



# Conservation and Restoration of Icelandic Wetlands: An Evaluation of Progress Towards Implementation of the Ramsar Convention on Wetlands

Tom Barry<sup>1</sup> 

Received: 13 December 2024 / Accepted: 13 February 2025 / Published online: 17 March 2025  
© The Author(s) 2025

## Abstract

This paper is focused on implementing a framework to evaluate Ramsar implementation at the national level and evaluating one country's (Iceland) progress towards achieving the goals of the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar) —the only global Multilateral Environmental Agreement (MEA) focused exclusively on the conservation and wise use of a specific ecosystem type. It does so through: Exploring the status and trends of Ramsar-designated wetlands and wetlands in general in Iceland; Evaluating progress towards Iceland's goals for wetland restoration and conservation; Analysing Iceland's Ramsar reporting to determine its adequacy in assessing progress towards Ramsar goals; Comparing Iceland's performance against its Ramsar commitments to assess its effectiveness in meeting these obligations; and Comparing Iceland's progress in wetlands conservation and restoration with other Arctic states. In addition to improving our understanding of Iceland's progress in implementing its commitments to Ramsar, evaluating two key actions—wetlands conservation and restoration—is crucial. These actions have significant climate change adaptation and mitigation benefits and are important not only for Ramsar but also with regards to Iceland's ability to meet its commitments to two key global MEAs: the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD).

**Keywords** Iceland · Ramsar · Wetlands · Restoration · Protection · Governance · Effectiveness

## Introduction

Healthy ecosystems are more resilient to climate change and hold the potential to support efforts to mitigate and adapt to its impacts. However, changing climate means changing habitats and therefore avoiding and reversing the loss and degradation of carbon- and species-rich ecosystems is crucial to ensuring biodiversity conservation and climate change mitigation (Pörtner et al. 2021; European Commission 2021). Harnessing potential Nature-Based Solutions through protecting and altering ecosystem performance and usage are therefore increasingly proposed as important ways to respond to climate change, improve biodiversity, and enhance human well-being (Sowińska- Świerkosz and García 2022). It is within this

context, that this paper examines progress within one state (Iceland) towards achieving the goals of *the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar)* —the only global Multi-lateral Environmental Agreement (MEA) focused exclusively on the conservation and *wise use* of a specific ecosystem type.

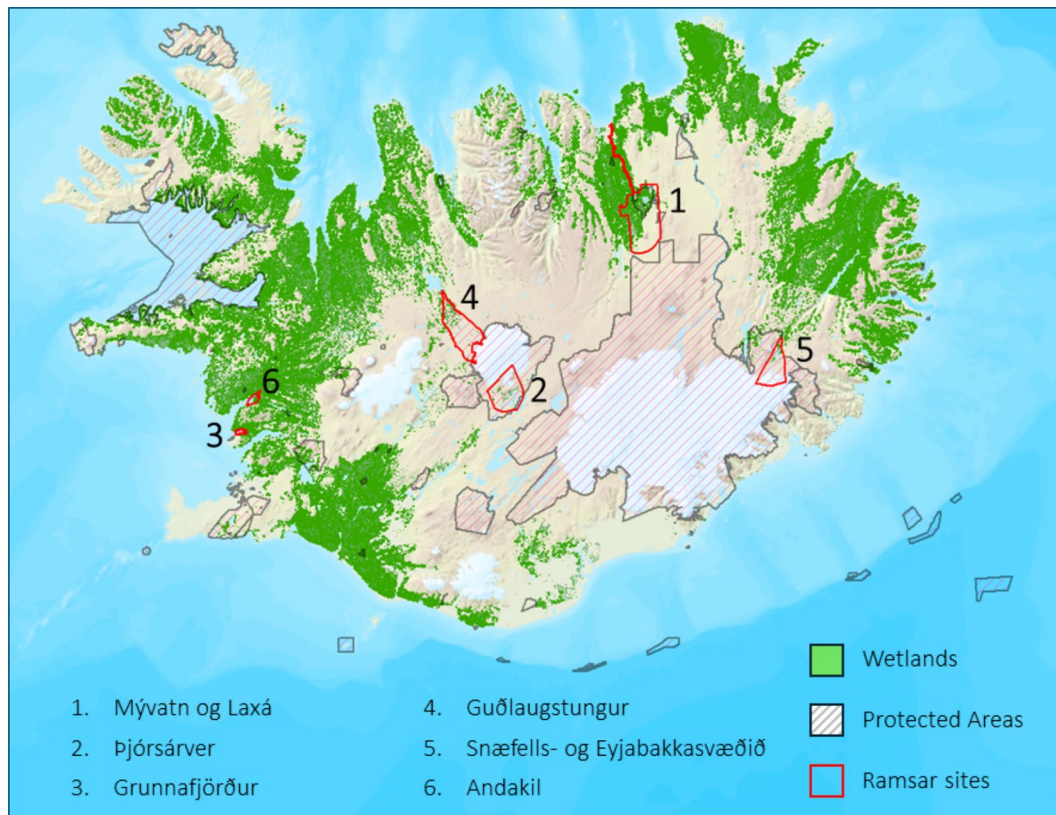
The paper takes the model developed by Barry (2024) to evaluate MEA implementation at the Circumpolar scale, and scales it to the national scale, allowing us to test implementation of an MEA (Ramsar) at the national level i.e. in Iceland. This entails:

- Exploring the status and trends of Ramsar-designated wetlands and wetlands in general in Iceland;
- Evaluating progress towards Iceland's goals for wetland restoration and conservation;
- Analysing Iceland's Ramsar reporting to determine its adequacy in assessing progress towards Ramsar goals;
- Comparing Iceland's performance against its Ramsar commitments to assess its effectiveness in meeting these obligations; and

---

✉ Tom Barry  
tom@unak.is

<sup>1</sup> School of Humanities and Social Sciences,  
and the Stefansson Arctic Institute, University of Akureyri,  
Akureyri, Iceland



**Fig. 1** Icelandic wetlands, Ramsar sites, and protected areas (LMI 2024; Ramsar 2024; CAFF 2024; LBHI 2024)

- Comparing Iceland's progress in wetlands conservation and restoration with other Arctic states.<sup>1</sup>

In addition to improving our understanding of Iceland's progress in implementing its commitments to Ramsar, evaluating two key actions—wetlands conservation and restoration—is crucial. These actions have significant climate change adaptation and mitigation benefits and are important not only for Ramsar but also with regards to Iceland's ability to meet its commitments to two key global MEAs: the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) (UNFCCC 2021; CBD 2016).

## Wetlands in Iceland

Iceland's wetlands cover between 8,950–10,300 km<sup>2</sup> depending upon data used and how wetlands are defined (Arnalds et al. 2016; Arnalds and Guðmundsson 2020; Keller et al. 2019; VSÓ Ráðgjöf 2020; Statistics Iceland 2024).

<sup>1</sup> Canada, Finland, Iceland, Kingdom of Denmark (including the Faroe Islands and Greenland), Norway, Russia, Sweden, and the US.

If more conservative figures from the Icelandic Statistics Office (8,950 km<sup>2</sup>) are used, they account for 37.6% of Iceland's vegetated surface and 8.7% of its land area (Fig. 1). Strikingly it is estimated that about half of all wetlands below 400 m have been disturbed with some areas having no undisturbed wetlands (Iceland 2021a; Arnalds et al. 2016). These are crucial habitats with 75% of Icelandic bird species relying on wetlands either partially or entirely for their habitat (Arnalds et al. 2016). Internationally, some are significant as migratory stopovers and breeding sites e.g. the Guðlaugstungur Ramsar site is home to the world's largest breeding colony of Pink-Footed Geese (Náttúrufræðistofnun Íslands 2024a), while almost the entire European population of Barrows Goldeneye breeds in the Mývatn and Laxá Ramsar site (Náttúrufræðistofnun Íslands 2024b).

Following WWII a state-subsidized drainage programme aiming to expand agricultural land covered up to 70% of drainage costs resulting in the drainage of an estimated 4,200 km<sup>2</sup> of wetlands, and 29,680 km of ditches being dug (Andrason 2022; Arnalds et al. 2016; Gísladóttir et al. 2009; Arnalds and Guðmundsson 2020). Despite the end of this programme in 1987 (Snæbjörnsson et al. 2010) and more recent efforts by Icelandic authorities to prioritise wetlands conservation and restoration, wetlands extent has continued to decline with 207,7 km<sup>2</sup> or 2.3% of its total extent

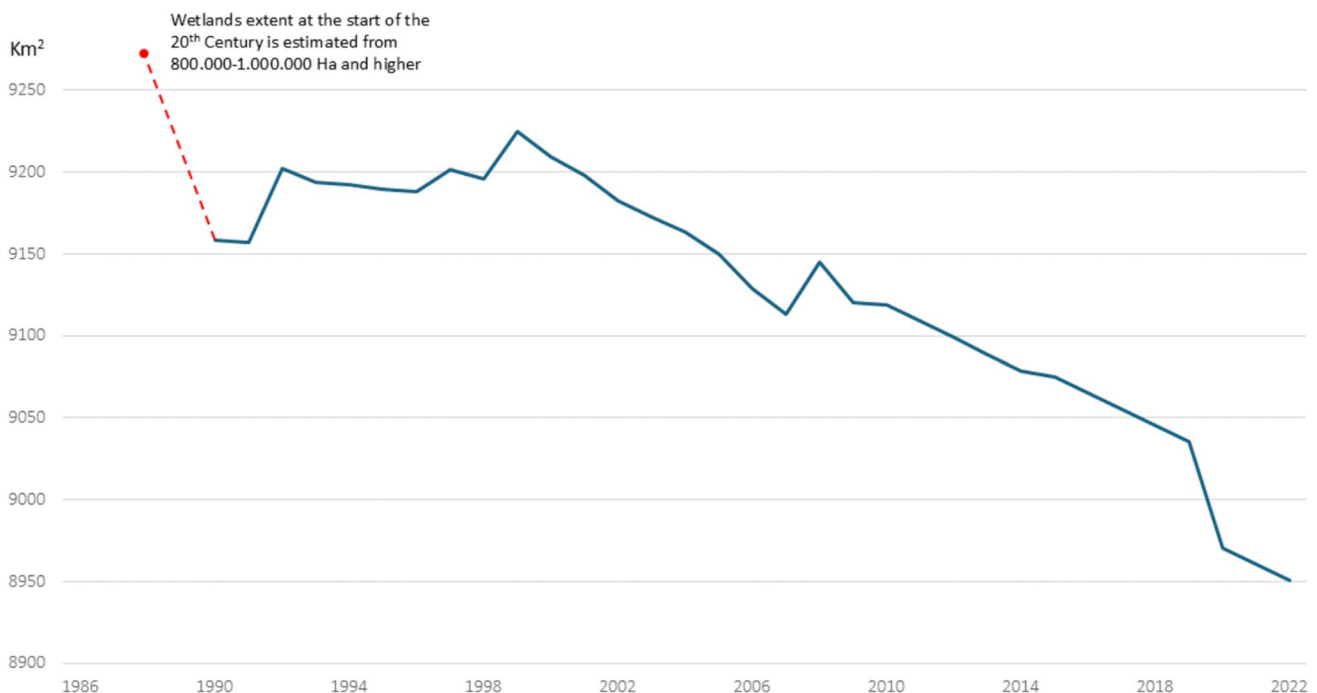
lost between 1990–2022 (Fig. 2). Indicating that despite an increased focus by Iceland on wetlands conservation and restoration, wetlands continue to be lost – some due to roadworks and deepening of existing ditches but also including previously undisturbed wetlands (Iceland 2021a).

Disturbed wetlands are the primary source of carbon emissions from Iceland's Land Use, Land-Use Change, and Forestry (LULUCF) sector. In 2022, the LULUCF sector emitted 9,497 tons of CO<sub>2</sub>, with 86% coming from drained wetlands (Pétursdóttir 2024). Wetland conservation and restoration are therefore crucial for Iceland to achieve its goal of becoming carbon-neutral by 2040 (Iceland 2020a). Iceland's Climate Action Plan includes two actions targeting wetland conservation and restoration (Actions 1.3 and 1.4). These actions if successful would reduce greenhouse gas emissions from the LULUCF sector, support biodiversity conservation, and significantly increase carbon sequestration. Iceland's wetland restoration goals if achieved could lead to a reduction of 107,000 tonnes of CO<sub>2</sub> in Icelandic land-based emissions by 2030 and 210,000 tonnes by 2040 (Fig. 3) (Iceland 2020a).

