Advancing precision agriculture for sustainable farming in Canada

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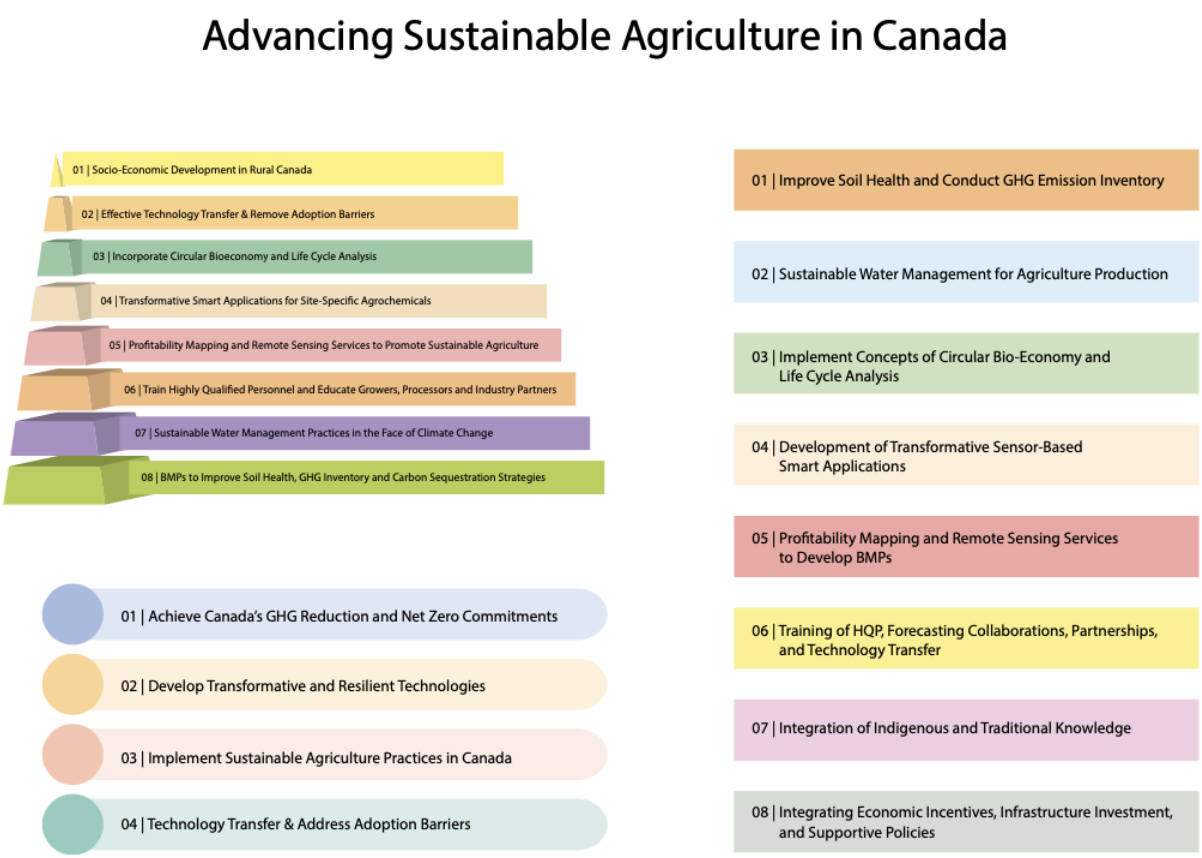

Advancing Sustainable Agriculture in Canada

Canada aims for a more sustainable and environmentally responsible agricultural sector, with precision agriculture playing a crucial role, according to Professor Aitazaz A. Farooque and Professor Qamar U. Zaman

Canadian agriculture is vulnerable to the impacts of climate change, which is diminishing the economic viability of farming. Canada strives for a more sustainable and environmentally responsible agricultural sector, with precision agriculture (PA) playing a crucial role in this transition. Researchers and farmers are improving efficiency while reducing environmental impact by harnessing advanced technology and smart farming solutions.

Embracing PA into traditional farming will enable Canadian farmers to enhance productivity, safeguard natural resources, and secure long-term food sustainability. Through innovation and research, education, and collaboration, Canada has the potential to become a global leader in sustainable farming.

Key focus areas for advancing sustainable agriculture in Canada include:

Improve soil health and conduct GHG emissions inventory: Nitrogen (N) fertilizer use has doubled in the last three decades due to intensive agricultural production and deteriorating soil health. Canada's greenhouse gas (GHG) emissions from agriculture increased significantly due to excessive use of N fertilizer and other management practices. Research and development on crop rotations, cover crops, and optimizing management practices can help to develop sustainable best management practices (BMPs) to improve soil health, conduct GHG inventory and scenarios, improve crop yield and quality, sequester carbon, and lower nutrient leaching and runoff.

