

WETLANDS CAN BE INFRASTRUCTURE, TOO

CASE STUDY



SUMMARY

Infrastructure is the underlying structure that helps a country and its economy function. While most people think of infrastructure as concrete structures like bridges and ports, wetlands are also doing critical work. Wetlands can absorb and store carbon dioxide, reduce the severity of floods, filter pollutants from air and water, and provide species habitat and food. Protecting and restoring wetlands will be critical to both reducing greenhouse gas emissions and adapting to a changing climate.

The devastating floods in Calgary in 2013, and the ongoing policy response, highlight the importance of considering wetlands as urban flood management infrastructure. Protecting and restoring wetlands can be more cost-effective than engineered solutions, while also supplying other benefits. Government policy is essential to protect valuable wetlands—on both public and private lands—and to encourage investment in wetland restoration.

This case study is part of a collaborative series between the Canadian Institute for Climate Choices and the Smart Prosperity Institute exploring the value of urban natural infrastructure within the context of climate change and other economic, environmental and societal objectives. Other case studies in the series cover green roofs and urban forests.



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WHAT ARE WETLANDS?

Wetlands are natural depressions in a landscape that are either covered by water or saturated with water for at least part of the year. In Canada, there are three broad categories of wetlands:

1. Mineral Wetlands (inland or coastal)

- Swamps
- Marshes
- Shallow open water (pothole, pond, slough)

2. Peatlands (also known as muskeg)

- Bogs
- Fens
- Peat swamps

3. Constructed wetlands (restored/engineered)

- Agricultural
- Hydroelectric
- Urban water or wastewater management

Due to the relatively flat terrain, presence of water, and other natural resources associated with them, areas surrounding wetlands have long attracted human settlements and provided them with key ecosystem services. Development, urbanization, and agriculture have made wetlands among the world's most degraded ecosystems. In settled areas of Canada, wetlands cover only 30 per cent of their former extent (GoC, 2010).

Indigenous Peoples are connected to nature, including wetlands that support culturally significant plants and species.

Many see themselves as caretakers with responsibilities to preserve water and life for current and future generations (Laidlaw, 2010). Initiatives aimed at conserving and restoring wetlands should learn from Indigenous approaches to sustainable management of land and waters, and should be designed and implemented with Indigenous participation and consent (Townsend, Moola, & Craig, 2020).

WHAT ARE THE BENEFITS OF WETLANDS?

Wetlands are one of the most valuable ecosystems and will play a key role in helping to address climate change, both in terms of managing emissions and reducing the impacts of a changing climate. At the same time, they also provide multiple other benefits in terms of filtering pollution, recharging groundwater, and providing species habitat and recreational and commercial opportunities.

Table 1. Benefits of Wetlands

Wetland Benefit	Why it Matters
Limit flooding and coastal storm surge	Climate change will increase the frequency and intensity of rainfall and storms in some regions, raising the risk of flooding in cities. Wetlands provide natural protection against flooding and coastal storm surges. They function like a sponge, absorbing a significant amount of water and storing it temporarily.
Carbon sequestration	Peatlands are one of the most effective carbon sinks on the planet, and one third of peatlands are in Canada. Globally, peatlands represent just three percent of total land area, but sequester 42 per cent of all soil carbon. Drained and burned peatlands account for up to 5 per cent of global annual greenhouse gas emissions.
Filter pollution	Wetlands act as natural water filters. They trap pollutants such as phosphorus and heavy metals in their soils, transform dissolved nitrogen into nitrogen gas, and break down suspended solids to neutralize harmful bacteria.
Recharge groundwater	Wetlands connected to underground sources of water retain surface water, rainwater, or snow melt that seeps into the ground. They provide time for water to filter down and recharge aquifers and replenish groundwater.
Species habitat	Wetlands support an exceptional level of biodiversity. Their combination of shallow water, high levels of nutrients, and high biomass production provides the ideal roosting, nesting, and feeding habitat for waterbird, fish, amphibian, reptile, and plant species.
Recreation and tourism	Wetlands offer several recreational opportunities that contribute to social well-being. These include hiking, fishing, bird watching, photography, and hunting.
Commercial value	Wetlands also generate commercial value. In some cases, such as certain fishing or specialty food harvesting, it may be possible to undertake commercial activities without significant loss of ecosystem services. In others, such as peat extraction, commercial activities result in the loss or degradation of wetlands.

