostam (agus mar sin a' neartachadh tapachd nàdarra); a' leasachadh co-obrachadh eadar manaidsearan agus luchd-rannsachaidh DC; agus a' neartachadh oidhirpean rannsachaidh is sgrùdaidh gus atharrachaidhean ann an siostam na mara a ro-innse agus a thuigsinn nas fheàrr. Chomharraich a' bhùth-obrach cuideachd luach frèam-obrach a bha follaiseach is a ghabhadh cleachdadh gu cunbhalach airson measadh luath a dhèanamh air buaidhean gnàth-shìde air seilbhean dualchais.

A bharrachd air stiùireadh ionadail, tha e riatanach gum bi gnìomh cruinneil ann sa bhad gus sgaoilidhean gasa taigh-glainne a lùghdachadh gu mòr. Gus buaidhean atharrachadh gnàth-shìde a lùghdachadh san ùine fhaisg, tha am measgachadh de ghnìomhan riatanach airson atharrachadh gnàth-shìde a lùghdachadh agus taic a thoirt do fhreagarrachadh gnàth-shìde gus LCS Hiort a chumail suas.

INTRODUCTION

Northern gannets in flight, St Kilda
(Jim Richardson, used with permission)

1.1 Background to this report

This report outlines the results of applying the Climate Vulnerability Index (CVI) to assess the St Kilda World Heritage (WH) property*, one of six UNESCO WH properties in Scotland and the only mixed** WH property in the UK.

St Kilda is a small archipelago off the west coast of mainland Scotland. Towering out of the storm-tossed waters of the Atlantic Ocean, the breathtaking scenery of the three islands and the nearby sea stacs clamours with the sounds of thousands of birds in dense seabird colonies, including the UK's largest colony of Atlantic puffins. The surrounding waters provide diverse habitats to support marine ecosystems but also greatly influenced the course of human settlement.

Internationally recognised for its birdlife, St Kilda is no less famous for its human history. A community existed here for at least 4,000 years, exploiting the harsh environment by harvesting the seabirds for food, feathers and oil, farming crops and raising livestock. However, the final 36 islanders remaining were evacuated in 1930 after they voted to leave as their way of life was no longer sustainable. Today, the remains of that remarkable heritage together with the archipelago's dramatic scenery and its wildlife draws an increasing number of visitors.

Climate change is a growing global risk to most WH properties, many of which – natural, cultural, and mixed – are already being impacted.

"The impacts of [climate-related] changes are already damaging infrastructure, ecosystems and social systems – including cultural heritage – that provide essential benefits and quality of life to communities." (ICOMOS[1])

The Intergovernmental Panel on Climate Change (IPCC) has predicted with 'high confidence' that *'global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate'*[2]. The IPCC has therefore stated that *"Climate-related risks for natural and human systems (will)… depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options"*[3].

1.2 Overview of the Climate Vulnerability Index

The Climate Vulnerability Index (CVI) is a systematic and rapid assessment tool that is values-based, science-driven and community-focused. It was initially developed to assess the vulnerability of climate change upon all types of WH properties, considering the Outstanding Universal Value (OUV) and the associated 'community' (local, domestic, and international).

The CVI process (see also Section 5) is best undertaken through a workshop of diverse stakeholders – including the managers, researchers, community representatives, other agency representatives and stakeholders.

The CVI methodology is based on a risk assessment approach and builds upon the vulnerability framework described by the IPCC[4]. The CVI process works sequentially through the steps outlined in Chapter 5, enabling a systematic evaluation of the threats of climate change. Extending upon the IPCC approach, the CVI comprises two distinct primary outcomes assessing:

+ **OUV Vulnerability** based upon the IUCN vulnerability framework and assesses the exposure, sensitivity, and adaptive capacity of the key values of the property (i.e., the WH attributes that convey the OUV), assessing how they will be impacted by the three key climate stressors chosen to be the most relevant for that property; and

* The term World Heritage 'property' is the formal name in the international convention referring to a site or an area that is inscribed on the WH List; however, terms such as WH site are often used locally in other documents.

** It is regarded as 'mixed' because it is inscribed for both natural and cultural heritage criteria.

+ **Community Vulnerability** through the economic, social, and cultural connections of the community associated with the WH property (local, national, and international), the dependency of the community upon the property, and the capacity of the community to cope with climate change-related decline in WH values.

Both of these assessments of vulnerability are highly relevant for key stakeholders including site managers, management agencies, and the community associated with the property. The Community Vulnerability component of the CVI is an integral and fundamental component and is one key aspect that distinguishes the CVI from many other risk assessment approaches. Through its application, the CVI enables managers and stakeholders to consider what may be appropriate adaptive capacities for the management of their natural, cultural and social assets.

While the CVI was initially developed in Australia, input and guidance for the CVI has subsequently come from many experts around the world. This includes the International Council on Monuments and Sites (ICOMOS) and the International Union for Conservation of Nature (IUCN), two of the advisory bodies for the WH Committee.

1.3 Why was St Kilda chosen for the CVI?

St Kilda is one of only 39 WH properties globally to hold mixed status and this was the first time the CVI had been applied to a mixed WH property anywhere in the world. Historic Environment Scotland (HES) was keen to apply the CVI process following the success of similar CVI workshops in three other Scottish WH properties[5,6,7]. HES stated its intention to hold CVI workshops for all six Scottish WH properties and build the results into future management planning.

As climate change has become a critical factor for managing WH properties, Scotland saw potential in the CVI methodology to assess and understand the impacts of climate change, especially due to a loss of WH values. These WH values include the obvious built heritage, as well as the species that are unique to St Kilda such as the sheep, field mice and wrens on the islands. Similarly, the surrounding oceanic waters that support a diverse range of animals and plants are part of the OUV.

Dr Rebecca Jones and Dr Ewan Hyslop, then at HES, together with Professor Scott Heron of James Cook University, submitted an application to the Royal Society of Edinburgh's Arts and Humanities Research Networks fund in autumn 2020. This application was successful with the grant award running from 2021-23. The funding was intended to both aid the refinement of the CVI methodology as well as provide a platform to build capacity and train those involved in managing Scotland's WH properties and support their global partner networks.

The CVI co-developers, Professor Scott Heron and Dr Jon Day from James Cook University, Australia were therefore engaged to apply the full CVI framework to St Kilda. They travelled to Scotland to lead the workshop in September 2022 and were fortunate that the weather was good enough to visit St Kilda three days before the workshop commenced. The CVI workshop for St Kilda was then conducted on South Uist in September 2022 (Appendix 4 provides the workshop schedule, which was run in a hybrid format over three full days, and the participants are listed in Appendix 5).

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2

ST KILDA

Stac an Armin
(Jon Day)

2.1 Location

The St Kilda archipelago, the remotest part of the British Isles, lies in the North Altantic Ocean, 66 km (41 miles) northwest of Benbecula in Scotland's Outer Hebrides (Figure 2.1).

At 670 hectares (1,700 acres) Hirta is the largest island in the group and comprises more than 78% of the land area of the archipelago. Next in size are Soay (English: "sheep island") at 99 hectares (240 acres) and Boreray ('the fortified isle'), which measures 86 hectares (210 acres).

There are also three towering sea stacs (Stac an Armin or 'warrior's stack', Stac Lee or 'grey stack' and Stac Levenish or 'torrent stack').

The dominant natural elements of the archipelago are the sea, the islands and the towering sea stacs that collectively form the most important seabird breeding area in north-west Europe. The waters around the isolated archipelago provide one of the best places in Britain for diving because of the clear water and its submerged caves, tunnels and arches, which support abundant marine life.

Figure 2.1 St Kilda Archipelago lies 66 km west of the main islands of the Outer Hebrides in the North Atlantic Ocean. CC BY-SA 3.0 *(adapted from Kelisi)*.

Figure 2.2 The St Kilda World Heritage property (red boundary) includes the waters surrounding the islands (blue) of Hirta, Boreray, Dun and Soay, and the three sea stacs (also blue) of Levenish, Stac an Armin and Stac Lee. *(adapted from https://whc.unesco.org/en/list/387/maps/)*

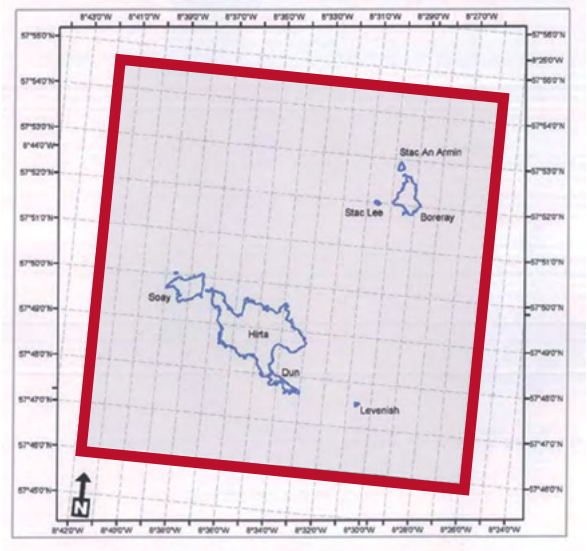
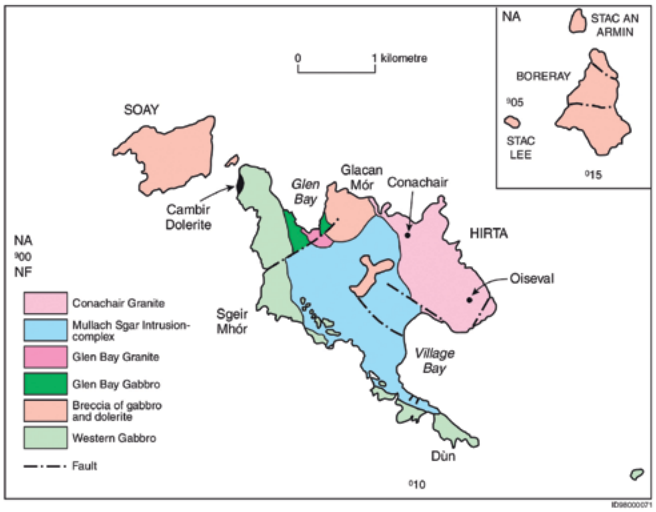


Figure 2.3 Geological map of St Kilda *(British Geological Survey P914138)* [2]



The World Heritage (WH) property covers over 24,000 hectares, of which approximately 850 hectares (3.5%) is land. The WH boundary is roughly shaped as a square in the Atlantic Ocean (Figure 2.2), coinciding with the Special Area of Conservation (SAC), and is included within a Special Protection Area (SPA). There is no Buffer Zone for the WH property.

2.2 Geology

The islands of the St Kilda archipelago rise steeply out of the Atlantic Ocean. They represent the core of an eroded Tertiary volcano that was active about 55 million years ago and are part of a suite of volcanoes associated with the crustal rifting that accompanied the opening of the North Atlantic Ocean at that time. The islands are composed of a range of intrusive igneous rocks, typical of those formed beneath central volcanoes, and which are now exposed by erosion[1]. The earlier part of the volcanic activity created a layered intrusion of basic igneous rocks (gabbro), which was later cut through by granites, followed by sheets and dykes of dolerite and felsite.

The oldest rock is the Western Gabbro (Figure 2.3), a banded and layered intrusion which along its eastern margin has been intensely sheared and recrystallised prior to intrusion of the younger granite rocks of the Mullach Sgar Complex which form the central part of Hirta. Smaller outcrops of basic igneous rocks (dolerites and gabbros) are in the northern parts of Hirta, predating the Glen Bay Granite. Blocks of gabbro, identical to the Western Gabbro, have been mixed with other gabbros and dolerites and form a widespread breccia which comprises most of Boreray, Soay and Glacan Mor. The last major intrusion on St Kilda was the Conachair Granite which was followed by later sheets and dykes which cut the major intrusions and represent the last phase of igneous activity.

2.3 Landscape

The dominant topographical features of St Kilda are the result of Quaternary glaciation and a small valley glacier probably occupied Village Bay during the Devensian glacial maximum about 22,000 years ago. At that time all of Scotland and Ireland (and most of Wales and

northern England) was underneath the ice sheet, which gradually retreated and shrank to completely disappear by 11,300 years ago. Locally derived glacial till deposits consisting of boulders in a gravel and sand matrix occur in the low cliffs above the beach and in the lower reaches of Abhainn Mhor above Village Bay. At higher levels beyond the extent of the glacier, periglacial slope deposits and debris lobes are developed particularly on the eastern slopes of Mullach Sgar and Ruaival. Some superficial deposits post-date the glaciation including early screes which cut across the till in Village Bay, formed as a result of severe frost action which also produced block fields on Carn Mor, Ruaival, Dun, Stac an Armin and southeast Soay. On Ruaival and Dun the blocks are partly cemented by phosphate likely derived from guano.

The spectacular cliffs and stacs for which St Kilda is well known are the result of post glacial marine erosion. Landslips on the Cambir Neck and above Mol Ghiasgar are the most recent evidence of this process. A series of early faults trend NW–SE on Hirta and later NE–SW tensional faults are partly responsible for significant topographic features such as the Dun Passage and the Cambir Neck (Figure 2.3). The numerous small igneous sheets and dykes provide lines of weakness allowing erosion and are responsible for some of the range of coastal features including stacs, arches and the ledges utilised by nesting seabirds. Between Hirta and Boreray the presence of an extensive submarine platform at 60 metres depth indicates that marine erosion was formerly at a lower level. Many of the stacs and cliffs descend steeply below present water level to form submarine cliffs occasionally containing submerged caves. At the time of glaciation global sea level was more than 120 metres lower than present, so that today St Kilda is part of a drowned landscape.

The highest point in the archipelago, Conachair ('the beacon') at 430 metres (1,410 ft), is on Hirta, immediately north of the village. Boreray reaches 384 metres (1,260 ft) and Soay 378 metres (1,240 ft). The island of Dùn ('fort') protects Village Bay from the prevailing southwesterly winds and was at one time joined to Hirta by a natural arch. The extraordinary Stac an Armin reaches 196 metres (643 ft), and Stac Lee, 172 metres (564 ft), making them the highest sea stacs in Britain.

Outcomes of a desktop hydrological modelling study for Hirta were presented to the workshop by Dr Hazel Blake, as part of her PhD studies on improving the understanding of precipitation impacts on three World Heritage properties in Scotland[3]. Surface hydrological networks were identified using the Spatial Analysis Hydrology tool in ArcGIS, utilising a topographical model derived from 0.25 m resolution LiDAR data[4], effectively mapping drainage basins at a range of scales. The work shows the influence of upstanding archaeological features and historical land management practices on the surface drainage network in the Village Bay area, highlighting locations where changes in precipitation patterns could potentially lead to erosion or other impacts resulting from changes in surface run-off. Through repeated decadal topographic survey and hydrological modelling, the tool has potential to monitor changes that are happening to the cultural landscape over time, including the effects of climate change. The modelling was undertaken remotely, and its application to site management would require integration with on-site knowledge and landscape management practices.

A coastal change assessment for Village Bay undertaken within the Dynamic Coast project[5] was presented to the workshop by participant Dr Alistair Rennie. This analysis included modern quantitative data (mean high water during spring tides, MHWS, since 1968; erosion reports and data, 1999-2014; and digital models of elevation and terrain derived from LiDAR[4] and aerial photography, 2011-2021) complemented by historical qualitative information (e.g., derived from photographs, since 1886). These suggest that the rate at which parts of the Village Bay coastline receded was on the order of 8 cm/year during the period 1886-2006, noting that Gabion baskets were installed at the end of this period. Importantly, the risks of coastal flooding and erosion will increase with climate change-driven sea level rise, including wave impacts, beach instability and landslips extending further inland (additional

discussion of climate and the influence of climate change on St Kilda is in Section 4). While only a small part of the coastline of St Kilda is vulnerable to coastal erosion/flooding, Village Bay is the most culturally sensitive as it has been the focus of human activity since the first settlers.

2.4 Human habitation

There have been people on St Kilda since prehistoric times, exploiting the resources of the sea, growing crops and farming animals. There is some evidence from stone tools and pottery found on Hirta that Neolithic travellers visited the archipelago some 4,000–5,000 years ago.

The islands' human heritage includes numerous unique architectural features from the historic and prehistoric periods, although the earliest descriptions of island life date from the Late Middle Ages with some earlier records (Norse sagas; 14th century texts) potentially also referring to the islands. Permanent habitation on the islands possibly extends back at least two millennia; the population probably never exceeded 180, a level recorded in the late 17th century. Evidence suggests that the permanent population lived on the largest island, Hirta, with seasonal use of the other islands. At the time of the 1861 census, there were 71 inhabitants. The village on Hirta was rebuilt twice in the 19th century, but the population ebbed and waned. Whalers and fishing fleets worked in St Kildan waters and brought supplies to the islanders, and from 1877 regular summer tourist cruises visited St Kilda. Some islanders produced goods to sell to tourists, including sheepskins, tweeds, knitted gloves and scarves, eggs and ornithological items (Figure 2.4).

In 1912 there were acute food shortages, followed in 1913 by an outbreak of influenza and the upheaval of the First World War. Throughout the 1920s the population decreased further as young people left to seek opportunities elsewhere. In August 1930, the community, by then numbering only 36 residents, chose to evacuate, leaving a relict cultural landscape, particularly visible on the island of Hirta.

Figure 2.4. Historic photographs of St Kilda residents with hunted seabirds, 1907 *(NTS, Milne album)*

In the 1950s, the UK Government decided to incorporate St Kilda into its new missile testing range in the Hebrides, located on Benbecula, South Uist and St Kilda. This led to the construction of a military base in Village Bay on Hirta in 1958, and this has recently been sensitively replaced with modern infrastructure by the Ministry of Defence.

Today, the only year-round residents are personnel stationed at the military base. They share the island with a variety of conservation workers, volunteers and scientists who spend time on the islands monitoring the wildlife and undertaking conservation work on the many ruined buildings left behind by the original St Kildans.

2.5 The World Heritage property

The UK Government ratified the World Heritage (WH) Convention in 1984 and St Kilda was added to the UNESCO WH List in 1986, part of the first group of sites to be nominated by the UK. The UK has many WH properties, but St Kilda is the UK's only mixed WH property, recognised for both its natural and cultural significance.

i Natural values

When St Kilda was first inscribed on the WH List in 1986, it was solely for its outstanding natural heritage (criteria *vii* and *x*), including the highest sea cliffs in the United Kingdom and the most important seabird breeding location in north-west Europe.

+ *Seabirds* – With their exceptional cliffs and sea stacs, the islands are a breeding ground for many important seabird species including one of the world's largest colonies of northern gannets (approximately 24% of the global population) nesting on Boreray and the sea stacs. There are significant populations of Atlantic puffin *(Fratercula arctica)* and Leach's storm petrel *(Hydrobates leucorhous)*, as well as the largest colony of fulmars *(Fulmarus spp.)* in Britain. Before 1828, St Kilda was their only UK breeding ground, but they have since spread and established colonies elsewhere. The last Great auk *(Pinguinus impennis)* seen in Britain was killed on Stac an Armin in July 1840.

  The St Kilda archipelago and its seabird colonies are now recognised as an Important Bird Area (IBA) by BirdLife International and major surveys of the seabirds occur periodically on and around the islands.

+ *Sheep* – Two different early sheep types have survived on these remote islands, the Soay, a Neolithic type, and the Boreray, descended from an Iron Age type. A research project studying the Soay sheep begun in the 1950s continues today. All Soay sheep in the world are descended from those found on the island of Soay in the St Kilda archipelago. These small sheep are one of the most primitive forms of domestic sheep in the world and have probably remained virtually unchanged for thousands of years.