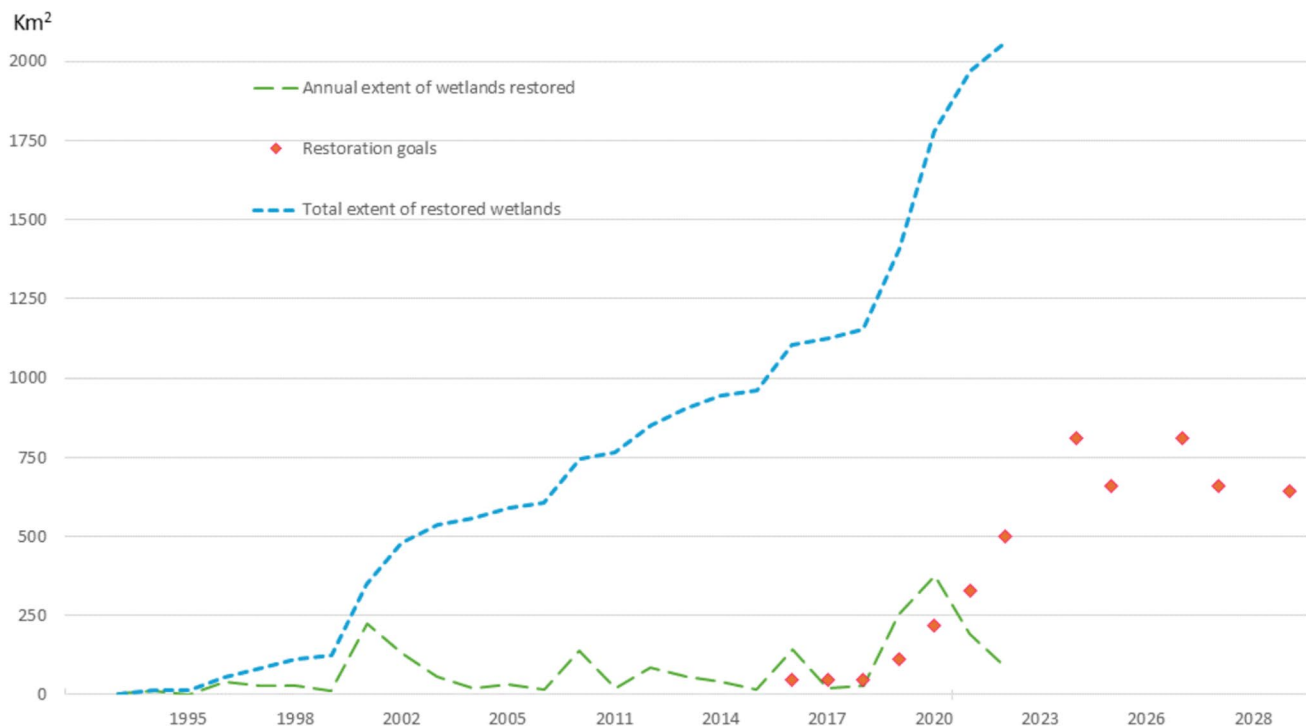
A caveat to keep in mind when considering these figures is that despite establishment of a regulatory framework supporting wetland protection and restoration, efforts to accelerate restoration have sparked a debate involving scientists, landowners, and farmers on the validity of the science underpinning arguments for restoration. Key issues in this debate, as reflected in "The Farmers Paper," Iceland's leading agricultural newspaper, include:

- How reliable is the science behind the climate mitigation benefits of wetlands restoration in Iceland? e.g. (Þorvaldsson 2021)
- Are calculations for wetlands in Iceland's climate change accounting reliable, and are IPCC emission factors appropriate given Iceland's soil, environmental and climate conditions? e.g. (Kristjánsson 2022; Guðmundsson and Þorvaldsson 2018).
- If not, then is Iceland's climate change accounting regarding wetlands accurate, and are its restoration goals realistic? e.g. (Kristjánsson 2022; Eðvarðsson 2018).
- How much of drained wetlands not used for agriculture are available for restoration and is their potential to capture carbon enough to justify restoration? e.g. (Guðmundsson and Þorvaldsson 2018)
- Should potential agricultural use be considered when designating drained wetlands for restoration, even if these lands are currently used for agriculture? e.g. (Ólafsson 2020).

While 2,082 ha were restored between 1993–2022 the impact of these debates is reflected in Iceland's failure to meet its 2021–2022 annual restoration goals (Iceland 2020a) (Fig. 3), suggesting that these goals may be unrealistic or that there are challenges in acquiring sufficient land for restoration. If Actions 1.3 and 1.4 are to be successful then more reliable baselines are needed to inform restoration decisions and more accurately calculate greenhouse gas storage and release rates. There is also a need for more



**Fig. 2** Changes in the extent of inland wetlands (Statistics Iceland 2024; Þórhallsdóttir and Óskarsson 2017)



**Fig. 3** Annual extent of wetlands restored, and total extent of wetlands restored 1993–2022 Supplementary Table A); and wetlands restoration goals 2016–2029

effective communication of the benefits of wetlands restoration (Arnalds and Guðmundsson 2020).

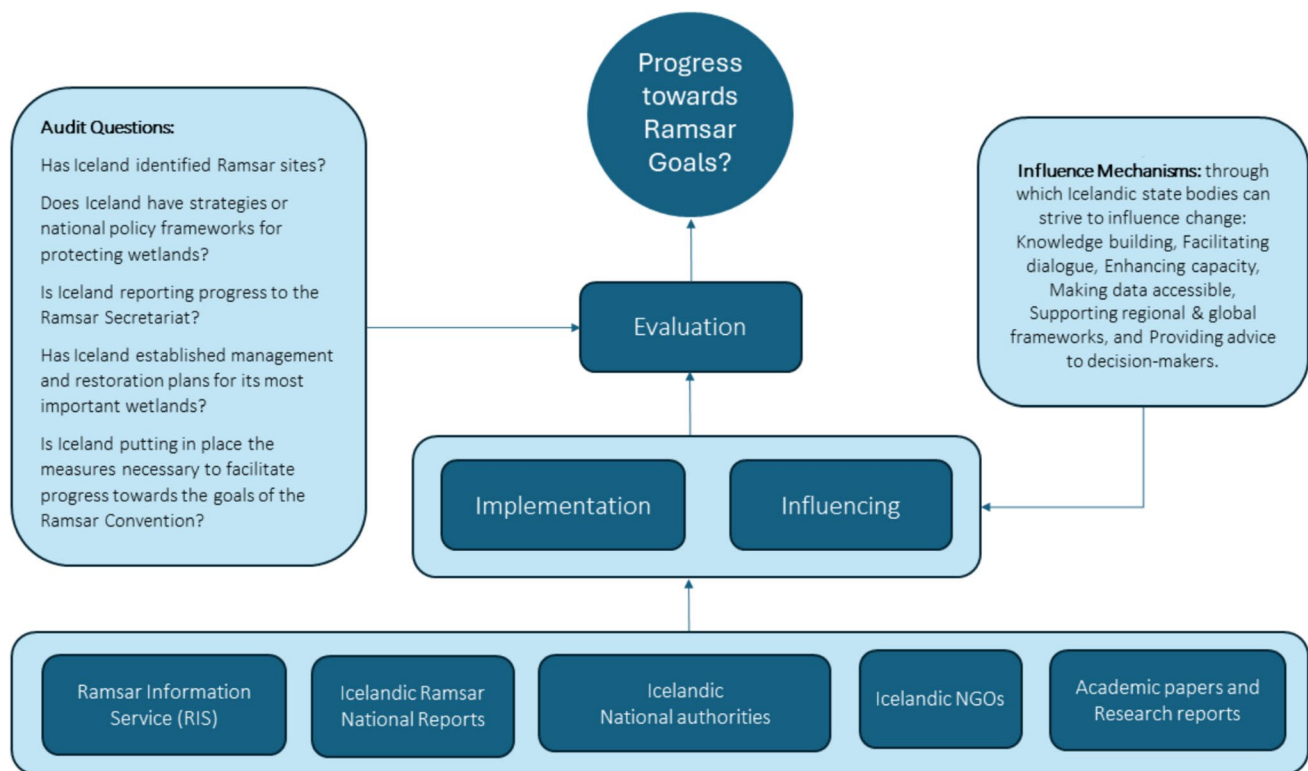
## Ramsar Effectiveness

While Ramsar's enforcement capabilities are limited, member states must designate at least one wetland for inclusion in the List of Wetlands of International Importance. They must also include wetland conservation priorities in national land-use planning, promote the wise use of wetlands, establish nature reserves in wetlands (including those not internationally important), encourage training in wetland research and management, and collaborate with other Ramsar parties on implementation (Ramsar 2013). However, despite Ramsar's existence, global wetland coverage and health have continued to decline, with the extent of natural wetlands declining by 35% between 1970–2015 (IPBES 2019; Ramsar 2018; Ramsar 2021). This decline is mirrored in Iceland where the overall trend is of a reduction in wetlands with their extent declining by 2.3% (207,7 km<sup>2</sup>) between 1990–2022 (Fig. 2) accompanied by the deteriorating ecological character of both Ramsar sites and wetlands in general (Iceland 2018a).

The global decline in wetlands has attracted attention from scholars who begin to question the effectiveness of Ramsar in achieving its goals and its impact e.g. has it slowed down the decline of wetland coverage and health?

(Bridgewater and Kim 2021; Davidson et al. 2020; Gaget et al. 2020; Kingsfort et al. 2021; Van Geelen and Hamman 2017; Barry 2024). These investigations have revealed organizational challenges affecting Ramsar's ability to meet its goals including a widespread lack of compliance with Ramsar reporting requirements and the convention's limited power to compel or enforce progress towards its goals. Efforts to tackle these issues have entailed trying to strike a balance between Ramsar's original mission and broader environmental objectives. The goal being to ensure Ramsar's continued relevance and effectiveness in the face of intensifying and accumulating impacts of climate change on ecosystems (Bridgewater and Kim 2021; Barry 2024). This has entailed establishing joint workplans with the CBD and the Convention on Migratory Species (CMS) (CBD and Ramsar 2011; CMS and Ramsar 2004). The Ramsar Secretariat is also part of the Biodiversity Liaison Group, which facilitates coordination and information sharing among the biodiversity-related conventions<sup>2</sup> (CBD 2024). A Ramsar working group also examined the convention's efficiency and proposed improvements, resulting in Resolution XIV.3 providing a path towards improved efficiency (Ramsar

<sup>2</sup> CBD, CMS, Ramsar, International Plant Protection Convention, International Treaty on Plant Genetic Resources for Food and Agriculture, International Whaling Commission, and the World Heritage Convention.



**Fig. 4** Framework to evaluate the effectiveness of Ramsar implementation in Iceland (modified from (Barry 2024))

2022a). It will be interesting to see how the outcomes of these proposals are reported upon at the 2025 Conference of the Parties (COPs). See Barry (2024) for more detail on the challenges facing Arctic States in implementing Ramsar in their Arctic territories.

## Evaluation Framework

MEAs, such as Ramsar, are commonly used by states to tackle environmental problems. However, determining the extent to which these agreements lead to tangible changes on the ground can be challenging. Evaluations of their effectiveness often encounter obstacles due to data gaps, conceptual complexities, and methodological issues. Attributing improvements to a specific agreement can be difficult since effectiveness may vary depending on a state's level of commitment and the complexity of the issues in question (Barry 2024; Barry et al. 2020; INTOSAI 2007; Mitchell 2025; Einarsson 2013). To evaluate progress towards Ramsar goals in Iceland, this paper applies Barry's (2024) evaluation framework designed to evaluate Arctic states' progress towards implementing Ramsar in their Arctic territories. Adapting this framework involved scaling it up to the national level and incorporating approaches developed by the International Organization of Supreme Audit Institutions

(INTOSAI) to audit a state's progress in implementing Ramsar (Fig. 4) (INTOSAI 2010). Application of this framework provides a baseline from which to evaluate Iceland's progress towards Ramsar's goals through:

- exploring measures Iceland has taken to facilitate wetlands conservation and restoration e.g., site management plans and national wetland policies;
- exploring mechanisms used to influence Ramsar implementation in Iceland; and
- considering how tools provided via Ramsar to support implementation have been applied in Iceland i.e., the Montreaux Record and Ramsar Advisory Missions (RAM).

The information used in applying this framework is derived from 1) Iceland's reporting to Ramsar; 2) Icelandic agencies and NGOs responsible for wetland conservation and restoration; and 3) academic papers and research reports.

Iceland reports to Ramsar through National Reports (NRs) and Information Sheets on Ramsar Wetlands (RIS). NRs are submitted by Ramsar Parties to each COP which usually occur at three-year intervals and parties are also expected to provide site updates every six years. the online Ramsar Sites Information Service (RSIS) provides access to detailed data on Ramsar sites and provided by Ramsar

**Table 1** NR sections; and values added to responses to each indicator question in Sect. 3 (Barry 2024)

Sections	Description	Values	Explanations
1	Details on national authority(s) responsible for Ramsar implementation	0	Nothing being done
2	Challenges and achievements in implementation	1	Plans being prepared
3	Ninety indicator questions divided between the convention's four goals	2	Plans partially in place
4–5	Optional sections, where states can provide information regarding Ramsar sites and national wetlands targets developed to support implementation of Ramsars Strategic Plan (Ramsar 2022b)	3	Plans in place

<sup>a</sup>Site of Iceland's only home-grown—terrorist action where local landowners blew up a hydroelectric dam being built to harness the Laxá river

Parties in their RISs. They provide standardized responses on a state's wetland management and conservation. Each NR is divided into five sections, covering different aspects of Ramsar implementation. Sections 4 and 5, focusing on national targets and additional information on indicators relevant to each Wetland of International Importance, are optional, and Iceland has not included them in its reports. Therefore, this paper focuses on Sects. 1–3, where implementation progress is measured by assigning values from 0–3 to the indicator questions in Sect. 3, with higher scores indicating greater progress (Table 1). In order to fill gaps in Iceland's reporting, the following sources were also mined:

- A literature review on Icelandic wetlands conducted using the 1) Institute for Scientific Information (ISI) [Web of Science database](#); 2) [Skemman](#), the Icelandic repository of academic and research documents; 3) [IRIS](#), the Icelandic Research Information System; 4) publications from government agencies and committees involved in wetland disturbance, conservation, and restoration<sup>3</sup>; and 5) [Rafhlaðan](#), the National and University Library of Iceland depository. The search criteria used were "Wetland" OR "Peatland" AND "Iceland" AND "Carbon" OR ("Restoration" or "Conservation").
- The Arctic Council's Resilience and Management of Arctic Wetlands initiative (RAW) (CAFF 2017) which includes information on Iceland and the state of knowledge on Arctic wetlands in response to drivers such as land-use change and climate change (CAFF 2019,2021a); a review of scientific literature related to Arctic wetlands (Seifollahi et al. 2019), and a suite of policy recommendations designed to maintain and strengthen resilience of Arctic wetlands (CAFF 2021b).
- Nordic Council publications containing information on Iceland's wetlands, commitments to Ramsar, policy

measures, and impacts of climate change. These include the Nordic wetland conservation report (Nordic Council of Ministers 2004); Peatlands and Climate in a Ramsar context: A Nordic-Baltic Perspective assessment (Barthelmes et al. 2015), Alkaline fens: Valuable wetlands but difficult to manage (Nielsson 2016), and Enhancing Carbon Sequestration in Forests, Agricultural Lands and Wetlands in the Nordic Countries: Technical Measures and Policy Instruments (Naingolan et al. 2021).

