

Responsible Innovation in Precision Agriculture: Inclusive Design for Ethical, Equitable, and Sustainable Food Systems

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Our Challenge: How to feed our growing population?

Goals:

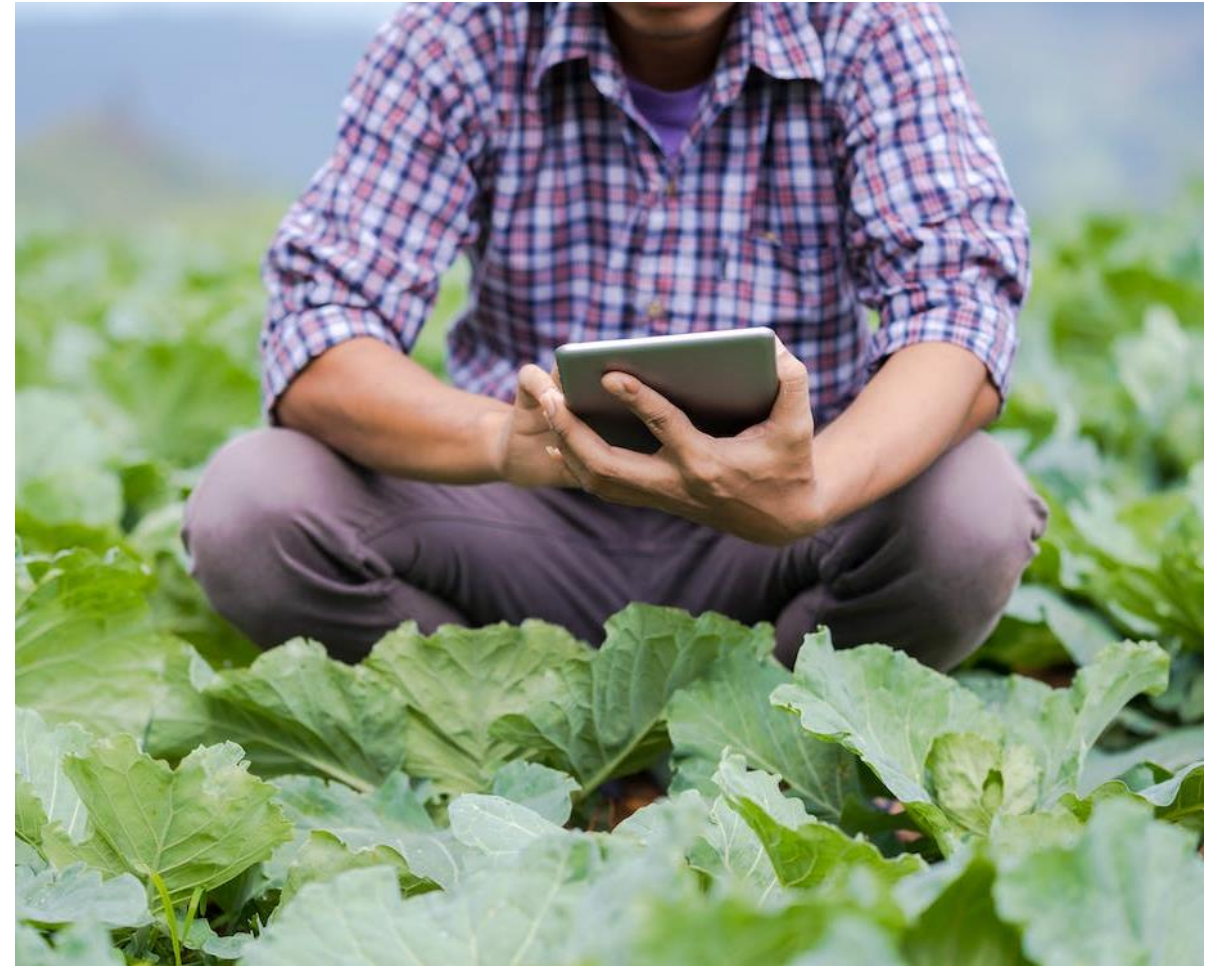
- Increase global food production 70% by 2050 (*UN*)
- Sustainably feed growing Canadian population (*Sustainable CAP*)
- Increase yields & promote Ontario-grown food (*Grow Ontario*)



How can we sustainably intensify food production?

Experts call for:

- Increased agri-food technology and adoption
- Harnessing the potential of precision agriculture
- Development of responsible and inclusive innovation systems



What is Precision Agriculture?