+ *St Kilda mice* – Two kinds of mouse used to be found on St Kilda. Both were larger sub-species of the mainland house mouse and wood mouse. The St Kilda fieldmouse *(Apodemus sylvaticus hirtensis)* is still common on Hirta and is also present on Dùn. It mainly feeds on snails, insects, moss and seeds but will also feed on the carcasses of dead sheep, birds and any delicacies left by visitors. The St Kilda house mouse became extinct after the evacuation of the human inhabitants in 1930, as it was strictly associated with settlements and buildings.

+ *St Kilda wren* – the St Kilda wren *(Troglodytes troglodytes hirtensis)* is a larger sub-species of the mainland wren; there are only a few hundred pairs, making it a great rarity. Specimens of the adult birds and their eggs were highly prized and the St Kildans used to collect eggs for selling to collectors. Today, it is fully protected on St Kilda.

+ *Marine life* – In more recent years there has been a growing interest in the marine life. In 2004, the WH inscription was extended to

include the surrounding marine environment* (criterion *ix*). The clear and nutrient rich waters have resulted in dense kelp forests surrounding the islands. This supports a rich underflora of red algae together with a variety of sea anemones, sponges and bryozoans. This colourful seascape with underwater arches and caves has made the archipelago very attractive to divers.

+ *Other biodiversity* – The archipelago's isolation has resulted in a lack of biodiversity. The most diverse are flies (~200 species) followed by beetles with approximately 140 species. There are no bees on the islands, so flies are probably important pollinators of plants. One beetle, the rare and endangered weevil *(Ceutorhynchus insularis)*, is known from only Dùn and an archipelago off the coast of Iceland. Less than 100 species of butterfly and moth occur, compared with 367 recorded on the Western Isles.

ii Cultural values

The islands' human heritage includes numerous unique architectural features from the historic and prehistoric periods. However, the earliest written records of island life date from the Late Middle Ages (and the origin of the name St Kilda is a matter of conjecture). Isolated by heavy seas throughout much of the year, the original inhabitants of St Kilda sustained their community through hunting and gathering seabirds and their eggs, as well as small-scale farming.

The medieval village on Hirta was rebuilt in the 19th century but improving standards of living on the Scottish mainland and Western Isles and the upheaval of the First World War contributed to the islanders' evacuation in 1930, seeking the promise of a higher standard of life, regular work and better access to emergency medicine.

In 2005 the archipelago became the UK's first and only mixed World Heritage Site, when the islands' relict cultural landscape was also inscribed on the WH List** (criteria *iii* and *v*). The justification for inscribing St Kilda includes the unique interaction between humans and nature over a long period of time and the WH Committee summarised the significant values:

"The archipelago, uninhabited since 1930, bears the evidence of more than 2,000 years of human occupation in the extreme conditions prevalent in the Hebrides. Human vestiges include built structures and field systems, the cleits and the traditional Highland stone houses."
(UNESCO[6])

There are hundreds of cleitean*** scattered around the village area. These are drystone storage structures used to store and dry birds, eggs and feathers, harvested crops, and peat and turf used for fuel. There are unique to St Kilda and are found across all the islands and stacs in the archipelago, around 1,430 in total (1,260 cleitean on Hirta and a further 170 on the other islands).

2.6 Identifying the key values of the World Heritage property

i Statement of Outstanding Universal Value

When formally listing an area as a WH property, UNESCO's WH Committee summarises the significant values and attributes in a Statement of Outstanding Universal Value (SOUV), a fixed description of the values of the property referenced to the date of inscription. The SOUV for St Kilda (Attachment 1) forms part of the property's UNESCO webpage[6].

* https://whc.unesco.org/en/decisions/102
** https://whc.unesco.org/en/decisions/482
*** A cleit (pl. cleitean) is a stone hut for storage or accommodation; while many still exist, only a percentage are repaired and maintained as part of a cultural landscape management plan.

Prior to the CVI workshop, excerpts from the SOUV for St Kilda were identified and grouped together to form five 'key values' (listed below and expanded in Table 2.1). This was initially compiled by the CVI developers and subsequently endorsed by the workshop's Steering Committee. The key values are underpinned by associated 'attributes', which are the elements of a heritage place that convey its heritage/conservation values and enable an understanding of those values. Attributes can be physical qualities, material fabric and other tangible features but can also be intangible aspects such as processes, social arrangements, cultural practices, associations and relationships that are reflected in physical elements of the property. Management is typically undertaken considering the tangible attributes. Table 2.1 shows how the excerpts from the SOUV were grouped to derive these key values and summarise their attributes.

The five key values identified for St Kilda (with images depicting each key value shown in Appendix 2) are:

1. Scenery and landscape
2. Seabirds
3. Genetic interest and biodiversity
4. Marine environment
5. Relict cultural landscape

These key values became a foundation for the initial assessments in the CVI process.

ii Other Significant Property Values

As well as values that have been internationally recognised as being of OUV, WH properties invariably include other significant values, whether they are heritage values (tangible or intangible) or other values (e.g., social, cultural, economic, spiritual, environmental, scientific). These values may be important locally, regionally, or nationally, and may even be considered 'significant' under local or regional by-laws or even national legislation. For the CVI, these are referred to as *other Significant Property Values* (SPVs), recognising their importance – and noting that they will also be subject to impacts from stressors like climate change. Appendix 3 provides the list of other SPVs developed for St Kilda.

2.7 Evaluation of current condition and recent trend of the key World Heritage values

Using the key values of the property and the corresponding excerpts from the SOUV, assessments were made of the current condition (four-point categorical scale from Good to Critical) and recent trend (since inscription; Improved, Stable, Deteriorated or Unknown) during a plenary session of the workshop. Where the assessments were consistent across all excerpts within a key value, they were reported at the key value level; where there was variation, excerpts were grouped accordingly (Table 2.1, following pages). In general, this shows the key values as being in Good condition (noting some concerns) and have been Stable since inscription (though there is insufficient information to ascribe trends for the St Kilda wren and the marine environment). The notable exception is that Seabirds have Deteriorated since inscription in 1986 and were considered to be in Critical condition.

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Table 2.1 Key values derived from the Statement of Outstanding Universal Value, together with the current condition and recent trend since inscription in 2004 assessed within the CVI process (legend below table).

Key values	Excerpts taken directly from the Statement of OUV	Attributes (site-specific characteristics that inherently contribute to a key value)	Assessment of current condition and recent trend (since 1986 inscription)
Scenery and landscape	The tiny archipelago of St Kilda	Tangible attributes + cliffs + bay + archipelago/ islands/stacs + grass slopes + marine life + bird life + volcanic rim Intangible attributes + seascape + aesthetics	→
	rim of an ancient volcano associated with the opening up of the North Atlantic some 65-52 million years ago		
	intensely dramatic, jagged landscape of towering cliffs – some of the highest sea cliffs in Europe – and sea stacks present stark black precipitous faces plunging from steep grass-green slopes in excess of 375m		
	Scenically, every element appears vertical, except the smooth amphitheatre of Village Bay on Hirta with its relict historic landscape		
	Exposure to some of the greatest wave heights and strongest wind speeds in Europe plays a major role in shaping the coastal ecology		
	Scenery – superlative and has resulted from its volcanic origin followed by weathering and glaciation to produce a dramatic island landscape		
	precipitous cliffs and sea stacks; underwater scenery – concentrated in a compact group that is singularly unique		

Good
The property's values are in good condition and are likely to be maintained for the foreseeable future, provided that current conservation measures are maintained.

Good with some concerns
While some concerns exist, with minor additional conservation measures the property's values are likely to be essentially maintained over the long-term.

Significant concern
The property's values are threatened and/or may be showing signs of deterioration. Significant additional conservation measures are needed to maintain and/or restore values over the medium to long-term.

Critical
The property's values are severely threatened and/ or deteriorating. Immediate large-scale additional conservation measures are needed to maintain and/or restore values over the short to medium-term or the values may be lost.

→ **Stable**

↘ **Deteriorated**

↗ **Improved**

? **Unknown**

Key values	Excerpts taken directly from the Statement of OUV	Attributes (site-specific characteristics that inherently contribute to a key value)	Assessment of current condition and recent trend (since 1986 inscription)
Seabirds	nearly one million seabirds present at the height of the breeding season largest seabird colony in the north-east Atlantic size and diversity of global significance making it a seabird sanctuary without parallel in Europe very high bird densities… occur in this relatively small area complex and different ecological niches existing in the site and the productivity of the surrounding sea, make St Kilda unique populations of Northern Gannet, Atlantic Puffin and Northern Fulmar sight and sound of these myriad seabirds adds significantly to the scenic value and to the experience of the archipelago during the breeding season very high bird densities – relatively small area conditioned by the complex and different ecological niches existing in the site one of the major sites in the North Atlantic and Europe for seabirds with over 1,000,000 birds using the island particularly important for gannets, puffins and fulmars	Tangible attributes + bird species (gannet, puffin, fulmar) + seabird colony and size Intangible attributes + bird sounds and sight + scenic value + experience + diversity + ecological niche	
Genetic interest and biodiversity	islands' isolation has led to two outstanding examples of remote island ecological colonisation and subsequent genetic divergence – the St Kilda Wren and St Kilda Fieldmouse feral Soay sheep – an ancient breed, descendants of the most primitive domestic sheep found in Europe a living testament to the longevity of human occupation of St Kilda potentially significant genetic resource rare breed of potential genetic resource significance	Tangible attributes + wren + mouse + soay sheep + genetic resource Intangible attributes + genetic divergence	wren  mouse  sheep  genetic 

Key values	Excerpts taken directly from the Statement of OUV	Attributes (site-specific characteristics that inherently contribute to a key value)	Assessment of current condition and recent trend (since 1986 inscription)
Marine environment	oceanic influences (proximity of deep ocean currents along the continental slope, extreme exposure to waves and oceanic swell, high water clarity	Tangible attributes + geological setting + maritime grassland turf + marine zones + (northern & southern) range extremes + underwater rock faces + sealife Intangible attributes + intactness + colour	?
	local geology around the archipelago		
	a marine environment of unparalleled richness and colour		
	seabed communities are outstanding in terms of biodiversity and composition, including 'northern' and 'southern' species at the extremes of their range		
	plunging underwater rock faces are festooned with sea life – a kaleidoscope of colour and form kept in constant motion by the Atlantic swell, creating an underwater landscape of breathtaking beauty		
	complex ecological dynamic in the marine environment is essential to maintenance of both the terrestrial and marine biodiversity		
	complex ecological dynamic in the three marine zones present in the site that is essential to the maintenance of both marine and terrestrial biodiversity		
	maritime grassland turf and underwater habitats are also significant and an integral element of the total island setting		
	marine environment is largely intact		
	Conservation of the marine environment – greater protection in the future will be critical		

Good
The property's values are in good condition and are likely to be maintained for the foreseeable future, provided that current conservation measures are maintained.

Good with some concerns
While some concerns exist, with minor additional conservation measures the property's values are likely to be essentially maintained over the long-term.

Significant concern
The property's values are threatened and/or may be showing signs of deterioration. Significant additional conservation measures are needed to maintain and/or restore values over the medium to long-term.

Critical
The property's values are severely threatened and/or deteriorating. Immediate large-scale additional conservation measures are needed to maintain and/or restore values over the short to medium-term or the values may be lost.

→ **Stable**

↘ **Deteriorated**

↗ **Improved**

? **Unknown**

Key values	Excerpts taken directly from the Statement of OUV	Attributes (site-specific characteristics that inherently contribute to a key value)	Assessment of current condition and recent trend (since 1986 inscription)
Relict cultural landscape	rich cultural landscape that bears exceptional testimony to millennia of human occupation archipelago has been occupied on and off for over 4000 years houses, large enclosures and cleits – unique drystone storage structures found, in their hundreds, across the islands and stacks within the archipelago – culminates in the surviving remains of the nineteenth and twentieth century cultural landscape of Village Bay time depth, preservation and completeness of the physical remains, provides a tangible and powerful link to the islands' past history, its people and their way of life, a distinctive existence, shaped by the St Kildan's response to the peculiar physical and geographic setting of the islands exceptionally well preserved and documented example of how, even in the most extreme conditions of storm-swept isolated island living, people were able to live for thousands of years from exploiting natural resources and farming physical witness to a cultural tradition that has now disappeared, namely reliance on seabird products as the main source of livelihood and sustenance, alongside subsistence farming age-old traditions and land uses that have so shaped the landscape – contributed to its aesthetic appeal external pressures led to decline, and, in 1930, to the abandonment of the islands exceptional testimony to over two millennia of human occupation in extreme conditions outstanding example of land use resulting from a type of subsistence economy based on the products of birds, cultivating land and keeping sheep cultural landscape reflects age-old traditions and land uses, which have become vulnerable to change particularly after the departure of the islanders exemplary and well preserved remains of the distinctive way of life that persisted in this remote area, unaltered after the St Kildans abandoned the islands	Tangible attributes + houses + cleitean + drystone structures + completeness of physical remains Intangible attributes + rich landscape + testimony of occupation + cultural traditions + subsistence economy + St Kildan way of life + aesthetic appeal + abandonment	

3

MANAGEMENT OF ST KILDA

Maintaining infrastructure, Village Bay
(NTS)

3.1 Management and governance of the World Heritage property

Management of the historic and natural environment in Scotland is a devolved matter, with a concordat between the UK and Scottish Governments providing that Scottish Ministers are responsible for ensuring the proper management of all Scottish WH properties. However, the responsibility for reporting on Scottish WH properties to UNESCO remains at the UK Government level.

The entire archipelago is owned by the National Trust for Scotland, a conservation charity which has overall responsibility for management of the archipelago. St Kilda is administratively a part of the Comhairle nan Eilean Siar (CnES) local authority area. A small part of the main island of Hirta is leased to the Ministry of Defence. The surrounding seabed is owned by the Crown and the sea, which forms the larger part of the WH property, is the responsibility of Marine Scotland, a Directorate of the Scottish Government.

Both the land and sea elements are covered by a number of statutory designations that protect all the values of the SOUV. As well as being a WH property, St Kilda is formally recognised as a Special Area of Conservation (the SAC boundary coincides with the WH boundary) and it is included within a Special Protection Area (SPA). These designations protect species or habitats under the European Union Habitats Directive and the protection afforded is not altered by the UK's exit from the European Union. St Kilda is also a National Nature Reserve, a Site of Special Scientific Interest, a National Scenic Area, a Marine Environmental High Risk Area and includes four Scheduled Monuments.

Because of the historic interdependency of landscape, wildlife and culture, it is essential that the management of St Kilda balances the differing conservation needs. The Trust works closely with partners from Historic Environment Scotland, NatureScot, Comhairle nan Eilean Siar, and the Ministry of Defence for decision-making about the WH property. Working together, these partners ensure that the islands continue to be protected, cared for, and enjoyed.

A Management Plan (2022-2032)[1] developed by the National Trust for Scotland addresses all areas of management delivered in collaboration with four key stakeholders. Management is informed by the Trust's 2018 Conservation, Learning, Access & Enjoyment Principles[2] as well as a range of local, national and international policy and legislation. This approach prioritises conservation of heritage of national and international significance, and decisions that are in the best long-term interests of Scotland's heritage, environment and people. To enable informed decision making, a regular programme of monitoring and research is undertaken.

Specific ongoing monitoring on St Kilda includes:

- Population & productivity studies of seabirds
- Population study of wrens in Village Bay
- Population and productivity studies on Soay sheep
- Monitoring of condition of buildings
- Visitor numbers, including dates and mode of transport

Current and recent research has been undertaken on:

- Soay sheep genetics, parasites and ageing
- Wren DNA analysis
- Foraging patterns of Leach's storm petrels
- Diet studies of Great skuas and Atlantic puffins

3.2 Cumulative pressures on the management of the World Heritage property

The current St Kilda Management Plan[1] describes key threats to the OUV and the management of St Kilda (identified through the UNESCO Periodic Reporting process), as well as the ongoing monitoring of the site and engagement with research and stakeholders. Identified issues include:

- Climate change
- Invasive non-native species
- Historical repair and conservation work
- Pollution
- Impact of pandemics
- Off-shore developments

Among these issues, climate change is a major issue and the key topic for the workshop described in this report; relevant climate and climate change factors are outlined in Section 4. This was also emphasised in the most-recent IUCN Outlook report that noted potential climate impacts upon fish stocks, seabirds (breeding and foraging) and Soay sheep from changes in temperature and ocean circulation[3].

The introduction of invasive, non-native species – including mammals, plants, invertebrates and disease agents – poses a significant ongoing threat to both marine and terrestrial eco-systems. This is managed through robust biosecurity measures.

Works to the historic fabric of buildings on St Kilda have been carried out since 1957, much unrecorded until the late 20th century. In some cases, the use of unsuitable materials or poorly designed interventions has resulted in contemporary issues. These are identified through the Trust's monitoring programme and rectified when possible and necessary.

A range of other pressures currently impact St Kilda or have potential to do so. The current levels of pollution in the oceans, including plastic, are an ongoing threat to all marine life including seabirds. Global pandemics, or local outbreaks, that affect movement of people are a threat to the monitoring and management of the site. These impact on the deployment of staff, researchers and contractors as well as essential deliveries and visitors. This also affects global and local economies which can have an impact on funding and resources. Pandemics affecting other species, such as the current outbreak of avian flu, are a current and potential threat to species and eco-systems. Offshore development associated with oil exploration and renewable energy in the North Atlantic is a potential threat. However, further research is required about the potential impacts and mitigation. Finally, while visitor numbers are currently within manageable levels, this also has the potential to impact negatively on the site and will require continuing monitoring and management.

3.3 Cultural & socio-economic context

St Kilda is part of the Outer Hebrides of Scotland. It is believed that the islands of St Kilda were some of the last to be settled, perhaps around 4500 years ago, by people from the neighbouring islands as they have a shared common history and culture that is reflected in the vernacular architecture, artefacts, language and traditions.

However, the perceived remoteness of St Kilda fostered a fascination in the community and its culture which continues to this day. Measuring cultural significance can be complex but an indication of the significance may be measured through the number of publications, art installations, music, museum exhibitions, television and radio broadcasts. However, very little of this reflects the actual voices of the St Kildans.

Some of the earliest photographic images in Scotland were taken on St Kilda in 1860 and the landscape and islanders continued to be photographed and filmed until they left, leaving a rich visual archive (Figure 2.4; Appendix 2). In 1937, the director Michael Powell made the film *The Edge of the World* loosely based on the evacuation of St Kilda in 1930. This film explores the tension between the younger generation leaving for opportunities on the mainland and the abandonment of a more traditional life on island. These themes can be applied to many islands and settlements in the Highlands and Islands of Scotland and St Kilda is perhaps a focus to explore these. Today that fascination continues and film crews from around the world make regular applications to film the natural and cultural heritage.

Three communities in the Western Isles have plans and aspirations to host a St Kilda visitor centre, to interpret the island's rich natural and cultural history and offer a supplement or alternative to the long sea voyage. The Outer Hebrides Tourism Strategy[4] recognises the value of heritage and diaspora tourism throughout the Western Isles and anticipates an increased interest in the archipelago around the centenary of the evacuation in 2030.

