Climate Science Workshop:
Regional Climate Modelling Capacity in Ontario

Workshop Report
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YORK UNIVERSITÉ UNIVERSITY

TORONTO AND REGION Conservation
for The Living City

This workshop summary report was prepared by the Climate Science Workshop Committee. Lura Consulting provided facilitation services for the climate science workshop on behalf of Toronto and Region Conservation Authority (TRCA) and York University. This report is not intended to be a verbatim transcript of the day. Rather, it captures the key discussion points raised during expert presentations, plenary discussions, a lunchtime keynote address and workshop breakout sessions.

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We would be pleased to know that this report was helpful to your organization. If you have any questions or comments regarding the summary, please contact:

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Executive Summary

Climate modelling in Ontario has reached a tipping point. To prepare for and, to the extent possible, mitigate the anticipated impacts of climate change, Ontario's public and private sector decision makers must integrate robust climate adaptation strategies into key planning, operational and policy processes. This requires access to regional-scale climate modelling information, detailed impact scenarios and vulnerability assessments. Unfortunately, as the demand across all sectors for this kind of authoritative climate change intelligence continues to build, funding for climate science (particularly at the federal level) is diminishing and Ontario is losing its climate science capacity as research scientists continue to leave for the United States and Europe.

To counter these trends, connections and partnerships must be cultivated to efficiently harness the available expertise and resources. Participants at the "Climate Science Workshop" have called for a new collaborative model to fund and support an integrated regional climate modelling program in Ontario. The proposed Ontario regional climate modelling partnership would include universities, governments, conservation authorities, non-governmental organizations and the private sector. Workshop participants also recommended that an ad hoc committee develop a proposal and a business case for the partnership, identify partners who could be engaged in the process, and determine the next steps for drafting a formal memorandum of understanding among willing participants.

Jointly hosted by Toronto and Region Conservation Authority (TRCA) and York University, the one-day Climate Science Workshop was held February 5, 2010. More than 135 attendees, representing 13 universities, as well as the federal, provincial and municipal governments, conservation authorities and the private sector, participated in the discussions and breakout sessions.

Dr. Daniel Caya, Director of Climate Science for OURANOS, opened the workshop with a plenary presentation on Quebec's experience in building a regional climate modelling centre over the last 10 years, as well as the institutional and scientific challenges that the organization has faced. Dr. Caya emphasized the need to secure long term funding and partner commitments; regional climate modelling for impact and adaptation purposes is very demanding in terms of the time and resources required.

Following the plenary presentation, a panel of experts explored "The State of the Art – Perspectives on Regional Climate Modelling (RCM) in Ontario." Panel participants addressed:

- the federal government climate research program and the broader national context;
- implications for coupling regional climate models with Great Lakes modelling;
- coupling hydrological models with climate models;
- the importance of the interaction of the cryosphere with other climate processes;
- the role of remote sensing in evaluating and improving regional climate modelling;
- the need for significant amounts of computing infrastructure as enhanced resolution of regional climate models increases;
- the necessity of building regional modelling capacity in Ontario universities, where the modelling research takes place; and
- the need for a regional modelling partnership to build and enhance climate modelling capacity in Ontario.

Panellists and workshop participants agreed on the importance of bringing researchers and practitioners together at the beginning of the research and planning process in order to create a new model of partnership and enhance Ontario's regional climate modelling capacity.

Dr. Gordon McBean, chair of the Canadian Foundation of Climate and Atmospheric Sciences, gave the luncheon keynote address on the "Future of Climate

Science in Canada". Dr. McBean reminded participants that the trajectory for climate change would continue for the next 20 to 30 years, regardless of what is done to reduce greenhouse gas emissions. While developing climate change adaptation strategies across the country, climate researchers must collaborate with each other, work with local communities, and assist policy makers and the general public to understand the need to assess potential impacts. However, recent federal funding cuts and the lack of Natural Sciences and Engineering Research Council (NSERC) funding for climate science must be addressed if Ontario is to effectively address climate adaptation issues.

The afternoon presentation session, "Opportunities for Collaboration", highlighted the experience of three experts from Canada and the United States who provided lessons learned from the Ontario Expert Panel Report, *Adapting to Climate Change in Ontario: Towards the Design and Implementation of a Strategy and Action Plan*, as well as the Urban Climate Leaders program and the North American Regional Climate Change Assessment Program. The presenters pointed to progress on international initiatives undertaken in the developing world (such as National Adaptation Programmes of Action) and by subnational governments, such as municipalities and the province of Ontario. Presenters noted encouraging signs of progress are being demonstrated by urban leaders (in New York, Chicago and Toronto) through major climate adaptation initiatives and their willingness to work with universities and the research community. It is important that decision makers understand both the opportunities and limitations of modelling approaches and outcomes; we must transform end users into engaged users of regional climate modelling outputs.

Following the afternoon presentations, breakout sessions focused on identifying the implications of physically-based regional climate outputs and research agendas for three sectoral areas: the built environment (infrastructure, disaster management, health and socio-economic), the natural environment (agriculture, forestry and ecosystems), and water resource management and source protection. A fourth breakout session explored the next steps in strengthening physically-based regional climate modelling in Ontario.

Introduction

The Need for Collaboration

The effects of climate change are already being felt around the globe and its impacts are set to become more pervasive over time. In 2009, the Ontario Expert Panel on Climate Change Adaptation produced a report entitled *Adapting to Climate Change in Ontario.* This report emphasized the need to develop integrated and robust climate change adaptation strategies in Ontario. The recommendations from the report highlight the importance of enhancing Ontario's climate science and modelling capacity and establishing and maintaining long term, collaborative commitments with agencies and governments to better understand the possible impacts of climate change in Ontario.

Workshop Overview

The Climate Science Workshop was jointly hosted by Toronto and Region Conservation Authority (TRCA) and York University on February 5, 2010. The workshop brought together a diverse group of climate experts from provincial and U.S. universities, all three levels of government, conservation authorities, international climate science and adaptation institutes, and private industry.

Although climate change is experienced at the local or regional level, most climate change scenarios and predictions stem from global climate models (GCMs). GCMs present little in the way of regional detail, leading to a rise in the use of GCM-driven regional climate models to forecast climate change (i.e., changes in precipitation, severe weather, summer pollution events, etc.).

The purpose of this workshop was to explore the state of regional climate modelling in Ontario in order to assist Ontario in meeting the challenges of a changing climate and to assist the province in addressing the expert panel recommendations (summarized below).

Workshop Objectives

1. Delineate tools, techniques and resource requirements for state-of-the-art, physically-based, regional climate modelling.

2. Inventory current regional climate models and related impact and adaptation research, including individual and organizational research foci.

3. Assess the ability of the province to carry out regional climate modelling by identifying strengths and gaps.

4. Identify potential opportunities for collaboration.

The Way Forward

The climate science workshop was a stimulating day of frank and open dialogue about the current state of regional climate modelling in Ontario and the goals of climate researchers, practitioners and policy makers. As highlighted throughout the plenary discussions, the future of a sustainable and effective climate science research program in Ontario relies on the collaboration of diverse end users and climate researchers. In particular, successful case studies were explored and discussed with experts from Quebec, Canada and the United States.

The workshop presentations highlighted the importance of developing partnerships among all levels of government, academics and private industry, in order to foster innovative climate science research in Ontario. In addition, workshop particpants emphasized the need to increase communication among climate researchers and end users. Lastly, participants stressed the importance of utilizing existing and future climate science research to develop robust climate change adaptation strategies in Ontario.

Very early in the workshop, support emerged for the establishment of a partnership to build and enhance regional climate modelling capacity in Ontario and to act as a focal point for the province's regional climate modelling activities. Participants underscored the need to engage users of regional climate modelling outputs as central to the effective development and application of regional climate modelling. The policy and decision makers who are the end users of the climate modelling work require sophisticated data interpretation and integrative climate models, not simply more maps and data. In addition, strengthening the links between climate modellers, researchers, policy makers and practitioners is essential to helping society prepare for a changing climate and to addressing the needs and gaps in both research and policy.

It was proposed that an Ontario regional climate modelling partnership be created. The first step in the process will be to establish an ad hoc committee. This ad hoc committee would be tasked with identifying key players who should be involved in the establishment and operation of a partnership, the administrative framework and legal agreements for members.

At the conclusion of the workshop, TRCA volunteered to facilitate the ad hoc committee development.

Conference Proceedings

Keynote Presentation: The Need for Adaptation and the Role of Regional Climate Modelling

Dr. Daniel Caya, Director of Climate Science, OURANOS

Dr. Caya presented an outline of climate simulations and projections undertaken by OURANOS. He emphasized that accurately modelling climate change over time is a difficult task, due to the challenge of characterizing the variability of the complex climate systems when reducing spatial scales for impact studies and adaptation work.

He outlined regional climate modelling currently undertaken by OURANOS and emphasized that such research is effectively used by policy makers, government and private institutions within the province of Quebec. He also highlighted the strong partnerships between OURANOS and Hydro Quebec. In addition, Dr. Caya summarized a number of challenges facing researchers in this field, specifically the need for large amounts of computing power, the time required to conduct the analysis of the computer results, and the need to hire well-trained, highly qualified personnel.

Dr. Caya concluded his presentation by suggesting that Ontario establish a regional climate modelling partnership similar to OURANOS. However, he emphasized that if Ontario is going to embark on establishing a regional climate modelling partnership, it must follow the steps necessary in securing commitments from interested stakeholders for years to come, specifically long term financial commitments from interested organizations.

Panel Presentations: State of the Art–Perspectives in Regional Climate Modelling in Ontario

Regional Climate Modelling – Environment Canada Perspective, Dr. Francis Zwiers, Director, Climate Research Division, Environment Canada

Dr. Zwiers opened his presentation by outlining the climate modelling capacity of Environment Canada. He highlighted work that is taking place across the country to develop both regional climate models and global climate models that are used to understand the impacts of climate change in Canada. In particular, Dr. Zwiers mentioned that Environment Canada's national program has a strong presence in Ontario: more than half of its staff, approximately 130 people, are currently located within the Greater Toronto Area. Dr. Zwiers said that research activities in Toronto include the development of regional climate modelling aimed at understanding regional hydrological budgets and the development of model components, including the Canadian Land Surface Scheme (CLASS), which is used in the Canadian Regional Climate Model and as a platform for many process studies.

