The Oldman River dam was constructed in 1992 in response to the many droughts experienced by Southern Alberta farmers.
(credit: D. Flaten)

Resiliency will be enhanced by policies that support the development of multiple approaches to encourage preparedness for a range of possible climate change scenarios. Area-specific contingency plans will help to operationalize a range of strategies and provide a basis from which to develop further innovations and improvements. Government initiatives to construct infrastructure to support increased resiliency will be needed, such as facilities that store water and increase irrigation capacity. Monitoring systems are also important components of preparedness strategies, allowing governments and industry to respond to risks in early stages, when issues are usually more manageable.

Policy instruments to target outcomes of increased diversification of agricultural production according to areas of strength will provide new opportunities from which to build success in uncertain futures. Incentives to leverage momentum and private investment through collaboration with other efforts to diversify the economic base on the Prairies will be an important means of bringing new ideas and assets from a broad range of industry, research, and stakeholder perspectives. Review of policies to support resiliency and adaptation to climate change in other areas than agricultural production, such as municipal development and health services, will identify new opportunities where momentum can be increased by collaboration and integration. A variety of policy approaches can be designed to reward progress towards attaining desired outcomes at multiple levels (e.g. farm, processor, distributors and general public). Policies to encourage integration of new knowledge and technology to optimize resource use and productivity will bring added benefits of increased competitiveness and reduced risk. These approaches will also require collaborative and transparent processes of assessment, planning and prioritization with regular evaluation of metrics to measure progress towards identified outcomes of increased resiliency.

Although the challenges of adaptation to a changing climate are considerable and fraught with high uncertainty, comprehensive, dynamic and outcome-based government policy approaches can draw on past and current successes to heighten the resiliency of agricultural systems to impacts of future conditions on the Canadian Prairies.

How Will Technical Innovation Help Us to Deal With Climate Change Risk?

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Technical development is widely recognized as a substantial contributor to the capacity of Canada's agri-food industry to adapt to climate change[3-7]. Climate change will spur the development of a variety of technical innovations to deal with the challenges of variable weather and climate change directly, or indirectly through consequences such high input prices, rising cost of transportation, or greenhouse gas emission penalties. New opportunities to earn carbon credits or grow new, higher-yielding crops in a warmer, longer growing season, will also encourage further innovation.

Continuous development and adoption will continue to be imperative: The agri-food sector is a highly competitive industry where, if we don't innovate as quickly or as well as

Red Queen Effect

"... Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

Lewis Carroll

Through The Looking-Glass

"we will need to continue to invest in a combination of measures that enhance our capacity to be flexible"
(credit: W. Reimer)

our competitors, we will fall behind. As Julian Alston[8] states, it's similar to the classic "Red Queen Effect" in evolution, where our industry resembles the Red Queen's world from Lewis Carroll's *Through the Looking-Glass*, "it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!" Individually and collectively, we will need to continue to invest in a combination of measures that enhance our capacity to be flexible and adapt to new realities that will face the agri-food sector in the next decades.

Technical developments are difficult to predict: Historically, technical developments have been difficult to anticipate or predict. No one knows when another plateau in productivity may be reached or transcended; in large part because the fundamental nature of discovery is that it is a path that leads into unknown territory. In some cases the complexity of development from the basic through applied to commercialization stages will require both focused and comprehensive approaches to ensure acceptance by the user of the technology, the producer, as well as the general public. Situations in which industry and/or public confidence is challenged will increase development costs. At the 2014 annual meeting for the Weed Science Society of America in Vancouver, Damon Palmer, from Dow AgroSciences, estimated it now costs $250 million to research and develop a new crop protection product[9] and those costs are not likely to decrease. In other cases, especially where there is less perceived risk to human health or the environment, development of new techniques and technology may be faster than in the past because science and engineering tools for development have progressed substantially and because technology transfer is a global industry. Shifting drivers in the decision making process make predictions of future trends a subjective exercise, especially when one attempts to gauge the impact of future technologies applied collectively.

Technical developments require investment: One aspect of technical development is easy to predict: without any investment of time, effort and money, technical development is not going to occur. This important link between investment and return may be cause for some concern going forward to 2050. Traditionally, Canada's federal and provincial governments have been large investors in agricultural research, which has yielded large dividends to the regional and national economies. However, as noted by Veeman and Gray[10] in their review of agricultural production and productivity in Canada, real public agricultural research expenditures in Canada for crops and livestock has been declining. That total domestic research and development, a "knowledge stock" variable that is calculated as a 20-year stock of federal, provincial, and private sector research and development expenditures, has levelled off for crops and livestock in Prairie agriculture since 1990[10] is of even greater concern. This stagnant to declining investment in agriculture research has occurred even though return on investment in agricultural research and development is widely recognized as paying very large dividends for public, private, and producer group investors[7,10,11,12].