Tourism accounts for 10% of the local economy in the Western Isles, contributing over £50 million per annum[5]. No exact figures are available on the impact of St Kilda on the local economy but at least six local companies offer day trips and around 10 companies offer a visit to St Kilda as part of a longer trip in the islands. Around 30 cruise ships visit St Kilda each year. Of the 148,641 leisure visitors to the Western Isles in 2017 just under 5,000 visited St Kilda. Stormy weather can frequently disrupt planned visits, which is one reason for the importance of information about St Kilda elsewhere in the Western Isles. Tourism is not only an important income stream for the conservation of St Kilda but is also an opportunity to engage people in conservation and interpret the natural and cultural heritage.

In addition to tourism the main areas of employment in the Western Isles are the public sector, small-scale agriculture, fishing and the defence industry. Although rates of employment are higher in the Western Isles than the Scottish average, gross value added (GVA) and average wages are noticeably lower (CnES Socio Economic Update 44[6]).

On St Kilda the largest single employer is QinetiQ, a defence contractor, with approximately 7 FTEs; the National Trust for Scotland and research account for a further 7 FTEs. In addition to this, several contractors are employed, including those in traditional skills such as drystone dyking.

Since 1930 there has been no permanent population on St Kilda but there are people there all year round working, either on the Ministry of Defence facility or as National Trust for Scotland staff engaged in conservation and visitor management. This small 'population' is supplemented by researchers and can vary between 6 and 25 people over the year. The population of the Western Isles is declining and ageing, with a trend for younger people leaving to seek opportunities on the mainland. This is being addressed through the CnES Corporate Strategy[7] that aims to have socially and economically thriving communities with a focus on sustaining our quality of life, natural heritage, and Gaelic language and culture.

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4

CLIMATE AND ITS INFLUENCE ON ST KILDA

Runoff during heavy rainfall
(NTS)

4.1 Current climate

The archipelago of St Kilda has a cool and temperate maritime climate, relatively mild for its northerly latitude (57°N) due to moderation by the North Atlantic Current. The microclimate of the islands is heavily influenced by the local topographies of high and sheer-sided cliffs. Temperature extremes are rare, frosts uncommon and snow falls are notable events.

St Kilda's nearest long-term weather station is located 160 km south-southeast on South Uist, the second largest island in the Outer Hebrides. This station is part of the UK Met Office network[1] and is designated to be within the North Scotland region. Three automated weather stations have been operational on St Kilda in the vicinity of Village Bay, Hirta since 1999, installed and maintained by Sunadal Data Solutions[2]. Discussion of current climate in this section is based on the average of data from the three weather stations for the period 2001-2021 and the most recent three decades recorded by Met Office (1991-2020), supplemented by broad-scale datasets that provide further insight to St Kilda's climate.

In the last two decades, St Kilda's average annual temperature has been 9.1°C, with a yearly range from −0.5 to 19.0°C. The warmest month was July with an average temperature of 12.8°C, while February was the coldest month with an average temperature of 6.3°C (Table 4.1). This is comparable to South Uist, which experiences similar temperature ranges and distributions in its location on the western edge of Scotland. Both the North Scotland region and Scotland as a whole experienced slightly cooler annual-average temperatures, with marked differences seen between October and March.

The annual-average rainfall for St Kilda was 1513.6 mm (126.1 mm per month). January was typically the wettest month with an average of 193.1 mm of rainfall, while June was the driest (81.8 mm; Figure 4.1). St Kilda consistently received greater amounts of average rainfall than neighbouring South Uist and is comparable with that of North Scotland and Scotland. St Kilda is directly in the path of westerly winds that bring warm moist air from the North Atlantic Ocean to form rain clouds.

St Kilda received 1006.4 hours of sunshine on average per year, with May the sunniest at 160.2 hours of sunshine (average of 4.6 hours per day) while December was the dimmest at 19.5 hours (average of 0.6 hours per day; Figure 4.2). No sunshine data were collected for South Uist but when compared to North Scotland (1103.9 hours) and Scotland (1200.1 hours) as a whole, St Kilda receives less than regional and mainland totals. This is likely associated with the previously mentioned effect of westerly winds and the resulting cloud cover.

Table 4.1 Monthly-average temperature for weather stations on St Kilda (2001-2021; Sunadal[2]) and for South Uist, North Scotland and Scotland (1991-2020; Met Office[3]).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
St Kilda	6.6	6.3	6.7	7.8	9.3	11.3	12.8	12.5	11.7	9.9	8.0	6.8
South Uist	5.7	5.5	6.4	8.0	10.2	12.3	13.8	14.0	12.7	10.1	7.7	6.0
North Scotland	2.9	2.9	4.1	6.3	8.7	11.2	13.0	12.8	11.0	7.9	5.1	3.0
Scotland	2.9	3.1	4.4	6.6	9.2	11.7	13.5	13.3	11.3	8.2	5.2	3.1

Wind measured at the stations on St Kilda had an annual average speed of 7.6 knots, with the windiest month being January (9.5 knots) and the stillest month in July (5.7 knots; Figure 4.3). In comparison, South Uist experienced double the St Kilda average wind speed with 15.1 knots, with North Scotland (11.2 knots) and Scotland (10.8 knots) speeds between the St Kilda and South Uist values. The discrepancy between St Kilda and South Uist may have resulted from differing heights of the wind sensors (~2 m on St Kilda compared with the standardised 10 m height for Met Office instruments). In addition, the location of the three weather stations are somewhat sheltered in the vicinity of Village Bay and span altitudes of approximately 15-115 m above sea level, which may also contribute to the observed variation. To further consider this, satellite-based sea-wind speeds were extracted for the waters adjacent to St Kilda[4], which were comparable with the range of weather station measurements. The seasonal variation was consistent across all datasets.

As a small archipelago in the North Atlantic Ocean, the influence of ocean temperature is also important to consider for St Kilda. Local monthly-average sea-surface temperature (SST)[5] ranged 8.7-14.0°C (Figure 4.4), with a seasonal variation that is approximately one month later in its timing than St Kilda's air temperature (Table 4.1). As noted, despite the northern latitude of St Kilda, these are relatively mild conditions, which result from the warm current of the western Atlantic Gulf Stream that extends into the northeast-directed North Atlantic Current. This oceanic transport is a key component of the net northward surface flow across the Atlantic basin (part of the Atlantic Meridional Overturning Circulation).

Figure 4.1. Monthly-average rainfall totals for St Kilda (2001-2021; Sunadal[2]) and for South Uist, North Scotland and Scotland (1991-2020; Met Office[3]).

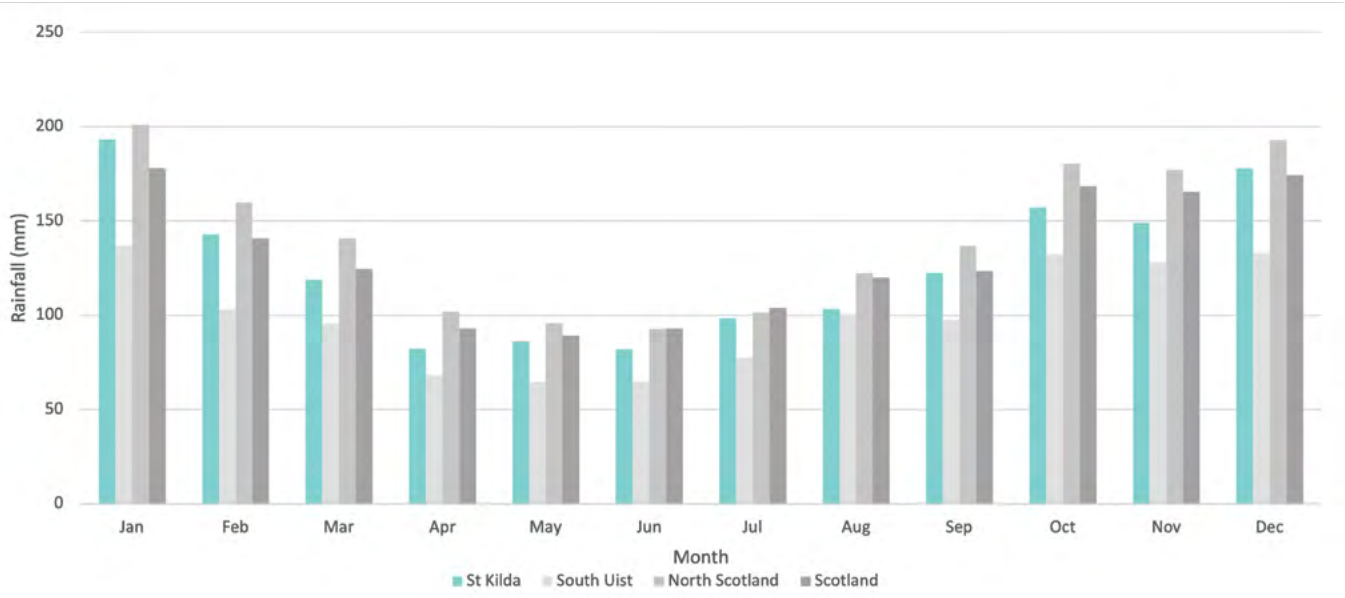


Figure 4.2. Monthly-average sunshine data for St Kilda (2001-2021; Sunadal[2]) and for North Scotland and Scotland (1991-2020; Met Office[3]). Data for South Uist not recorded.

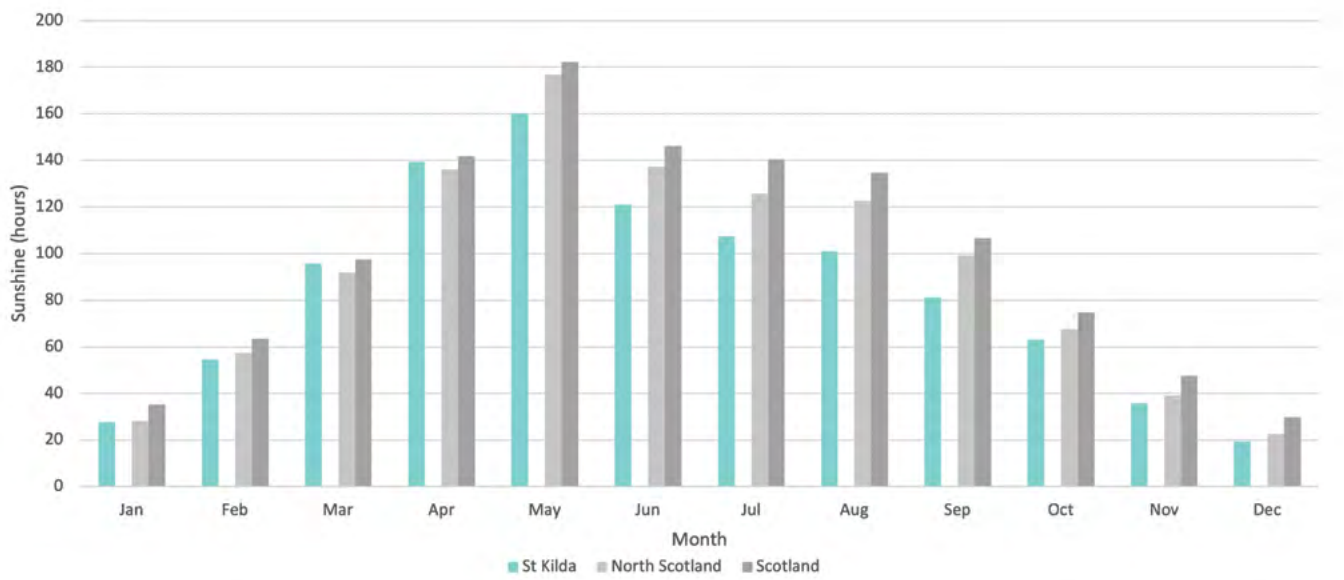


Figure 4.3. Monthly-average wind data for St Kilda (2001-2021; Sunadal[2]), St Kilda seawinds (1995-2005; NOAA Blended Seawinds[4]) and for South Uist, North Scotland and Scotland (1991-2020; Met Office[3]).

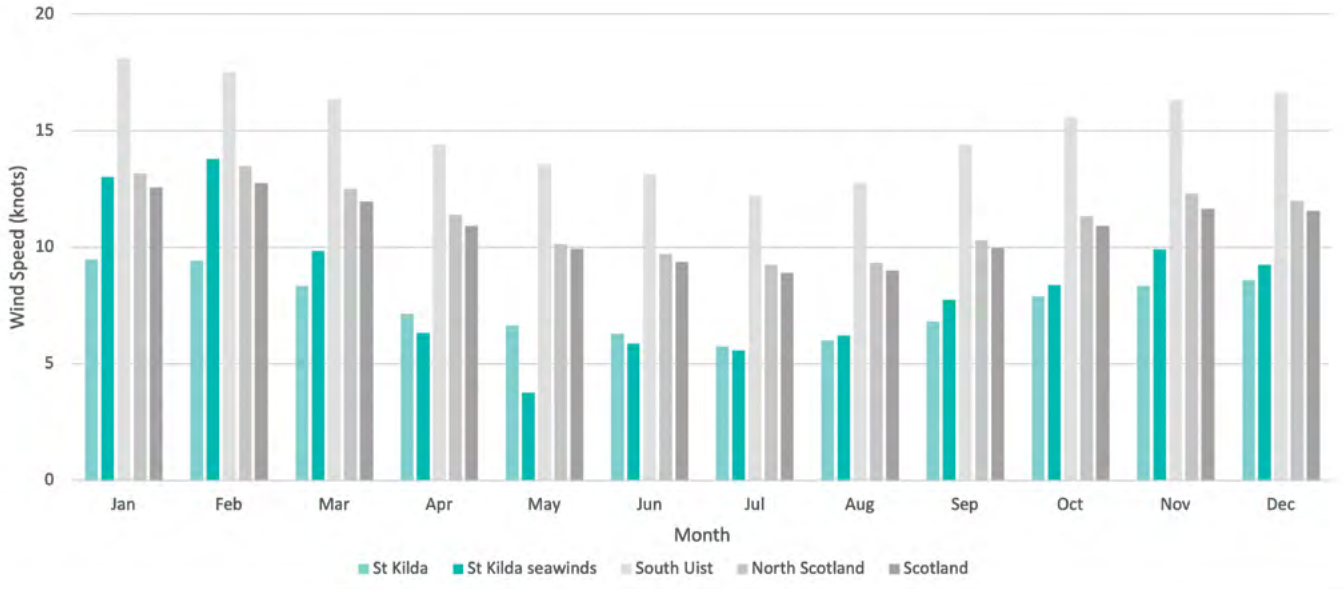
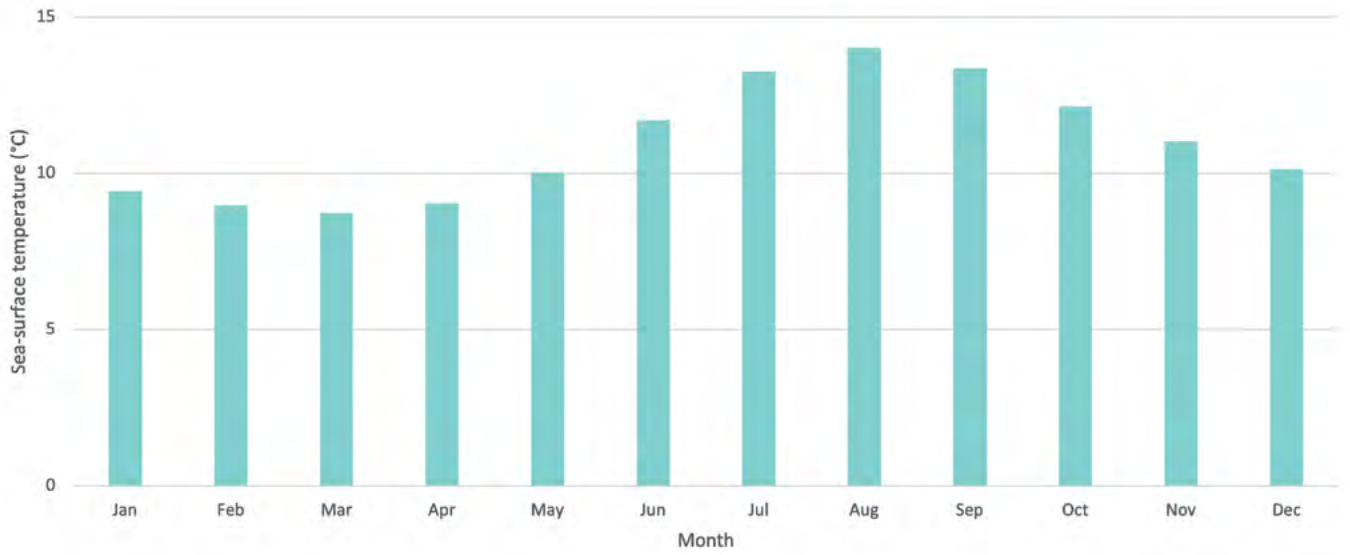


Figure 4.4. Monthly-average sea-surface temperature near St Kilda (1991-2020; NOAA Coral Reef Watch[5]).



4.2 Observed climate trends

The effect of climate change has been clearly recognised, with Scotland experiencing an average temperature increase of 0.5°C and a 5% increase in winter rainfall over the last 30 years[6]. These national trends are also apparent at a regional level. The observed climate trends discussed here for the North Scotland region, as defined by the UK Met Office, and averaged across Scotland. Temperature records began in 1884 and show that the North Scotland region has experienced a ~1°C rise in the last 138 years (Figure 4.5).

Total rainfall records began during 1836 and show that rainfall in the North Scotland region typically exceeds the Scotland average. Annual totals have increased by 400 mm over the last 185 years, averaging over 1700 mm in the decade 2011-2020. This increase is greater than the Scotland trend and results from increasing trends in autumn, winter and spring seasons (Figure 4.6).

Records of seasonal sunshine began in 1919 and indicate an increase in spring-time sunshine hours in the North Scotland region of over 3 hours/decade, in contrast to a marginal increase in winter and marginal decreases in summer and autumn. Overall, annual sunshine hours for the region increased by just under 3 hours/decade.

A long-term ocean temperature dataset[7] derived principally from historical ship-board measurements, in situ measurements and (most-recently) satellite data reveals that SST near St Kilda has increased at a rate of 0.36°C/century over the past 150 years (Figure 4.7). Around this warming trend, fluctuations with a periodicity of 60-80 years reflect the effect of the Atlantic Multidecadal Oscillation (AMO; AMO Index[8] in Figure 4.7).

The Atlantic Meridional Overturning Circulation is a measure of the transport of warm surface water northward from the equator. The volume rate of water moving north across latitude 26.5°N is estimated, via model reconstructions[9] supported by in situ measurements[10], to have decreased by approximately 15% since the mid-20th century[11] (Figure 4.8). This has broad-scale implications for oceanic currents around St Kilda. Three noteworthy rapid decreases in

Figure 4.5. Annual-average temperature data for North Scotland (1884-2021)[6].

