

WATER AND AGRICULTURE IN CANADA: TOWARDS SUSTAINABLE MANAGEMENT OF WATER RESOURCES

Executive Summary



**WATER AND AGRICULTURE IN CANADA: TOWARDS SUSTAINABLE
MANAGEMENT OF WATER RESOURCES**

**The Expert Panel on Sustainable Management of Water in the Agricultural
Landscapes of Canada**

THE COUNCIL OF CANADIAN ACADEMIES

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Library and Archives Canada Cataloguing in Publication

Water and agriculture in Canada [electronic resource] : towards sustainable management of water resources / The Expert Panel on Sustainable Management of Water in the Agricultural Landscapes of Canada. Issued also in French under title: L'eau et l'agriculture au Canada. Includes bibliographical references and index. Electronic monograph in PDF format. Issued also in print format.

ISBN 978-1-926558-56-1

1. Water in agriculture – Canada. 2. Water-supply, Agricultural – Government policy – Canada. 3. Sustainable agriculture – Government policy – Canada. 4. Agriculture and state – Canada. I. Council of Canadian Academies. Expert Panel on Sustainable Management of Water in the Agricultural Landscapes of Canada

S494.5.W3W37 2013 333.91'3170971 C2013-900247-2

This report should be cited as: Council of Canadian Academies, 2013. Water and Agriculture in Canada: Towards Sustainable Management of Water Resources. The Expert Panel on Sustainable Management of Water in the Agricultural Landscapes of Canada, Council of Canadian Academies.

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Printed in Ottawa, Canada



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Acknowledgements

The Expert Panel on Sustainable Management of Water in the Agricultural Landscapes of Canada was established in response to a request from the federal Minister of Agriculture and Agri-Food, who asked the Council for scientific advice to assist in guiding the sustainable management of water for agriculture in Canada. On behalf of the Panel, I would like to thank the Minister for putting forward this timely and important question.

The following report reflects the efforts and contributions of 15 experts drawn from diverse fields of expertise from Canada and abroad. I am deeply grateful for my colleagues on the Panel who contributed so much of their time and effort to ensure the depth and quality of this report. The result embodies the Panel's collective insights and judgment, and an undertaking of this magnitude would have been impossible without their wisdom and support.

I would also like to acknowledge John Kolk, who provided many helpful contributions to our discussions but stepped down from the Panel before the conclusion of the report in order to run as a candidate for Little Bow, Alberta, in the 2012 provincial election.

Thanks as well to the professional staff of the Council for all their support and assistance throughout this process. Their efforts contributed to ensuring a smooth process for us and helped to enhance the work of the Panel throughout. Lastly, thanks to Elizabeth Dowdeswell, President of the Council, for all her wise advice and ongoing support to the Panel throughout this process. Her efforts were much appreciated.



Howard Wheater, Chair

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Report Review

This report was reviewed in draft form by the individuals listed below — a group of reviewers selected by the Council of Canadian Academies for their diverse perspectives, areas of expertise, and broad representation of academic, policy, and non-governmental organizations.

The reviewers assessed the objectivity and quality of the report. Their submissions — which will remain confidential — were considered in full by the Panel, and most of their suggestions were incorporated into the report. They were not asked to endorse the conclusions nor did they see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the Expert Panel on the Sustainable Management of Water in the Agricultural Landscapes of Canada and the Council of Canadian Academies.

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The report review procedure was monitored on behalf of the Council's Board and Scientific Advisory Committee (SAC) by **Daniel Krewski**, Professor of Epidemiology and Community Medicine and Scientific Director of the McLaughlin Centre for Population Health Risk Assessment, University of Ottawa (Ottawa, ON).

The role of the report review monitor is to ensure that the panel gives full and fair consideration to the submissions of the report reviewers. The Board of Governors of the Council authorizes public release of an expert panel report only after the report review monitor confirms that the Council's report review requirements have been satisfied. The Council thanks Dr. Krewski for his diligent contribution as review monitor.