Dr. Zwiers indicated that the current work undertaken by Environment Canada is highly collaborative. An existing partnership among the Canadian Centre for Climate Modelling and Analysis (CCCma), Recherche Prévision Numérique (RPN), and L'Université du Québec à Montréal (UQAM) is aiming to develop a new regional climate model for Canada. Environment Canada's Climate Research Division collaborates with many researchers in Ontario, including those from the University of Toronto, York University, University of Waterloo, McMaster University and the University of Guelph, among others. Dr. Zwiers also noted that future research cannot be entirely focused on regional climate modelling domains because the climate in any specific region is affected by change taking place elsewhere. Thus, global climate models play a crucial role in understanding the broader policy implications of global climate change and provide the boundary conditions that drive regional climate models.

Dr. Zwiers said that current regional modelling focuses primarily on physical climate processes, with only limited quantification of features such as lakes that are important determinants of regional climate. He also stated that future regional climate models will have increased resolution, incorporate improved representation of physical and biogeochemical processes, and include interactive representations of lakes, rivers, the biosphere (carbon cycle), atmospheric chemistry and surrounding oceans. As was indicated in other presentations, some of these capabilities are beginning to emerge, but considerable work remains to bring them to maturity so that they can be applied robustly for the study of climate at regional scales. In order to reach this state, Dr. Zwiers emphasized the need for extensive collaboration. He strongly advocated for stable and sustainable funding for this research and highlighted the need to work together as continued uncoordinated and dispersed efforts would hinder progress.

Hydrodynamic Models of the Great Lakes and Linkages with Atmospheric Models, Dr. Ram Yerubandi, Research Scientist, Environment Canada

Dr. Yerubandi presented his current research on hydrological modelling in the Great Lakes, highlighting the need to create effective climate models in order to fully understand the hydrodynamics of the Great Lakes in Ontario. He stated the need for regional climate models to begin to integrate lake hydrodynamics, which is important for developing a better understanding of regional climate patterns.

Dr. Yerubandi said Great Lakes hydrodynamic models need to be coupled with Canadian Regional Climate Models (CRCM) when developing a regional climate model in Ontario, since the dynamic nature of the lakes would impact the outcomes of the models. High resolution hydrodynamic models for the Great Lakes are currently used and they contribute valuable information for policy and decision makers. Dr. Yerubandi concluded his presentation, stating that coupled lake-atmospheric models are needed to improve modelling of regional weather and lake conditions across the province.

The Cryosphere, Dr. Claude Duguay, Interdisciplinary Centre on Climate Change (IC3), University of Waterloo

Dr. Claude Duguay stated that the purpose of his presentation was to represent the cryosphere (i.e., that portion of the Earth's surface where water is frozen, including snow, permafrost, floating ice and glaciers) in the discourse about regional climate modelling in Ontario. He explained that the research group, Interdisciplinary Centre on Climate Change (IC3), is actively seeking to understand how the cryosphere interacts with other elements in the global climate system. It is important to examine the impacts of the cryosphere on climate variability in order to better understand the feedback mechanisms that exist between the cryosphere and the global climate.

Dr. Duguay said that the increased representation of cryosphere processes in climate models has already begun to reduce uncertainties in climate simulations. However, he explained that Ontario needs to develop cryosphere datasets from surface observations and remote sensing in order to evaluate and improve regional climate models.

Dr. Duguay outlined the need to increase research capacity in Ontario and form a partnership among government, academia and industry with a strong commitment from both provincial and federal governments to ensure success for future regional climate modelling in the province.

Collaboration in Climate Change, Dr. Richard Peltier, Director of the Centre for Global Change Science, University of Toronto

Dr. Peltier began his presentation by outlining key collaborations between the University of Toronto and the University of Waterloo that aim to better understand the connections between climate change and hydrology.

His research team has begun to use the Weather Research Forecasting model at 10 kilometre resolution for Ontario and 30 kilometre resolution for North America. However, Dr. Peltier noted that increasing the resolution of regional climate models requires significant amounts of computer infrastructure and funding, and that his project at the University of Toronto is in its early stages.

Looking to the future, Dr. Peltier advocated for the establishment of a provincial centre of excellence in climate research. Ontario is lagging behind other provinces in Canada at effectively modelling climate change. Dr. Peltier suggested that the Government of Ontario, in collaboration with universities and other agencies, take a lead role in establishing this partnership.

Climate Change Research at York University, Dr. John McConnell, Professor of Atmospheric Science, York University

Dr. McConnell's presentation outlined the importance of developing climate change adaptation strategies in Ontario and the current research being undertaken by York University to develop regional climate models to assist in that process. However, despite local expertise in areas of modelling processes related to hydrology, forestry, ecology, cyrosphere and air quality, only a limited amount of integrated regional climate modelling is taking place in Ontario across

universities and government agencies. Furthermore, he emphasized that Ontario is currently losing high quality researchers to international climate modelling organizations because research funding is limited and there is little support in Ontario to engage in integrated regional climate modelling research.

Dr. McConnell stated that in order to develop effective climate models for Ontario, a broad collaboration of agencies and universities across Ontario is needed, potentially through the establishment of a climate research partnership. These groups would build research capacity, use resources more efficiently, amalgamate advances in research, provide a steady and robust stream of data, and effectively engage end users. If such agreements are going to be formed in Ontario, Dr. McConnell emphasized the critical role that universities play in researching and developing innovative regional climate models in Ontario.

Dr. McConnell highlighted the need for effective regional climate models and also touched on the importance of developing integrated global climate models to better develop adaptation strategies for the future.

Summary of Key Messages from Panel Speakers

- Global climate models play a crucial role in understanding the greater policy implications of global climate change and they provide the boundary conditions that drive regional climate models.
- There is a need to fully understand the hydro-dynamics of the Great Lakes in Ontario, and to integrate lake hydrodynamics into regional climate models.
- There is a need to examine the impacts of the cryosphere on climate variability in order to better understand the feedback mechanisms that exist between the cryosphere and the global climate.
- Stable and sustainable funding and adequate computer infrastructure for climate modelling are required.
- Ontario is currently losing high quality researchers to the United States and Europe due to inadequate funding and reduced support to engage in integrated regional climate modelling research.
- To develop effective climate models for Ontario, a broad collaboration of agencies and universities across the province should be created through the establishment of a research partnership.

Lunch Keynote: The Future of Climate Science in Canada

Dr. Gordon McBean, Professor, University of Western Ontario and Director, Policy Studies, Institute for Catastrophic Loss Reduction

Dr. Gordon McBean focused on the need to establish comprehensive climate science programs that inform agencies and individuals across the country on how to adapt to climate change. He said that in order to be effective, climate modelling scenarios need to address the interconnected systems and complex interactions that make up our climate system in Canada. Because our climate is rapidly changing and will continue to change in the future, climate researchers must collaborate with each other, engage local communities and assist policy makers and the general public to better understand the need for climate change adaptation strategies to be developed across the country.

Dr. McBean underlined that the climate trajectory is set for the next 20 to 30 years regardless of what we do today and, consequently, we need to produce robust adaptation strategies to address climate change in Ontario. Specifically, he spoke of the need for adaptation strategies to address the impacts of changes in climate extremes (floods, storms and droughts) in Canada and the importance of understanding how these extreme weather events

occur and affect natural ecosystems and the lives and property of Canadians. He outlined that 75 per cent of catastrophic loss events, often described as natural disasters, are weather related and account for 50 per cent of global loss of life each year. Furthermore, Dr. McBean stressed that these events are moving closer to home, citing examples of a severe rain event in Toronto in 2005 and the Southern Ontario tornadoes of 2009, both of which caused extensive infrastructure damage, millions of dollars of insurance claims and widespread property damage.

Dr. McBean concluded that the role of climate science today and in the future is to provide scientifically-based information on what is expected to happen in Canada as a result of climate change and the roles that Canadians can play in reducing the impacts and moderating the changes in the longer term. He advocated for strong collaboration between the science community and policy makers so that effective adaptation strategies and plans for mitigation of catastrophic loss can be established in Canada.

He outlined that this structure for climate research requires an interdisciplinary approach to research and it requires sustained financial support in order to ensure that resources and staffing are in place for the future. The building blocks for this new approach can be found in the recommendations from the expert panel. However, recent federal budget announcements did not include any funding for climate science and there is a lack of NSERC funding for climate modelling research. These two issues need to be addressed so that Ontario can increase its capacity to develop effective regional climate models and adaptation strategies for the future.

Panel Presentations: Opportunities for Collaboration

Report of the Expert Panel on Climate Change Adaptation,Dr. Ian Burton, Co-chair, Ministry of the Environment Expert Panel on Adaptation

Dr. Burton began his presentation by articulating that the global community has focused its main efforts on mitigation (reducing greenhouse gas emissions) rather than adaptation to climate change. Dr. Burton also stressed that regardless of the attempts made to reduce the impacts of climate change, Canadians will experience personal and daily impacts from climate change in the future.

Dr. Burton also noted that Canada has lagged behind other countries in developing effective adaptation strategies. In particular, he cited many countries in the European Union and Africa that have already developed national climate change adaptation plans and strategies, while in Canada we have not even begun to discuss the potential.

Dr. Burton concluded his presentation with the observation that Ontario is taking a leadership role on adaptation to the changing climate, as a result of the 2009 report, *Adapting to Climate Change in Ontario*. He suggested that climate change adaptation could be better integrated into the work of various ministries and agencies. Lastly, he said that collaborating to create regional climate models that take into consideration climate variability will help scientists and policy makers in Ontario to better understand how to develop adaptation strategies for the future.

Urban Leaders Climate Initiative, Mr. Josh Foster, Manager of Climate Adaptation and the Urban Leaders Climate Initiative, Centre for Clean Air Policy

Mr. Foster provided workshop attendees with practical examples of the importance of using climate research to inform policy and planning decisions. He also

outlined how the research community can support government agencies to develop policies and strategies on how society can best adapt to climate change. He emphasized that it is essential to integrate climate adaptation or "mainstream" climate considerations into policy and operational decision making. Mainstreaming climate adaptation can be more challenging than communicating information on mitigation; adaptation requires shifting the focus away from the "gloom and doom" of anticipated climate change impacts and toward a new understanding of opportunities that will arise from our need to build more resilient communities (e.g., water reclamation plants, roof top gardens, etc.).