### Measures to Support Ramsar Implementation

Ramsar includes the following measures to support implementation of its goals and resolutions (1) the designation of wetland sites as Wetlands of International Importance; (2) Parties are obliged to inform the Ramsar Secretariat if the ecological character of any of its Ramsar wetlands has changed, is changing or is likely to change (Ramsar 1994); (3) obligating states to provide NRs to COPs; (4) states are required to provide regular RIS site updates; (5) placing sites on the Montreux Record, a register of sites where ecological changes are occurring or are likely due to human activities (Ramsar 1993); (6) conducting RAMs upon request of a contracting party when there are changes in the ecological character of a site and advising on measures to facilitate removal of sites from the Montreux Record, and assessing the success of these measures (Ramsar 1994); and (7) adopting resolutions at COPs to address various aspects of Ramsar implementation, new and emerging wetland issues and threats (Barry 2024). The first two impose obligations on states, whereby upon joining Ramsar, states must list at least one site and report on changes in ecological character of Ramsar sites. However, placing sites on the Montreux Record is voluntary, and RAMs only occur upon a state's request. Although Ramsar parties are required to submit NRs and RIS updates, compliance is low, with no penalties for non-compliance (Davidson et al. 2020; Barry 2024). These challenges are reflected in the increasing number of resolutions agreed at Ramsar COPs, often without clear

<sup>3</sup> The Land and Forestry Agency, Environment Agency, Icelandic Road and Coastal Administration, Evangelical Lutheran Church of Iceland, National Power Company of Iceland, IINR, and the Government of Iceland.

paths to ensure follow-up on their implementation. It can therefore be unclear whether resolutions have had an impact upon the tasks they were designed to tackle. These issues raise questions regarding the convention's effectiveness in achieving its objectives and concerns about a blurring of Ramsar's mandate.

### Informal measures to support Ramsar implementation

While Ramsar has limited authority and resources to engage in implementation and enforce compliance, it can influence behaviour and encourage desired actions through knowledge building, dialogue facilitation, capacity enhancement, data accessibility, supporting regional and global frameworks, advising decision-makers, and establishing a community of influential individuals within key organizations. These influencing mechanisms, often overlooked when considering authority or resources, are essential for effecting change (Barry et al. 2020). Ramsar employs several such mechanisms to raise awareness of the importance of wetlands, such as World Wetlands Day (Ramsar 2023a), awards that recognize contributions to wetland conservation (Ramsar 2023b), and the Ramsar Programme on Communication, capacity building, Education, Participation, and Awareness (CEPA) (Ramsar 2023c). Although these initiatives and those by the Icelandic Wetlands Fund e.g. (Votlendissjóður 2022a, b), may have raised awareness of wetlands in Iceland, their effectiveness in promoting restoration remains uncertain given ongoing debates on the potential benefits of restoration in Iceland. Nevertheless, more effective use of these mechanisms will be crucial in driving progress in future wetland conservation and restoration.

### Evaluation

Through addressing audit questions derived from the INTO-SAI Working Group on Environmental Auditing (WGEA) (Fig. 4), this section considers Iceland's progress towards the goals outlined in Ramsar's 2016–2024 Strategic Plan (Ramsar 2022b), helping evaluate Iceland's efforts in wetland conservation and restoration. As the most recent Icelandic NR from was submitted in 2018, information gaps were filled by utilizing government reports and information from Icelandic authorities.

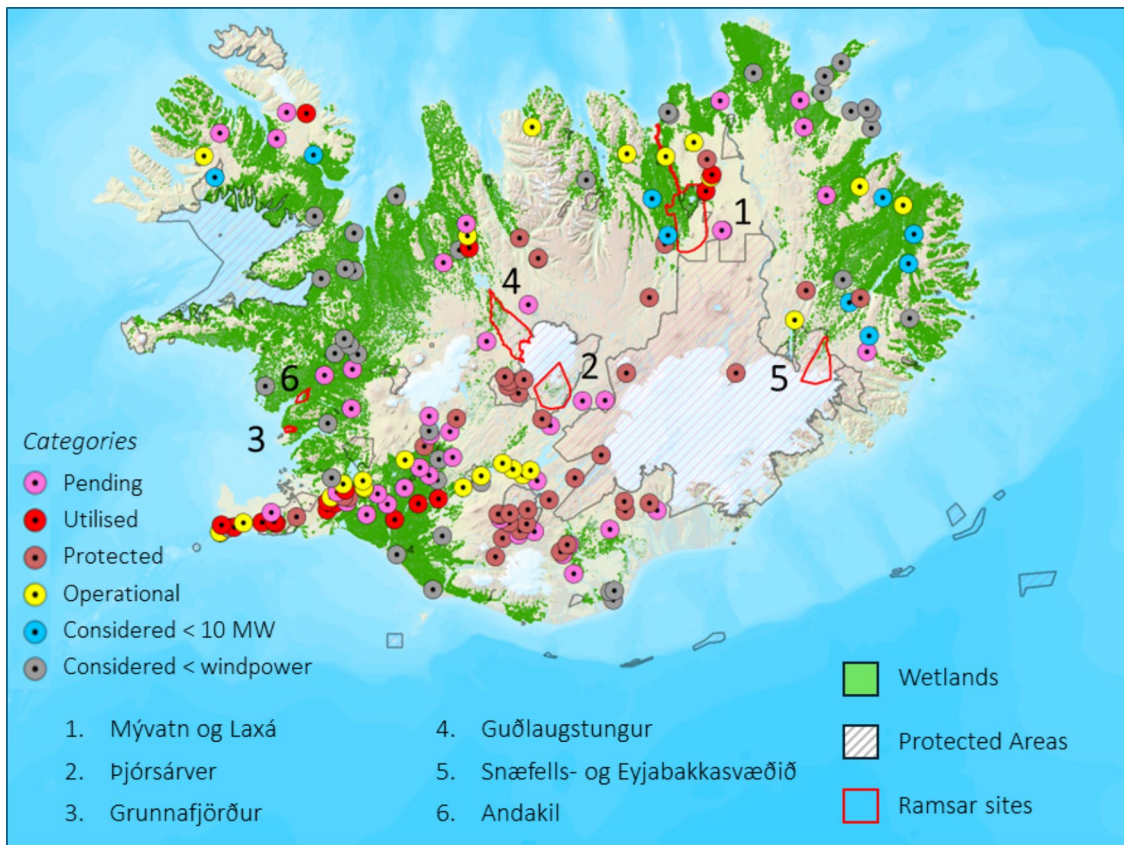
#### Has Iceland Identified Ramsar Sites?

Iceland ratified Ramsar in 1978 and has designated six Ramsar sites (Fig. 1). These sites cover 128,670 ha and according to Iceland's Ramsar reporting the majority are inland wetlands, with coastal wetlands comprising 2.4%

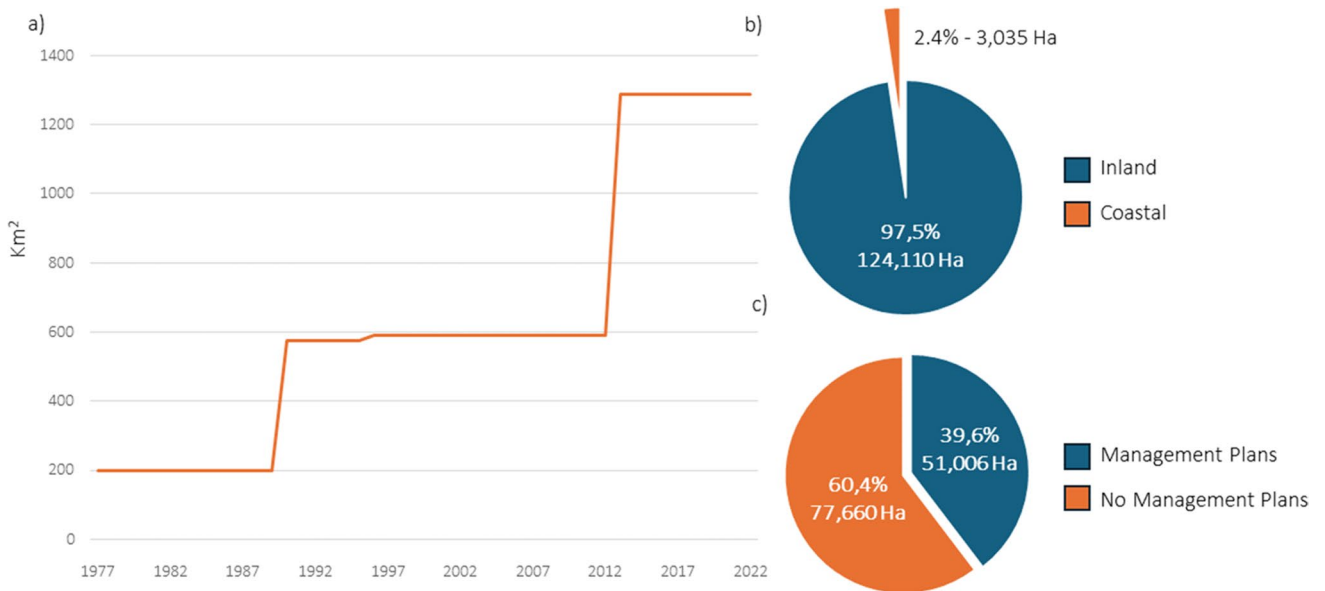
(3,035 ha) (Table 2) (Ramsar 2024). While site designations increased until 2013, no new Ramsar sites have since been designated by Iceland (Fig. 6) or by any other Arctic state within their Arctic territories. This lack of new designations could be attributed to several factors, including challenges in reaching agreement on potential sites. However, in Iceland's case, the absence of new designations does not reflect a lack of potential sites e.g. Breiðafjarðar (Breiðafjarðarnefndar 2021) and other potential sites can be found on Iceland's Nature Conservation Register which also functions as a tool for meeting Iceland's international conservation obligations (Náttúrufræðistofnun Íslands 2025). The lack of new nominations is more likely a reflection of complex dynamics surrounding use of the country's natural resources, including wetlands, and changing political views. Some of which may be in areas sought after for hydroelectric developments, such as in Þverá in Vopnafirði, Orravatnsrústir or the Þjórsárver Ramsar site while others may be sought after for use as windfarms, summer cottage areas and road building. Figure 6 shows the location of planned, existing, and potential sites for energy developments, many of which are located in wetlands and in the case of Mývatn-Laxá found within a Ramsar site (Fig. 5). Another possible reason may be the limited authority of Ramsar to enforce compliance or provide incentives for Iceland to work towards achieving Ramsar goals. Consequently, Iceland may be focusing its attention and resources on obligations with stronger consequences for non-compliance, such as commitments to the EU and higher-profile MEAs such as the UNFCCC.

#### Has Iceland Developed Strategies or National Policy Frameworks for Protecting Wetlands?

Spurred by the loss of habitat and impacts on biodiversity Iceland's early recognition of the role of wetlands in combating climate change, marked by the cessation of ditch drainage subsidies in 1987, led to a growing emphasis in state policies on wetland conservation and restoration (Iceland 2009; Iceland 2008; Garðarsson et al. 2006). Continuing this trend, the Icelandic Nature Conservation Act provided legal protection for wetlands larger than 20,000 m<sup>2</sup> as well as lakes and ponds larger than 1,000 m<sup>2</sup>, including salt marshes and mudflats, covering a significant portion of Iceland's wetlands (Iceland 2013). Successive climate strategies e.g. (Iceland 2020a; Iceland 2018b) emphasized wetlands' importance in climate adaptation and mitigation, culminating in the 2021 action plan to protect wetlands (Iceland 2021a). This contains twelve actions aimed at enhancing wetland protection and restoration, but despite deadlines for several actions expiring in 2023, no analysis of outcomes has been released. Inconsistent and declining restoration rates suggest these actions may not have been as effective as intended (Supplementary Table B). Building upon the current framework of laws and



**Fig. 5** Icelandic wetlands, Ramsar sites, and locations used, planned, or identified as potential sites for energy production. Data sources: (Ramsar 2024; Landvernd 2024)



**Fig. 6** a) Changes in total area of Ramsar Sites 1974–2024; b) extent of Marine or coastal wetlands versus Inland waters in Ramsar sites; and c) extent of Ramsar sites with and without Management plans (Ramsar 2024)

**Table 2** Iceland Ramsar sites (Ramsar 2024)

State	Designated	Extent (ha)	Last RIS update	Montreux Record	RAM	Management Plan (MP)	Cross-Sectoral Committee	Wetland type	Category
Mývatn og Laxá <sup>a</sup>	1977	20,000	1992	Added 5/7/90 removed 16/6/93	Yes	Yes (Iceland 2011) <i>under revision</i>	Yes	Inland	Protected by special legislation
Þjórsárver	1990	37,500	1992	Added 4/7/90 Removed 16/6/93	Yes	No <sup>1</sup>	Yes	Inland	Nature Reserve
Grunnafjörður	1996	1,470	1996		No	No	Yes	Marine and Coastal	Nature Reserve
Guðlaugstungur	2013	40,160	2013		No	No <sup>2</sup>	Yes	Inland	Nature Reserve
Snæfells- og Eyjabakkasvæðið	2013	26,450	2013		No	Yes (Iceland 2022a) <sup>3</sup>	Yes	Inland	Habitat/Species Management Area
Andakíll	2013	3086	2013		No	Yes (Iceland 2019a)	Yes	Marine and Coastal	Habitat/Species Management Area

1. 1992 RIS update, and NR noted a MP was in preparation.