Precision Agriculture (PA):

- Farming practices + sensors, smart devices, intelligent systems, and cloud computing
- Enhances resource efficiency and production
- May support sustainable development goals

Early Impacts:

- Favors larger-scale industrial farming operations
- Limited adoption in smaller-scale farming
- Significant threat of reinforcing existing spatial, economic, and social divides

Literature

PA Studies:

- Majority of research focuses on technical aspects of innovation
- Tech producers hold a specific set of values about good farming and good tech
- Some concerns about skills demand, uneven benefits & burdens, identity, and well-being

Gap:

- Limited examination of social, spatial, or political context influencing design, adoption, or use
- No critical assessment of innovation processes & responsibility in PA
- Few studies exploring how PA innovation can respond to societal concerns
- Lack of studies applying Responsible Research & Innovation (RRI) framework

Research Objective & Questions

Objective: This research will identify and explain factors influencing design and adoption of PA, by integrating a human-centered design research methodology with the Responsible Research and Innovation (RRI) framework

Questions:

- 1) How can the RRI framework be informed by a human-centered design in the context of family, unconventional, and other labour-intensive farming?
- 2) What factors influence PA technology adoption?
- 3) How can PA technologies consider the family, unconventional, and other labour-intensive farming context in their design?

RRI Framework

Dimension

Assessment Goals

Anticipation

How do anticipation and foresight in science and innovation enhance governance and outcomes?

Inclusion

How can debates and participation in innovation be broadened to include stakeholders?

Reflexivity

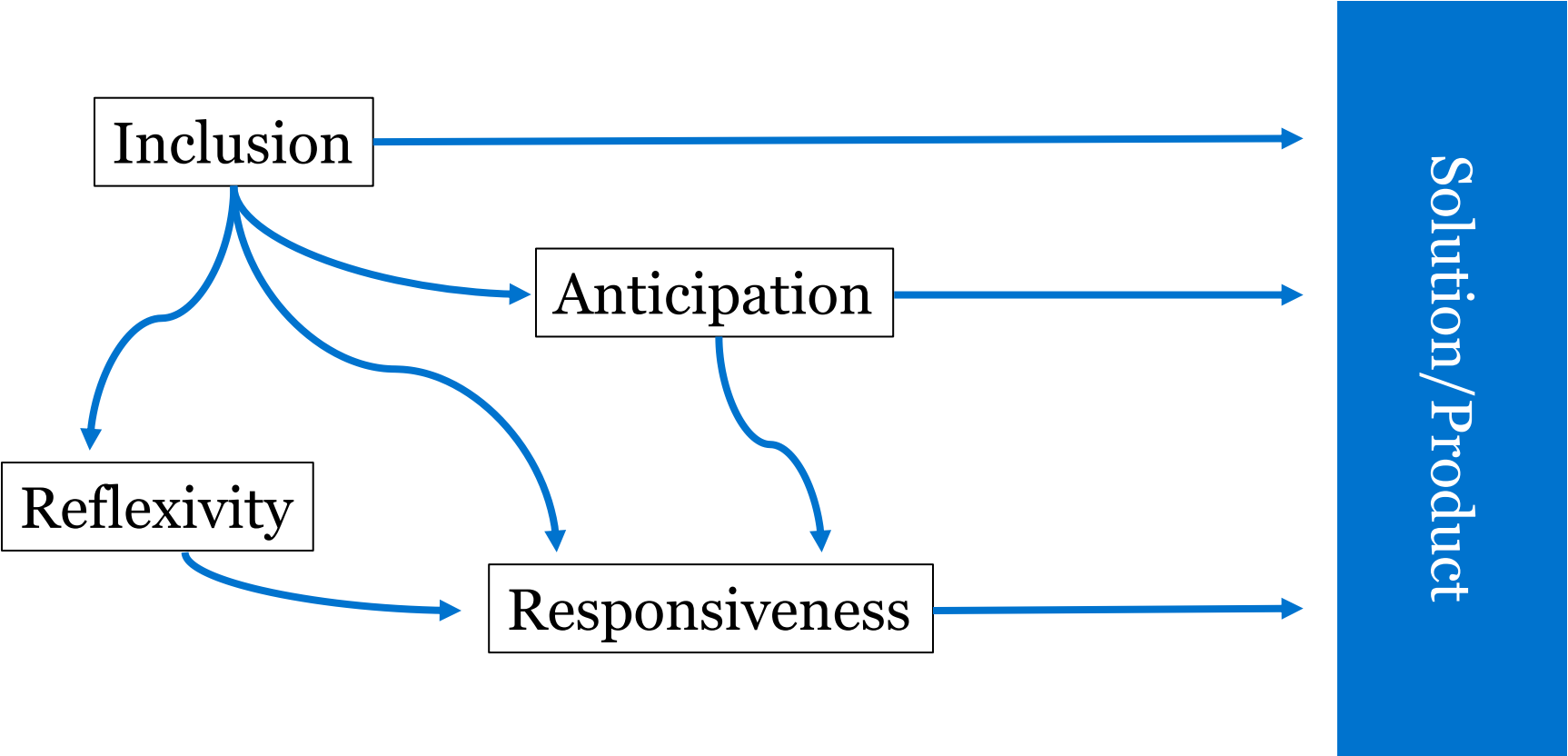
How can innovation processes be more reflexive to assess personal or individual motivations and assumptions, while acknowledging the perspectives of other actors?