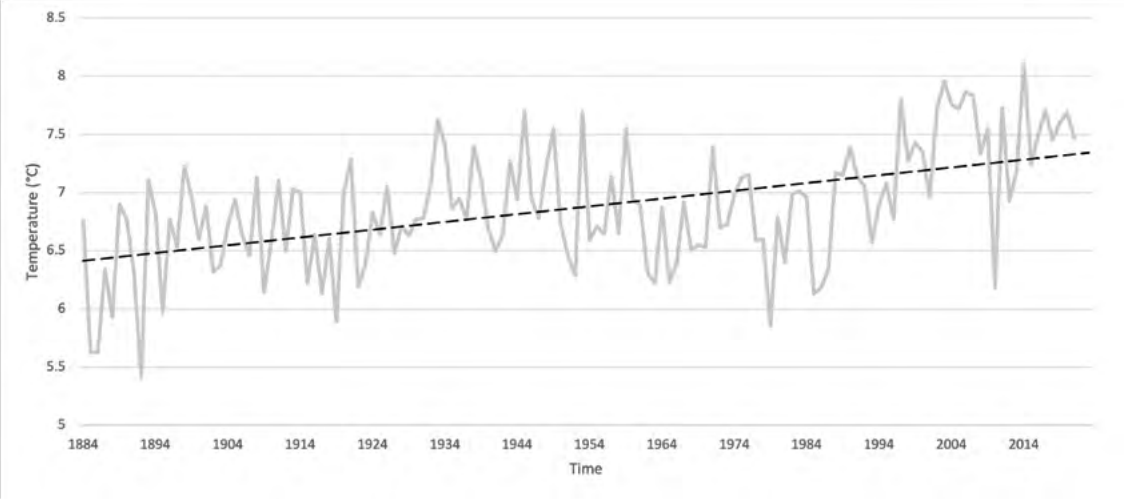


Figure 4.6. Average seasonal rainfall for North Scotland, 1837-2021 (Met Office[6]).

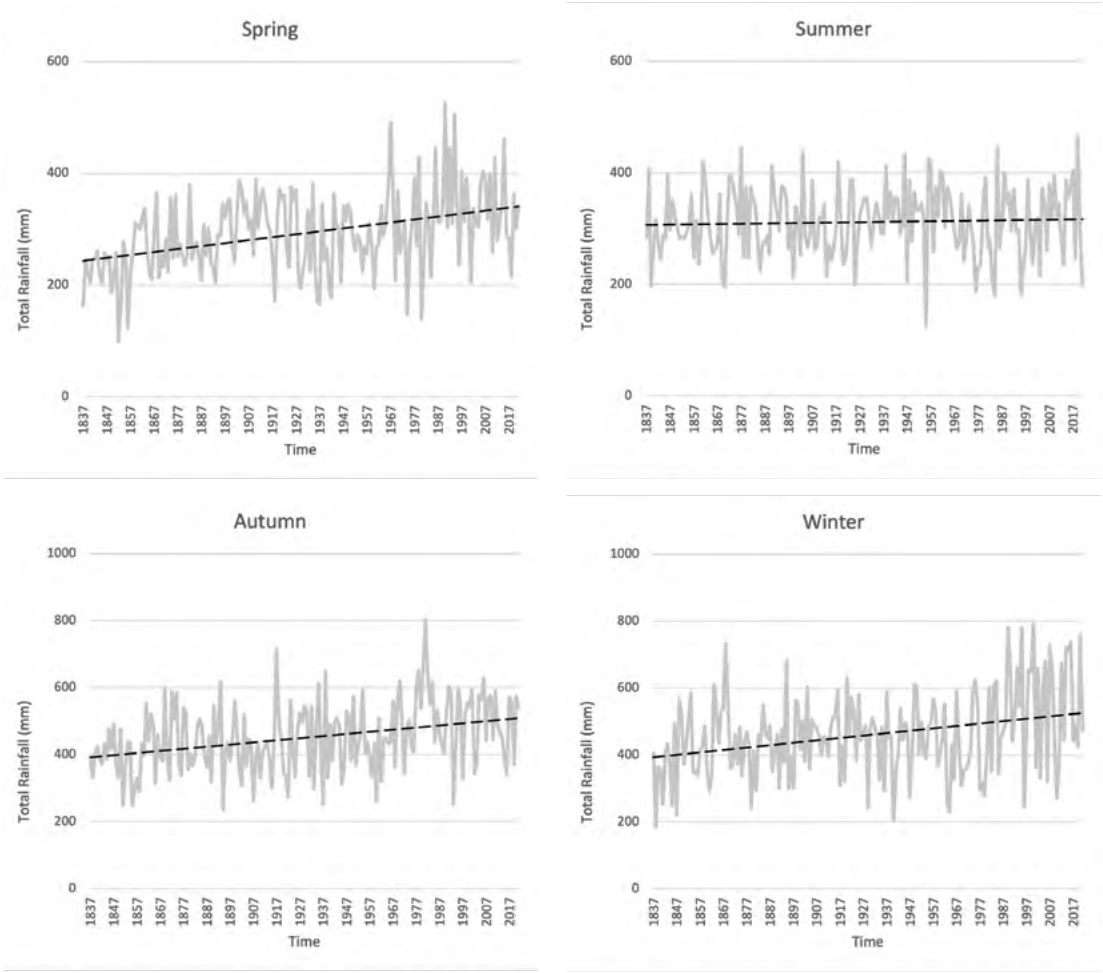


Figure 4.7. Annual-average sea-surface temperature[7] near St Kilda from 1870-2022 reveals a warming trend (black dashed), with 60-80 year fluctuations associated with the Atlantic Multidecadal Oscillation[8] (grey).

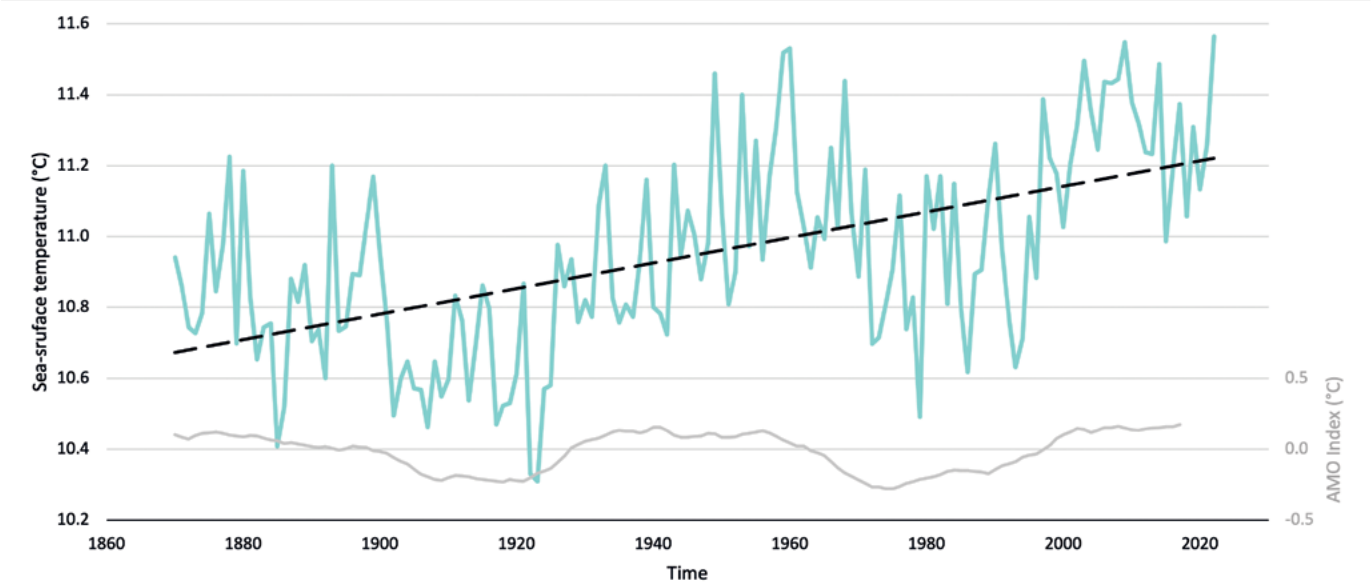


Figure 4.8. Recent variation in the Atlantic Meridional Overturning Circulation (AMOC) from model output (Copernicus Marine Service Information[9]) and observations (RAPID[10]).

AMOC transport (around 1998, 2009 and 2022) may be associated with strong variations in the El Niño-Southern Oscillation in the Pacific basin.

Data collected by International Council for the Exploration of the Sea[12] from 1975-2011 indicate the waters around St Kilda initially experienced an increase in temperature and salinity (1975-2011), followed by a decrease from 2011-2021 (Figure 4.9). This is likely related to a change in the flow of the eastern North Atlantic Current system, which transports warm, saline, subtropical waters northward, with greater input from of the Iceland-Scotland Overflow that brings cool, fresh, subpolar waters into the region. These patterns are consistent with variations in the AMO Index (Figure 4.7).

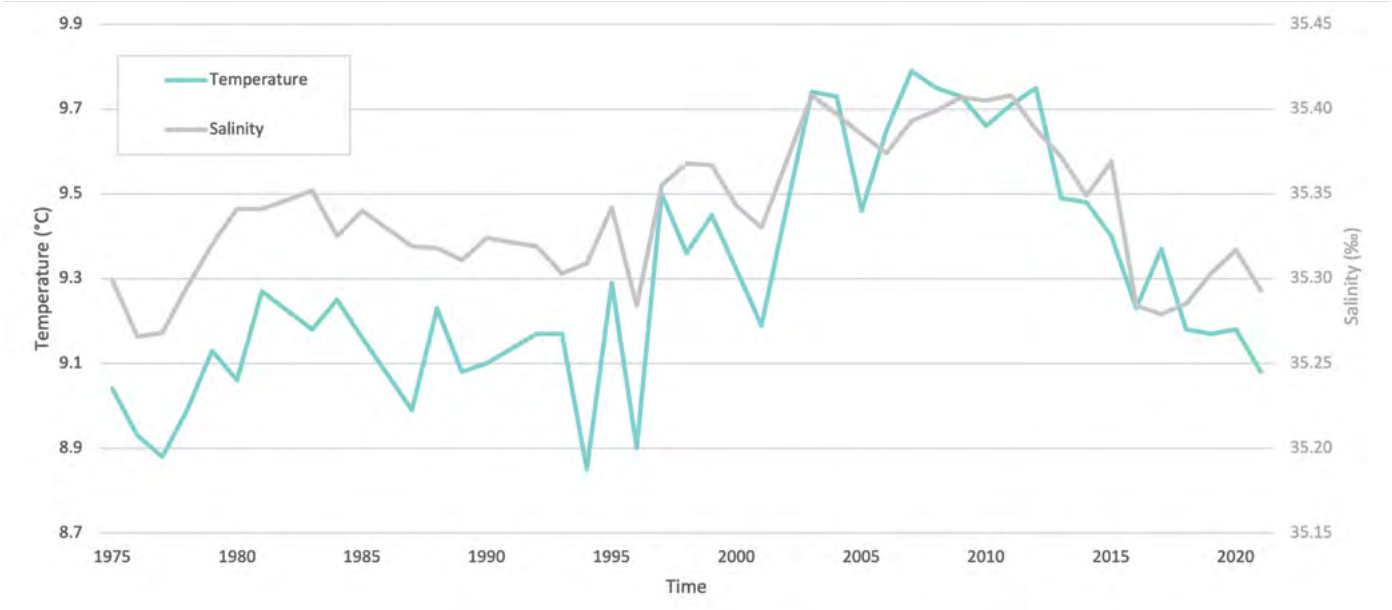
4.3 Anticipated climate change

Rapid climate change is occurring with global temperatures already having increased by more than 1.2°C. This is principally due to the release of CO_2 and other greenhouse gases (GHGs) since the mid-1800s.

Globally, the 10 warmest years on record have all occurred within the most recent decade. Scotland's climate has already begun to change, with all of the warmest years on record having occurred since 1997[13].

The UK Climate Projections 2018 (UKCP18) project provides information on changes in 21st century climate for the UK. However, as the archipelago of St Kilda is not included within these Met Office climate projections, the information presented here is for Scotland as a whole. UKCP18 uses multiple Representative Concentration Pathways (RCP) based on different emission scenarios[14]. RCP 2.6 is a low-emissions pathway in which GHG emissions are strongly reduced, while RCP 4.5 represents a medium-emissions pathway in which emissions are stabilised. RCP 8.5 is a high-emissions scenario in which emissions continue to grow that is the most likely among these scenarios to occur based on current global targets and the likelihood of meeting them. These radiative forcing scenarios are complemented by global socioeconomic characterisations to describe Shared Socioeconomic

Figure 4.9. Depth-averaged temperature and salinity data of the upper water column (30-800 m) collected along the 340 km Extended Ellett Line between the Scottish continental shelf break and Rockall for 1975-2021[12].



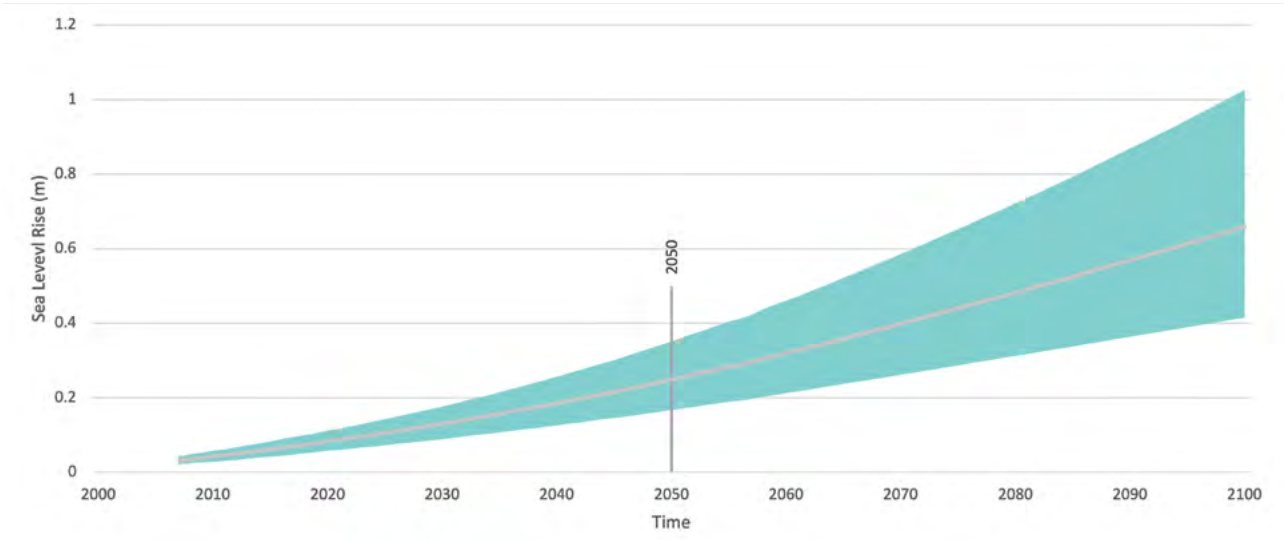
Pathways (SSP), used in the latest IPCC reporting[15] and whose nomenclature incorporates the RCP numerical values (e.g., SSP5-8.5 involves fossil-fueled development aligned with high emissions, while SSP2-4.5 represents a medium-emissions future in which social, economic, and technological development follows historical trends).

Climate change projections for Scotland indicate a continuation of the trends observed over recent decades. This means that, on average, annual temperature is projected to become warmer, moreso in summer than in winter. By 2070 under the high-emissions scenario (RCP 8.5), warming is predicted to be in the range 1.3-5.1°C in summer and 0.6-3.8°C in winter[14]. Precipitation varies on seasonal and regional scales and will continue to do in the future. However, this variability will become more marked and there will be a change in the seasonality of extremes, such as the intensity of heavy summer rainfall events. Winters are projected to become wetter, both in total amount of rainfall and the number of wet days, with the intensity of rainfall on wet days also expected to increase. While expected to affect all of Scotland, the increase is expected to be larger in western Scotland than in the east[14].

Sea level and the risk of coastal flooding is expected to increase across the UK over the next century and beyond, under all Met Office marine projections[16]. While St Kilda is not covered by the marine projections, its nearest landmass South Uist provides a suitable proxy. Based on the Met Office high-emissions scenario (RCP 8.5), South Uist is estimated to experience a mean sea level rise between 17-35 cm in 2050 (Figure 4.10). This, coupled with increased ocean warming and sea-surface temperature, will drive more intense storms and greater rates of inundation in coastal and low-lying regions[17].

Having warmed by approximately 0.5°C in the past 150 years, St Kilda's marine environment is projected to experience further ocean warming of around 1°C by 2050 and as much as 3°C by the end of century (SSP5-8.5; Figure 4.11). The observed weakening of broad-scale Atlantic Ocean northward flow (AMOC)

Figure 4.10. Projected sea level rise at South Uist from Met Office UKCP18 marine projections based on the RCP 8.5 scenario (2007-2100).[7]



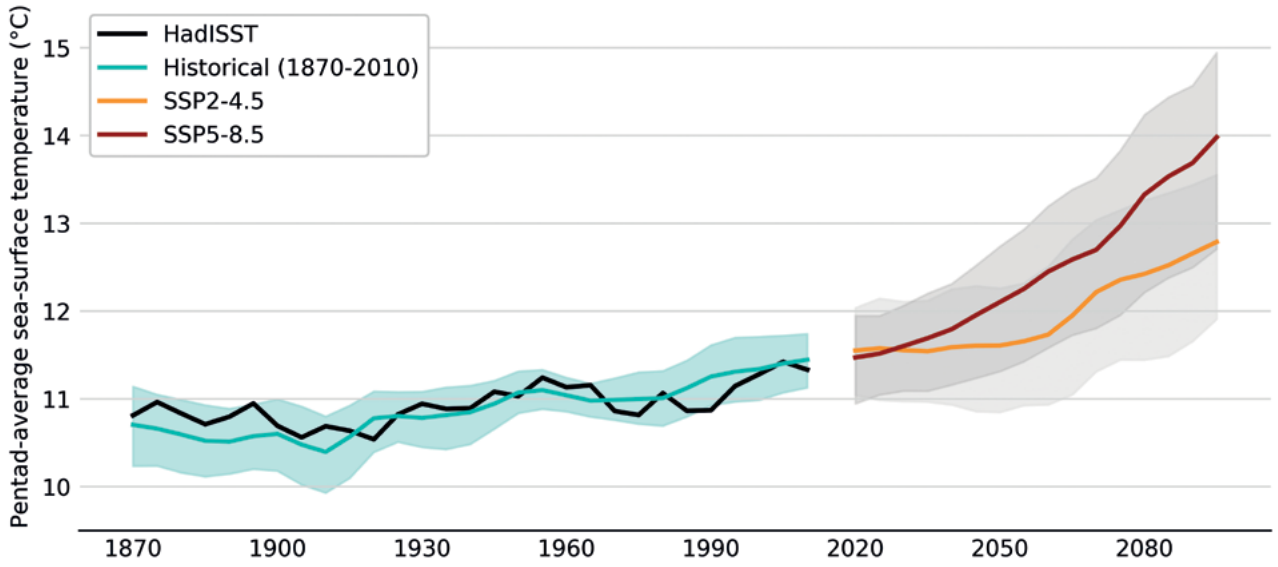
is also considered likely to continue[11]; there is also the potential for a mid-century collapse of the AMOC[18], which could have dramatic consequences for St Kilda.

The impacts of climate change on St Kilda will be felt in a variety of ways, including on the islands, their heritage and on the cultural resources. The climatic factors will be compounded by interactions with other stressors such as expanding tourism, infrastructure development and management practices. These impacts are expected to include:

+ More extreme seasonality where the combination of changes in temperature, precipitation, wind and relative humidity will likely put pressure on the historic environment by affecting the preservation of buildings, buried archaeology and pathways across the islands. Impacts on wildlife may include: increased sheep mortality (particularly during spring-time lambing); and reduced feeding (and potential starvation) of seabirds.
+ Potential changes in wind pattern and/or direction, though projections are unclear. If occurring, they will have a potentially major influence on the built environment, surface erosion and storm damage.
+ Sea level rise has already been documented and is expected to further increase, driving storm surges and coastal flooding. In turn this will contribute to changes in marine habitats, increasing exposure of the islands and exacerbating coastal erosion.
+ Changing currents and sea temperatures may affect the marine ecosystem with follow-on effects on food availability for nesting seabird colonies. Any breakdown of ocean circulation would likely have substantial consequences on the marine environment.