In order to implement effective adaptation strategies, Mr. Foster said that agencies should develop baseline climate research and a comprehensive understanding of future climate scenarios in order to more effectively communicate with the public and decision makers about what is required to successfully adapt to climate change. A part of this process, he emphasized, is the development of climate models that suit various spatial and time scales, so that professionals can more effectively apply research across disciplines and jurisdictions. Mr. Foster concluded his presentation by highlighting success stories from his work assisting urban and rural communities to develop climate change adaptation plans that incorporate regional climate models into their planning framework.

U.S. and International Opportunities for Collaboration, Dr. Bill Gutowski, Coordinator of the Regional Climate Modeling Laboratory, Iowa State University

Dr. Gutowski provided highlights of his experience in developing integrated regional climate models in the United States. He explained that although early modelling projects were commonly conducted in isolation, today there are extensive efforts to develop projects using ensembles of several climate models both regionally and globally. Dr. Gutowski identified the opportunity for increased collaboration between Canada and the United States when developing climate models.

Dr. Gutowski asserted that the purpose of developing climate modelling programs is to obtain information, not just data, which can be used to increase our knowledge of climate change adaptation requirements. We need to turn the "end users" (e.g., policy makers, provincial ministries, municipalities, agricultural communities) of regional climate modelling into "engaged users" who are involved with the development of modelling programs from the very beginning. This allows individuals to better understand both the opportunities and limitations of various modelling approaches and outcomes. Dr. Gutowski suggested that increased dialogue between climate modellers and end users will allow organizations and agencies to become more confident in how they use climate models for decision making and developing successful adaptation strategies. Dr. Gutowski said that Ontario has a great opportunity to advance climate modelling by including end users in the discussion from the beginning, as was done in this workshop.

Summary of Key Messages from Panel: Opportunities for Collaboration

- Canada has lagged behind other countries in developing effective climate change adaptation strategies.
- There is increased need for collaboration within Ontario to conduct effective climate research.
- Regional climate models and climate research need to inform policy and planning decisions.
- Canada and the United States need to collaborate further when developing regional climate models that include the Great Lakes.
- Agencies must engage end users (e.g., policy makers, provincial ministries, municipalities, agricultural communities) in the development of regional climate models.
- Ontario should develop a climate science research program that engages end users early in the process of developing regional climate models.

Breakout Group Discussions: Regional Climate Science Research Needs

After the presentations on "Opportunities for Collaboration", workshop attendees had the opportunity to participate in focused breakout sessions tailored to their areas of expertise. The objective of each breakout session was to identify the regional climate science research needs and agenda for each topic area: physically-based regional climate modelling, the built environment, the natural environment, and water resources management and source water protection. Specifically, each session sought to:

- identify the current state of knowledge;
- identify the current state of practice with respect to both science and policy development;
- identify the gaps in regional climate modelling science and policy specifically for the subject of the breakout session; and
- prioritize the climate science and regional climate modelling research agenda for their session's subject matter.

Physically-Based Regional Climate Modelling

The physically-based regional climate modelling breakout session was attended by climate researchers from universities, practitioners from all levels of government, regional municipalities, conservation authorities, non-profit organizations, and private industry. The session opened with a general discussion about the state of regional climate modelling in Ontario. Participants were quick to highlight that although the intellectual capacity is present in Ontario for effective regional climate modelling, further collaboration is needed among organizations and researchers currently engaged in climate science research. Although Ontario has built up technological capacity over the past 10 years, federal funding for regional climate modelling has decreased and research programs are in danger of disappearing. This was of great concern to the group as they stressed the need to maintain the existing momentum and resources, so that the province can remain competitive in the global research community and provide the necessary information to policy makers. Once research programs disappear, it takes years to rebuild abandoned programs.

Participants recognized that although end users at the provincial level (e.g., the Ministry of Natural Resources and the Ministry of the Environment) have been engaged in using climate data for some time, modellers have missed a large group of stakeholders who would be interested in regional climate models, chiefly municipalities, private industry and conservation authorities.

The group discussion moved into the need to collaborate with end users to develop focused research that would meet the needs of policy makers, private industry, and governments. However, representatives with experience working with the climate science centre in Quebec (OURANOS) pointed out that building such relationships takes significant resources (time, infrastructure and finances). These relationships and resources are required to establish a research program that is both innovative and meets the practical needs of end users. The group recognized that fostering connectivity between these groups also requires extensive dialogue and training in order to help end users understand both the capacities and opportunities for climate models to assist in the development of climate change adaptation strategies in Ontario.

To establish an effective regional climate modelling program in Ontario, long term (10 year) sustainable funding needs to be available from both federal and provincial governments. Strong connectivity among the modelling community and the establishment of a focused and central research group/facility is needed in order to pool resources, experience and knowledge. The workshop attendees advocated for the creation

of a regional climate modelling partnership in Ontario where the principal computational infrastructure would be housed and strong connections would be established to form a network of highly qualified researchers, scientists and policy makers at various institutions and organizations. This partnership could be created by a memorandum of understanding among all willing organizations currently interested in undertaking regional climate modelling in Ontario. Once established, the partnership would ensure that research in Ontario will continue to advance in an effective manner for years to come.

Concluding the discussion, participants underscored the importance of establishing a regional climate modelling partnership in Ontario that would engage in integrated regional climate modelling and research. Representatives agreed that the partnership must have a focused vision, working to develop effective climate models and adaptation strategies to be used by diverse end users (e.g., all levels of government, conservation authorities, private industry and non-governmental organizations).

Participants reached consensus on the idea of establishing an Ontario regional climate modelling partnership ad hoc committee that would develop a proposal and business case for a regional climate modelling partnership, identify partners who could be engaged in the process, and identify next steps for establishing formal agreements (Memoranda of Understanding) among willing participants. The document produced by this modelling partnership would consider the discussions of this workshop's breakout sessions and plenary discussions and be informed by the recommendations outlined in the recently tabled *Report of the Expert Panel on Climate Change Adaptation*. Workshop attendees agreed that the following organizations should be represented in the Ontario regional climate modelling partnership ad hoc committee: Environment Canada, the Ministry of the Environment, the Ministry of Natural Resources, Toronto and Region Conservation Authority, the City of Toronto, the Association of Municipalities of Ontario, Ontario Power Generation and various representatives from universities.

Key Messages from the Breakout Session: Physically-Based Regional Climate Modelling

- Organizations engaged in regional climate modelling need to collaborate in order to increase research capacity and utilize computational resources.
- Effective regional climate modelling programs require sustainable, long term funding commitments.
- The research community needs to better engage end users of regional climate models.
- An Ontario regional climate modelling partnership should be established to focus existing modelling efforts and encourage greater collaboration in Ontario.
- Following the workshop, an Ontario regional climate modelling partnership ad hoc committee should be formed to establish a proposal and business case for a climate modelling partnership.

The Built Environment–Infrastructure, Disaster Management, Health and Socio-Economic Factors

The breakout session pertaining to the built environment began with a discussion of the importance of regional climate modelling forecasts to the planning and managing of the built environment in Ontario. Initially, many participants, including municipal planners and academics, agreed that recent reports, such as the Ontario Expert Panel on Climate Change Adaptation, have helped illustrate emerging trends related to climate change and the development of adaptation strategies at the local level. However, as the discussion progressed,many participants emphasized that there is a lack of certainty and accuracy in regional climate data in the province. Defining and improving the scope of regional climate modelling accuracy could

assist agencies in developing effective disaster mitigation and climate change adaptation strategies. Participants agreed that a lack of communication between modellers and end users exists, particularly relating to the translation of how regional climate models can be used and interpreted by end users of the research.

Workshop attendees noted that policy makers and other end users often under utilize regional climate modelling outputs. This was attributed to both a lack of collaboration with end users and a number of barriers associated with the complexity of the topic, including the difficulty of disseminating localized data and the need to clearly communicate the level of uncertainty and limitations of existing models. Consequently, workshop attendees stated, practitioners often use old climate data to inform infrastructure needs and future requirements. As they are not utilizing current climate data, organizations engaged in infrastructure development have likely been unsuccessful at developing resilient and robust systems that take into account the impacts of changing climate conditions and potential extreme events. Moreover, the participants suggested that in the case of infrastructure, various stakeholders should be concerned with potential cascading impacts (i.e., one form of infrastructure being impacted by severe weather could result in negative impacts on other forms of infrastructure).

The participants also noted that the workshop breakout group was not representative of all stakeholders, as utility companies and other industrial sectors were absent from the workshop discussions. In the future, these organizations should be consulted when developing regional climate models, as they are the end users of the models. Furthermore, the workshop participants observed that the private sector and crown corporations are not significantly engaged in the pursuit of climate change adaptation. As mentioned during the expert presentations, this could be attributed to the need for better communication and outreach to these groups.

The group discussed the next steps that should be taken in order to develop a more robust and integrated climate science research agenda in the province. First, participants emphasized the need for a bioregional set of future climate assumptions that would be available for everyone to use and would provide more information on extreme weather events in Ontario. Second, the group suggested that climate scientists should consolidate their resources by forming a partnership that would share information and provide a forum for intellectual engagement with researchers from diverse modelling fields, not just climate modelling. Lastly, a centralized Internet site should be created so that research communities can effectively share their knowledge with end users across the province.

Key Messages from the Breakout Session: The Built Environment

- Regional climate modelling outputs are under-utilized in Ontario by end users due to a lack of certainty in regional climate data.
- Private sector and crown corporations are not engaged in the pursuit of climate change adaptation research.
- Ontario needs to develop a more robust and integrated climate science research agenda.
- A bioregional set of future climate assumptions should be developed that would provide more information on extreme weather events in Ontario.
- Climate scientists should consolidate their resources by forming a research partnership that would share information and provide a forum for intellectual engagement with researchers from diverse modelling fields.