2. 2013 RIS update, and NR noted a MP was in preparation.

3. Included in Vatnajökull National Park MP.

resolutions addressing wetlands conservation and restoration there are proposals and resolutions under discussion which include wetlands-relevant actions. Examples include the proposed resolution, *Green Enticements for Farmers* which is concerned with finding ways for farmers to benefit from sensitive and damaged ecosystems such as through wetlands restoration (Iceland 2024a); and a proposed amendment to the *Law on Conservation and Energy Use* proposing that Icelandic Ramsar sites be excluded from areas used to exploit wind power (Iceland 2024b) (Table 3).

The 2018 Icelandic NR noted that wetland benefits feature in national policies, strategies, and plans for key sectors including forestry, agriculture, national biodiversity strategy and action plans, tourism, urban development, infrastructure, pollution control, wastewater management, and water quality. Wetland benefits are also partially included in national policies or strategies related to water resource management, energy and mining, aquaculture, fisheries, pollution control, and management. However, few details were provided on how wetlands are incorporated into these strategies. While the land reclamation programme and forestry (Land og Skógur 2022), water (Environment Agency 2022), and national urban and rural planning (Iceland 2024c) strategies acknowledge the importance of wetland conservation and restoration, the fisheries strategy does not mention wetlands, and there are no strategies in place for mining or aquaculture. The agriculture (Iceland 2022b), tourism (Iceland 2019b), and infrastructure strategies (Iceland 2016a) do not directly reference wetlands but refer in general terms to

the importance of nature protection and conservation. This raises questions about how the term "wetland benefits" is understood, the extent to which general references to wetlands translate into tangible support for their conservation or restoration, and how different sectors view wetlands.

The wetlands protection plan is supported by the emphasis on wetlands in the National Planning Strategy (Iceland 2024b), and assignment of the issue of wetland restoration to the Land and Forestry agency. However, in 2015 the Nature Conservation Act was amended so that the threshold for wetland protection was increased from 10,000 m<sup>2</sup> to 20,000 m<sup>2</sup> (Iceland 2015a) significantly reducing the extent of wetlands protected. Iceland's 2018 NR also noted Iceland does not have an inventory of Invasive Alien Species (IAS) that could affect wetlands and lacks mechanisms to notify authorities of human-induced changes in Ramsar Sites. Iceland is a member of the North European and Baltic Network on Invasive Alien Species (NOBANIS), whose purpose is to minimize or prevent damage by IAS, however, while NOBANIS includes information on IAS that could threaten Iceland's wetlands, it has largely been inactive in recent years (NOBANIS 2024).

The Land and Forest Agency is responsible for overseeing wetland restoration with several other agencies contributing to wetland restoration and conservation. The Institute of Nature Research (IINR) focuses on classifying, mapping, monitoring conservation status, allocating conservation values on wetlands, and proposing suggestions for new protected areas and/or habitat types to the Nature Conservation Register. The Icelandic National Church has incorporated

**Table 3** Key steps in development of a framework to support wetlands conservation and restoration, 1970–2024

Year	Action	Description
1970	Halldor Laxness article (Laxness 1970)	Public attention drawn to the decline of Icelandic wetlands by Halldor Laxness Iceland's Nobel laureate in 1970 with an article in the country's main paper <i>Morgunblaðið</i> entitled <i>War against the countryside</i> which described how large wetlands areas were being destroyed with serious consequences for biodiversity
1973	First survey of Iceland's wetlands (Nordisk Ministerrad 1973)	
1974	1st Ramsar site: Snæfells- og Eyjabakkasvæðið	
1977	2nd Ramsar site: Þjórsárver	
1987	Ditch drainage subsidies stopped	Following WWII, a state-subsidized drainage programme covering up to 70% of drainage costs instigated to support expansion of land available for agriculture
1990	3rd Ramsar site: Grunnafjörður	
1996	Wetlands restoration committee established (Garðarsson et al. 2006)	Minister of Agriculture established a committee, to develop proposals on where/how to restore drained wetlands
2004	Law on the protection of Mývatn og Laxá in southern Þingeyjar municipality (Iceland 2004)	This law promotes conservation of the Mývatn and Laxá river basin and associated and protects biodiversity, geological formations, and landscapes
2006	Wetlands restoration committee proposals released (Garðarsson et al. 2006)	Provided recommendations in support of wetlands restoration and conservation: <ul style="list-style-type: none"> <li>• Wetland areas will only be disturbed if absolutely necessary</li> <li>• Clear rules formulated for wetland restoration</li> <li>• Restoration of wetlands will exceed their annual disturbance</li> <li>• Explore the potential of wetlands restoration to meet obligations to the Kyoto Protocol (Article 3.7)</li> <li>• Restoring wetlands should be an option for landowners in terms of green payments in agriculture</li> </ul>
2013	4th Ramsar site: Andakíll 5th Ramsar site: Guðlaugstungur 6th Ramsar site: Mývatn og Laxá	
2013	Nature Conservation Act amended (Iceland 2024d)	Special protection granted to wetlands, such as slope marshes, bays, floodwaters, rubble marshes, which are 10,000 m <sup>2</sup> or larger, lakes and ponds, which are 1,000 m <sup>2</sup> or larger, including seaweeds and mudflats;
2014	Stakeholder committee established to develop a Wetlands Action Plan	
2016	First Wetlands Action Plan released (Iceland 2016b)	Contains three goals and eleven actions designed to achieve these goals
2017	Nature Conservation Act amended (Iceland 2024d)	The minimum size at which wetlands were afforded protection doubled to 20,000 m <sup>2</sup> reducing the extent of wetlands protected
2018	Climate Change and its impact on Iceland report released (Björns-son et al. 2018)	Emphasizing the importance of wetlands and the role their restoration could play in Icelandic climate mitigation and adaptation
2018	IINR proposals for areas to be added to the Nature Conservation Register (Part B) (IINR 2018)	Some areas include areas covered by wetlands
2019	Wetlands Fund established	Initially active but in recent years activities have decreased, as it became more challenging to convince landowners to restore wetlands
2020	Climate change law amended with a new article 35 (Iceland 2020b)	Emissions from the binding of carbon in vegetation and soil or from the reclamation of wetlands per Iceland's international obligations are to be accounted for in Iceland's accounting – Kyoto Protocol
2020	Improvement Plan 2020–2023 for Iceland's accounting of greenhouse gas emissions and carbon sequestration from land use released containing (Iceland 2020c)	L.7 Develop specific emission factors/binding factors for wetlands
2021	Law on Environmental Impact Assessment and Planning—2ii(f) and 2iv(a) (Iceland 2021b)	Contains directions on the need to assess impacts any action might have on vulnerable and protected areas such as wetlands
2021	Wetlands Protection Plan released (Iceland 2021a)	12 Actions (Table 2)

**Table 3** (continued)

Year	Action	Description
2021	Amendment to the 2003 Law on taxable income (Iceland 2021c)	Makes allowances for businesses to make deductions from income for businesses donations and contributions to actions contributing to carbon offsetting and financial contributions to wetlands restoration and conservation (not more than 1,5% of revenues annually)
2024	National Planning Strategy released with wetlands criteria	A.3.6: Establish a policy on protecting and restoring wetlands and implemented it in planning provisions on land use with the aim of conserving carbon and protecting biodiversity C.1. Rural planning shall establish a land-use policy that reduces greenhouse gas emissions and increases carbon sequestration, through afforestation, wetland, and soil restoration C. 5. Urban planning will establish a policy to reduce greenhouse gas emissions and carbon sequestration within urban areas, with regards to the protection of wetlands, forestry, and carbon sequestration in bedrock

wetlands restoration into its environmental policy, (Þjóðkirkjan 2024) restoring 18.5 ha between 2021–2022. The National Power Company (NPC) is engaged at the intersection of energy development and wetland conservation, including Ramsar sites. Although its environmental strategy (Landsvirkjun 2024) does not link wetlands to climate change commitments, the NPC acknowledges the value of restoration for climate mitigation, while emphasizing that it cannot replace the need for emission reductions from other sectors. In recent years, it provided small grants for restoration projects e.g. (Landsvirkjun 2023) and collaborated with the Land and Forestry Agency, restoring 30.5 hectares of wetlands and monitoring the outcomes of restoration in two wetlands (Áskelsdóttir et al. 2022). From 2001–2014, the Road and Coastal Administration (RCA), restored 383,8 ha of wetlands, and its 2016–2017 annual reports mention an agreement with the Ministry of Infrastructure to replace wetlands disturbed by road construction with restored wetlands of equal or greater size as a mitigation measure (Vegagerðin 2016, 2017). The RCA also commissioned a report exploring the potential for coastal wetland restoration, drawing on lessons learned from other countries (Sturlaugsdóttir 2018). However, the RCA's 2019–2022 annual reports do not mention wetland restoration, or contain information regarding the extent of wetlands disturbed by roadworks. Their 2024–2028 strategy also does not include any reference to wetlands, creating uncertainty about their current approach towards wetlands including the outcome of the above-mentioned agreement, and whether they have continued restoration efforts (Vegagerðin 2024).

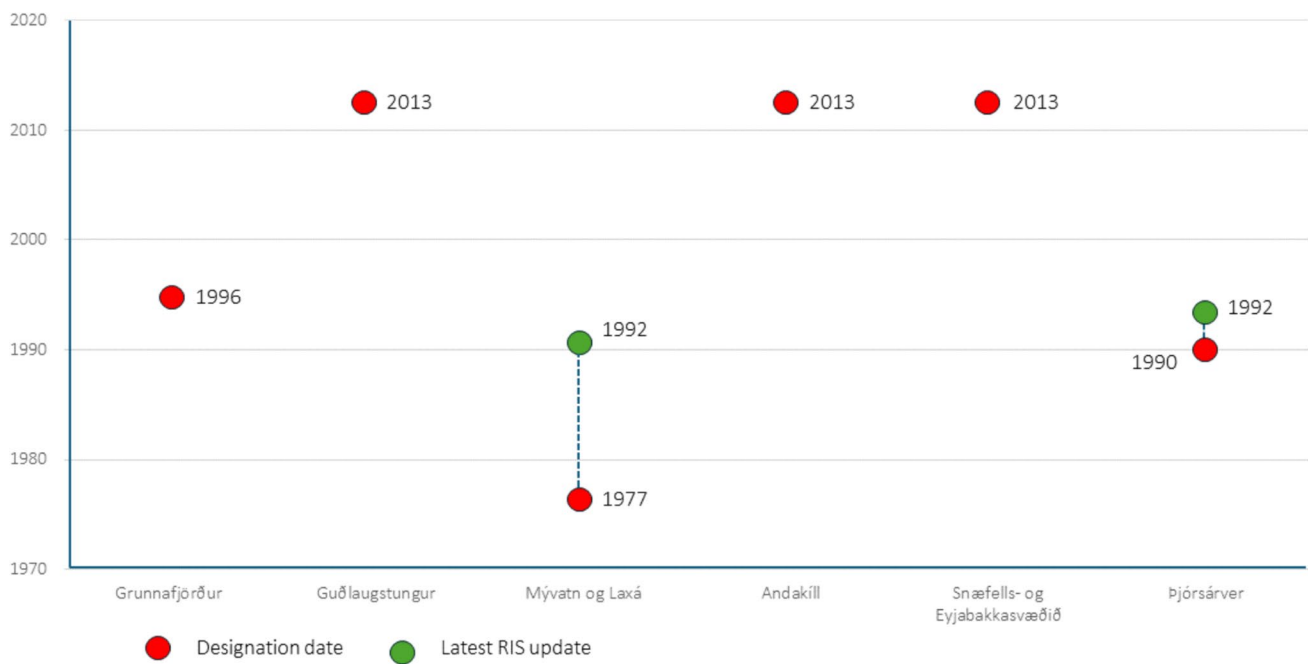
### Is Iceland Reporting Progress to the Ramsar Secretariat?

Iceland is significantly behind in its obligatory Ramsar reporting, with its last NR submitted in 2018. Only two sites have received RIS updates since their designation i.e.

Þjórsárver and Mývatn og Laxá, and these were 32-years ago (Fig. 7). This fragmented and outdated information complicates the assessment of Iceland's Ramsar sites using Ramsar-derived information. Nearly half of all Arctic RIS sites have missed their required six-year updates, raising concerns regarding the reliability of the RIS in tracking and reporting wetland status, reflecting a global issue within Ramsar (Barry 2024; Munguía and Heinen 2021; Davidson et al. 2020). Iceland's NRs, though more current, are still six years old and often lack detail or supporting documentation. These delays may be due to burdensome reporting requirements, limited resources within Icelandic reporting bodies, overlaps between NR and RIS obligations, or a reluctance to report on poorly performing commitments. Similar delays are observed in other Arctic states, with only Iceland and Russia behind in NR submissions (Barry 2024).

### Has Iceland Established Management, and Restoration Plans for its Most Important Wetlands?

Three of Iceland's Ramsar sites, Andakil, Mývatn-Laxá, and Snæfell and Eyjabakkar, have management plans, of these the plan for Mývatn-Laxá has expired and it is being revised (Umhverfisstofnun 2025). In 1992, Iceland reported that plans for Þjórsárver and Grunnafjörður were under development, and a management plan for Guðlaugstungur was reported in 2013 as being in preparation, however, no updates have since been provided on the status of these plans (Table 2). As a result, 60.4% of the areas covered by Iceland's Ramsar sites, 77,660 hectares, lack management plans. No evaluations of the effectiveness of existing management plans have been conducted, making it challenging to assess their impact or success. Given the necessity of clear and transparent management regimes to effective management this lack of management regimes for over half of Iceland's Ramsar areas is concerning. The assignment



**Fig. 7** RIS site updates (Ramsar 2024)

of responsibility to oversee restoration efforts to the Land and Forest Agency has helped improve coordination and transparency regarding securing approval to embark on and complete restoration initiatives. However, the restoration database managed by this Agency is incomplete as there are inconsistencies when compared with data from other sources e.g. it doesn't contain records before 2016.