It is also recognised that these climate-related factors may also affect operational management impacting on the deployment of staff, researchers and contractors, delivery of essential supplies and on visitor numbers, an important source of revenue.

Figure 4.11. Five-year (pentad) averages of historical and projected temperature of the ocean surface near St Kilda. Historical values are from the HadISST dataset and complemented by hindcasts from CMIP6 models, from which projected temperatures were extracted for the SSP2-4.5 (RCP 4.5) and SSP5-8.5 (RCP 8.5) scenarios.



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2 Sunadal Data Solutions www.sunadal.co.uk
3 Met Office UK climate averages https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gf4wr9twt
4 NOAA Blended Sea Winds https://www.ncei.noaa.gov/products/blended-sea-winds
5 NOAA Coral Reef Watch *CoralTemp* product suite https://coralreefwatch.noaa.gov/
6 Met Office UK and regional past climate series https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-and-regional-series
7 Hadley Centre Sea Ice and Sea Surface Temperature data set (HadISST) https://www.metoffice.gov.uk/hadobs/hadisst/
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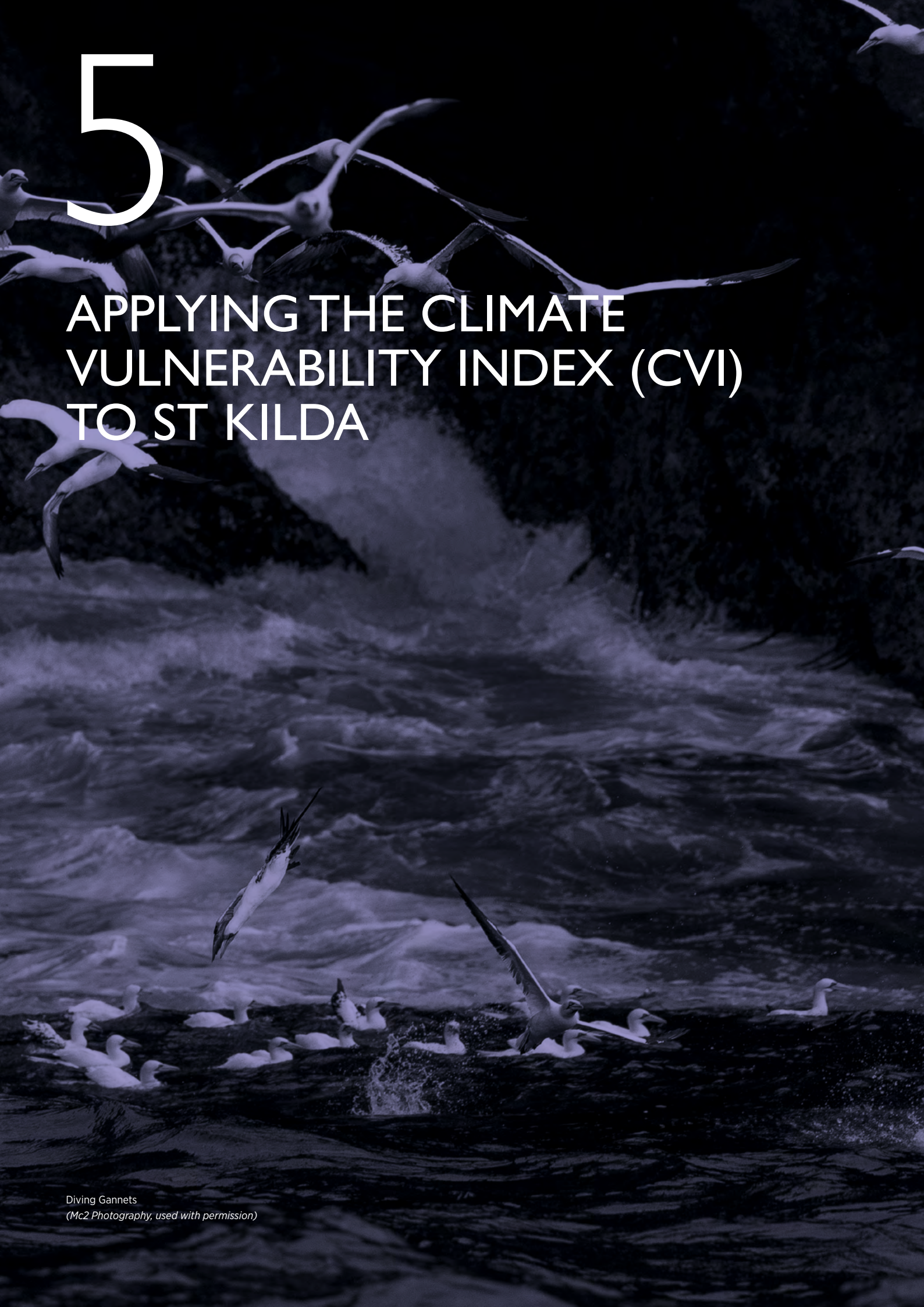
18 Ditlevsen P, Ditlevsen S (2023) Warning of a forthcoming collapse of the Atlantic meridional overturning circulation. *Nature Communications* 14:4254. doi: https://doi.org/10.1038/s41467-023-39810-w

5

APPLYING THE CLIMATE VULNERABILITY INDEX (CVI) TO ST KILDA



Diving Gannets
(Mc2 Photography, used with permission)

5.1 Background

The Climate Vulnerability Index (CVI) is a systematic and rapid tool developed to assess the vulnerability to climate change of all types of WH properties (natural, cultural and mixed), considering the Outstanding Universal Value (OUV) and the associated community (local, national and international). The CVI framework builds upon the vulnerability framework approach described in the 4th Assessment Report of the Intergovernmental Panel on Climate Change[1].

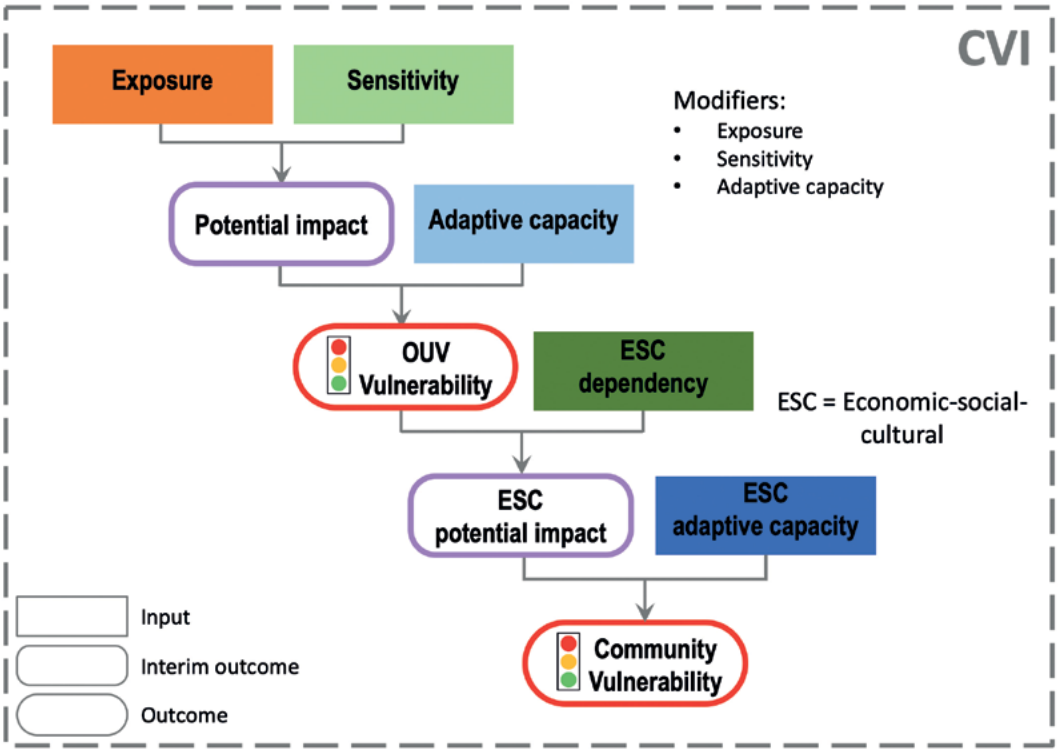
The first phase of the CVI process (assessing the OUV Vulnerability) is determined by assessing the exposure, sensitivity and adaptive capacity (Figure 5.1) with respect to the three chosen key climate stressors. The OUV Vulnerability then becomes the exposure term to assess the vulnerability of the community associated with the property (the second phase), combining with assessments of economic-social-cultural dependency (sensitivity) and adaptive capacity. A customised spreadsheet-based worksheet is used to determine outcomes based on user inputs. A more detailed outline of the CVI methodology is provided by Day et al.[2]

The foundation for the CVI process is the Statement of OUV for a property (Appendix 1), from which key WH values are summarised (Table 2.1). The key climate stressors most likely to impact the key values (and attributes) are identified for a defined and agreed time scale (e.g., by 2050) from a list of possible stressors (Table 5.1). With this foundation established, the CVI process is initiated.

At the time of this report, applications of the CVI had occurred in natural WH properties in Australia, Germany/Netherlands/Denmark, Finland/Sweden, and Seychelles, and in multiple diverse cultural WH properties in Scotland and Africa (see CVI website*).

* https://cvi-heritage.org/resources

Figure 5.1 The CVI framework used to undertake rapid assessment of climate change vulnerability of World Heritage properties and the associated community



5.2 The CVI process for St Kilda

Prior to application of the CVI framework in St Kilda, various preparatory steps were undertaken:

1. The Statement of OUV for St Kilda was analysed and distilled into key values and their accompanying attributes (see Table 2.1);
2. Background information was prepared outlining key aspects of climate change;
3. A list of other Significant Property Values (SPVs) was compiled (see Appendix 3); and
4. An overview of information related to economic, social and cultural connections was compiled.

The CVI application for St Kilda was undertaken during a hybrid CVI workshop conducted at the Cnoc Soilleir Centre on South Uist in September 2022.

The participants joined the workshop in-person or online from locations across Scotland. The workshop assessed the OUV Vulnerability and Community Vulnerability, with information presented and discussed and assessments undertaken in a combination of plenary and breakout sessions. Four breakout groups were defined (in-person and online) and all assessed outputs from the groups were reported back to subsequent plenary sessions for synthesis. Outcomes for each component were recorded in a customised spreadsheet to determine final results.

5.3 Key climatic stressors

A list of 15 climate stressors typically considered in the CVI process was provided to participants at the workshop (Table 5.1). Participants analysed those likely to have the most impact on each of the key values of OUV (Table 2.1). The workshop selected the time scale to consider impacts as ca. 2050 and considered future effects under a high-emissions climate scenario (RCP8.5, SSP5-8.5) – decisions consistent with CVI applications previously undertaken in other Scottish WH properties[3,4,5]. The climate stressors appearing in the top three for each value (including equal-third) were used to rank the stressors (Table 5.1; Figure 5.2). While the climate stressor Intense Precipitation Events was ranked in the overall top-three, participants determined that these effects could be effectively represented within the consideration of Storm Intensity & Frequency. Furthermore, this would allow the inclusion of Changing currents in the subsequent assessment given the likely significance of that stressor for the marine environment. As a result, the workshop participants determined the three key climate stressors to consider in the CVI analysis as:

- Temperature Trend (air and/or water) – TT;
- Storm Intensity & Frequency – SIF; and
- Changing Currents – CC.

Notably, the impacts resulting from these three key climate stressors have the potential to unveil at different timepoints. While effects of all three may be apparent to some degree, changes in temperature and storms (and the associated impacts) are already occurring. In contrast, the greatest effects from changes to currents may not occur until later this century.

5.4 OUV Vulnerability

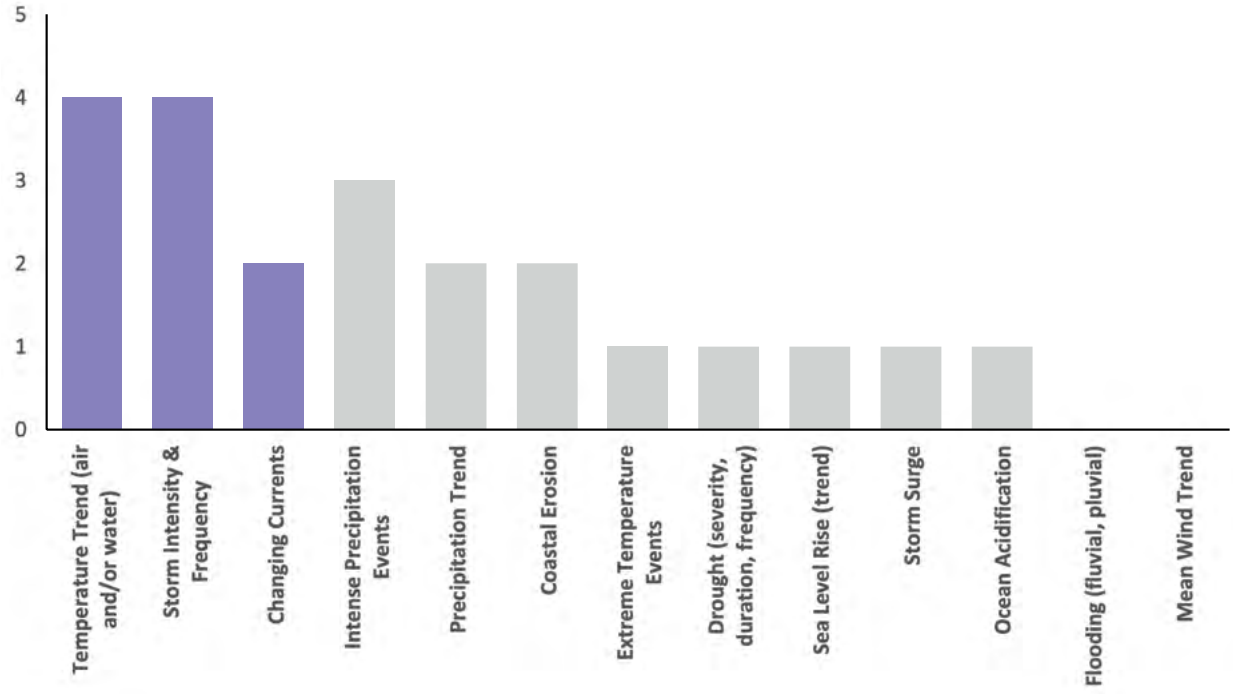
Assessments of **exposure** and **sensitivity** of the OUV system to each of the identified three key climate stressors were undertaken using a five-point categorical scale, adapted from categories used by IPCC and IUCN analyses (see [2] for details). Modifiers were applied to the initial assessments to include effects of temporal scale and trend (for exposure), and spatial scale and compounding factors (for sensitivity).

Results from exposure and sensitivity assessments undertaken in breakout groups were synthesised in plenary. Exposure to Temperature Trend was assessed to be **Very likely** (>90%, highest category). The initial assessment of exposure to Storm Intensity & Frequency was determined to be **Likely** (67-90%, second highest category), while for Changing Currents was at the transition point between the **Likely** and **Very likely** categories. The inclusion of modifiers incremented the exposure for the latter two stressors to **Very likely**

Table 5.1 Climate stressors identified as likely to have the greatest impact for each of five key values of OUV (the sixth key value was not assessed, see text). Marked cells indicate that the climate stressor was in the top three responses (including equal-third) for each key value. Stressor impacts were assessed for ca. 2050 and a high-emissions climate scenario.

Key values of OUV	Temperature Trend (air and/or water)	Extreme Temperature Events	Precipitation Trend	Intense Precipitation Events	Flooding (fluvial, pluvial)	Drought (severity, duration, frequency)	Mean Wind Trend	Storm Intensity & Frequency	Sea/Lake Ice Change	Snow Cover Change	Sea Level Rise (trend)	Coastal Flood	Storm Surge	Coastal Erosion	Changing Currents	Ocean Acidification
	Climate stressors															
Scenery and landscape	X	X	X	X		X		X			X		X	X		
Seabirds	X			X				X							X	
Genetic interest and biodiversity	X		X					X								
Marine environment	X														X	X
Relict cultural landscape				X				X						X		
Conservation and management																
Total	4	1	2	3	0	1	0	4	0	0	1	0	1	2	2	1

Figure 5.2 Histogram of the number of key values of OUV for St Kilda for which each of 15 climate stressors were among the top three likely to cause impacts (ca. 2050, high-emissions scenario).



(and maintained this for Temperature Trend; Table 5.2). Participants noted changes to currents are already apparent but also that knowledge and confidence in future projections of this stressor were uncertain.

Sensitivity of OUV to Temperature Trend and Storm Intensity & Frequency was determined as **High** (second highest category), indicating potential for loss or alteration of many key WH values, and remained at this level after including modifiers. Whilst the sensitivity to Changing Currents was initially **High**, inclusion of the modifiers raised this to the transition point between **High** and **Very high**, where the latter indicates major loss or alteration of the majority of key WH values. Participants noted the vast marine domain of the property, particularly noting sensitivity to changes in temperature and currents. These were linked to compounding factors within the marine environment (such as the replacement and invasive species, and downstream effects on seabird food sources), while an increase in tourism (from currently low levels) could exacerbate storm-related climate impacts (i.e., damage from footfall, biosecurity factors). Participants noted that seabirds may be affected by a variety of compounding factors – avian disease, disturbance from increased tourism, food availability and winter survival. The **potential impact**, derived from exposure and sensitivity, was determined as **Extreme** (highest on a four-point scale, low to extreme) for each of the three climate stressors (Table 5.2).

The **adaptive capacity** of a system to respond to stress can reduce the potential impacts. Adaptive capacity of the OUV system was assessed for each key climate

Table 5.2 Rapid assessment of OUV Vulnerability to identified three key climate stressors. Assessed values of exposure, sensitivity and adaptive capacity contribute to derived outcomes for potential impact and OUV Vulnerability. Colours correspond with elements of the CVI framework (Figure 5.1).

Key Climate Stressors:	Temperature Trend (air and/or water)	Storm Intensity & Frequency	Changing Currents
Exposure	Very likely	Likely	Likely/Very likely
Temporal scale	On-going	Frequent	Frequent
Trend	Moderate/rapid increase	Moderate increase	Slow increase
Exposure	**Very likely** ○○○○●	**Very likely** ○○○○●	**Very likely** ○○○○●
Sensitivity	High	High	High
Spatial scale	Widespread	Localised	Widespread
Compounding factors	Moderate probability	Low/mod. probability	Moderate probability
Sensitivity	**High** ○○○●○	**High** ○○○●○	**High/Very high** ○○○◑◐
Potential impact	**Extreme** ○○○●	**Extreme** ○○○●	**Extreme** ○○○●
Local management response	Low/Moderate	Moderate	Moderate
Scientific/technical support	Moderate	Moderate	Moderate
Effectiveness	Low/Moderate	Moderate	Very low
Adaptive capacity	**Moderate** ○○●○	**Moderate** ○○●○	**Low** ○●○○
OUV Vulnerability	**Moderate** ○●○	**Moderate** ○●○	**High** ○○●
Combined OUV Vulnerability	**Moderate** ○●○		

stressor by considering the levels of local management response and scientific/ technical support (four-point scale), as well as the effectiveness of these to address impacts from each stressor (four-point scale).