The Natural Environment–Land Management, Forestry, Agriculture and Ecosystems

Preliminary discussion in the natural environment breakout session outlined a need for increased integration between the modelling and monitoring communities. Participants identified

significant barriers that currently exist between modelling groups and other researchers with different research priorities (e.g., hydrologists, ecologists). Specifically, participants referred to a lack of funding and interest in developing better monitoring networks that could be used to validate the climate models that are produced. It was noted that managers require more than mere access to data or modelling results; they require that information be interpreted/analyzed to highlight pressing issues arising from the research in their fields to aid in decision making. Moreover, participants pointed out that existing monitoring programs lack strategic plans that outline how monitoring networks could beused to improve regional climate models and assist in the development of climate change adaptation strategies. The group discussion focused on balancing the needs of modellers with the needs of those who measure natural processes on the ground, so that robust and integrative research programs can be developed.

The group highlighted the importance of integrating ecosystem processes into regional climate models in order to develop an effective climate science research agenda. In particular, concerns were raised about the lack of two-way communication between those who develop ecosystem models and those who develop regional climate models, because ecosystem observations at the local level do not currently contribute to informing modelling outcomes at the regional scale. The group outlined the importance of improving the representation of physical processes in the development of future regional climate models including, ecosystem processes, surface and groundwater interactions, carbon fluxes and system thresholds in the creation of new regional climate models. Workshop participants agreed on the importance of monitoring networks gaining access to regional climate modelling results from researchers so that the network may improve its own regional, physically-based modelling systems. Organizations should collaborate in order to develop a strategic approach to both monitoring and the integration of physical processes into the development of regional climate models.

The group emphasized the need for more networks of real data collection and the value of opening up governmental data sets and archives to practitioners in the field. Participants suggested that an integrated climate data warehouse should be formed that would collect, store and host data online via a climate modelling portal, linking end users and climate researchers. In this manner, two-way communications between policy makers and scientists could be established and maintained, so that existing research can be better utilized and future research encouraged.

Key Messages from the Breakout Session: The Natural Environment

- There is a lack of communication between those who develop ecosystem models and those who develop regional climate models in Ontario.
- The representation of physical processes in the development of regional climate models needs to be improved.
- Practitioners need to develop a strategic approach to both monitoring and the integration of physical processes into the development of regional climate models.
- Governmental data sets and archives must be accessible to monitoring agencies.
- An integrated climate partnership should be formed that would collect, store and host data online and would link end users and climate researchers.

Water Resource Management and Source Water Protection

Throughout the breakout session, it was apparent that there is great interest on the part of Ontario water management agencies to integrate the results of regional climate modelling into the hydrological models used for water resource management and

source water protection planning. While a number of agencies, in particular conservation authorities, have attempted to incorporate climate change scenarios in their water resources modelling activities, it is difficult to conduct comprehensive and defensible analyses due to the lack of regionally relevant climate projections and an absence of standardized methods for utilizing such projections as input to hydrological models.

The group noted that efforts were being undertaken by the Ministry of the Environment, the Ministry of Natural Resources and organizations like Pollution Probe to assist water resource managers by informing them of climate change data. However, at this stage most guidance is 'high level' and does not address the technical challenges of conducting climate change impact assessments using hydrological models. One notable exception is the guidance document currently being developed by the Ministry of Natural Resources with respect to climate change and source water protection. This guide will attempt to address some technical challenges, but practitioners will still be limited by the absence of regional climate projections at the temporal and spatial scales required to support such studies.

Additionally, workshop attendees noted that the level of capacity to address climate change in water resource management varies across Ontario. Specifically, the group highlighted resource constraints among smaller conservation authorities that hinder their ability to incorporate climate scenarios and sensitivity analysis into their water resources models. Even though climate change information is required by legislation as part of the Assessment Report in source water protection planning, there is a need for a more focused effort to integrate climate change into water management and protection planning. To that end, the Ministry of the Environment will be posting a discussion paper on the Environmental Bill of Rights Environmental Registry in the spring to ask for feedback on a proposed plan of action to integrate climate change science in source water protection plans.

After examining the current state of practice in Ontario, the group identified the following gaps in regional climate modelling and climate science as it relates to source protection and water resources management.

- Lack of information sharing between jurisdictions, agencies and decision makers, which has contributed to an incomplete understanding about the state of current climate modelling practices, capacities and methods. Participants identified the need to consistently and defensibly incorporate climate model outputs, in hydrological modelling, of both water quality and quantity.
- Lack of monitoring data to support hydrological modelling or to understand the impacts of climate change on water resources, particularly in northern communities in Ontario.
- Currently available climate model outputs and projections, which are generally from global climate models, do not provide information at sufficiently detailed temporal or spatial scales to support impact assessments at a watershed scale, and they do not provide useful information regarding the potential effect of climate change on rainfall extremes.
- The uncertainty and variability in climate model outputs have not been quantified or framed in such a way that allows water managers to account for these in decision making.
- There are significant gaps in other data required to support water resources modelling. Data related to water quality, water quantity, groundwater, soils and land use are incomplete and difficult to access.
- There is an overall lack of policy guidance in planning for the impacts of climate change in water resources management and source water protection in terms of both water quantity and quality. Floodplain management policy was highlighted as an another area of concern, as floodplains in Ontario continue to be managed

on the basis of risk associated with the historic climate, despite acknowledgement by the provincial government that climate change will most likely increase the risk of flooding.

- There is a need to involve private sector agencies, such as Ontario Power Generation (OPG), that are involved in business related to water resources. It was noted that OPG has expressed interest in investigating implications of climate change for their business, but there is a general lack of technical guidance and methodology to pursue that avenue of research.

Concluding their discussion, the breakout group highlighted the importance of creating a collaborative ensemble of climate modelling research and model outputs in Ontario. According to participants, this ensemble needs to be an open research group that would act as a "one-stop-shop" for obtaining climate models, research and guidance on the best techniques for practically applying this information. This one-stop-shop is needed in Ontario, since differing climate scenarios and methods for the practical application of these scenarios in climate change impact studies are currently being used by various proponents and agencies. The result is that decision making and policy development are overly complicated when it comes to creating climate change adaptation strategies at the local level. For that reason, the group supported the notion of forming a regional climate modelling partnership in Ontario. However, members stressed that when a partnership is formed, the group should have a mandate that extends beyond modelling to include the needs of all end users of regional climate modelling outputs. Specifically, a climate change partnership should integrate the needs of the water resource community to produce a dataset of climate model outputs and scenarios for Ontario (including extremes) that are suitable for water resources, source protection and other local/regional impact studies. The breakout group felt that a consensus on the model outputs by the ensemble of climate scientists would assist in quantifying the uncertainty associated with climate modelling in a manner that is suited to risk assessment and sensitivity analysis.

Key Messages from the Breakout Session: Water Resource Management and Source Water Protection

- There is a lack of regionally relevant climate projections, data and standardized methods for integrating climate change into hydrological models.
- There is a lack of information sharing between jurisdictions, agencies and decision makers in the province.
- There are significant gaps in monitoring, climate modelling and other water resources data required to support water resource managers in understanding the impacts of climate change on water resources in Ontario.
- There is an overall lack of policy guidance in planning for the impacts of climate change in water resources management and source water protection planning.
- A collaborative partnership between climate modelling researchers should be established, to provide agencies with climate models, research and strategic support for utilizing climate science data in disciplines such as water resources management.

Appendix A

Summary of Key Messages, Climate Science Workshop: Regional Climate Modelling Capacity in Ontario

Appendix A – Summary of Key Messages, Climate Science Workshop: Regional Climate Modelling In Ontario

Perspectives on Regional Climate Modelling in Ontario

- Global climate models play a crucial role in understanding the greater policy implications of global climate change, and they provide the boundary conditions that drive regional climate models.
- There is a need to fully understand the hydrodynamics of the Great Lakes in Ontario, and to integrate lake hydrodynamics into regional climate models.
- There is a need to examine the impacts of the cryosphere on climate variability in order to better understand the feedback mechanisms that exist between the cryosphere and the global climate.
- Stable and sustainable funding and computer infrastructure for climate modelling are required.
- Ontario is currently losing high quality researchers to the United States and Europe due to inadequate funding and reduced support to engage in integrated regional climate modelling research.
- In order to develop effective climate models for Ontario, a broad collaboration of agencies and universities across the province is needed through the establishment of a research partnership.

Opportunities for Collaboration

- Canada has lagged behind other countries in developing effective climate change adaptation strategies.
- There is increased need for collaboration within Ontario to conduct effective climate research.
- Regional climate models and climate research need to inform policy and planning decisions.
- Canada and the United States must collaborate further when developing regional climate models that include the Great Lakes.
- Agencies need to engage end users (e.g., policy makers, provincial ministries, municipalities, agricultural communities) in the development of regional climate models.
- Ontario should develop a climate science research program that engages end users early in the process of developing regional climate models.

Physically-Based Regional Climate Modelling

- Organizations engaged in regional climate modelling need to collaborate in order to increase research capacity and utilize computational resources.
- Effective regional climate modelling programs require sustainable, long term funding commitments.
- The research community needs to better engage end users of regional climate models.
- An Ontario regional climate modelling partnership should be established to focus existing modelling efforts and encourage greater collaboration in Ontario.
- Following the workshop, an Ontario regional climate modelling partnership ad hoc committee should be formed to establish a proposal and business case for a climate modelling partnership.

The Built Environment

- Regional climate modelling outputs are under-utilized in Ontario by end users due to a lack of certainty in regional climate data.
- Private sector and crown corporations are not engaged in the pursuit of climate change adaptation research.
- Ontario needs to develop a more robust and integrated climate science research agenda.
- A bioregional set of future climate assumptions should be developed that would provide more information on extreme weather events in Ontario.
- Climate scientists should consolidate their resources by forming a research partnership that would share information and provide a forum for intellectual engagement with researchers from diverse modelling fields.

The Natural Environment

- There is a lack of communication between those who develop ecosystem models and those who develop regional climate models in Ontario.
- The representation of physical processes in the development of regional climate models must be improved.
- Practitioners need to develop a strategic approach to both monitoring and the integration of physical processes into the development of regional climate models.
- Governmental data sets and archives need to be accessible to monitoring agencies.
- An integrated climate partnership should be formed that would collect, store, and host data online and would link end users and climate researchers.