Elizabeth Dowdeswell, O.C., President & CEO
Council of Canadian Academies

Executive Summary

The agricultural sector is an important contributor to Canada's prosperity and well-being. Primary agriculture plays a vital role in the food sector which is linked to close to \$100 billion per year in economic activity and approximately 1 in 7.5 jobs. It is a key source of food security and a support for rural communities. And for many Canadians, it is not just a source of income, but a way of life.

There are substantial opportunities for Canadian agriculture in the coming decades. Population growth and other factors are projected to more than double global demand for food by 2050, while rising world incomes shift global patterns of food consumption towards higher value (but more water-intensive) forms of agricultural production (e.g., meat and dairy products) and increase demands for non-food agricultural products such as biofuels and natural fibres.

At the same time, growing competition for water, land, and other resources, as well as the uncertain impact of climate change and climate variability, will place increased stresses on agricultural production throughout the world. Within Canada, significant risks and uncertainties include agriculture's impact on water quantity and water quality; the agricultural sector's access to water, land, and other resources; and how the sector can meet the challenges posed by climate change and other developments. These risks and uncertainties must be addressed expeditiously for Canada to maintain a robust agricultural sector that can seize opportunities and contribute to meeting the world's food needs.

To help prepare for these opportunities and challenges the Minister of Agriculture and Agri-Food (the Sponsor) asked the Council of Canadian Academies (the Council) to assemble a panel of experts to address the following question:

What additional science is needed to better guide sustainable management of water to meet the needs of agriculture?

In response to this question, the Council assembled a multidisciplinary panel of Canadian and international experts with backgrounds in hydrology, agriculture, climate, engineering, economics, water management and governance, and other fields. The Expert Panel on Sustainable Management of Water in the Agricultural Landscapes of Canada (the Panel) gathered and analyzed evidence pertaining to areas such as Canada's water resources, water futures for agriculture and other industries, agriculture and the environment, Beneficial Management Practices (BMPs) from Canada and other countries, trends in technology and innovation,

public policy frameworks and economic instruments, and communication and stakeholder engagement aspects of land and water management. Information from this review was combined with the Panel's expertise, experience, and judgment.

THE FINDINGS

After a review of the existing evidence, the Panel identified five key areas in which additional science and required action can contribute to better sustainable management of water in agriculture. The following overview summarizes these under five headings, corresponding to each of the main chapters in the report.

- 1. Achieve a better understanding of risks and uncertainties in areas such as market conditions, competition for land and water resources, and climate change to inform management decisions, leading to more effective management practices and outcomes (discussed in Chapter 2).*

Identifying what additional scientific knowledge is needed for sustainable management of water in Canadian agriculture requires an understanding of the main global drivers affecting the future of the agricultural sector, as well as the economic, environmental, and social contexts in which Canada's agricultural sector operates. For the purpose of this report, the Panel examined the scientific evidence that refers to future trends and possibilities up to 2050. The Panel observed that during this period, changing market conditions are likely to result in new export opportunities, calling for more water-intensive forms of agricultural production. This would be happening at a time when urban and industrial development, climate change, and other factors will place greater pressures on land, water, and other resources in Canada and around the world. Moreover, given the resulting intensification in the competition for resources, social pressures may also require the agricultural sector to demonstrate more effectively its contributions to economic growth, food security, and environmental protection, while regulatory and non-regulatory risks may require changes to production methods and locations. Additional research in these and other areas of opportunities, risks, and uncertainties can help agricultural producers, government policy-makers, and other stakeholders make more informed decisions in production planning, infrastructure investments, and agricultural policies.