"Electronic communication technology enables farmers to access information directly"
(credit: C. Jorgenson)

New technology and techniques have no effect unless they are adopted: The rate of adoption of new technology is unpredictable[13]. Social factors such as education, attitudes and access to information are important; as are economic factors such as profitability, access to capital, and degree of risk or uncertainty. Electronic communication technology enables farmers to access information directly from public and private research organizations through a variety of channels, including web pages and Twitter. There is concern that the research community cannot meet the demand for information and lead research programs, and this has started to give rise to information brokers or consultants who are paid by industry. The economic incentives for farmers to integrate new knowledge or technology into their operations are linked to market opportunities and financial risk capacity. As major exporters of commodities and manufactured food and beverage, adoption of new technologies will be driven by international competitiveness, stability of trading partners and policy incentives or barriers to adaptation.

How much innovation can be imported, borrowed or adapted: Many people in the agri-food industry will continue to look elsewhere for technologies and techniques that might be new to them, but which are not really new. For example, soybean acreage in Manitoba has exploded over the last 10 years. Even though soybeans are a relatively new crop for most Manitoba farmers, they have been grown in the US and Central Canada for decades, so our farmers and agronomists are adopting and adapting techniques and technology for soybeans that are well proven in other regions. Nevertheless, the extent to which innovation can be imported or borrowed without any adaptation remains an important issue. The interactions between soil, crop, climate and market factors will result in unique challenges and rewards for agricultural production in the Prairies vs. the US and Central Canada.

Responding to the indirect side-effects of climate change challenges and opportunities: As the agri-food industry and society react to the challenges and opportunities associated with climate change, incentives for innovation will be created. For example, public demand for greenhouse gas mitigation may introduce substantial carbon credits, along with new regulations and penalties for greenhouse gas emissions. This regulatory environment could have a major impact on energy use in crop rotations and the need for new tools to enhance and validate carbon sequestration practices. As another example, warmer and longer growing seasons coupled with improved crop genetics may enable high yields of grain corn or other high yield crops to be grown across the Prairies. This could put a substantial strain on transportation capacity to provide sufficient amounts of fertilizer, as well as transportation access to move the higher grain volume to traditional export positions. Regionally this could translate into decisions that constrain the expansion or corn acres or promote more investment in livestock production to create local market for the energy and proteins crops grown.

Climate change adaptation will have to fit with other challenges and opportunities: Obviously, climate change is not the only challenge or opportunity that our agri-food industry will need to address. Some of the other major drivers that will shape the agri-food industry over the next 40 years will be complementary with efforts to adapt to or mitigate climate change and some will not. For example, carbon credits and concerns about agricultural sustainability, soil erosion and degradation may drive farmers towards innovations that improve soil quality (eg., water infiltration and water storage), which can improve farm profitability and sustainability, as well as the capacity of the land and cropping system to adapt to climate change. Conversely, if tight or negative margins force farmers towards short term exploitation strategies for management of land resources, their capacity to adapt to climate change may be reduced.

Innovation's capacity to help adapt to climate change is helpful but limited: Innovative technologies and practices can help to reduce the frequency of weather-based problems in our agricultural systems but extreme events will continue to periodically overwhelm our capacity to adapt. The probability and consequences of those periodic failures will likely vary among adaptation strategies. For example, the risk of flood damage to agricultural land from intensive rainfall or snowmelt events might be mitigated with levees, diversions, streambank stabilization measures, or reassignment of land use. Each of those strategies has a different risk in terms of the probability and consequences of failure. That type of risk is important to determine and then communicate to our professional colleagues, policy-makers and the general public.

Educational Systems for 2050 – Lessons from History

Michael Trevan, Dean, Faculty of Agricultural and Food Sciences, University of Manitoba

"Education is what survives when what was learned has been forgotten"

(B.F. Skinner 1964, *New Scientist*, 21 May)

"[Education] has produced a vast population able to read but unable to distinguish what is worth reading, an easy prey to sensations and cheap appeals"

(G. M. Trevelyan 1942, in *English Social History*)

Taken together these quotes are pivotal to the type of educational systems we will need by 2050. Education is not school, especially when dealing with the so-called "wicked" problems of growing population, war and conflict, diminishing extractable resources, social and environmental activism, fluctuating demographics, economic boom and bust, internet generated experts and critics, and the vagaries of climate change and weather instability.

Learning how to be adaptable and adaptive comes from a variety of inputs and situations, only some of which are found in the traditional classroom. In the rapidly changing world of today and tomorrow access to "information" is instant and universal, the key question is how the validity of that information might be ascertained. Will we need teachers to stand in front of a class and attempt to fill their students' heads with presently known facts? Clearly this is not even necessary today, the student has multiple means of accessing "facts", but few means to validate their relevance or accuracy, or to understand possible connections between apparently incongruent fields.

A student is not just the registered attendee of an educational institution who aims to gain a qualification, but anyone who is motivated to learn for whatever reason.

When Wilhelm von Humboldt founded the University of Berlin in 1810, he set in train the beginnings of the type of university that we know today, one that links research to teaching, producing both innovations for industry and society, and knowledgeable people. Humboldt's fundamental belief was that a university education was not defined by a