In breakout groups, workshop participants brainstormed adaptation strategies (Table 5.3). The strategies were then prioritised in plenary as high (for existing strategies that could be expanded upon or those under consideration), potential (for those feasible but not yet in consideration) and low (not currently feasible). Participants commented that several of the strategies in the high category are large in scale (including beyond St Kilda) and therefore require substantial financial resourcing, which may need to come at a national (rather than localised) level (e.g., for seabirds). Scale was also relevant to comments that strategic actions on land (e.g., conservation of small structures) may be easier than at-sea (involving seabird colonies and ocean environments), which also noted that most of property area is marine. Many strategies involve expanded monitoring, which is an important step to identify appropriate actions; however, monitoring alone would not provide effective response to reducing threats (and those responses may be more difficult and require more resourcing). Finally, participants noted that while techniques for several identified actions are known, they would require considerable numbers of specialists (which would require commensurate resourcing).

The assessments of adaptive capacity were focused on the subset adaptation strategies within the High category marked in bold (Table 5.3). The adaptive capacity was determined to be **Moderate** (second highest on a four-point scale, very low to high) with respect to Temperature Trend and Storm Intensity & Frequency; and **Low** (second lowest) for Changing Currents. It is of note that these outcomes are more optimistic than the low potential to mitigate threats of climate change conveyed in the most-recent IUCN Outlook report[6].

Combining the determined Potential impact with the assessed Adaptive capacity for each climate stressor revealed the OUV Vulnerability (three-point scale, low to high) as **Moderate** with respect to Temperature Trend and Storm Intensity & Frequency; and **High** for Changing Currents. As a result, the combined **OUV Vulnerability** for St Kilda was determined as **Moderate** (Table 5.2).

5.5 Community Vulnerability

The assessment of Community Vulnerability considers the economic, social, and cultural (ESC) aspects of the community associated with the property using two metrics.

+ **Dependency** reflects the extent to which the loss of WH values will affect ESC indicators in the future. These effects can be positive or negative. Separate assessments for economic, social and cultural dependency are combined to give an overall ESC dependency.
+ **Adaptive capacity** reflects the current level of capacity within each component to adapt in the face of loss of WH values due to key climate stressors, and only has a positive directionality. As for dependency, separate assessments for economic, social and cultural adaptive capacity are combined to give an overall ESC adaptive capacity.

Assessments were undertaken in small breakout groups, which again resulted in a spectrum of responses for each that was resolved in plenary.

A specific scenario was provided to participants to guide assessment of likely climate change impacts on the economic, social and cultural aspects. The selected scenario elements, based on climate projections for ca. 2050 (Section 4), were:

i Temperature Trend: an increase by 1.5°C in air temperature and 1.0°C in water temperature above the 1981-2000 baseline;

Table 5.3 Strategies for adaptive capacity brainstormed during the workshop, prioritised by feasibility or likelihood for implementation, noting the relevant key climate stressors (TT: Temperature Trend (air and/or water); SIF: Storm Intensity & Frequency; CC: Changing Currents) and key values (numbered in Table 2.1) for each.

Feasibility/ likelihood	Adaptation strategy	Key climate stressors			Relevant key value/s					
		TT	SIF	CC	1	2	3	4	5	6
High	**Expand research into seabird foraging patterns & winter migration**	X	X	X		■		■		
	Expand Active Conservation Programme (e.g., cleitean) & expand surveying of cultural landscape	X	X						■	
	Expand survey of marine areas	X		X				■		
	Expand biosecurity plan, awareness raising	X	X			■	■			
	Upgrade natural/built coastal defences (incl. possibly remove gabions)		X						■	
	Watercourse mgmt.		X						■	
	Improve drainage & gutters		X		■				■	
Potential	Volunteer engagement									
	Better boat landing facilities (access)		X		■	■		■	■	■
	Expand visitor monitoring	X	X						■	
	Remove nearby pressures (fishing, naval activity, renewables)	X	X	X	■	■	■	■	■	■
	Install damp-proof courses		X						■	
	Soay sheep management, incl. grazing exclosures to assess impact of sheep	X	X		■		■		■	
	Marine nutrient enrichment			X				■		
Low	Move the feather store		X						■	
	Supplementary feeding for seabirds	X	X	X		■				
	Supplementary feeding for wrens & mice	X	X				■			
	Mitigate military activity impacts on cetaceans	X		X				■		
	Culling soay sheep	X	X		■		■		■	
	Limit visitation	X	X						■	
	Vaccinate commercial poultry	X	X	X		■				

ii Storm Intensity & Frequency: increased frequency and intensity of heavy (torrential) rainfall events with an undetermined change in wind speeds/ gusts; and
iii Changing Currents: weakening of the Atlantic Meridional Overturning Circulation, which was reduced by 15% in recent times and is anticipated to reduce a further 15% by 2050.

The economic component considers the economic effects on economic activities/business types that are directly associated with the WH property. In preparation for the workshop, the Steering Committee developed a list of eight such activities:

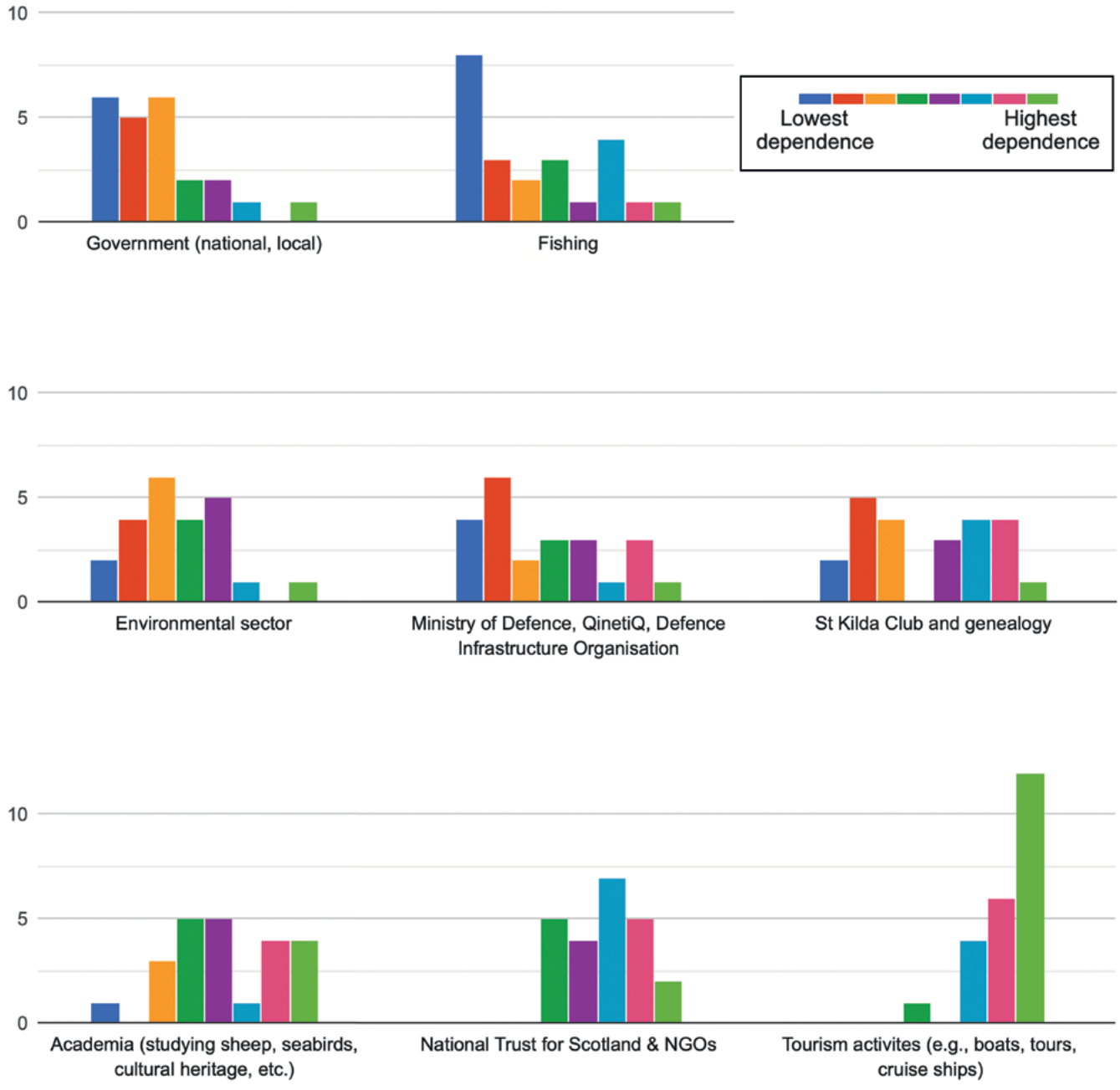
+ Tourism activities (e.g., boats, tours, cruise ships)
+ National Trust for Scotland & NGOs
+ Academia (studying sheep, seabirds, cultural heritage, etc.)
+ Fishing
+ Government (national, local)
+ Environmental sector
+ Ministry of Defence, QinetiQ, Defence Infrastructure Organisation
+ St Kilda Club and genealogy

Participant responses to an online poll, conducted at the end of the first workshop day, ranked these business types by their dependence upon the WH values. This analysis revealed Tourism; activities undertaken by the National Trust for Scotland (the responsible management agency) and non-governmental organisations (NGOs); and Academia as the most dependent on the values, whilst Government activities and Fishing were the least dependent (Figure 5.3).

Assessments of economic dependency and adaptive capacity were undertaken by each breakout group, drawing upon the baseline information on economic valuation that had been presented to the workshop. Economic dependency was assessed for each business type on an eight-point scale ranging from high-positive down to minimal-positive, then minimal-negative down to high-negative; adaptive capacity was assessed only with a positive directionality with the four-point scale from high down to minimal. Participant rankings of relative dependency (Figure 5.3) were considered for the final assessment (in plenary). Six of the eight business types were assessed as likely to experience a negative economic effect, the exceptions being the environmental and defence sectors. Overall, the economic dependency term was assessed as **Minimal-negative** (i.e., a negative impact at a minimal level). The adaptive capacity was assessed as either Moderate or High for each business type, leading to an overall assessment of economic adaptive capacity of **High** (Table 5.4).

Intangible effects (e.g., social cohesion, aesthetics) were considered within the social and cultural components. An important distinction between these components is that social connections require a physical interaction with the property (i.e., a visit), whereas cultural connections can exist without a physical interaction. For each component, three groupings of people were considered to assess dependency and adaptive capacity: local, domestic, and international. For the assessment, given the remote and unpopulated nature of St Kilda, workshop participants determined that locals would be defined to include residents of the Western Isles, while the definition of the domestic grouping was determined as people residing within the United Kingdom (rather than Scotland or the British Isles).

Figure 5.3 Participant rankings of eight business types by their dependence upon the St Kilda key values.



Social indicators used to inform the assessments can be considered within four categories: Human capital; Social capital; Natural capital; and Built capital (after [7]). After some discussion, workshop participants determined that social connections would be considered equitably across all three people groupings. The assessments also revealed that locals would likely be socially impacted to a higher degree than the other two groupings but also had a higher capacity to adapt. Overall, social dependency was assessed as **Moderate-negative**, whilst the existing capacity to adapt to future changes was **Moderate** (Table 5.4).

Cultural indicators were also considered within four categories pertaining to: Self; People; Environment; and Pleasure (after [8]). Cultural connections were also assessed equitably across the three groupings. While cultural connections can exist irrespective of location, participants indicated cultural impacts for locals would be higher than those in the other people groupings but that, as for social connections, locals would better adapt. Cultural dependency was assessed as **Low-negative**, whilst the adaptive capacity was **Moderate** (Table 5.4).

Combining the three components, the overall ESC dependency was determined as **Low-negative**, which, combined with the OUV Vulnerability (as the exposure term), resulted in the ESC potential impact being assessed as **Low** (three-point scale, low to high; Table 5.4). The combined ESC adaptive capacity was assessed as **Moderate** (three-point scale, low to high). These outcomes determined the **Community Vulnerability** as **Low** (three-point scale, low to high; Table 5.4).

Table 5.4 Rapid assessment of Community Vulnerability to identified three key climate stressors. Assessed values of economic, social and cultural (ESC) dependency (sensitivity, ranging from negative to positive) and adaptive capacity contribute to derived outcomes for ESC potential impact and Community Vulnerability.

Economic	*Minimal-negative*
Social	*Moderate-negative*
Cultural	*Low-negative*
ESC dependency	**[-] ○ ○ ● ○ Low-negative ○ ○ ○ ○ [+]**
ESC potential impact	**Low ● ○ ○**
Economic	*High*
Social	*Moderate*
Cultural	*Moderate*
ESC adaptive capacity	**Moderate ○ ● ○**
Community Vulnerability	**Low ● ○ ○**

5.6 Public event

The workshop culminated with a public event to present information about World Heritage (globally and in Scotland); St Kilda and its management; and the outcomes of the CVI process. This fostered substantial discussion amongst those present (approximately 25 people; Figure 5.4) regarding vulnerability to climate change of both the WH property and the community. Notably, these discussions confirmed many of the perspectives shared within the breakout and plenary sessions of the workshop.

5.7 Summary

Temperature Trend (air and/or water), Storm Intensity & Frequency and Changing Currents were identified as the three climate stressors likely to most impact the WH values of St Kilda. Potential impact from each of these key stressors was scored in the **Extreme** category, with adaptive capacity to mitigate impacts from each being assessed as **Low** (for currents) or **Moderate** (for the other two stressors). As a result, the **OUV Vulnerability** was determined to be in the middle category (**Moderate**). Impacts from the key climate stressors were judged as likely to lead to a **Negative** future impact at a **Low** level on the economic, social and cultural aspects of the wider community associated with St Kilda. As the adaptive capacity of the community to the climate stressors was determined to be at a **Moderate** level, the overall **Community Vulnerability** was assessed to be **Low** (in the lowest category). The workshop results indicate the changes that might be expected over the next 30 years (ca. 2050 scenario) are anticipated to have significant effects on the values that comprise the OUV of the property.

Figure 5.4 The public meeting at Cnoc Soilleir on 15th September 2022. *(Jon Day)*

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6

NEXT STEPS

Soay sheep are descended from those found in the St Kilda archipelago and are one of the most primitive forms of domestic sheep in the world *(Mc2 Photography, used with permission)*

6.1 Recommendations for St Kilda in a changing climate

Climate projections for St Kilda to 2050 indicate that rising temperatures and increasing storm intensity and frequency are very likely to occur. These are predicted to cause impacts upon both the natural and cultural heritage of the islands. For example, storm events may increase the rate and extent of coastal erosion, putting archaeological deposits and some structures at a heightened risk of damage and potential loss[1]. As indicated in Table 5.3, the CVI workshop recommendations included expanding the active conservation programmes (for cleitean and other heritage structures), management of water courses, upgrading the natural/man-made coastal defences, and improving drainage and gutters.

In the marine environment, sea-surface temperature around the archipelago is predicted to increase and ocean currents around St Kilda are predicted to change. These changes are expected to have an impact not only on marine species but also on the colonies of seabirds breeding in the archipelago[1]. Table 5.3 shows the workshop recommendation to expand research into seabird foraging patterns, as well as expanding surveys to better understand the surrounding marine ecosystem that is integral to the sustainability of the area.

Climate change may also affect operational management and visitor use. Travel to and from St Kilda may be adversely affected by increasing storm intensity and frequency, which will have an impact on the deployment of staff, researchers and contractors; it may also impact essential deliveries of food, materials and equipment, and visitor numbers[1]. Periods of drought may necessitate the importing of water or restrictions on the number of people living on the island.

While the impacts on the built heritage are predicted to be manageable, there may be unknown synergistic impacts that could affect this heritage, especially its more vulnerable aspects. Heritage impact assessments should therefore be undertaken for all adaptation strategies being considered to avoid unintended consequences. The identified key values (and other SPVs; Appendix 3) should be included to ensure such impact assessments are comprehensive. A precautionary approach must be the rule and new activities on the islands should not be implemented before sufficient knowledge of the potential impact is understood.

The results from the CVI workshop are important for adaptive management, especially as climate change is recognised (along with invasive non-native species) as one of the two biggest threats to St Kilda. An objective in the current Management Plan (2022-2032)[2] states, "Develop and implement objectives for climate change adaptation and mitigation, based on the outcomes of a Climate Vulnerability Index assessment (CVI)".

In addition to the recommended adaptive strategies in Table 5.3, the CVI workshop also proposed the following for further investigation:

Research gaps

- Research efforts to better predict and understand changes in the marine ecosystem and how St Kilda might be affected (e.g., seabirds, seals)
- Knowledge and understanding of changing currents and their impacts
- Minimal data on benthic habitats (which exhibit no evidence of current decline)
- Plankton research into productivity and trophic interactions, including use of satellite-derived ocean productivity metrics
- Impact of sea level rise on bird species that nest on lower cliffs
- Environmental monitoring, especially in the marine environment (e.g., potentially a food shortage for the seabirds?)
- Risk of avian flu for seabirds
- Level of stability of the sea cliffs and impacts of increased storminess and temperature change, which can further impact marine life and seabirds
- Assessing the potential impacts of climate change upon St Kilda's endemic species (e.g., St Kilda wren, noting the unknown historical trend, Table 2.1; St Kilda field mouse).
- Research into potential genetic divergence of other flora and fauna (e.g., dandelions)
- Investigate small-scale variations in weather

conditions (micro-climate), such as using weather monitoring systems in select locations together with collars on some sheep to look at interstitial locations and their reaction to weather events
+ Monitoring of social and cultural views and connections (including the cultural affinity to St Kilda of people in the Western Isles)
+ Monitoring the reasons for and impacts of tourism (e.g., cruise ships; footfall impacts in popular locations, including comparison with 2020 absence of visitors; use of fixed-point photo monitoring) and potential for climate-related responses (e.g., visitor fees; climate offsets)
+ Impact of climate stressors (especially increased storminess) on businesses, such as boat operators, the National Trust for Scotland and defence contractors

Policy and guidance gaps

+ The lack of a high-quality weather station on St Kilda (i.e., supported by the UK Met Office) limits the capability of climate analyses and may also contribute to the lack of location-specific climate projection information
+ Creel fishing catch is unclear – are there data beyond number of fishing days?
+ Linking analyses of seabird diet between St Kilda and the Western Isles
+ Develop specific research agenda for archaeology on St Kilda to benefit general understanding of human occupation of islands
+ Develop a searchable database for St Kilda's cultural heritage, links to climate change and strategic responses
+ Establish a research plan that addresses conservation goals and monitoring needs to support that, which includes consideration of the feasibility of activities
+ Need for a tourism strategy, which includes appropriate monitoring (e.g., post-tour assessment) and considers infrastructure needs, noting the increase in tourism across the Western Isles

Research priorities should be closely linked to the priority management needs. Conservation decisions that respond to the threats of climate change begin with understanding the key areas of climate vulnerability. The research opportunities identified through the CVI process are a starting point and will require appropriate resourcing, as will the management activities informed by research outcomes. Continuing to link research with management-relevant outcomes is essential.

