ADAPTING CANADA'S WORKFORCE

ESTIMATING THE SKILLED WORKFORCE NEEDED TO DEVELOP MUNICIPAL FLOOD RISK MANAGEMENT INFRASTRUCTURE ACROSS CANADA

Smart Prosperity Institute

OCTOBER 2022

About Smart Prosperity Institute

Smart Prosperity Institute is a national research network and policy think tank based at the University of Ottawa. We deliver world-class research and work with public and private partners – all to advance practical policies and market solutions for a stronger, cleaner economy.
institute.smartprosperity.ca

Acknowledgements

The primary authors of this report are Mohsina Atiq, Anik Islam, Una Jefferson, John McNally and Harshini Ramesh. Teslin Augustine and Mike Moffatt provided writing and editing support, and the authors would like to thank Robin Edger, Jason Clark, Craig Stewart, Abdullah Khan, Daniel Henstra, Ryan Ness, Joanna Eyquem and others for their contributions, feedback and insights that strengthened this work. The authors also extend thanks to Alice Irene Whittaker, Karianne Blank, Mac Radburn, and Trudi Zundel for their contributions to the development and realization of this report.

This report was made possible by funding from the Insurance Bureau of Canada. Responsibility for the final product and its conclusions is Smart Prosperity Institute's alone, and should not be assigned to the reviewers, interviewees, or any external party. Being interviewed for or reviewing this report does not mean endorsement, and any errors remain the authors' responsibility.

Suggested Citation

Atiq, M., Islam, A., Jefferson, U., McNally, J. & Ramesh, H. (2022). *Adapting Canada's workforce: Estimating the skilled workforce needed to develop municipal flood risk management infrastructure across Canada*. Smart Prosperity Institute.

October 2022

With support from

Smart Prosperity Institute

1 EXECUTIVE SUMMARY

Canada is facing the prospect of serious impacts from climate change. Already, the country is warming twice as fast as the global average – and three times as fast in the North.[1] This warming is making events that threaten the safety and wellbeing of those living in Canada more frequent and more intense, including flooding along Manitoba's Red River, wildfires in both Lytton and Fort MacMurray, and Hurricane Fiona's impacts in Atlantic Canada, to name only a few.[2] A report from the Canadian Climate Institute identified that climate damages will result in large national incomes losses in the coming years, estimating Canada will experience $25 billion in losses by 2025, rising to $78-101 billion annually by mid-century.[3] Adapting to climate change is an urgent challenge for Canada, which must be addressed alongside efforts to mitigate greenhouse gas emissions. Solutions to advance adaptation include retrofitting, and building new, infrastructural solutions – both built and natural infrastructure – as well as "soft" adaptation measures like administrative changes and programs. This undertaking will require major investments. A report from the Insurance Bureau of Canada and Federation of Canadian Municipalities have estimated that $5.3 billion annually will be required out to 2050 for investments into municipal infrastructure and local adaptation measures alone.

At a moment of constrained government spending and cost-of-living concerns for households and businesses in the transition to a net zero economy, these investments in Canada's climate resilience can offer multiple benefits. First, they can reduce many of the cost's climate change will bring upon households, communities, and the economy. The decreases in incomes and investment portfolios, and increases in the cost of living, that climate impacts are expected to bring about make swift investments in adaptation an important part of supporting future affordability.[4] Second, beyond the impacts on households, proactive investments will reduce the host of broader economic, environmental, and social costs that a changing climate will bring. Finally, spending on climate resilience to manage risk and mitigate these costs can also create a significant number of jobs for Canadians across the country designing, building, and maintaining these investments in our resilience. These jobs will be created in all provinces and territories that advance infrastructure solutions and are a key benefit that spending on adaptation solutions offers.

Despite this benefit, and the need to advance adaptation rapidly, there is still limited understanding of the workforce requirements to build these projects, both in terms of the workers needed to construct projects, and the skills required for this work. This report estimates the number of workers needed, and the skills they will require, to build out adaptation projects that reduce flood risk in municipalities across Canada. This analysis focusses on workforce needs from flood risk management solutions, and clearly shows that:

- **Spending on municipal flood risk management infrastructure projects can create 60,465 jobs across Canada between now and 2030.** This analysis included both existing spending under the federal Disaster Mitigation and Adaptation Fund (DMAF), and additional spending to advance resilience to flood risk in municipalities across the country.
- **This report finds that the flood risk management infrastructure projects advanced in the DMAF portfolio, as currently funded, will create almost 23,000 direct and indirect jobs in the coming decade,** mostly in construction, through the total committed funding envelope of $3.5 billion. These benefits will be national, with the largest job growth occurring in Ontario, Manitoba, and Alberta. If the current DMAF program was to be recapitalized with expanded program criteria, as this report suggests, that number would increase.
- **Federal, provincial, and territorial government should increase total spending on flood risk management projects to $6.47 billion by 2030 to avoid the worst impacts of flooding and erosion. This additional spending will create nearly 38,000 more jobs across the country.** Most of these jobs will be in the construction sector, primarily in engineering construction, repairs, and other construction activities such as land clearing and site preparation. There will also be labour demand in the building supplies, engineering design, and environmental and technical consulting sectors. These benefits will similarly be national, with much of the work required to build flood-protection projects between 2022 and 2030 occurring in Ontario, Alberta, British Columbia, and Quebec. This is due to a combination of factors, including identified climate impacts and spending costs.
- **This analysis includes only flood risk management projects for municipalities.** This means that it does not include any analysis of job creation impacts from spending to improve resilience and manage increased risk from wildfires, heatwaves, storms, or any other impact of a changing climate. This was due primarily to data availability. In practice, this means that spending on other forms of resilience will require more workers with different skillsets and offer opportunities to create more jobs advancing resilience. These additional workers will also need training, and this may have impacts on skilled labour shortages in certain sectors.

Table 1: Total no. of direct and indirect jobs needed to advance projects in both workforce analyses

Direct & Indirect Jobs by Sectors	No. of jobs created under DMAF, 2018-2030	No. of jobs created to advance flood risk management projects, 2022-2030
Direct	**14,384**	**25,039**
Architectural, Engineering and Related Services	565	201
Building Material and Supplies Merchant Wholesalers	2,198	5,908
Greenhouse, Nursery and Floriculture Production	60	29
Management, Scientific & Technical Consulting Services	459	310
Other Activities of The Construction Industry	2,932	3,470
Other Engineering Construction	4,324	8,068
Repair Construction	2,201	3,902
Transportation Engineering Construction	1,646	3,133
Indirect	**8,312**	**12,730**
Indirect Jobs	8,312	12,730
TOTAL	**22,696**	**37,769**

In order to support the growth of the skilled workforce needed to advance adaptation through flood risk management infrastructure, **this report makes the following recommendations:**

- Increase federal, provincial, and territorial spending by at least $6.47 billion by 2030 through programs that mitigate adverse impacts and risk of floods for municipalities across the country.
- Reform programs like the Disaster Mitigation and Adaptation Fund (DMAF), and develop new programs, to allow municipalities to advance adaptation projects more aligned with their local needs and financial realities, while prioritizing risk reduction for communities most exposed to climate impacts.
- Create training programs to support the growth of the skilled adaptation workforce that align with existing and new resilience standards, such as upcoming changes to Canada's national Building, Electric and Fire codes.
- Develop a roadmap for growing the skilled adaptation workforce that is tied to expected or anticipated climate impacts in each province, including how each region will be affected by climate impacts such as wildfires, heatwaves, storms, flooding, and sea level rise.

Key takeaways from this report

- Overall, the additional funding to support municipal flood risk management is expected to create more jobs than DMAF. The level of additional funding included in this analysis was meant to represent municipal adaptation needs for flood risk out to 2030. This report identified that **DMAF spending is not currently at high enough levels to support municipal flood risk management needs as Canada's climate changes** (the cost of flood risk management projects under DMAF is $3.5 billion, and additional spending for flood-protection projects by 2030 is estimated to amount to $6.47 billion). To ensure Canadian communities have the levels of investment needed to avoid the worst impacts, more spending will be needed.
- **The types of jobs required will be directly connected to the types of projects that are funded.** Offering greater support to one form of adaptation measure will require more skilled workers to advance those specific projects. Investing in natural infrastructure projects, for example, creates significantly different types of jobs than traditional built infrastructure, or even hybrid infrastructure that incorporates both built and natural components. As planners and governments grow more familiar with the benefits of natural infrastructure for some adaptation uses

Table 2: Insights on skills requirements for flood risk management workforce by sector for jobs needed by 2030

Sector	Type of jobs created in these sectors	Standout Skills
Construction	Contractors and supervisors Trade labourers Carpenters	Monitoring Coordination Decision making Time management Complex problem solving
Building materials and supplies merchant wholesaler	Retail and Wholesale Trade Managers Sales and Accounts Representatives Material Handlers	Social perceptiveness Persuasion Negotiation Coordination Monitoring
Architectural, engineering and related services	Civil engineers Architects Mechanical engineers	Complex problem solving Judgement and decision making Monitoring Active learning Time management
Management, scientific and technical consulting services	Business/environmental management professionals Human resource managers Ergonomists	Judgement and decision making Systems evaluation Complex problem solving Monitoring Social perceptiveness
Greenhouse, nursery and floriculture production	Nursery and greenhouse workers Horticulture workers Landscape managers and workers	Coordination Monitoring Social perceptiveness Time management Operations & control

and more of these projects are advanced, more jobs could be created in sectors like greenhouses, nurseries, and tree planting and maintenance services.

- **The skills most in demand across the flood resilience workforce are process, social and problem solving skills, given the need to bolster soft adaptation skills to advance natural and built infrastructure projects.** Soft adaptation measures pertain to equipping workers with the skills they need to execute these projects and build resilience to climate change-related flooding. This will have an impact on the entire workforce, including a number of skilled trades. Across all of the sectors expected to see growth in jobs as a result of spending on natural, built and hybrid adaptation measures, skills such as critical thinking, monitoring, social perceptiveness, coordination, complex problem solving, judgment and decision making, and time management will be the most important. This implies a growing importance for workers in low, medium, and high skilled professions to have a wide range of skills beyond core technical skills, such as those shown in **Table 2**, in order to learn how to dynamically respond to the changing needs of adaptation infrastructure.

Description of this analysis and identified limitations

- This report estimates the number of workers and types of skills needed to realize both current and future adaptation infrastructure projects targeted specifically at flood risk management in Canadian municipalities. This analysis focuses on infrastructure for flood risk management: flooding is the costly weather-related disaster that will be exacerbated in Canada,[5] with projections suggesting that adapting to flooding will cost 1.25% of GDP to 2050.[6]
- This analysis estimates both the job creation impacts of constructing the current portfolio of municipal flooding projects supported by the federal Disaster Mitigation and Adaptation Fund (DMAF), and how additional increases in spending in response to a changing climate will drive the need for workers out to 2030. It then analyzes the impacts on skills for these workers to build out expected projects, to support programs for skills training, retraining and worker readiness, including in a number of skilled trades.
- The estimated jobs do not reflect all work that will be required to advance climate adaptation projects, but only investments in municipal flood risk management infrastructure projects out to 2030. This does not include workforce impacts from other flood risk management approaches, including other approaches for accommodating, avoidance, or managed retreat. This also does not include any jobs related to disaster clean-up and repair from flooding.
- Higher spending is likely to lead to a larger number of jobs, but any discussions of job creation should be interpreted alongside the growing environmental, social, and economic costs that the impacts of a changing climate will bring forward.
- The number of jobs required to advance climate adaptation infrastructure will be higher to create a climate-resilient Canada past 2030, as climate impacts will worsen in the coming decades.

TABLE OF CONTENTS

Figures

TABLE OF CONTENTS

Tables

Glossary

DMAF	Disaster Mitigation and Adaptation Fund
EU	European Union
FCM	Federation of Canadian Municipalities
ICIP	Investing in Canada Infrastructure Program
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
NAS	National Adaptation Strategy
PCF	Pan-Canadian Framework on Clean Growth and Climate Change

2 INTRODUCTION

There is overwhelming evidence that the Earth has warmed since the industrial era, and the primary driver of this warming has been human activity. A 2019 assessment of Canada's climate identified that the country is warming approximately twice as fast as the global average temperature increase, and that the country's North is warming three times faster.[7] Responding to the impacts that our changing climate is having, and will continue to have moving forward, on people, communities and the economy is one of the most urgent challenges of our time. The Government of Canada has committed to developing the first-ever National Adaptation Strategy as a step towards addressing these expected impacts.[8]

In this context, Canada must transition to a climate-resilient country in the coming years and decades. Investments in existing, as well as new, built, and natural infrastructure will be key to building greater resilience to at least partially redress the impacts of adverse weather events on communities. As climate impacts worsen, a larger volume of investment will be required to foster resilience to avoid the worst impacts of a changing climate. Building these projects will require skilled workers, so understanding the number and types of jobs that will be created across sectors is important. This knowledge of the resources and workforce required for ramping up climate adaptation investments can inform the development of training programs critical to ensuring workers have the skills necessary to fill these roles.

This report aims to be the first to fill this identified research gap and provide policy recommendations to support action. It is an early attempt to assess the job creation that could result from advancing flood risk management projects at the municipal level across Canada, which will be needed to adapt to expected climate impacts by 2030. This report has three objectives. The first is to clearly show that investments in adaptation can create jobs in communities across Canada, while also preventing future damages and adverse impacts on communities. The second is to identify the kinds of jobs and occupations associated with different types of flood risk management (FRM) projects. The third is to inform discussions about worker and skills needs associated with developing greater resilience in Canadian communities. Municipal FRM projects are only a subset of the adaptation initiatives that will be required to foster resilience to all the adverse impacts that a changing climate is expected to bring about by 2030 and beyond, so future research should focus on the workforce and skill sets needed to advance other resilience priorities. The analysis in this report is a starting point for a discussion about the workforce required to advance adaptation projects and initiatives across Canada. This work also considers the characteristics of the workforce needed to build FRM infrastructure projects currently under development through the DMAF, as well as future projects that will be necessary to ensure Canada is prepared to advance FRM infrastructure in municipalities at adequate levels.

When assessing the economic benefits associated with adaptation measures, one must consider the full range of social, environmental, and economic costs climate change is expected to impose on communities and individuals. Some of these costs will be incurred directly by households. A report from the Canadian Climate Institute identified that if emissions continue to climb, and action to improve Canada's resilience to climate change is not taken, life will become even more expensive as incomes decrease, investment portfolios decline, and the cost of living continues to rise.[9] This same report notes that these costs will impact the lowest cost households most of all. Even in an era of high inflation, investing proactively in adaptation measures is worthwhile. Swift action on improving resilience can ensure greater affordability for households moving forward, will create jobs, and can lower the overall costs climate change will impose on communities and households.[10] These benefits of investing in adaptation infrastructure stem from both the reduction of these economic and household costs, and from the positive economic benefits of job creation. This nuance is important, since it highlights that Canada's transition to a climate-resilient economy can offer material improvements, serving as a job creator in communities across the country that would otherwise have to incur significant damages and costs.