The Panel believes that priority areas include research on changing market conditions, policies, and social perceptions that may present new risks and opportunities for agriculture; implications of heightened competition for land, water, and other resources; and impacts of climate change and increased climate variability in agricultural regions across Canada. The Panel noted that climate

change is likely to pose increasing challenges for agriculture world-wide. Some of the world's major agricultural regions can expect substantially less precipitation. Across Canada, changing climate will affect both growing conditions for dryland agriculture, and the surface water and groundwater resources that support irrigation and livestock operations. Globally, increasing frequency of extreme weather events, including floods and droughts can be expected; recent events in North America and world-wide have shown the potential implications for global food production. In Canada, the Prairies have a history of flood and drought. The Panel was concerned to note that new research suggests an increasing risk of extreme Prairie drought under climate change scenarios. The Panel observed that given the high levels of uncertainty concerning future conditions, new approaches will be needed to support development of policy, governance, and management of water for agriculture. In particular, research is needed into the potential for adaptive management to provide robust strategies that can assist in accommodating uncertainty in water futures, and the role of foresight studies in informing those strategies.

- 2. Improve monitoring information targeted to specific areas of concern using a risk-based approach, as well as enhance scientific capacity for the interpretation of these data to foster a better understanding of Canada's water resource base and ongoing changes in hydrology, ecology, and climate, and to facilitate adaptive management (discussed in Chapter 3).*

Access to a reliable supply of sufficient fresh water resources is a fundamental requirement for agriculture. Most agricultural production depends on natural precipitation (rain or snow), sometimes called "green water." Concerns about water for precipitation-fed agriculture focus on (a) climate suitability for crop production (i.e., the reliability of adequate precipitation from year to year, the extremes of too much or too little water, and climate change); (b) managing the land to optimize the water environment for crops (e.g., through drainage or tillage practices); and (c) the impacts of agricultural activities on the quantity and quality of water in surface water and groundwater systems.

Irrigation and other agricultural uses of water (e.g., for intensive livestock production, or food processing) rely on surface water sources (rivers or lakes) or groundwater aquifers. This is sometimes called "blue water" and its use often competes with other demands for water (e.g., drinking water, other urban water use, industry, hydropower, or to maintain healthy ecosystems). Irrigation is essential for agriculture in areas where natural precipitation is low and/or variable, and it can also generate increased productivity, diversity (high-value crops), and product

quality. Irrigation is also, however, the world's largest consumer of blue water (70 to 80 per cent of global water consumption). Concerns for blue water use include the quantity and quality of the available water, as well as the impacts of agricultural activities on the quality of surface water and groundwater resources.

A serious threat to the health of the agricultural sector is water stress, whether related to the quantity or the quality of water used by agriculture or the quantity or quality of water flowing from agricultural lands. Causes of water stress depend on local conditions. In parts of the Prairies, for example, irrigation is a dominant consumer of blue water in areas where water resources are fully allocated, while the region's green water supply has been affected by both major floods (e.g., 2011) and droughts (e.g., 2001–2002). In regions of British Columbia, agricultural uses of water face significant competition from other users and the environment. For instance, the Okanagan Valley, a region where agricultural activity depends on irrigation, has seen significant population growth in recent years and is already nearing or exceeding the available water supply. Contamination of surface water and groundwater bodies due to agricultural runoff is a major concern in most agricultural regions across the country.

With stress on water resources projected to increase in the future, agriculture and other sectors need to work toward developing more efficient and sustainable methods for managing water use and consumption. Improved water monitoring is needed for contributing to this effort by providing decision-makers and stakeholders with the information they need to manage water more effectively. However, Canada does not currently possess the data and jurisdictional coordination necessary to fully understand either the quantity or quality of fresh water resources across the country, especially in less populous areas, or to adequately define the water currently used by agriculture and needed for future agricultural purposes.

The Panel believes that improvements in water quantity and quality monitoring and modelling would provide for better risk management in agriculture. Such information is critical to informing the development of adaptive management strategies that will be essential in helping agricultural producers, policy-makers, and other stakeholders to accommodate heightened uncertainties relating to market conditions, climate, and other risks. The Panel also suggests that the development of integrated water and climate monitoring and forecasting capabilities could make substantial contributions to Canada's ability to sustainably manage its water resources for agriculture, providing much needed input for mitigating risks, capitalizing on opportunities, and informing policy and management decisions.