Water Resource Management and Source Water Protection

- There is a lack of regionally relevant climate projections, data, and standardized methods for integrating climate change into hydrological models.
- There is a lack of information sharing between jurisdictions, agencies, and decision makers in the province.
- There are significant gaps in monitoring, climate modelling, and other water resources data required to support water resource managers in understanding the impacts of climate change on water resources in Ontario.
- There is a overall lack of policy guidance in planning for the impacts of climate change in water resources management and source water protection planning.
- A collaborative partnership between climate modelling researchers should be established, to provide agencies with climate models, research, and strategic support for utilizing climate science data in disciplines such as water resources management.

Appendix B

Survey Report: Regional Climate Modelling Capacity in Ontario

Appendix B – Survey Report: Regional Climate Modelling Capacity In Ontario

Prior to and following the Climate Science Workshop: Regional Climate Modelling Capacity in Ontario, a short survey was distributed to invited scientists and researchers with the intention of identifying "who is doing what" with regard to climate modelling, impacts and adaptation in Ontario. The survey was primarily directed towards the academic scientific community, with invitations sent to a few government climate scientists; however, the results are useful for both the public and private sector in helping to inform knowledge of what capacity exists in the province for evidence-based climate change decision making.

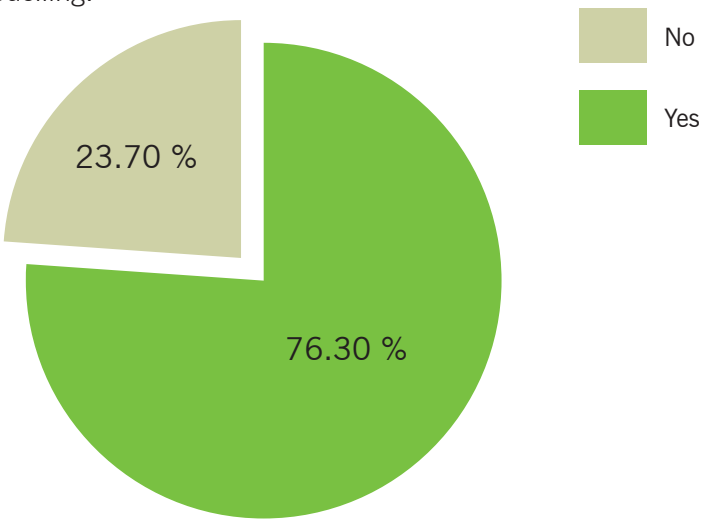
In total, of the 65 individuals contacted to participate in the survey, 40 responded. The respondents were primarily based within Ontario; one was from Quebec, and one from the United States. The survey was distributed to individuals at Carleton University, Lakehead University, Laurentian University, McGill University, McMaster University, Nipissing University, Queen's University, Trent University, University of Guelph, University of Ottawa, University of Toronto, University of Waterloo, University of Western Ontario and York University, along with L'Université du Québec à Montréal and Iowa State.

The interview questions were designed to be brief and easy to answer in order to capture a snapshot of the current state of climate modelling and climate science research activity within Ontario. This is a first step towards developing a more exhaustive, comprehensive understanding of the state of not only physically-based regional climate change modelling but related fields such as: impact modelling, adaptation research and adaptation planning. The initial survey is intended to assist provincial efforts in creating an Ontario climate modelling and climate science partnership by contributing descriptive information on "who does what and where" in the province. Later stages of this survey work will focus interview efforts on developing a deeper understanding of mechanisms that will enhance the ability of clusters of Ontario researchers with a range of expertise to work more collaboratively in addressing questions and needs raised by government, the private sector, and private citizens in the face of a changing climate.

This report provides a brief overview of the survey responses, represented in charts and graphs, along with additional narrative comments. The survey information is presented on a question-by-question basis.

Question 1:

Are you currently involved in physically-based modelling?



Note: 38 respondents answered the question.

Question 2:

If you answered 'YES' to Question 1, please select the type of modelling in which you are involved (maximum of three selections).

- Regional Climate Modelling
- Radiative Transfer Modelling
- Surface Energy Balance Modelling
- Cryosphere Modelling
- Great Lakes Modelling
- Ocean Modelling
- Carbon Cycle Modelling
- Global Circulation Modelling
- Severe Weather
- Hydrology
- Paleoclimatology
- Weather Forecasting
- Air Quality
- Cloud Modelling
- Meso-Scale Modelling

	Response Percentile	Response Count
Global Circulation Modelling	31.0%	9
Severe Weather	10.3%	3
Hydrology	37.9%	11
Paleoclimatology	3.4%	1
Weather Forecasting	3.4%	1
Air Quality	13.8%	4
Cloud Modelling	3.4%	1
Meso-Scale Modelling	3.4%	1
Regional Climate Modelling	27.6%	8
Radiative Transfer Modelling	0.0%	0
Surface Energy Balance Modelling	20.7%	6
Cryosphere Modelling	27.6%	8
Great Lakes Modelling	6.9%	2
Ocean Modelling	0.0%	0
Carbon Cycle Modelling	24.1%	7
Other (Please Specify)	13.8%	4

Note: 29 respondents answered the question. In addition to the choices available, the respondents self identified research concentrations focused on the following modelling:

- Stratospheric
- Cryosphere
- Ecosystem
- Hydrology
- Biochemical

Specific initiatives include:

- Integrated assessment modelling
- The study of ecosystem biogeochemical exchanges
- Physically-based modelling using remote sensing
- Integration of surveillance data and environmental conditions with regard to disease spread modelling
- Wild fire numerical modelling

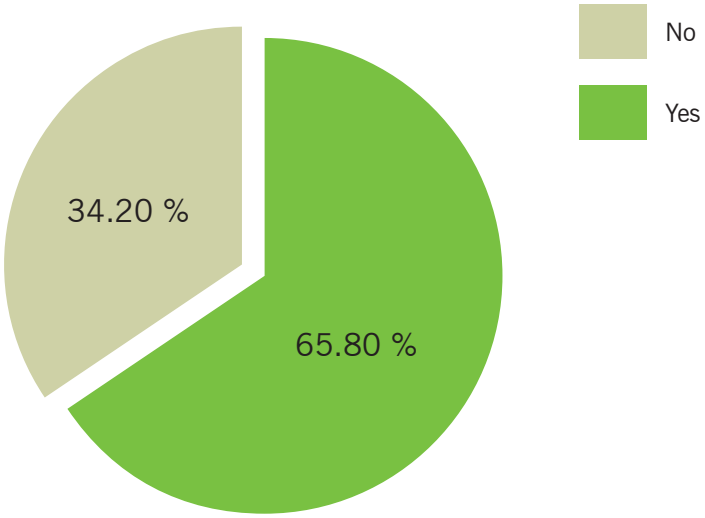
The information collected demonstrates that physically-based modellers engage in a diverse array of initiatives. The challenge lies in adequately defining the scope of such research to ask appropriate questions. Are the current definitions of physically-based modelling adequate to describe the tremendous breadth and scope of research initiatives underway? Furthermore, given the important questions that need to be asked, how can policy makers, researchers and scientists be brought together to formulate meaningful research questions to aid decision makers in both government and industry if clarity is required to fully understand and appreciate the scope of research?

University	Physically-based Modelling
Carleton University	Cryosphere Modelling, Hydrology, Surface Energy Balance Modelling, Carbon Cycle Modelling, Air Quality
Lakehead University	Hydrology
McMaster University	Global Circulation Modelling, Surface Energy Balance Modelling, Carbon Cycle Modelling
Nipissing University	Cryosphere Modelling
Queen's University	Carbon Cycle Modelling, Ecosystem Modelling (Carbon/Nitrogen Cycle)
University of Guelph	Global Circulation Modelling, Hydrology, Severe Weather, Great Lakes Monitoring
University of Toronto	Hydrology, Carbon Cycle Modelling, Surface Energy Balance Modelling, Paleoclimatology, Regional Climate Modelling, Cryosphere Modelling, Stratospheric Modelling
University of Waterloo	Regional Climate Modelling, Cryosphere Modelling, Physically-based Modelling in Microwave Remote Sensing
University of Western Ontario	Integrated Assessment Modelling, Hydrology, Biogeochemistry (Carbon/Nitrogen), Severe Weather, Regional Climate Modelling
York University	Cloud Modelling, Integrated Surveillance of Disease Vectors and Environmental Change, Severe Weather, Weather Forecasting, Meso-Scale Modelling, Air Quality and Regional Climate Modelling

Note: 29 respondents answered the question. Table is representative of survey results only.

Question 3:

Are you currently involved in impacts/adaptation modelling/research?



Note: 38 respondents answered the question.

Respondents also identified additional research interests including:

- Air Quality
- Ecosystems
- Water Quality and Quantity
- Human Health
- Protected Areas
- Tourism
- Peat Lands
- Hydroelectric Power Generation
- Economic

Question 4:

If you answered 'YES' to Question 3 please make one or more selections (maximum of three selections).

- Water Sewage and Sanitation
- Water Supply and Distribution
- Agriculture
- Health
- Hydrology
- Infrastructure
- Forestry
- Emergency Management
- Business and Industry
- Trade
- Energy Production and Distribution

	Response Percentile	Response Count
Water Sewage and Sanitation	4.0%	1
Water Supply and Distribution	20.0%	5
Agriculture	28.0%	7
Health	12.0%	3
Hydrology	48.0%	12
Infrastructure	8.0%	2
Forestry	32.0%	8
Emergency Management	12.0%	3
Business and Industry	4.0%	1
Trade	4.0%	1
Energy Production and Distribution	12.0%	3
Other	24.0%	6

Note: Respondents were able to choose up to a maximum of three selections;
25 respondents answered the question.

University	Adaptation and Climate Impacts Research
Carleton University	Infrastructure, Hydrology, Agriculture, Protected Areas, Health
Lakehead University	Water Supply, Agriculture, Hydrology, Forestry
McMaster University	Forestry, Hydrology
Queen's University	Agriculture, Forestry, Energy Production and Distribution
University of Guelph	Agriculture, Hydrology
University of Toronto	Water Supply and Distribution
University of Waterloo	Hydrology, Protected Areas, Tourism
University of Western Ontario	Hydrology, Emergency Management, Forestry, Water Quality, Supply and Distribution, Energy Production and Distribution, Economics
York University	Forestry, Emergency Management, Health, Trade, Business and Industry, Agriculture

Note: Table is representative of survey results only.