The sooner action is taken to adapt to climate change, the more prepared communities will be as adverse impacts worsen. This report estimates how many jobs could be created through investments in municipal FRM infrastructure at levels needed to adapt to expected impacts by 2030. Since adverse impacts are expected to worsen in the years to come, this report acknowledges that more spending will be needed past this point to support continued resilience. This additional spending will also create jobs, and it is worth noting that this job creation will support the generation of economic benefits in communities, similar to any other form of job creation.

There are critical reasons why identifying and addressing labour and skills needs is an imperative for advancing adaptation to municipal flooding in Canada. The first is that expected job creation through investments in climate resilience will require a skilled workforce to fill. The second reason is that policies, programs, and practices aimed at equipping these workers with the necessary skills will need to take two realities into account: (1) many Canadian sectors are already experiencing labour shortages and (2) competition for existing workers will become more intensive as demand is driven by other trends. Worker shortages are evident in key sectors like construction, where 259,100 workers (or 20 percent of the 2020 labour force) are expected to retire over the next decade.[11] A report from BuildForce Canada estimates that 309,000 new construction workers will be needed in the next decade to offset retirements and fill new jobs, driven by the aging population.[12] Over the next several years, labour needs will continue to increase, exacerbating the difficulty of filling climate adaptation jobs. Understanding the workforce requirements of projects that are pledged or under development is critical to help communities prepare and to inform future policies and programs.

Advancing adaptation investments will require overcoming some of the existing skilled worker shortages seen today. Competition for skilled workers in many sectors related to climate adaptation is exacerbated by broader labour market trends, so Canada might not have enough skilled workers to fill all the jobs created through its spending on adaptation initiatives. One example of a competing priority for workers is the large number of climate mitigation projects that are underway and anticipated, which previous analysis from Navius research[13] has identified could create up to 123,000 – 208,000 clean economy jobs between 2020 and 2030.[14] Many of these roles are expected to be in manufacturing and construction. Another competing priority is the demand for new housing construction. A report from the Canadian Mortgage and Housing Corporation identified that Canada is likely to build 2.2 million homes in the next decade, but that an additional 3.53 million housing units would be required to restore affordability.[15] While the total number of housing units that will be built in the next decade is not certain, any serious national push for greater affordability will need to reckon with housing construction at this scale. A final challenge is redressing the existing infrastructure deficit, which has been estimated to be between $150 billion and $1 trillion.[16] While there will be some overlap between these four areas of demand, the scale of skilled labour required to advance Canada's shared infrastructure and construction priorities is enormous. If Canada's transition to greater climate resilience is to be supported through investments in municipal FRM, and if urgent action is to be taken in the near-term to avoid the escalating costs that municipalities will experience in the coming decades, then supporting the supply of skilled workers is imperative.

Thoughtful, coordinated, and targeted workforce development and support programs must be initiated to avoid intersectoral competition that will worsen labour shortages, raising costs and impeding the development of adaptation projects. Given the risks and costs associated climate change, policymakers must advance the adaptation workforce to fill the jobs that investments are expected to create and must ensure workers have the skills required to build out new projects.

Structure of this report

The rest of the report is structured as follows: It begins with a discussion of climate adaptation in Canada, and why the focus of this analysis centers on flooding. The report then defines climate adaptation jobs and skills describes the analysis taken in this report. The next section presents the results and analysis of the jobs and skills analysis and discusses the implications emerging from this exercise. The report concludes with recommendations for policymakers to consider the skilled workforce needs of future adaptation projects.

The impacts of a changing climate in Canada

Tracking global climate change over the years reveals that not only is climate change one of the most urgent issues of our time but that countries like Canada are warming at a much faster pace than others. Between 1948-2016, the country's annual average land temperature has increased by around 1.7°C, with an increase of 2.3°C in northern Canada during the same time period. This observed warming is, on average, approximately double the magnitude of global warming.[17] The frequency, intensity, and duration of extreme events such as heatwaves, wildfires, and floods has increased and will continue to increase over the coming decades.[18] Moreover, gradual changes such as rising sea levels, thawing permafrost, or shortening cold periods will continue to alter ecosystems, communities, and livelihoods in Canada.[19]

Canada needs to advance climate adaptation to adjust to and thrive in this new climate reality. Recent extreme weather events have shown the costs of climate change and its negative impacts. These impacts will outpace current adaptation efforts unless significant investments are made on climate resilient infrastructure.[20] Analysis by the Federation of Canadian Municipalities (FCM) and Insurance Bureau of Canada (IBC) estimated that Canada needs an average annual investment of C$5.3 billion per year till 2050 in municipal infrastructure and local adaptation measures to adapt to climate change.[21] While the study focuses on a limited number of climate risks, and cost estimates are based on a small subset of communities and locations, it helps to gauge the actual investment requirement in the long run.

Of particular concern in the Canadian context is the risk and impacts of flooding and erosion. The IBC and FCM report referenced above indicated that the costs of flooding in Canada may exceed 1.25% of national GDP by 2050. Flooding costs are projected to increase between $4.5 to $5.5 billion annually for the next 30 years, jumping three to four times their costs today.[22] Nearly 80 percent of cities in Canada sit on floodplains, making Canadian cities particularly vulnerable to severe and frequent floods.[23] Development patterns in major Canadian cities are not easing these concerns. A 2020 analysis from the Canadian Institute for Climate Choices identified that, over the last three years, over $1 billion of building permits for new builds have been approved for construction within a 100-year flood plain, leaving asset owners at risk.[24] Without changes to development patterns, or major investments in greater FRM infrastructure, population growth and developments in flood-prone areas are likely to exacerbate socioeconomic impacts associated with urban flooding.[25] This comes with real costs. In 2016, seventy-eight percent of government disaster assistance payments for property damage was related to flooding.[26] Beyond government assistance, the costs for flooding are also borne by homeowners, coming in the form of losses in real estate value, restrictions in property use, potential increases in insurance premiums and mortgage payments, and potential loss of rental income.[27] These impacts highlight the need for measures to be taken to mitigate the risk and severity of flooding in Canadian communities to reduce costs and risks to renters, homeowners and municipal governments.

Box 1: What are climate change adaptation measures?

While there are many working definitions of adaptation, the most common one was given by the Intergovernmental Panel on Climate Change's (IPCC) in their assessment report:

> "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2018)

Climate change adaptation is a fast-evolving concept that encompasses a broad range of activities, such as updating standards, codes, and procedures, constructing built and natural infrastructure to improve resilience from climate impacts, and advancing novel modes of adaptation finance. The changing definition of climate change adaptation makes it difficult to concretely narrow the scope of a quantitative analysis that aims to identify impacts of investing in adaptation measures, including macroeconomic impacts. For any analysis to be meaningful and consistent, it is important to offer a specific definition of climate change adaptation that aids in narrowing the scope. This is because at its broadest, climate change adaptation can refer to any activity or measure that 'accounts for existing or expected changes in climate'. This can depend on the context within a community, region, or country and can include physically distinct and measurable actions such as building flood resilience infrastructure and switching to drought-resistant crops to intangible and immeasurable actions such as revamping business operations, designing new policies and frameworks, and upgrading building codes and regulations.

While complex, classifications for measures and projects do exist. Adaptation measures can be classified as green, grey, and soft. Grey adaptation focuses on technological and engineering solutions such as dikes, sea walls, expanded water treatment capacity, and fire-resistant building materials. Green adaptation focuses on nature-based solutions: protecting, strengthening, and modifying natural systems such as wetlands, mangroves, forests, and soil nutrition. Soft adaptation emphasizes legal, socio-cultural, political, and financial management policies and systems that enable adaptation. While soft adaptation plays a key role in adapting to a changing climate, the focus of this report is on grey and green adaptation measures, discussed in this work as built and natural infrastructure.[28]

Climate adaptation measures in Canada

In December 2016, Canada adopted the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) to respond to rapidly changing climate needs. Covering over 50 policy actions, it is Canada's first climate action plan to achieve its Paris Agreement targets. One of the four pillars of this plan encompasses 'measures to adapt to the impacts of climate change and build resilience', including through building traditional built infrastructure as well as living natural infrastructure.[29] To strengthen its commitments, the Government introduced *A Healthy Environment and a Healthy Economy* in December 2020, a plan in which the government committed to developing the first National Adaptation Strategy (NAS). The objective of NAS is to advance climate resiliency, increase collaboration on adaptation across all levels of government, and establish a framework to measure progress. These investments would include $1.9 billion to support disaster response and recovery efforts as well as wildfire resilience, flood maps, health adaptation, and infrastructure resilience. The development of NAS is envisioned to involve a multi-stakeholder engagement process, and some preliminary engagement and information-gathering sessions have already taken place.[30] With the NAS set to be completed by the end of 2022, this report aims to inform its development by driving the case for programs and policies needed to develop the workforce needed to support increased investments in adaptation.

Beyond these two reports, Canada has committed to advancing climate change adaptation and building resiliency to its impacts through several other plans, frameworks, and strategies. These include the Greening Government Strategy, the Arctic Policy Framework, the Federal Sustainable Development Strategy, and the Federal Adaptation Policy Framework. The 2011 Adaptation Policy Framework pre-dated the PCF and aimed to understand the impacts of climate change on the lives of Canadians, ensure that the tools needed to adapt to these impacts are in place, and improve the resiliency of the federal government itself to

a changing climate. While the Framework does seek to set domestic strategies to guide climate action, and inform the development of international policy to climate action, a 2018 Auditor General report identified that only 5 of 19 departments had undertaken assessments of climate risk to their mandates, limiting its overall impact.[31] Future federal policies, including the upcoming NAS, have endeavored to address identified gaps, including enabling greater leadership on adaptation measures, and ensuring the risks posed to mandates are assessed across all departments.[32]

A number of initiatives and investments have been led by many stakeholders both within and outside the policies and programs outlined above to further adaptation efforts. As an example, Infrastructure Canada has supported climate-resilient infrastructure projects under the Disaster Mitigation and Adaptation Fund (DMAF), and the Green Stream of the Investing in Canada Infrastructure Program (ICIP). The department has also supported capacity building measures through the Municipalities for Climate Innovation and Asset Management Programs, in partnership with the Federation of Canadian Municipalities (FCM).[33]

Flood risk management measures across Canada

Within adaptation policies and programs, there are a number of policies or programs developed specifically to reduce flood risk, or support FRM. Many programs developed to support FRM, or reduce the risk of flooding, are provincially or municipally administered.[34] For example, as of 2020, subsidies and grants are available for property owners to offset expenses related to FRM in five provinces across the country.[35] Other interventions include education programs or filling technical expertise gaps, to empower local communities to pursue their own resiliency efforts. The Home Flood Risk Management Program, launched by Intact Centre on Climate Adaptation at the University of Waterloo, provides training courses for residents, flood risk management educators, and flood resilience professionals, to prepare community members to raise awareness and take action to prepare homes against flood risks.[36] The Saskatchewan-based Emergency Flood Damage Reduction Program supports several stakeholders including rural municipalities, businesses, and non-profit organizations, to access "cost-sharing assistance for flood risk management measures" and engineering or other technical support required to assess potential risks.[37]

There are still federal efforts directed at FRM, including some of those listed above, such as the Advisory Council on Flooding, which formed a public-private sector working group on the financial risk of flood management to assess options for better management of flood costs. Another federal initiative includes the National Disaster Mitigation Program which aims to address significant and recurring flood risks and costs with targeted investments and supports work on facilitating private residential insurance. This program offers funding for provincial and territorial governments.[38]

Climate change adaptation jobs and skills

What are climate change adaptation jobs, or "adaptation jobs"?

Climate adaptation jobs differ, to some extent, from 'green' jobs that are defined as jobs that are dependent on the environment or are created or evolve during the transition towards a greener economy.[39] Climate adaptation jobs focus exclusively on proactively preparing for, and responding to, climate change impacts. 'Green' jobs encompass adaptation but also resource efficiency, energy efficiency and jobs that focus on decreasing the environmental impact of economic activities. More specifically, adaptation jobs are defined as:

> "Covering all jobs created, sustained or redefined in the process towards building resilience to the existing and projected impacts of climate change. This means jobs related to climate risk management solutions and measures to cover short-, medium- and longer-term climate change risks. These jobs are a result of economic activities related to adaptation, including financial, physical, technical and capacity building activities." – (Triple E Consulting, 2014)

Even though the channels through which climate adaptation impacts the economy and jobs is complex, a report commissioned by the European Union attempts to outline these mechanisms.[40] In the short term, adaptation measures that involve investments can increase spending and demand for goods and services, impacting employment. This spending can be on the operational as well as the capital side, extending employment impacts beyond the short-term. Additional employment impacts may also arise from preventing job losses due to climate change, classified as the indirect impacts of adaptation measures.[41]

The employment impacts of investment in climate adaptation infrastructure can be disaggregated into three effects: direct effects, indirect effects (industries that supply inputs for infrastructure), and induced effects (jobs created by increased consumption as incomes from the first two effects rise).[42] However, this analysis focuses on just direct and indirect jobs (a justification that is outlined in **Appendix 1**). Additionally, climate adaptation measures are expected to lead to not just an increase in jobs but also to the prevention of job losses that would otherwise have resulted from the economic impacts of climate change. In the European Union (EU), increased adaptation-related expenditures, in a reference scenario, have the potential to create around 500,000 additional direct jobs (approximately 0.2 percent of the working population) by 2050. In addition, around 136,000 job losses will be prevented by 2050 in sectors that would otherwise have been affected negatively by climate change. In a more ambitious scenario, in which expenditure on adaptation is increased to 1 percent of GDP in the EU up to 2050, approximately 1 million jobs could be created while up to 330,000 job losses could be prevented. Most of the projects that were part of these adaptation measures were infrastructure related while most of the jobs created were in the construction, business, and public services sectors.[43]

Developing skills is considered to be another important adaptation measure as it allows workers to transition from job losing sectors to job growth sectors, helps promote innovation and competitiveness, and is required to implement adaptation strategies.[44] There has been little analysis done globally about which skills will be required within the labour market to advance adaptation projects. Discussions have largely emphasized that many skills in demand will be a mix of 'generic' and 'new' skills, meaning there will be a need to both repurpose existing skills within the labour market and offer training for new skills.[45] Some efforts have been made in Canada to identify competencies required for skills work, through projects like the Climate Adaptation Competency Framework by the Adaptation Learning Network.[46] While projects such as these have identified some of the new or unique competencies required to advance climate action, they have not done so in direct relation to workforce needs, and have not connected skills needs to existing taxonomies used in the development of skilled workforce policies and programs. The analysis in this report is largely the first of its kind in Canada, although it does recognize other work has been conducted, and it aims to complement previous and ongoing initiatives.

Box 2: How could the skills gap affect adaptation projects?