Responsiveness

How do innovation processes respond to societal needs and major challenges, and change direction or scope as they progress?

RRI Framework

Interactions between RRI Dimensions



Human-Centered Design Research Methodology

	<i>Phase 1:</i> Exploring Context	<i>Phase 2:</i> Design Criteria Foundations	<i>Phase 3:</i> Design Decisions	<i>Phase 4:</i> Knowledge Mobilization
Approach	<ul style="list-style-type: none">• Understand users and context• Explore barriers	<ul style="list-style-type: none">• Explore users' thoughts, feelings, and experiences• Co-generate solution ideas	<ul style="list-style-type: none">• Test different solution ideas• Solicit immediate feedback	<ul style="list-style-type: none">• Share learnings• Bidirectional knowledge exchange

Research Setting & Location



Areas representing highest concentration of small farms and mix of crop types

Southern Ontario:

- Middlesex
- Niagara Region

Western Ontario:

- Wellington
- Waterloo

Central Ontario:

- Kawartha Lakes
- Prince Edward County

Target Research Participants

Category	Sub-Types	Definition
Family Farms	Family-run or family-owned	Relying on family capital and family labour
Unconventional Farms	Organic	Certified by National Canadian Organic Standards (government regulation and oversight)
	Regenerative	Promoting soil regeneration to mitigate climate change, restore biodiversity, improve water cycles, and support food system
	Biodynamic	Certified by Demeter Canada; focuses on creating self-contained farm individualities
	Conservation Agriculture	Balancing productivity with preservation and enhancement of the resource base and environment
	Polyculture or Intercrop	Co-planting of several species of plants in the same field or plot
Other labour-intensive farms	Heritage, traditional methods, agri-tourism	Growing, saving, and researching heritage or rare seeds, grains, plants, and/or animal breeds; sustaining farm revenue through agri-tourism

Phase 1: Exploring Context

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Goal	Consider the broad context of needs and constraints related to PA consideration, adoption, and use, across spatial, economic, environmental, and social dimensions
Methods	Systematic review of literature & document review (e.g., government reports, industry websites, journal articles)



Analysis of RRI dimensions
across regional PA context

Phase 2: Design Criteria Foundations

<i>Phase 2: Design Criteria Foundations</i>	
Goal	Explore contextual, social, and political factors that influence design, adoption, and use of PA
Methods	Survey of Ontario farmers, technology developers, intermediates, and other key informants in the agriculture industry

Survey questions grounded in RRI:

- **Anticipation:** foresight exercise questions
- **Inclusion:** questions seeking open and critical input
- **Reflexivity:** questions encouraging acknowledgement of motivations
- **Responsiveness:** questions about response to societal needs or challenges

Phase 3: Design Decisions

	<i>Phase 3: Design Decisions</i>
Goal	Establish preliminary, inter-related sets of design decisions based on user requirements, stakeholder needs, and contextual factors
Methods	Semi-structured interviews where participants will map PA use cases and share priorities, preferences, implications, and trade-offs related to potential design innovations and corresponding training approaches



Semi-structured interview topics organized by RRI dimensions

Phase 4: Knowledge Mobilization

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Goal	Share results with participants
Methods	Develop peer-reviewed journal publications, conference presentations, and other forms of knowledge sharing (targeted journals: <i>Regional Studies</i> , <i>Industry and Innovation</i> , <i>Canadian Geographer</i> , and the <i>Journal of Rural Studies</i>)

Paper 1: Advancing the RRI Framework with Human-Centered Design Methodology

Paper 2: Adoption of PA Technology

Paper 3: Small-Scale Farming Considerations in PA Design

Anticipated Contributions

- 1. Advancement of Theory:** A refined and expanded RRI framework that integrates a human-centered design approach to account for farmer & stakeholder needs, their barriers, and their social and political context
- 2. Design Enhancements:** Pinpoint opportunities for PA design enhancements to address barriers among farmers in Ontario and implementation strategies for rural and resource-constrained environments
- 3. Targeted Skilling:** Recommendations for technology skilling and training approaches to support farmer adoption of PA
- 4. Policy Recommendations:** Policies supporting rural technology adoption/use and the development of rural economies

For Discussion

1. How best to recruit farmer participants (small-scale/family farms in Ontario)?
2. What types of outputs from this research would be impactful (e.g. stakeholder map, solution requirements, etc.)?
3. How should geographical factors of farms and technology inform analysis?

Thank you!

Questions or feedback?

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University of Waterloo Disruptive Technologies Website:

<https://uwaterloo.ca/disruptive-technologies-economic-development/>