Sources: UNEP, 2020; IUCN, 2020



HOW VALUABLE ARE WETLANDS?

In urban areas and their periphery, wetlands continue to be drained for buildings, industry, and agriculture. They are also degraded by pollution and waste. In most cases, the current and future public benefits of wetlands are not fully considered in decision-making. It is often difficult to place a monetary value on all of the benefits of wetlands without in-depth studies, and there is usually little funding or time provided for site-specific research. Actions affecting wetlands on private land may also face limited regulation, unless they are designated to be of value (e.g. Ramsar internationally important wetlands).

There are a growing number of studies that provide a sense of the monetary value of wetlands, however, which provide dollar estimates associated with the benefits such as those highlighted in table 1. The most recent global estimates place the cumulative value of wetlands at US \$47 trillion dollars per year (Davidson et al., 2019). Of course, place-based factors can influence the value of a wetland significantly. For example, in a 2013 study, the value of global inland wetlands lay between US \$981 and \$44,597 per hectare per year (Russi et al., 2013). In this example, the wetland values are higher near dense urban areas because the costs of floods and other natural disasters are higher when there is property damage and disrupted transport systems.

Several studies have highlighted the value of wetlands for flood mitigation. A study in southern Ontario found that if wetlands were maintained in their natural state instead of being converted to agriculture, flood damage costs would decrease by 38 per cent—from \$135.6M to 84.5M (Moudrak et al., 2017). Had they been replaced by urban, largely impervious surfaces (such as buildings, roads, and parking lots), costs would increase further. Another cost-benefit study reported that the destruction of wetlands in Smith Creek, Saskatchewan would result in the loss of \$1.83 million of annual benefits from flood control (Pattison-Williams et al., 2018). The wetlands and forests of Ontario's Greenbelt prevent an estimated \$224 million of flood damage to properties each year (Greenbelt Foundation, 2018).

Other ecosystem services values are illustrated in the table below. Regardless of the specific numbers they identify, such valuations can help us better understand the range of benefits from wetlands, their connection to our economies, and the extent to which they have historically been undervalued, so that we may better consider the impact of land use decisions without detailed site-specific studies.





Table 2. Estimated Monetary Value of Wetlands

Ecosystem service	Range of estimate	Source
Water filtration	US\$1.15 to US\$1,087.67 per hectare per year	Kazmierczak (2001); Chichilnisky and Heal (1998)
Wastewater treatment	US\$2,522 to US\$3,899 per hectare per year	Breaux et al. (1995)
Biodiversity	\$9.36 to \$18.97 per person per year	Birol et al. (2006)
Habitat for fish	US\$348.48 per person	Carlsson et. al. (2003)
Aesthetics, flood control, ground water recharge	US\$19 to US\$24 per hectare per year	Lupi et al (1991); Mahan et al. (2000)
Research and education	\$4.74 to \$13.1 per person per year	Birol et al. (2006)
Fisheries	US\$0.10 to US\$135.44 per hectare per year	Bell (1997); Freeman (1991)

Conserving remaining wetlands is the most cost-effective means to accessing optimal ecosystem service delivery. A 2011 report commissioned by the Ontario Ministry of the Environment found that every dollar invested in protecting wetlands around the Great Lakes generates an economic return of \$35 (Marbek, 2011).

Restoring degraded or lost wetlands has also been shown to be cost effective and to offer a high return on investment. For example, a 2 per cent increase in wetlands (~ 17,544 ha) in the White Zone (settled areas) of Alberta would cost between \$175 million and \$335 million

(Ducks Unlimited, 2014). Assuming that one hectare of wetland can store 2850 m³ of water, this would create additional water storage of 50 million m³ (Government of Alberta, 2013). At a per-unit storage cost of \$3.5- \$6.7 per m³ a restored wetland can store water at a cost comparable to a dry dam (estimated to cost \$1.4 - \$7 per m³) but with further carbon sequestration, habitat, and climate adaptation benefits (Ducks Unlimited, 2014). For example, over a 33-year period, the same restoration could sequester 12 Mt of carbon (Ducks Unlimited, 2014).