Building the infrastructure needed to adapt to climate-linked flooding will require a skilled workforce in the construction and engineering industries. Without policy action, there is a danger that there will not be a large enough skilled workforce to fill this demand. This deficiency is already a problem since Canada is facing shortages in civil engineers and skilled tradespeople that will make filling these adaptation jobs difficult.

Tackling skilled labour shortages at levels needed to advance infrastructure projects does not mean that specialized experts are needed for all occupations in every individual municipality across Canada where each project will be built. Many municipalities commonly outsource technical design, construction, and construction management responsibilities for infrastructure projects. However, workforce shortages can still raise the costs of labour, and delay completion timelines for projects, if they persist.

This labour shortage is a critical bottleneck to achieving Canada's 2030 and 2050 climate targets. In the construction sector alone, 259,100 workers or 20 percent of the 2020 labour force is expected to retire over the next decade. It is projected that 309,000 new construction workers will be needed over this time period to offset the aging population and fill jobs expected to be created.[47] Over the next several years, labour needs will continue to increase, exacerbating the problem of filling jobs central to fighting climate action.

3 OVERVIEW OF THE ANALYSIS UNDERTAKEN IN THIS REPORT

This report focuses on the need for workforce readiness and preparedness to advance climate adaptation projects across Canada. The analysis conducted in this report seeks to answer three questions:

- What are the current workforce needs for pledged spending under the federal DMAF on adaptation projects related to municipal flood risk management and protection?
- What are the workforce needs for advancing projects at the levels required to adapt to the worst impacts a changing climate will bring on municipal infrastructure from flooding by 2030, in line with the adverse impacts anticipated by 2030?
- What skills will the workforce building these projects require?

In order to identify how to support the growth of the skilled workforce needed to advance projects at levels required to combat the worst impacts of climate change, this analysis estimates the job creation impacts of two different sets of projects. **The first is an estimate of the job creation impacts of the current projects aimed at mitigating flooding risk and impacts pledged under the federal DMAF program.** This evaluation aims to estimate the number of jobs created as a result of these projects in an effort to show how currently pledged spending on adaptation measures from flooding will impact the labour market. This, in turn, helps to understand both the occupations affected, and the geographic distribution of these jobs, and to generate insights for future skills and workforce development programs.

The second is an estimate of the job creation impacts of building out municipal flood risk management infrastructure at the levels needed for Canada to adapt to the worst impact of flooding. The figure used to assess spending levels needed to mitigate damages from a changing climate is based on an estimate conducted by IBC and FCM. That previous report estimated total costs required to adapt to a changing climate and used a project cost database that identified spending required to advance municipal FRM projects at levels needed to adapt to climate change. This analysis used the same project cost database and pulled out the portion of that figure used to identify investments in projects that are needed to adapt to flooding between 2022 and 2030. This cost was calculated as $719 million annually, adding up to a cumulative spending of over $6.47 billion over this nine-year period, and it was used to calculate how many jobs would be required to build out this volume of flooding infrastructure, which will be required this decade to adapt to the worst impacts of Canada's changing climate.

Critically, this figure does not represent all adaptation costs required for Canada to advance resilience to the impacts of climate change, as it focuses only on municipal FRM infrastructure and calculates a level of spending required to address expected impacts to 2030. This estimate should therefore be interpreted as a measure of only a portion of total needs, with the final figure only being calculable once the methodology used in this report can be applied to a wider range of adaptation projects. Additionally, as this report has previously stressed, developing resilience in line with longer-term impacts in the near-term will create more jobs, and minimize negative long-term economic, environmental, and social costs that adverse impacts are expected to bring about. The projects whose estimates were evaluated were similar to those contained within DMAF, which allowed this analysis to estimate how an increase in commitment could drive job creation across Canada. This evaluation is useful for identifying the size of the workforce that will be needed to help municipalities install flood risk management infrastructure projects by 2030.

Finally, the third estimate in this report is an analysis of the skills requirements that will be needed for this future workforce to advance adaptation projects at the levels identified by 2030. This analysis allows for a discussion of which skills will become more in demand, and where greater support will be required to equip and support the workers responsible for advancing projects.

This analysis highlights the number of jobs required to build these projects and where they will be located, for both currently pledged spending on DMAF projects and additional projects required out to 2030. This component allows for a discussion of the size of the workforce that will be required regionally and can inform the development of provincial skills policies to support this growth.

Box 3: What is the Disaster Mitigation and Adaptation Fund? (DMAF)

Launched in 2018, the DMAF is a $2 billion fund spanning 10 years that aims to invest in infrastructure projects across the country to increase climate resiliency of communities impacted by climate change. Projects eligible for funding support under this portfolio include construction of new infrastructure as well as upgrading and modification of existing infrastructure. In Budget 2021, an additional $1.375 billion of funding was committed over a span of 12 years with a minimum $138 million reserved for Indigenous projects. While projects were initially required to cost at least $20 million or above, the government revised this criterion in 2021 to make projects with a total cost of under $20 million also eligible for DMAF funding. Currently, the portfolio is split into two streams with $670 million committed to projects under the $20 million threshold and the rest committed to projects over the $20 million threshold.

The current DMAF portfolio comprises 69 projects across Canada with a total cost of $4.4 billion, out of which $1.9 billion is funded by Infrastructure Canada. These infrastructure projects cut across a range of categories including water supply, wastewater and stormwater, marine infrastructure, land transportation, buildings, and energy and ICT infrastructure. The scope of the analysis in this report is limited to flood risk management infrastructure in the DMAF portfolio for several reasons that make the program a representative sample of many of the types of flood risk management projects that will be advanced in Canada to support adaptation efforts in the coming decade. First, the portfolio covers a wide range of infrastructure projects aimed at climate mitigation and adaptation across Canada, ranging from $20 million to $495 million.[48] Second, the portfolio includes projects across a range of cost profiles, from smaller community-level projects to larger regional-level projects. Third, these projects closely represent adaptation infrastructure priorities identified by provinces, regions, and municipalities. Fourth, this stream reflects accelerated effort by the federal government to respond to Canada's increasing climate adaptation needs and hence, represents a credible sample of infrastructure adaptation projects being implemented or to be implemented in the near future.

Methodology used for analysis

This section summarizes our methodology for identifying jobs, both direct and indirect, and skills needs; more detail is available in **Appendix 1**.

Table 3: Overview of methodology used to conduct evaluation of skilled workforce needs in this project

Steps in analysis	Estimating workforce impacts of current DMAF flood risk management projects	Estimating workforce impacts of flood adaptation in Canada from 2021-2030
Step 1: Select projects	Used the list of FRM infrastructure projects that currently receive funding from the DMAF. This information was collected via an informal survey of a sample of DMAF-funded projects. Using this data, three project templates were created and used: A built infrastructure project, a natural infrastructure project, and a hybrid project. The use of project templates allowed this analysis to avoid selection bias and be more representative of different project types.	Same methodology, with the assumption that project types would remain roughly similar.
Step 2: Breakdown the expenditures for a given project template across sectors	Spending in a project was connected to different economic sectors, which allowed for an understanding of how spending will flow within the economy.	Same methodology, with an assumption that spending on different projects would remain roughly similar.
Step 3: Estimate how spending will increase in coming decade	N/A	Use a project cost database developed for an existing meta-estimate of the costs of climate adaptation infrastructure developed by FCM and IBC to calculate how much additional spending will be needed on projects by 2030. This figure, calculated by the authors of this report, is $719 million annually.
Step 4: Estimate number of workers required to advance projects	The spending categories above were multiplied by employment multipliers in each sector. Multipliers are figures that represent the average number of jobs created directly and indirectly per million dollars spent in a given sector in a given region in a given year. This analysis shows the number of direct jobs (people hired to provide the good or service) and indirect jobs (people hired to produce the inputs required to make that good or service) created through spending.	Same methodology, although employment multipliers were projected to 2030 using historical data. This was done to account for changes in the number of jobs that could be created by spending into the future, which is affected by changes in factors such as labour intensity.
Step 5: Estimate skills needs for the workforce to build projects	N/A	Using the sectors identified above, this analysis used the O*NET database (a database of skills associated with specific occupations) to identify skills needs of this workforce. This was done by analyzing the relative importance of 35 different skills common for a given occupation, and the share of employment across different occupations for the sectors.

Box 4: How does spending vary across built, green and hybrid adaptation projects?

The analysis in this report used three project templates to represent the variety of costs incurred on each project for built, natural and hybrid (built and natural) infrastructure projects. The use of project templates allowed this analysis to avoid selection bias and be more representative of a wider variety of different project types. The natural, built, and mixed infrastructure projects represented in templates and captured in the survey sample spent their money on different economic sectors, as shown in **Figure 1**. The largest expenditures for traditional built infrastructure projects were in construction, specifically on engineering construction, construction of transportation infrastructure, and other construction activities including land preparation and site clearing.

The single natural infrastructure project in the sample – the only DMAF flood-protection project that focused entirely on natural infrastructure – was a tree-planting project that made most of its expenditures to tree nurseries and tree care services. Mixed infrastructure projects spent most of their expenditures on construction sectors, like the traditional built projects, but spent less on building materials (e.g., concrete) and more on design services.

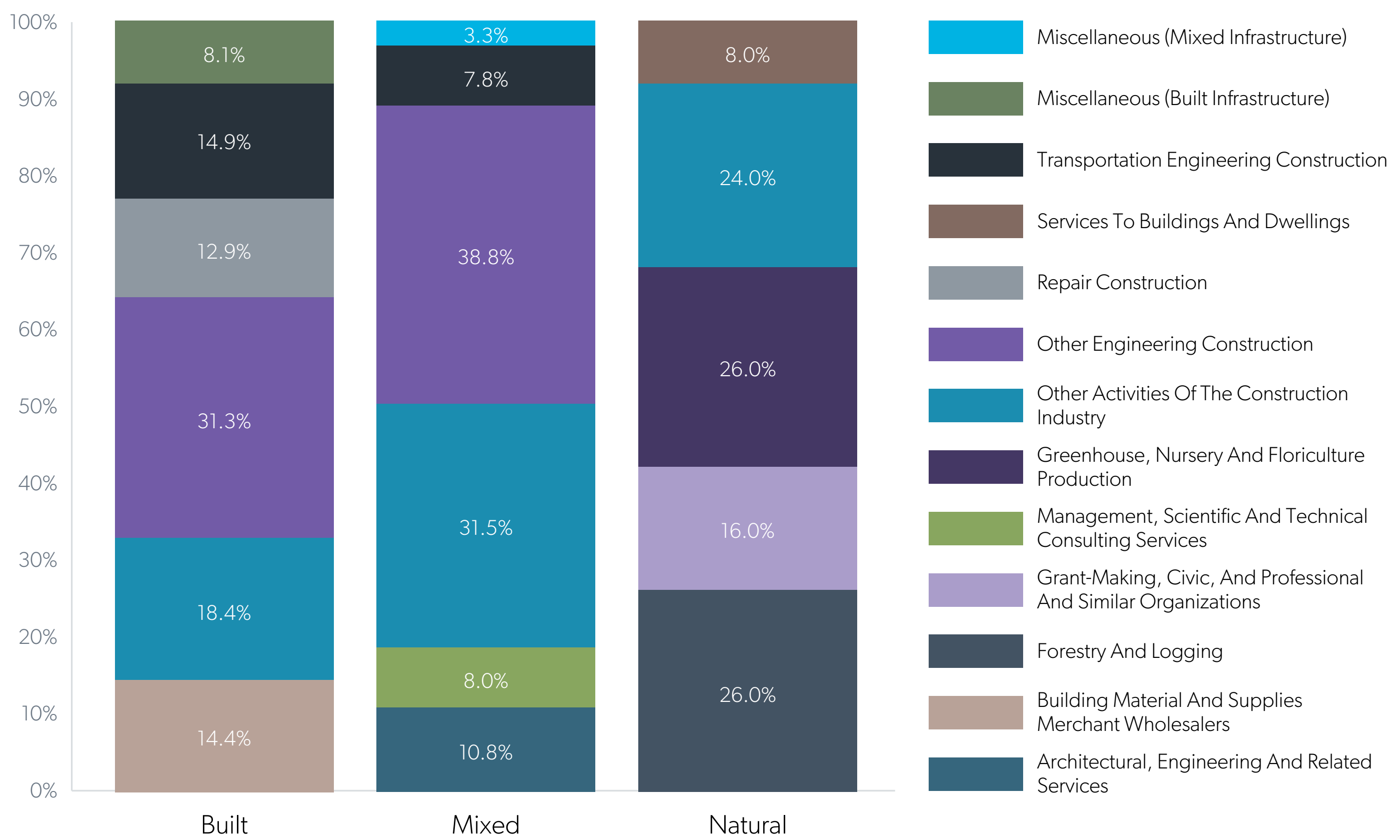

Figure 1: Average expenditure profile of built, natural, and mixed infrastructure projects in the sample

4 RESULTS AND DISCUSSION

This analysis outlines the workforce needs that could be required to advance municipal FRM projects. It presents three sets of findings from the analyses: An evaluation of the workforce needed to advance DMAF projects, an evaluation of the workforce required to build out flooding infrastructure at levels needed by 2030, and an analysis of the skills that this workforce will require to advance these projects.

Key assumptions

It should be noted that this analysis represents the workforce needs for the projects modelled, and that different kinds of jobs would be created by future FRM projects if more natural infrastructure projects were taken on. Without commenting on the specific projects for which the cost estimates were generated, it appears built infrastructure is still generally preferred[49] by public asset-planning authorities in Canada even when natural infrastructure could provide the same services more cheaply and with environmental and social co-benefits.[50]

However, a growing number of municipalities are developing policies and procedures to consider natural infrastructure when planning assets,[51] with support from organizations like the Municipal Natural Assets Initiative. The expenditure survey used in this work indicated that natural infrastructure projects spend money on very different economic sectors than built or mixed infrastructure projects, often on economic sectors – like the forestry and greenhouse/nursery sector – that have very high employment multipliers. If natural infrastructure becomes more mainstream, and a larger number of natural infrastructure projects are advanced, the analysis done in this brief should be updated to consider the employment implications of planned projects.

Additionally, this report looks at jobs created through development of new infrastructure, or refurbishment and repair of existing infrastructure. That means this analysis does not touch on job creation, or skills changes required, for many operations, assessment or inspection roles that will also be affected once these projects are built and will need to be maintained. As new resilient infrastructure and construction standards continue to be developed and adopted,[52] these roles will be impacted as well.