### Is Iceland Putting in Place Measures Necessary to Facilitate Progress Towards Ramsar's Goals?

Considering the responses to questions 5.1–5.4, it is clear that Iceland has been putting in place measures to support Ramsar implementation. However, the absence of Iceland's 2018 NR and significant delays in updating RIS site data means that conclusions based solely upon Iceland's Ramsar reporting would be unreliable, being based upon fragmented and out-of-date data. Similarly, the lack of management plans for three of Iceland's six Ramsar sites means a key component to ensure progress towards Ramsar's goals is missing.

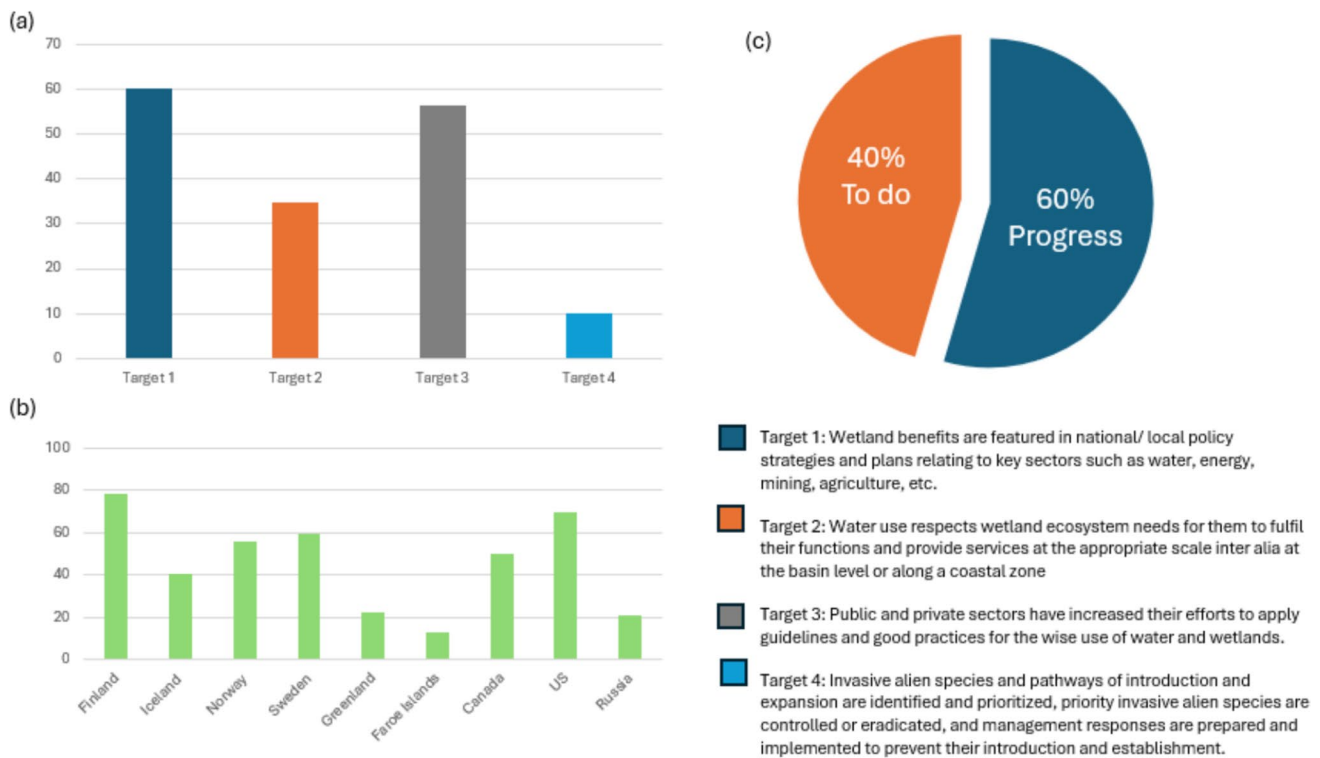
### Progress towards Ramsar goals

The Ramsar Strategic Plan contains four strategic goals, each with a series of targets designed to monitor progress towards implementation. Under each target, a suite of indicators allows for the evaluation of progress by Iceland towards

each target (Ramsar 2022b). This section examines the status of Iceland's advancement towards each goal and provides a comparative analysis with other Arctic states. As previously noted, information gaps and outdated information were supplemented with updates from official Icelandic government agencies and publications.

### Goal 1: Addressing Drivers of Wetland Loss and Degradation

Iceland has achieved 60% progress towards Goal 1, surpassing Greenland and the Faroe Islands but trailing other Arctic states. Target 1 shows the highest progress at 60%, followed by Target 3 at 56%, Target 2 at 35%, and Target 4 at 10% (Fig. 8). In 2018, Iceland reported having a partial national wetland management strategy, which has since been expanded to include Iceland's Wetlands Protection Action Plan developed as part of Iceland's Climate Change Action Plan (Iceland 2021a), though this has not yet been reported to Ramsar. Responses to Target 1 noted that wetland benefits are featured in strategies, and plans relating to key sectors including water, agriculture, tourism, infrastructure, and forestry, but specifics are lacking (see Sect. 5.2 for more detail). Under Target 2, Iceland noted it planned to use constructed wetlands for sewage treatment but provided no details. Some responses suggest limitations regarding the usefulness of some of these indicators e.g. the response to the question "How is the functional status of wastewater treatment plants?" simply stated "Functional."



**Fig. 8** (a) Progress towards each target under Goal 1 (b) Progress by each Arctic state towards Goal 1; and (c) Overall progress by Iceland towards Goal 1

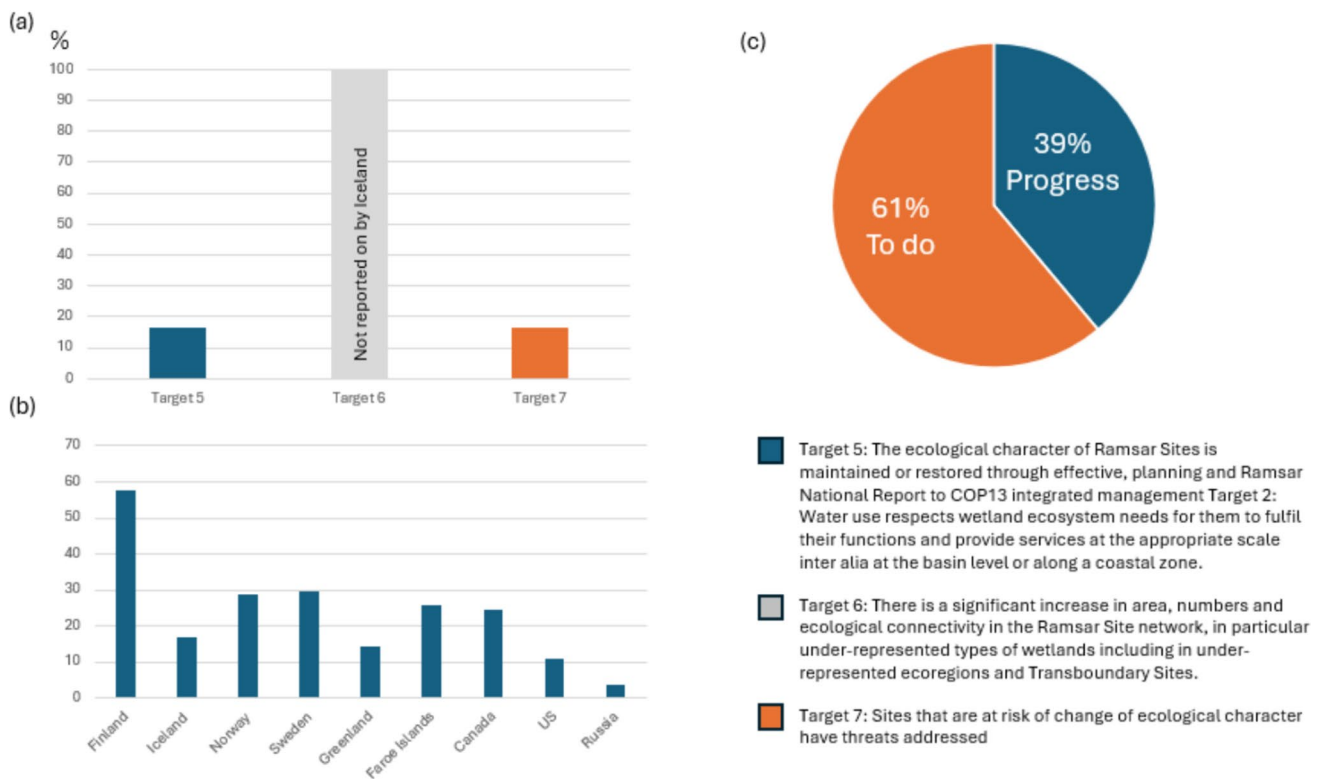
Under Target 3, Iceland reported that the private sector was partially encouraged to apply Ramsar's wise use principles through Environmental Impact Assessments. However, confusingly private sector involvement in Ramsar site management was also deemed irrelevant, despite the multiple uses of Ramsar sites for farming, industry, and tourism. Some examples of "partial" engagement were provided, primarily the establishment of the Wetlands Fund NGO, aimed at reducing greenhouse gas emissions through wetlands restoration. Target 4 responses highlighted actions to incentivize wetland conservation, including ending subsidies for ditch drainage and incorporating wetlands conservation and restoration actions in Iceland's Climate Change Action Plan designed to preserve carbon in wetlands. Additionally, it was noted that Iceland's urban and rural planning policies support wetlands restoration through the 2024–2038 National Planning Strategy (Iceland 2024b), although while a license is required to restore wetlands, this is not the case when draining wetlands.

Under Target 4, Iceland reported it lacked a national inventory of IAS that impact the ecological character of wetlands and does not have national policies or guidelines in place for IAS control and management in wetlands. While the 2018 NR did not mention plans to develop such tools, it noted municipalities had eradicated hogweed species including *Heracleum mantegazzianum*, *H. persicum*, and *H.*

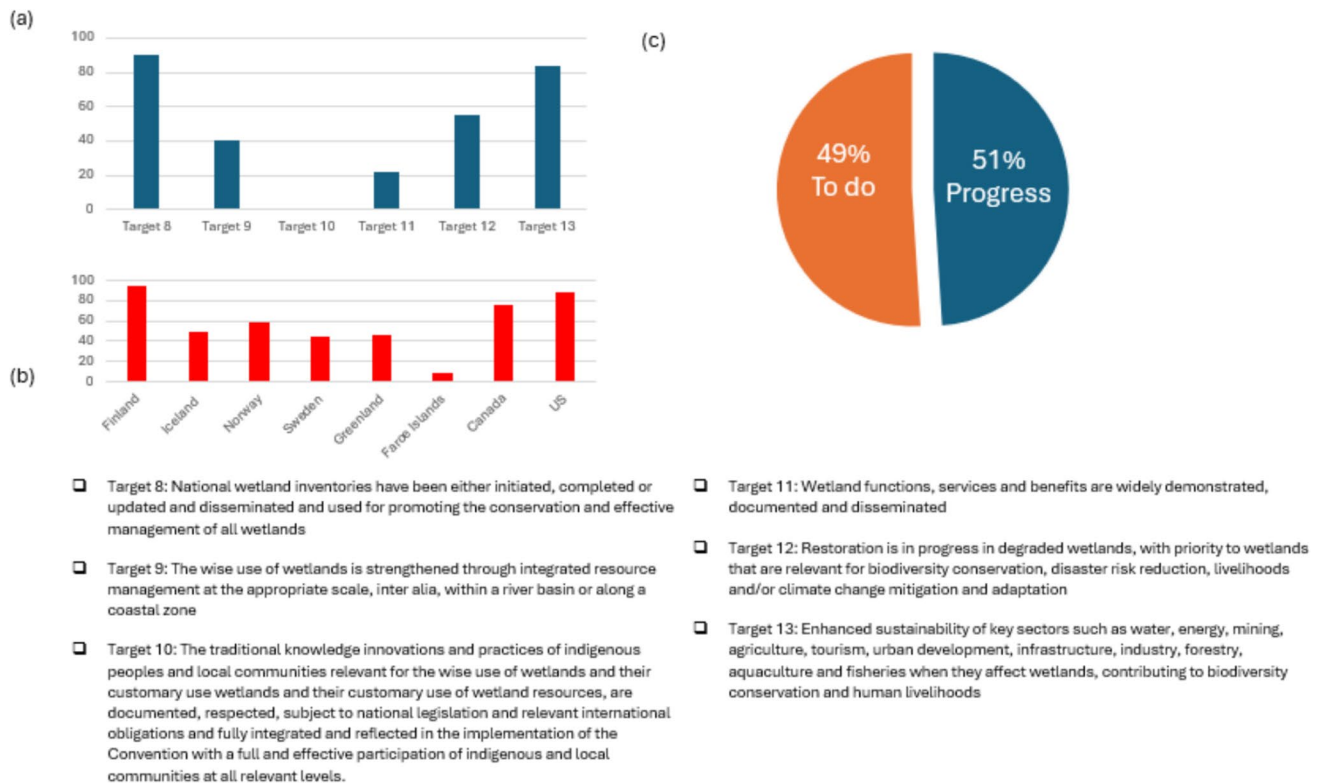
*sosnowskyi*; that efforts were underway to eradicate *Lupinus nootkatensis* and *Anthriscus sylvestri* from protected areas; and that there are ongoing efforts to eradicate *Neovison vison*. See Sect. 5.2 for details on NOBANIS.