Question 5:

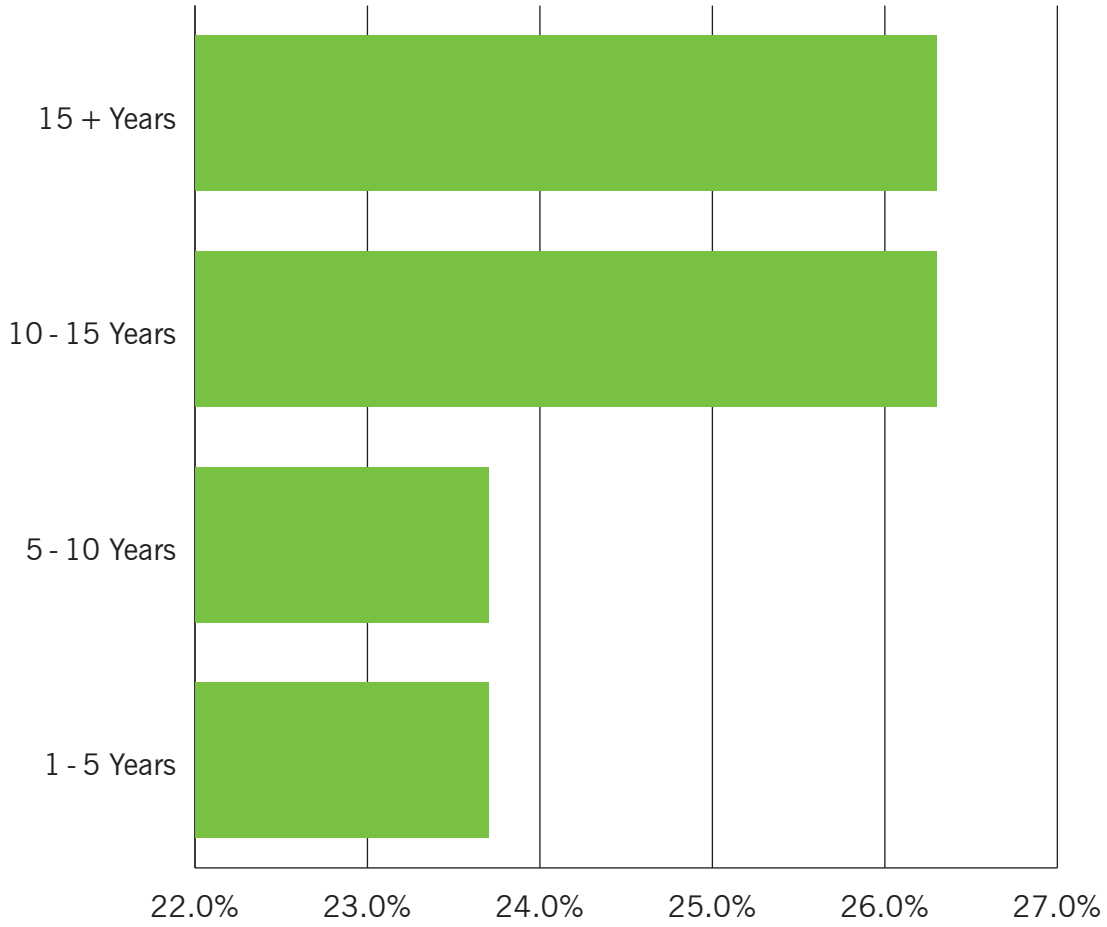
How long have you been involved in the study of climate change, impacts or adaptation?

1-5 years

5-10 years

10-15 years

15+ years



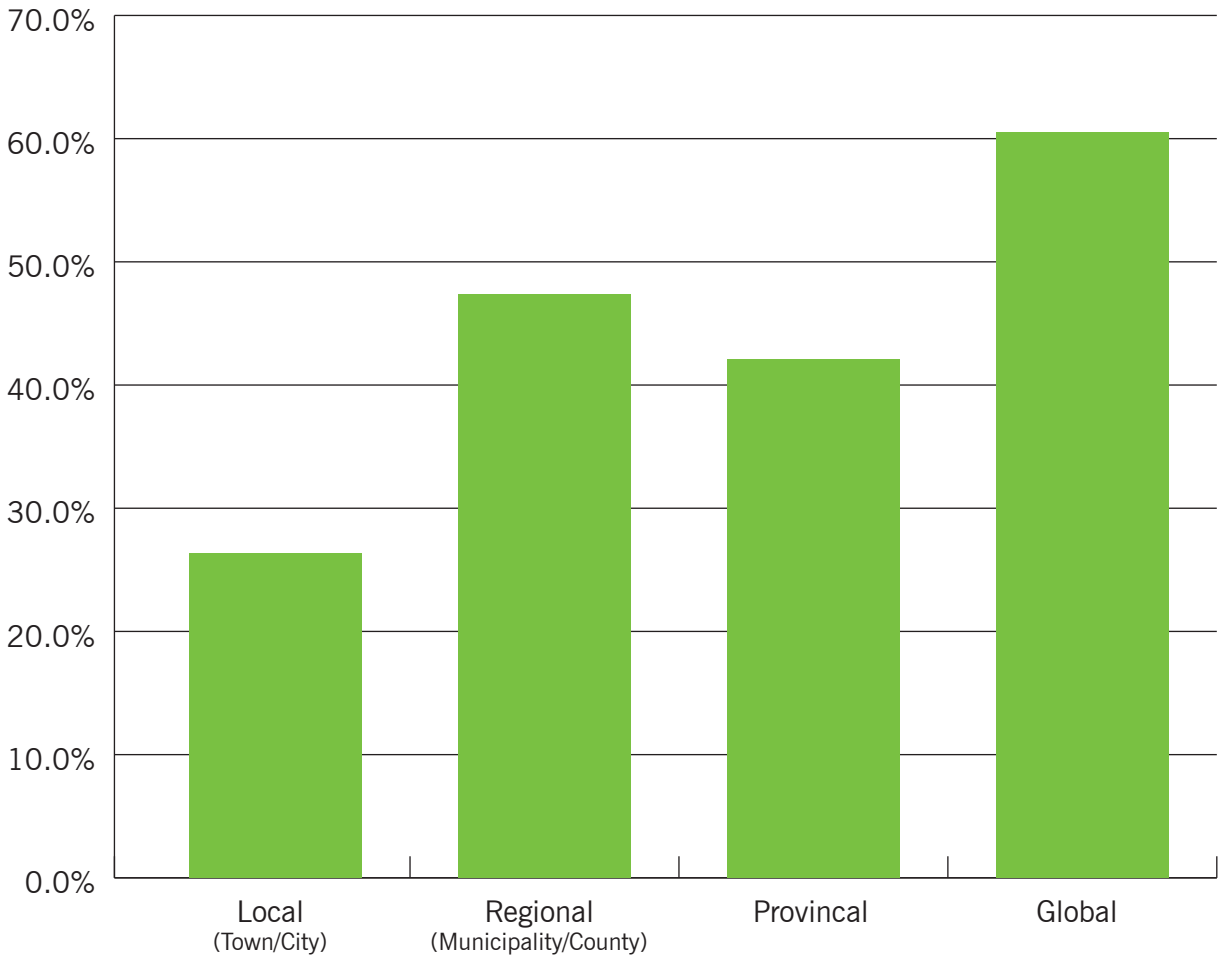
Note: 38 respondents answered the question.

The survey found that experience in the study of climate change was fairly evenly distributed. Of the individuals who responded, 26.3 per cent had between 10 to 15 years and over 15 years respectively. The other 23.7 per cent of individuals had been involved for between 1 to 5 years and 5 to 10 years. This level of experience represents an existing investment in training and education over a period much greater than 15 years. A vision focused on not only supporting current researchers, but also a plan for educating and training the next generation of scientists is required to maintain existing levels of expertise and experience.

Question 6:

On what scale is your research focused? (e.g., regional/global.)

- Local (Town/City)
- Regional (Municipality/County)
- Provincial
- Global



Note: 38 respondents answered the question.

Although the chart demonstrates a focus on global and regional issues, the raw data illustrates that researchers and scientists are clearly participating in research across scales.

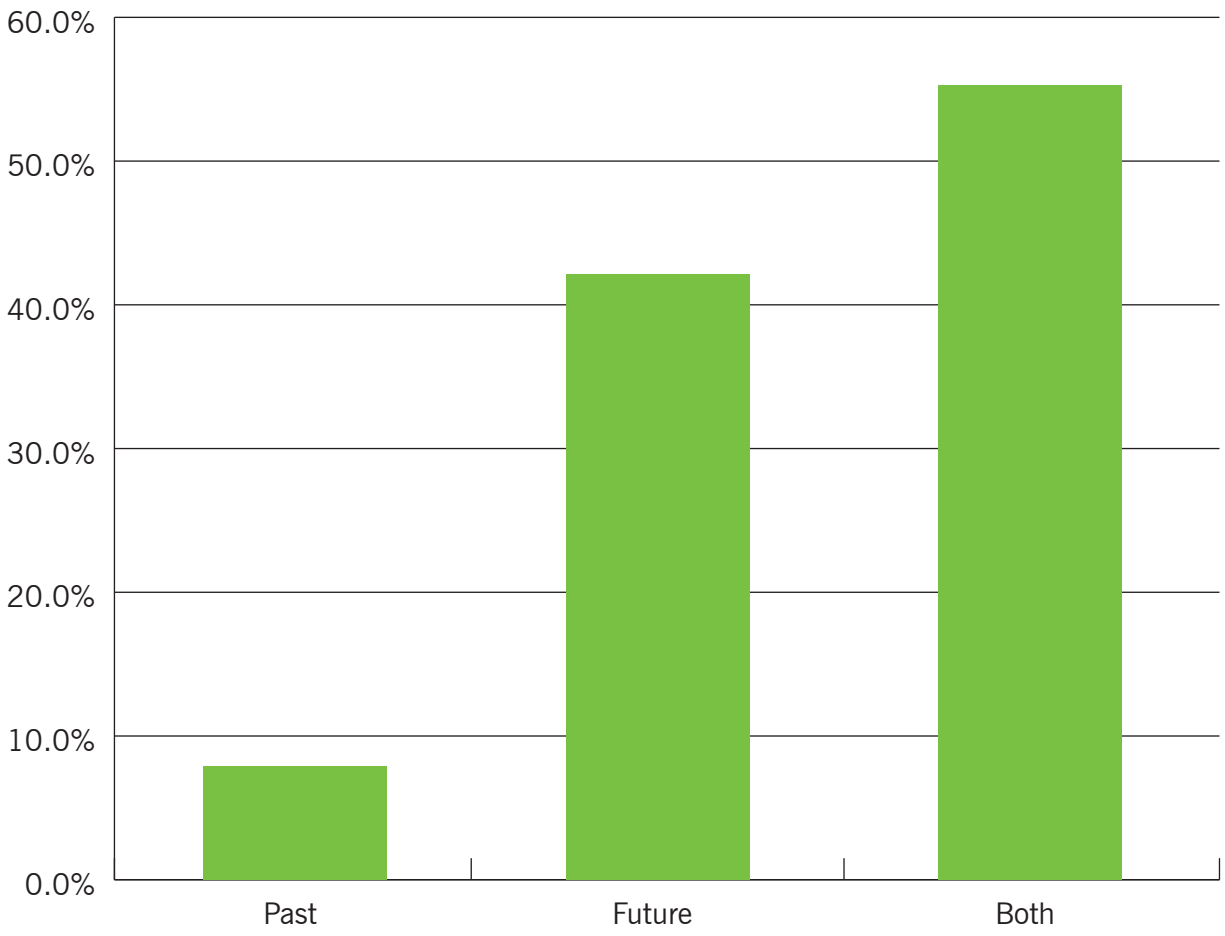
Question 7:

Does your research centre on the past, the future or both? (e.g., paleoclimatology or future climate scenarios.)