Workforce impacts of DMAF projects

As **Table 4** shows, the current expenditures under the DMAF portfolio will require around 23,000 jobs across Canada to advance. Out of these, 14,384 are direct jobs and 8,312 are indirect jobs. DMAF currently funds 48 flood-protection projects with a total cost of $3.5 billion.[53] There are 34 traditional built infrastructure projects, 13 projects with a mix of built and natural components, and one project that consists of solely natural infrastructure. If these projects spend their money according to the pattern observed in the sample, this spending creates jobs in different sectors (direct jobs). For example, direct jobs for construction labourers and managers will be created from a stormwater sewer development project to prevent flooding. Projects can also create jobs in supporting and supplying sectors which provide inputs to these sectors (indirect jobs). In the case of the stormwater sewer project, this could include jobs created for transport and logistics workers and managers. While no analysis was conducted to evaluate the impacts for workers in the skilled trades, it is understood that this level of activity will likely require a number of skilled tradespeople.

Table 4: Total no. of direct and indirect jobs created under DMAF

Direct & Indirect Jobs by Sectors	No. of Jobs
Direct	**14,384**
Architectural, Engineering and Related Services	565
Building Material and Supplies Merchant Wholesalers	2,198
Greenhouse, Nursery and Floriculture Production	60
Management, Scientific & Technical Consulting Services	459
Other Activities of The Construction Industry	2,932
Other Engineering Construction	4,324
Repair Construction	2,201
Transportation Engineering Construction	1,646
Indirect	**8,312**
Indirect Jobs	8,312
TOTAL	**22,696**

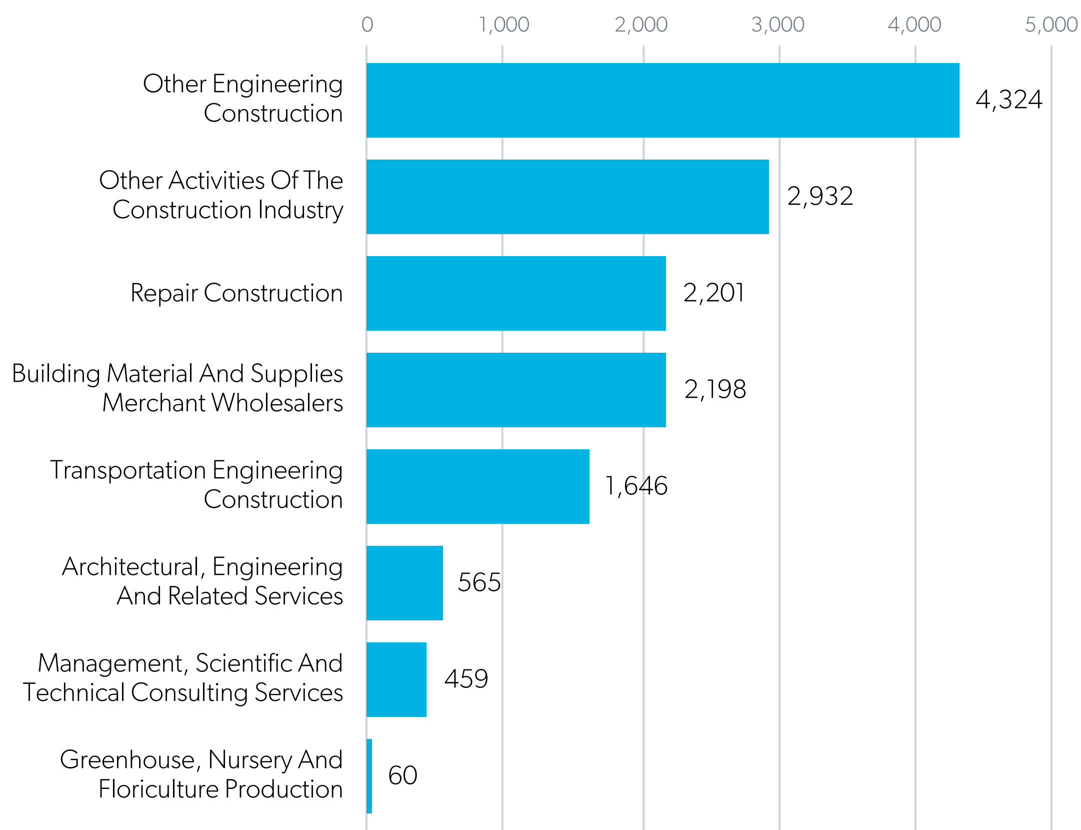

Figure 2: No. of direct jobs created by DMAF-funded flood-protection projects across sectors

Figure 2 shows that the direct jobs created by these projects are distributed across different sectors.[54] The most affected sector for direct job growth is the construction industry, mainly for engineering and repair construction work. Jobs needed in these sectors would include contractors and supervisors, construction trade labourers, heavy equipment operators and others. This is followed by building materials and supplies merchant wholesalers. Jobs in this sector would include sales and account representatives, trade managers and others. Finally, direct jobs would be created, and workers would be needed in related services such as architectural, engineering design and management, scientific and technical design. These would include different jobs such as civil engineers, construction inspectors, environment and business management professionals and others. It should be noted that these estimates serve as lower-bound estimates of the direct jobs that could be created by flood-protection

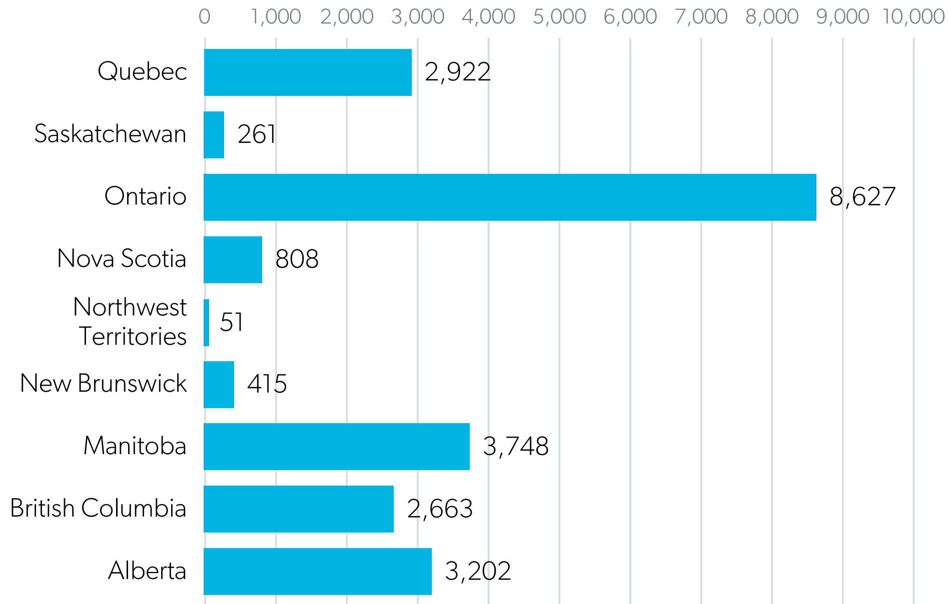

Figure 3: No. of jobs created by DMAF-funded flood-protection projects across provinces

projects funded through DMAF.[55] Nevertheless, the numbers are substantial, pointing to a growing need for labour supply across a variety of sectors, particularly construction.

Figure 3 shows how the jobs needed to advance DMAF projects are created across the provinces and territories. As shown, the largest number of jobs is created in Ontario, followed by Manitoba and Alberta. This is because nearly half of the projects funded under DMAF are in these provinces. While the geographic distribution of jobs might change in the future depending on the expenditure, it is important for the provinces and territories to be prepared for these job creation impacts. A detailed table showing how job creation for DMAF projects varies in the sectors across the provinces and territories is provided in **Appendix 2**.

Workforce impacts of increased climate adaptation projects by 2030

By 2030, at least $6.47 billion will need to be spent on municipal FRM infrastructure to avoid the expected worst impacts of a changing climate by 2030. As **Table 5** shows, this level of adaptation activity, which is above and beyond DMAF, is estimated to create an additional 37,769 jobs across Canada. This would include 25,039 direct and 12,730 indirect jobs.[56]

Table 5: Total no. of jobs created for flood risk management projects from 2022 – 2030

Direct & Indirect Jobs by Sectors	No. of Jobs
Direct	**14,384**
Architectural, Engineering and Related Services	565
Building Material and Supplies Merchant Wholesalers	2,198
Greenhouse, Nursery and Floriculture Production	60
Management, Scientific & Technical Consulting Services	459
Other Activities of The Construction Industry	2,932
Other Engineering Construction	4,324
Repair Construction	2,201
Transportation Engineering Construction	1,646
Indirect	**8,312**
Indirect Jobs	8,312
TOTAL	**22,696**

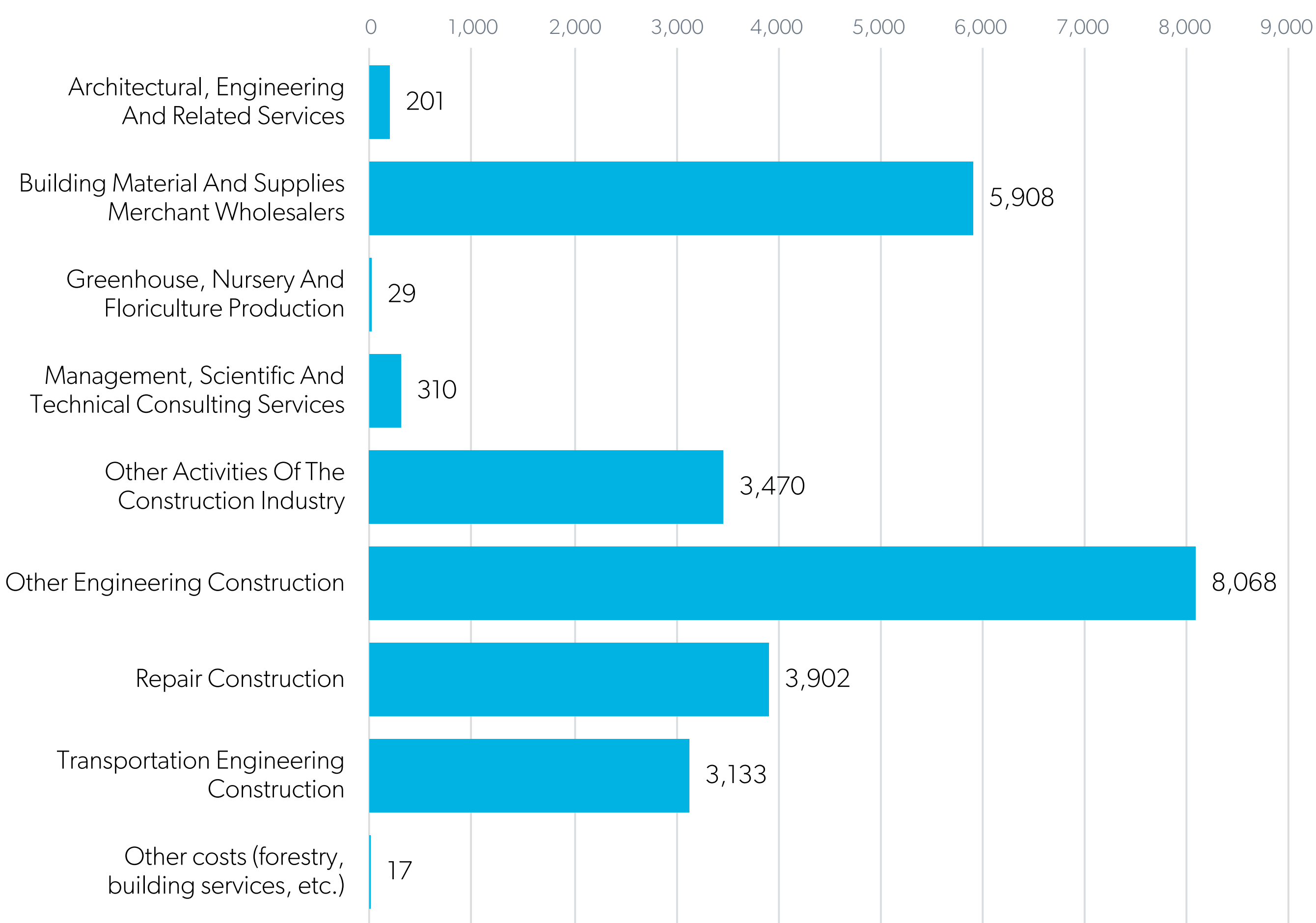

Figure 4: No. of direct jobs created across sectors by flood risk management projects between 2022 – 2030

Figure 4 shows the distribution of direct jobs created by FRM projects in addition to DMAF projects between 2022 and 2030. Similar to the current DMAF portfolio, more than half of the jobs needed are in the construction sector across engineering, repair, and transport engineering. A large portion of jobs are also created in the building materials and supplies sector. This reflects the fact that while some of the costed projects involve natural or mixed infrastructure, many of them are traditional built infrastructure. A number of jobs will also be created in management, scientific and technical consulting services.

Figure 5 shows the number of jobs created from FRM infrastructure across the provinces and territories. As seen, the province set to experience the highest job creation by these future flood-protection projects is Quebec, with almost 59% of capital spending on flood risk management infrastructure occurring in the province, leading to the creation of the majority of jobs from adaptation spending. The reason why this analysis shows different job creation impacts than the one conducted above for DMAF has to do with the methodology used to determine job creation impacts. This expenditure breakdown was based off a project cost database used for the existing meta-analysis outlined above. This analysis identified which percentage of total project costs in each province, and for each project type, would be incurred by 2030. This expenditure was then used to identify the job creation potential of spending in different industries and provinces. This means that job creation is based off the expected volume of spending needed to avoid the worst impacts of climate change in each province, which is tied to both the overall expected volume of projects that need to be built, and how much each project is expected to cost.

These results stand in contrast to more jobs being created in different provinces for the present DMAF projects, although this spending still results in significant job creation in provinces like British Columbia, Alberta, and Ontario. A detailed table estimating how job creation for flood risk management projects in different sectors varies across the provinces & territories by 2030 is provided in the **Appendix 2**.

From the two estimates, it is seen that spending at levels needed to avoid the worst impact of a changing climate by 2030 (which will cost $6.47 billion by 2030) is likely to create more jobs than current DMAF spending (which is approximately $3.5 billion in spending in total). This is primarily due to the higher expenditure profile of the two spending patterns. This finding also makes a case for spending more on FRM infrastructure then is currently being spent to avoid the worst effects of a changing climate.