CITY OF CALGARY RIVER FLOOD MITIGATION PROGRAM

In June 2013, Calgary and southern Alberta experienced severe floods. Thousands of families were displaced, businesses were disrupted and destroyed, private and public property was damaged, and four people lost their lives. Flood damages were in excess of \$5 billion across Alberta and an estimated \$400 million to the City of Calgary's infrastructure (City of Calgary, 2016). While the 2013 flood was the costliest flood in Alberta's history, several major floods have been recorded in the region (CDD, 2020). Climate change is increasing the likelihood of extreme rainfall in the region, adding to flood risks (Teufel et al. 2017).

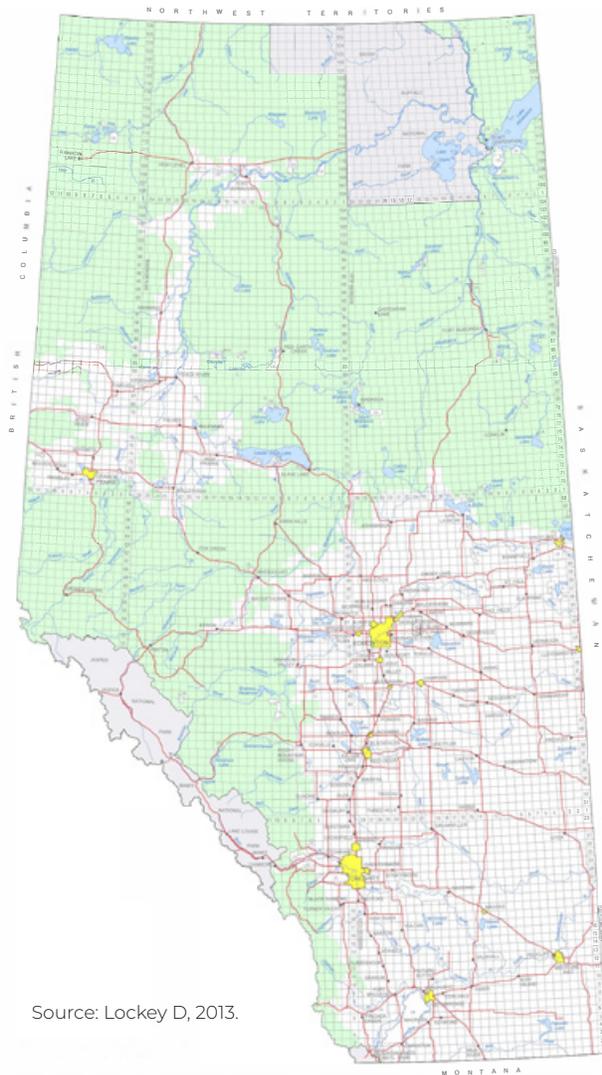
Following the 2013 flood, the City of Calgary established the River Flood Mitigation Program to investigate flood mitigation issues and required responses. As part of the mitigation program, it also formed an independent Expert Management Panel to make recommendations for a more resilient Calgary and better prepare for future events. In 2014, the Panel released recommendations across six themes: managing flood risk, watershed management, event forecasting, storage, diversion and protection, infrastructure and property resiliency, and changing climate (Expert Management Panel on River Flood Mitigation, 2014).