Sustainable water management for agriculture production: Climate change poses significant challenges to agriculture water management, and droughts are projected to be more common. Uneven and temporally variable climatic fluctuations (i.e., amount and timing of rainfall, temperature fluctuations, degree days, relative humidity, etc.) and spatially variable micro-climates pose a risk to the sustainability of agricultural production in Canada.

Higher temperatures caused by global warming are impacting soil moisture, driving GHG emissions, fluctuating crop water requirement, and creating an imbalance of available water in spatially distinct microclimates. This situation demands designing, developing, and implementing transformative and adaptive irrigation strategies by employing state-of-the-art technologies and systems to promote the long-term sustainability of agriculture and the economic viability of agricultural production.

Implement concepts of regenerative agriculture, circular bioeconomy, and life cycle analysis for sustainable agriculture: Canada has the highest biomass per person and is well-placed to lead the global bioeconomy. To realize this potential, innovative research is needed to improve how biomass is processed and used. A national strategy has highlighted the need to understand better biomass sources and how to turn waste into useful products. Turning farm waste and low-grade biomass into sustainable, carbon-neutral products to improve soil health, boost yields, and store carbon. By combining the right materials, efficient processes, and economic analysis, this research and development will guide the implementation of the concept of circular bioeconomy to promote sustainable agriculture.

Development and implementation of transformative sensor-based smart applicators: Smart applicators play a crucial role in promoting sustainable agriculture in Canada by enabling precise and efficient use of inputs such as water, fertilizers, and pesticides. These technologies use real-time data to target specific areas of the field, reducing waste and minimizing environmental impact. These PA systems support Canada's climate goals by enhancing resource efficiency and lowering GHG emissions while improving soil health and long-term agricultural productivity. Additionally, smart applicators help farmers make data-driven decisions, adapt to changing climate conditions, and comply with environmental regulations, making sustainable farming practical and economically viable.

Profitability mapping and remote sensing services to develop BMPs: Profitability mapping and remote sensing services can play a vital role in promoting sustainable agriculture in Canada by enhancing productivity, resource efficiency, and environmental stewardship. Profitability mapping allows farmers to identify which areas of their fields are economically viable, enabling more targeted input use and better financial decision-making.

Meanwhile, remote sensing offers real-time monitoring of crop health, soil conditions, and environmental changes, supporting PA and early intervention for issues like pests or drought. Together, these technologies help reduce waste, improve yields, and support climate adaptation, which are critical benefits in Canada's diverse and often challenging agricultural landscapes. They also align with national sustainability goals and aid in meeting environmental compliance and accessing incentive programs.

Training of highly qualified personnel, fostering collaborations and partnerships, and technology transfer: Advancing sustainable agriculture in Canada requires a holistic approach, integrating the training of highly qualified personnel, fostering collaborations and partnerships, and promoting technology transfer. Well-trained professionals bring the latest scientific knowledge to farms, driving innovation and informed decision-making.

Collaborative efforts between academic institutions, farmers, governments, producer associations, and private sectors ensure sustainable practices are tailored to local needs and supported by effective policies. Meanwhile, technology transfer accelerates the adoption of cutting-edge tools and solutions, such as PA and climate-smart practices, making agriculture more efficient and resilient. Together, these efforts create a dynamic ecosystem that drives sustainable agricultural growth across Canada.

Integrating Indigenous and traditional knowledge with PA technologies offers a powerful pathway to sustainable farming. By combining the deep, localized ecological insights of Indigenous practices with advanced data-driven tools, farmers can optimize crop management, soil health, water use, and biodiversity conservation. This fusion allows for adaptive strategies that respect both cultural values and ecological systems, ensuring resilience in the face of climate change. Ultimately, this integration fosters a more sustainable, efficient, and culturally inclusive approach to agriculture, creating a balanced future where technology and tradition work hand in hand.

Promoting sustainable agriculture in Canada requires a comprehensive and coordinated approach that includes integrating economic incentives, infrastructure investment, and supportive policies. Financial incentives like subsidies, grants, and tax credits can reduce the financial burden, while broadband and data infrastructure investments ensure accessibility for rural farmers. Tailored education programs, clear regulations on data privacy, and sustainability rewards can foster trust and ease adoption.

Furthermore, public-private partnerships and research tailored to Canadian conditions can drive innovation and make technologies more affordable and relevant. By combining these efforts, Canada can empower its agricultural sector to embrace PA, boosting productivity, sustainability, and global competitiveness.

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