- 3. Achieve a better understanding of the complex interactions between land management and water resources, including assessment of the economic and environmental efficacy of BMPs and the potential for conservation agriculture and ecosystems services approaches to the management of natural resources (including land and water) (discussed in Chapter 4).*

Agriculture can affect the physical environment in complex ways through irrigation, tillage, drainage, and other land and water management practices. Certain impacts on water quantity, water quality, and habitats are controversial, but they remain poorly understood and quantified. One such example is the loss of wetlands through agricultural drainage, which is an issue that can be a source of conflict between different parts of a community.

One of the major water quality issues arises due to high nutrient loads, particularly nitrogen and phosphorus. Issues of concern in Canada include high phosphorus concentrations in the Prairies. Associated effects on rivers and lakes include algal blooms, with implications for ecosystems, drinking water, and recreation. Other impacts on ecosystem health, recreation, and drinking water quality include high nitrate concentrations in areas such as Prince Edward Island, with concentrations in groundwater and some surface water sources exceeding drinking water standards. Pressures like these are seen world-wide. In Europe, one recent study estimated that reactive nitrogen effects from agriculture resulted in between €20 and €150 billion of environmental damage per year, compared to the benefit of nitrogen fertilizer to farmers, which was valued at between €10 and €100 billion per year. Other issues include impacts on water quality from pathogens, pesticides, and veterinary medicines.

As efforts to increase agricultural production intensify, issues pertaining to agriculture's impact on water and the environment will become more pressing, particularly as additional pressures are also being exerted by population growth, urban expansion, and industrial development.

Although agriculture is associated with some of the effects on water quality and the environment stemming from global intensification, there are many opportunities to manage agriculture's relationship to the water environment in ways that increase water use efficiency and enhance environmental protection. BMPs, technological innovations, governance strategies, and policy tools are some of the ways in which this can be accomplished. Given the various concerns for agriculture's adverse

effects on the water environment, and the particular concerns for nutrients, a critical policy question will be determining the potential for various mitigation options, such as BMPs, technologies, governance strategies, and policy tools, to reduce these effects.

BMPs also provide the context for two related concepts that offer the potential for important benefits connected with a more diverse agricultural sector: conservation agriculture, which aims to create resilient, productive landscapes in the face of uncertain futures; and an ecosystem services approach, which recognizes the value of non-marketable services, such as flood control, water quality, and ecological diversity. These broader perspectives on the role of agriculture in providing a wider range of ecosystem goods and services to society could provide significant benefits and opportunities for the agricultural industry.

Important research priorities therefore concern quantification of the effects of agricultural land management practices on water quantity and quality and on ecosystem health, and the potential of BMPs to mitigate those effects. Particular issues include:

- the local and regional impacts of changing cropping and tillage practices on runoff processes and water quality;
- the role of agricultural drainage and loss of wetlands on flood risk, drought resilience, water quality, and habitat at local and regional scales; and
- the potential effects of BMPs on nutrient loads to surface water and groundwater systems.

Addressing this latter issue will require targeted research on BMP performance that quantifies local and regional scale effectiveness, identifying the best means for encouraging uptake of sustainable practices and technologies, and assessing options for the sharing of costs and benefits among different stakeholders, including the public. The Panel maintains that the development of an ecosystems services perspective on the role of agriculture requires significantly improved data on the relationship between agriculture, habitat, and biodiversity than are currently available.

- 4. Improve knowledge of promising farm-scale technologies and research priorities, contributing to better water use efficiency, reduced environmental impacts, and sound investment decisions by governments, industry, and agricultural producers (discussed in Chapter 5).*

Technological developments have had dramatic impacts on the overall productivity of agricultural systems and experts are optimistic about the future improvements in productivity that can be achieved. Within Canada, there is a range of technological options relating to irrigation, precision and smart agriculture, pesticide and fertilizer formulation, low-cost water treatment, and many other areas that can contribute to maximizing opportunities and managing risks by improving water use efficiency, mitigating environmental impacts, and enhancing the productivity and resiliency of agriculture.