## Goal 2: Effectively Conserving and Managing the Ramsar Site Network

Targets 5–7 track progress towards Goal 2, with ten indicators designed to evaluate progress towards these targets (Fig. 9). Overall, Iceland has made little progress, only 16.7%, towards implementing Goal 1. This places Iceland behind other Arctic states, except for Russia, the US, and Greenland. Target 5 shows the most progress for Iceland, at 33.3%, followed by Target 7 at 16.7%. No Arctic state reported on Target 6, which focuses on increasing the extent of protected wetlands and ecological connectivity in the Ramsar network. National strategies and site management plans are key to ensuring effective implementation of Ramsar, however, apart from Iceland, only Finland and Canada have national strategies and priorities in place to facilitate designation of Ramsar Sites. Sweden and the US have no plans. Three of Iceland's Ramsar sites have management plans or other management measures in place, and according to Iceland's 2018 NR each of its Ramsar sites has a cross-sectoral management committee (Table 2).



**Fig. 9** (a) Progress by Iceland towards each target under Goal 2 (b) Progress by each Arctic state towards Goal 2; and (c) Overall progress by Iceland towards Goal 2



**Fig. 10** (a) Progress towards each target under Goal 3 (b) Progress by each Arctic state towards Goal 3; and (c) Overall progress by Iceland towards Goal 3

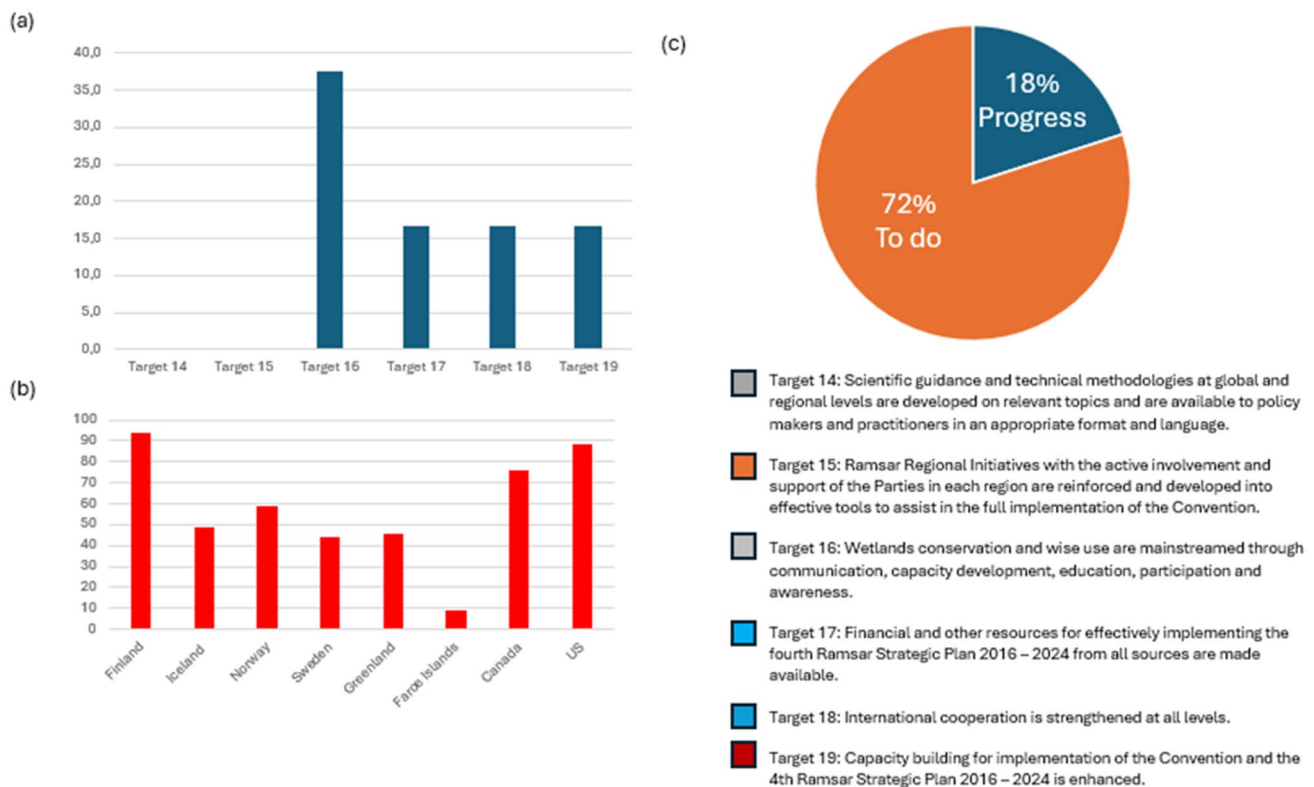
### Goal 3: Wisely Using All Wetlands

Targets 8–13 track progress towards Goal 3, with twenty-nine indicators designed to evaluate progress towards these targets (Fig. 10). Overall, Iceland has achieved 48.6% progress, falling behind Finland, Norway, Canada, and the US. However, Iceland is slightly ahead of Greenland and Russia, and significantly ahead of the Faroe Islands. Among the targets, Target 8 has shown the most progress, followed by Targets 13, 12, 9, and 11. No information was reported on Target 10, which is not relevant for Iceland given its focus on Indigenous Peoples and their knowledge. In 2018, Iceland reported having a National Wetlands Inventory. However, the status of actions C.1–5 (Table 2) outlined in its Wetlands Protection Plan (Iceland 2021a) suggest this inventory is unsatisfactory. A search of the National Mapping Agency returns several different wetland data layers (LMI 2024), while the Agricultural University provides an additional source (LBHI 2024), making it unclear which is the official national inventory or how these different sources are connected. The 2018 NR also notes that this inventory is accessible to all stakeholders, but upon closer examination, it is not easily accessible and appears fragmented. Iceland's 2012 and 2015 NRs reported the ecological status of its Ramsar sites as improving with no change in wetlands (Iceland

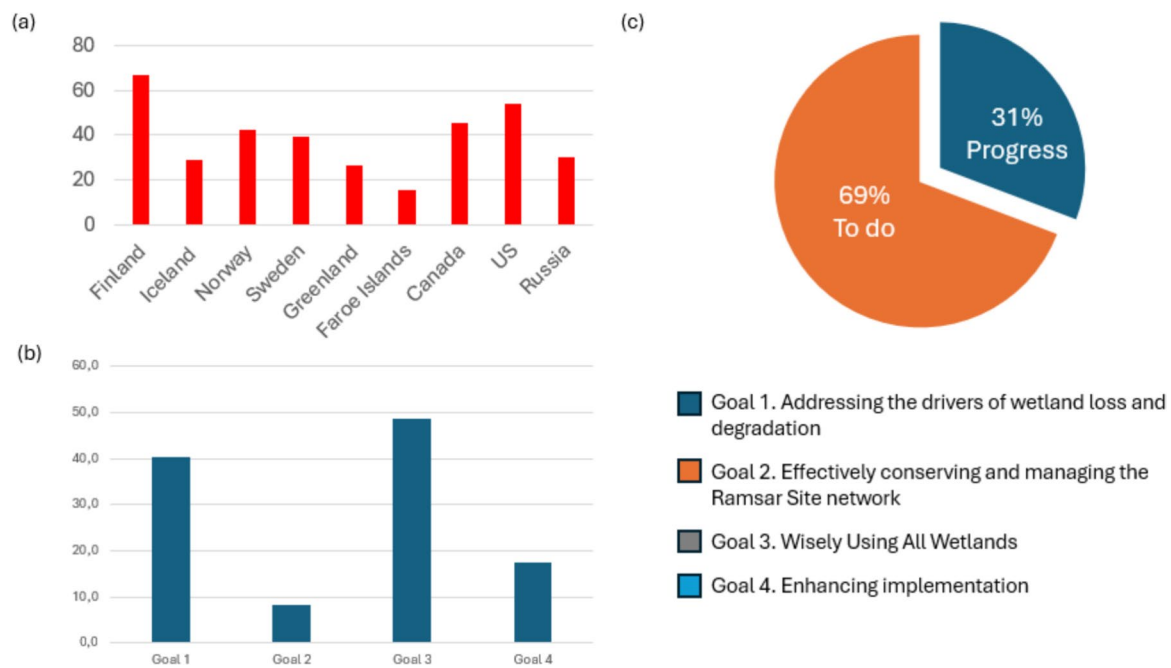
2012, 2015b), while in its 2018 NR reported that the overall ecological status of its wetlands had deteriorated (Iceland 2018b), a situation mirrored in the Faroe Islands, Norway, Sweden, and the US. Reasons for this deterioration are not provided, making it difficult to identify causes, aside from Climate Change. This lack of specificity may reflect limitations in the ability of NRs to capture nuances in the status and trends of wetlands.

### Goal 4: Enhancing Implementation

Iceland has made limited progress toward Targets 14–19, achieving only 18%, the lowest among Arctic states (Fig. 11). The highest progress was on Target 16 at 38%, with Targets 17–19 each at 17%. No Arctic state reported on Target 14, focused on providing scientific guidance to policymakers and practitioners. A worrying absence given the importance of guidance and advice to policy and decision-makers on wetlands management. Iceland also did not report on Target 15, related to cooperation on Ramsar Regional Initiatives. Under Target 16 which highlights participation in wetland conservation awareness and management initiatives, Iceland reported establishing visitor centres and promoting stakeholder involvement but provided few details. Iceland has no national wetlands Committee and establishment of such a



**Fig. 11** (a) Progress towards each target under Goal 4 (b) Progress by each Arctic state towards Goal 4; and (c) Overall progress by Iceland towards Goal 4



**Fig. 12** (a) Progress of Iceland towards each goal (b) Progress by each Arctic state towards Ramsar goals; and (c) Overall progress by Iceland towards Ramsar goals

committee was highlighted as a key priority including the need to establish mechanisms for cooperation and information sharing among MEA focal points. Mechanisms to share Ramsar guidelines with site managers and government bodies were partially implemented, but specifics were lacking. Awareness initiatives have largely been limited to news items e.g. on World Wetlands Day. The most significant action taken has been creation of the Wetlands Fund NGO and use of its website [www.votlendi.is](http://www.votlendi.is) to communicate restoration and conservation efforts. However, the Wetlands Fund has subsequently encountered challenges, and its website is currently not updated. Participation in knowledge-sharing activities, such as with Scottish Natural Heritage, has occurred. Iceland has not effectively used NRs to monitor Convention implementation, raising further concerns about NR format and usefulness. Iceland has paid its financial contributions to Ramsar but provided no additional support to developing states.

### Overall Progress Towards Achieving Ramsar Goals

This evaluation framework provides indications of progress towards Ramsar's goals. However, it can be challenging to extrapolate from NRs and the RIS the extent to which self-reporting is accurate. This is further complicated by delays in Iceland's Ramsar reporting. With these caveats in mind, Iceland has made overall progress of 31% towards achieving Ramsar's goals, putting Iceland ahead of the Faroe Islands but behind all other Arctic states. Goal 3 has seen the most progress, followed by Goals 1, 4, and 2 (Fig. 12).

### Conclusions

Public attention was first drawn to the decline of Icelandic wetlands by Halldor Laxness, Iceland's Nobel laureate in 1970 via an article titled "War against the countryside," published in *Morgunblaðið*, the country's main paper where Laxness described the thoughtless destruction of large areas of wetlands with serious consequences for biodiversity (Laxness 1970). The debate sparked by Laxness continues to this day among landowners, experts, and the state, and although Iceland has taken significant steps towards wetland conservation and restoration, the ecological character and extent of Iceland's wetlands continue to decline.

The evaluation framework used in this paper allows for an assessment of Iceland's progress towards implementing and MEA (Ramsar) and offers an approach that could be applied to other MEAs at the national level. This model allowed an evaluation of Iceland's progress towards Ramsar's objectives and comparisons with neighbouring Nordic and Arctic states. However, due to delays in Iceland's Ramsar reporting additional information had to be obtained in order to effectively utilize this framework. It is important to take this caveat into account when applying this framework at a national level. The outcomes of its application in Iceland support both Barry's (2024) findings regarding Ramsar implementation in the Arctic and the RAW policy recommendations and identifies actions needed to improve our understanding of Iceland's wetlands, support management

efforts, establish a baseline for measuring progress towards Ramsar implementation, and contribute to improvements in wetland conservation:

## Recommendations

### Reporting:

- *Update Iceland's NR and RIS reporting obligations with clarity regarding who is responsible for this reporting:* Iceland's failure to meet its Ramsar reporting obligations undermines the reliability of Ramsar-derived information. Meeting these requirements would allow for a better understanding of Iceland's efforts to achieve Ramsar goals.
- *Streamline Ramsar reporting requirements and assess how data provided could be more useful.* The amount of information required may be contributing to an overly burdensome reporting system and is a factor causing reporting delays. NRs consist of 106 indicators, and reporting on each can be challenging, especially for smaller bureaucracies like Iceland's. Given the often-low level of detail provided, the usefulness of some indicators is unclear; and could benefit from consideration as to their purpose and how or if they are of practical use.
- *Align Ramsar reporting requirements with other MEAs, particularly the Global Biodiversity Framework (GBF)* would alleviate reporting burdens, especially for small states like Iceland.

### Site designations:

- To support resilience of Iceland's wetlands and improve their management, it is important to understand why no new site designations have been made since 2013. Is this due to challenges in agreeing on possible candidates? Or is it linked to a growing emphasis on harnessing Iceland's natural resources? Alternatively, is it because of insufficient incentives to encourage compliance, leading Iceland to prioritize obligations with stronger consequences for non-compliance?