Past

Future

Both

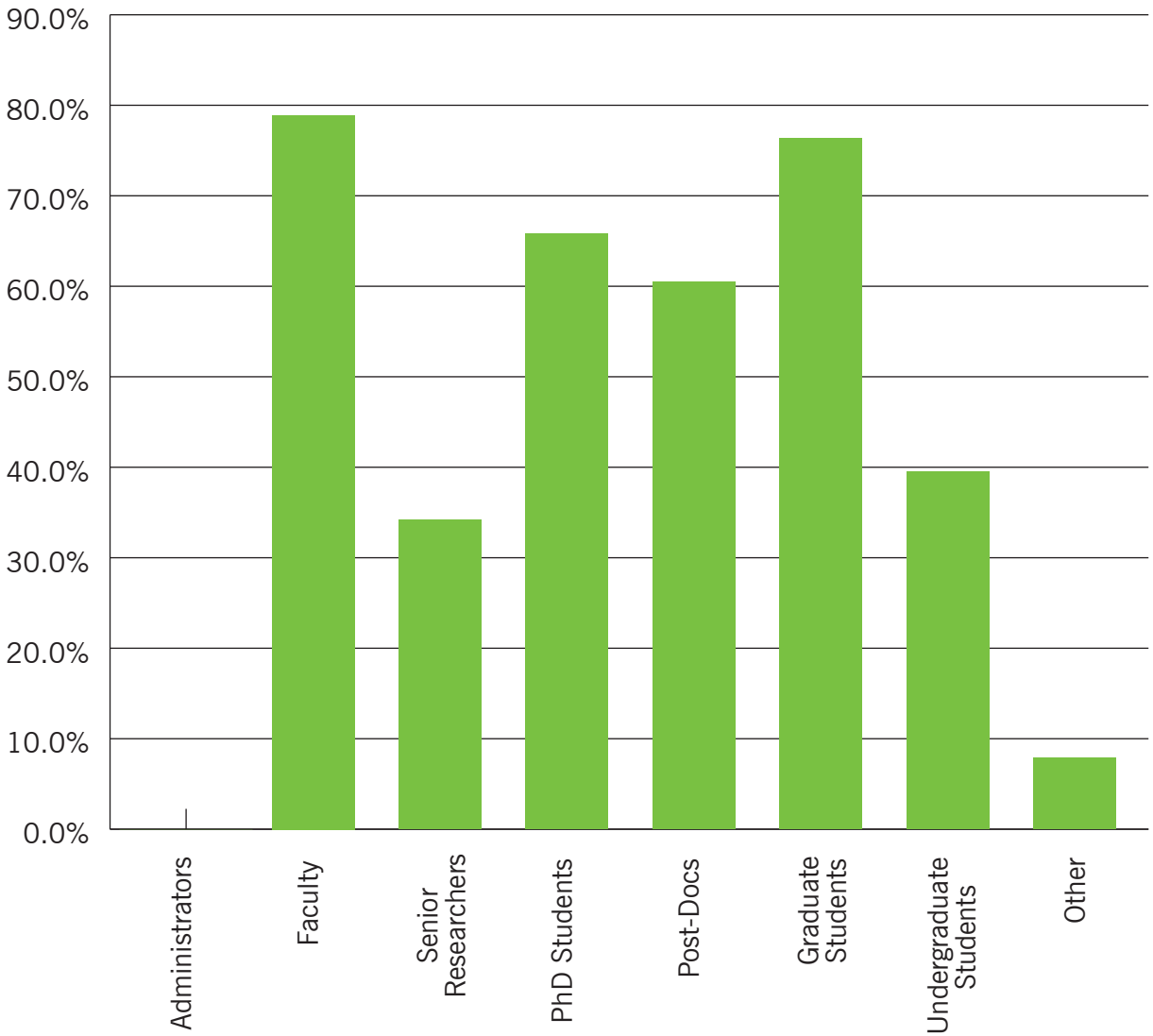


Note: 38 respondents answered the question.

Question 8:

Who is currently involved in your research efforts?

- Administrators
- Faculty
- Senior Researchers
- PhD Students
- Post-Docs
- Graduate Students
- Undergraduate Students
- Other



Note: 38 respondents answered the question.

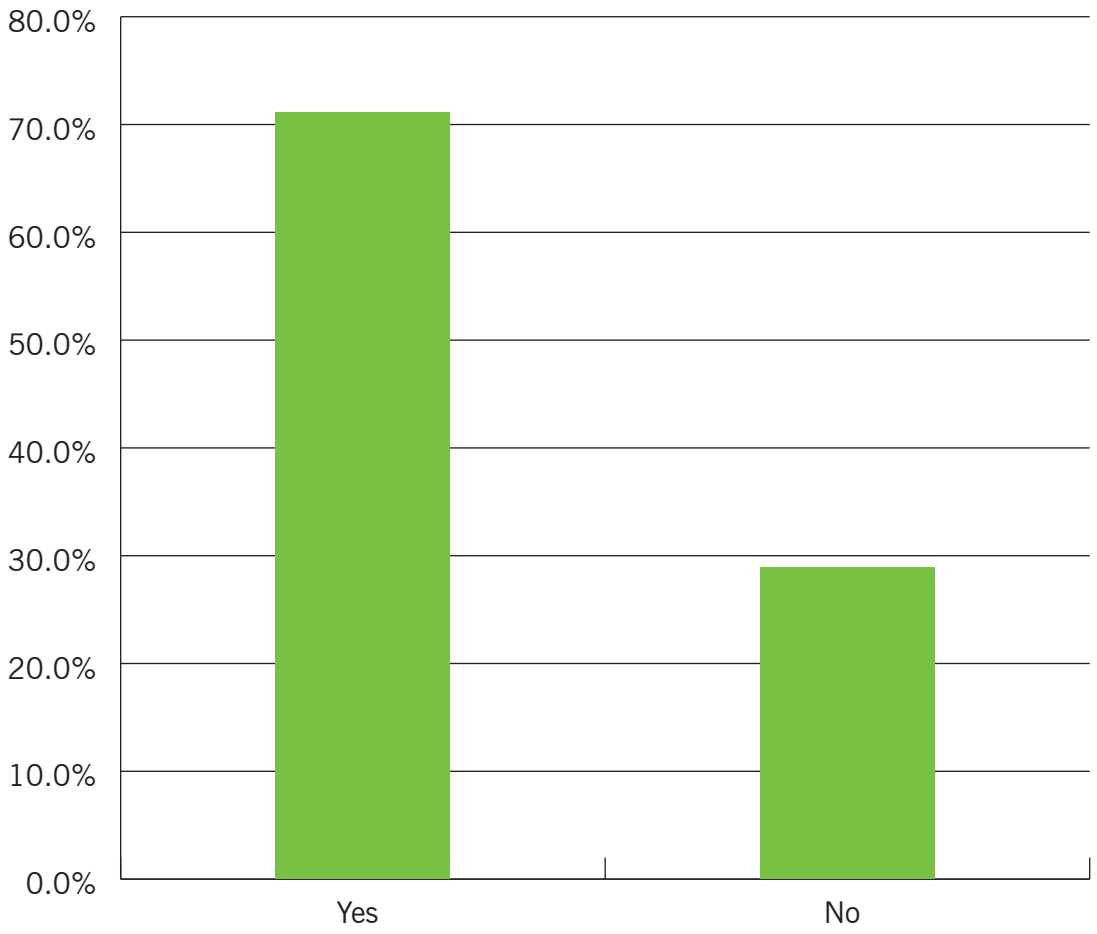
Question 9:

Are you currently involved in any national/international or industry collaborations?

Yes

No

Please specify



Note: 38 respondents answered the question.

Over 20 respondents took additional time to note the considerable degree of collaboration involved in their current research efforts. As one respondent noted, they were involved in too many initiatives to list them all. Respondents noted collaborations within Canada and Europe, as well as South America, and Asia. The list of collaborations and collaborators is diverse and representative of a great deal of expertise and experience.

Some examples of collaboration include:

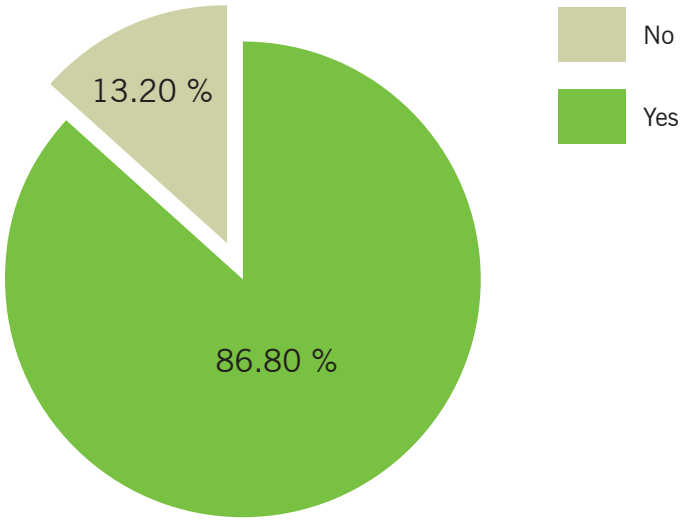
- International Polar Year
- Polar Climate Stability Networks
- UNESCO International Flood Initiative
- NASA
- European Space Agency
- Environment Canada
- US Forest Service
- Canadian Carbon Program
- IDRC
- North American Carbon Program
- Hydro Quebec
- Hydro Manitoba
- BC Hydro

Question 10:

Would you be interested in collaborating on a regional climate modelling/adaptation initiative?