While most of the 27 recommendations by the Panel focused on engineered infrastructure options to mitigate floods, the Panel did highlight the role of managing the Bow River Watershed in buffering small floods where long steady rainfall saturates the ground and eventually causes the river to overflow. Alberta's Watershed Resiliency and Restoration Program also identified

flooding and drought as major watershed issues. This program is working to mitigate these hazards through the creation and/or enhancement of natural systems such as wetlands and riparian areas (adjacent to rivers and streams) to improve watershed functioning (Government of Alberta, n.d.). Ducks Unlimited Canada (DUC) also released a report following the flooding, advocating for more flood mitigation measures in the Bow River Basin and the South Saskatchewan River Basin to include wetland conservation and restoration. Their report highlighted that wetlands offer triple benefits: long-term flood mitigation, cost-effectiveness, and the fact that wetlands are one of the only forms of flood mitigation that also perform other services including water supply, biodiversity, and habitat protection (DUC, 2014).

Wetland loss has long been an issue in the Bow River Basin. In the White Zone of Alberta (i.e. populated areas), 64 per cent of wetlands have already been lost and the region continues to lose wetlands at a rate of 0.3-0.5 per cent per year (see Figure 1 for a map of green and white zones). In the City of Calgary, losses are in the range of 90 per cent (Government of Alberta, 2013). The loss of 133,000ha of wetlands in Alberta over the past 40-60 years has resulted in approximately 379,000,000 m³ of lost water storage capacity (roughly 21 times the volume of water stored in Calgary's Glenmore Reservoir). By reducing the ability of the landscape to store water, the loss of wetlands results in increased flow and volumes downstream following rainfall events, exacerbating flood risk.

Figure 1: Map of Green and White Zones in Alberta



Source: Lockey D, 2013.

	Green area	White area
Settlement	Unsettled	Settled
Land cover	Covers 61 of Alberta	Covers 39% of Alberta
Population	Unpopulated northern Alberta, some mountains and foothills	Populated southern, central, and Peace River areas
Land uses	Forestry, oil and gas, oil sands, mining, tourism	Settlements, agriculture, oil and gas, mining, tourism
Regulatory authority	Provincial government	Municipal government on private land, provincial government on Crown land
Main wetland type	Muskeg	Sloughs

The new Alberta Wetland Policy was released in 2013 and came into effect in the White Area in 2015. The policy was developed to complement Alberta's provincial water sustainability strategy, called "Water for Life." The goal of the Alberta Wetland Policy is to maintain wetland areas in Alberta such that the ecological, social, and economic benefits that wetlands provide are maintained. The policy focuses on four outcomes to achieve this goal:

1. **Value:** Wetlands are not of equal value; they vary in form, function and use. The new policy seeks to protect wetlands of the highest value using the wetland rapid evaluation tool (see Figure 2).
2. **Benefits:** The benefits of wetlands are conserved and restored in cases where losses have occurred.
3. **Mitigation:** Wetlands are managed by avoiding loss or degradation of the wetland, minimizing damage where avoidance is not possible, and replacing wetlands where loss is unavoidable.
4. **Regional management:** Wetland management considers regional context (Government of Alberta, 2013)



Figure 2: Alberta Wetland Rapid Evaluation Tool

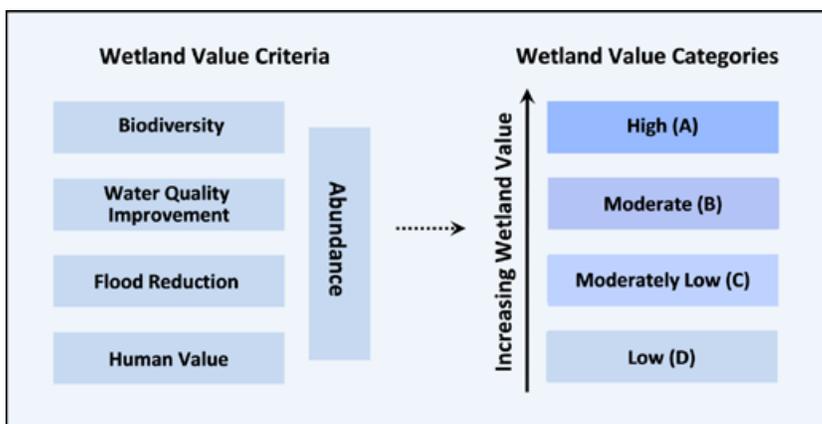


Figure 2. Through the Alberta Wetland Policy, wetlands are valued according to five characteristics: the relative abundance of a wetland on a landscape, human uses of the landscape, the ability of the wetland to improve water quality, the hydrologic function of the wetland, and the ability of the wetland to support biodiversity. Based on this assessment the wetland is categorized from A (highest value) to D (lowest value). The relative values are intended to further decision support for land use planners, developers, and decision makers to consider the wetland in the context of the landscape and adapt strategic and informed wetland management decisions.