Skills Analysis of 2030 workforce needs

After understanding some of the jobs created across different sectors within built, natural, and mixed infrastructure projects, it is useful to explore the skill sets considered important to perform the jobs involved in these projects. In this report, skills were quantified using the O*NET skills database. The figures in the table represent scores of how "important" a given skill is in a particular occupation. Higher scores are illustrative of greater importance, and this table only represents skills that were shown to be of relatively high importance across the analysis. As such,

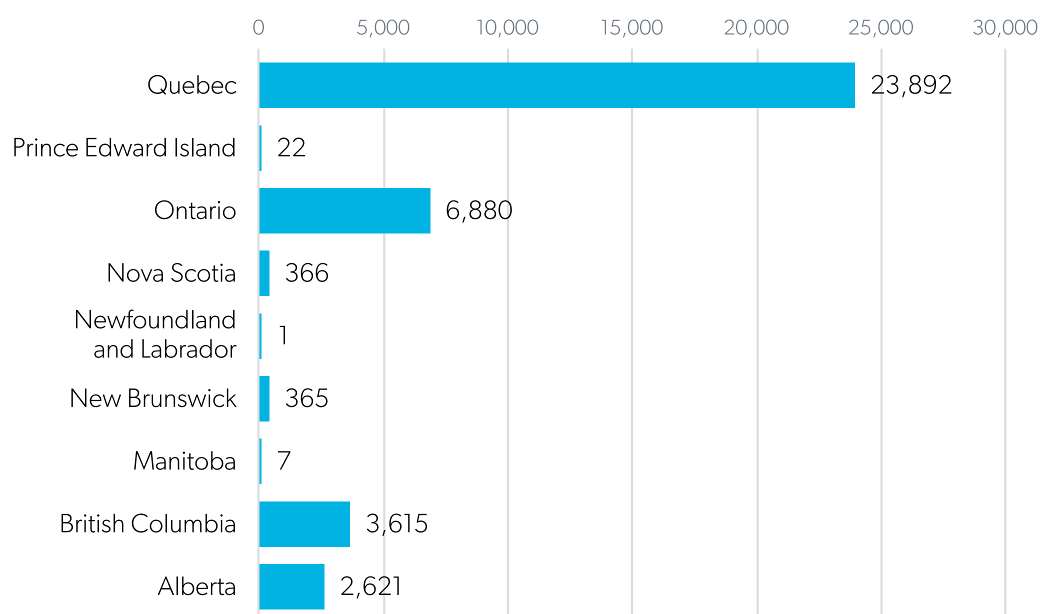

Figure 5: No. of jobs created across provinces by flood risk management projects between 2022 and 2030

the skills outlined below do not represent the full range of potential skills that could be required to advance these projects.

Table 6 below summarizes the most important skills, based on the ratings, that workers will require for the five main sectors (a detailed table with all categories of skills is provided in **Appendix 4: Table A.7**). The skills are categorized into 6 different categories: process, social, problem solving, technical, systems and resource management.[57] To help interpret the relative importance of skills scores in this analysis, the ranges for each third of the analysis are separated by mean ± standard deviation[58]:

<31: Bottom third of skills importance scores;
32-54: Middle third of skills importance scores;
>55: Top third of skills importance scores.

Overall takeaways

First, occupations relevant for designing and building climate adaptation projects require a wide range of skills, many of which are non-technical skills. This not only includes systems and resource management skills but also process, social and problem-solving skills. These non-technical skills will enable engineers, architects, managers in construction and horticulture, as well as inspectors to work in collaboration with experts in construction and building materials. This is the reason why critical thinking, active learning, monitoring, social perceptiveness, coordination, and complex problem solving are consistently ranked high across all the five sectors. For example, civil engineers must work with architects, urban planners, economists, first responders and emergency experts, and those in the insurance industry and experts in social equity.[59]

Table 6: Important skills required by flood risk management workforce by 2030 in each sector

Categories	Skills	Construction	Building material and supplies merchant wholesalers	Architectural, engineering, and related services	Management, scientific and technical consulting services	Greenhouse, nursery, and floriculture production (except cannabis)
Process	Critical Thinking	50.4	59.2	63.3	68.4	52.2
	Active Learning	41.2	48.8	52.6	54.6	37.8
	Learning Strategies	34.6	34.6	42.7	45.5	34.0
	Monitoring	47.7	52.8	53.0	60.3	50.2
Social	Social Perceptiveness	41.9	58.2	47.1	60.1	45.5
	Coordination	47.7	53.0	50.0	57.5	51.5
	Persuasion	34.0	54.7	43.6	47.9	36.0
	Negotiation	32.9	53.4	41.2	45.2	33.4
Problem Solving	Complex Problem Solving	44.2	51.4	58.7	62.0	38.7
Technical	Operations Monitoring	41.3	26.4	34.8	20.1	42.4
	Operation & Control	37.1	25.8	20.3	5.7	41.4
	Quality Control Analysis	38.5	17.9	38.6	17.1	36.3
Systems	Judgement & Decision Making	46.1	52.0	55.7	63.1	43.6
	Systems Analysis	32.9	34.9	50.1	57.6	23.3
	Systems Evaluation	32.4	35.0	46.9	58.1	18.8
Resource Management	Time Management	46.1	50.7	51.1	49.9	43.6
	Management of Personnel Resources	37.9	32.2	41.2	44.1	40.4

Source: Calculated from the 2019 Labour Force Survey and the United States O*NET skills database

Second, systems and resource management skills will grow more important for these workers. The ability to judge, decide, analyze, and evaluate systems, and the capacity to manage time and resources are foundational along with process and social skills. For instance, for civil and mechanical engineers and architects working in the consulting services sector, systems management and resource management will be important alongside the individual technical skills they bring to the table.

Third, technical skills will remain critically important in the future, but the specific importance of these technical skills varies across sectors. The scores above show that while social, process, systems and resource management skills will be in demand across all sectors, the importance of technical skills is often based in a specific sector, but not shared across all sectors. Given that specialization is an important component of adaptation projects, this makes sense. For example, operations monitoring, operations control and quality control stand out as important technical skills for all the sectors. However, for construction and greenhouse, nursery, and floriculture production, they are relatively more important compared to building materials wholesaler, architectural and management consulting services.

Insights by sector

Table 7 provides examples of jobs that are prominent in the sector and the highest rated skills required for those jobs based on the analysis. For the construction and greenhouse nursery and floriculture production sectors, skills such as monitoring, coordination and time management are important for all the jobs that will be created. On the other hand, for architectural, engineering and management, scientific and technical services sectors, complex problem solving, decision making, and active learning are some of the skills that our analysis ranked as more important. For building materials and supplies merchant wholesale sector, jobs require more social perceptiveness, persuasion, and negotiation skills.

Table 7: Insights on skills requirements for flood risk management workforce by sector for jobs needed by 2030

Sector	Type of jobs created in these sectors	Standout Skills
Construction	Contractors and supervisors Trade labourers Carpenters	Monitoring Coordination Decision making Time management Complex problem solving
Building materials and supplies merchant wholesaler	Retail and Wholesale Trade Managers Sales and Accounts Representatives Material Handlers	Social perceptiveness Persuasion Negotiation Coordination Monitoring
Architectural, engineering and related services	Civil engineers Architects Mechanical engineers	Complex problem solving Judgement and decision making Monitoring Active learning Time management
Management, scientific and technical consulting services	Business/environmental management professionals Human resource managers Ergonomists	Judgement and decision making Systems evaluation Complex problem solving Monitoring Social perceptiveness
Greenhouse, nursery and floriculture production	Nursery and greenhouse workers Horticulture workers Landscape managers and workers	Coordination Monitoring Social perceptiveness Time management Operations & control

5 RECOMMENDATIONS

Recommendation #1: Increase federal, provincial, and territorial spending through programs that mitigate adverse climate impacts in communities across the country, and reform or create new spending programs to allow for more kinds of projects.

This analysis clearly shows that spending on solutions to mitigate flood risk for municipalities across the country can create tens of thousands of jobs across the country. Given the economic opportunity this presents, federal, provincial, and territorial governments should commit more funding to adaptation priorities. Levels of funding should be increased to match the level of flood risk Canada faces. This report identified that spending an additional $6.47 billion through programs like DMAF could have substantial economic benefits, and this report recommends boosting overall spending through funding programs by at least this much to ensure projects are developed by 2030. Proactive spending will help avoid future costs being incurred to households and municipalities from climate disasters. As previously noted, even with rising costs of living, this additional spending makes economic sense, as it offers a host of economic, environmental, and social benefits, creates jobs, and supports greater affordability moving forward.

As spending is allocated, it should be paired with reforms to existing programs, and the development of new programs. Greater flexibility is needed under existing program streams to ensure the projects that fit best within local circumstances can be advanced in municipalities across the country. Communities have identified a host of challenges with funding programs like DMAF, noting that the program application requirements are high enough that they can dissuade smaller municipalities from applying,[60] funding structures do not always account for how municipalities need to spend many on adaptation projects,[61] and minimum project size requirements can prevent small, but effective, projects from being considered. These changes can help advance a larger number of projects that better fit local needs, supporting the development of more FRM projects. However, if changes to programs that allow for these changes is not possible, additional program funding should be made available under new programs with revised application processes that remove these bottlenecks to investment.

Recommendation #2: Create training programs to support the growth of the skilled adaptation workforce.

This analysis reveals that many occupations required to build adaptation infrastructure and support municipal flood management are not unique to adaptation and will differ by province. Governments need to create training programs to ensure that the workforce in affected sectors, like construction, engineering and a number of skilled trades have the skills needed to develop adaptation infrastructure projects in every province, given the increase that is expected to be built in the coming years. These reforms to training and education need to include changes to training and education to ensure workforce training aligns with existing or emerging standards or guidelines that advance resilience. Some of these standards or guidelines have already been developed, such as the Flood Resilience Guidelines for new communities by the Canadian Standards Association[62] and the FireSmart home maintenance and development guidelines.[63] Others remain under development, such as changes to Canada's National Building, Electric and Fire codes.[64]

Different regions are likely to have different skills needs because of the project spread across provinces, and therefore policies will need to be targeted to the demand in a given area. An example from the analysis wherein a large portion of jobs advancing FRM projects are created in building material and supplies merchant wholesalers in Quebec, compared to construction in Alberta. The occupations and corresponding skillsets required differ – for instance, specialized technical skills like operations monitoring or equipment selection in Alberta – which should be accounted in the creation of programs. Provinces must consider the projects they choose to commit to, and the standards or guidelines they will be built to, to guide the design of training programs that prepare the adaptation workforce. One limitation of this analysis is that the methodologies used cannot reveal skills needs for projects outside of the sample used in this report. Communities may seek to advance natural infrastructure projects due to their co-benefits beyond adaptation, which include reduced recovery and replacement costs, habitat provision, and improved air quality.[65] It is important to recognize there are a host of adaptation projects, specifically related to natural infrastructure, that are not covered in the analysis. Given that there is increased interest in natural infrastructure projects, training and education programs should also reflect skills needs for these other project forms.

Recommendation #3: Develop a roadmap for growing the skilled adaptation workforce that is tied to expected or anticipated climate impacts.

This analysis represented an initial attempt to identify both the workforce demand from building out municipal FRM infrastructure at levels needed to avoid the worst impacts of climate change by 2030, and to identify the skills needs of this adaptation workforce. However, flooding is far from the only threat Canada will face from a changing climate. Increased rates of wildfires, more frequent and intense droughts, longer and hotter heat waves, rising sea levels and melting permafrost are only a handful of the impacts a changing climate will bring, to say nothing of the implications of a warming Canada for public health, community planning, ecosystem management, agriculture and forestry practices, and any other aspect of society and the economy. In order to ensure the country has the workforce needed to advance all projects and measures required to manage these impacts, Canada should create a roadmap for training the adaptation workforce to ensure new and current occupations acquire the skills necessary at all levels. An adaptation workforce roadmap should reflect the policies and programs necessary to meet adaptation infrastructure needs, and address accessibility to these skills opportunities. The roadmap should enable the creation of avenues for employers to access regionally- and sector-specific skills as well as opportunities for worker reskilling or upskilling initiatives specific to adaptation needs. Key focus areas include a comprehensive understanding of the skills needs for adaptation, the tools necessary for workers to close skills gaps, key information about needed training programs, and avenues or platforms necessary to access jobs and skills training. As noted, job opportunities will also depend on the roles in demand. Regional variation should be accounted for in creating opportunities for reskilling and upskilling; there is a need to understand which sectors receive attention and how different groups will gain skills for adaptation projects.

A critical component of this roadmap will be integrating considerations around advancing greater equity and inclusivity in workforce participation. The design of these training programs must account for the composition of the workforce and factors shaping a worker's ability to access training opportunities. Equity-deserving groups in particular face specific barriers, which may be alleviated and addressed through design. For example, mainstreaming gender considerations in skills training and development has been discussed as a lever to support the mobility of women from low-skill and entry-level to high skilled jobs.[66]

6 AREAS OF FUTURE RESEARCH

This report aimed to estimate the number of workers and types of skills needed to implement current and future adaptation infrastructure projects. The analysis is not meant to be prescriptive or a blueprint for climate adaptation infrastructure projects, but instead aims to be the first of its kind to highlight the potential workforce required to undertake climate adaptation projects in communities within Canada. The report identifies the following areas of research to build upon this and other work, in an effort to better understand future workforce needs.

First, greater research into skilled workforce needs is necessary to advance two of the recommendations outlined above. This report focuses on municipal FRAM projects that are currently funded by, or eligible for funding under, DMAF, and therefore represent a small subset of the infrastructure adaptation projects undertaken in Canada. As noted above, similar analyses should be conducted for other disaster events to understand the workforce and skills required for the development of built, mixed, and natural infrastructure projects to address climate impacts. A better understanding of these workforce needs will not only fill a key knowledge gap but will also highlight labour and skills shortages for infrastructure projects across key sectors, and a number of skilled trades. Outlining the skilled workforce gaps will assist in preparing for competing interests for different infrastructure projects, including housing and urban development, in addition to climate adaptation efforts.

Second, this report selected a subset of projects advanced under DMAF. However, research and discussions identified that the structure of infrastructure funding programs often limited a community's ability to advance projects that fit well within their local needs. While this topic was outside the scope of this report to address, several challenges arose in discussions that merit additional research in future work. While some attention has been devoted to increasing financing for climate adaptation projects through portfolios – such as the DMAF, the Green Infrastructure stream under the Investing in Canada Infrastructure Program, and the Municipal Natural Assets Initiative (MNAI) – insufficient focus has been placed on enabling recipients of this funding to effectively implement these projects on time. This is particularly a challenge for smaller municipalities that have a dearth of shovel-ready projects, as well as a lack of skills and fiscal margins, or existing capacity, to meet project timelines. Moreover, several smaller municipalities have to rely on external consulting resources to aid in preparing applications for funding streams like the DMAF, indicating burdensome application processes that might be preventing some municipalities from applying.[67] Even when smaller municipalities are able to compete for funding for climate adaptation, the disbursement agreements or the eligibility of certain expenses can put a strain on municipal fiscal budgets. For instance, for some of the smaller municipalities that are DMAF recipients and participated in the expenditure survey, implementing flood-protection projects can entail significant real estate implications. This means the municipality has to buy out property for the project construction, which is a project cost that can be quite large for smaller municipalities. For some of these projects, legal costs associated with negotiating buyouts are not eligible for reimbursement under the funding agreement. These costs can be high – for instance, for one municipality in British Columbia, this buyout plan constituted up to 30% of the total project cost. These land acquisition deals can take time, presenting an additional scheduling constraint in addition to others.[68] Moreover, for expenses that are eligible for reimbursement, the process for claiming those expenses can be slow, exacerbating the fiscal crunch for such municipalities. Finally, funding structures can make natural infrastructure projects less attractive, as the structure of traditional funds introduces impediments.[69] DMAF and Investing Canada Infrastructure Plan – which is also available for natural infrastructure funding – present limitations by requiring a minimum project size, not presenting options for bundling projects to meet the minimum size, and not considering the co-benefits associated with natural infrastructure.[70] Further research is needed to better understand how funding structures and programs can be designed differently to allow for the development of project types that might fit better with local needs. While greater flexibility has been incorporated into application and eligibility guidelines within both DMAF and the Investing in Canada Infrastructure Plan, lessons learned from existing DMAF projects under development should be further incorporated into future criteria to allow for greater innovation.