The Panel believes that additional research is needed to better understand the priority options that can provide the greatest contributions to improving water use efficiency, mitigating environment impacts, and enhancing the productivity and resiliency of agriculture. Targeted research is also needed to better understand the options and priorities most appropriate to each agricultural context. In addition, demonstration projects and agricultural extension are necessary to increase the uptake and successful deployment of technological developments and other research.

5. *Build a foundation for sustainability by adopting appropriate governance structures, valuation techniques, economic incentives, and knowledge transfer strategies to facilitate better management decisions, improve uptake of sustainable practices, and enable the agricultural community to build strong working relationships with other sectors and stakeholders to resolve cross-sectoral issues (discussed in Chapter 6).*

Based on its research and deliberations, the Panel concludes that effective governance is an essential prerequisite to sustainable water management in agriculture. Water governance in Canada is highly fragmented, with multiple levels of government holding or sharing responsibility. Contemporary water governance processes are diverse and include traditional regulatory approaches, collaborative processes, and market-based processes — as well as combinations of all of these. The roles of non-government actors, indigenous peoples, civil society groups, and businesses are increasing and changing relative to previous decades. Consequently, a host of new challenges exist relating to the effectiveness, capacity, legitimacy, and accountability of management decisions. Understanding how best to address these challenges is uneven.

Differences in legal regimes, institutional settings, and socio-economic contexts across the country mean that there is no single framework that will be effective in all jurisdictions. Therefore, the Panel focused on principles and promising practices that have been shown to be effective in supporting sustainable management of water resources. These include:

- Ensuring governance operates at the appropriate scale, which can help to facilitate coordination of management efforts across relevant jurisdictions and stakeholders.
- Integrating land-use planning with water management decisions, which can assist in incorporating the needs of multiple users, while ensuring sustainable water management in the long run.
- Incorporating knowledge into the decision-making process (including scientific, traditional, and local knowledge), which can lead to more robust solutions that account for the complex and interconnected nature of current water management and governance challenges. Transdisciplinary research, where researchers and partners from the farm community, industry, and government jointly define problems and research programs, is an important way to facilitate knowledge co-production.

Agricultural policy strongly influences stakeholder decisions that affect water use in agriculture, often striving to ensure the sector is economically competitive, while also addressing relevant environmental and social concerns. Experiences from across Canada and around the world demonstrate that economic instruments — when designed properly and implemented appropriately — can support the goal of sustainable water management. The Panel considered the potential for economic valuation techniques, economic incentives, pricing, and water markets to contribute to sustainable management of water for agriculture. Investigation of how these tools can be used effectively in the Canadian context is needed, as are mechanisms to measure their success.

Water governance decisions also need to incorporate the views and opinions of stakeholders. Stakeholder engagement should both disseminate information to the public and encourage a sense of responsibility over the sustainable management of water. Consequently, the Panel maintains that research into knowledge transfer strategies, as they relate to agriculture and water use, can contribute to improving communication between decision-makers and relevant stakeholder groups (including the public). This will be critical for addressing the cross-sectoral issues that affect sustainable management of water for agriculture.

MOVING FORWARD

The mix of opportunities, risks, and uncertainties for agriculture will vary by subsector and region. Decision-makers, therefore, need to adapt and apply solutions that are tailored to their particular circumstances. Doing so will require additional research, time, and investment. It will also require a concerted action by all stakeholders in their respective areas of responsibility, combined with a collaborative effort to coordinate activities and integrate knowledge from across jurisdictions. To prepare for the future, it is essential that such efforts begin now to ensure that the Canadian agriculture sector can remain resilient and continue to be a leader in productivity and innovation, as well as an important contributor to Canada's economic growth, food security, and the well-being of local communities.



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