Source: Government of Alberta.

In 2018, the policy was updated with a provision for grants to finance private wetland restoration. This shift in policy provides more flexibility and access to wetland restoration funds for farmers and other landowners who face cost barriers to restoring wetlands.

While largely seen as a positive step to better assess and consider wetlands in land use decisions, Alberta's Wetland Policy has some limitations. The mitigation policy does not have a framework to document and quantify avoidance and mitigation of wetland loss or degradation. In Calgary, revenue generated from the city and provincial wetland policies has been difficult to spend on wetland restoration due to regulatory constraints, including closed basin order and water

license restrictions. For developers, it has often been simpler and more cost effective to pay compensation to remove wetlands than to conserve them.

However, the economic case for conservation and restoration continues to be made. Using a social-return-on-investment (SROI) approach that considers public and private benefits, a recent study in east-central Alberta found that resources invested in the enforcement of an effective policy that halts the further loss of wetlands would yield a return of almost 7:1. Investment in low to moderate levels of restoration provides a smaller, yet still substantial return for every dollar invested (DUC, n.d.). In Calgary, properties adjacent to wetlands are valued more highly, both in terms of aesthetics as well as market value, helping developers and planners





better understand the value to residents. To better facilitate the restoration process of wetlands, the provincial government recently streamlined requirements under the Wetland Policy, adding a “wetlands restoration Code of Practice”. This change will make restoration of small wetlands significantly easier and less costly, resulting in more wetlands on the landscape.

Calgary's newly updated [Municipal Development Plan](#) (Approved Feb 2021) also takes a significant step forward by emphasizing the role of natural infrastructure in building a resilient city. Doing so enables councillors and decision makers in city departments to be more proactive with natural infrastructure since it is now a more clearly defined part of their mandate. Natural infrastructure and nature-based solutions are also central to the new [Calgary Climate Resilience Strategy](#). The city is currently undertaking natural asset valuation, which will inform action in municipal and climate plans.

Calgary is already a city that has shown leadership in natural infrastructure, particularly in response to the 2013 floods. The alignment of the new MDP, resilience strategy, and streamlining of provincial processes will lead to substantial investment and scaling of wetland restoration in the near future.

Box 1: Mikisew Cree First Nation initiative leads to protection of critical ecosystem

Thanks to the leadership of the Mikisew Cree First Nation, the Alberta Government created the Kitaskino Nuwenēné Wildland Provincial Park in 2019, and expanded it in 2021 (Joannou, 2021). The park includes wetlands and forest important to caribou, bison and other species, and supports the exercise of Treaty and harvesting rights, as well as other traditional uses, including cultural activities, for Indigenous Peoples. The park expands an area that forms the largest contiguous protected boreal forest in the world (Alberta Parks, 2019)."

LEADING NORTH AMERICAN WETLAND INFRASTRUCTURE PROJECTS

Nanaimo, British Columbia: The Buttertubs Marsh Conservation Area (BMCA) is a 55-hectare reclaimed wetland and floodplain habitat in the City of Nanaimo on Vancouver Island in British Columbia (Municipal Natural Assets Initiative, 2018). It lies adjacent to the Millstone River, which flows through the center of the city and comprises two separated wetlands. The conservation area was created through the purchase of the east marsh by the Nature Trust of B.C. in 1976 and was expanded in 2012 when the west marsh was jointly purchased by Ducks Unlimited Canada and the city.