### National Inventory:

- *Ensure access to a reliable and updated National wetland inventory.* A reliable inventory is essential to effective wetlands management and understanding status and trends in Iceland's wetlands, and challenges being faced.
- *Ensure a reliable baseline on the carbon capture and release potential of Icelandic wetlands* to 1) inform landowners' decision-making regarding land allocation

for restoration; 2) ensure more accurate calculations for Iceland's climate change accounting including emission per unit area, and the overall size of drained areas; 3) establish realistic restoration goals; and 4) capture the scale of emissions across different wetland areas.

- *Make sure such baseline information is easily accessible and communicated to stakeholders,* allowing for more productive debate regarding the benefits of wetlands sequestration and biodiversity enrichment.

### Management:

- *Develop site management plans for each of Iceland's Ramsar sites and evaluate their effectiveness.* Only half of Iceland's Ramsar sites have management plans, leaving 77,660 Ha without such regimes. The application of the Ramsar Site Management Effectiveness Tracking Tool (R-METT), adopted at COP12 to support improving site management (Ramsar 2015), could provide insights into what is working and what is not in management of Iceland's Ramsar sites.
- *Clarify the extent of measures whereby wetlands are restored as a compensation measure e.g. by the RCA.*

The successful conservation and restoration of Iceland's wetlands depends upon how effectively the wetlands actions defined in its Climate Change Action Plan are implemented. Key to kickstarting restoration will be Iceland's commitment to restoring state-owned drained wetlands. The Icelandic state owns 310 farms containing drained wetlands covering 18,030 ha which emit annually an estimated 351,585 tonnes of CO<sub>2</sub>. Thus far restoration efforts on these lands have been confined to 80 ha, resulting in the sequestration of approximately 1,560 tonnes of CO<sub>2</sub>. However, there is potential for restoring an additional 12,750 ha of disturbed wetlands—almost three times the area covered by Iceland's 2024–2029 restoration goals. These lands are not classified as fields or farmland and could potentially be suitable for restoration. The state has expressed interest and willingness to explore their restoration (Iceland 2022c) offering a way to break the current impasse in securing land for restoration.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s13157-025-01913-z>.

**Acknowledgements** I would like to thank Hlynur Óskarsson, Sunna Áskelsdóttir, Andrés Skúlason, Hugl Ólafsson, Snorri Sigurðsson, Brynhildur Bjarnadóttir, Hrefna Jóhannesdóttir, and Ævar Pétursson for all their helpful information, observations, and insights during the development of this paper.

**Author Contributions** The author “Tom Barry” is responsible for conducting all writing, material preparation, data collection and analysis.

**Data Availability** The author confirms that all data generated or analysed during this study are included in this article.



- heimt-votlendis-1996-2006-sk%C3%BDrsla-Votlendisnefndar.pdf. Accessed 4 Feb 2025
- Gísladóttir F, Guðmundsson J, Áskelsdóttir S (2009) Mapping and density analyses of drainage ditches in Iceland. Agricultural University of Iceland, Hvanneyri. From [https://www.researchgate.net/publication/259218476\\_Mapping\\_and\\_density\\_a](https://www.researchgate.net/publication/259218476_Mapping_and_density_a). Accessed 3 Feb 2025
- Guðmundsson Þ, Þorvaldsson G (2018) Meira um losun gróðurhúsalofttegunda úr votlendi. Bændablaðið. From <https://www.bbl.is/frettir/meira-um-losun-grodurhusalofttegunda-ur-votlendi>. Accessed 3 Feb 2025
- Iceland (2004) Lög um verndun mývatns og laxár í suður-þingeyjarsýslu. Icelandic Government. From <https://www.althingi.is/lagas/154b/2004097.html>. Accessed 3 Feb 2025
- Iceland (2008) Wetland restoration and management: background paper produced by Iceland for AWG-KP 6, part I meeting in Accra, August 2008. Retrieved 5 February, 2025 from [https://unfccc.int/files/kyoto\\_protocol/application/pdf/iceland.pdf](https://unfccc.int/files/kyoto_protocol/application/pdf/iceland.pdf)
- Iceland (2009) Informal data submission on LULUCF to the Ad-Hoc working group on further commitments for annex I parties under the Kyoto protocol (AWG-KP). Icelandic Government, Reykjavík. From [https://unfccc.int/files/kyoto\\_protocol/application/pdf/awgkplulucficeland081209.pdf](https://unfccc.int/files/kyoto_protocol/application/pdf/awgkplulucficeland081209.pdf). Accessed 4 Feb 2025
- Iceland (2011) Mývatns og laxá: verndaráætlun 2011–2016. Icelandic Environment Agency. From <https://ust.is/library/Skrar/utgefing-efni/Verndaraaetlanir/verndar%20%20m%20%20m%20%20g%20og%20Lax%20%20a%20l-r-www.pdf>. Accessed 4 Feb 2025
- Iceland (2012) Ramsar National Report to COP11: Iceland. Accessed from <https://www.ramsar.org/sites/default/files/documents/pdf/cop11/nr/cop11-nr-iceland.pdf>
- Iceland (2013) Lög um náttúruvernd. Icelandic Government. Accessed January 6, 2025, from <https://www.althingi.is/altext/141/s/1395.html>
- Iceland (2015a) Lög um breytingu á lögum um náttúruvernd, nr. 60/2013, með síðari breytingum (varúðarregla, almannaréttur, sérstök vernd, framandi tegundir o.fl.). Accessed September 7, 2024, from Icelandic Government: <https://www.althingi.is/altext/stj/2015.109.html>
- Iceland (2015b) Ramsar National Report to COP12: Iceland. Ramsar Secretariat. Accessed from [https://www.ramsar.org/sites/default/files/documents/2014/national-reports/COP12/cop12\\_nr\\_iceland.pdf](https://www.ramsar.org/sites/default/files/documents/2014/national-reports/COP12/cop12_nr_iceland.pdf)
- Iceland (2016a) Landsáætlun um innviði. Reykjavík: Icelandic Government. Accessed February 6, 2025, from <https://www.stjornarradid.is/verkefni/umhverfi-og-natturuvernd/natturuvernd/ferdamenn-og-nattura/landsaaetlun-um-innvidi/>
- Iceland (2016b) Endurheimt votlendis; Aðgerðaáætlun Samráðshópur um endurheimt votlendis. Reykjavík: Icelandic Government. Accessed February 6, 2025, from <https://www.stjornarradid.is/gogn/rit-og-skyrslur/stakt-rit/2016/04/06/Endurheimt-votlendis-Adgerdaaetlun/>
- Iceland (2018a) Ramsar national report to COP13: Iceland. Gland: Ramsar secretariat. Retrieved from [https://www.ramsar.org/sites/default/files/documents/importftp/COP13NR\\_Iceland\\_e.pdf](https://www.ramsar.org/sites/default/files/documents/importftp/COP13NR_Iceland_e.pdf)
- Iceland (2018b) Loftslagsbreytingar og áhrif þeirra á Íslandi: skýrsla vísindanefndar um loftslagsbreytingar. Retrieved 3 February, 2025 from <https://www.vedur.is/media/loftslag/Skyrsla-loftslagsbreytingar-2018-Vefur-NY.pdf>
- Iceland (2019a) Verndarsvæði í andaklí í borgarbyggð: stjórnunar- og verndaráætlun 2019–2028. Icelandic Environment Agency. Retrieved 5 February, 2025 from <https://www.ust.is/library/Skrar/Einstaklingar/Nattura/Verndaraaetlanir/Stj%20%20b3nunar%20og%20verndar%20%20a%20l-r-www.pdf>
- Iceland (2019b) Framtíðarsýn og leiðarljós íslenskrar ferðapjónustu til 2030. Retrieved 2 February, 2025 from <https://www.stjornarradid.is/verkefni/atvinnuvegir/ferdathjonusta/islensk-ferdathjonusta-til-2030/framtidarsyn-og-leidarljós-islenskrar-ferdathjonusta-til-2030/>
- Iceland (2020a) Aðgerðaáætlun í loftslagsmálum: Aðgerðir íslenskra stjórnvalda til að stuðla að samdrætti í losun gróðurhúsalofttegunda til 2030. Reykjavík: Iceland Ministry of the Environment and Natural Resources. Accessed February 1, 2025, from <https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Adgerdaaetlun%20i%20loftslagsmalum%20onnur%20utgafa.pdf>
- Iceland (2020b) Lög um breytingu á lögum um loftslagsmál, nr. 70/2012, með síðari breytingum (skuldbindingar og losunarmheimildir). Icelandic Government. Accessed August 6, 2024, from <https://www.althingi.is/altext/stj/2020.098.html>
- Iceland (2020c) Umbótaáætlun 2020–2023 Vegna bókhalds Íslands um losun gróðurhúsalofttegunda og bindingu kolefnis vegna landnotkunar. Áætlun unnin í samræmi við aðgerðaáætlun Íslands í loftslagsmálum. Umhverfis- og auðlindaráðuneytið. Accessed February 6, 2025, from <https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Umbotaaetlun%202020-2023.pdf>
- Iceland (2021a) Landgræðsluáætlun 2021–2030. Land and forest Iceland, Reykjavík. From <https://land.is/wp-content/uploads/2022/02/Landgraedsluaetlun-2021-2030.pdf>. Accessed 3 Feb 2025
- Iceland (2021b) Verndun votlendis aðgerðir I4 á grundvelli aðgerðaáætlunar í loftslagsmálum. Icelandic Government, Reykjavík. From <https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Verndun%20votlendis%202021.pdf>. Accessed 6 Feb 2025
- Iceland (2021c) Lög um umhverfismat framkvæmda og áætlana. Icelandic Government. Accessed February 3, 2025, from <https://www.althingi.is/lagas/154b/2021111.html>
- Iceland (2022a) Stjórnunar- og verndaráætlun Vatnajökulsþjóðgarðs: Náttúruvernd, útivist og byggðapróun. Vatnajökulsþjóðgarður. Accessed February 5, 2025, from [https://prismic-io.s3.amazonaws.com/vatnajokulsthjodgardur/2c39eb78-dd8b-4122-ad29-300826409421\\_3.-utgafa-sogv-med-samth.-vidaukum-og-breytingum-juli-2022-hreint-skjal.pdf](https://prismic-io.s3.amazonaws.com/vatnajokulsthjodgardur/2c39eb78-dd8b-4122-ad29-300826409421_3.-utgafa-sogv-med-samth.-vidaukum-og-breytingum-juli-2022-hreint-skjal.pdf)
- Iceland (2022b) Landbúnaðarstefnu til ársins 2040. Icelandic Government. Accessed February 6, 2025, from <https://www.althingi.is/altext/153/s/1930.html>
- Iceland (2022c) Svar matvælaráðherra við fyrirspurn frá Þorbjörgu Sigríði Gunnlaugsdóttur um endurheimt votlendis á ríkisjörðum. Icelandic Government. Accessed August 8, 2024, from <https://www.althingi.is/thingstorf/thingmalalistar-efrir-thingum/ferill/152/134/?ltg=152&mn=134>
- Iceland (2024a) Grænir hvatar fyrir bændur. Reykjavík: Icelandic Government. Accessed August 7, 2024, from <https://www.althingi.is/thingstorf/thingmalalistar-efrir-thingum/ferill/154/43/?ltg=154&mn=43>
- Iceland (2024b). Frumvarp til laga: um breytingu á lögum um verndar- og orkunýtingaráætlun, nr. 48/2011 (virkjunarkostir í vindorku). Icelandic Government, Reykjavík. From <https://www.althingi.is/thingstorf/thingmalalistar-efrir-thingum/ferill/154/900/?ltg=154&mn=900>. Accessed 7 Aug 2024
- Iceland (2024c) Þingsályktunum landsskipulagsstefnu fyrir árin 2024–2038 ásamt fimm ára aðgerðaáætlun fyrir árin 2024–2028. Reykjavík: Icelandic Government. Accessed February 5, 2025, from <https://www.landsskipulag.is/>
- Iceland (2024d) Lög um náttúruvernd. Icelandic Government. Retrieved August 7, 2024, from <https://www.althingi.is/lagas/154b/2013060.html>
- Iceland Environment Agency (2024) Losun gróðurhúsalofttegunda á Íslandi: samantekt - söguleg losun til 2022. From <https://ust.is/loft/losun-grodurhusalofttegunda/stada-losunar-a-islandi/#losun-lulucf>. Accessed 25 June 2024