Yes

No



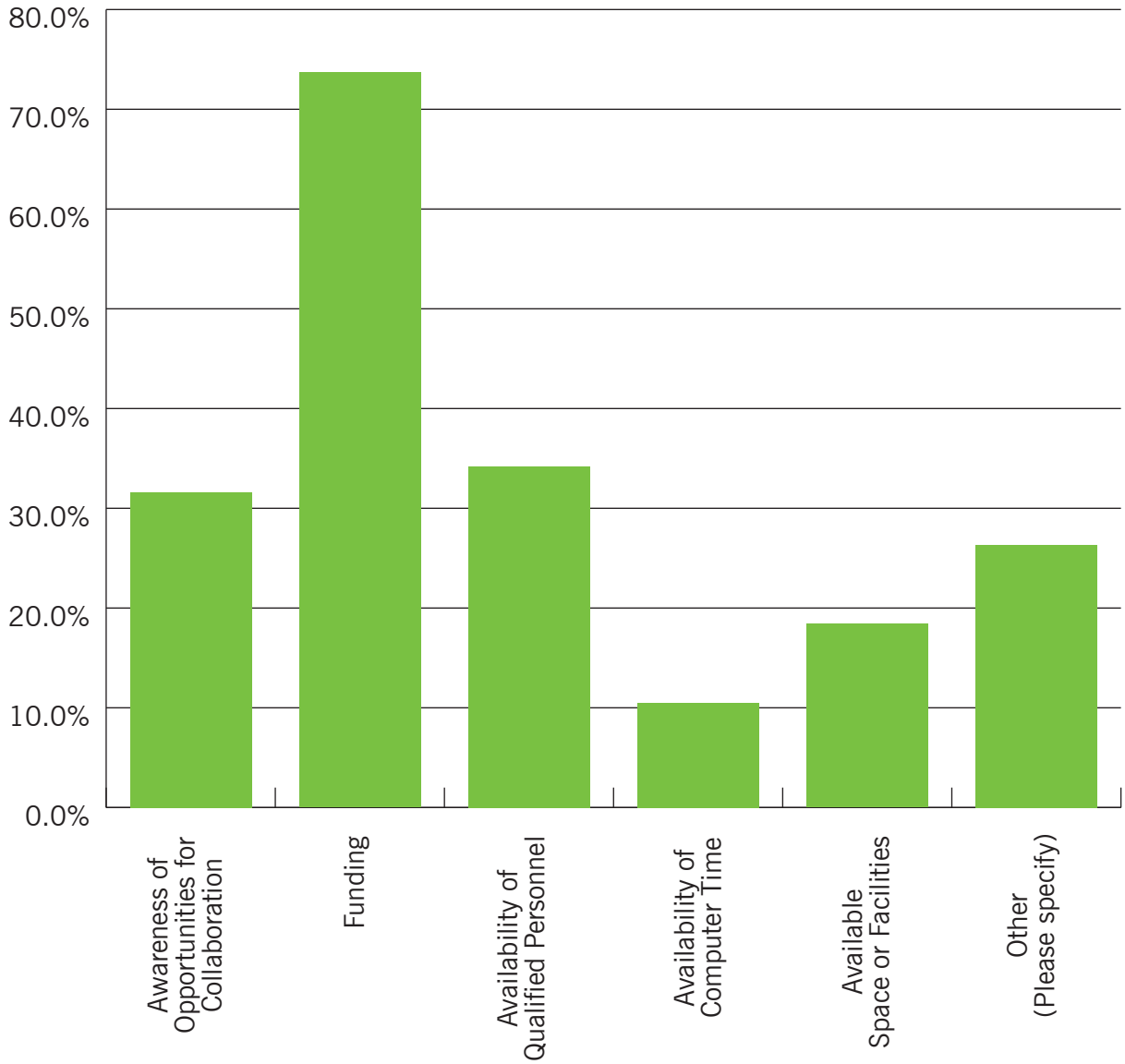
Note: 38 respondents answered the question.

A large proportion of those that responded to the survey indicated an interest in participating in a regional climate modelling and adaptation initiative. While support for such an initiative was strong, respondents noted the need for additional information before committing, and the necessary funding to support administration staff and post-docs if such an initiative were to be developed. Despite significant interest, respondents noted that existing commitments and time constraints represent a limiting factor.

Question 11:

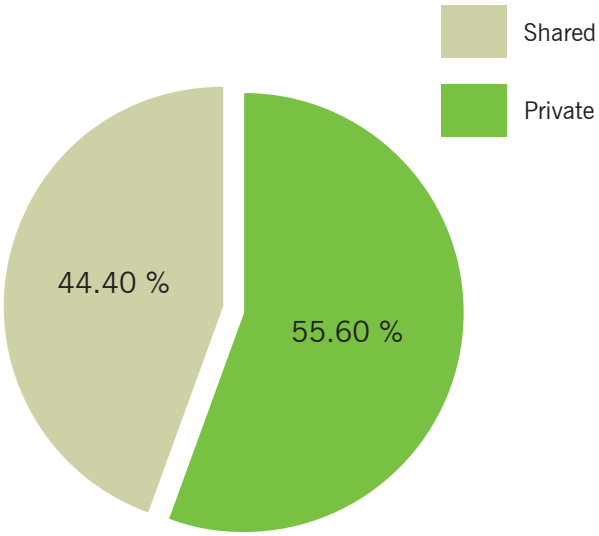
What current barriers/limitations do you currently face? Please pick one or more.

- Awareness of Opportunities for Collaboration
- Funding
- Availability of Qualified Personnel
- Availability of Computer Time
- Available Space or Facilities
- Other (Please specify)



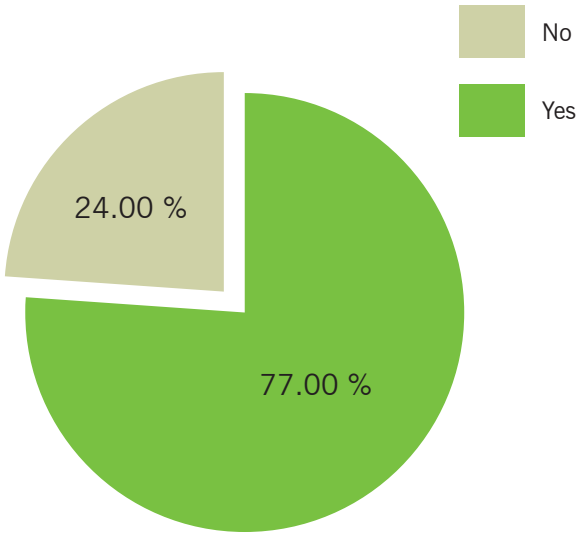
Note: 38 respondents answered the question.

Question 12:
Is your computing facility private or shared?
Private
Shared



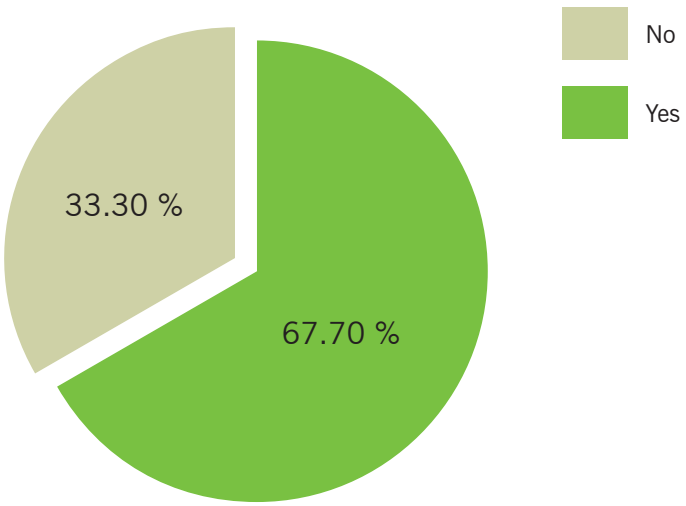
Note: 36 respondents answered the question.

Question 13:
If shared, can resources be efficiently utilized?
Yes
No



Note: 17 respondents answered the question.

Question 14:
Do you develop or modify (adapt) physically-based models? (e.g., GCMs, cloud models, etc.)
Yes
No



Note: 36 respondents answered the question.

Question 15:

What models are you currently using? (e.g., GCMs, regional hydrology models, atmospheric models, etc.)

- Global Circulation Models
- Severe Weather Forecasting Models
- Hydrology
- Paleoclimatology
- Weather Forecasting
- Air Quality
- Ocean Modelling
- Cloud Modelling
- Meso-Scale Modelling
- Regional Climate Modelling
- Radiative Transfer Modelling
- Surface Energy Balance Modelling
- Cryosphere Modelling
- Great Lakes Modelling
- Other

Please select one or more.

	Response Percentile	Response Count
Global Circulation Modelling	30.8%	8
Severe Weather Forecasting Models	7.7%	2
Hydrology	34.6%	9
Paleoclimatology	3.8%	1
Weather Forecasting	7.7%	2
Air Quality	19.2%	5
Cloud Modelling	7.7%	2
Meso-Scale Modelling	3.8%	1
Regional Climate Modelling	30.8%	8
Radiative Transfer Modelling	3.8%	1
Surface Energy Balance Modelling	15.4%	4
Cryosphere Modelling	11.5%	3
Great Lakes Modelling	3.8%	1
Ocean Modelling	7.7%	2
Carbon Cycle Modelling	26.9%	7
Other (Please Specify)	30.8%	8

Note: 26 respondents answered the question.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