Third, additional research is needed to explore differences in community approaches and benefits from climate adaptation infrastructure projects. Building community resilience against climate events will be driven by communities themselves, based on their needs and available workforce. Better understanding the specific needs of individual communities and the infrastructure projects they choose to pursue can assist various levels of government and other related stakeholders create the necessary supports and resources to enable communities to advance infrastructure projects.

7 CONCLUSION

As witnessed most recently across Canada, people, communities, and the economy are currently unprepared to face extreme climate events, from record high temperatures to wildfires and extreme flooding. Infrastructure needs in Canada are significant – both to repair and maintain existing infrastructure but also to build new adaptation infrastructure to protect people, homes, and communities. There is a dire need for the government, at all levels, to ramp up existing investment streams such as the DMAF, but also to expand the eligibility of projects being funded under such streams. Building the infrastructure needed to advance Canada's transition to a climate-resilient economy can avoid a host of negative environmental, social, and economic costs, support future affordability, and can offer job creation benefits to communities across Canada. However, for climate adaptation to advance in Canada at the scale needed to avoid the worst impacts of a changing climate, Canada will need a large and highly skilled workforce.

The analysis in this report focused on the requirements to build currently pledged municipal flood risk management projects and additional projects needed to adapt to worsening climate impacts. It highlighted that workforce needs will be concentrated in sectors that are central for this transition, including construction, engineering, building supplies, and professional services, and that there is the potential to create over 60,000 jobs across the country by 2030 if adaptation needs are advanced at needed levels. Understanding how many of these jobs, which types of these jobs will be created, and the skills needs of this workforce in these sectors is an important first step towards preparing a workforce to take these jobs up. As Canada advances action, it has the potential to realize these benefits and to avoid the worst impacts of a changing climate. Doing so will require navigating skilled labour bottlenecks. In an environment of accentuated labour market shortages, especially within the construction sector, policymakers can use the results of such analyses to guide the design of future-proof labour market and skills policies and programmes.

Appendix 1: Detailed methodology for evaluating current and 2030 infrastructure needs, and workforce impacts

To evaluate current infrastructure needs, this project used the list of current DMAF-funded infrastructure projects, because it is a major federal funding program for adaptation infrastructure, and it contains projects of a variety of sizes from across the country. Job creation estimates were developed using total project cost figures, not just the portion covered by federal funding. That said, it is by no means a comprehensive list of adaptation infrastructure projects in Canada. For analyzing future infrastructure needs, this analysis used a meta-analysis used by Green Analytics Corp (2020). Importantly, these expected impacts for infrastructure needed differ substantively, even within a given climate scenario, depending upon the time horizon (t-value) selected. As such, this analysis assumes the volume of infrastructure built above is in alignment with the level of resilience needed to reduce the impacts climate change is expected to bring about by 2030.

The meta-analysis this report draws from estimates infrastructure costs on a 50-year time horizon. However, this analysis required estimates for yearly costs until 2030. This was obtained by dividing Green Analytics' total cost estimates for projects by the lifespan of each infrastructure project, allowing for an estimate of how much of the total value of each project is likely to be spent by 2030 to better understand how costs may be distributed over the 5-year period. Many projects gave estimates for their lifespans, from which the shorter project lifespan was selected. This reflected an attempt to account for uncertainty about the future severity of climate impacts, which many reports recognize represent conservative estimates of prospective damages.

It should be noted that using this source to estimate flood infrastructure needs in 2030 is likely to underestimate costs, for a variety of reasons:

- The meta-analysis includes only existing, public cost estimates
- Costs for administrative infrastructure were excluded since the data on expenditure profiles for this type of infrastructure was not available. Administrative infrastructure made up less than 1% of total estimated costs for flood risk management.
- It is heavily likely that costs, and infrastructure needs, will increase following 2030, and this analysis does not account for attempts to prepare for any impacts beyond 2030.

Job creation estimates based on advancing adaptation needs are based on two key assumptions. The first is the volume of projects required, which this report takes from the Green Analytics Corp estimate. The second is the presumed level of impacts expected to be brought about by the adverse impacts of a changing climate, which are also taken from the Green Analytics report.

Estimating expenditures

To estimate how built, natural, and mixed (built-natural) infrastructure projects distributed their expenditures, expenditure data was collected from the proponents of a sample of DMAF projects. The sample was obtained by contacting proponents of projects whose start date had passed, meaning that these projects were in the process of being implemented (49 projects out of a total of 59). Ultimately, past and projected expenditures were obtained from 11 projects addressing flooding. Past and projected expenditures from these projects were classified using the Input-Output Industry Classification (IOIC), the classification system for industrial sectors used by Statistics Canada for its input-output tables. When classifying project expenditures, expenditures on obtaining easements and relocating residents were not included, since these were not classified as "job-creating expenditures" in the analysis. Recurring expenditures were also left out, since these were rare and were small compared to one-time expenditures.

Table A.1. Top economic sectors in terms of average expenditure share

Economic sector	Type of infrastructure where sector is affected
Architectural, Engineering And Related Services	Mixed
Building Material And Supplies Merchant Wholesalers	Built
Forestry And Logging	Natural
Grant-Making, Civic, And Professional And Similar Organizations	Natural
Greenhouse, Nursery And Floriculture Production	Natural
Management, Scientific And Technical Consulting Services	Mixed
Other Activities Of The Construction Industry	All
Other Engineering Construction	Mixed, Built
Repair Construction	Built
Services To Buildings And Dwellings	Natural
Transportation Engineering Construction	Mixed, Built

In each of the three expenditure profiles (built, natural, and mixed), only the five economic sectors with the highest average expenditure share in the sample were included. These top sectors are listed in **Table A.1**.

When estimating 2030 job creation, it was assumed that expenditures would be distributed according to the same average expenditure profiles. This assumption is limiting, as expenditure patterns may change, particularly for newer infrastructure types like natural and hybrid infrastructure.

Using employment multipliers

Multiplier selection

For this analysis, Statistics Canada's employment multipliers were utilized. It contains information on total jobs created per million dollars spent. "Total jobs" treats full- and part-time jobs as the same. The direct multiplier for total jobs is essentially direct labour income divided by average annual labour income for a given economic sector and province or territory. For the analysis, only direct and indirect multipliers were used. Induced multipliers were left out because the induced impacts are more contested in their methods, and can be predicted with less certainty, given changes in consumer behaviour.

Strengths and weaknesses of input-output multipliers

Input-output (I-O) multipliers are a simple, accessible tool for estimating the job creation impacts of expenditures. But they also rely on simplifying assumptions. Most importantly, I-O tables provide a static image of the economy. In reality, adaptation infrastructure projects compete for limited inputs; large projects in small towns may drive up the cost of inputs for other firms, changing job creation impacts. This is particularly true as there is a shortage of labour with many government-funded projects competing as highlighted in one of the examples in the next section.

Projecting multipliers

Historical job multiplier values were obtained back to 2000 (or, in the case of the Building Material sector, 2010). The log multiplier values were regressed over time using the Ordinary Least Squares econometric method for each multiplier type (i.e., direct or indirect), sector, and province/territory (see **Figure A.1**). Since the Building Material sector did not exist prior to 2010, data was pooled across provinces for this sector to increase the size of our dataset.

Where the slope coefficient was significantly ($p>0.05$) different from zero, the regression equation was used to project 2030 multiplier values. Otherwise, the mean historical multiplier value was used. Slope coefficients' difference from zero tended to be either highly significant ($p<0.01$) or insignificant. A few jurisdiction-sectors, notably in Nunavut, the Yukon, and the Northwest Territories, had significant positive slopes that, if extrapolated into the future, gave unfeasibly high multiplier values. To avoid these tendencies, the mean historical multiplier value for these jurisdiction-sectors were used, since qualitative sources indicate that in the long term, multipliers are likely to trend downwards[71]; in a more detailed analysis in the future, it would be helpful to use adaptive priors to regularize parameter estimates in these jurisdiction-sectors.

Figure A.1. Projected changes in direct multipliers (total jobs per $1 million in output)

Indirect multipliers

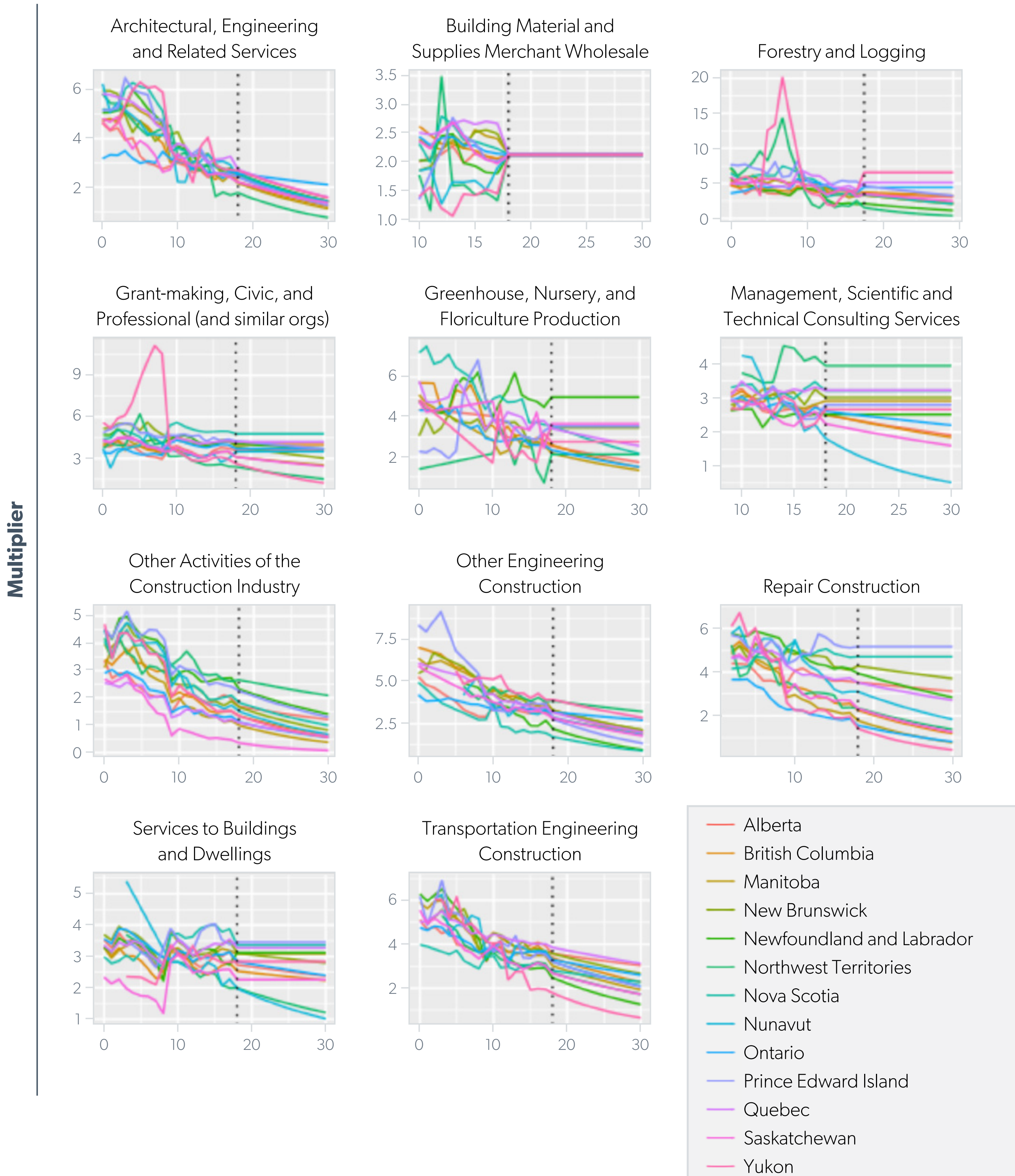

Figure A.2. Projected changes in indirect multipliers (total jobs per $1 million in output)

Appendix 2: Job Creation Impacts of Projects: Summary tables

Table A.2: No. of jobs created by DMAF projects by sectors across provinces and territories

Sectors	AB	BC	MB	NB	NT	NS	ON	QC	SK
Architectural, Engineering and Related Services	77	142					241	105	
Building Material and Supplies Merchant Wholesalers	343	136	496	52		109	794	268	
Greenhouse, Nursery and Floriculture Production							60		
Management, Scientific and Technical Consulting Services	74	131					170	84	
Other Activities of The Construction Industry	368	413	519	71		71	1,088	295	107
Other Engineering Construction	557	433	600	189		254	1,549	672	70
Repair Construction	205	163	525			77	1,049	182	
Transportation Engineering Construction	153	179	356			107	604	247	
Indirect Jobs Across Sectors	1,425	1,066	1,252	103	51	188	3,073	1,069	84

Table A.3: No. of jobs created by flood risk management projects in 2030 by sectors across provinces and territories

Sectors	AB	BC	MB	NB	NL	NS	ON	QC	PE
Architectural, Engineering and Related Services	110							90	
Building Material and Supplies Merchant Wholesalers	202	763		61	0.2	63	1155	3661	3
Greenhouse, Nursery and Floriculture Production		21	4					4	
Indirect Jobs	1239	1330	0	133	0	101	2152	16124	7
Management, Scientific and Technical Consulting Services	185							126	
Other Activities of The Construction Industry	257	386		39	0	0	703	2083	2
Other Engineering Construction	406	474		83	0	136	830	6133	6
Repair Construction	53	386		18	0	23	1460	1962	1
Transportation Engineering Construction	168	241		33	0	44	580	2064	3
Grand Total	**2621**	**3,615**	**7**	**365**	**1**	**366**	**6880**	**23,892**	**22**

Appendix 3: Estimating skills needs

Once the job impacts were calculated across economic sectors, the analysis continued to assess how changes in workforce need will impact demand for skilled workers. For this purpose, the economic sectors emerging from the modelling were analyzed in depth. This entailed using the IOIC codes and identifying their corresponding North American Industry Classification System (NAICS) codes using a concordance table prepared by Statistics Canada. **Table A.4** below outlines the results of this concordance table showing the NAICS codes for the top economic sectors identified by the input-output analysis. These NAICS codes represent sectors where the majority of jobs are created through flood-protection DMAF projects. Unfortunately, there is no one-to-one concordance across the construction subsectors in the IOIC and the NAICS construction subsectors. For this reason, the skills analysis for the NAICS construction sector was conducted at the two-digit level, i.e., as a whole.