6.2 Revisiting the CVI process for St Kilda

It is recommended that the CVI process is repeated on a periodic basis to systematically assess system changes on St Kilda as well as the effectiveness of management responses. Furthermore, new research and knowledge will aid workshop participants in their discussions. A CVI application should occur prior to any review of the Management Plan which is expected in approximately 6-8 years' time. Any review of the Plan must ensure that climate change mitigation and adaptation are addressed throughout the entire Plan rather than being a stand-alone objective.

Input for Periodic Reporting could involve one of the shorter delivery modes of the CVI (i.e., Snapshot or Consult[3]) rather than repeating the full Workshop mode, and with local facilitation. To ensure that trends and results are comparable, it is proposed that the next CVI workshop apply the same methodology, beginning with a systematic review of the 2022 workshop assumptions. One suggestion might be to consider whether the public event should be brought forward in the workshop schedule – involving the community earlier may enable more local perspectives and knowledge to be considered into the workshop or provide different perspectives on relevant issues.

6.3 Lessons for other UK World Heritage properties

There is an ongoing need for improved liaising between managers and experts/researchers (e.g., universities and research agencies) for more effective monitoring and research. This begins with identifying and prioritising the research activities needed (building upon Table 5.3 and Section 6.1). Effective and ongoing communication with researchers regarding a prioritised list of research activities is essential. Bringing researchers from different and relevant fields together with site managers and stakeholders at local, regional

and national levels can broaden perspectives; however, experience-based and local knowledge remains foundational for minimizing local impacts and adapting to climate change at the property level.

The CVI workshop for St Kilda provided an arena for learning and exchange of knowledge and experience for all participants. Workshop attendees were encouraged to take the learnings elsewhere and focus even further on climate change and the special challenges facing other heritage places, such as national parks and listed cultural landscapes.

6.4 Management implications – international, national and local

Climate change, as a threat to the OUV of St Kilda, is primarily due to practices happening outside the property and outside the direct control of the property managers. However, local actions can limit localised impacts and help build resilience to better cope with the changes inevitably expected to occur.

Through the CVI process, Scotland now has a basis for reporting to UNESCO on the status of climate vulnerability for four WH properties* (via Periodic Reporting). This will contribute to the mobilisation of global efforts on climate action and add to the role that WH properties can play in climate mitigation and adaptation efforts.

One potential suggestion is that WH properties would benefit from a thematic analysis, based on shared or similar values, that could inform a systematic monitoring programme. While the importance of the addressing specific needs for each property would remain, a thematically-based programme has the potential to inform other heritage places that share similar values and/or will be exposed to comparable climate stressors.

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* It is hoped that all Scottish WH properties will have completed a climate vulnerability assessment by 2025.

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St Kilda residents, ca. 1907
(NTS, Milne album)

Many people contributed to the success of the CVI workshop for St Kilda:

- The Steering Group:
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  - Rebecca Jones, Ewan Hyslop and Mairi Davies from Historic Environment Scotland
  - Susan Bain, Western Isles Property Manager / St Kilda World Heritage Coordinator, National Trust for Scotland
- Kirstie Wright prepared and presented the climate data analysis, despite having only started her role at HES a few weeks earlier
- Alistair Rennie and Hazel Blake presented on coastal change and hydrological mapping, respectively, for St Kilda
- Rebecca Rennell from UHI Outer Hebrides coordinated all the logistics at Cnoc Soilleir and chaired the public event
- The break-out group leaders: Susan Bain, Emily Gal, Kevin Grant, Alice Lyall, Rebecca Rennell and Lyn Wilson
- The note-takers, Mairi MacLean and Emily Gal, without whose detailed notes this report would have been incomplete
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- Laura Mackenzie from Historic Environment Scotland did all the administrative coordination for the workshop and was helped by Mike Elliot; Rory Cameron (also from HES) helped with bringing the report to publication
- All the participants listed in Appendix 5 gave their time and expertise to the workshop, which greatly benefited from the diverse range of perspectives and views about St Kilda
- Members of the community who attended the public event
- Jo MacDonald (Jo NicDhomhnaill) for translating the Executive Summary into Gaelic

For John Love and Alisdair Fleming, who both loved St Kilda and wanted future generations to enjoy the islands as much as they did.

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RSE The Royal Society of Edinburgh
KNOWLEDGE MADE USEFUL

APPENDICES

Intertidal zone at the base of a sea cliff
(Jon Day)

APPENDIX I

Statement of Outstanding Universal Value for the St Kilda World Heritage property
Adopted by UNESCO World Heritage Committee Thirty-seventh session, Phnom Penh, Cambodia, June 2013 http://whc.unesco.org/en/list/387

Brief Synthesis
The tiny archipelago of St Kilda, lying off the west coast of mainland Scotland, is breathtaking. Formed from the rim of an ancient volcano associated with the opening up of the North Atlantic some 65-52 million years ago, the intensely dramatic, jagged landscape of towering cliffs – some of the highest sea cliffs in Europe – and sea stacks present stark black precipitous faces plunging from steep grass-green slopes in excess of 375m. Scenically, every element appears vertical, except the smooth amphitheatre of Village Bay on Hirta with its relict historic landscape. Exposure to some of the greatest wave heights and strongest wind speeds in Europe plays a major role in shaping the coastal ecology.

With nearly one million seabirds present at the height of the breeding season, St Kilda supports the largest seabird colony in the north-east Atlantic, its size and diversity of global significance making it a seabird sanctuary without parallel in Europe. The very high bird densities that occur in this relatively small area, conditioned by the complex and different ecological niches existing in the site and the productivity of the surrounding sea, make St Kilda unique. Of particular significance are the populations of Northern Gannet, Atlantic Puffin and Northern Fulmar. The sight and sound of these myriad seabirds adds significantly to the scenic value and to the experience of the archipelago during the breeding season.

The islands' isolation has led to two outstanding examples of remote island ecological colonisation and subsequent genetic divergence in the two endemic sub-species, the St Kilda Wren and St Kilda Fieldmouse. The feral Soay sheep, so much a feature of the landscape, represent an ancient breed, descendants of the most primitive domestic sheep found in Europe. They provide a living testament to the longevity of human occupation of St Kilda and, in addition, are a potentially significant genetic resource.

The combination of oceanic influences (proximity of deep ocean currents along the continental slope, extreme exposure to waves and oceanic swell, high water clarity) and local geology around the archipelago has created a marine environment of unparalleled richness and colour. The seabed communities are outstanding in terms of biodiversity and composition, including 'northern' and 'southern' species at the extremes of their range. The plunging underwater rock faces are festooned with sea life – a kaleidoscope of colour and form kept in constant motion by the Atlantic swell, creating an underwater landscape of breathtaking beauty. The complex ecological dynamic in the marine environment is essential to maintenance of both the terrestrial and marine biodiversity.

Overlaying the spectacular natural landscape and giving scale to it all, is a rich cultural landscape that bears exceptional testimony to millennia of human occupation. Recent research indicates that the archipelago has been occupied on and off for over 4000 years. The landscape including houses, large enclosures and cleits – unique drystone storage structures found, in their hundreds, across the islands and stacks within the archipelago – culminates in the surviving remains of the nineteenth and twentieth century cultural landscape of Village Bay. The time depth, preservation and completeness of the physical remains, provides a tangible and powerful link to the islands' past history, its people and their way of life, a distinctive existence, shaped by the St Kildan's response to the peculiar physical and geographic setting of the islands.

The islands provide an exceptionally well preserved and documented example of how, even in the most extreme conditions of storm-swept isolated island living, people were able to live for thousands of years from exploiting natural resources and farming. They bear physical witness to a cultural tradition that has now disappeared, namely reliance on seabird products as the main source of livelihood and sustenance, alongside subsistence farming. These age-old traditions and land uses that have so shaped the landscape, have also unquestionably contributed to its aesthetic appeal.

St Kilda represents subsistence economies everywhere – living off the resources of land and sea and changing them over time, until external pressures led to decline, and, in 1930, to the abandonment of the islands. The poignancy of the archipelago's history, and the remarkable fossilised landscape, its outstanding and spectacular natural beauty and heritage, its isolation and remoteness, leave one in awe of nature and of the people that once lived in this spectacular and remarkable place.

Criterion (iii): St Kilda bears exceptional testimony to over two millennia of human occupation in extreme conditions.

Criterion (v): The cultural landscape of St Kilda is an outstanding example of land use resulting from a type of subsistence economy based on the products of birds, cultivating land and keeping sheep. The cultural landscape reflects age-old traditions and land uses, which have become vulnerable to change particularly after the departure of the islanders.

Criterion (vii): The scenery of the St Kilda archipelago is particularly superlative and has resulted from its volcanic origin followed by weathering and glaciation to produce a dramatic island landscape. The precipitous cliffs and sea stacks as well as its underwater scenery are concentrated in a compact group that is singularly unique.

Criterion (ix): St Kilda is unique in the very high bird densities that occur in a relatively small area, which is conditioned by the complex and different ecological niches existing in the site. There is also a complex ecological dynamic in the three marine zones present in the site that is essential to the maintenance of both marine and terrestrial biodiversity.

Criterion (x): St Kilda is one of the major sites in the North Atlantic and Europe for seabirds with over 1,000,000 birds using the island. It is particularly important for gannets, puffins and fulmars.

The maritime grassland turf and underwater habitats are also significant and an integral element of the total island setting. The feral Soay sheep are also an interesting rare breed of potential genetic resource significance.

Integrity

The islands encompass exemplary and well preserved remains of the distinctive way of life that persisted in this remote area, unaltered after the St Kildans abandoned the islands. They encompass the complete fossilised cultural landscape. The natural heritage of the archipelago is the result of natural processes coupled with its long history of human occupation and, more recently, external human influences. The marine environment is largely intact.

Ownership and stewardship of the archipelago by the National Trust for Scotland, the statutory designations in place, the archipelago's remote location, the difficulty of accessing it and human activities almost entirely centred upon Hirta, have significantly contributed to retaining the integrity of the archipelago's heritage.

However, both natural and cultural attributes are threatened to a degree by a range of remote and local environmental and anthropogenic factors such as climate change and unsustainable tourism. Climatic conditions and coastal erosion remain the main threat to the abandoned houses, cleits and other archaeological remains across the archipelago. Large-scale off-shore developments could pose a potential threat to the pristine setting of the islands. Accidental introduction of invasive species poses a significant threat to the natural heritage; and probably the most severe potential threat to the integrity of the marine environment comes from variations in the marine ecosystem, especially the plankton, caused by climate change. Lack of strong protection of the marine environment, unsustainable fishing methods and oil spills also pose a threat to the marine environment and seabird colonies.

The modern installations, the radar base and related buildings, associated with the UK Ministry of Defence (MOD) operations on Hirta, take up a relatively small footprint, although they do still have an impact on the landscape, as do the coastal defences.

Authenticity

The challenge for conservation of the cultural landscape is to keep a balance between the principle of minimum intervention and active conservation work necessary to minimise decay, whilst keeping records of all the work that is done. With few exceptions this has meant re-using fallen materials, with little introduction of new materials. Where new materials have necessarily been required these have largely, and as far as possible, been like-for-like replacements. A representative sample of the 1400 cleits is monitored and actively maintained.

Protection and management requirements

The primary legislation that protects the archipelago and surrounding seas and their key attributes are: The Conservation (Natural Habitats. & C.) Regulations 1994, as amended; The Wildlife and Countryside Act 1981; The Land Reform Act 2003; Nature Conservation (Scotland) Act 2004; The Ancient Monuments and Archaeological Areas Act 1979; The Planning etc. (Scotland) Act 2006; and The Environmental Liability (Scotland) Regulations 2009. The Scottish Historic Environment Policy (SHEP) sets out the primary policy guidance on the protection and management of the historic environment in Scotland.

The archipelago and surrounding seas are protected by a number of national and international designations, both statutory and non-statutory. For the natural values, the property is designated as a Special Area of Conservation, Special Protection Area, National Nature Reserve, Site of Special Scientific Interest, National Scenic Area, Marine Consultation Area and Geological Conservation Review Site. For the cultural values, selected areas of Hirta are designated as Scheduled Monuments. These designations are backed up by UK, Scottish and local policies, plans and legislation.

The National Trust for Scotland (NTS), a charity, owns and manages the archipelago of St Kilda. Management is guided by a Management Plan which is approved and its implementation overseen by the major stakeholders.

Currently, the MOD has the only full time presence on the islands, although NTS and other conservation bodies/researchers are there for a significant part of the year. The current management regime is vulnerable to the withdrawal of the MOD and to resource constraints within the NTS.

Management of the cultural heritage will proceed on the basis of the minimum intervention required to sustain the attributes of the property's Outstanding Universal Value, underpinned by the recent intensive and systematic archaeological survey of the whole archipelago, carried out by the Royal Commission on the Ancient and Historical Monuments of Scotland. Conservation of the marine environment, at present, lacks the strong protection of the terrestrial heritage, and ensuring its greater protection in the future will be critical. Management of the natural heritage is and will continue to be one of non-intervention, allowing natural processes to take their course, except where a feature of greater heritage significance is under threat.

Many of the challenges facing St Kilda and/or the NTS in its management of the archipelago -e.g. the threat of invasive species, unsustainable tourism or fishing practices, coastal erosion, etc. -are tackled through working closely with relevant stakeholders, undertaking systematic research and monitoring, providing adequate resources and implementation of the approved and endorsed Management Plan for the property.

APPENDIX 2

Images depicting key value #1 – Scenery and landscape

Figure A Steep cliffs occur on the islands and stacs
(Jon Day)

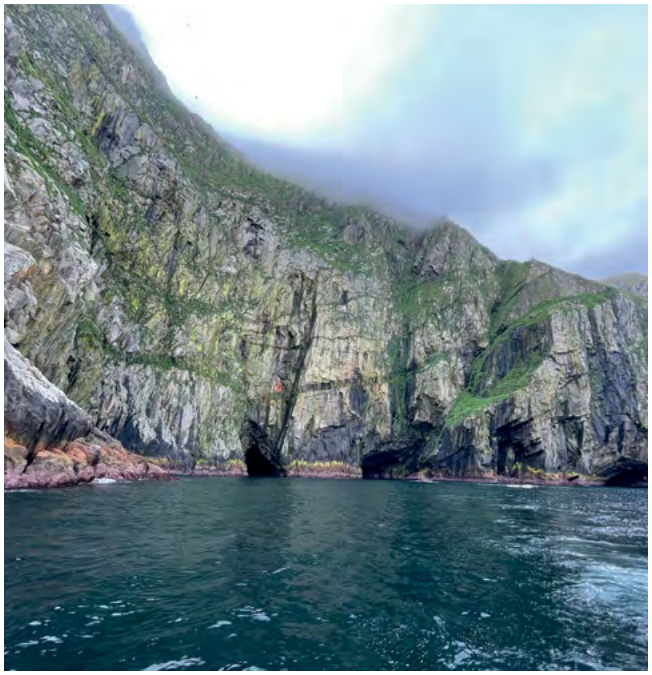


Figure B Village Bay
(Jon Day)

Figure C Looking across Village Bay
(Jon Day)

Figure D Looking towards the island of Dun
(Jim Richardson, used with permission)

Images depicting key value #2 – Seabirds

Figure A Northern gannet
(NTS- Craig Nisbet)

Figure B Leach's storm petrel
(Craig Nisbet, used with permission)

Figure C Nesting fulmars
(Craig Nisbet, used with permission)

Figure D Atlantic puffins
(Mc2 Photography, used with permission)

Images depicting key value #3 – Genetic interest and biodiversity

Figure A Soay sheep on Hirta
(Jon Day)

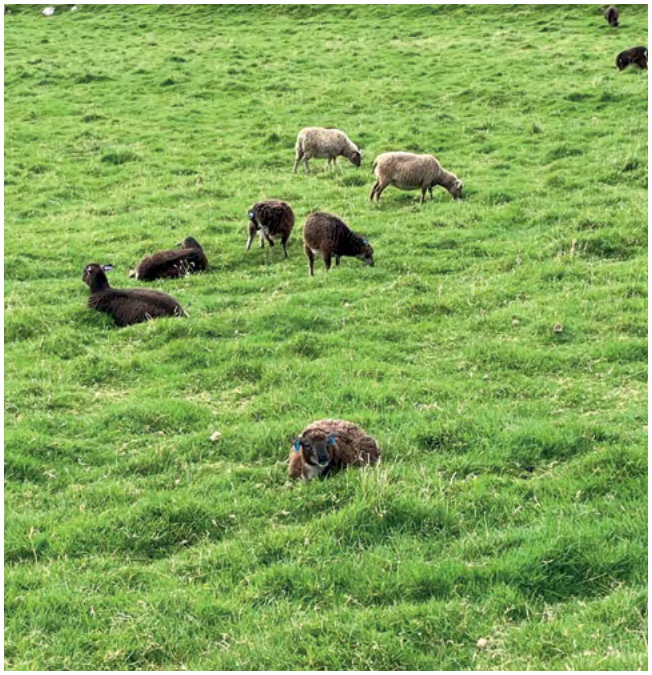


Figure B St Kilda mouse
(Mc2 Photography, used with permission)

Figure C St Kilda wren
(Mc2 Photography, used with permission)

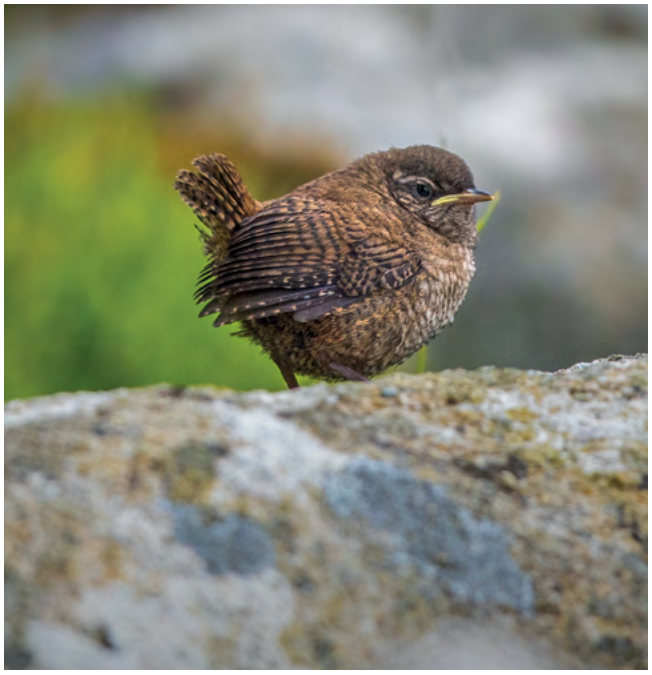


Figure D Atlantic grey seal
(Mc2 Photography, used with permission)

Images depicting key value #4 – Marine environment

Figure A Lion's mane jellyfish in Village Bay, St Kilda
(NatureScot)

Figure B A diver in the mouth of Seal Cave at St Kilda
(NatureScot)

Figure C Sea anemones in a sea cave
(NatureScot)

Figure D Anemones on a rock wall outside a sea cave
(NatureScot)

Figure E Looking out from a sea cave
(NatureScot)