Recognizing the stormwater retention and flood mitigation properties of the BMCA, the city undertook a study in 2017 to investigate the financial value of these services. By estimating the cost of engineered solutions that would be required to serve the same stormwater detention function, such as stormwater management ponds or constructed wetlands, the study estimated that the BMCA had an asset value of \$4 to \$4.5 million under contemporary conditions. This value rose to \$8 million under climate change conditions derived from the US EPA stormwater management model paired with Intensity-Duration-Frequency analysis of forecasted conditions in 2050-2100 (methods details can be found in Municipal Natural Assets Initiative report). This analysis emphasizes the increasing importance of natural assets in providing critical services to municipalities in the future and their role in increasing community resilience.

The City is now working towards translating the results of this study into core management and financial processes. It has outlined a broad framework that includes the development of a natural asset

register and an inventory of natural and potential engineered storm assets in the city. This means natural infrastructure such as these marshes and grey infrastructure are managed and assessed in the same way. This framework will be refined over the coming months and years in an attempt to manage natural assets in a financially and environmentally sustainable way.

The upfront capital cost for the natural infrastructure approach was less than 25 per cent of the cost for a traditional system.

Inver Grove Heights, Minnesota: The City of Inver Grove Heights is located southeast of St. Paul, Minnesota. The Northwest Area of the city is primarily natural and agricultural land cover across a prairie pothole/kettle lake landscape with numerous wetlands. Anticipating the development of over 3 000 acres in this area, the city created a plan for a new stormwater management system in 2006 (EOR, 2019). Rather than opting for the traditional approach of conveying urban runoff by a system of storm sewers, ponds and pumps, the city investigated natural infrastructure as a distributed flood management storage strategy that would protect and preserve existing depressions in the landscape.

They used a hydrologic and hydraulic model to study the basin's natural storm water capacity, asking whether it could retain a once-in-100-years runoff event when the ground was frozen (a conservative method for estimating flood retention capacity). The upfront capital cost for the natural infrastructure approach was less than 25 per cent of the cost for a traditional system. Further, the 30-year operation and maintenance cost of the natural infrastructure approach was very similar to the long-term cost of upkeep of a traditional system, making the life cycle cost of the natural infrastructure approach almost half the lifecycle cost of the traditional alternative.

Based on these results, the city created a plan to protect their natural infrastructure. The plan mapped and established the natural depressions and wetlands as protected areas that could not be developed. In development areas, it

further outlined requirements to treat stormwater through on-site rain gardens or other stormwater management practices that would result in a volume of runoff comparable to pre-development volumes after a once-in-five-years rainfall over 24 hours.

Box 2: Moving beyond colonialist mindsets

Recognizing the value of nature in decision making requires moving away from perspectives that see natural assets as barriers to progress. Indigenous approaches — used for thousands of years - are more holistic and consider the interconnected cumulative effects of development both today and in the future (Mayer, 2020).



WHY ARE WETLANDS NOT TREATED AS INFRASTRUCTURE?

Resistance to Change: In urban areas, wetland loss is primarily a result of drainage and land use conversion for development. Traditional “grey” water management infrastructure solutions are well understood, both technically and economically. In contrast, natural infrastructure solutions are less common and involve more government departments and types of expertise to develop and approve. As a consequence, natural infrastructure solutions are more time-consuming to implement and introduce different types of up-front costs and maintenance.

Data and Metrics: Developing wetland-based natural infrastructure requires assessing a wetland’s ecological quality, but also accounting for wetland attributes and co-benefits in terms that are meaningful for engineers, project developers, and municipal accountants. Quantifying benefits requires considerable resources for data collection and processing — at least until such practices are mainstreamed. It also requires different tools and data sources which may be difficult to obtain or compare. This is especially challenging given that natural infrastructure decisions are very location-specific and require location-specific data.

Capacity and Skills: There is lack of institutional capacity in Canada to conceive, plan, and monitor natural infrastructure in municipal settings. The cross-cutting nature of many of the co-benefits of natural infrastructure make it difficult to align with any one government department. In particular, municipalities generally do not have a framework in which to integrate natural infrastructure within existing policy structures and often lack financial and operational capacity.