Using these NAICS codes, all of the occupations employed within these sectors was extracted from the 2019 Labour Force Survey, from the Real-Time Remote Access (RTRA) tool of Statistics Canada. For instance, almost 1.7 million workers were employed in the construction sector alone in 2019. NAICS sector 416 – building wholesalers employed over 105,000 workers while 5413 – architectural and engineering services employed over 300,000, 5416 – consulting services employed over 170,000, and 1114 – greenhouse and nursery employed over 52,000 workers. The distribution of this employment across these sectors is given in the **Appendix Table A.5**.

Next, in order to extract the skills needed for these occupations, the U.S. Occupational Information Network (O*NET) database was used. In addition to a variety of other aspects, the O*NET lays out the quantitative importance of each of 35 skills associated with any particular occupation (list of skills mentioned below in O*NET Skills Classification). To be able to use this wealth of data, another concordance table or crosswalk between the Canadian National Occupational Classification (NOC) and the O*NET was used.[72] This concordance table allows us to use the quantitative score for each of the 35 skills for each Canadian occupation employed in each of the sectors used in this analysis. The weighted average of these scores was calculated across occupations in each sector using the share of employment for each occupation as the weight. This weighted average score allows us to gain insights into the relative importance of skills at a sectoral level. It is also possible to analyze this relative importance for each of the occupations employed within that sector but since the total number of occupations involved in this analysis is huge, we restrict the discussion of the results of the skills analysis at a sectoral level and quote some examples of specific occupations most relevant to DMAF projects that help prevent flooding.

Strengths and weaknesses of the approach

The greatest strength of using this approach to analyze skills required for projects like the ones in the DMAF portfolio is that it is not just a qualitative or anecdotal analysis but rather a quantitative approach. It helps in identifying concrete skills from a widely recognized database and by analyzing their quantitative scores for any occupation, it is possible to get a sense of skills relevant to design and construct climate adaptation projects. Another strength of the approach is the utilization of the Labour Force Survey which allows us to access individual occupations associated with each NAICS subsector down to the four-digit level. The ability to link these two databases together allows us to have a more concrete discussion around skills requirements at an occupational level.

Table A.4: Concordance between Input-Output Industry Classification (IOIC) 2016 sectors emerging from the analysis and North American Industry Classification System (NAICS) 2017

NAICS	NAICS title	IOIC	IOIC Title
1114	Greenhouse, nursery and floriculture production	BS1114A0	Greenhouse, nursery and floriculture production (except cannabis)
23	Construction	BS23E	Other Construction
23	Construction	BS23C50	Other Engineering Construction
23	Construction	BS23D	Repair Construction
23	Construction	BS23C10	Transportation Engineering Construction
5413	Architectural, engineering, and related services	BS541300	Architectural, engineering, and related services
416	Building material and supplies merchant wholesalers	BS416000	Building material and supplies merchant wholesalers
5416	Management, scientific and technical consulting services	BS541600	Management, scientific and technical consulting services

On the other hand, the two concordance or crosswalk tables used in this analysis did not offer perfect one-to-one conversions. For example, as mentioned above, the construction sub sectors in the IOIC used in the first part of the analysis did not have their counterparts in the NAICS codes which is why the second part of the analysis had to rely on the two-digit construction sector as a whole. Similarly, the crosswalk between the O*NET U.S. occupations and the Canadian NOCs contained some occupations for which the one-to-one conversion did not exist and had to be dropped from the skills analysis.

Second, the analysis is based on the 35 skills identified in the U.S. O*NET database. These skills cover a range of technical as well as nontechnical skills (such as process and social ones) but remain static in nature. This means the list of skills may evolve over time, changing the implications of this analysis, especially in the future. Even so, given that these skills form the fundamental requirement of undertaking different tasks of any occupation, it can be said that most (if not all) will remain relevant in the near-to-medium future. For example, skills like decision-making, critical thinking, time/resource/personnel management, and problem solving will continue to be important, even as their application across occupations and sectors changes.

Similarly, it is also important to point out that the 35 skills used in this analysis do not pertain to the specific application of these skills in a specific task or role. For instance, for civil engineers, the analysis reveals critical thinking, problem-solving, operations analysis, and systems analysis to be the most important skills. However, a civil engineer working on a climate resiliency project might deploy these skills in a different manner compared to one working on a renewable energy project. For climate adaptation specifically, civil engineers need to embrace the role of being advisors and consultants in their field leveraging their coordination and critical thinking skills with a greater focus on systems thinking.[73]

O*NET Skills Classification

This section is adapted from the O*NET Analyst Occupational Skill Ratings: Procedures report by Tsacoumis & Willison (2010)[74] which compiles skill level and important ratings for the 35 skills which are part of the O*NET Database. Skills are proficiencies that are developed through training or experience. The 35 skills are divided into basic skills and cross-functional skills. Basic skills facilitate the acquisition of new knowledge and are further divided into content and process skills. Cross-functional skills extend across several domains of activities. Overall, these 35 skills are grouped into seven categories as explained below.

Table A.5: Basic Skills

Developed capacities that facilitate learning or the more rapid acquisition of knowledge

Sub-Categories	Skills Details
Content Background structures needed to work with and acquire more specific skills in a variety of different domains	**Reading Comprehension –** Understanding written sentences and paragraphs in work-related documents. **Active Listening –** Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times. **Writing –** Communicating effectively in writing as appropriate for the needs of the audience. **Speaking –** Talking to others to convey information effectively. **Mathematics –** Using mathematics to solve problems. **Science –** Using scientific rules and methods to solve problems.
Process Procedures that contribute to the more rapid acquisition of knowledge and skill across a variety of domains	**Critical Thinking –** Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems. **Active Learning –** Understanding the implications of new information for both current and future problem-solving and decision-making. **Learning Strategies –** Selecting and using training/instructional methods and procedures appropriate for the situation when learning or teaching new things. **Monitoring –** Monitoring/Assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action

Table A.6 Cross-Functional Skills

Developed capacities that facilitate the performance of activities that occur across jobs

Sub-Categories	Skills Details
Social Skills Developed capacities used to work with people to achieve goals	**Social Perceptiveness –** Being aware of others' reactions and understanding why they react as they do. **Coordination –** Adjusting actions in relation to others' actions. **Persuasion –** Persuading others to change their minds or behaviour. **Negotiation –** Bringing others together and trying to reconcile differences. **Instructing –** Teaching others how to do something. **Service Orientation –** Actively looking for ways to help people.
Complex Problem-Solving Skills Developed capacities used to solve novel, ill-defined problems in complex, real-world settings	**Complex Problem Solving –** Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.
Technical Skills Developed capacities used to design, set up, operate, and correct malfunctions involving the application of machines or technological systems	**Operations Analysis –** Analyzing needs and product requirements to create a design. **Technology Design –** Generating or adapting equipment and technology to serve user needs. **Equipment Selection –** Determining the kind of tools and equipment needed to do a job. **Installation –** Installing equipment, machines, wiring, or programs to meet specifications. **Programming –** Writing computer programs for various purposes. **Operation Monitoring –** Watching gauges, dials, or other indicators to make sure a machine is working properly. **Operation and Control –** Controlling operations of equipment or systems. **Equipment Maintenance –** Performing routine maintenance on equipment and determining when and what kind of maintenance is needed. **Troubleshooting –** Determining causes of operating errors and deciding what to do about it **Repairing –** Repairing machines or systems using the needed tools. **Quality Control Analysis –** Conducting tests and inspections of products, services, or processes to evaluate quality or performance.
Systems Skills Developed capacities used to understand, monitor, and improve socio-technical systems	**Judgment and Decision Making –** Considering the relative costs and benefits of potential actions to choose the most appropriate one. **Systems Analysis –** Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes. **Systems Evaluation –** Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.
Resource Management Skills Developed capacities used to allocate resources efficiently	**Time Management –** Managing one's own time and the time of others. **Management of Financial Resources –** Determining how money will be spent to get the work done, and accounting for these expenditures. **Management of Material Resources –** Obtaining and seeing to the appropriate use of equipment, facilities, and materials needed to do certain work. **Management of Personnel Resources –** Motivating, developing, and directing people as they work, identifying the best people for the job

Appendix 4: Skill Requirements Across Sectors of Projects: Summary tables

Sectoral employment distribution – Labour Force Survey

Table A.7: Distribution of occupations employed in sectors relevant for the DMAF portfolio per the 2019 Labour Force Survey

Construction		Building material and supplies merchant wholesalers		Architectural, engineering and related services	
Occupation	**Share**	**Occupation**	**Share**	**Occupation**	**Share**
Contractors and supervisors	13%	Sales and account representatives	43%	Civil engineers	10%
Construction trades labourers	9%	Retail and wholesale trade managers	9%	Engineers (other)*	8%
Home building and renovation managers	9%	Truck Drivers	5%	Architects	7%
Carpenters	8%	Material handlers (manual)	5%	Engineering managers	5%
Electricians (except industrial & power system)	7%	Material handlers (equipment operators)	5%	Mechanical engineers	6%
Heavy equipment operators (except crane)	5%	Shippers and receivers	5%	Drafting technologists/technicians	5%
Construction managers	5%	Supervisors (supply chain, scheduling, office etc.)	5%	Civil engineering technologists/ technicians	5%
Plumbers	3%	Accounting and related clerks	3%	Administrative assistants	3%
Residential and commercial installers/ servicers	3%	Store shelf stockers, clerks and order fillers	2%	Architectural technologists/technicians	3%
Painters and decorators (except interior)	3%	General office support workers/clerks	2%	Construction inspectors	2%
Plasterers/Lathers/Drywall Installers	2%	Other	17%	Non-destructive testers and inspection technicians	2%
Heating, refrigeration, air conditioning mechanics	2%			Geoscientists/Oceanographers	2%
Truck Drivers	2%			Land survey technologists/technicians	2%
Roofers/Shinglers	2%			Mechanical engineering technologists/ technicians	2%
Construction estimators	1%			Industrial engineering and manufacturing technologists/technicians	2%
Other	27%			Other	37%
Total	**100%**	**Total**	**100%**	**Total**	**100%**

* Includes Agricultural and bio-resource engineers, Biomedical engineers, Engineering physicists and engineering scientists, Marine and naval engineers, Textile engineers

Table A.7: Distribution of occupations employed in sectors relevant for the DMAF portfolio per the 2019 Labour Force Survey (continued)

Management, scientific and technical consulting services		Greenhouse, nursery and floriculture production	
Occupation	**Share**	**Occupation**	**Share**
Occupation	Share	Occupation	Share
Business management consultants	48%	Nursery and greenhouse workers	68%
HR professionals	9%	Managers in horticulture	14%
Ergonomists/patent agents/tech transfer officers	6%	Contractors/managers/supervisors landscaping & grounds maintenance	6%
Mathematicians/statisticians/actuaries	2%	General farm workers	5%
Other business services managers	2%	Harvesting labourers	4%
Health policy professionals	2%	Managers in agriculture	2%
Professions in marketing, advertising, public relations	2%	Other	1%
Accounting technicians and bookkeepers	2%		
Public/environmental/occu. health & safety inspectors	2%		
Administrative assistants	2%		
General office support workers/clerks	2%		
Business development officers	2%		
Other	19%		
Total	**100%**	**Total**	**100%**

Source: Calculated from the 2019 Labour Force Survey, Statistics Canada

Sectoral Skill Requirements by 2030

Table A.8: Skills required by flood risk management workforce by 2030 in each sector

Categories	Skills	Construction	BS416000 - Building material and supplies merchant wholesalers	BS541300 - Architectural, engineering, and related services	BS541600 - Management, scientific and technical consulting services	BS1114A0 - Greenhouse, nursery, and floriculture production (except cannabis)
Content	Reading Comprehension	45.8	57.5	64.6	69.6	41.3
	Active Listening	51.0	65.7	63.6	69.5	49.7
	Writing	36.7	52.2	55.6	64.8	37.0
	Speaking	49.1	65.3	60.7	67.4	50.6
	Mathematics	34.2	34.0	52.6	45.2	23.0
Process	Science	12.5	4.4	39.4	25.3	20.0
	Critical Thinking	50.4	59.2	63.3	68.4	52.2
	Active Learning	41.2	48.8	52.6	54.6	37.8
	Learn Strategies	34.6	34.6	42.7	45.5	34.0
	Monitoring	47.7	52.8	53.0	60.3	50.2
Social	Social Perceptiveness	41.9	58.2	47.1	60.1	45.5
	Coordination	47.7	53.0	50.0	57.5	51.5
	Persuasion	34.0	54.7	43.6	47.9	36.0
	Negotiation	32.9	53.4	41.2	45.2	33.4
	Instructing	36.7	42.2	43.0	47.3	33.9
	Service Orientation	37.4	49.1	43.4	48.4	36.0
Problem Solving	Complex Problem Solving	44.2	51.4	58.7	62.0	38.7

Table A.8: Skills required by flood risk management workforce by 2030 in each sector (continued)

Categories	Skills	Construction	BS416000 - Building material and supplies merchant wholesalers	BS541300 - Architectural, engineering, and related services	BS541600 - Management, scientific and technical consulting services	BS1114A0 - Greenhouse, nursery, and floriculture production (except cannabis)
Technical	Operations Analysis	23.3	21.4	43.3	41.7	14.6
	Technology Design	15.4	15.0	26.5	15.3	4.5
	Equipment Selection	27.4	6.8	14.0	5.2	27.2
	Installation	16.2	2.6	5.0	0.4	2.0
	Programming	5.2	12.0	22.4	18.4	3.4
	Operations Monitoring	41.3	26.4	34.8	20.1	42.4
	Operation & Control	37.1	25.8	20.3	5.7	41.4
	Equipment Maintenance	27.2	8.9	12.3	1.7	30.5
	Troubleshooting	33.4	12.3	23.4	7.5	28.7
	Repairing	28.2	7.5	13.5	1.5	27.8
	Quality Control Analysis	38.5	17.9	38.6	17.1	36.3
Systems	Judgement & Decision Making	46.1	52.0	55.7	63.1	43.6
	Systems Analysis	32.9	34.9	50.1	57.6	23.3
	Systems Evaluation	32.4	35.0	46.9	58.1	18.8
Resource Management	Time Management	46.1	50.7	51.1	49.9	43.6
	Management of Financial Resources	20.9	24.7	29.2	22.2	17.9
	Management of Material Resources	23.5	25.2	30.9	23.3	19.5
	Management of Personnel Resources	37.9	32.2	41.2	44.1	40.4

ENDNOTES

1 Bush, E., & Lemmen, D. (Eds.). (2019). Canada's Changing Climate Report (p. 444). Natural Resources Canada. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR_FULLREPORT-EN-FINAL.pdf