- IINR (2018) Nature conservation register. From <https://www.ni.is/is/midlun/naturuminjaskra#Tillogur>. Accessed 5 Feb 2025
- INTOSAI (2007) Auditing biodiversity: guidance for supreme audit institutions international organization of supreme audit institutions (INTOSAI): working group on environmental auditing. INTOSAI. From <https://wgea.org/media/pwunkx1m/guidance-for-supreme-audit-institutions.pdf>. Accessed 2 Feb 2025
- INTOSAI (2010) Auditing biodiversity: guidance for supreme audit institutions. INTOSAI working group on environmental auditing (WGEA). From [https://www.environmental-auditing.org/media/3235/eng07pr\\_fs\\_guidebiodiversity.pdf](https://www.environmental-auditing.org/media/3235/eng07pr_fs_guidebiodiversity.pdf). Accessed 4 Feb 2025
- IPBES (2019) Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services. IPBES Secretariat, Bonn. From <https://www.ipbes.net/global-assessment>. Accessed 3 Feb 2025
- Keller M, Stefani M, Einarsdóttir SR, Helgadóttir ÁS, Guðmundsson J, Snorrason A, ... Tinganelli L (2019) Icelandic national inventory report 2019. Emissions of greenhouse gases in Iceland from 1990–2017. The Environment Agency of Iceland, Reykjavík. From <https://unfccc.int/documents/194840>. Accessed 2 Feb 2025
- Kingsfort RT, Bion G, Finlayson CM, Falster D, Fitzsimons JA, Gawlick DE, ... Thomas RF (2021). Ramsar Wetlands of international importance—improving conservation outcomes. *Frontiers in Environmental Science* (9), 1–6. <https://doi.org/10.3389/fenvs.2021.643367>
- Kristjánsson H (2022) Langtímalosun kolefnis úr framreistu ræktarlandi er líklega margfalt minni en fullyrt hefur verið. Bændablaðið. From <https://www.bbl.is/frettir/frettaskyring/langtimalosun-kolefnis-ur-framraestu-raektarlandi-er-liklega-margfalt-minni-en-fullyrt-hefur-verid>. Accessed 2 Feb 2025
- Land og Skógur (2022) Landgræðsluáætlun og landsáætlun í skógrækt: Stefna og framtíðarsýn í landgræðslu og skógrækt til ársins 2031. Land og Skógur, Reykjavík. From <https://www.skogur.is/is/nyskograekt/landsaaetlun-i-skograekt/landsaaetlun-i-skoguraekt>. Accessed 5 Feb 2025
- Landsvirkjun (2023) Úthlutun úr Orkurannsóknasjóði 2023. From <https://www.landsvirkjun.is/uthlutun-orkurannoknasjods-2023>. Accessed 9 Aug 2024
- Landsvirkjun (2024) Lostlags-og umhverfisstefna. Landsvirkjun. From <https://www.landsvirkjun.is/loftslagsmal/loftslags-og-umhverfisstefna>. Accessed 9 Aug 2024
- Landvernd (2024) Náttúrukortið. From <https://landvernd.is/natturukortid/>. Accessed 4 Aug 2024
- Laxness H (1970 December 31) War against the Countryside. Morgunblaðið.
- LBHI (2024) Kortavefsjá landbúnaðarháskóla Íslands. Retrieved September 7, 2024, from <https://gis.lbhi.is/portal/apps/webappview/index.html?id=7c1134a79cc34c628ec0994c9beec898>
- LMI (2024) Icelandic mapping agency of Iceland. From <https://www.lmi.is/is/landupplýsingar/gagnagrunnar/is-50v/ornefnis50v>. Accessed 30 Aug 2024
- Ministerrad N (1973) Oversigt over vigtige våde fugleområder i Norden. Nordisk Ministerrad, Copenhagen
- Mitchell RB (2025) The international environmental agreements (IEA) database project. From <https://www.iea.ulaval.ca/en>. Accessed 3 Feb 2025
- Munguía SM, Heinen JT (2021) Assessing Protected Area Management Effectiveness: The Need for a Wetland-Specific Evaluation Tool. *Environmental Management* 68:773–784. <https://doi.org/10.1007/s00267-021-01527-1>
- Naingolan D, Pohjola J, Martinsen L, Gyldenkerne S, Elofsson K, Hasler B (2021) Enhancing carbon sequestration in forests agricultural lands and wetlands in the nordic countries: technical measures and policy instruments. Nordic Council of Ministers. From <https://www.norden.org/en/publication/enhancing-carbon-sequestration-forests-agricultural-lands-and-wetlands-nordic-countries>. Accessed 5 Feb 2025
- Náttúrufræðistofnun Íslands (2024a) Heiðgæð (Anser brachyrhynchus). From <https://www.ni.is/is/biota/animalia/chordata/aves/anseriformes/heidagaes-anser-brachyrhynchus>. Accessed 4 Aug 2024
- Náttúrufræðistofnun Íslands (2024b) Húsönd (Bucephala islandica). From <https://www.ni.is/is/biota/animalia/chordata/aves/anseriformes/husond-bucephala-islandica>. Accessed 4 Aug 2024
- Náttúrufræðistofnun Íslands (2025) Náttúruminjasrá. <https://www.ni.is/is/midlun/naturuminjaskra#Tillogur>. Accessed 8 Feb 2025
- Nielsson K (2016) Alkaline fens: valuable wetlands but difficult to manage. Nordic Council of Ministers. From <https://www.norden.org/en/publication/alkaline-fens>. Accessed 2 Feb 2025
- NOBANIS (2024) The north european and baltic network on invasive alien species (NOBANIS). From NOBANIS: <https://www.nobanis.org/>. Accessed 5 Feb 2025
- Nordic Council of Ministers (2004) Nordic wetland conservation. Nordic Council of Ministers. From <https://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A702196&andswid=2695>. Accessed 3 Feb 2025
- Ólafsson Þ (2020) Enn um endurheimt votlendis. Bændablaðið. From <https://www.bbl.is/skodun/lesendaryni/enn-um-endurheimt-votlendis>. Accessed 3 Feb 2025
- Pétursdóttir ÞW (2024) Landnýting og loftslag – losunarbókhald, loftslagsmarkmið og staða aðgerða. Loftslagsráð, Reykjavík. From <https://loftslagsrad.is/landnyting-og-loftslag/>. Accessed 2 Feb 2025
- Pörtner, H, Scholes R, Agard J, Archer E, Arneth A, Bai XB, ... Ngo H (2021) IPBES-IPCC co-sponsored Workshop Report: Biodiversity and Climate Change. IPCC-IPBES. <https://doi.org/10.5281/zenodo.4782538>
- Ramsar (1993) Ramsar information paper no. 6: the montreux record and the ramsar advisory missions. Ramsar Secretariat, Gland. From <https://www.ramsar.org/sites/default/files/documents/library/info2007-06-e.pdf>. Accessed 5 Feb 2025
- Ramsar (1994) Convention on wetlands of international importance especially as waterfowl habitat. Gland Ramsar. From [https://www.ramsar.org/sites/default/files/documents/library/current\\_convention\\_text\\_e.pdf](https://www.ramsar.org/sites/default/files/documents/library/current_convention_text_e.pdf). Accessed 6 Feb 2025
- Ramsar (2013) The Ramsar Convention Manual: a guide to the convention on wetlands. Gland: Ramsar. Retrieved 2 February, 2025 from <https://www.ramsar.org/sites/default/files/documents/library/manual6-2013-e.pdf>
- Ramsar (2015) Ramsar site management effectiveness tracking tool (R-METT) (Resolution XII.15). Gland: Ramsar Secretariat. Accessed from [https://www.ramsar.org/sites/default/files/documents/library/guide\\_r-mett\\_e.pdf](https://www.ramsar.org/sites/default/files/documents/library/guide_r-mett_e.pdf)
- Ramsar (2018) Global wetland outlook: state of the world's wetlands. Ramsar Convention Secretariat, Gland. From <https://www.global-wetland-outlook.ramsar.org/>. Accessed 3 Feb 2025
- Ramsar (2021) Global wetland outlook: special edition 2021. Gland: secretariat of the convention on wetlands. Retrieved February 2, 2025 from [https://static1.squarespace.com/static/5b256c78e17ba335ea89fe1f/t/61b8a904f3ceb458e9b5ca44/1639491853577748/Ramsar+GWO\\_Special+Edition+2021%E2%80%9393ENGLISH\\_WEB.pdf](https://static1.squarespace.com/static/5b256c78e17ba335ea89fe1f/t/61b8a904f3ceb458e9b5ca44/1639491853577748/Ramsar+GWO_Special+Edition+2021%E2%80%9393ENGLISH_WEB.pdf)
- Ramsar (2022a) SC59/2022 doc.11: effectiveness working group (EWG) final report. Ramsar Secretariat, Gland. From [https://www.ramsar.org/sites/default/files/documents/library/sc59\\_2022\\_11\\_ewg\\_report\\_e.pdf](https://www.ramsar.org/sites/default/files/documents/library/sc59_2022_11_ewg_report_e.pdf). Accessed 3 Feb 2025
- Ramsar (2022b) The 4th Strategic Plan 2016 – 2024. Ramsar Secretariat, Gland. From [https://www.ramsar.org/sites/default/files/documents/library/4th\\_strategic\\_plan\\_2022\\_update\\_e.pdf](https://www.ramsar.org/sites/default/files/documents/library/4th_strategic_plan_2022_update_e.pdf). Accessed 3 Feb 2025
- Ramsar (2023a) Worlds Wetlands Day. Accessed December 2023, from <https://www.worldwetlandsday.org/>

- Ramsar (2023b) The Ramsar Awards. Accessed February 5, 2025, from <https://www.ramsar.org/our-work/activities/ramsar-awards>
- Ramsar (2023c) The Convention on Wetlands' Programme on communication, capacity building, education, participation and awareness (CEPA). Accessed December 2023, from <https://www.ramsar.org/our-work/activities/cepa-programme>
- Ramsar (2024) Ramsar information service. Retrieved June 26, 2024, from [https://rsis.ramsar.org/ris-search/?language=en%26f\[0\]=regionCountry\\_en\\_ss%3AIceland%26pagetab=1](https://rsis.ramsar.org/ris-search/?language=en%26f[0]=regionCountry_en_ss%3AIceland%26pagetab=1)
- Seifollahi S, Kalantari Z, Destouni G (2019) Scoping for resilience and management of arctic wetland appendix a: scoping study of literature. CAFF Secretariat, Akureyri. From <http://hdl.handle.net/11374/2358>. Accessed 3 Feb 2025
- Snæbjörnsson A, Hjatardóttir D, Blöndal E, Petursson JG, Eggertsson O, Halldórsson O (2010) Athugun á notkun og varðveislu ræktanlegs lands (Committee report on land use. The use and preservation of arable land). Ministry of Fisheries and Agriculture, Reykjavík. From [https://www.stjornarradid.is/media/atvinnuvegaraduneyti-media/media/frettir/skyrsla\\_nefndar\\_um\\_landnotkun.pdf](https://www.stjornarradid.is/media/atvinnuvegaraduneyti-media/media/frettir/skyrsla_nefndar_um_landnotkun.pdf). Accessed 7 Jul 2024
- Sowińska-Świerkosz, B, García G (2022) What are Nature-based solutions (NBS)? Setting core ideas for concept clarification. *Nature-Based Solutions*, 100009(2). <https://doi.org/10.1016/j.nbsj.2022.100009>
- Statistics Iceland (2024) Statistics Iceland: land and air. From <https://statice.is/statistics/environment/land-and-air/>. Accessed 27 June 2024
- Sturlaugsdóttir H (2018) Endurheimt votlendis við sjó. Vegagerðin. From <https://www.vegagerdin.is/vegagerdin/gagnasafn/skyrslur/rannsoknaskyrslur/umhverfi/endurheimt-votlendis-vid-sjo>. Accessed 8 Aug 2024
- Þjóðkirkjan (2024) Umhverfisstefna þjóðkirkjunnar. From <https://kirkjan.is/kirkjan/graen-kirkja/umhverfisstefna/>. Accessed 8 Aug 2024
- Þorhallsdóttir ÞE, Óskarsson H (2017) Country chapter: Iceland. In H Joosten, F Tanneberger (Eds.), *Mires and peatlands of Europe: Status, distribution and conservation* (pp. 441–448). Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller). <https://doi.org/10.1111/rec.12865>
- Þorvaldsson GP (2021) Endurheimt votlendis verður að byggja á traustum grunni. Bændablaðið. From <https://www.bbl.is/skodun/lesendaryni/endurheimt-votlendis-verdur-ad-byggja-a-traustum-grunni>. Accessed 3 Feb 2024
- Umhverfisstofnun (2025) Stjórnunar- og verndaráætlanir. Umhverfisstofnun. From <https://www.ust.is/nattura/stjornunar-og-verndaraetlanir/>. Accessed 8 Feb 2025
- UNFCCC (2021) Resolution 75/317 adopted by the general assembly. From <https://documents.un.org/doc/undoc/gen/n21/238/18/pdf/n2123818.pdf?token=QPNjNettL0051TkQH6andfe=true>. Accessed 15 Jul 2024
- Van Geelen T, Hamman E (2017) The montreux record under the Ramsar convention: an effective mechanism for promoting state party compliance? Asian Wetland Symposium. Accessed from [https://eprints.qut.edu.au/115001/15/Hamman\\_Montreux%2BRecord\\_2017.pdf](https://eprints.qut.edu.au/115001/15/Hamman_Montreux%2BRecord_2017.pdf)
- Vegagerðin (2016) Ársskýrsla Vegagerðarinnar 2016. Vegagerðin. From <https://www.vegagerdin.is/vegagerdin/gagnasafn/skyrslur/arsskyrslur/vegagerdin/arsskyrsla-2016>. Accessed 8 Aug 2024
- Vegagerðin (2017) Ársskýrsla Vegagerðarinnar 2017. Vegagerðin. From <https://www.vegagerdin.is/vegagerdin/gagnasafn/skyrslur/arsskyrslur/vegagerdin/arsskyrsla-vegagerdarinnar-2017>. Accessed 9 Aug 2024
- Vegagerðin (2024) Vegagerðin strategy 2024–2028. Vegagerðin. From <https://www.vegagerdin.is/vegagerdin/gagnasafn/stefnur/stefna-2024-2028>. Accessed 8 Aug 2024
- VSÓ Ráðgjöf (2020) Losun Gríðurhúsalofttegunda úr votlendi: yfirlit umræðu og rannsókna. VSÓ Ráðgjöf, Reykjavík. From <https://www.vegagerdin.is/vegagerdin/gagnasafn/skyrslur/rannsoknaskyrslur/umhverfi/losun-grodurhusalofttegunda-ur-votlendi-yfirlit-umraedu-og-rannsokna>. Accessed 8 Aug 2024
- Votlendissjóður (2022a) Alþjóðlegi votlendisdagurinn. From <https://www.votlendi.is/aljolegi-votlendisdagurinn>. Accessed 3 Aug 2024
- Votlendissjóður (2022b) Votlendissjóður tilnefndur til Umhverfisverðlauna Norðurlandaráðs. From <https://www.votlendi.is/tilnefning-til-umhverfisverlauna-norurlandarads>. Accessed 3 Aug 2024

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.