Implementing natural infrastructure projects requires experts from

different subject areas (for example, ecological and engineering professionals) to work together. For practitioners, working on natural infrastructure projects may necessitate acquiring new skills, integrating new research-based knowledge into practice, and applying new standards.

Access to Funding: The key federal infrastructure programs that fund natural infrastructure and water management are the Disaster Management and Adaptation Fund (DMAF) and Investing in Canada Infrastructure Plan (ICIP). Several limitations, such as minimum project size, inability to bundle projects in order to achieve the minimum size, lack of consideration of co-benefits associated with natural infrastructure, and lack of earmarking for natural infrastructure projects within these programs have resulted in their funding relatively few wetland projects.

WHAT CAN GOVERNMENTS DO TO PROTECT AND RESTORE WETLANDS?

Prioritize protection of existing wetlands — All levels of government have policy levers to slow the loss of wetlands in Canada. Some examples include federal and provincial protected areas, funding for conservation on public and private lands, land-use plans, strengthened local conservation authorities, and new or amended legislation on drainage.

Natural infrastructure financing — Increase direct funding via existing programs that focus on watershed protection and restoration, while earmarking funding specifically for natural infrastructure, such as the new Natural Infrastructure Fund announced in Budget 2021.

All levels of government have policy levers to slow the loss of wetlands in Canada.

Provide financial support for capacity-building and interdepartmental collaboration — Ecosystems and watersheds do not abide by political boundaries, and consequently nature-based solutions (NBS) inherently pose jurisdictional and management challenges, along with consideration of how to collaborate effectively. Without financial support for capacity-building, incentives, and tools that facilitate collaboration, the pool of possible NBS projects is likely reduced. Climate resilience planning with an explicit focus on natural infrastructure is one structural mechanism to bring relevant municipal parties together to address climate concerns that span across departments.

Explicitly acknowledge co-benefits — Wetlands deliver a targeted action, like flood mitigation, as well as a suite of co-benefits such as habitat for biodiversity, recreational opportunities, and nutrient management. They provide tremendous added value that is rarely accounted for. Increasing the inclusion and valuation of co-benefits in decision making can raise the profile of nature-based solutions when compared to grey infrastructure or engineered adaptation strategies. Increased funding for measuring and monitoring these benefits would help improve information available to decision makers.

Box 3: Financial Incentives for Private Investment in Wetland Infrastructure

The city of Halifax has implemented a stormwater credit program in which non-residential properties can receive up to 50 per cent off their water utility bill if they create additional water storage capacity, including engineered wetlands.

The municipality of Washington, DC requires developers to purchase stormwater retention credits for new construction. A price floor and guaranteed buy-out by the municipality has created a market for restoration. Environmental NGOs can aggregate projects and target priority areas with confidence that the municipality will purchase credits not sold on the open market.

Sources: (City of Halifax, 2020; Washington DC MOE, 2019)



Incentivize action on private lands —

Under Alberta’s wetland policy, farmers are eligible to access funding and income support to restore wetlands on agricultural land. Private lands are an important part of landscape and watershed function, and financial incentives are one pathway to engage a broader set of stakeholders

Raise profile of natural infrastructure in the Climate Lens —

The Climate Lens — an assessment framework developed by Infrastructure Canada — already applies to projects seeking funding under the Investing in Canada Infrastructure Program, Disaster Mitigation and Adaptation Fund, and Smart Cities Challenge. Depending on the type of project, projects may be assessed based on the anticipated greenhouse gas emissions impact of a project, the climate change resilience of the project, or both. Natural infrastructure is only captured in a limited way

since ‘indirect impacts on land use’ are among the Scope 3 emissions to be considered in the greenhouse gas assessment. The resilience assessment is intended to consider impacts from multiple perspectives (e.g., economic as well as public health), both extreme and slow onset events, and cascading and cumulative impacts. Because the assessment focuses on the sensitivity of the asset to climate change, rather than the effect of the asset on a community’s sensitivity to climate change, the assessment may fail to capture all of the benefits of natural infrastructure. Bringing more attention to natural infrastructure as a component of the Climate Lens could help raise the profile of projects that integrate natural assets.



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