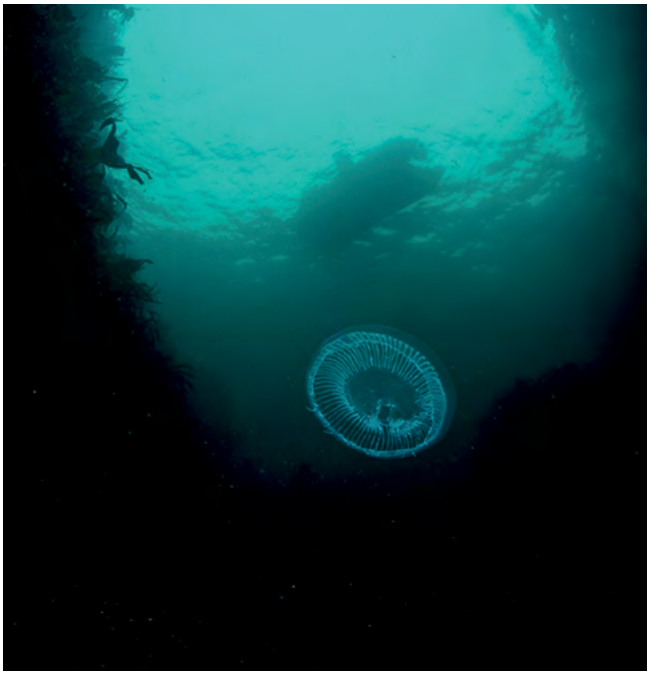


Figure F A kelp forest in shallow waters at St Kilda
(NatureScot)

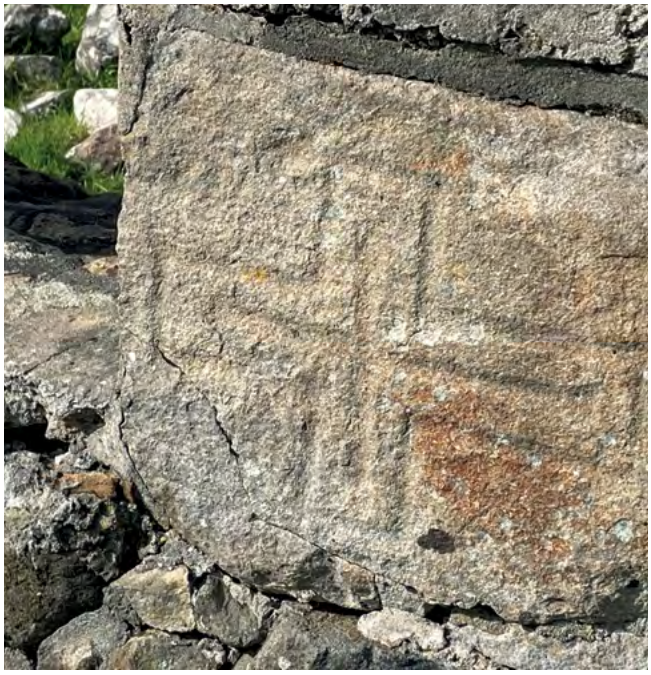
Images depicting key value #5 – Cultural landscape

Figure A Historic image of children on Main Street, 1907
(NTS Milne album)

Figure B Abandoned enclosures and cleitean, Hirta
(Mc2 Photography, used with permission)

Figure C Storage cleit, Hirta
(Jon Day)

Figure D Cross-incised stone at house 16, Hirta
(Jon Day)



APPENDIX 3

List of other Significant Property Values (SPVs) that are locally, regionally or nationally significant for St Kilda

Broad Groupings of SPVs	Key SPVs	Additional Justification
Biological diversity (e.g., other flora, fauna or habitats of significance in the SOUV)	Terrestrial vegetation, especially arctic-alpine plants	e.g., St Kilda dandelion *(Taraxacum pankhurstianum)* is recognisably distinct species; purple saxifrage *(Saxifraga oppositifolia)*; moss campion *(Silene acaulis)*; nationally important bryophytes and lichens (including globally rare liverwort).
	Maritime vegetation	Some of the most extensive and best examples of Atlantic maritime vegetation in Europe; e.g., Roseroot *(Sedum rosea)*; Scots lovage *(Ligusticum scoticum)*; sea campion *(Silene uniflora)*; thrift *(Armeria maritima)*.
	Terrestrial fauna	e.g., Borerary blackface sheep; weevil species currently only recorded on Dun and the Westman Islands of Iceland; rare fly Calliphora uralensis; 10 ichneumons (parasitic wasps)
	Vulnerability of ecosystems	Range of terrestrial and marine habitats, flora and fauna are sensitive to climate change.
	Natural designations	e.g., Special Area of Conservation (SAC) for reefs and underwater caves; Special Protected Area (SPA) for seabirds; National Nature Reserve (NNR); Site of Special Scientific Interest (SSSI); Marine Consultation Area; Geological Conservation Review Site (GCRS).
	Invasive non-native species	Mammals, plants, invertebrates and disease that poses a significant ongoing threat to the natural heritage of both the marine and terrestrial ecosystems. E.g., Avian Flu
Aesthetic values or phenomena (e.g., any specific scenic qualities or phenomena that are significant)	Emblematic image of St Kilda	The 19th century reshaping of Village Bay to the ordered fan of field boundaries and the associated neatness of The Street creates an emblematic image of St Kilda.
	Landscape designation	National Scenic Area (NSA)
	Modern infrastructure (post-1930)	Radar base and related buildings associated with the UK Ministry of Defence (MoD), coastal defences etc now form part of the landscape of St Kilda.
Economic values (e.g., provide income or employment opportunities through tourism, fishing, or other commercial activities, etc.)	Employment	Direct and indirect employment across the Hebrides; e.g., day boats departing from Lewis, Harris and Skye provide direct employment, supports accommodation and hospitality across the Hebrides.
	Tourism	St Kilda brings visitors to the island and the Hebrides more widely which is a significant economic resource for the Western Isles.
Recreational values (e.g., provide for recreational activities like hiking, camping, wildlife viewing etc.)	Creel fishing	Local industry providing employment and income
	Walkers, hikers	Main island of Hirta is as a recreational resource for visitors wanting to walk/hike.
	Tourism	Destination for thousands of visitors arriving by private yacht, charter boat and cruise ships.
	Marine diving	One of the premier marine dive locations in Britain

Broad Groupings of SPVs	Key SPVs	Additional Justification
Historic/cultural values (e.g., features or locations that represent history or enable traditions or ways of life to continue)	Place names	Speak of the islands' past, of Gaelic and Norse influences, and help to improve our understanding of the history and use of the islands.
	Oral History	An extensive oral history collection provides invaluable primary and secondary source material on a range of subjects, from St Kilda's history and folklore to songs of the islands.
	Family associations	Associated with Clan MacLeod, the island's owner at time occupants left for the mainland, who sold the islands to the Earl of Dumfries (later the 5th Marquess of Bute) who then ran St Kilda as an unoccupied bird sanctuary after first recognising the value of the bird population.
	Genealogy	For communities in the Western Isles and across the world, there are still genetic connections where people can trace their genealogy to inhabitants who left St Kilda in 1930.
	Artefacts	Artefacts of past and current societies on St Kilda show tangible and intangible parts of St Kilda cultural practices, many of which are no longer part of the living culture
	Traditional skills	Drystone dyking and some building forms are visible evidence of skills and traditions still carried out today.
	Gaelic language	Particular dialect of St Kilda is no longer spoken but the language itself is still widespread use throughout the Western Isles.
Learning/ scientific values (e.g., opportunities for scientific research, nature interpretation etc)	Education	Provides both formal and informal educational opportunities.
	Outreach	Important outreach work with local stakeholders including schools, tour operators and proposed visitor centres in the Hebrides.
	Scientific Research	Different universities and research institutions use the island for important ecological, archaeological and evolutionary scientific research, e.g., Soay sheep research project.
	Environmental evidence	Soils samples and biofacts provide information about the ecological diversity of the site.
	Artefact collection	There are numerous collections of artefacts – both on the island, in museums, with organisations or private individuals – which form a valuable resource to interpret the material culture of St Kilda.
	Documentary sources	National Trust has an extensive collection of documents and images, telling the story of life on St Kilda, day to day lives were lives and how St Kildan's were viewed by the outside world. The quantity is rare and perhaps unique for such a remote rural society.
	Intellectual access	Provided in various media, from books and films to the internet.
Spiritual/ philosophical fulfilment (e.g. areas that are sacred, religious, or spiritually significant etc.)	Village Bay	The settlement holds the soul of St Kilda which holds a unique emotional and spiritual power in communities across the Hebrides and experienced by visitors today. This is amplified by its remoteness and difficulty to access.
	Power of nature	The steep cliffs and pounding seas around the archipelago give a sense of the overwhelming power of nature, against which the very visible remains of human habitation can only fill the modern visitor with a sense of awe and respect for past generations.
Other/special places (if places are special, state reason why)	Inalienable	In 1696 the Trust declared the island of St Kilda 'inalienable'. This provides the maximum protection the Trust can afford a property as inalienable properties cannot be removed from Trust ownership against the Trust's will, except by prescribed parliamentary procedure.

APPENDIX 4

CVI workshop schedule 13th-15th September 2022

Day 1 – Tuesday 13 September 2022

1 Welcome, overview of aims, logistics
2 Introductions of participants

AIM 1: Understand the Climate Vulnerability Index (CVI) framework and its application in St Kilda

3 Brief overview of the CVI process

AIM 2: Understand the significant values that comprise the OUV for St Kilda; and assess condition and trend. Discuss other significant values (i.e., Significant Property Values, SPVs)

4 Ensure all participants are aware of the Statement of OUV for the St Kilda and how the table of key values and attributes were derived from the Statement of OUV
5 Undertake high-level assessment of current condition of key values and the recent trend in those values (i.e., since the date of inscription, 2004)
6 Discuss other values that are significant at a local/regional scale (i.e., other SPVs) but are not part of OUV

AIM 3: Background info on St Kilda and future climate change facing the St Kilda

7 Introduction to climate change globally and in the Outer Hebrides
8 Provide overview of climate change projections for St Kilda; agree upon the climate scenario and time scale for the assessment (e.g., Business-as-usual for 2050)

AIM 4: Assess the climate stressors impacting the values of St Kilda and select key climate stressors

9 Show list of climate stressors – check for (i) understanding? (ii) timescales? Demonstrate selection of top three climate stressors impacting each key value
10 Using the list of climate stressors provided, small groups to brainstorm what are the top three climate stressors impacting the key values of OUV
11 Bring outputs from #10 back to plenary and ensure all participants agree on which climate change stressors are impacting the attributes of OUV

AIM 5: Evaluate vulnerability of OUV to key climate stressors, considering exposure, sensitivity and adaptive capacity for a selected climate scenario (e.g., 'Business as Usual' or 'Paris Agreement')

12 Revisit process for exposure, including detail of categories, and review modifiers
13 Participants in breakout groups assess the exposure term (and modifiers) for each of the three key climate stressors
14 Bring outputs from #13 back to plenary and discuss any variation in assessments of exposure
Wrap up discussion, review Day 1; preview Day 2

Day 2 – Wednesday 14 September 2022

15 Brief recap of Day 1 and overview of Day 2
16 Introduction of CVI process for sensitivity (including categories and modifiers) and review potential impact matrix that combines sensitivity with exposure; remind all of climate scenario for analysis
17 Participants in breakout groups assess the sensitivity (and modifiers thus determining potential impact) for the key CC stressors
18 Bring outputs from #17 back to plenary and review the potential impact matrix that combines sensitivity with exposure; discuss any variation in assessments of exposure or sensitivity
19 Introduction to adaptive capacity and task to identify existing strategies used to mitigate climate related impacts and potential adaptive capacities
20 Participants in breakout groups assess the adaptive capacity (thus determining OUV vulnerability) for the key CC stressors
21 Bring outputs from #20 back to introduce adaptive capacity assessment
22 Participants in breakout groups assess the adaptive capacity (thus determining the OUV Vulnerability) for the key CC stressors
23 Bring outputs from #22 back to plenary and discuss any variation in assessments of adaptive capacity; prioritise in terms of feasibility/likelihood to be undertaken
24 Plenary discussion of assessments of exposure, sensitivity and adaptive capacity and any effect on OUV Vulnerability

AIM 6: Consider economic, social and cultural dependencies (sensitivity) and adaptive capacity, to determine Community Vulnerability

25 Revisit process for analysing economic, social and cultural (ESC) dependency and adaptive capacity
26 ESC overview for St Kilda
27 Discussion of business types for analysis and introduction to Economic breakout group
28 Participants in breakout groups assess the economic dependency and adaptive capacity for St Kilda
29 Bring outputs from #28 back to plenary and discuss any variation in assessments of economic dependent and adaptive capacity
Wrap up discussion, review Day 2; preview Day 3

Day 3 – Thursday 15 September 2022

30 Brief recap of Day 2 and overview of Day 3
31 Introduction to Social dependency breakout groups
32 Participants in breakout groups assess the social dependency and adaptive capacity for St Kilda
33 Bring outputs from #32 back to plenary and discuss any variations of social dependencies and corresponding adaptive capacities
34 Introduction to cultural dependency breakout groups
35 Participants in breakout groups assess the cultural dependency and adaptive capacity (thus determining Community Vulnerability) for St Kilda
36 Bring outputs from #35 back to plenary and discuss any variation in assessments of cultural dependencies and corresponding adaptive capacities

AIM 7: Summary, feedback and next steps

37 Summarise outcomes and present final analysis
38 Discussion of items 'parked' during the workshop
39 Discussion of next steps
40 Receive feedback on CVI framework and workshop process
41 Complete workshop evaluation forms; receive other feedback from participants
42 Thanks and close

APPENDIX 5

List of participants in the CVI workshop (in person and online)
Workshop Steering Group members indicated by *

Name	Role	Organisation
Susan Bain*	Western Isles Manager	National Trust for Scotland
Janine Ballantyne	Policy Officer	National Trust for Scotland
Hazel Blake	Geophysical Survey Officer	Historic Environment Scotland
Will Boyd-Wallis	Operations Manager for the North West	National Trust for Scotland
Iain Buchanan	Director	Ionad Hiort
Jacob Davies	Research Ecologist	British Trust for Ornithology
Mairi Davies*	Climate Change Policy Manager	Historic Environment Scotland
Jon Day*	CVI Workshop Facilitator	James Cook University, Australia
Johanne Ferguson	Operations Manager, Outer Hebrides	NatureScot
Alisdair Fleming	President	The St Kilda Club
Emily Gal	Archaeology Lecturer	UHI Outer Hebrides
Colin Govier	Vice-President	The St Kilda Club
Kevin Grant	Archaeology Manager	Historic Environment Scotland
Jim Hansom	Dynamic Coast, School of Geographical & Earth Sciences	University of Glasgow
Diarmid Hearns	Head of Public Policy	National Trust for Scotland
Clare Henderson	St Kilda Archaeologist	National Trust for Scotland
Scott Heron*	CVI Workshop Facilitator	James Cook University, Australia
Patrick Hughes	Operations Officer, Outer Hebrides	NatureScot
Liz Humphreys	Principal Ecologist – Seabirds	British Trust for Ornithology
Ewan Hyslop*	Head of Research and Climate Change	Historic Environment Scotland
Rebecca Jones*	Head of Heritage Recording & Archaeology	Historic Environment Scotland
Sarah Lawrence	Biosecurity for LIFE Officer	Royal Society for the Protection of Birds
Sue Loughran	St Kilda Ranger	National Trust for Scotland
John Love	Trustee	Sealladh Hiort

Name	Role	Organisation
Alice Lyall	Deputy Head of World Heritage: Heart of Neolithic Orkney Coordinator	Historic Environment Scotland
Donella MacDonald	Director	Ionad Hiort
Laura MacKenzie	World Heritage Support Officer	Historic Environment Scotland
Stephen MacKinnon	Business Manager	Northton Heritage Trust
Mairi MacLean	Student	UHI Outer Hebrides
Sarah Maclean	CEO	Outer Hebrides Tourism
Kevin Murphy	Western Isles Archaeologist	Comhairle nan Eilean Siar
Berwyn Murray	Heritage Planner	National Trust for Scotland
Craig Nisbet	St Kilda Seabird and Marine Ranger	National Trust for Scotland
Dan Nussey	Chair of Evolutionary Ecology	University of Edinburgh
Ellie Owen	Senior Seabirds Officer	National Trust for Scotland
Robin Pakeman	Plant Ecologist	The James Hutton Institute
Josephine Pemberton	Chair of Natural History	University of Edinburgh
David Pickthall	Establishment Manager Scotland	Ministry of Defence
Rebecca Rennell	Archaeology Lecturer	UHI Outer Hebrides
Alistair Rennie	Dynamic Coast Project Manager	NatureScot
Simon Smith	Environment Advisor – Scotland	QinetiQ
Craig Stanford	Archaeology Officer	Historic Environment Scotland
Laura Steel	Marine Advisor	NatureScot
Ian Stevenson	Director	Sunadal Data Solutions
Mairi Thomson	Project Development Manager	Outer Hebrides Tourism
Paula Whitelaw	Senior Heritage Planner	National Trust for Scotland
Lyn Wilson	Head of Programme for Research and Climate Change	Historic Environment Scotland
Kirstie Wright	Climate Science and Resilience Projects Officer	Historic Environment Scotland

APPENDIX 6

Glossary and acronyms

Adaptive capacity
The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Anthropogenic
Resulting from or produced by human activities.

Cleit (pl. cleitean)
A stone storage hut, uniquely found on the isles and stacs of St Kilda

Climate
The composite or generally prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.

Climate change
A change in the pattern of weather, and related changes in oceans and land surfaces, occurring over time scales of decades or longer.

Climate projection
A projection of the response of the climate system to emission or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based upon simulations by climate models. Projections from the Coupled Model Intercomparison Project Phase 6 (CMIP6) are referred to in this report.

Exposure
A measure of the contact between a system (whether physical or social) and a stressor.

Sensitivity
The degree to which a system is affected, either adversely or beneficially, by climate variability or change.

Extreme weather event
A weather event that is rare at a particular place and time of year. Definitions of 'rare' event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability.

Intergovernmental Panel on Climate Change (IPCC)
The United Nations body, established in 1988, for assessing the science related to climate change; it was created to provide policymakers with regular scientific assessments on climate change, its implications, and potential future risks, as well as to put forward adaptation and mitigation options. The IPCC is the most authoritative international body on climate science and is an essential component of the world's response to climate change.

Mitigation (of climate change)
A human intervention to reduce emissions or enhance the sinks of greenhouse gases (GHGs). Mitigation measures in climate policy are technologies, processes or practices that contribute to mitigation, for example renewable energy technologies, waste minimisation processes, public transport commuting practices, etc.

Restoration (in an environmental context)
Involves human interventions to assist the recovery of an ecosystem that has been previously degraded, damaged, or destroyed.

Stac (also stack)
A geological formation of an isolated pinnacle of rock surrounded by the sea at high tide. The Gaelic term *stac* is used frequently in place names.

Weather
The state of the atmosphere – its temperature, humidity, wind, rainfall and so on – over hours to weeks.

CC	Changing Currents
CVI	Climate Vulnerability Index
HES	Historic Environment Scotland
ICOMOS	International Council on Monuments and Sites
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
NTS	National Trust for Scotland
OUV	Outstanding Universal Value
RCP	Representative Concentration Pathway
SIF	Storm Intensity & Frequency
SOUV	Statement of Outstanding Universal Value
SPVs	(Other) Significant Property Values
SSP	Shared Socioeconomic Pathway
TT	Temperature Trend
UHI	University of the Highlands and Islands
WH	World Heritage

CVI

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JAMES COOK UNIVERSITY AUSTRALIA

NATIONAL TRUST *for* SCOTLAND

RSE *The Royal Society of Edinburgh* KNOWLEDGE MADE USEFUL

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