2 Tutton M. (October 6, 2022). "Fiona demonstrated wild hurricane future, and need to adapt". The Globe and Mail. https://www.theglobeandmail.com/canada/article-fiona-demonstrated-wild-hurricane-future-and-need-to-adapt/; Farooqui, S. (June 28, 2022). "Return to Lytton: The village frozen by fire". The Globe and Mail. https://www.theglobeandmail.com/canada/article-wildfires-lytton-bc-rebuild/; CTV News Edmonton. (May 3, 2021). "A look back: 5 years after the Fort McMurray wildfire". CTV News Edmonton. https://edmonton.ctvnews.ca/a-look-back-5-years-after-the-fort-mcmurray-wildfire-1.5411861; Kives, B. (May 26, 2022). "Everything, everywhere, all at once: The 2022 flood season in Manitoba." CBC. https://www.cbc.ca/news/canada/manitoba/flood-2022-manitoba-analysis-1.6465372;

3 These estimates reflect damage estimates relative to a stable emissions scenario, and the $78-101 billion cost figure by mid-century represents a range between low to high emissions scenarios. Canadian Climate Institute. (2022). *Damage Control: Reducing the costs of climate impacts in Canada*. Canadian Climate Institute. https://climateinstitute.ca/reports/damage-control/

4 Canadian Climate Institute, 2022

5 Floods have historically been the most destructive and costly category of natural disasters in Canada, representing 37% of all natural disaster costs since 1970 (Public Safety Canada, 2019). A 2021 report from the Canadian Climate Institute estimated that 25% of the value of Canada's homes and buildings is exposed to flooding, and the risk to these homes and buildings is increasing as climate impacts worsen (Canadian Climate Institute, 2022). Public Safety Canada. (2019). Canadian Disaster Database. Retrieved June 2022, from https://www.publicsafety.gc.ca/cnt/rsrcs/cndn-dsstr-dtbs/index-en.aspx

6 Insurance Bureau Canada (IBC), & Federation of Canadian Municipalities. (2020). Investing in Canada's Future: The Cost of Climate Adaptation at the Local Level. (Referred to in this report as "Green Analytics, 2020.") http://assets.ibc.ca/Documents/Disaster/The-Cost-of-Climate-Adaptation-Report-EN.pdf

7 Bush, E., & Lemmen, D. (Eds.), 2019

8 Environment and Climate Change Canada. (2020). A Healthy Environment and a Healthy Economy: Canada's strengthened climate plan to create jobs and support people, communities and the planet. Environment and Climate Change Canada. https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf

9 Canadian Climate Institute, 2022

10 Canadian Climate Institute, 2022

11 BuildForce Canada. (2021). *Construction & Maintenance Looking Forward—National Summary Highlights 2021-2030.* https://www.buildforce.ca/system/files/forecast_summary_reports/2021%20National%20Summary%20Constr%20Maint%20Looking%20Forward_0.pdf

12 Ibid.

13 These figures are based off calculations that Canada's current clean economy workforce, which is 431,000 workers, could grow to 554,000 – 639,000 by 2030 under policies outlined in the Pan-Canadian Framework, and the Healthy Environment and Healthy Economy Plan. Melton, N. & Moawad, B. (2021). Canada's clean energy economy out to 2030. Navius Research Inc. https://www.naviusresearch.com/publications/clean-energy-economy-2021/

14 Ibid. Importantly, this result examined "clean economy" jobs, whereas the analysis in this report analyzes only jobs from investments in municipal flood risk management infrastructure.

15 Canada Mortgage and Housing Corporation. (2022). Canada's housing supply shortages: Estimating what is needed to solve Canada's housing affordability crisis by 2030. Canada Mortgage and Housing Corporation. Retrieved from: https://www.cmhc-schl.gc.ca/en/professionals/housing-markets-data-and-research/housing-research/research-reports/accelerate-supply/housing-shortages-canada-solving-affordability-crisis

16 Advisory Council on Economic Growth (ACEG). (2016). Unleashing productivity through infrastructure. Government of Canada. https://www.budget.gc.ca/aceg-ccce/pdf/infrastructure-eng.pdf

17 Bush, E., & Lemmen, D. (Eds.), 2019

18 IPCC. (2018). IPCC, 2018: Annex I: Glossary. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. https://www.ipcc.ch/site/assets/uploads/2019/01/SYRAR5-Glossary_en.pdf; Bush, E., & Lemmen, D. (Eds.). (2019).

19 Warren, F., & Lulham, N. (Eds.). (2021). Canada in a Changing Climate: National Issues Report (p. 734). Government of Canada. https://changingclimate.ca/site/assets/uploads/sites/3/2021/05/National-Issues-Report_Final_EN.pdf

20 Swanson, D., Murphy, D., Temmer, J., & Scaletta, T. (2021). Advancing the Climate Resilience of Canadian Infrastructure: A review of literature to inform the way forward (p. 118). The International Institute for Sustainable Development (IISD). https://www.iisd.org/system/files/2021-07/climate-resilience-canadian-infrastructure-en.pdf

21 Insurance Bureau Canada (IBC), & Federation of Canadian Muncipalities. (2020). Investing in Canada's Future: The Cost of Climate Adaptation at the Local Level. (Referred to in this report as "Green Analytics, 2020.") http://assets.ibc.ca/Documents/Disaster/The-Cost-of-Climate-Adaptation-Report-EN.pdf

22 Canadian Institute for Climate Choices. (2021). Under Water: The Costs of Climate Change for Canada's Infrastructure. Canadian Institute for Climate Choices. https://climatechoices.ca/wp-content/uploads/2021/09/Infrastructure-English-FINAL-Sep29.pdf

ENDNOTES

23 Chakraborty, L., Thistlethwaite, J., & Henstra, D. (2021, August 13). Flood Vulnerability and Climate Change. Canadian Institute for Climate Choices. https://climatechoices.ca/publications/flood-vulnerability-and-climate-change/

24 Clark, Dylan G. & Dena Coffman. 2020. "Underwater assets." Canadian Institute for Climate Choices [blog], December 9. https://climatechoices.ca/underwater-assets/

25 Chakraborty et al., 2021

26 Office of the Parliamentary Budget Officer. (2016). Estimate of the Average Annual Cost for Disaster Financial Assistance Arrangements due to Weather Events (p. 49). Government of Canada. https://qsarchive-archiveqs.pbo-dpb.ca/web/default/files/Documents/Reports/2016/DFAA/DFAA_EN.pdf

27 Canadian Institute for Climate Choices, 2021.

28 Climate-ADAPT. (2017). Adaptation options. https://climate-adapt.eea.europa.eu/knowledge/adaptation-information/adaptation-measures

29 Government of Canada. (2016). Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy. https://www.deslibris.ca/ID/10089724

30 Government of Canada. (2021). *Adapting to the Impacts of Climate Change in Canada: An update on the National Adaptation Strategy*. Environment Canada. https://www.canada.ca/content/dam/eccc/documents/pdf/reports/report-update-national-adaptation-strategy.pdf

31 Office of the Auditor General of Canada. (2018). Perspectives on climate change action in Canada – a collaborative report from Auditors General – March 2018. Office of the Auditor General. Parliamentary Report. Retrieved from: https://www.oag-bvg.gc.ca/internet/English/parl_otp_201803_e_42883.html

32 Ibid.

33 Swanson et al., 2021

34 Intact Centre on Climate Adaptation. (2020). *Canadian Provincial and Municipal Flood risk management Subsidy/Grant Programs*. https://www.intactcentreclimateadaptation.ca/wp-content/uploads/2020/01/Canadian-Municipal-Subsidy-Program-Formal-1.pdf

35 Ibid.

36 Intact Centre on Climate Adaptation. (n.d.). *Climate Adaptation in Canada—Home Flood risk management Program | Preparing for Flooding*. ICCA. Retrieved February 10, 2022, from https://www.intactcentreclimateadaptation.ca/programs/home_flood_protect/

37 Water Security Agency. (n.d.). *Emergency Flood Damage Reduction Program*. Water Security Agency. Retrieved February 10, 2022, from https://www.wsask.ca

38 Public Safety Canada. (2018, December 21). *National Disaster Mitigation Program (NDMP)*. Government of Canada. https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/ndmp/index-en.aspx

39 International Labour Organization. (2018). *The employment impact of climate change adaptation*. Submitted to G20 Climate Sustainability Working Group. International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_645572.pdf

40 Triple E Consulting. (2014). Assessing the implications of climate change adaptation on employment in the EU. European Commission. https://ec.europa.eu/clima/sites/default/files/adaptation/what/docs/climate_change_employment_eu_en.pdf

41 Ibid.

42 International Labour Organization, 2018

43 Triple E Consulting, 2014

44 International Labour Organization, 2018

45 International Labour Organization, 2018

46 Cox, R., Niederer, S., Forssman, V. & Sikorski, L. (2021). Climate Adaptation Competency Framework. Resilience by Design Lab. Adaptation Learning Network, Royal Roads University. https://adaptationlearningnetwork.com/sites/weadapt.org/files/aln-competencyframework_2021_1.pdf

47 BuildForce Canada, 2021

48 Infrastructure Canada. (2018, June 22). Backgrounder: Applying a Community Employment Benefits requirement to major infrastructure projects [Backgrounders]. https://www.canada.ca/en/office-infrastructure/news/2018/06/backgrounder-applying-a-community-employment-benefits-requirement-to-major-infrastructure-projects.html

49 Bassi, A. M., Ronja, B., Caiser, L., & Cutler, E. (2021). How Can Investment in Nature Close the Infrastructure Gap? (p. 25). International Institute for Sustainable Development. https://nbi.iisd.org/wp-content/uploads/2021/10/investment-in-nature-close-infrastructure-gap.pdf

50 Bassi et al., 2021; Cairns, S., Arros, P., & O'Neille, S. J. (2016). Incenting the Nature of Cities: Using Financial Approaches to Support Green Infrastructure in Ontario (Green Prosperity Papers, p. 36). Metcalf Foundation. https://institute.smartprosperity.ca/sites/default/files/publications/files/Metcalf_GreenProsperity_Incenting-Cities_web.pdf; O'Neill, S. and Cairns, S. (2016.) *New*

ENDNOTES

Solutions for Sustainable Stormwater Management in Canada. Sustainable Prosperity (now Smart Prosperity Insitute). https://institute.smartprosperity.ca/sites/default/files/stormwaterreport.pdf

51 O'Neille & Cairns, 2016; Ogden, M., Wilson, S. J., & Cairns, S. (2019). What are Municipal Natural Assets: Defining and Scoping Municipal Natural Assets (p. 12) [Decision-maker Summary]. The Municipal Natural Assets Initiative. https://mnai.ca/media/2019/07/SP_MNAI_Report-1-_June2019-2.pdf

52 Canadian Centre for Climate Services. (2022). "Developing climate resilient standards and codes". Government of Canada. https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services/basics/developing-climate-resilient-standards-codes.html

53 While only a portion of funding for these projects is covered by DMAF, all projects that DMAF contributes to are considered to be part of the DMAF funding portfolio.

54 Figure Y only displays sectors where more than 50 jobs are created in any province or territory.

55 We only considered projects that had already been costed, and where cost estimates provided a range, we chose the lowest value. We also only include jobs in the most important economic sectors in terms of job creation.

56 $719 million is the yearly cost of flood-protection infrastructure according to existing cost estimates, with the level of spending incurred by 2030 calculated by identifying how much of each total project cost would be spent by 2030 when discounted over each project's life-cycle (see Green Analytics Canada 2020). This annual cost, reflected over a nine-year period, adds up to roughly $6.47 billion CAD in total spending.

57 These categories are based on the O*NET Skills Classification, detailed in Appendix Section 4. Notably, the table excludes the 'Content' category with basic literacy skills. These skills obtain the highest scores as they provide the foundation for any of the jobs that are likely to be obtained across the sectors.

58 This separation of scores into tiers should be used purely for interpretation of the numbers in this table and does not denote any significance or contain any meaning beyond the facilitation of interpretation for a given number in this table.

59 Reid, R. L. (2022, January 3). *How to make infrastructure more resilient against climate change*. American Society of Civil Engineers. https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/issues/magazine-issue/article/2022/01/how-to-make-infrastructure-more-resilient-against-climate-change

60 Gee, E. (2021, December 14). *We need an equity-based approach to fighting the climate crisis*. First Policy Response. https://policyresponse.ca/we-need-an-equity-based-approach-to-fighting-the-climate-crisis/

61 Dinsdale, J. (2020). *City of Grand Forks: DMAF Program Charter* (p. 25). https://pub-grand-forks.escribemeetings.com/filestream.ashx?DocumentId=10475

62 Canadian Standards Association (CSA). (2019). *CSA W204:19 Flood resilient design of new residential communities*, CSA Group. https://www.csagroup.org/store/product/CSA%20W204:19/

63 FireSmart Canada (2022). *FireSmart Home Development Guide*. The Institute for Business and Home Safety & The Cooperators. https://firesmartcanada.ca/wp-content/uploads/2022/01/FireSmart_Canada_Home_Development_Guide.pdf

64 Canadian Centre for Climate Services. (2022). "Developing climate resilient standards and codes". Government of Canada. https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services/basics/developing-climate-resilient-standards-codes.html

65 Infrastructure Canada. (2019, May 21). Canada helps York Region build climate change resilience through urban forest restoration and enhancement [News releases]. https://www.canada.ca/en/office-infrastructure/news/2019/05/canada-helps-york-region-build-climate-change-resilience-through-urban-forest-restoration-and-enhancement.html; U.S. Federal Emergency Management Agency. (2021). *Building community resilience with nature based solutions: A guide for local communities*. https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf

66 International Labour Organization, 2018

67 Gee, 2021

68 Dinsdale, 2020

69 Bourque, J., Olmsted, P., Patel, S., & Samson, R. (2021, May 3). Green is the new grey. Smart Prosperity Institute. https://institute.smartprosperity.ca/GreenIsTheNewGrey

70 The creation of the new Natural Infrastructure Fund, introduced in 2021 to support large-scale natural infrastructure projects, is an important step, but more work will likely be needed to ensure smaller municipalities who do not have the resources to meet the program requirements of larger funding streams can also be supported.

71 See, e.g., https://brookfieldinstitute.ca/the-talented-mr-robot/

72 For more information on this concordance, refer to LMI Insight Report no. 35, September 2020: https://lmic-cimt.ca/publications-all/lmi-insight-report-no-35-job-skills-mapping-building-concordance-between-the-us-onet-system-and-canadas-noc/

73 Reid, 2022.

74 Tsacoumis, S. and Willison, S. (2010). *O*NET® Analyst Occupational Abilities Ratings: Analysis Cycle 10 Results*. National Center for O*NET Development. Report. https://www.onetcenter.org/dl_files/Wave10_Results.pdf

Smart Prosperity Institute

1 Stewart St. (3rd Floor)
Ottawa, ON K1N 6N5